DAIRY FARM PRODUCTIVITY IN NORTHERN EUROPE

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Abstract. The milk sector has received much attention in Europe due to the abolishment of milk quotas in 2015 and its potential effect on the geographical distribution of milk production across countries. As a way of assessing the competitive advantage of Nordic EU countries, we investigated the productivity level and productivity growth of milk farms across eight countries of the Baltic Sea region from 1995 to 2010. We found considerable discrepancy in productivity performance across countries. TFP growth rates indicate that the competitive positions of the "old" EU members are stable, and that there is no catching up from the newer EU entrants. We offer explanations for this evolution based on the different patterns of structural change followed by the studied countries.

Key words: productivity, dairy farms, comparison, Northern Europe

1. Introduction

The weight of Northern Europe or – as we call the group of countries in this study – the Baltic Sea region in EU's dairy sector is remarkable, it accounted for 37,4% in the volume of milk deliveries to dairies in 2012. The group includes Germany, Denmark, Sweden, Finland, Estonia, Latvia, Lithuania and Poland. Dairying has traditionally been one of the most important production branch within the agrifood sectors in all these countries. Competitiveness of milk production is considered to be of crucial importance in the future, especially when the supply control mechanisms of the EU are removed.

Although several definitions of competitiveness are available in the literature, we consider here that the competitiveness of an industry such as the dairy sector is achieved when individual companies within that industry are able to sell goods or services at a price and quality that compare favourably to those of competitors. Two important ideas, stressed in the conclusion of a review paper on the competitiveness in the Agri-Food sector commissioned by the OECD (Latruffe, 2010), follow. First, competitiveness is a relative concept and should be measured with respect to a benchmark. Here, the eight countries, which account for most of the trade in dairy products in the region, often have the same multi-national dairy processors, and share some natural conditions such as climate. Second, in spite of the simple definition, competitiveness is a complex concept that incorporates a multitude of aspects, which vary in the ease with which they can be measured.

Competitiveness relates closely to the concept of productivity, defined as the efficiency of the process by which firms (or sectors) transform inputs into outputs. Indeed, for entire countries or large sectors of an economy, some prominent economists consider that competitiveness is just "a funny way of saying 'productivity'" (Aiginger, 2006, summarizing Krugman, 1994). Against this background, the objective of this study is to assess productivity levels and productivity growth in the dairy farms of the eight countries of the Baltic Sea region.

2. General Approach and Methodology

The productivity of a firm or sector is simply defined as the ratio of outputs (e.g., yoghurt, butter) to inputs (e.g., labour, milk) (Coelli et al., 1998: 2). While the value of the index is uninformative by itself, its rate of change measures the growth in output that is not explained by the growth in inputs and therefore directly captures how the efficiency of the production process changes over time. This is why the results of a productivity analysis are often presented in the form of growth accounting that decomposes output growth into its component parts, including productivity growth. Our analysis therefore compares productivity growth of the dairy sectors in eight countries of the Baltic Sea area.

2.1. Partial versus Total Factor Productivity

If the production process involved a single input and a single output, calculating productivity levels would be straightforward, but this is unfortunately never the case in reality, where firms combine multiple production factors in order to manufacture a whole range of products. Hence, the problem of measuring productivity becomes one of aggregating inputs and outputs into appropriate indices. This can be achieved by application of various methods that differ in terms of accuracy, ease of implementation and data requirements, but two types of measures can be usefully distinguished:

- Partial productivity measures, which simplify the problem of aggregating inputs and/or output by focusing on only one of each (e.g., milk for outputs, labour, dairy cows or land for inputs). The main advantage is the ease of calculation and interpretation, but it comes at the cost of accuracy. For instance, a high level of labour productivity can reflect high efficiency resulting from the use of a superior technology, but it can also be due to the inefficient substitution of capital for labour. In a similar vein, at the level of a farm, high milk yields can be sub-optimal if they are achieved through an inefficient use of costly feeds. It is therefore clear that partial productivity measures can provide a misleading indication of overall productivity when considered in isolation.
- Total Factor Productivity (TFP) measures, which integrate all inputs and all outputs in the calculation.

