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REGIONAL DIFFERENCES IN THE SLOVAK DAIRY FARM PERFORMANCE

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Abstract

Milk sector in Slovakia significantly contributes to the domestic agricultural production in terms of value. In the paper we analysed regional differences in productivity and efficiency of dairy farms in Slovakia with regard to pooled sample technological frontier as well as with regard to particular regional frontiers over period 2004-2008. Technical efficiency and productivity changes were expressed by the Malmquist indices and estimated by non-parametric DEA. We used balanced panel FADN data of 106 dairy farms with prevailing dairy production. Dairy farms in all regions showed technical inefficiency, ranging from 11% in Western Slovakia (WS) to 23% in Eastern Slovakia. Western Slovakia dairy farms were the most efficient, with the highest level of technical efficiency and higher homogeneity of the farm performance. Differences in total technical efficiency, calculated with regard to both, the common and particular region frontier, result from differences in managerial efficiency rather than from differences in scale efficiency. We found only minor total factor productivity (TFP) improvement over the observed period. The highest average yearly productivity growth was observed in 2007 when the new programming period of RDP started and direct payments per livestock unit were introduced. The TFP growth resulted more from technological progress than from technical efficiency improvement and this technical efficiency change was driven mainly by managerial efficiency improvement. The highest TFP growth achieved Western and Eastern Slovakian farms, while the highest managerial efficiency improvement reached farms in Eastern Slovakia. Our findings suggest that policies designed to support improvement of efficiency of the Slovak dairy farm would have been desired.

Keywords: Data envelopment analysis, dairy farms, efficiency, Malmquist indices, productivity

JEL classification: *C61, Q12*

1 Introduction

Milk is produced in every single EU Member State without exception and represents approximately 15% of agricultural output in terms of value (EC, 2014). Milk production in the EU has been regulated by milk quota system, introduced in 1984 to address the overproduction problems. The milk quota system was abolished in April 2015. There were different predictions how the milk quota abolition could impact of dairy farming and milk production (e.g. Bouamra-Mechemache et al. 2008, Chantreuil et al. 2008, EC, 2009, Jansik et al., 2014). Generally, quota abolition was not expected to result in a radical change in the overall level of EU milk production or alteration in the process of farm restructuring, as the majority of EU member states already operated below quota constraints (Ernst & Young, 2013). Price volatility however became a serious problem of milk production and its processing. There are big differences regarding the average farm size and the farming systems among the EU Member States. On average, milk-specialised farms are larger in the old Member States (on average 54 dairy cows per farm). Bulgaria and Romania keep five dairy cows on average (EC, 2017).

In the paper we assess the Slovak regional differences of dairy farm efficiency and productivity over post-accession period until 2008, prior to period when agricultural markets instability increased.

1.1 Milk production in the SR and the EU

Although the Slovak milk production reached in 2009 only 1% of the EU milk production, the share of the domestic agricultural production was approximately 13%.

The share of specialized dairy farms in Slovakia, similarly as in the Czech Republic is considered the lowest in the EU (EC, 2014a). Livestock herds and animal production has been declining, especially since the accession to the EU. During 2004-2012 the average number of dairy cows was reduced by more than a quarter. The main factors were highly competitive imported dairy products, low profitability of milk production, the European milk crisis, the volatility in agricultural markets (Matošková et al., 2013). As a consequence, the total production of cow's milk in Slovakia fell by 11%. Moreover, Slovakia belongs to the EU MS with the lowest consumption of milk (166 kg per capita in 2015) (RIAFE, 2016). In order to prevent further decline of animal production in Slovakia, the complementary national direct payments on livestock units (LU) were introduced in 2007. In addition, promotion of milk and milk products consumption was supported.

Dairy farming after the accession to the EU has undergone significant modernization and gradual adaption to EU standards, improving the gene pool of

animals. During the years 1999-2007 share of crop production has been dominated in agricultural output. In 2007 there were 704 milk producers owning dairy quota, 40 of milk buying companies, 26 milk processing companies, 10 production and trade cooperatives and 4 trade companies (SZVM, 2007). The Slovak dairy production filled the nation milk quota only at approximately 79% in 2012. The milk production has been declining over the period 2007-2015. Among factors affecting fall of production and dairy cow's number in Slovakia were low competitiveness, increasing volatility in agricultural markets, increasing milk and dairy products import. After 2015 new specialised dairy farms have been expanding and addressing the milk crisis by investment to increase efficiency of their production.

