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TECHNICAL, COST AND ALLOCATIVE EFFICIENCY IN THE HUNGARIAN DAIRY FARMS

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Abstract: *The general aim of the research was to explore the main indicators of the dairy sector in Hungary, and then define and systematize their efficiency and the factors relevant concerning dairy farms. Moreover, the objective is to introduce the most commonly used methods for measuring technical efficiency, which can explore hidden reserves within the dairy sector. To achieve the research objective, first the main indicators of the industry will be introduced, which will be explained in the first part of the literature section. The Hungarian dairy sector production trends and indicators where mainly came from FAOSTAT, EUROSTAT, KSH (Hungarian Central Statistical Office) and AKI (Research Institute of Agricultural Economics) databases. For my assessment, I will use the most reliable and comprehensive domestic agricultural economics database, the AKI- FADN (Farm Accountancy Data Network) database. In accordance with my objective, based on the database, a representative sample was selected in my analyses to represent the national dairy sector. More than 6800 data points were analysed in the different DEA models, which includes data from about more than 950 dairy farms in Hungary. Based on the secondary database (FADN), I created a technical efficiency inputs in four main economic areas (current assets, fix assets, human resources and livestock) which were characterized by using dairy farms efficiency differences of different size, year and regional categories. The model input variables comes from Hungarian FADN database. I confirmed that the used efficiency methods for measuring complex efficiency level were higher in my sample in the case of the large-sized farms than for small and medium-sized farms. The average technical efficiency of the Hungarian dairy sector during the examined 10 years was 64.6%, which means that the farmers can scale down their inputs with 35.4%, without changing the level of output (efficiency reserve). Large and small farms regarding the livestock number are more efficient (93.3%) than the medium sized farms (83.0%) and the small sizes farms (65.8%) maybe, because the medium and small farms are mixed profile farms.*

Keywords: *DEA; technical efficiency; cost efficiency; allocative efficiency; dairy farms; Hungary.*

JEL Classification: *Q12; Q13.*

1. Introduction

In an economics and social point of view, increasing the efficiency level of the milk production is a highly important area of the European Union (EU) and Hungarian

agriculture as well. If milk producers would like to increase their profitability, resulting almost exclusively from the preceding, the only way they can follow is to increase their efficiency level.
The general objective of my research was to explore the main efficiency indicators of the dairy sector in Hungary. Moreover, our objective is to introduce the most commonly used methods for measuring efficiency, which can explore hidden reserves within the sector. During the research, we seek to find the answers to the following general objective related questions:

1. How does the Hungarian dairy farms perform from 2008 to 2017 in a technical and cost efficiency point of view?
2. Are there any differences arise during those 10 years in a different farms size in the Hungarian dairy farms?

2. Materials and methods

Measuring farm level performance or in this research we can tend as an efficiency is a widely used concept in economics. Economic (or overall) efficiency 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 (Begum el. al. 2009; Coelli et. all 2005). There have been several methods to measuring efficiency; the generally used methods are data envelopment analysis (DEA), which involves mathematical programming and econometric methods, respectively.
In this research we use input orientation to measure the DEA VRS technical-, allocative and cost efficiency. 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.
To measure technical efficiency we use the radial measures of technical efficiency. The advantage of the radial approach is that its technical efficiency measures are easily interpreted and communicated as the maximum percentage reduction of inputs required to produce a given output bundle, or the maximum percentage expansion of outputs allowed for at given inputs.
DEA VRS (input oriented) model and Directional Input Distance function:

$$\begin{aligned} &\underset{\beta,\lambda}{Max}\ \beta \\ &s.t. \quad -y_i + Y\lambda \geq 0 \\ &\qquad x_i - \beta g_x - X\lambda \geq 0 \\ &\qquad \lambda'1 = 1 \\ &\qquad \lambda \geq 0 \end{aligned}$$

- where:

- *ß = Technical Inefficiency score*
- *λ= vector of parameters (firm weights)*
- *X and Y are matrixes with all outputs and inputs*

Figure 2 presents a space, where we have for example two inputs like labour hours (X_1) and machines hours (X_2) and one output like milk production in EUR (Y). The negative slope parabolic curve represents the production possibility curve or as the DEA literature mentioned frontier. The other negative line is an iso-cost line for the two input prices. A dairy farm (K) on this space is not efficient, because it is not on the frontier. The distance between the frontier (point T) and the sample dairy firm K represents the technical inefficiency of the farm K. The technical inefficiency can be calculated as 0T/K for farm K. Point T represent a fully efficient farm, which is on the frontier. Farm K can be allocative efficient, if it reduce their inputs (X_1 and X_2) and do their production on point A. This allocative efficiency can be calculated as 0A/OT. This is a theoretical optimum, because this is not technically feasible. What technically feasible for farm K is the point C, where it can be cost and technically efficient too, but to do that they have to change their technology too. The cost efficiency can be calculated as: 0A/OK. But that can be an ultimate goal for a farm to be cost and technically efficient in the same time.
Thus, assuming input-orientated technical efficiency of 80 percent for a farm, that means the farm can decrease inputs by 20 percent without changing outputs (*Figure 1*).

