https://doi.org/10.17221/234/2018-AGRICECON

Subsidies and technical efficiency of Czech food processing industry

Zdeňka Náglová, Marie Šimpachová Pechrová*

Institute of Agricultural Economics and Information, Prague, Czech Republic
**Corresponding author: naglova.zdenka@uzei.cz*

Citation: Náglová Z., Šimpachová Pechrová M. (2019): Subsidies and technical efficiency of Czech food processing industry. Agricultural Economics – Czech, 65: 151–159.

Abstract: At present, the New Common Agricultural Policy for the period 2021–2027 has been currently formulated. Future of the agriculture and food industry is now widely discussed. These sectors play an important role, and it is necessary to maintain their competitiveness and sustainability. In this context, the main aim of the paper is to evaluate the technical efficiency of food processing firms by using Stochastic Frontier Analysis applying True Fixed Effect model on production function. It was identified, that increase of subsidies cause a slight increase in the mean of technical inefficiency. Also, the technical efficiency of the firms without subsidies is higher than in the subsidised firms and differs statistically significantly in the time and also with respect to the region of the firm. To summarise, the effect of subsidies is negative as the obtaining of the subsidies is not related to higher technical efficiency.

Keywords: food industry; manufacturing; Stochastic Frontier Function; subsidies; technical efficiency

In the Czech Republic (CR), food and drink industry belong to key sectors of the manufacturing industry. Long-term issue of this industry is lower labour productivity than the average in the European Union (EU). Lower labour productivity is in the bakery and meat industry (Ministry of Agriculture 2017). They are the key drivers of food industry according to their share in sales, enterprises and employees. There is also a long-term decrease in the number of workers, and they are rewarded by low wages which further reduces their attractiveness. According to Vokoun et al. (2015), Czech and Slovak food industry is capable to react to changes relatively quickly and are stable, thanks to the medium, and large companies.

According to the current situation stated above, one way to solve this unfavourable issue can be investments and innovations. According to Skuras et al. (2006), investment subsidies are a major instrument of industrial and regional policy for economically developed countries all over the world.

To improve the situation, food industry enterprises in the CR can also draw EU or national funds. These enterprises were supported by Rural Development Programme 2007–2013 (RDP) from measure I.1.3 Adding value to agricultural and food products. From current RDP 2014–2020 enterprises can apply for grants mainly from the operation 4.2.1 Support for investments in processing/marketing and/or development of agricultural products. Supports are aimed at small and medium enterprises. Together with support from the Ministry of Agriculture (MoA), national subsidies (title 13 Support for processing of agricultural products and increasing competitiveness) they are the main source of grants. However, only larger enterprises can be supported by national subsidies. This aids can be drawn by enterprises which produce certain types of listed products and whose production and processing fall within the scope of the Common Agricultural and Fisheries Policy of Annex I of the Treaty on the Functioning of the EU. Most of these are products with a direct link to agriculture. Enterprises with production and processing which is not stated in this document can obtain funds from operational programmes of Ministry of Industry and Trade (Op-

Supported by Institutional support for long-term conceptual development of the research organization Institute of Agricultural Economics and Informatrion, project „Technical Efficiency of Food Industry Enterprises“ (1130/2019).

https://doi.org/10.17221/234/2018-AGRICECON

erational programme Enterprise and Innovations 2007–2013 and following Enterprise and Innovations for Competitiveness 2014–2020). There is a large scope of programmes that food businesses can use (Innovation, Marketing, Eco-energy, Property, Potential, Consulting, Development).

According to Minviel and De Wite (2017), subsidy efficiency nexus is a crucial research question for agricultural policy makers and can provide information on the influence of public subsidies and the optimal use of production factors. Only a few papers dealing with the efficiency of the food industry in Europe can be found (Keramidou et al. 2011; Čechura and Hockmann 2010).

Different effects of subsidies on technical efficiency can be found. The empirical studies differ not only in the context of the study (country, period, and types of farms) but also in the data used (number of farms, cross-sectional or panel data) and in the methodology employed (Minviel and Latruffe 2017). Some authors evaluated the effects of capital subsidies on factors' productivity and firm performance as questionable (Skuras et al. 2006). According to Minviel and Latruffe (2017), public subsidies are commonly negatively associated with farm technical efficiency. It can be related to the income guarantee by subsidies (Zhu and Oude Lansink 2010).

Dimara et al. (2008) found that high technical efficiency increases. Developments in innovations in the food sector and competition policy are likely to affect technical and scale efficiency.

Rudinskaya and Náglová (2018) indicated a positive impact of subsidies on meat processors efficiency in the Czech Republic. Náglová (2018) found that subsidies in the meat sector did not contribute to increasing business performance. Also, other studies that dealt with the technical efficiency in Czech agriculture such as Pechrová and Vlašicová (2013) or Pechrová (2015) found a decreasing effect of subsidies on technical inefficiency.

