https://doi.org/10.7896/j.1919 Studies in Agricultural Economics 122 (2020) 37-43

Krisztián KOVÁCS* and István SZŰCS*

Exploring efficiency reserves in Hungarian milk production

This paper aims to explore the efficiency of Hungarian dairy farms. Based on FADN data representing more than 950 dairy farms in Hungary, our sample contains more than 6800 data points which we analysed by applying different Data Envelopment Analysis models. Results suggest that the average technical efficiency of the Hungarian dairy sector during the examined 10 years was 77.6%, meaning that output could be increased by 22.4% without changing the level of input (efficiency reserve). Large and small farms are more efficient (79.2%) than medium sized farms (59.2%). Moreover, large farms keeping more than 501 dairy cows were found to be more efficient (92.5%) than the other two size categories (77.9% and 65%, respectively). Farms located in Northern Hungary had less efficiency reserves (23.6%) that the farms operating in the Great Hungarian Plain, Central Hungary (34.8%) or in the Transdanubian Region (27.6%). All this suggests high reserves for potential efficiency growth.

Keywords: DEA, dairy farms, efficiency, Hungary, milk sector

JEL classifications: Q12, Q13

* University of Debrecen, Faculty of Economics and Business, Institute of Applied Economic Sciences. Böszörményi út 138, 4032-Debrecen, Hungary. Corresponding author: kovacs.krisztian@econ.unideb.hu

Received: 2 October 2019, Revised: 16 December 2019, Accepted: 7 January 2020.

Introduction

Milk and milk products play an important role in human nutrition; thus milk production is an important issue in the global food supply chain, particularly in developing countries. Milk is one of the most valuable human staple foods of high nutritional value. Although many nutrients and vitamins are found in vegetables and can be produced synthetically as well, this type of animal protein is essential for a balanced diet.

Consequently, in terms of global nutrition supply, it is essential to increase milk production efficiency in the future to meet the enormous dairy product demand of explosive global population growth. From an economics as well as a social perspective, increasing the efficiency level of milk production is a highly important issue for most countries of the world. Production efficiency should be a priority area for both European Union and Hungarian dairy farms to ensure that a single dairy farm can also produce milk competitively and efficiently for the national and global markets in an economically, socially and ecologically sustainable way.

Oligopolistic Hungarian dairy processors exhibit price setting behaviour directed towards the milk producers, who have to follow a price-taking behaviour in the market because of their low level of market concentration. If milk producers want to increase their profitability, the only way of doing so is to increase their efficiency level.

The aim of this paper is to explore the efficiency of Hungarian milk production. More concretely, we would like to answer the following research questions:

1. What differences are observable in the overall technical efficiency of Hungarian dairy farms between 2008 and 2017?
2. What differences can be observed in the technical efficiency of Hungarian small, medium and large scale dairy farms?
3. What differences exist in the three main Hungarian regions' technical efficiency indicators for milk production?

Global cow milk production has shown a continuously rising trend in the last three decades. According to Fasostat (2019) data, global cow milk production has increased by more than 50 percent between 1983 (450 million tonnes) to 2017 (678 million tonnes). The biggest cow milk producer in terms of quantity in the world is Europe (32.69%), followed by Asia (30.18%) and the American continent (27.21%). Hungary produced 1.967 million tonnes of milk in 2017, which was around 0.29 % of the global and 0.89% of the European production (Faostat, 2019). Regarding countries, the biggest cow milk producer in the world was the European Union in 2017 with 164.5 million tonnes of production, giving around 24.27% of global production alone (Table 1).

As to trade, global cow milk exports – measured as milk equivalent – totalled 126.6 million tonnes in 2017, out of which 59.51% came from the European Union (75.34 million tonnes), while 14.74% (18.66 million tonnes) came from New Zealand. Inside the EU, the biggest milk exporter country was Germany (16.21 million tonnes), followed by the Netherlands (11.81 million tonnes). On the import side, 125.25 million tonnes of cow milk were imported all around the globe in 2017, most of which went to the European Union (45%) and China (11%).