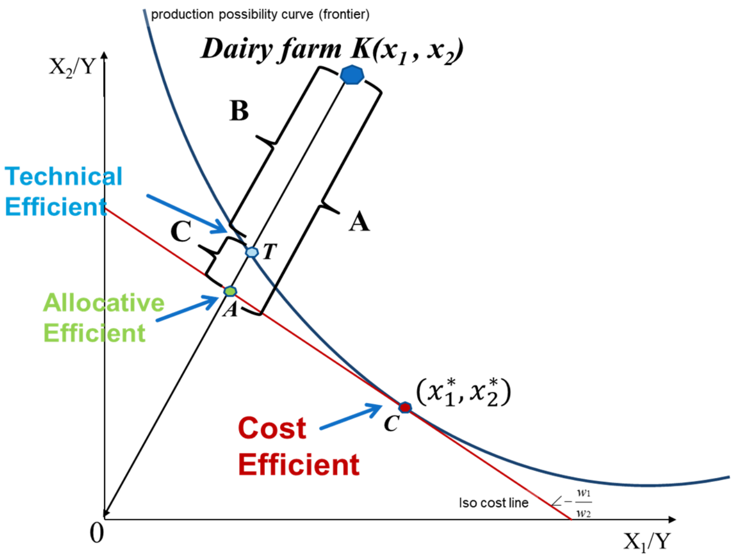


Figure 1: Measuring technical-, cost- and allocative (in)efficiency in input orientation

In this research we use a database from the European Farm Accountancy Data Network (FADN). From the database we selected the dairy farms from Hungary from 2008 to 2017.
We use **two outputs** in our input orientated DEA models, the output variables are the
(1) cow's milk and milk products variable (*values expressed in EUR in the database under the following code: SE216);* and as another income, they sold **(2) beef and veal variable** *(values expressed in EUR in the database under the following code: SE220)*.
For the farms model (KOVACS, 2016), the five input variables were, namely:
(1) Total fixed assets: It includes land associated to agricultural activity and the buildings and is expressed in EUR, these assets remain constant all the time, or at least for a prolonged time to serve the population of economic activity and they do not wear out are not, or only slightly wear out during production. This is shown as the following code in the FADN database: SE441.
(2) Total current assets: The current assets comprise (stocks and other rotating equipment) and expressed in EUR is basically the value of the breeding animals which wear during production, or stocks wholly destroyed, or else pass through the target assets, so that continuous replacement is essential. *This is shown as the following code in the FADN database: SE465*
(3) Labour input: It contains the total number of working hours. *This is shown as the following code in the FADN database: SE011*
(4) Major cost items: This input factors include the biggest three categories of costs and is expressed in EUR. These are usually the highest per capita livestock feed costs, but it represents a significant cost item in energy costs as well. The unit cost of energy includes fossil fuels and electrical energy costs, as well as the value of the plant and lubricants as well. The third component of this category of categories other direct costs, which is the biggest factor in the cost of veterinary expenses, but includes a variety of tests, or storage costs that can be directly charged to the sector. *It is listed with the following code in the FADN database: SE310 + SE330 + SE345.*
(5) Dairy cows: This category includes female sex cattle on the farm European livestock units (LSU), which are held primarily for milk production. European livestock units of the dairy cow are 1, while younger than two years old calves take account of between 0.4 and 0.6. *This is stated in the following codes in the FADN database: SE085.*
The following *Tables 1* contains the descriptive statistic from the used dataset.
Both input and output factors of the model were derived from the Hungarian AKI (Research Institute of Agricultural Economics) FADN database. The 6818 data points were analysed in the model, which includes data from about 974 dairy farms in Hungary.
During my examination set by the research questions, efficiency indicators of dairy farms were analysed from the year *2008 to 2017*. We also explore the efficiency *level of small, medium and large holdings* regarding to their the number of dairy cow livestock.

We presumed input orientation for the DEA model, which suggests that the farms in the database, we estimate how much input amounts (outputs) can be proportionally decreased (minimized) without varying the output quantities used (KOVACS, 2009).