In the Czech agrarian sector, technical inefficiency is a significant phenomenon. The supports and policy tools should be sector-specific because the food industries differ from each other (Čechura and Hockmann 2010). Čechura and Malá (2014) denoted a dissimilarity between the analysed sectors and countries. Technical efficiency was high in all analysed sectors and higher in the Czech Republic than in the Slovak Republic. Čechura and Hockmann (2010) results suggest that serious adjustment problems exist, including problems on the capital market. The scale effect was identified to be relatively small in food processing.

The aim of the paper is to evaluate the technical efficiency of food processing firms and to assess whether this efficiency differs between supported and non-supported firms by subsidies. The differences in efficiency with respect to the year of drawing and region are also done.

MATERIAL AND METHODS

Data

The data were mainly obtained from the Albertina database (Albertina Database 2018). In this database, there are stated financial statements and other additional indicators. The data were selected according to the sectors (CZ-NACE), particularly CZ-NACE 10 Manufacturing of food products and CZ-NACE 11 Manufacturing of beverages. We created the unbalanced panel data set for the period of 2007–2016. To mitigate the influence of the price changes, the data were adjusted by price indexes. We gain a sample of 708 enterprises. As the sample was not balanced – there were between 3 to 10 observations (8.4 on average) per each firm forming altogether 5 918 observations. Statistical description of the variables is displayed in Table 1.

Information about the subsidies was obtained from the database of the Ministry of Agriculture (RDP), measure I.1.3. Adding value to agricultural and food products which was valid in 2007–2013, but some subsidies were refunded after this date. Second subsidies source was obtained from the database of the Ministry of Industry and Trade (MIT), where are all refunded subsidies from the year 2007. This data was specially provided for this purpose, they are unpublished. This information was linked to the Albertina database. There were 724 observations with subsidies either from MIT or RDP. 253 companies got subsidies from MIT and 474 from RDP. The average height of the subsidy was approximatelly 225 thousand EUR (we used the average exchange rate of Czech Central National Bank (CNB) – for years 2007–2016). The number of subsidised firms and the number of supported firms varied in time (Figure 1). It was tested whether the technical efficiency statistically significantly differs between the years. As the distribution of technical efficiency was not supposed to be normal (which was proved by Shapiro-Wilk normality test), we chose the nonparametric Kruskal-Wallis equality-of-populations rank test between the supported and non-supported group. We applied a non-parametric Wilcoxon rank-

https://doi.org/10.17221/234/2018-AGRICECON

Table 1. Statistical description of the sample of food and beverages manufacturing companies

Variable	Mean	Standard deviation	Minimum	Maximum
Revenues – adjusted (thousand EUR)	17 532.00	50 555.00	0.00	106 4774.00
Fixed assets – adjusted (thousand EUR)	5 674.00	24 689.00	0.00	576 276.00
Current assets – adjusted (thousand EUR)	5 436.00	14 373.00	–98.00	187 767.00
Equity (thousand EUR)	5 689.00	24 490.00	–7433.00	954 099.00
Liabilities (thousand EUR)	5 214.00	18 568.00	–24.00	412 171.00
Number of employees	4.61	9.28	0.04	133.57
MIT subsidies	9.95	86.58	0.00	2 862.30
RDP subsidies	17.54	105.91	0.00	3 434.76
Total subsidies	27.49	135.74	0.00	3 434.76

RDP – Rural Development Programme

Source: own elaboration based on data from Albertina database (Albertina Database 2018) and unpublished data specially provided by Ministry of Industry and Trade (MIT) and Ministry of Agriculture (MoA); average exchange rate for 2007–2016 by CNB (Czech National Bank)

sum test (the non-parametric equivalent of Mann-Whitney test). The null hypothesis was H_0: there are no statistically significant differences in the mean of the two samples, alternative hypothesis H_A expressed the opposite.

The data set was also divided according to the region of the firm, and it was tested by Kruskal-Wallis test whether the mean of technical efficiency also differs by this criterion. Consequently, it was also analysed, whether the technical efficiency is statistically different within one region between supported and non-supported firms. We used again Wilcoxon rank-sum test. Figure 2 shows the number of supported firms and non-supported firms and average subsidy.

