DUTCH, HUNGARIAN AND GERMAN DAIRY FARMS TECHNICAL EFFICIENCY COMPARISON

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Abstract: The abolishment of the dairy quota system in the EU is expected to increase competition across dairy farms in Europe. Assuming a common price for milk in the EU, only the most efficient farms will survive in the new environment. The main objective of the paper is to compare dairy farms in Germany, The Netherlands and Hungary about their technical efficiency. In the first part of the research, the efficiency is measured by partial efficiency indexes using one dimensional efficiency measuring. In the second part, the Data Envelopment Analysis (DEA) have to be used to measure efficiency in a multidimensional space, using six inputs and two outputs.

It appears from the results that the highest efficiency farms are in the Netherlands, and then Germany and Hungary follow. If we want to eliminate the low sample size effect, we can assume a common frontier, which decreases the efficiency scores a bit, and makes the Hungarian results more reliable.

With respect the abolishment of the dairy quota system, our results suggest that the Dutch farms are the most efficient, thus probably they will increase their production after the quota system. But because the size of the country we cannot expect dramatic changes in the European Dairy market. The Germans farms efficiency is lower, but their efficiency is also lower, so we won't expect high increase about the dairy supply. The Hungarian dairy sector is not so efficient like the Dutch, and the size of the sector has also small among the European countries, thus if they want to survive the quota system demolishing, they have to increase their technical efficiency.

Key words: efficiency, dairy quota system, dairy farming, Data Envelopment Analysis

1. Introduction

The world milk production shows a continuous rising trend since 1961. In 2005 the world total fresh milk production was 541 million tonnes (FAOSTAT 2010). Since the introduction of milk quotas in 1984 the European Union (EU) production has stagnated around 149 million tonnes (EUROSTAT 2010). The milk quota system was introduced to stop over-production in Europe.

The biggest milk producer in the EU is Germany (18.98%), the second is France (16.13%), and the third is the United Kingdom (9.83%). The Netherlands and Hungary account for 7.31% and 1.22% of total EU production, respectively (FAOSTAT 2010). Currently, dairy farms in a given EU country are expected to be more or less competitive when compared to dairy farms in other countries. A reason for that is the quota system, which does not allow trading between countries, may protect farmers from international competition. Given that the quota system will be abolished in 2013, this will put pressure on less competitive farms in different countries. The issue of optimal use of resources becomes important.

As noted by *Bauer* et al. (1998), policy makers are particularly interested in the potential impact of their decisions on performance of firms. A firm that is inefficient is wasting inputs because it does not produce the maximum attainable output, given the quantity of inputs used, and hence the possibility of reducing average costs. Irrespective of whether a developed or developing economy is under consideration, findings from the study of technical efficiency have far-reaching policy implications.

Studying farm efficiency and the potential sources of inefficiency are therefore important from a practical and a policy point of view. On the one hand, farmers could use this information to improve their performance. On the other hand, policymakers could use this knowledge to identify and target public interventions to improve farm productivity and farm income (*Solís* et al., 2009).

The first objective of the research is to measure dairy farms efficiency in Hungary, Germany and The Netherlands. Based on the results, we can assess the potential of dairy farms in the three countries to survive of the abolishment of the dairy quota system. The second objective is to compare parametric and non-parametric methods of efficiency measurement in practise. The research questions of this thesis are: What are the differences and the similarities in the Dutch, German and Hungarian dairy sectors? The dairy farms in which country (the Netherlands, Hungary or Germany) are more efficient compared to their national frontier?

1.1 Introducing the Dutch, German and the Hungarian dairy sector

The European Union is the largest milk producer in the world and the EU dairy sector is one of Europe's most important farming sectors. To compare the three countries dairy farms efficiency, it is essencial to examine the structural differences between the countries.