There has been growing number of studies on national competitiveness, productivity and efficiency of dairy farms of individual or selected member states of the EU e.g. Reinhard et al. (2000), Luik et al. (2011), Omel and Luik (2014), Omel and Värnik (2014), Niskanen and Heikkilä (2014). Productivity and efficiency of dairy farms in Slovak and Czech regions NUTS II was analysed by e.g. van Berkum (2009), Michaličková et al. (2013), Cechura et al. (2014), Zdenek and Lososova (2014) and others. Zhu et al. (2012) assessed dairy farm efficiency for some European countries. They found that CAP subsidies granted since 1992 have not had a positive effect on efficiency in the dairy sector.

Zdenek and Lososova (2014) estimated the impact of factors affecting productivity in the milk sector in the EU Member States. The number of cows per worker was one of the most important factors affecting productivity. Both the Czech Republic and Slovakia showed lagging labour productivity with relatively high milk yield. Michaličková et al. (2013) also found low technical efficiency of milk production in Slovakia in the period 2006-2010. Cechura et al. (2014) analysed productivity and efficiency of the Czech and Slovak milk producers by regions, using parametric approach SFA (Stochastic Frontier Analysis). They used FADN data over 2004-2011.

Madau et al (2017) estimated technical efficiency and total factor productivity change of dairy farms in EU countries from 2004 to 2012, using DEA output-oriented approach and aggregated data. They used average farm data for each country and for each observed year. Their estimation of total factor productivity (TFP) and its components suggest that the European milk farms show small scope for improving technical efficiency and that the European milk sector has suffered a decline in productivity. Their results suggest that the ability of milk farmers to produce efficiently can only increase slightly in the future, implying that external factors (e.g., market shocks, milk price volatility) might play a crucial role in conditioning economic performance in the absence of milk quotas.

We estimated efficiency and productivity changes of the Slovak dairy farms in NUTS II regions on the basis of FADN data over the period 2004-2008. This post accession period with relatively stable economic conditions was chosen to assess regional differences prior the term when agricultural markets instability increased. While previous available studies assessed average economic performance of dairy farms on country level, we assumed and analysed significant regional differences in efficiency, productivity and hence differences in competitiveness of the Slovak dairy farms. Regional analysis of farm productivity and efficiency, decomposition of the productivity changes with emphasis on management and new technology contributions could provide valuable information on sources of farm economic performance and competitiveness.

2 Data and Methods

Technical efficiency and total factor productivity changes (measured by Malmquist indices) of dairy farms were estimated using non-parametric method Data Envelopment Analysis (DEA). Farm productivity and efficiency measures were calculated with regard to the frontier common for all three regions, as well as to particular region frontier. Total factor productivity change of dairy farms is expressed with the Malmquist indices (Färe et al. 1994). The Malmquist index is decomposed to technical efficiency change and technological changes. Technical efficiency change is then decomposed into pure technical (managerial) efficiency change and scale efficiency change.

A software DEAP (Coelli, 1996) was used to estimate measures of technical efficiency and productivity. We used FADN (Farm Accounting Data Network) panel data of 106 dairy farms from Western (WS), Middle (MS) and Eastern Slovakia (ES). The farms in the sample were those with dairy production exceeding 50% of their gross animal production over 2004-2008.

In the study following six inputs and two output variables were used. Output variables: 1. Milk production representing cows' milk and milk products (€); 2. Other production (€) representing farm output not included in milk production variable.

Input variables: 1. Labour expressed in annual work units (AWU), 2. Land represents total utilised agricultural area (UAA in ha). It consists of land in ownership, rented land and land in share-cropping. 3. Assets represent the total fixed assets and consist of agricultural land, farm buildings, forestry capital, buildings, machinery, equipment, breeding livestock (€); 4. Dairy cows (in livestock units LU), represent female bovines which have calved and are held principally for milk

production for human consumption. 5. Feed for grazing livestock (€); 6. Total specific costs (€).