In the case of Hungary, milk production has been continuously increasing since 2009, and it has now reached 1.924 million tonnes per year (HCSO, 2019). Production in terms

Table 1: The TOP 5 cow milk producers in 2017.

Country	Cow milk production (tonnes)	Share (%)
European Union	164,472	24.27
United States of America	97 762	14.43
India	83,634	12.34
Brazil	33,312	4.92
China	30,772	4.54
Total	677,671	100.00

Source:own calculations based on Faostat (2019) data

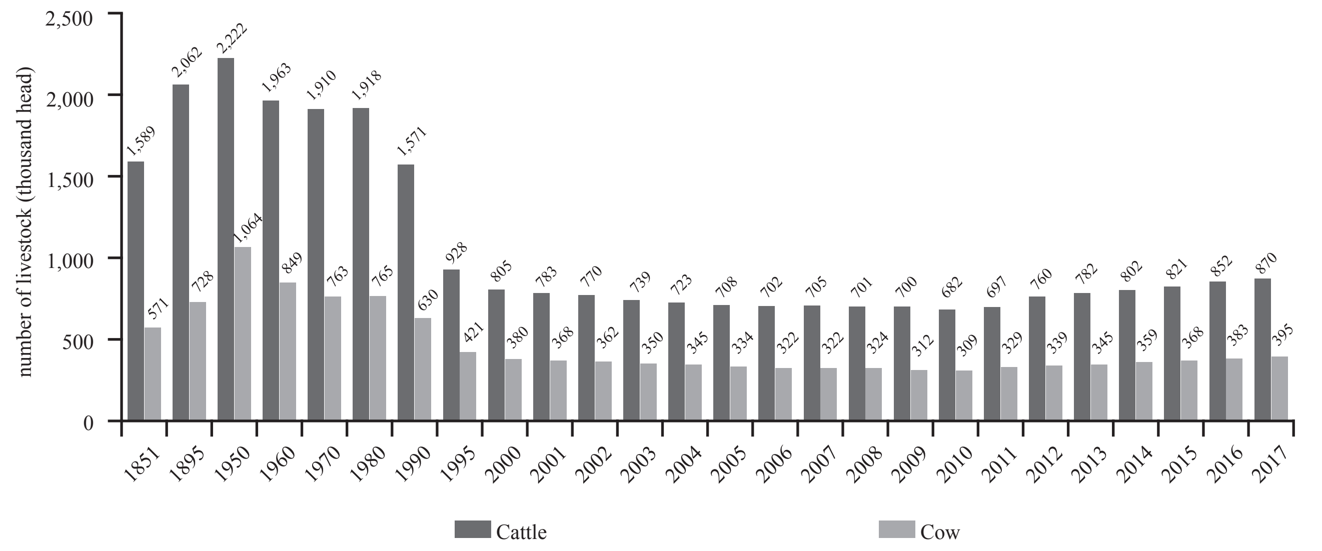

Figure 1: Hungarian cattle and cow livestock numbers from 1851 to 2017.

Source: own composition based on HCSO (2019) data

Table 2: Regional share of Hungarian cattle and cow livestocks.

Region	**Cattle**			**of which: cow**	**Livestock per 100 hectares**
	Corpo-rations	**Indi-vidual farms**	**in total**	**in total**	
Budapest	7.0	0.7	7.7	2.5	16
Pest Region	42.4	29.5	71.9	26.8	21
Central Hungary	**49.3**	**30.2**	**79.5**	**29.3**	**20**
Central Transdanubia	72.4	35.9	108.3	51.3	18
Western Transdanubia	79.1	36.9	116.0	50.6	20
Southern Transdanubia	68.0	41.7	109.6	51.9	14
Transdanubia	**219.5**	**114.4**	**333.9**	**153.9**	**17**
Northern Hungary	45.8	36.0	81.8	42.9	14
Northern Great Plain	116.9	93.4	210.3	94.6	18
Southern Great Plain	84.3	95.0	179.3	82.2	15
Great Plain and Northern Hungary	**247.0**	**224.4**	**471.4**	**219.6**	**16**
Total	**515.8**	**369.0**	**884.8**	**402.8**	**17**

Source: own calculations based on HCSO (2019) data

of quantity was the highest in 1988 when Hungarian annual milk production was 2.95 million tonnes, coinciding with a record number of dairy cows (2.5 million). Cattle numbers have significantly decreased since 1990 - in 2017, Hungary had 630,000 cattle and 395,000 cows (Figure 1).