The hungarian dairy farms are mainly large in terms of land. 70 percent of the farms use more than 100 hectares of land for their business. The German farm's represent a mix of small (less than 50 hectares land), medium (between 50 and 100 hectares land) and big (more than 100 hectares) farms. The Dutch dairy sector consists of many small and middle-sized farms, with the big dairy farms accounting for only 8 percent of the whole land. The Hungarian dairy sector is land extensive in contrast to the Dutch dairy sector which is land intensive. This intensive farming practices can involve very large numbers of animals raised on limited land which require large amounts of food, water and medical inputs. The German dairy sector about the land use is somewhere in the middle of the other two examined countries. This specialisation will be discussed in later sections.

Another way to compare the dairy farms size examines the distribution of dairy farms according their size in terms of dairy cows (DC) in percentage. 73 percent of the Hungarian dairy livestock which means 0.19 million dairy cows live in big farms where there are more 100 dairy cows are kept. The average herd size is 22 dairy cows per holding (EUROSTAT 2010b).

The German farms characteristics are still the same as the previous comparison, so there are several types of farm working in Germany. 55% of the cows, which means 2.25 million dairy cows, live in big farms, where there are more than 100 dairy cows. The average size of the herd is 40.7 dairy cows per holding (EUROSTAT 2010c).

The Dutch farms are more specialised about dairy cows, so they own less land, but they keep the dairy cows in a big (more that 100 DC per farm) farms. 64 percent of the Dutch dairy cows, which means 0.946 million dairy cows live in dairy farms, with more than 100 cows. The average size of the herd is 59.9 dairy cows per holding (EUROSTAT 2010a).

The EU-25 produced around 146 million tones of whole fresh cow milk in 2005 (EUROSTAT, 2010), which was 27.5 percent of the world production. Among the three countries Germany is the largest milk-producing country with 28.49 million tonnes. The Netherlands and Hungary produced 10.98 million and 1.94 million tonnes respectively.

The milk production was stable, but a small reduction was observed on the number of dairy cows during the examined period. The country with the biggest cow population was Germany (4164 million heads in 2005) and the reduction was approximately 7 percent from 2001 to 2005. The Dutch dairy cows' number was 1486 million heads in 2005, which was quiet stable during the examined period. However a 4.2 percentage decrease occurred from 2001 to 2005. The Hungarian dairy cows' number was 285 thousand heads in 2005, which decreased 17.4 percent from 2001. Hence this was the highest decrease among the three countries.

An interesting observation is that during the examined period the number of cows decreased in all chosen countries, but the milk production was quite stable. This was caused by the increasing performance of the cows. The average milk production per year per cow is the highest in The Netherlands (7615 kg); and lower in Germany (6984 kg) and Hungary (6850 kg).

Based on *Table 1.1* the Dutch farms are more efficient regarding the technical partial productivity indexes. It seems that after the dairy quota system abolishment the Dutch farmers will increase their production potential and they will reach the best efficiency results among the three countries. After the quota system abolishment the Hungarian farms should have to increase their technical efficiency, otherwise they will decrease their production potential, now it seems that they are producing extensively, but in a big volume per farm. The German farms are lied in between of the other two countries.

Table 1.1: Partial productivity indicators in the examined countries in 2005

	Germany	Hungary	The Netherlands
Milk production per cow (kg/DC)	6 984	6 850	*7 615
Milk production per total operating cost (kg/€)	1 828	2 900	*3 369
Milk production per total labor (kg/AWU)	172 464	85 374	*333 553
Milk production per forage area (kg/ha)	7 324	5 849	*12 572
Milk production per total input (kg/€)	939	*1 928	1 603
Milk production per farm (kg/farm)	332 856	*584 814	540 356

AWU: annual working unit; DC: dairy cow; *the best result among the three countries
Source: FADN REPORT 2010.

So far we measured the efficiency only through partial productivity indicators. Although it is impossible to decide which counties technical efficiency is the highest. So far the different countries measuring was limited by measuring one input and one output performance of the farms. Thus the measuring of the inputs and the outputs was separately, during the following chapters the efficiency performance measuring regard with respect to all inputs and all output as many authors called (*Farrel,* 1957; *Begum* el. al. 2009; *Coelli* et. all 2005., *Tauer*, 1998; *Jaforullah and Whiteman,* 1999; *Stokes* et al., 2007; *Kumbhakar and Lovell,* 2000; *Emvalomatis,* 2010) in the literature the *"multiple input and output measurement"*.