Table 1: Variable averages in the examined dairy cow (DC) livestock size categories

Livestock's size category	Cows' milk & milk products production *(1000 EUR)*	Beef and veal production *(1000 EUR)*	Total fixed assets *(1000 EUR)*	Total current assets *(1000 EUR)*	Labour input *(1000 hour)*	Major direct cost *(1000 EUR)*	Number of dairy cows *(head)*	**Total number of farms *(piece)***
DC large (DC > 501)	2 453	371	4 382	2 585	180	2 209	1 015	**79**
DC medium (51< DC <500)	365	58	754	407	30	334	190	**397**
DC small (DC<50)	23	7	120	47	3	23	19	**498**

Source: Own calculation based on the AKI FADN database 2008-2017

For the efficiency indicators calculation we used the R 3.6.1 software with the R Studio 1.2.1335 version software and we calculated the technical, allocative and cost efficiency with a Benchmarking packages version 0.27 (BOGETOFT – OTTO, 2018).

3. Results and discussion

The research results shows that the 10 years long model variables of efficiency of the Hungarian dairy farms produce an average of 64.6% efficiency based on DEA method (technical efficiency under variable returns to scale (vrsTE)). This means that effective backup solution (reserves) lies in an average of 35.4% of the Hungarian milk producing farms during the examined ten years. This means the Hungarian milk producing farms can still have an opportunity to increase the efficiency by 35.4% to minimise the level of their input resources to get the same output value.
If we take a look at the *Table 2*, we can see that during the examined period, the most efficient year was 2011 and 2013. The biggest technical efficiency reserves was in 2009, where the dairy farms can decrease their inputs with 26.7% without changing the produced output quantity. On the year, 2015 and 2016, the dairy farms also lost their efficiency and they can decrease their used inputs with 24.1-25.0% to reach the sector specific production possibility output level (curve) of their production.
The farm scale category, what we generated during this examination was the size regarding the individual farm livestock number. There are three category were generated large size farms regarding the number of dairy cows (DC) on the farms (more than 501 DC/farm). The medium size farms has dairy cows between 51 and 500. The small size farms has less than 50 dairy cows. In the sample the large farms represents 8%, the medium size farms represents 41% and the small farms has 51% shares of the total 974 dairy farms *(Table 3).*

Table 2: The technical efficiency numbers in different years in the Hungarian Dairy Sector

Year	No. of firms	vrsTE	vrs Techn.INEF	allocative INEF	cost INEF
2008	*92*	**0.786**	0.214	0.194	0.408
2009	*110*	**0.733**	0.267	0.238	0.505
2010	*95*	**0.754**	0.246	0.230	0.476
2011	*90*	**0.842**	0.158	0.276	0.433
2012	*94*	**0.801**	0.199	0.257	0.456
2013	*87*	**0.839**	0.161	0.284	0.445
2014	*93*	**0.817**	0.183	0.231	0.414
2015	*109*	**0.759**	0.241	0.230	0.471
2016	*100*	**0.750**	0.250	0.219	0.470
2017	*104*	**0.788**	0.212	0.300	0.512
All period (2008-2017)	***974***	**0.646**	**0.354**	**0.235**	**0.589**

Source: Own calculation based on the AKI FADN database 2008-2017.

Table 3: The technical efficiency numbers in the examined dairy cow (DC) livestock size categories

Livestock's size category	No. of firms	vrsTE	vrs Techn.INEF	allocative INEF
DC large (DC > 501)	**79**	**0.933**	**0.067**	**0.016**
DC medium (51< DC <500)	**397**	0.830	0.170	0.336
DC small (DC<50)	**498**	0.658	0.342	0.231
Total:	**974**			

Source: Own calculation based on the AKI FADN database 2008-2017.

On the sample, the highest efficiency number during the ten years belongs to the large farms (93.3%), which means that they are close to their possible production curve line; their efficiency reserve are 6.7%. The medium farms efficiency are 83.0%. The small fames efficiency are the lowest with 65.8% technical efficiency indicator. That means that they can decrease their input use with 34.2%, without any output change. The allocative inefficiency in this case means, what how much more the different farm categories can scale down their inputs, to become cost efficient as well. The medium farms has to decrease 33.6% more of their inputs to became cost efficient as well. The large dairy farms only need to scale down 1.6% more inputs to be cost efficient as well.