Table 2 summarises Hungarian cattle and cow livestock numbers in a regional breakdown. The Great Plain represents 44.02% of the total cattle livestock and 43.89% of the cow livestock, followed by Northern Hungary (9.26% and 10.65%) and the Transdanubia region (37.74% and 38.21%), respectively. Average cattle density in Hungary is 17 dairy cows/100 ha (HCSO, 2019).

Figure 2 shows basic efficiency indicators of Hungarian milk production. The number of dairy cows has been dramatically decreasing until 2010, but annual milk production seems to have stagnated around 1.8 million tonnes, implying an increasing yield per dairy cow indicator. Yield growth of milk production per dairy cow is clearly observable from 5000 litres/head to 8000 litres/head on average from 1990 to 2017.

Measuring the productive efficiency of the dairy sector is important to both the practical experts and the policymakers. *“If economic planning is to concern itself with practical industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources.”* (Farrell, 1957) Thus, measuring the technical performance can be important for the sector not only with the purpose of increasing the dairy cows’ yield performance, but also for increasing the efficiency of other resources, as well as for raising incomes at individual dairy farms. The question of considerable substance is how we can measure dairy farms’ performance, using not only one output and one input, but also several parameters, which best represent dairy farm management practices.

In the scientific literature, a number of different papers can be found analysing a country’s technical efficiency with different methods. Based on the excellent work of Bravo-Ureta *et al*. (2007), Table 3 summarises the most important papers written until 2005. A recent review on available articles in the topic was provided by Galluzzo (2019).

Method and data

Measuring efficiency is a widely used concept in economics. Economic (or overall) efficiency is expressed as a combination of technical and allocative (or price) efficiencies. Technical efficiency is the ability of the farmer to obtain maximal output from a given set of inputs, while allocative efficiency measures the ability of the farmer to use inputs in optimal proportions, given their input prices and technology (Coelli *et al*., 2005). Various methods exist in economics to measure efficiency, out of which probably the most well-known is Data Envelopment Analysis (DEA).