2. Materials and methods

Measuring 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.

Farell (1957) distinguishes input and output orientated measures depending on which factor we assume altering. So in the input orientated measure the input quantities changing 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 regarding to *Farell* (1957) and *Coelli* et. al. (2005) is the output orientated measure, which is the opposite of the input orientated. By this measuring the question is: *"By how much can output quantities be proportionally expanded without altering the input quantities used?" (Coelli et. al. 2005).* If the technology is characterized by constant returns to scale the two orientations produce the same technical efficiency score. Differences, however, appear under variable returns to scale.

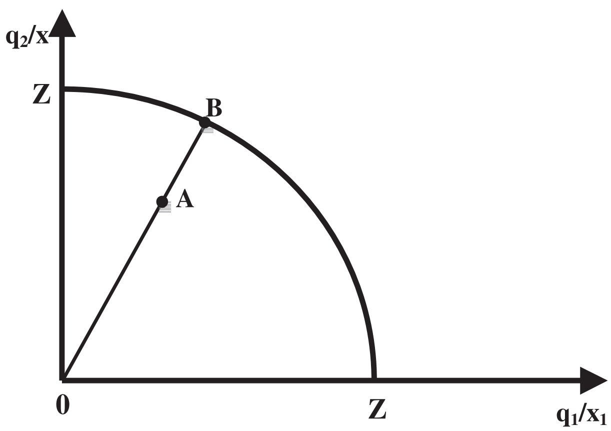

Figure 2.1: Technical efficiency from an output orientation

Figure 2.1 presents the technical efficiencies from an output orientation, here following Coelli et. al. (2005) and considering a firm with two outputs (q_1 and q_2) and a single input (x_1) and keep the input quantity fixed (because it is an output orientation measure), ZZ' represents the production possibility curve and point A the inefficient firm *(Figure 2.1)*.

The distance AB measure 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 practise the efficient isoquant is not known, the researchers have to estimate it from the sample data using different kinds of analyses. These will be introduced in the following sections. These analyses are the non-parametric data envelopment analysis and the parametric stochastic frontier analysis.

2.1 Introducing the Data Envelopment Analysis (DEA) Method

This section is divided into several subsections. The first part introduces a basic DEA model, in which a constant returns to scale (CRS) technology is assumed, the following part describes a more general variable returns to scale (VRS) DEA model.

The framework for the Data Envelopment Analysis (DEA) approach has been introduced by *Farrell* (1957) at first and popularized by *Charnes, Cooper & Rhodes* (1978). Data envelopment analysis is a non-parametric mathematical programming approach to frontier estimation.

The first and widely applied model was the input orientated CRS models, which solves the following linear programming problem for each firm to obtain the efficiency score:

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

Where regarding to *Coelli* et. al. (2005), 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 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. There is one problem with this formulation, because it has an infinite number of solutions. *Charnes, Cooper & Rhodes* (1978) solve it by adding one constrain $v'x_i$ =1 and reformulate the objective function a bit, this form we known as the multiplier form of the DEA. Using the duality linear programming method from the multiplier formula the envelopment form can get, which is the following:

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

where λ represents the vector of peer weights. θ is a scalar and the value of it will be the efficiency score for the i-th firm, the value of 1 indicate the frontier and hence a technically efficient firm (but in practise it is not exist). 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.

Regarding to the Eq. (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 (refer Eq. (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 Eq. (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 the firms with imperfect competition do not behave like that. *Banker, Charnes and Cooper* (1984) suggested a model which can deal with 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, which accounts for the variable returns to scale. The model regarding to *Banker, Charnes and Cooper* (1984) and *Coelli and Perelman* (1996) presents an output oriented model, when the firms have fixed quantity of resources (capital, labour, livestock, land) and want to produce output (milk, calf) as much as possible. This model is very similar to the input orientated model. So the formula of an output orientated VRS model is the following:

$$\begin{aligned} &\max_{\phi\lambda} \phi, \\ &\text{constrains:} \quad -\phi y_j + Y\lambda \geq 0, \\ &\qquad x_i - X\lambda \geq 0, \\ &\qquad N1'\lambda = 1 \\ &\qquad \lambda \geq 0, \end{aligned} \tag{3}$$

where the N1 is an N*1 vector of ones moreover $1 \leq \phi < \infty$ 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.