Methods

Technical efficiency refers to the ability of a decision-making unit (usually a firm) to minimise input used in the production of a given output vector, or the ability to obtain maximum output from a given input vector (Kumbhakar and Lovell 2003). “Consequently, a firm is fully technically efficient if it produces the maximum possible output from a fixed level of inputs

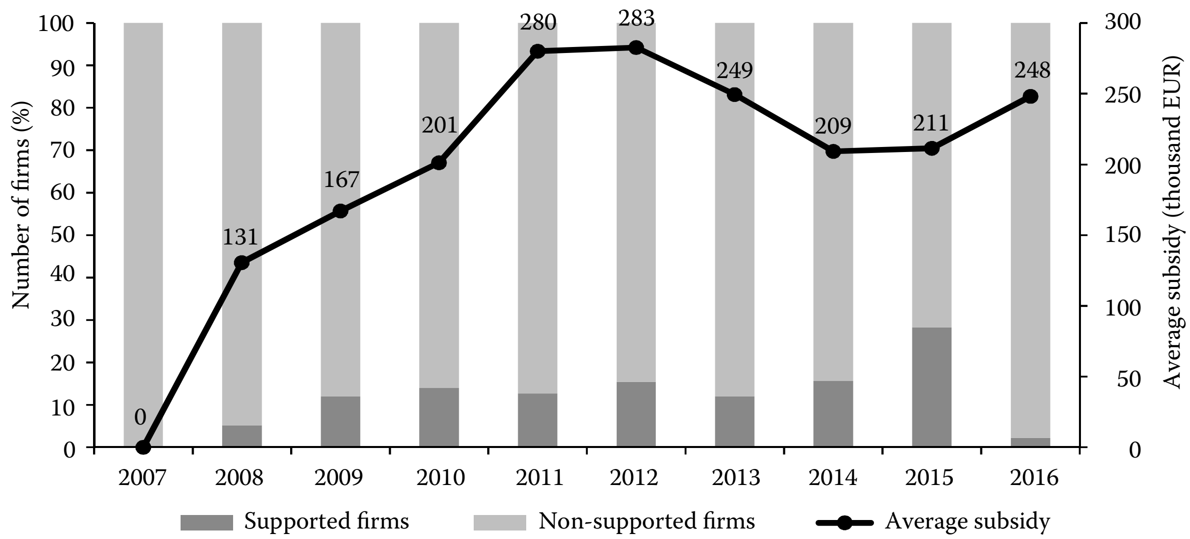

Figure 1. Development of the number of (non) supported firms and average amount of subsidies

Source: own elaboration based on data from Ministry of Industry and Trade (MIT) and Ministry of Agriculture (MoA)

https://doi.org/10.17221/234/2018-AGRICECON

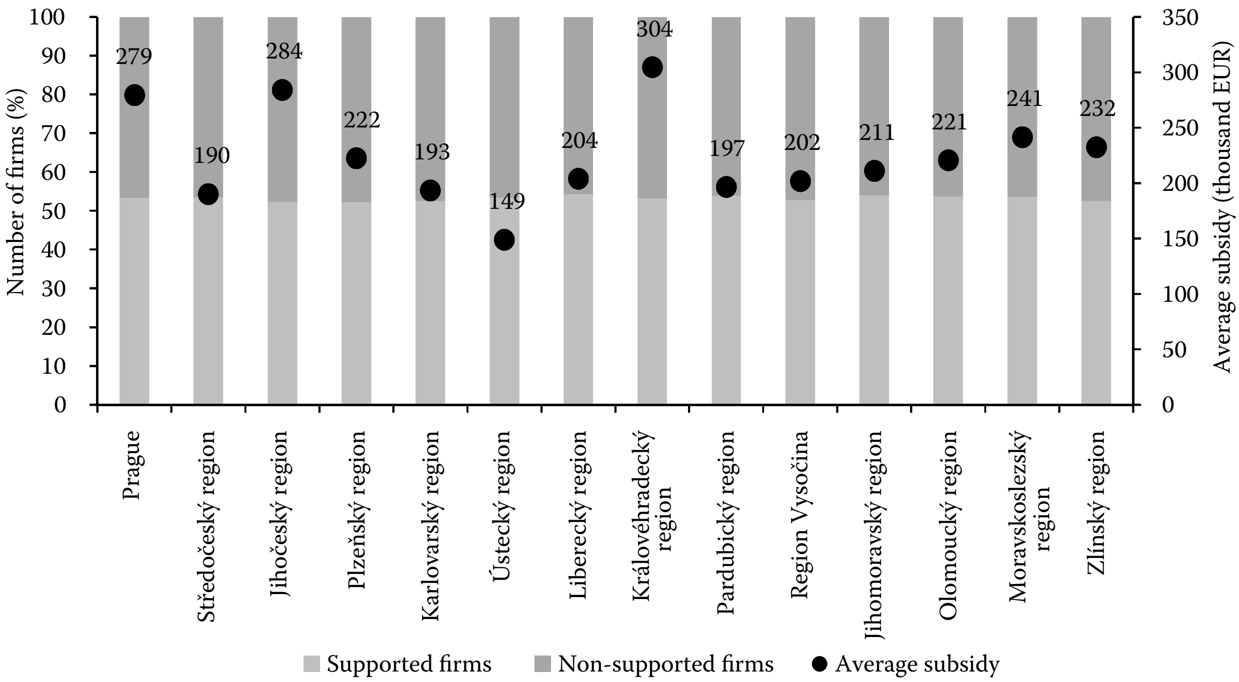

Figure 2. Number of (non) supported firms and average amount of subsidies according to the region

Source: own elaboration based on data from Ministry of Industry and Trade (MIT) and Ministry of Agriculture (MoA)

(output orientation), or if it uses the minimum possible input to produce a given level of output (input orientation)" (Setiawan et al. 2012).