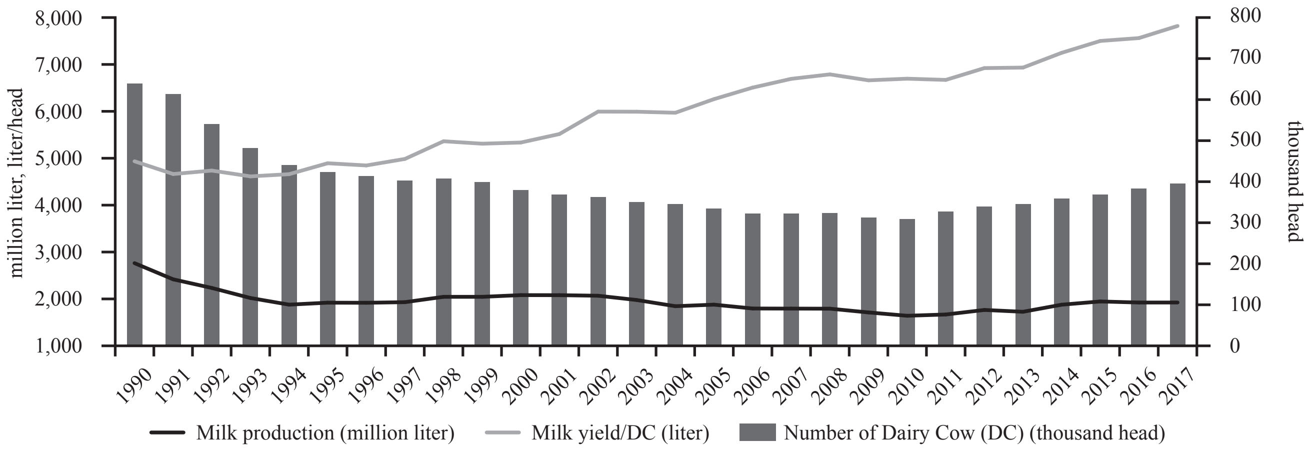

Figure 2: Hungarian milk production and its efficiency.

Source: own calculations based on HCSO (2019) data

Table 3: Most important articles measuring efficiencies in the dairy sector, 1990-2005.

Author	Year	Country	Sector	Sample	Average technical efficiency
		I. Non-parametric (DEA)			
FRASER	1999	Australia	Milk	50	88.5
ASMILD	2003	The Netherlands	Milk	1,808	80.5
LATRUFFE	2004	The Netherlands	Milk and Grain	222	64.0
LATRUFFE	2005	The Netherlands	Milk and Grain	199	69.8
REINHARD	2000	The Netherlands	Milk and Grain	1,535	79.7
CLOUTIER	1993	Canada	Milk	187	89.8
WEERSINK	1990	Canada	Milk	105	91.8
PIESSE	1996	Slovenia	Milk	272	93.0
JAFORULLAH	1999	New-Zealand	Milk	264	89.0
TAUER	1993	USA	Milk	395	78.3
TAUER	1998	USA	Milk and Beef	630	91.8
THOMAS	1994	USA	Milk	125	89.2
		II. Parametric methods: Deterministic frontier (DF)			
KARAGIANNIS	2002	United Kingdom	Milk	2,147	77.6
MAIETTA	2000	Italy	Milk	533	55.0
HALLAM	1996	Portugal	Milk	340	62.5
ALVAREZ	1999	Spain	Milk	410	72.0
ALVAREZ	2004	Spain	Milk	196	70.0
OREA	2004	Spain	Milk	445	65.9
PIESSE	1996	Slovenia	Milk	272	57.5
TURK	1995	Slovenia	Milk	272	77.1
AHMAD	1996	USA	Milk	1,072	76.5
BRAVO-URETA	1986	USA	Milk	222	82.2
BRAVO-URETA	1990	USA	Milk	404	63.3
POE	1992	USA	Milk	675	74.8
TAUER	1987	USA	Milk	432	69.3
		Stochastic frontier (SFA)			
BATTESE	1988	Australia	Milk	336	70.7
DAWSON	1987	United Kingdom	Milk	434	85.3
DAWSON	1988	United Kingdom	Milk	406	81.0
DAWSON	1990	United Kingdom	Milk	306	86.9
DAWSON	1991	United Kingdom	Milk	306	86.0
BAILEY	1989	Equator	Milk	68	78.1
BRÜMMER	2002	Germany, Poland, The Netherlands	Milk	300	86.9
CUESTA	2000	Spain	Milk	410	82.7
AHMAD	1996	USA	Milk	1,072	81.0
BRAVO-URETA	1990	USA	Milk	404	83.9
BRAVO-URETA	1991	USA	Milk	511	83.0

Source: own composition based on Bravo-Ureta *et al*. (2007)

Farell (1957) distinguishes input and output orientated measures depending on which factor we assume altering. In the input orientated measure, the input quantities change without changing the output quantities. The assumed objective is to reduce the input quantities as much as possible, without changing the output quantities. The other measure of efficiency referred to by both Farell (1957) and Coelli *et al*. (2005) is the output orientated measure. Here the question is by how much output quantities can be proportionally expanded without altering the input quantities. If technology is characterised by constant returns to scale, the two orientations produce the same technical efficiency score. Differences, however, appear under changing returns to scale.