2.2 Description of the data

In this research we use a database from the European Farm Accountancy Data Network (FADN). From the database we selected the dairy farms from Germany, Hungary and the Netherlands from 2001 to 2005. We focussed mainly on those dairy farms, whose revenues from cow's milk production are at least 75% of their total revenues for every year.

We use two outputs in our model, the revenues from cow's milk production and the revenues from other outputs. This other output revenues includes revenues from beef and veal and other output production that a dairy farm can produce. For the better estimation to account for the dependence of revenues on inflation, the output revenues and the input costs are deflated with country-wide price indices for each category of products, with prices obtained from EUROSTAT.

The analysis uses six deflated (base year is 2000) inputs categories, which cover the whole input side of the dairy business. These categories are the following:

1; Capital (K) consists of the buildings and fixed equipment like: tractors, lorries, milking machines, cleaning machines, feeding automats.
2; Labour (L) is measured in working hours and includes both family and hired labours.
3; Land (A) is measured in hectares, and includes the total utilized agricultural area (UAA) of the holding. Does not include areas used for woodland, roads, non-farmed areas.
4; Total material inputs (M) includes all deflated farm specific costs, that arise in the dairy business like: seeds and plants, fertilizers, crop protection, crop and livestock-specific cost (storage cost, marketing cost, veterinary cost) and energy (fuel, electricity, heating) costs.
5; Livestock (S) is measured in standardized livestock unit (LSU) which is the total number of livestock heads on the farm aggregated with European standard weight coefficients.
6; Purchased feed (F) is measured in deflated monetary value, and includes purchased feed and concentrates for grazing and home-grown livestock, but excludes the value of feed produced within the farm.

The following *Table 2.1* contains the descriptive statistic from the used dataset

Table 2.1: Variable averages in the examined countries

	Germany	The Netherlands	Hungary*
Milk revenues (€)	104 587	186 221	154 573
Other revenues (€)	32 553	32 807	52 265
Capital (€)	167 258	196 327	89 124
Labor (AWU)	4 085	4 251	16 038
Land (UAA)	63	50	164
Material inputs (€)	44 699	52 230	81 718
Livestock (DC)	92	113	159
Purchased feed (€)	20 448	33 099	58 596

AWU: annual working unit; UAA: utilized agricultural area; *time interval is 2001 to 2008 for Hungary
Source: Own calculation based of the FADN database 2001-2005.

2.3 Empirical specification of the DEA model

The objective of this section is to compare dairy farms efficiency in Germany, Hungary and the Netherlands. We assume the farms produce two kinds of output, which are the revenues of cow's milk and the revenues of other output. The other output includes all the other outputs of the farms which are valuable except the cow milk. The other outputs variable is equal to the difference of the total outputs and the sum of the farm use production and the total cow milk production.

The model uses output orientation variable returns to scale (VRS) configurations. We assume output orientation, instead of the input orientation, however the European dairy market is restricted by the quota system, but the dairy farmers can trade with the quotas among themselves (inside the country) in every examined country. On the other hand we assumed that the dairy farms easily can buy more quotas if it's necessary than change the quantity of their inputs. So we assumed that the inputs are more fixed than the outputs. This output orientated VRS model is quite similar to the constant returns to scale (CRS) model except by adding convexity constraint (N1'λ = 1) to the model, which account for the variable returns to scale.

The model is an output oriented model, when the firms have fixed quantity of resources (capital labor, land, total material inputs, livestock and feed) and wanted to reach as much revenues, which is measures the quantity of the outputs (milk, other) as possible. The farms have six inputs, which covers approximately all the input what they use to produce milk. These inputs are: capital (machinery and buildings), labor, land, total material inputs, livestock and feed.