2.2. Measuring productivity

The analysis is based on a combination of partial productivity and TFP indices. Partial productivity measures are often self-explanatory but, at the farm level, the selection of specific indicators is guided by the literature on technical change and development in agriculture of Hayami & Ruttan (1991). Specifically, labour productivity (Y/L) is partitioned into output per dairy cow (Y/C) and the number of dairy cows per worker (C/L) according to the relationship: Y/L=Y/C*C/L. The advantage of this decomposition lies in the sources of growth in each of the partial productivity indicators: an increase in output per dairy cow (i.e. milk yield) reflects mainly biological innovations, such as genetic improvements or the amelioration of feed composition. On the other hand, the number of dairy cows per worker changes mainly with mechanical innovations, such as the labour requirement of milking machines or automation of other production processes such as feeding, cleaning, maintenance etc.

A variety of methods are available for the measurement of TFP growth. When prices of all outputs and all inputs are available, that information can be combined with quantity data in order to produce traditional indices, such as Laspeyres, Paasche, Fisher, and Tornqvist indices. Coelli et al. (1998) demonstrate that the Tornqvist index has superior economic properties and it is therefore used in this analysis. Formally, it is constructed from an output index and an input index:

$$\ln(\frac{Input_t}{Input_{t-1}}) = \sum_{i=1}^{n} 1/2(\alpha_{i,t} + \alpha_{i,t-1})\ln(\frac{x_{i,t}}{x_{i,t-1}})$$

$$\alpha_{i,t} = \frac{w_{i,t}x_{i,t}}{\sum_{j=1}^{n} w_{j,t}x_{j,t}} \tag{1}$$

$$\ln(\frac{Output_t}{Output_{t-1}}) = \sum_{k=1}^{m} 1/2(\beta_{k,t} + \beta_{k,t-1})\ln(\frac{y_{k,t}}{y_{k,t-1}})$$

$$\beta_{k,t} = \frac{p_{k,t}y_{k,t}}{\sum_{l=1}^{m}p_{l,t}y_{l,t}}$$

(2)

where $x_{i,t}$ denotes the quantity of input i used in period t; $w_{i,t}$ is the price of that input; $y_{k,t}$ denotes the quantity of output k produced in period t and sold at a price $p_{k,t}$. In spite of the cumbersome notations, these expressions have a simple interpretation once it is recognized that, for any variable v, $\ln(v_t/v_{t-1})$ is the growth rate of v between t-1 and t. The total growth rate of inputs $\ln(Input_t/Input_{t-1})$ is therefore a weighted average of growth rates of individual inputs $\ln(x_{i,t}/x_{i,t-1})$, with the weights equal to the average cost shares of the inputs i. Similarly, the total growth rate of outputs $\ln(Output_t/Output_{t-1})$ is a weighted average of growth rates of individual outputs $\ln(y_{k,t}/y_{k,t-1})$, with the weights equal to the average revenue shares of each output j. TFP growth, defined as the growth in ouput not explained by growth in inputs, is therefore calculated as the difference between the two previous expressions:

$$\ln(\frac{TFP_t}{TFP_{t-1}}) = \ln(\frac{Output_t}{Output_{t-1}}) - \ln(\frac{Input_t}{Input_{t-1}})$$

(3)

3. Data and construction of variables

The analysis of productivity of dairy farms relies on the aggregate data provided by the European Commission's Public Database of the Farm Accountancy Data Network (FADN)[1]. For the eight countries of the Baltic Sea region included in the study, the information extracted from the database pertains to the TF14 grouping entitled "Specialist milk farm" (i.e., group 41 for the old classification based on gross margins before year 2004, and group 45 for the new classification based on standard output thereafter). The study covers the period from 1995 to 2010. The database, being run by EU institutions, only contains information from member states and this means that for the relatively new entrants, the data is only available from the year of EU accession (2004 for the three Baltic States and Poland).

Detailed information is available on the main aspects of the production process. Output values at current prices are recorded for milk, crop productions and beef/veal, which makes it possible to calculate the revenue shares β in equation (2). The corresponding quantity indices entering the definition of the output index (2) for crop productions and beef/veal are then calculated by deflating the current value figures, using the deflators in the EUROSTAT database[2]. For milk, information is available on the number of dairy cows as well as milk yield, and it is therefore possible to infer a physical quantity of milk produced.