Figure 3 presents technical efficiencies from an output orientation, considering a firm with two outputs (q_1 and q_2) and a single input (x_1). Keeping input quantity fixed, ZZ' represents the production possibility curve and point B represents an efficient, while point A an inefficient firm. The distance AB measure shows the technical inefficiency, hence the output orientated technical efficiency is the ratio of 0A and 0B, which shows the percentage by which outputs could be increased without requiring extra input.

The input and the output orientated models estimate the same frontier and identify the same set of firms as being efficient. The difference is the efficiency measures associated with the inefficient firms that may differ between the two methods (Coelli *et al*., 2005). In practice, the efficient isoquant is not known, hence researchers have to estimate it from the sample data using different kinds of analyses. These will be introduced in the following section.

The DEA framework was introduced by Farrell (1957) and popularised by Charnes *et al*. (1978). It is a non-parametric mathematical programming approach to frontier estimation. The first models were the input orientated CRS models, solving the following linear programming problem for each firm to obtain the efficiency score:

$$\max_{u,v} (u'y_i / v'x_i),$$
$$\text{constrains: } u'y_j / v'x_j \leq 1, \quad j = 1, 2, \ldots, N, \quad (1)$$
$$u,v \geq 0$$

assuming K inputs and M outputs for each N firms. For the i-th firms the column vectors are represented by x_i and y_i,

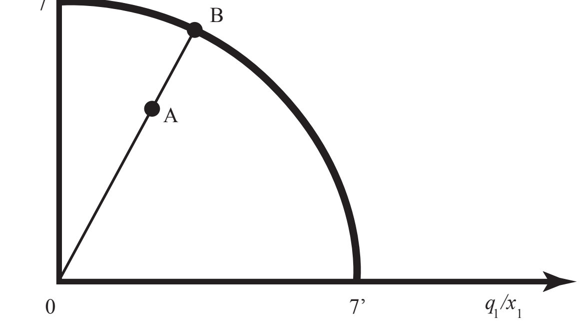

Figure 3: Technical efficiency from an output orientation.

respectively. X indicate the K*M input matrix and Y shows the M*N output matrix for all N firms. To measure efficiency we want to obtain the measure of the ratio of all outputs over all inputs, like $u'y_i / v'x_i$, where u represents the M*1 vector of output weights and v represents the K*1 vector of input weights. The obtained efficiency score will be less than or equal to one. As this model has an infinite number of solutions, Charnes *et al*. (1978) added one more constrain ($v'x_i = 1$) and reformulated the objective function a bit, thereby creating the multiplier form of DEA. Using the duality linear programming method from the multiplier formula, we get the envelopment form as follows:

$$\text{xmin}_{\theta\lambda}\, \theta,$$
$$\text{constrains: } -y_j + Y\lambda \geq 0, \quad (2)$$
$$\theta x_i - X\lambda \geq 0,$$
$$\lambda \geq 0,$$

where λ represents the vector of peer weights. θ is a scalar and its value is the efficiency score for the i-th firm, where the value of 1 indicates the frontier and hence a technically efficient firm (which does not exist in practice). This linear programming problem must be solved N times, once for each firm in the sample. Hence, each firm has its own θ efficiency score (Coelli *et al*., 2005). The points of the fully efficient firms determine the fully efficient frontier line.

Equation 2 takes the *i-th* firm and then seeks to radially contract the input vector, x_i, as much as possible, while still remaining within the feasible input set. The inner boundary of this set is a piece-wise linear isoquant (see Equation 1), determined by the observed data points which are the firms in the sample. The radial contraction of the input vector, x_i, produces a projected point, ($Y\lambda$, $X\lambda$), on the surface of this method. This projected point is a linear combination of these observed data points. The constraints in Equation 2 ensure that this projected point cannot lie outside the feasible set (Coelli *et al*., 2005).

The constant returns to scale assumption is acceptable if the firms in the sample are operating at an optimal scale, but in practise, firms with imperfect competition do not behave like that. Banker *et al*. (1984) suggested a model which deals with a variable returns to scale (VRS) situation. This model is quite similar to the CRS model except by adding a convexity constraint ($N1'\lambda = 1$) to the model, accounting for the variable returns to scale.