We estimate the technical efficiency for the three countries for every year individually. That procedure gives the German and the Dutch technical efficiency score from 2001 to 2005 and from 2001 to 2008 for Hungary, thus we can create an average technical efficiency score for the countries, to compare them.

3. Results of the DEA

Table 3.1 presents the estimated mean values of technical efficiency which on average for 2001 to 2005 is 83 percent assuming variable returns to scale (Vrste) for Germany with 982 observations per year. The scale efficiency is the ratio of the constant and variable returns to scale (0.80/0.83), which is on average 0.96 and indicate that the difference between the constant and variable returns to scale is only 4% which is close to constant returns to scale (CRS) part of the technology.

Table 3.1: Summary of the technical efficiency in Germany

Year	Crste	Vrste	Scale	Observations
2001	0.80	0.84	0.96	982
2002	0.80	0.83	0.96	982
2003	0.80	0.83	0.97	982
2004	0.80	0.83	0.97	982
2005	0.81	0.84	0.96	982
Average	0.80	**0.83**	0.96	982

Note: crste = technical efficiency from CRS DEA; vrste = technical efficiency from VRS DEA; scale = scale efficiency = crste/vrste
Source: Own calculation based of the FADN database 2001-2005.

Table 3.2 presents the estimated mean values of technical efficiency which on average for 2001 to 2005 is 92 percent assuming variable returns to scale (Vrste) for the Netherlands with 178 observations. The scale efficiency is on average 0.96 and indicates that the difference between the constant and variable returns to scale is only 4% which is also close CRS part of the technology.

Table 3.2: Summary of the technical efficiency in The Netherlands

Year	Crste	Vrste	Scale	Observations
2001	0.88	0.92	0.96	178
2002	0.89	0.92	0.97	178
2003	0.90	0.93	0.97	178
2004	0.89	0.92	0.97	178
2005	0.89	0.93	0.97	178
Average	0.89	0.92	0.96	178

Note: crste = technical efficiency from CRS DEA; vrste = technical efficiency from VRS DEA; scale = scale efficiency = crste/vrste
Source: Own calculation based of the FADN database 2001-2005.

The Hungarian database is quiet problematic, because of the small specialised dairy farm number of the sample. Thus to deal with the small sample size, we used aggregate dataset over time (from 2001 to 2008) and we weren't apply that restrictions, that the farms have to be in the database at least five years. *Table 3.3* presents the estimated mean values of technical efficiency which on average for 2001 to 2008 is 90 percent assuming variable returns to scale (Vrste) for Hungary with 94,5 observation on average. The scale efficiency is on average 0.96 and indicates that the difference between the constant and variable returns to scale is only 4% like the other two countries. The high technical efficiency score caused by the low number of observation and the big specialised dairy farms in Hungary in the sample.

Table 3.3: Summary of the technical efficiency in Hungary

Year	Crste	Vrste	Scale	Observations
2001-2004	0.86	0.90	0.95	120.0
2005-2008	0.86	0.89	0.96	67.0
Average	0.86	0.90	0.96	94.5

Note: crste = technical efficiency from CRS DEA; vrste = technical efficiency from VRS DEA; scale = scale efficiency = crste/vrste
Source: Own calculation based of the FADN database 2001-2008.

Table 3.4: Comparing technical efficiency assuming common frontier using DEA

	GERMANY				**The NETHERLANDS**				**HUNGARY**			
Year	**Crste**	**Vrste**	**Scale**	**Obs**	**Crste**	**Vrste**	**Scale**	**Obs**	**Crste**	**Vrste**	**Scale**	**Obs**
2001	0.74	0.76	0.98	982	0.87	0.89	0.98	178	0.70	0.82	0.87	51
2002	0.75	0.77	0.97	982	0.87	0.89	0.98	178	0.76	0.84	0.92	33
2003	0.74	0.76	0.97	982	0.88	0.90	0.98	178	0.75	0.80	0.93	20
2004	0.76	0.78	0.98	982	0.87	0.90	0.97	178	0.81	0.88	0.93	16
2005	0.75	0.78	0.97	982	0.88	0.91	0.97	178	0.79	0.84	0.94	15
Ave-rage	0.75	0.77	0.97	982	0.88	0.90	0.98	178	0.76	0.84	0.92	27

Note: crste = technical efficiency from CRS DEA; vrste = technical efficiency from VRS DEA; scale = scale efficiency = crste/vrste; Obs=Observation per year
Source: Own calculation based of the FADN database 2001-2005.