3 Results and Discussion

3.1 Farm Sample Description

Generally, the average size of farms in Slovakia has been higher compared to the farm average size in majority of the EU Member States. In our farm sample extracted from the FADN SR (Table 1) large farms prevails, with an acreage between 1000 and 2000 ha and an average number of 100 to 300 cows, at both national and regional levels.

The average utilised agricultural area of a dairy farm in our sample was 1625 ha (Table 1). The Eastern Slovakia (ES) dairy farms were on average even bigger. The most frequent farm herd size in all regions was from 100 to 300 LU. The Western Slovakia dairy farms were the most productive in terms of average milk yield per cow (Table 2). Over the period 2004 -2008 average size of a dairy herd was declining, while milk yield and thus milk production was increasing. Similarly, the average number of AWU declined in all but Eastern Slovakia region.

There were differences in the level of labour productivity across the regions in our sample. Differences in labour productivity on farms were driven primarily by differences in labour requirements per LU.

Table 1 **Distribution of dairy farms in the sample (%)**

	Western Slovakia	Middle Slovakia	Eastern Slovakia	Western Slovakia	Middle Slovakia	Eastern Slovakia	Total
Utilised Agricultural Area in ha							
less than 500	15	13	9	25	33	42	100
500 - 1000	25	23	13	26	37	37	100
1000 - 2000	35	43	48	15	28	57	100
more than 2000	25	20	30	18	21	61	100
Total	100	100	100				
Dairy Cows in LU							
less than 100	20	10	16	25	19	56	100
100 - 300	55	63	63	17	29	54	100

	Western Slovakia	Middle Slovakia	Eastern Slovakia	Western Slovakia	Middle Slovakia	Eastern Slovakia	Total
more than 300	25	27	21	20	32	48	100
Total	100	100	100				

Source: Own estimation, FADN data.

3.2 Regional Differences in Efficiency and Productivity

Technical and scale efficiency were calculated with regard to the frontier common for all three regions (Table 3). For the whole period 2004-2008 the average technical efficiency, both CRS and VRS were highest for Western Slovakia (0.89; 0.92 respectively), the lowest levels were displayed for Eastern Slovakia (0.77; 0.80 respectively). This indicates that farms in WS can increase their output by 11% and ES farms by 23% without having to increase their input use, but both with respect to the best practice (technology) within the country sample. More Western Slovakia's farms were on, or closer to the common efficiency frontier than farms of the other regions.

Regional differences in total technical efficiency (under CRS) (Table 3) mainly result from differences in pure technical efficiency (under VRS) (0.92 vs. 0.80) rather than from differences in scale efficiency (0.97 vs. 0.96). Major source of performance differences among regions was managerial inefficiency and less inefficiency due to non-optimal scale. The development of all three yearly indicators is in accordance with above conclusions based on period averages.

Table 2 **Selected indicators of dairy farms in the sample**

Indicator	Western Slovakia		Middle Slovakia	
	mean	std dev	mean	std dev
Milk production (€)	430808	364313	371690	314108
Other production (€)	1235694	1003594	625618	602588
Labour (AWU)	64	48	50	36
Land (UAA)	1343	906	1498	1086
Average no. of dairy cows (LU)	251	206	259	184
Feeds (€)	259857	313785	246141	267528
Assets (€)	3294191	3083817	3260289	3358835
Specific costs (€)	664364	490955	392884	348377

Indicator	Eastern Slovakia		Panel	
	mean	std dev	mean	std dev
Milk production (€)	346153	326350	369353	332324
Other production (€)	825951	739834	846563	791054
Labour (AWU)	56	35	55	38
Land (UAA)	1793	1061	1625	1058
Average no. of dairy cows (LU)	245	183	250	188
Feeds (€)	213283	231935	231370	260324
Assets (€)	3550376	4165537	3419939	3768314
Specific costs (€)	548621	408210	526383	420824

Note: AWU - annual work unit, LU - livestock unit, UAA - utilised agricultural area, WS – Western Slovakia, MS – Middle Slovakia, ES – Eastern Slovakia.
Source: Own estimation, FADN data.

