DAIRY FARM COST EFFICIENCY IN LEADING MILK PRODUCING REGIONS IN POLAND

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Introduction

Recent years have witnessed the process of dairy farming restructuring in Poland. Dairying has been declining in some areas, while at the same time changing its character from the commercial milk production to organic milk production and the artisan dairy product manufacturing. Commercial dairy farms have been under pressure to keep production costs low because the restructuring has also affected the diary-processing sector. There have been mergers among the previously independently operating regional dairy processing companies.

Price milk volatility has increased on the European market since 2007 (Wysokiński and Jarzębowski, 2013). The need for comparative analysis of milk production costs across the European and Polish dairy farms Ziętara (2012) and the evaluation of the relative competitiveness of Polish dairy farms has been suggested (Ziętara, 2010; 2012).

This paper examines the cost efficiency of dairy farms in two regions (administratively the name of the region is "voivodship) leading in commercial milk production in Poland, i.e., Wielkopolskie and Podlaskie. Both illustrate the tendency toward more regionally concentrated production driven by the natural resource base. The geography in two regions includes wide river valleys suitable for pasture and hay production. In some areas of both regions, land quality is low and field crop farming would generate marginal returns. Production costs are also associated with regional wage rates. Whereas a relatively high wages and incomes characterizes Wielkopolskie, Podlaskie reports incomes considerable below the national average. Consequently, costs of hire labor are potentially lower in Podlaskie adding to its competitive position against Wielkopolskie Voivodship. The non-farm jobs are limited, especially in certain areas (Klepacka 2012) and outmigration has intensified after Poland's accession to the EU in 2004. Podlaskie Voivodship has been affected by outmigration in combination with depopulation relatively more than Wielkopolskie Voivodship, but some migrants have been returning recently as a result of the economic crisis in several EU economies.

Regional differences in the level of economic development have been present in Poland for decades. The differences also include various productivity levels of farms. The adoption of the market mechanism has become a major force reallocating resources and re-structuring the economy changing the relative competitiveness of regions. In terms of agricultural production, despite the existence of CAP, somewhat insulates the market rigour, but the competition among milk processors is also a source of pressuring production costs on dairy farms. Poland's milk production begun to increase slowly, within limits permitted by the CAP, after the EU accession in 2004. The production reached 12 bil liters in 2011 (Lira 2013).

The regional differences in milk production have become increasingly visible Parzonko (2013) although some report that the Pomorze and Mazury regions held the competitive advantage in milk production over other regions, followed by Małopolska and Pogórze, while Mazowieckie and Podlaskie Voivodships placed third (Domanska, 2013). Barnes, Revoredo-Giha and Sauer (2011) reported on a relatively strong position of the Polish dairy sector. In an earlier study, Revoredo-Giha and Renwick (2010) dairy farms showed a similar level of cost efficiency across farm sizes and across four FADN regions in Poland. The regional polarization of milk production was reflected in the diverting milk procurement trends between Podlaskie and Podkarpackie Voivodship between 2004/2005 and 2010/2011 (Parzonko, 2013).

In recent years, there has been a notable concentration of the dairy processing capacity. Wielkopolskie and Podlaskie Voivodships have a good network of processing facilities in their or in neighboring regions. Both areas have large markets, Podlaskie targets Warsaw, the largest city in Poland, while Wielkopolskie has an easy access to several large cities. Some large farms in there ship milk for processing to processing plants in Germany. Consequently, the competitiveness of dairy farms and dairy processing plants appear to be separate issues. To provide insights into the competitiveness of dairy farms in two selected regions of Poland, we apply the cost frontier approach. The calculated index of cost efficiency allows assessing the relative cost efficiency of each farm in the sample against the most efficient farm in the region. A wide differences among farms, suggest that there are substantial reserves in cost efficiency within each region. A region can continue to remain competitive in milk production as the less cost efficient producers make gains and approach the level of the most technically efficient farm.