In our case, the technical efficiency of the holdings was assessed by stochastic frontier analysis (SFA) based on the production function. The firms that are lying on the production function are 100% efficient, while those under this frontier are inefficient. One of the key assumptions in benchmarking the efficiency of firms is that they are homogeneous. Therefore, as proclaimed by Le et al. (2018), "the comparison of the efficiency of firms operating under different technologies can be problematic". However, we compare food and beverages manufacturers in the Czech Republic, where the main position has three branches, and they may have relatively similar technology, and we can assume homogeneity of some degree.

The production was expressed by the total revenues from own products and services in thousand EUR. As we used data for a long period, the effect of inflation was mitigated by the deflation of the revenues by the price index (2015 = 100) of food products, beverages and tobacco (CZSO 2018). Company's production (y_{it} – output) is represented by the revenues from own products and services. The explanatory variables were:

$x_{1,it}$ – fixed assets (thousand EUR)
$x_{2,it}$ – current assets (thousand EUR)
$x_{3,it}$ – equity (thousand EUR)
$x_{4,it}$ – foreign sources (thousand EUR)
$x_{5\ it}$ – number of employees

Subscript i (i = 1, 2, ..., N), where N is total number of firms, represents particular firm and t (t = 1, 2, ... , T) stays for a period for which are available company's observations.

We constructed true fixed effects model as proposed by Greene (2002) and estimated Cobb-Douglas production function in the following form (Equation 1) linearised by natural logarithms as Equation 2.

$$y_{it} = x_{1,it}^{\beta_1} x_{2,it}^{\beta_2} \dots x_{5,it}^{\beta_5} e^{u_{it}} e^{v_{it}} \quad (1)$$

$$y_{it} = \beta_1 \ln x_{1,it} + \beta_2 \ln x_{2,it} + \dots + \beta_5 \ln x_{5,it} + u_{it} - v_{it} \quad (2)$$

where β_1, ..., β_5 are coefficients of explanatory variables, u_{it} represents technical inefficiency of particular firm i in time t ($u_{it} \geq 0$), and v_{it} is pure stochastic noise (idiosyncratic error component). Cobb-Douglas (power) function has the advantage that the coefficients can be interpreted as a percentage change of the variables and the sum of the coefficients express the type of returns to scale. When the sum is lower than 1, the firms exhibit decreasing returns to scale, when it equals to 1, there are constant returns to scale present, and when it is larger than 1, there are increasing returns to scale.

https://doi.org/10.17221/234/2018-AGRICECON

The distribution of the inefficiency term u_{it} was assumed to be truncated normal (Equation 3) and of stochastic term v_{it} normal (Equation 4).

$$u_{it} \sim N^{+}(\mu, \sigma_u^2) \tag{3}$$

$$v_{it} \sim N(0, \sigma_v^2) \tag{4}$$

The mean of the technical inefficiency μ expresses the heterogeneity among firms and the variance of inefficiency σ_u^2 the heteroscedasticity. This heterogeneity of inefficiency term was explained by the constant and by the total amount of subsidies (Equation 5).

$$u_{it} \sim N^{+}(\delta_0 + \delta_1 z_{1,it}, \sigma_u^2) \tag{5}$$

where δ_0 is a constant and δ_1 is a parameter of variable $z_{1,it}$ that represents the subsidies. Where there were no subsidies obtained by a firm a small number was used as zero ($10e^{-5}$).

The model was estimated using the maximum likelihood method. Then the technical efficiency of each firm was estimated using JLMS estimate of technical efficiency (Jondrow et al. 1982) where the efficiency is estimated as $\exp[-E(u|e)]$. The calculations were done in econometric software StataIC version 15.