On the previous examination, we estimated only one frontier for the whole sample and select the different farms regarding their size and took an averages on the

different farm sizes and compared with each other. In this case we had only one frontier. But not we have three, where the same sized farms are competing each others only. On *Figure 3* we can observe an increasing technical efficiency on the small scale farms, till 2013, but after their technical efficiency will dropped down dramatically, and it can happened because of the milk quota system abolishment or the lower milk prices as a conclusion of it. The polynomial trend line is quiet clear in this case with good fit (R^2=0.862).
The medium scale farms presents the same trend as the small scale dairy farms during the examined period, but maybe higher level and smoother fluctuation on the technical efficiency indicators (R^2=0.488). However, the milk quota system abolishment and their low milk price effect also decreased their technical efficiency numbers. Definitely, the farms has less than 500 dairy cows had great benefit from the quota system in Hungary (*Figure 2*).

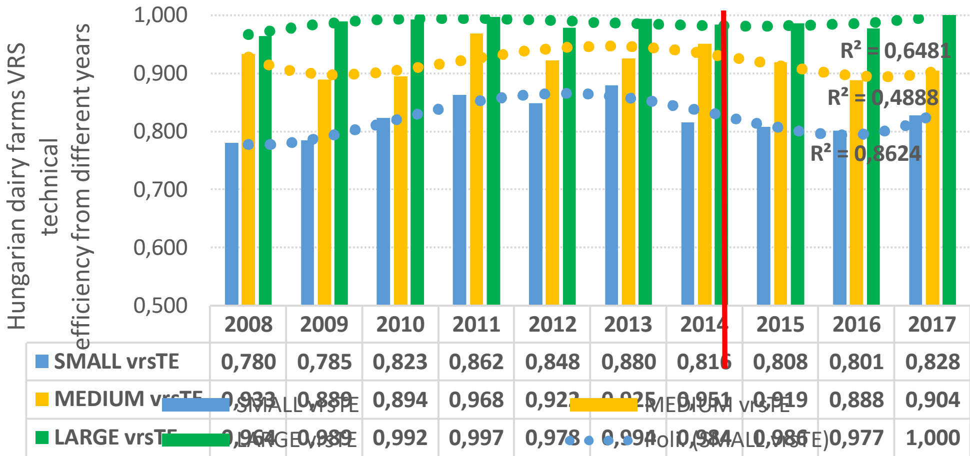


Figure 2: The technical efficiency (input orientated VRS) numbers in the examined dairy cow (DC) livestock size categories
Source: Own calculation based on the AKI FADN database 2008-2017.

The large scale farms, more than 501 dairy cows has almost no impact was observed because of the milk quota system abolishment for their technical efficiency. Their technical efficiency was changed between 96-100%. Which means that they are doing quiet good job, and use the external and internal opportunities much better than the smaller farms in the country.
To get a better picture about the situation in different years and different farm size in the Hungarian Dairy Farms, it is necessary to see other performance indicators like allocative efficiency or inefficiency, which measures that how far the exact farm has from the cost efficiency isocost line. Thus, it is and extra input down scaling from the production possibility curve. If we add the certain farm technical inefficiency and allocative inefficiency, we got the cost inefficiency, which means, that how far the that certain farm lie to be not only technical efficient but cost efficient too.

On *Figure 3* the large scales dairy farms allocative and technical efficiency were shown for the different years. The allocative inefficiency lies in between 16.6-28.4% during the examined period, while the VRS input orientated technical efficiency lies in between 12.0-21.5%. That means that in the small size farms are more allocative inefficient than technically. They have to focuses there financial performance more than to change their technology, however it is also important, because of their relatively high inefficiency numbers.

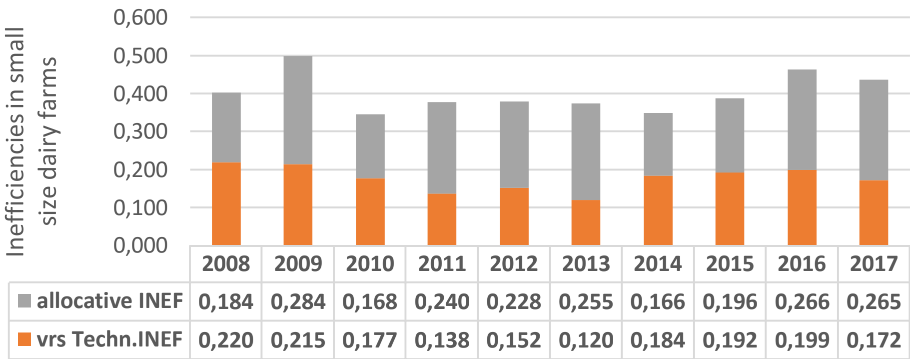


Figure 3: The technical inefficiency (input orientated VRS) in small sized dairy farms
Source: Own calculation based on the AKI FADN database 2008-2017.