Cost frontier estimation approach

An inefficient farm could improve its efficiency through better input use (Langemeier 2010). The current study focuses on cost efficiency in order to provide empirical evidence of the extent it may be lacking among farms in two leading dairy regions in Poland. The stochastic cost frontier model implies that the most efficient farms are located on the frontier function. The measure of cost efficiency, an index, assumes values from zero to one, where one is the highest efficiency level. The fixed effects stochastic cost frontier model can be written in the following way (Kumbakhar and Knox Lovell, 2003), where i denotes farms and t the periods:

$$(1) \qquad \ln E_{it} = \ln C(Q_{it}, W_{it}, \tau_t; \Omega) + v_{it} + u_i \ .$$

In equation (1), $\ln E_{it}$ is the logarithm of the observed expenditure and $\ln C(Q_{it}, W_{it}; \Omega)$ is the logarithm of the deterministic cost function that depends on the outputs Q_{it}, the input prices W_{it}, a deterministic trend τ_t to capture technological change, and a vector of parameters Ω. The statistical error is represented by v_{it}, which is assumed to be independent and identically distributed with mean zero and variance $\sigma_v{}^2$. The time invariant inefficiency term u_i is positive.

The estimation of the stochastic cost frontier (i.e., $\ln C(Q_{it}, W_{it}, \tau_t; \Omega) + v_{it}$) and the inefficiency terms (i.e., u_i) requires the choice of a functional form for the deterministic part of the stochastic cost frontier (i.e., $\ln C(Q_{it}, W_{it}, \tau_t; \Omega)$). The selection of a generalized multiproduct translog cost function (Caves, Christensen, and Tretheway, 1980) imposes fewer a-priori restrictions than other functional forms commonly used for the task. As explained by Caves, Christensen, and Tretheway (1980) in the context of multiproduct estimation, some outputs might not be present on a farm, and therefore the logarithm used in the translog function will produce an error. Instead, they propose the use of a Box-Cox transformation to substitute for the logarithm of the output terms. Note that the Box Cox transformation is only one of the possibilities. Therefore, this paper applies $f(Q) = Q$, which provides a hybrid between the translog function and the quadratic function. Thus, for the case of n inputs and m outputs, the cost function is given by:

$$(2) \qquad \ln C(Q_{it}, W_{it}; \Omega) = \alpha_0 + \varphi_0 \tau_t + \varphi_0 \tau_t{}^2 + \sum_{j=1}^{n} \alpha_j \ln W_{jt} + \tfrac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} \ln W_{jt} \ln W_{kt}$$
$$+ \tfrac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{n} \delta_{jk} f(Q_{jit}) \ln W_{kt} + \sum_{j=1}^{m} \gamma_j f(Q_{jit}) + \tfrac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{m} \rho_{jk} f(Q_{jit}) \cdot f(Q_{kit})$$

As the stochastic cost frontier is a cost function, it has to satisfy the properties of any cost function (Chambers, 1988). Price homogeneity and symmetry were directly imposed in (2) through the following restrictions to the parameters (3):

$$(3) \qquad \sum_{j=1}^{n} \alpha_j = 1; \ \sum_{j=1}^{n} \delta_{jk} = 0; \ \sum_{j=1}^{n} \beta_{jk} = 0; \ \sum_{k=1}^{n} \beta_{jk} = 0; \ \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} = 0; \beta_{jk} = \beta_{kj} \ .$$

A stochastic cost frontier using a panel data fixed effects model considers inefficiency as a time invariant (Schmidt and Sickles, 1984; Kumbakhar and Knox Lovell, 2003; Greene, 2005). A common problem in the estimation is that the use of a fixed effect model precludes the use of time invariant variables. However, in the context of cost function estimation, this can be overcome due to the fact that the parameters associated with input prices can be estimated from the cost share equations, where the inefficiency term (i.e., the fixed effect terms) do not appear.