RESULTS AND DISCUSSION

The results of true fixed-effects model (with the truncated-normal distribution of the mean of the technical inefficiency) are displayed in Table 2. The model was statistically significant at 5% level. All explanatory variables were also statistically significant and according to the expectations. If the fixed assets increase by 1%, the production (revenues from own products and services) increase by 0.16%. If current assets increase by 1%, the production increases by 0.23%. The increase of equity and liabilities by 1% brings an increase in production by 0.19% and 0.22% respectively. Finally, the increase in the number of employees by 1% brings an increase in production of 0.21%. Production is influenced the most by the changes in current assets and then by the changes in liabilities. On the opposite, Skuras et al. (2006) found in food and beverage manufacturing firms, that assets have a non-significant effect on technical efficiency. According to Minviel and Latruffe (2017), subsidies should primarily aim at increasing production, supporting firms' incomes and not explicitly at improving technical efficiency. The sum of coefficients is higher than 1 (1.03) that indicates mild returns to scale in this sample. Mild increasing scale effect was also identified by Čechura and Hockmann (2010).

Table 2. Results of true fixed-effects model

Name of parameter	Frontier				
	coefficient	standard error	p-value	lower bound (95%)	upper bound (95%)
β_1 (ln $x_{1,it}$)	0.1643	0.0007	0.0000	0.1320	0.1656
β_2 (ln $x_{2,it}$)	0.2329	0.0007	0.0000	0.2315	0.2343
β_3 (ln $x_{3,it}$)	0.1887	0.0018	0.0000	0.1851	0.1924
β_4 (ln $x_{4,it}$)	0.2232	0.0012	0.0000	0.2209	0.2255
β_5 (ln $x_{5,it}$)	0.2207	0.0016	0.0000	0.2038	0.2102
Inefficiency mean function					
δ_0 (constant)	–172.3592	18.7567	0.0000	–209.1218	–135.5967
δ_1 (ln $z_{1,it}$)	0.0014	0.0004	0.0010	0.0006	0.0021
Inefficiency variance function					
ω_0 (constant)	4.8956	0.1074	0.0000	4.6850	5.1061
Stochastic term variance function					
ρ_0 (constant)	–30.4099	5.6053	0.0000	–41.3961	–19.4236
σ_u	11.5627	0.0621	0.0000	10.4073	12.8465
σ_v	0.0000	0.0000	0.7210	0.0000	0.0001
λ	4.64E+07	0.6211	0.0000	4.64E+07	4.64E+07

$x_{1,it}$ – fixed assets; $x_{2,it}$ – current assets; $x_{3,it}$ – equity; $x_{4,it}$ – foreign sources; $x_{5,it}$ – number of employees; β_1, ..., β_5 – coefficients of explanatory variables; u – technical inefficiency; v – pure stochastic noise; for further explanation see section Methods

Source: own elaboration

https://doi.org/10.17221/234/2018-AGRICECON

The mean of inefficiency was explained beside constants also by the amount of subsidies ($z_{1,it}$). The increase of subsidies causes a slight increase in the mean of technical inefficiency. The variance of technical inefficiency was explained only by a constant (as we supposed that the term is homoscedastic). Similarly, we supposed that variance of the stochastic term is also homoscedastic and hence was also explained only by a constant. This negative relation was also found by Minviel and Latruffe (2017) or Čechura and Hockmann (2010).

Technical efficiency of supported and non-supported companies

Consequently, the technical efficiency was estimated using JLMS estimator. The descriptive statistics are displayed in Table 3. The efficiency ranged between 0 and 1 (there were 708 companies 100% efficient that were composing the stochastic frontiers). Average technical efficiency was 65.64%. A similar study in the food industry was done by Čechura et al. (2014), but they found higher technical efficiency (average is 84%).

Table 3. Descriptive characteristics of technical efficiency of food and beverages processing companies

Descriptive characteristics of technical efficiency		
Percentiles (%)	5	0.0766
	10	0.2432
	25	0.4505
	50	0.7175
	75	0.8927
	90	1.0000
	95	1.0000
Mean		0.6564
Standard deviation		0.2821
Minimum		0.0000
Maximum		1.0000
Variance		0.0796
Skewness		–0.6438
Kurtosis		2.4273

Source: own elaboration

Skewness and kurtosis of the technical efficiency show that the distribution is not normal. It is also proved by the histogram of technical efficiency (Figure 3), where it can be seen that the highest percentage of companies is close to 100% efficiency. Shapiro-Wilk test also confirmed that the distribution of technical efficiency was not normal.

It was tested by Wilcoxon rank-sum test whether there are statistically significant differences in technical efficiency between subsidised and non-subsidised firms. The technical efficiency of the firms without subsidies was 65.92%, the subsidised firms were efficient only from 63.65%. The test showed that the differences are statistically significant (probability that their means are equal is only 0.01) (Table 4). According to Martin and Page (1983), it may result from income stabilisation, that may distort incentives to produce efficiently. Their activities may be reduced if a larger part of their income is guaranteed by subsidisation. Subsidisation may enable firms to smooth their wealth without adopting efficient production strategies. On the other hand, subsidies may help overcome financial constraints that impede efficient restructuring or modernisation, and thus may increase technical efficiency by improving the firm's productive capacity through replacement investment in advanced technologies (Zhu and Oude Lansink 2010).