Table 3 **The average technical efficiency under CRS, VRS and SE scores. Pooled panel frontier**

Region		2004	2005	2006	2007	2008	Geomean
Pooled panel	TE CRS	0.79	0.82	0.78	0.82	0.79	0.80
	TE VRS	0.80	0.85	0.82	0.85	0.83	0.83
	SE	0.98	0.97	0.96	0.97	0.95	0.96
Western Slovakia	TE CRS	0.86	0.91	0.85	0.94	0.89	0.89
	TE VRS	0.88	0.92	0.89	0.97	0.93	0.92
	SE	0.97	0.99	0.96	0.97	0.96	0.97
Middle Slovakia	TE CRS	0.80	0.84	0.77	0.79	0.78	0.80
	TE VRS	0.82	0.86	0.80	0.82	0.83	0.83
	SE	0.98	0.97	0.97	0.97	0.94	0.97
Eastern Slovakia	TE CRS	0.75	0.79	0.75	0.79	0.76	0.77
	TE VRS	0.77	0.81	0.80	0.82	0.80	0.80
	SE	0.98	0.97	0.94	0.97	0.94	0.96

Note: CRS - constant returns to scale, VRS - variable returns to scale, SE – scale efficiency.
Source: Own estimation, FADN data.

In order to assess regional features, technical efficiency and scale efficiency were also calculated with regard to respective frontiers of regions (Table 4). Yearly and period average scores meaning are pertinent strictly in regional context. The highest regional scores are estimated for Western Slovakia. This suggests that within Western Slovakia performance of most of the farms are close to the best performing farms of the region (regional technology). The same pattern was observed for total efficiency, pure efficiency, as well as scale efficiency. This could be a result of a stronger farm competition in the WS region, while there was higher farm performance heterogeneity in remaining regions.

Decomposition of total efficiency to pure and scale efficiency (Table 4) suggests that inefficiency in Western Slovakia was more due to managerial inefficiency than non-optimal farms scale (0.95 vs 0.98). Trend analysis of the all three indicators show that both, total and pure efficiency have been improving. Scale efficiency shows negative tendency.

Situation in Middle Slovakia was very similar to the one in Eastern Slovakia. Lower level of average technical efficiency (TE CRS, TE VRS) might suggest that there were more farms far from the regional efficiency frontiers within both regions. The average total technical efficiency (0.87 vs. 0.88) and scale efficiency measures (0.97 vs 0.98) were almost identical. Pure efficiency scores were identical (0.9 vs 0.9). This three efficiency measures structure suggests that farms in the two regions were less productive mainly due to managerial inefficiency and then to non-optimal farms scale. Trend analysis shows slightly positive or stagnation tendencies in all three indicators.

Table 4 **The average technical efficiency under the CRS, VRS and SE scores. Regional frontiers**

NUTS II		2004	2005	2006	2007	2008	Geomean
Western Slovakia	TE CRS	0.92	0.94	0.92	0.96	0.92	0.93
	TE VRS	0.94	0.95	0.94	0.99	0.95	0.95
	SE	0.98	0.99	0.97	0.97	0.96	0.98
Middle Slovakia	TE CRS	0.88	0.88	0.84	0.86	0.90	0.87
	TE VRS	0.89	0.91	0.87	0.89	0.93	0.90
	SE	0.99	0.97	0.96	0.96	0.96	0.97
Eastern Slovakia	TE CRS	0.88	0.89	0.88	0.88	0.89	0.88
	TE VRS	0.77	0.91	0.89	0.91	0.91	0.90
	SE	0.99	0.98	0.98	0.97	0.98	0.98

Note: CRS - constant returns to scale, VRS - variable returns to scale, SE - scale efficiency.
Source: Own estimation, FADN data.