The equation to be estimated is presented in (4), where the intercept in (4) is $\alpha_{0i} = \alpha_0 + u_i$.

$$(4) \qquad \ln E_{it} = \alpha_{0i} + \varphi_0 \tau_t + \varphi_0 \tau_t^2 + \sum_{j=1}^{n} \alpha_j \ln W_j + \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \beta_{jk} \ln W_j \ln W_k + \frac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{n} \delta_{jk} f\left(Q_{jit}\right) \ln W_k + \sum_{j=1}^{m} \gamma_j f\left(Q_{jit}\right) + \frac{1}{2} \sum_{j=1}^{m} \sum_{k=1}^{m} \rho_{jk} f\left(Q_{jit}\right) \cdot f\left(Q_{kit}\right) + v_{it}$$

The dataset does not contain input prices for each farm. However, in the context of cross section estimation, the approach is to assume that all farmers face the same prices (e.g., Alvarez and Arias, 2003). However, for estimating a cost function using panel data it is possible to introduce prices, assuming that all the farmers face the same input prices within a year (i.e., across farms), but that prices change over time.[1]

Equation (4) was estimated for five inputs (i.e., n) and three outputs (i.e., m). Given the high number of parameters to be estimated, the following econometric procedure was employed. First, the system of $(n-1)$ cost shares was computed, using Iterative Seemingly Unrelated Regression Equations (ISURE) and imposing the constraints in (3). This step provided the values for all the terms in (4) that were associated to input prices. Second, all the remaining parameters of the cost function, except the fixed effect terms (i.e., output terms not associated with prices) were estimated using the within estimator (ordinary least square applied to the variables expressed as deviations of the means by farm as in Hsiao, 1993). Finally, the fixed effect terms used in the construction of the relative cost efficiency indices were estimated from equation (4) by evaluating the function at the mean value of the variables by farm (Atkinson and Cornwell, 1993; Kumbakhar and Knox Lovell, 2003; Pierani and Rizzi, 2003).[2]

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[1] In a different context, similar assumptions can be found in the estimation of demand systems, where price elasticities are sometime estimated from time series because of the lack of variability of prices in cross section datasets (Hsiao, 1993, p.206).

[2] The farm level estimated fixed effects used to compute the relative cost efficiency indices were

As shown in Kumbhakar and Knox Lovell (2003), the relative cost efficiency index (CEI_i) for a sample size N was computed as equation (5) based on the estimated fixed effect intercepts (i.e., $\hat{\alpha}_{0i}$), where for the most cost efficient producers it has a value equal to one:

$$(5) \qquad CEI_i = \exp\{-(\hat{\alpha}_{0i} - \min_i\{\hat{\alpha}_{0i}\})\} \qquad i = 1,\ldots,N.$$

The results of the cost function estimations for two voivodships (Wielkopolskie and Podlaskie) provided insights into cost efficiency differences and were used to calculate elasticities of substitution among the input categories. The majority of the calculated elasticities are statistically significant[3].

Data

The Farm Accounts Data Network (FADN) database has been available for the EU member countries for some time. It includes annual records of a wide range of financial and non-financial data for a selection of full-time farms across the EU. In case of Poland, the data used were available after the country's accession to the EU, i.e., since 2004/05. The country has been divided into four FADN regions and each consists from four administrative provinces called “voivodship.” To discern the cost efficiency within a particular voivodship, the authors using individual subregion codes subdivided the FADN region and the number of dairy farms was determined for each voivodship. The current study uses 189 dairy farms in Wielkopolskie Voivodship and 505 dairy farms in Podlaskie Voivodship. The obtained sample is an unbalanced panel set.

Costs and outputs by farm type were computed directly from the FADN data. Costs were allocated to one of five groups: materials (e.g., feed, fertilizer); energy; labor (i.e., all labor used including that of the farmer, farm family, business partners, and hired workers); land (owned and rented) and capital (e.g., rent, depreciation). The three outputs were considered: crops, livestock, and other outputs, all of them in real terms.

The estimation of cost functions requires input prices. But, FADN data include only input expenditures and not the paid input prices paid (or quantities used). Therefore, Eurostat's input

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assumed to be constant over time due to the short period covered by the sample (in the best case, information was available for some farms for eight years) (Kumbakhar and Knox Lovell, 2003, p. 170).