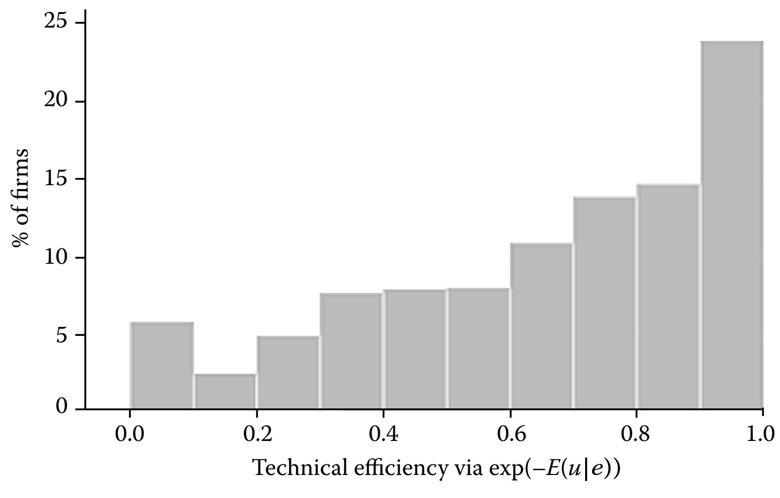

Figure 3. Histogram of technical efficiency

Source: own elaboration based on data from Albertina database (Albertina Database 2018), Ministry of Industry and Trade (MIT) and Ministry of Agriculture (MoA)

https://doi.org/10.17221/234/2018-AGRICECON

Table 4. Technical efficiency of supported and non-supported companies

Variable	Observations	Mean	Std. deviation	Minimum	Maximum	*p*-value
Non-subsided firms	5 194	0.6592	0.2830	0.0000	1.0000	0.0065
Subsided firms	724	0.6365	0.2753	0.0000	1.0000	

Source: own elaboration

Development of technical efficiency of supported and non-supported companies

Further, the technical efficiency in different years was estimated (Figure 4). It can be seen that the companies were surprisingly the most technically efficient on average in the year 2008 when the economic crisis began. Due to low capital intensity in sectors, processors requested to support small investment at the beginning of programme (on average 72.5 million EUR). There is a clear drop afterwards, as the technical efficiency decreased on average 61.35% in 2009 and on 59.21% in the year after. In these years of full crisis, manufacturers did not have to realise their products at reasonable prices and/or production had to be reduced. Another disadvantage is that the food industry is bound on agricultural raw material. According to Martin and Page (1983), if subsidies have the effect of decreasing technical efficiency, this may lead to the question of whether a more effective way of supporting might exist. Čechura and Hockmann (2010) recommended with respect to the market position and the role in the value chain to support also vertical integration and intensive marketing in food processing.

The situation started to get better after that, and the average technical efficiency was 69.56% in 2014, but the development turned down again in 2015 (the efficiency was 64.71%). The development of non-supported firms, in general, follows the mean of the whole sample. On the other hand, the efficiency of supported firms was lower in 2011 and since 2013. In 2008, 2009, 2010 and 2012, those companies were achieving higher efficiency of their production than non-supported firms. Subsidies have helped businesses to deal with, respectively to stabilise their economic situation during the financial crisis.

It was also tested whether the average technical efficiency statistically significantly differs in time. Results of the Kruskal-Wallis tests show, that the probability that technical efficiency is the same during the time (almost zero). Hence, there are statistically significant differences between technical efficiency in time at 5% level of significance.

Consequently, we tested for each year (with the exception of 2007 where there was no supported firm) whether there are statistically significant differences between supported and non-supported firms in technical efficiency. There were no statistically significant differences between these groups in the