Input values are recorded for the main variable production factors, namely fertilisers, commercial feeds, pesticides, energy and seeds. The issue of family labour, which represents typically an important factor of production that is not directly paid, is addressed as follows. An average wage rate is calculated as the ratio of the wage bill to the quantity of paid labour, which is then applied to the input of family labour in order to infer the total cost of labour (family as well as hired).

[1] Available online at: http://ec.europa.eu/agriculture/rica/index.cfm.

[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database, categories Agricultural prices and prices indices – Price indices of agricultural products (2005=100).

Capital inputs are more difficult to take into account because what should enter the productivity calculations are the flow variables, i.e., the productive services and associated costs provided by all the capital goods, although the database only records capital stocks for four classes of assets: land, buildings, machinery and livestock. Hence, for each asset class, we build the cost of capital as the sum of depreciation costs and opportunity cost of the investments. The first component is calculated assuming linear depreciation over 20 years for buildings, seven years for machinery, and five years for livestock, while land is assumed not to depreciate. The opportunity cost of capital is calculated as the interests that would have been earned by a near risk-free investment of the same value. The corresponding interest rate is approximated by the yield on long-run government bonds, as given by the European Central Bank database[3]. By adding the depreciation and opportunity costs of the four classes of capital goods, one obtains the total cost of capital which is then used to calculate the cost share in the total input index (1). The growth in the quantity of capital in (1) is then calculated by using deflated values of buildings, machinery and livestock, while the physical quantity of land (i.e., surface area) is used for that asset.

4. Results

4.1. Partial productivity

The performance of dairy farms in terms of labour productivity varies tremendously across countries (Table 1). In 2010, for instance, one hour of labour on a dairy farm produced on average 255kg of milk in Denmark but only 58kg in Finland and 15kg in Latvia – a variation of a factor 17. Labour productivity has been increasing rapidly in all countries. The speed of growth over the 1995-2010 period in the four old EU member states varies from 3.7% for Germany to 7.9% for Finland, However, those differences in growth rates for this group of countries are not enough to significantly change competitive positions: Denmark is the clear leader throughout the period, Sweden and Germany have rather similar levels of productivity, while Finland lags behind.

Turning to the situation of the new entrants, Estonia stands out from its large growth rate of labour productivity (+13% annually), which is significantly larger than the Finnish rate over the 2004-2010 period, and the labour productivity gap between Finnish and Estonian farms has therefore decreased. By contrast, there is no evidence of the other three new entrants catching up in terms of labour productivity, with Polish farms displaying particularly low rates of growth of that indicator.

The productivity calculations were conducted as part of a project in which structural characteristics of the dairy supply chains were investigated. Altogether over 100 interviews were carried out among the actors and experts of the dairy chains in order to reveal the effects of structural and market development on competitiveness. This experience is utilised to discuss an interesting parallel between labour productivity and farm structure.

The positions and slopes of the labour productivity curves suggest a relation to the initial farm structure and the speed of concentration over time. Denmark's initial position was 44 cows per farm in 1995 while Sweden, Germany and Finland had 27, 25 and 12 respectively. The average farm size increased in Denmark at a fairly moderate pace until 2000, when the pace of milk farm structure development accelerated, following precisely the same pattern as observed in the labour productivity curve (Figure 1 and Figure 2).

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[3] http://sdw.ecb.europa.eu/browse.do?node=bbn3146