Table 5 **The average Technical Efficiency under the CRS, VRS and SE scores. Regional vs pooled panel frontier.**

	NUTS II	TE CRS	TE VRS	SE	Number of farms
Region	Western Slovakia	0.93	0.95	0.98	20
	Middle Slovakia	0.87	0.90	0.97	30
	Eastern Slovakia	0.88	0.90	0.98	56
Pooled panel	Western Slovakia	0.89	0.92	0.97	20
	Middle Slovakia	0.80	0.83	0.97	30
	Eastern Slovakia	0.96	0.80	0.96	56

Note: CRS - constant returns to scale, VRS - variable returns to scale, SE - scale efficiency, TE - technical efficiency.
Source: Own estimation, FADN data.

Dairy farm productivity changes in the pooled sample as well as in subsamples by regions over 5 years, measured by Malmquist indices, were minor (1%) and they resulted more from technological progress (1.01) (the introduction of new technology, innovation) than from technical efficiency improvement (1.0) (Table 6). Farm productivity changes were positive in Western and Eastern Slovakia although differed by years. The highest average yearly productivity growth in the pooled sample as well as in regions was observed in 2007, when new programming period RDP 2007-2013 started and direct payments per LU were introduced. TFP growth of dairy farms of the sample is evident mainly in years 2005 and 2007 and can be attributed to growth in technical efficiency and more significantly to technological change. It means that technically inefficient farms were able to catch-up efficient farms by 6% and 5%, respectively. Technological change however, was more pronounced in those two years, reaching 2% and 14% progress in technology.

Table 6 **Dairy farm productivity changes by regions and years (2004-2008)**

	Total factor productivity				Technical efficiency change			
Year	**Panel**	**WS**	**MS**	**ES**	**Panel**	**WS**	**MS**	**ES**
2005/2004	1.08	1.08	1.08	1.08	1.06	1.07	1.05	1.06
2006/2005	0.89	0.85	0.89	0.9	0.94	0.95	0.91	0.96
2007/2006	1.2	1.22	1.17	1.2	1.05	1.08	1.03	1.05
2008/2007	0.91	0.94	0.9	0.9	0.96	0.94	0.99	0.96
Geomean	1.01	1.01	1	1.01	1	1.01	0.99	1.01
Cumulative	1.05	1.05	1.01	1.05	1.00	1.03	0.97	1.03
	Technological change				**Scale efficiency change**			
	Panel	**WS**	**MS**	**ES**	**Panel**	**WS**	**MS**	**ES**
2005/2004	1.02	1.01	1.03	1.02	1	1.01	0.99	0.99
2006/2005	0.94	0.89	0.99	0.94	0.98	0.97	1	0.97
2007/2006	1.14	1.13	1.14	1.14	1.01	1.01	1	1.02
2008/2007	0.94	1	0.91	0.94	0.98	0.99	0.97	0.98
Geomean	1.01	1	1.01	1.01	0.99	1	0.99	0.99
Cumulative	1.03	1.02	1.06	1.03	0.97	0.98	0.96	0.96
	Scale efficiency change							
	Panel	**WS**	**MS**	**ES**				
2005/2004	1	1.01	0.99	0.99				
2006/2005	0.98	0.97	1	0.97				
2007/2006	1.01	1.01	1	1.02				
2008/2007	0.98	0.99	0.97	0.98				
Geomean	0.99	1	0.99	0.99				
Cumulative	0.97	0.98	0.96	0.96				

Note: WS - Western Slovakia, MS - Middle Slovakia, ES - Eastern Slovakia
Source: Own estimation, FADN data.

Further decomposition of technical efficiency change into pure technical efficiency change and scale efficiency change indicate that technical efficiency change was driven mainly by pure (managerial) efficiency improvement (2005: 7%; 2007: 3%), while scale efficiency was stagnating.

According to cumulative values of estimated indicators over the whole period, the highest TFP growth of 5% was achieved by Western and Eastern Slovakian farms. The most evident technological progress was estimated for farms in

Middle Slovakia (6%). The best managerial (pure) efficiency improvement was achieved in farms of Eastern Slovakia, and modest worsening of scale efficiency was observed in Western Slovakian farms.