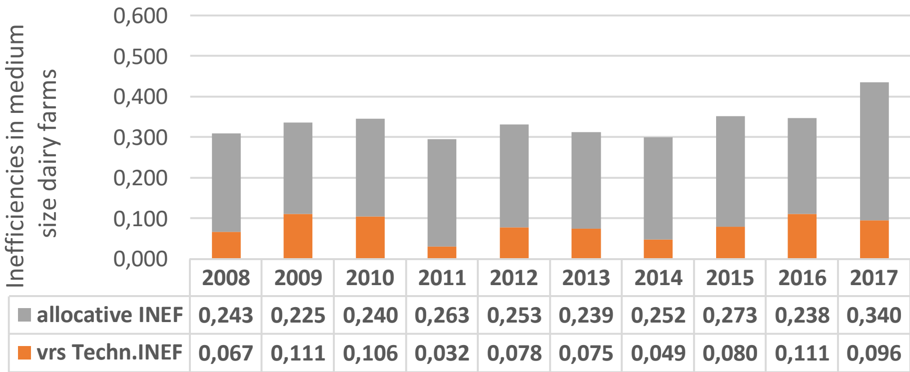
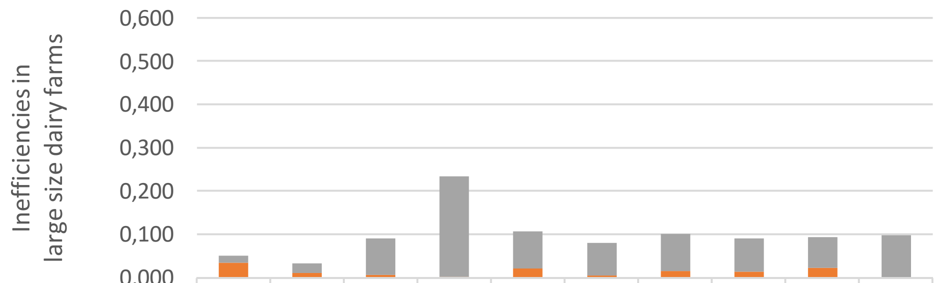


Figure 4: The technical inefficiency (input orientated VRS) in medium sized dairy farms
Source: Own calculation based on the AKI FADN database 2008-2017.

The medium size farms technical inefficiency trends shows on *Figure 4*. The technical inefficiency indicator is quiet low, comparing to the small scale farms results, it lies in between 3.2% and 11.1%. Thus, we can see that the medium size dairy farms are quiet homogenous group regarding their technical inefficiency. Thus, they do almost the same things to increase their technical efficiency. Nevertheless, their allocative inefficiency are relative high from 22.5%-34.0%. In the future the need to focus to decrease this number, if they want to be cost efficient too. Their technical performance is close to the efficient frontier, but their cost inefficiency is really high. The last size category what was examined are the large scale farms. Their overall performance was the best among all farms. However, what about if they are in a separate group and we measure their performance among them. *Figure 5* present the result on the large scale farms. The large farms technical inefficiency is low, comparing to the other two farm size. Their technical inefficiency are maximum 3.6%. That means that they are close to their production possibility frontier, and there are not so much to improve technically. Their allocative inefficiency numbers are low too; it lies in between 1.6 and 23.1%. The year 2011 was a bad year for them regarding to this number.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
allocative INEF	0,016	0,023	0,084	0,231	0,086	0,075	0,086	0,077	0,072	0,098
vrs Techn.INEF	0,036	0,011	0,008	0,003	0,022	0,006	0,016	0,014	0,023	0,000

Figure 5: The technical inefficiency (input orientated VRS) in large sized dairy farms
Source: Own calculation based on the AKI FADN database 2008-2017.

4. In conclusion

The average (input orientated) technical efficiency of the whole Hungarian dairy sector during the examined 10 years was 64.6%, which means that it can decrease their inputs with 35.4%, without changing the level of output (technical efficiency reserve) to be technical efficient. The farms can reduce their inputs by an additional 23.5% to be allocative and technically efficient too.
By changing the production structure, they can be cost and technical efficient too, by reducing their inputs with 58.9% (cost efficiency reserve).
The large farms, which kept more than 501 dairy cows are more efficient (93.3%) than the other two size farms (83.0% and 65.8%).
The small scale farms can reduce their inputs by 40.2% to be cost efficient. The medium farms can reduce by 33.7%, while the large scale farms can reduce their inputs by 9.9% to be cost efficient too!

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