Table 1. **Partial productivity of dairy farms**

	Germany	Denmark	Sweden	Finland	Estonia	Latvia	Lithuania	Poland
	Yield							
	Level (kg of milk/dairy cow)							
1995	5538	6392	7630	6865				
2004	6747	7900	7955	8165	5653	4629	4476	4682
2010	7493	8537	8329	8592	7318	5450	5213	5056
	Annual Growth							
1995-2010	2,0 %	1,9 %	0,6 %	1,5 %				
2004-2010	1,8 %	1,3 %	0,8 %	0,9 %	4,4 %	2,8 %	2,6 %	1,3 %
	Labour requirements							
	Level (hours/dairy cow)							
1995	127	69	140	321				
2004	93	46	111	222	258	341	404	319
2010	83	33	85	148	163	264	340	290
	Annual Growth							
1995-2010	-2,8 %	-4,7 %	-3,3 %	-5,0 %				
2004-2010	-1,8 %	-5,3 %	-4,4 %	-6,5 %	-7,3 %	-4,2 %	-2,8 %	-1,6 %
	Labour Productivity							
	Level (kg of milk/hour)							
1995	44	92	55	21				
2004	73	170	72	37	22	14	11	15
2010	90	255	98	58	45	21	15	17
	Annual Growth							
1995-2010	5,0 %	7,0 %	4,0 %	6,9 %				
2004-2010	3,7 %	7,0 %	5,4 %	7,9 %	12,6 %	7,2 %	5,6 %	2,9 %

Average farm size development of Sweden and Germany also resemble the development of labour productivity of the two countries. Sweden set off with a slightly higher average farm size in 1995. The two countries' farm structure developed at a relatively similar rate in the first half of the 2000s the process finally accelerated in Sweden in the last five years leaving Germany slightly behind, again precisely the same pattern as observed in the case of labour productivity development.

Finland started with a much lower level average farm size and the farm structure has changed at a steady albeit rather modest rate throughout the entire period. It reached the 1995 level of Sweden by 2010 – almost exactly the same way it did in the case of labour productivity development.
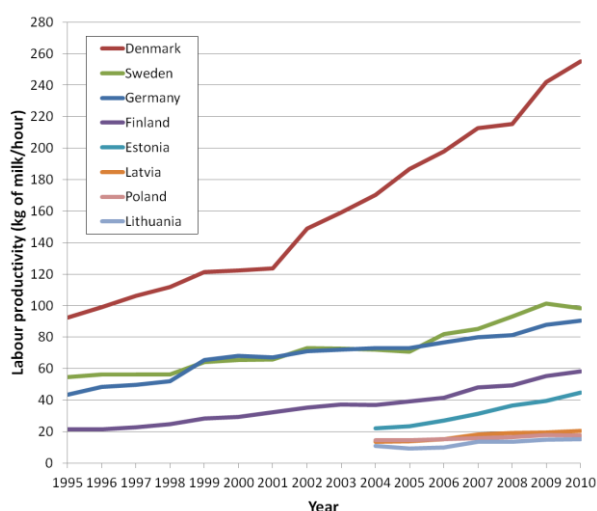

Figure 1. **Evolution of labour productivity in dairy farms**
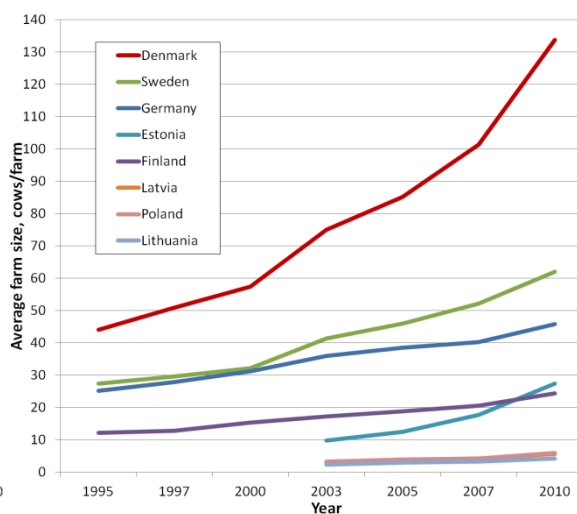

Figure 2. **Average farm size development (cows per farm)**

The similar evolution of milk farm structure and labour productivity is due to the close relation of farm size and the technical organisation of work in various typical dairy farm size categories.

In the case of new EU member states the initial positions in average farm size and the speed of farm structure changes also explain the different pace of labour productivity development. A similar parallel can be identified concerning the rankings of two indicators within the group of the new member states and in relation to the positions of the old member states.