Table 3.4 displays the average technical efficiency of the German, the Dutch and the Hungarian sample respectively, calculated under the assumption of a common frontier across three countries. In our case common frontier was necessary to eliminate the Hungarian low sample size and merge the three country dataset in one for the better estimation. The common frontier case assumes that the three counties can access to the most efficient technology.

Results show that the superiority, in terms of technical efficiency average, of the Dutch sample in the dairy sector remains when using the common frontier (average technical efficiency (assuming VRS) of 0.9 for the Dutch farms, 0.77 for the German farms and 0.84 for the Hungarian farms). This suggests that more Dutch dairy farms are closer to the efficient common frontier than Hungarian or even the German dairy farms. Furthermore this suggests that, if it is assumed that there is common technology between Dutch, German and Hungarian farms, the Dutch farmers make a more efficient use of this technology in the dairy sector.

Table 3.5 presents the technical efficiency results using DEA method. There are two cases inside the analysis, which are assuming national or common frontier. Observable that in the common frontier case all the countries technical efficiency scores under variable returns to scale are lower than the national frontier cases (VRS TE). That might have caused the bigger sample size, and the assumption that all the examined countries can operate in the same environmental conditions and can employ the same technology.

Table 3.5: Comparing summary of the technical efficiency using DEA

Type of the DEA frontier	Country	CRS TE	VRS TE	Scale	Observations
NATIONAL frontier	Germany	0.80	**0.83**	0.96	982
	The Netherlands	0.89	**0.92**	0.96	178
	Hungary*	0.86	**0.90**	0.96	23.4
COMMON frontier	Germany	0.75	**0.77**	0.97	982
	The Netherlands	0.88	**0.90**	0.98	178
	Hungary	0.76	**0.84**	0.92	27

Note: CRS TE = technical efficiency from DEA constant returns to scale; VRS TE = technical efficiency from DEA variable returns to scale; scale = scale efficiency = CRS TE / VRS TE

Note: * The Hungarian data's are unbalanced assuming national frontier from 2001-2008

Source: Own calculation based of the FADN database 2001-2005.

Table 3.5 shows that using DEA and assuming the national frontier, the highest efficiency score is 0.92 for the Netherlands, the second is Hungary (0.9), but the sample size in that case is quiet low So that result is not trustable, because it might represent just the biggest farms which are using the best technology in Hungary. Assuming the common frontier makes our technical efficiency scores lower, earlier we mentioned the reasons of it.

If we combine the two kinds of frontiers results and take the averages of the two methods and the two kinds of frontier, we get that the most efficient farms are in the Netherlands with 90–92% efficient. The German farms are 77–83% efficient. The Hungarian farms are 84–90% efficient.

4. Discussion

The method in this research was suitable and the most widely used method to compare dairy farms efficiency for farm and national level. The DEA method that has been used in this research help to measure technical efficiency with using multiple outputs and multiple inputs. From the literature review we saw that it is hard to compare countries using just the partial productivity indexes, where we can examine the farms efficiency in just one dimension. Using DEA method, we can examine the farm's technical efficiency in a multidimensional level.

The database of the research has been collected by the European Union's FADN system from 2001 to 2005 and from 2001 to 2008 for Hungary. The small number of observations per year is the reason why the Hungarian database continues more years in the sample. Thus the time horizon of the data is 5 or 8 years, but it can be longer like 10 or 20 years to get more valid results for the comparison. The number of dairy farms in the sample per year is 982 for Germany, 178 for the Netherlands and 23 for Hungary. In the future research it is desirable to increase the numbers of Hungarian dairy farms in the sample as high as the other countries farms number to get more clear view about their management for the comparison. But in the present FADN database for Hungary is not that wide about the specialised dairy farmers. On the other hand it is also possible that the Hungarian farms are not as specialised only for milk production as the Dutch or the German farms.