[3] Results of estimation are not shown due to space limitations, but are available from the authors upon request.

price indices data (base year 2004) were used for agricultural materials, energy, and capital as an estimate of prices paid by farmers. The labor and land input prices were estimated from the FADN data.

The national FADN farm panel consists of farms participating voluntarily, therefore, the panel may not be fully reflective of Poland's dairy sector. Farms with very small herds are likely underrepresented. However, the study focuses on the competitiveness of producers and their ability to create jobs in rural areas rather than milk self-supply, the primary reason behind a small animal herd.

Estimation results and implications

The cost efficiency index was calculated for every farm in each region or subregion against the most efficient farm in a particular area. The results are comparable among farms within an area, but not across areas because the most efficient farm, which serves as the benchmark, is different in every region or subregion. The efficiency indicators are relative with respect to the frontiers represented by the most efficient producer or producers. For example, if a cost efficiency coefficient equal 0.5, it implies that the cost at the frontier is 50 percent of the observed cost at that particular farm in the studied area and the maximum potential cost reduction at that farm resulting from cost efficiency improvement is 50 percent. Utlimately, it is the farmer's decision when and how to reduce costs. A farmer experiencing a decrease of revenues may withdraw from production altogether. It appears the many Polish dairy farmers have already chosen that route. Opportunities to expand herds is limited by the competition for land in Wielkopolskie Voivodship and the continuation of farming in Podlaskie Voivodship resulting from the lack of other opportunities in agricultural production.

The distribution of dairy farms in each area according to various levels of cost efficiency is illustrated in Figures 1 and 2. There is a wide distribution of farms in terms of their relative cost efficiency, but in different areas, the potential for improvement varies. The comparison between the two areas is indirect and based on the concentration of cost efficiency indicator within the range.

Figure 1 depicts the distribution of farms according to their relative cost efficiency in Wielkopolska Voivodship. It appears that a handful of farms has been very cost efficient in the regions and has outperformed the majority of farms. There is a portion of farms for which the calculated cost efficiency index ranged from 0.25 to 0.50, but really the bulk of farms has been assigned the index of the value lesser than 0.25. Clearly, in Wielkopolska voivodship the best farms outdistance the majority of dairy farms. The result supports casual observation of large, well organized dairy farms with hundreds of dairy cows, while the typical dairy farm in the region may have a much smaller herd because it depends primarily on farm-produced feed. The average farm size have been limited for decades and only the collapse of state sector in farming created possibilities of leasing large amount of hectares that could support a large dairy farm.

Another indirect evidence of large discrepancies in terms of cost efficiency among farms in Wielkopolskie Voivodship has been the consolidation of processing capacity. The previously existing processing plants might not have been competitive in terms of pricing and encouraged the shipping of raw milk to plants outside the region including plants in Germany. The restructuring in the processing sector has been demonstrated in dairy companies from other regions merging with smaller companies in Wielkopolskie Voivodship.

The area perceived as having the largest potential for dairy production is Podlaskie Voivodship (Figure 2). The majority of farms has been assigned the cost efficiency indicator ranging from 0.25 to 0.50, although the number of farms with an indicator value between 0.501 and 0.75 is noticeable larger than in Wielkopolskie Voivodship. As compared to the most efficient dairy farms in the region, the remaining farms have a narrower gap to close than in Wielkopolskie (Figure 1 and 2). Because several large processing facilities are located in the area, or within a reasonable distance in the neighboring voivodships (e.g., Mazowieckie or Warmińsko-Mazurskie), the dairy plants have a relatively large raw milk supply base. The relatively short transportation distance from farm to the processing plant is an important source of competitive advantage for the dairy sector, and enables plants to offer higher prices.

Concluding remarks

This study investigates the possibilities of cost reduction by dairy farms evaluated at a lowest aggregation level within the FADN regions in Poland to provide insights into the relative competitiveness of two leading dairy producing regions. In particular, Wielkopolska and and Podlaskie represent two voivodships with the natural resource endowment suitable for dairy production, well developed processing capacity and located in proximity to major milk demand centers.