Prior to their accession to the EU, in 2003, Estonia had over three times higher starting level of average farm size compared to Latvia, Poland and Lithuania. The pace of concentration has also been much sharper than in the other three countries, again an identical development to that of labour productivity. Apparently, the rapid farm concentration has been behind the fast catching up of Estonia's labour productivity towards the old member states, while a much slower concentration process seems to be responsible for the slower catching up of other countries.

There is, however, one exception to the numerous similarities between farm structure and labour productivity evolution. Estonia's 27 cows per farm already exceeded the average farm size of Finland of 24 cows in 2010. In terms of labour productivity Estonia's catching up is obvious but as of yet there has not been a flip in the ranking positions. This can be explained by the substantially different wage levels between the old and new member states. Salary differences between the two groups of countries may be three to fivefold. The inexpensive labour costs do not force large Estonian dairy farms to reduce their labour inputs radically. As the other side of the coin lower salaries impose a severe challenge on the Estonian dairy farms to find professional skilled labour force. Low wages often cause lack of motivation and non-efficient work.
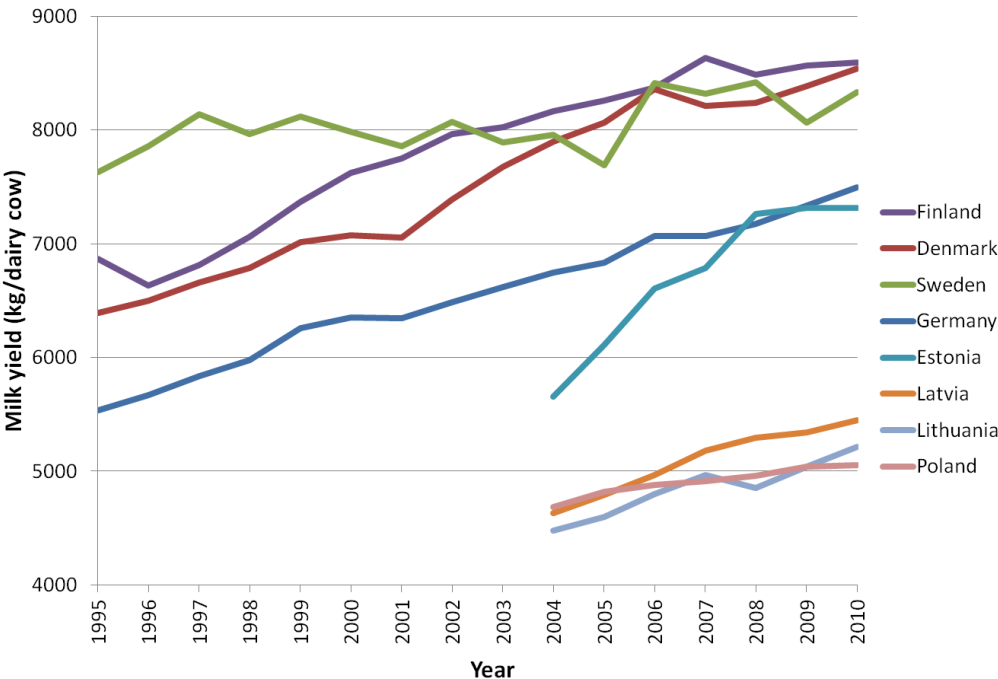

Figure 3.   Evolution of milk yields[4]

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[4] Note: Milk productivity trends are calculated on the basis of the FADN data set and may, therefore, deviate from the ones published by the national statistical institutes.

As discussed in the methodology section, labour productivity has two components, milk yields and labour requirements per dairy cow, which we now investigate. Figure 3 shows that there are important differences in yields across countries, but that three groups of countries can be defined at the end of the period:

- The yield leaders include Finland, Denmark and Sweden. For those countries, a dairy cow produces on average roughly 8500 kg of milk.
- Germany and Estonia form an intermediate group of countries, with yields around 7500kg per dairy cow.
- The "laggard" countries – Latvia, Lithuania and Poland – display yields around 5000kg per dairy cow.