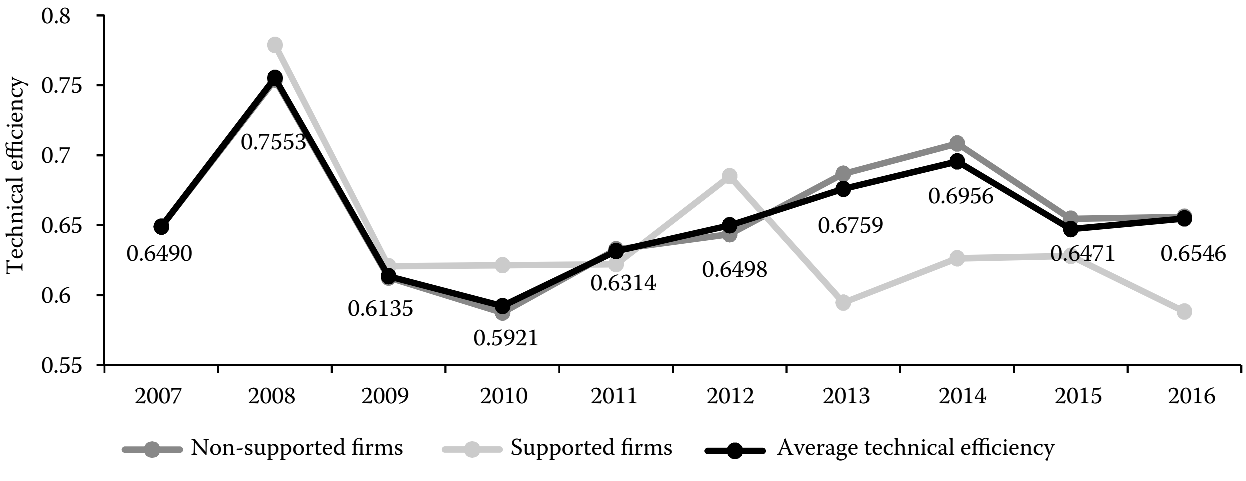

Figure 4. Development of technical efficiency of supported and non-supported companies

Source: own elaboration based on data from Albertina database (Albertina Database 2018), Ministry of Industry and Trade (MIT) and Ministry of Agriculture (MoA)

https://doi.org/10.17221/234/2018-AGRICECON

Table 5. Technical efficiency of supported and non-supported firms in regions

Region	Average technical efficiency	Average technical efficiency of non-supported firms	Average technical efficiency of supported firms	p-value
Prague	0.6499	0.6479	0.6644	0.0576
Středočeský region	0.6820	0.6754	0.7000	0.9474
Jihočeský region	0.6244	0.6259	0.6315	0.4728
Plzeňský region	0.6830	0.6618	0.7350	0.8468
Karlovarský region	0.7042	0.7690	0.8356	0.4578
Ústecký region	0.6316	0.6434	0.5752	0.6239
Liberecký region	0.6093	0.6161	0.6019	0.9735
Královéhradecký region	0.7126	0.6942	0.6642	0.2713
Pardubický region	0.6376	0.6317	0.6945	0.7994
Region Vysočina	0.6382	0.7146	0.7909	0.8135
Jihomoravský region	0.6347	0.6328	0.6619	0.1309
Olomoucký region	0.6511	0.6257	0.6009	0.0734
Moravskoslezský region	0.6075	0.6505	0.6820	0.6012
Zlínský region	0.6740	0.6427	0.6223	0.0341

Source: own elaboration

majority of years. Only in the year 2013 were found differences as the technical efficiency in not supported firms (68.67%) was statistically significantly higher than in supported firms (59.46%). Also in 2014 were non-supported firms more technically efficient (from 70.83%) than supported (62.63%).

However, it might also be because in other years there are only a few supported companies in comparison with non-supported and as a consequence, the difference cannot be proved statistically.

Technical efficiency of supported and non-supported companies in regions

We examined the companies according to the region where they are based. Which is also one of the important criterion (Key et al. 2008). First, the differences in average technical efficiency were tested. Kruskal-Wallis test revealed that technical efficiency in regions statistically significantly differs. The highest was in Královéhradecký region (71.26%) and the lowest in Moravskoslezský region (60.75%). In some regions, the non-supported firms were more efficient than supported, but only in Olomoucký and Zlínský region were statistically significant differences at 10% level of significance. This was proved by Wilcoxon rank-sum test. Otherwise, we cannot make a conclusion as there might be only a few supported companies in the region and the results cannot be statistically tested. Results are displayed in Table 5.

CONCLUSION

The paper dealt with the technical efficiency of food and beverage industry companies in the Czech Republic. This issue gains importance in the context of creating a new form of Common Agricultural Policy for the period 2020–2027, it is an actual topic. The main aim of the paper was to evaluate the technical efficiency of food processing firms. The technical efficiency of the holdings was assessed by Stochastic Frontier Analysis.

The true fixed-effect model was statistically significant at 5% level. All explanatory variables (fixed assets, current assets, equity, foreign sources and number of employees) were statistically significant and caused the increase of production. It was also identified, that increase of subsidies cause a slight increase in the mean of technical inefficiency.

Average technical efficiency was 65.64%. The technical efficiency of the firms without subsidies was 65.92%, the subsidised firms were efficient from 63.65%. The development of technical efficiency of supported companies can be considered as unstable and in some years also lower than the average. Technical efficiency of supported and non-supported firms differs statistically significantly also in the time. We examined the companies according to the region where they are based. Technical efficiency in some regions statistically significantly differs. Our study has comparable results with other Czech authors analysing this issue.

https://doi.org/10.17221/234/2018-AGRICECON

In this field, it is necessary to go more deeply and embroider the real problems. So, the next part of this research will be the evaluation of technical efficiency in different branches and firm sizes of the food industry, it should be beneficial to the policymakers to define the direction of new CAP.