The approach by Banker *et al*. (1984) and Coelli and Perelman (1996) presents an output oriented model, where firms have fixed quantity of resources (capital, labour, livestock and land) and want to produce output (milk and calf) as much as possible. This model is very similar to the input orientated model. The formula of an output orientated VRS model is the following:

$$\max_{\phi\lambda} \phi,$$
$$\text{constrains: } -\phi\, y_j + Y\lambda \geq 0,$$
$$x_i - X\lambda \geq 0, \quad (3)$$
$$N1'\lambda = 1$$
$$\lambda \geq 0,$$

where N1 is an N*1 vector of ones, $1 \leq \phi < \infty$ and ϕ–1 is the proportional increase in output that could be achieved by the i-th firm, with input quantities held constant. $1/\phi$ determine the technical efficiency score, which lies between zero and one. The DEA VRS formula envelopes the data points more tightly and provides higher or equal efficiency scores than the CRS model. The difference between the VRS and CRS technical efficiency scores is the scale inefficiency.

In this paper, we use the European Farm Accountancy Data Network (FADN) database, containing, inter alia, Hungarian dairy farm level data from 2008 to 2017. We use two output variables in our output orientated DEA model - the first is *cow's milk and milk products* (values expressed in euro in the database under the following code: SE216), while the second is the *beef and veal variable* (values expressed in euro in the database under the following code: SE220). For the farms model (Kovacs, 2014), the five input variables were as follows:

1. *Total fixed assets:* It includes land associated to agricultural activity and the buildings and is expressed in euro. These assets remain constant all the times, or at least for a prolonged time to serve the population of economic activity and they do not or just slightly wear out during production. This is shown under the following code in the FADN database: SE441.
2. *Total current assets:* The current assets comprise stocks and other rotating equipment and expressed in euro. This variable is basically the value of breeding animals which wear during production, or stocks wholly destroyed, or else pass through the target assets, so their continuous replacement is essential. The following code is associated in the FADN database: SE465.
3. *Labour input:* It contains the total number of working hours under the code SE011.
4. *Major cost items:* Most important cost categories pertain here and these items are also expressed in euro. This category includes livestock feed and energy costs as well as the value of the plant and lubricants as well. Direct costs also pertain here, containing veterinary expenses, but including a variety of tests or storage costs that can be directly charged to the sector. These are listed under the following codes in the FADN database: SE310 + SE330 + SE345.
5. *Dairy cows:* This category includes cows expressed in European Livestock Units (LSU) which are held primarily for milk production. This can be found under the following code in the FADN database: SE085.

The database contains 6818 data points, which includes data from about 974 dairy farms in Hungary. Efficiency indicators of dairy farms were analysed between 2008 and 2017. We presumed an output orientation DEA model, estimating to what extent production (outputs) can be proportionally increased (maximised) without changing the input quantities used (Kovacs, 2014).

Based on farms' standard production values, three categories can be created:

1. small farms (annual SPV between 4 000€ and 25 000€);
2. medium farms (annual SPV between 25 000€ and 500 000€) and
3. large farms (annual SPV more than 500 000€).

Among the examined 974 farms, 24% was large, 61% was medium and 15% was considered small.

As to livestock sizes, categories are as follows:

1. small farms (less than 50 dairy cows)
2. medium farms (between 51 and 500 cows)
3. large farms (more than 501 cows)

Large farms represents 8%, medium farms 41% and small farms 51% out of the total 974 dairy farms in this regard.

In terms of geographical regions, the majority of the farms (59%) were located in the Great Hungarian Plain and Central Hungary (574 farms). 30% of the farms in the sample (294 farms) was located in the Transdanubian Region and only 11% were located in Northern Hungary (106 farms).

The efficiency of Hungarian milk production

Before presenting results of our model runs, Table 4-7 contain the descriptive statistics of our variables used.