We can see in our database, that there are only few specialised big farms comparable to the Dutch and German farms, that's one reason for the small Hungarian sample. Although we can see that the farms are relatively efficient in the Hungarian sample comparing their national frontier. Nevertheless to get a better view about the break points of the different countries dairy efficiency, we need to make a SWOT (strength, weakness, opportunity, threats) analysis or examine allocative efficiency for their dairy sector, which require more time, capital and more experts opinions. Thus this can be a good topic for future research.

Directions for the future research can be also to estimate allocative efficiency models where the different countries, different inputs and outputs prices are also play an important role to compare efficiency among countries. Unfortunately the FADN database directly cannot contain information about prices, but indirectly we can calculate it. These analyses needs more time and more complicated model to estimate the frontiers. To get better view about the dairy sector efficiency in the future we need to analyse other important countries or sectors (feeding industry, plan cultivating sectors) which play important role of the sector or the examined country import-export market and use other methods to measure efficiencies like the Stochastic Frontier Analysis (SFA) or the total factor productivity (TFP) indexes.

The usability of these methods for other country, region sector is possible, if they have proper data for the analysis. The method is available to compare not just countries but regions inside the counties. The adaptability of this model is wide so we can analyse different sectors in the agriculture and different industrial sectors as well.

5. Conclusions

In this research we compare three countries partial efficiency indexes, which mainly comparing ratio of one input and one output. According to the results we can establish the dairy sector characteristic of the three countries. The biggest milk producer is Germany; the smallest is Hungary among the three countries. About the applied technology, the Hungarian dairy sector are land and labor extensive in contrast to the Dutch dairy sector which are land and labor intensive. This intensive farming practices can involve very large numbers of animals raised on limited land which require large amounts of feed, water and medical inputs. The German dairy sector about the land and labor are somewhere in the middle of the other two examined countries.

So far the measuring of the inputs and the outputs was carried separately, the next step was measuring the efficiency performance with respect to all inputs and all output called *"multiple inputs and output measuring"*. The non-parametric DEA method that has been used in this research help to measure technical efficiency with using multiple outputs and multiple inputs. The DEA method measures the relative efficiency of a farm in the presence of multiple inputs and outputs, without knowing the functional relationship between inputs and outputs and given the assumption that statistical noise does not exist.

We used two outputs in our models, the revenues from cow's milk production and the revenues from other outputs. For the better estimation to account for the dependence of revenues on inflation, the output revenues and the inputs are deflated with country-wide price indices for each category of products. The analysis used six deflated inputs categories, which cover the whole input side of the dairy business. These categories were the following: capital, labor, land, total material inputs, livestock and purchased feed.

The European Union's FADN database has been used for this research which contains data from 2001 to 2005 and from 2001 to 2008 for Hungary, because of the small sample size. The number of dairy farms in the sample per year was 982 for Germany, 178 for the Netherlands and 23 for Hungary. We define specialised dairy farm like those dairy farms, whose revenues from cow's milk production are at least 75% of their total revenues for every year.

It appears form the results that the Netherlands has highest technical efficiency; the second is Hungary and Germany. But the Hungarian results are less trustable than the others, because of the low sample size. Eliminating the low sample size effect with assuming a common frontier, which decrease the efficiency scores a bit, and it makes the Hungarian results more reliable. If we combine the two kinds of frontiers results and take the averages of the two kinds of frontier, we get that the most efficient farms are in the Netherlands after Hungary and Germany follows.

We can assume that if the quota system abolished and assuming a common price for milk in EU, only the efficient farms will survive the higher competition among the countries. In our case the Dutch farms are the most efficient, thus probably they will increase their production after the quota system. But because the size of the country we cannot expect dramatic changes in the European Dairy market. The Germans farms efficiency is lower, although their dairy sector size is bigger than the other two countries, so we won't expect high increase about the dairy supply. The Hungarian dairy sector is not as efficient as the Dutch, and the size of the sector is also small among the European countries, thus if they want to survive the quota system demolishing, they have to increase their efficiency.

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