The analysis at the level of a voivodship avoids pitfalls of the artificial formation of FADN regions. The cost efficiency histograms suggest differences in production costs. Cost efficiency comparisons are valid only within the region because the most efficient farm or farms determine the cost frontier. A number of very efficient farms is limited in each region, but relatively higher in the Podlaskie relative to the most efficient farm than in Wielkopolskie Voividship. The remaining farms in each region appear to have substantial reserve and capacity for cost reduction as compared to the most efficient farm, especially in Wielkopolska. Whether such opportunities will be realized depends on each farm operator and external pressures such as the access to milk processing plants and prices they offer for raw milk. There is relatively more farms that show very low cost efficiency in Wielkopolskie Voivodship.Opertors of such farms may cease to produce milk in coming years or will be absorbed by larger farms, some of which, depending on the region, may not continue dairy production.

Dairy farms utilize more labor than field crop farms and the continuing development of that subsector of agriculture could offer, however limited, job opportunities. Enlargement of herds eventually will require hired labor to improve economic returns. Already, between 2009 and 2010, the employment in agriculture increased by about 2,400 jobs (GUS, 2011), but the data do not provide details about the farm type or geographical area, where the new jobs were added. However, the general trend of an increase in agricultural employment is consistent with both the demographic changes and reversal of migration due to the shrinking job market in other EU countries. The full demonstration of the financial crisis in 2008 and the subsequent economic slowdown in many EU countries led to a decrease in demand for labor. Lower labor demand and the lack of prospects for a speedy recovery caused many job-seeking migrants from Poland to return home. The reverse migration increased the supply of labor, including the labor in rural areas and areas where outmigration was largest, that is Podlaskie Voivodship.

Among the limitations of the study is the potential imprecision of deflating prices of inputs and outputs. The lack of price information in the FADN data set also forces the assumption that farmers in both regions face identical prices. The labor cost likely varies due to wage and cost of living variation and could have affected the results.