It becomes evident from our model runs that the effectiveness of the Hungarian dairy farms is 77.60% on average (Table 7). This means that effective backup solution (reserves) lies in an average of 22.40% of the Hungarian milk producing farms. In other words, Hungarian milk producers can still have an opportunity to increase their efficiency by 22.40% simply by using their inputs more effectively.

According to Table 8, the most efficient years were 2011 and 2013, reflecting the record low levels of cattle livestock as evident from Figure 1. The biggest technical efficiency reserves was observable in 2009, where Hungarian dairy farms could have increased their output by 28.7% without using more inputs for milk production. Table 8 also reflects declining efficiency scores after 2013.

Table 9 shows our results by farm size. Efficiency of large farms was the highest with 79.2% technical efficiency, followed by 71.2% of technical efficiency for small farms and 59.2% technical efficiency of medium farms. This means that small farms are found to be more efficient than medium ones and the difference between the efficiency of small and large farms is not remarkable. On average, Hungarian dairy farms can increase their efficiency by 30%.

As to results by livestock sizes, the highest efficiency number belongs again to large farms (92.5%), which means that they are close to their possible production frontier curve line; their efficiency reserve is 7.5%. Efficiency of medium farms was 77.9%, while that of small farms was 65% (Table 10). It should be noted that medium size farms based on livestock sizes were found to be more efficient than on a simple farm size basis.

Last but not least, the technical efficiency by the three geographic regions was calculated. As evident from Table 11, the most efficient region was the Northern Hungarian Region, with a technical efficiency of 76.4%. It should be

Table 4: Sample descriptive statistics by year.

Year	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
2008	373,823	60,575	650,211	399,047	26,513	321,832	175	92
2009	281,889	45,010	562,776	331,901	19,415	240,213	142	110
2010	319,018	54,140	647,938	369,104	23,018	300,767	154	95
2011	402,807	80,091	867,799	534,022	29,873	389,513	177	90
2012	438,706	67,286	1,017,289	572,164	32,849	456,017	187	94
2013	483,666	67,620	1,094,249	587,617	33,378	481,023	200	87
2014	494,489	69,909	985,012	519,910	32,843	368,906	193	93
2015	412,914	58,714	924,484	483,252	30,495	347,278	194	109
2016	390,542	64,160	913,995	492,201	29,803	343,227	198	100
2017	476,826	63,947	883,324	498,396	28,099	421,946	191	104
Average	**405,457**	**62,681**	**849,944**	**475,702**	**28,463**	**364,212**	**181**	**97**
Standard Deviation	**1,012,899**	**139,091**	**2,066,493**	**1,163,696**	**68,579**	**894,611**	**368**	**8**
Minimum	100	49	2,119	1,710	270	552	2	87
Maximum	11,034,750	1,643,210	23,553,110	13,789,835	743,486	11,034,030	3,492	110

Source: own calculations based on FADN (2019) data

Table 5: Sample descriptive statistics by farm size.

Farm size category	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Large	945,194	135,374	1,784,327	1,019,456	71,546	862,764	407	229
Medium	189,051	36,320	426,814	218,417	16,727	170,284	103	599
Small	137,577	24,491	276,178	171,455	12,366	127,854	70	146

Source: own calculations based on FADN (2019) data

Table 6: Sample descriptive statistics by livestock size.

Livestock's size category	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Large	2,453,505	371,909	4,382,150	2,585,674	180,516	2,209,447	1,015	79
Medium	365,455	58,027	754,328	407,913	30,839	334,115	190	397
Small	23,147	7,989	120,568	47,897	3,540	23,466	19	498

Source: own calculations based on FADN (2019) data

Table 7: Sample descriptive statistics by region.

Region	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Great Hungarian Plain and Central Hungary	312,884	55,591	606,434	331,060	25,927	290,119	155	574
Transdanubia	453,031	62,466	954,236	536,351	33,976	412,761	201	294
Northern Hungary	338,652	56,744	686,329	376,273	30,980	277,204	156	106

Source: own calculations based on FADN (2019) data

Table 8: Technical efficiency numbers in the Hungarian dairy sector by year.