REFERENCES

Albertina Gold CZ online Database (Albertina Database) (2018): Albertina Gold CZ online Database. Bisnode Česká republika, a.s., Prague.

Czech Statistical Office (CZSO) (2018): Prices of producers – time series. Czech Statistical Office, Prague. Available at https://www.czso.cz/csu/czso/ipc_cr (accessed June 10, 2018).

Čechura L., Hockmann H. (2010): Sources of economical growth in the Czech food processing. Prague Economic Papers, 2: 169–182.

Čechura L., Hockmann H., Kroupová Z. (2014) Productivity and Efficiency of European Food Processing Industry. Final report COMPETE. Institute for Agricultural Development in Transition Economies (IAMO). Available at http://www.compete-project.eu/fileadmin/compete/files/working_paper/COMPETE_Working_Paper_7_Productivity_FP.pdf (accessed June 10, 2018).

Čechura L., Malá Z. (2014): Technology and efficiency comparison of Czech and Slovak processing companies. Procedia Economics and Finance, 12: 93–102.

Dimara E., Skuras D., Tsekouras K., Tzelepis D. (2008): Productive efficiency and firm exit in the food sector. Food Policy, 33: 185–196.

Greene W. (2002): Fixed and random effects in stochastic frontier models. Journal of Productivity Analysis, 23: 7–32.

Jondrow J., Lovell C.A.K, Materov I.S., Schmidt P. (1982): On the estimation of technical inefficiency in the stochastic frontier production function model. Journal of Econometrics, 19: 233–238.

Keramidou I., Mimis A., Pappa E. (2011): Estimating technical and scale efficiency of the meat products industry: The Greek case. Journal of Applied Sciences, 11: 971–979.

Key N., McBride W., Mosheim R. (2008): Decomposition of total factor productivity change in the U.S. hog industry. Journal of Agricultural and Applied Economics, 40: 137–149.

Kumbhakar S.C., Lovell C.A.K. (2003): Stochastic Frontier Analysis. Cambridge University Press, Cambridge.

Le V., Vu X.B., Nghiem S. (2018): Technical efficiency of small and medium manufacturing firms in Vietnam: A stochastic meta-frontier Analysis. Economic Analysis and Policy, 59: 84–91.

Martin J.P., Page J.M. (1983): The impact of subsidies on X-efficiency in LDC industry: Theory and an empirical test. The Review of Economics and Statistics, 65: 608–617.

Minviel J.J., Latruffe L. (2017): Effect of public subsidies on farm technical efficiency: a meta-analysis of empirical results. Applied Economics, 49: 213–226.

Minviel J.J., de Witte K. (2017): The infuence of public subsidies on farm technical efficiency: A robust conditional nonparametric approach. European Journal of Operational Research, 259: 1112–1120.

Ministry of Agriculture (2017): Panorama of Food Industry. Ministry of Agriculture, Czech Republic. Ministry of Agriculture, Prague. Available at http://eagri.cz/public/web/mze/potraviny/publikace-a-dokumenty/panorama-potravinarskeho-prumyslu/panorama-potravinarskeho-prumyslu-2016.html (accessed June 30, 2018).

Náglová Z. (2018): Investment subsidies in the meat industry and their impact on business economics. Central European Business Review, 7: 37–45.

Pechrová M. (2015): Impact of the Rural Development Programme Subsidies on the farms' inefficiency and efficiency. Agricultural Economics – Czech, 61: 197–204.

Pechrová M., Vlašicová E. (2013): Technical efficiency of organic and biodynamic farms in the Czech Repubic. Agris on-line Papers in Economics and Informatics, 5: 143–152.

Rudinskaya T., Náglová Z. (2018): Impact of subsidies on technical efficiency of meat processing companies. Agris on-line Papers in Economics and Informatics, 10: 61–70.

Setiawan M., Emvalomatis G., Oude Lansink A. (2012): The relationship between technical efficiency and industrial concentration: Evidence from the Indonesian food and beverages industry. Journal of Asian Economics, 23: 466–475.

Skuras D., Tsekouras K., Dimara E., Tzelepis D. (2006): The effects of regional capital subsidies on productivity growth: A case study of the Greek food and beverage manufacturing industry. Journal of Regional Science, 46: 355–381.

Vokoun M., Polanecký L., Stellner F. (2015): The impact of the recent economic crisis on the food industry in the Czech and Slovak Republic. Procedia Economics and Finance, 34: 142–148.

Zhu X., Oude Lansink A. (2010): Impact of CAP subsidies on technical efficiency of crop farms in Germany, the Netherlands and Sweden. Journal of Agricultural Economics, 61: 545–564.

Received July 30, 2018
Accepted August 28, 2018