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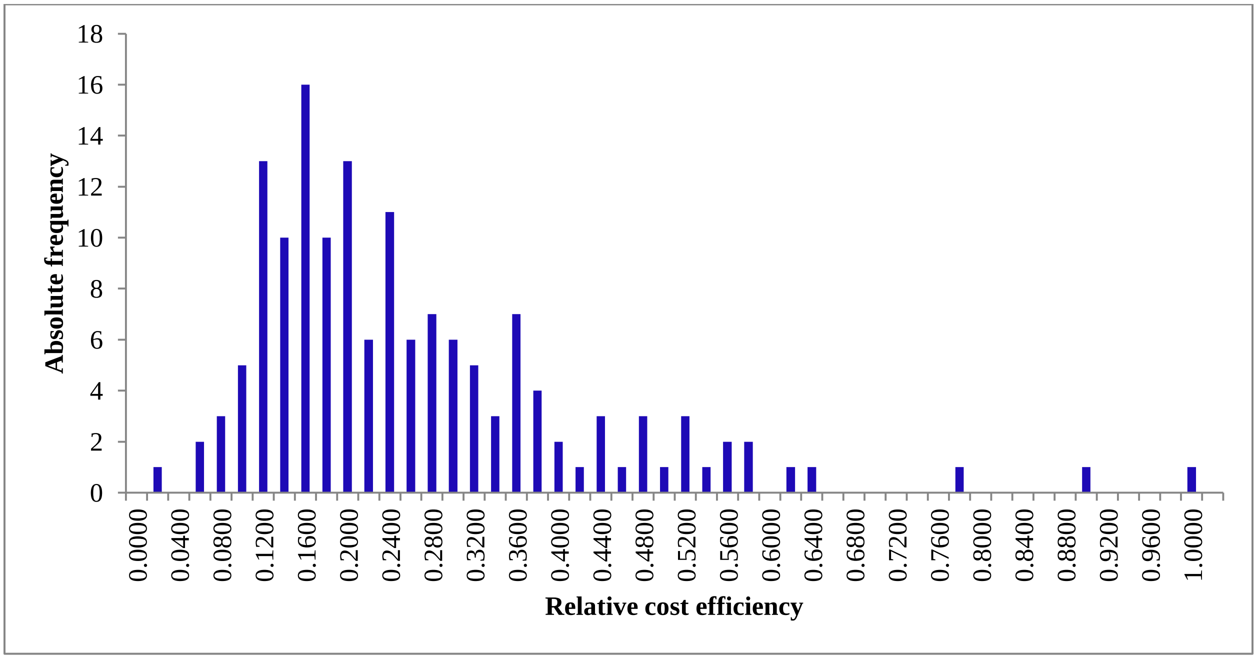
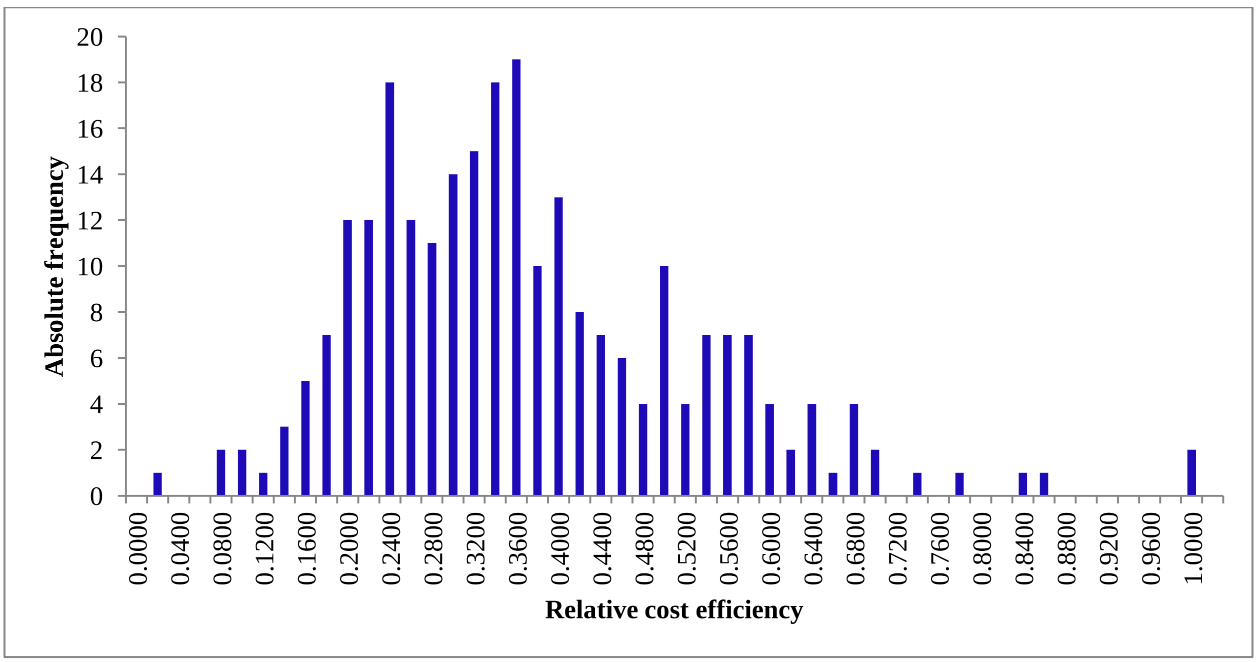
Figure 1. Cost efficiency index values of dairy farms in Wielkopolskie Voivodship included in the FADN database for Poland calculated for the period 2004-2009 (n=189).



Source: Authors' calculations based on estimation results using the FADN data.

Figure 2. Cost efficiency index values of dairy farms in Podlaskie Voivodship included in the FADN database for Poland calculated for the period 2004-2009 (n=505).



Source: Authors' calculations based on estimation results using the FADN data.