Our results show, that only 46% of dairy farms in the panel improved their technical efficiency towards the most efficient farms over the observed period (Table 7). Eastern Slovakia dairy farms were more successful in improving efficiency. Technical efficiency of 12% of dairy farms in the panel remained unchanged. Since 2004, technical efficiency fell down in half of dairy farms from the Middle Slovakia, 39% dairy farms from the Eastern Slovakia and the 35% dairy farms from the Western Slovakia in our sample. After the SR accession to the EU, only 19% of farms in the sample showed improvement of their total productivity by more than 10%.

Table 7 **Regional Dairy Farm Structure by Technical Efficiency Change**

Technical efficiency change	Panel		Western Slovakia		Middle Slovakia		Eastern Slovakia	
	No. Farms	Share %	No. Farms	Share %	No. Farms	Share %	No. Farms	Share %
More than 1	49	46	8	40	12	40	29	52
Equal 1	13	12	5	25	3	10	5	9
Less than 1	44	42	7	35	15	50	22	39
Total	106	100	20	100	30	100	56	100

Source: Own estimation, FADN data.

4 Conclusion

There is a low share of specialized dairy farms in Slovakia. In the analysed period milk is produced mainly in non-specialised farms. Large farms prevail in the sample, with an acreage between 1000 and 2000 ha and an average number of 100 to 300 cows in all three NUTS II regions of Slovakia with declining average acreage and herd size over time. Eastern Slovakia dairy farms were relatively larger, less competitive and lagging behind the Middle and Western Slovakia dairy farms in terms of productivity.

Estimated technical and scale efficiency with regard to the common frontier showed technical inefficiency for farms in all regions, ranging from 11% to 23%. Farms especially those in Eastern Slovakia showed large scope for improving efficiency using their own technical input. The best performance was revealed for the

Western Slovakia farms. Regional differences in total technical efficiency mainly resulted from differences in managerial inefficiency and in less extent from non-optimal scale. The efficiency and productivity measures have been improving over time.

Analysis of technical and scale efficiency measures with regard to regional frontier suggests stronger farm competition in Western Slovakia region, since farm performance there was more homogenous and close to the best performing farms. Cechura et al. (2014) analysed performance of the Czech and Slovak farms by regions and found significant differences in productivity. According to their results only farms from Western Slovakia can keep a pace with competitors.

Decomposition of farm inefficiency in our study was mainly a result of managerial underperformance and then to non-optimal farms scale in all Slovak regions.

Total factor productivity indices and their components showed variation over regions and time. The best results were achieved in 2007 what can be explained by support following from the new Rural Development Programme. Total factor productivity growth from 2004 to 2008 was found for farms from Eastern and Western Slovakia. This change was mainly driven by technological progress (improved economic conditions and availability of new technologies).

In the period from 2004 to 2008 farms in Western and Eastern Slovakia were more successful in catching up the best performing farms in their regions. The Middle Slovakia dairy farms however showed the highest technological improvement. The managerial efficiency increased especially in Eastern Slovakia dairy farms.

Relatively low TFP growth in all regions was affected by scale inefficiencies, non-optimal scale of farms, even farms in all regions improved their managerial efficiency. Madau et al. (2017) found similar results based on aggregated FADN data. They argue that the Slovak farms were technically inefficient, while pure efficiency change (managerial efficiency change) showed positive trend. In their study the Slovak farms also exhibited decreasing returns to scale, that means the sizes of the farms were, on average, supra-optimal and should be reduced to reach the optimal scale.

According to Zhu et al. (2012) CAP subsidies granted since 1992 have not had a positive effect on efficiency in the dairy sector. Madau et al. (2017) similarly do not recommend to support further improvement of farm efficiency by the EU policies, due to relatively low scope for improvement. The Slovak farms however were assessed as technically inefficient with low productivity by our and other studies.

Our findings of regional differences in the Slovak dairy farm performance suggest that policies designed to support improvement of efficiency of the Slovak dairy farm (direct payments) would have been desired. Development of total factor productivity changes and ability of the Slovak dairy farms to improve efficiency and productivity in the later period after 2007 was however affected by global crisis and growing instability of agricultural market, especially milk prices. In the period after 2008, combination of policies, such as policy directed to improving dairy farm efficiency and policies addressing exogenous factors, price volatility, agricultural market instability could enhance the Slovak dairy farm competitiveness. Our future study will investigate this development.

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