Year	No. of firms	crsTE	vrsTE	Scale	Efficiency reserves
2008	92	0.746	0.785	0.949	0.215
2009	110	0.627	0.713	0.891	0.287
2010	95	0.668	0.731	0.919	0.269
2011	90	0.744	0.822	0.909	0.178
2012	94	0.742	0.779	0.954	0.221
2013	87	0.875	0.841	0.940	0.159
2014	93	0.752	0.817	0.920	0.183
2015	109	0.677	0.746	0.913	0.254
2016	100	0.696	0.747	0.931	0.253
2017	104	0.683	0.776	0.888	0.224
Total	**974**	**Average**	**0.776**	**Average**	**0.224**

Source: own calculations based on FADN (2019) data

Table 9: Technical efficiency numbers in the Hungarian dairy sector by farm size.

Size category	Number of firms	crsTE	vrsTE	Scale
Large	229	0.776	0.792	0.981
Medium	599	0.564	0.592	0.955
Small	146	0.631	0.717	0.894
Total	**974**	**Average**	**0.700**	

Source: own calculations based on FADN (2019) data

Table 10: Technical efficiency numbers in the Hungarian dairy sector by livestock size.

Livestock's size category	No. of firms	crsTE	vrsTE	Scale
Large	79	0.879	0.925	0.951
Medium	397	0.705	0.779	0.908
Small	498	0.579	0.650	0.897
Total	**974**	**Average**	**0.785**	

Source: own calculations based on FADN (2019) data

Table 11: Technical efficiency numbers in the Hungarian dairy sector by region.

Region	No. of firms	crsTE	vrsTE	Scale
Great Hungarian Plain and Central Hungary	574	0.589	0.652	0.912
Transdanubia	294	0.669	0.724	0.927
Northern Hungary	106	0.709	0.764	0.934
Total:	**974**	**Average:**	**0.713**	

Source: own calculations based on FADN (2019) data

noted that this does not mean that these farms are the best in Hungary, although it is true that these farms used their resources most effectively, when compared with other regions. The dairy farms located at the Great Hungarian Plain and Central Hungarian Region were the least efficient ones compared to the other two regions. They could increase their output with 34.8% without using more resources.

Conclusions

This paper analysed the technical efficiency of Hungarian dairy farms from 2008 to 2017. We have seen some declining trends in efficiency after 2013 with significant differences by farm sizes and regions. On a farm size basis, large farms were found to be the most efficient ones, followed by small farms (simple size basis) and medium farms (livestock size basis). Regionally, farms in the Northern Hungarian Region were found to be the most efficient ones. All this suggests significant efficiency reserves in Hungarian dairy production. Besides the limitations of the methodology, this research can help decision makers to better understand the efficiency of diary farms under different scenarios. We would suggest that the future development of the sector should concentrate on large and medium farms, especially considering their magnitude and results obtained. Future research would be necessary to examine the reasons for the differences found between regions, in terms of livestock sizes and the standard production values of farms. There are many factors that could significantly influence the results obtained, ranging from farm characteristics to environmental and socio-economic factors.

Possible directions for future research might be to estimate allocative efficiency models involving different regions or maybe countries, taking into account that different input and output prices also play an important role when attempting to compare efficiency among the different regions. Unfortunately, the FADN database – when consulted directly – cannot contain information about prices, but indirectly we can calculate it. These analyses need more time and a more complex model so as to be able to estimate the frontiers. To get a better picture of dairy sector efficiency in the future we need to analyse other important fields or sectors (e.g. feeding industry, plan cultivating sectors) which play important role in the dairy sector or instead take the examined country import-export market and use other methods to measure efficiencies like the total factor productivity (TFP) indexes. These methods may be used for analysing other EU countries' or regions' sectors, if proper data is available for analysis. The adaptability of this model is wide so we can analyse different sectors in the agriculture sector and different industrial sectors as well.

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