Milk yields are clearly increasing over time (Figure 3 and Table 1) but the speed of the growth is limited, usually under 2% annually. The exception is Estonia, which managed to close its yield gap with Germany after joining the EU. From 1995 to 2010, the Finnish, Danish, and Swedish yields converged and the calculations suggest that growth in yields beyond 8000kg is becoming increasingly difficult. In particular, one notes that yields have not increased much among the yield leaders over the last four years of the study, and Table 1 also shows that for all four old EU member states but Sweden, growth in yields over the period 2004-2010 was significantly less than over the period 1995-2010. Hence, one can postulate that the biological innovations supporting yield growth, such as better genetics and improved feeding, are reaching a phase of marginal decreasing returns. This means in particular that improving performance on Finnish dairy farms through yield increases is becoming more and more difficult. On the other hand, as exemplified by the Estonian experience, Latvia, Lithuania and Poland probably have the potential to raise their productivity considerably through the achievement of higher yields.

Labour productivity is also dependent on labour requirements, measured by the number of hours of labour per dairy cow in Figure 4 and Table 1. The results indicate that this component is much more important than yields in explaining differences in levels and growth of labour productivity. For instance, in year 2010 a Lithuanian dairy cow required on average ten times more labour than a Danish cow, and it is clearly in that dimension that Finnish farms are performing poorly compared to their competitors, with a requirement of 148 hours per dairy cow in 2010. This is more than four times the corresponding figure for Danish cows, and nearly twice the labour requirements for German and Swedish cows. It is also worth noting that Estonia is also catching up with Finland in that dimension.

Changes in the structure of milk farms have direct impacts on both components of labour productivity and this is what ultimately explains the peculiar similarities between the evolution of average farm size and labour productivity. As a general rule larger family farms tend to pay more attention to milk output per cow than smaller ones. It especially applies in the new member states to the expansion of tiny farms with few cows to more market oriented production units with 10 to 60 cows.

The quick catch up of Estonian milk farms' labour productivity to the German level is also attributable to the special patterns of Estonia's dual milk farm structure and its concentration. Estonia has a few thousands of "small" herds with less than 10 cows, but over three fourth of the dairy cows are held in large herds of over 100 head. Most of the large herds feature extremely high labour productivity by international standards. Concentration is quick because the rapid exit rate of small farms, which results in the much higher weight of large farms. Consequently, labour productivity improves very fast.

Average farm size affects the labour requirement per cow through the special features of the organisation and utilisation of work at dairy farms. Up to 60-100 cows dairy farms can in principle be operated with the bare utilisation of labour input from the owner-farmer and his family members. Dairy farms include a lot of fixed work phases regardless of the number of

animals such as general management of the farm, maintenance of fixed assets and servicing of the equipment. Even feeding and milking involve phases such as cleaning of the milking equipment or transport of feeds on the farm, which require the same amount of work for 20 or 50 cows. The bigger the herd, the less work is needed per unit of output, because the marginal use of labour is sharply decreasing for an additional milk cow.

In the farm size categories of over 80 cows technological development and the replacement of labour with capital have driven labour productivity growth to entirely new levels. One milking robot usually serves a 70-head herd, but single robot is rarely installed on expanding farms. Milking robots have determined the stages of farm expansion into discrete 70, 140, 210 etc units. If robots are to be used, most usually two or several of them are installed in expanding farms, which radically decreases the amount of labour needed for one cow. Similarly feeding, cleaning and manure removal have been automated to a great extent in the new investments of over 150 cows. These technological aspects explain the sharp labour productivity development in Denmark, where the average farm size jumped from 50 to over 130 cows in just about ten years.

Expanding farms achieve higher labour productivity in all countries due to higher use of capital and better organisation of work. The technology installed in the expanding farms of Germany, Sweden and Finland is the same as in Denmark. Nevertheless, it is the intensity of new investments and the number of expanding farms that determine the pace of farm structure concentration and concurrently the pace of labour development growth. This explains the different patterns of labour productivity growth across the countries.

Farm structure development has been relatively easy to forecast, because the tendency is rather steady – unless a sharp turning point occurs for some reason, which was the case in the mid 2000s in Denmark. Given the strong relation between the two indicators, labour productivity growth can also be forecast with fairly high accuracy.
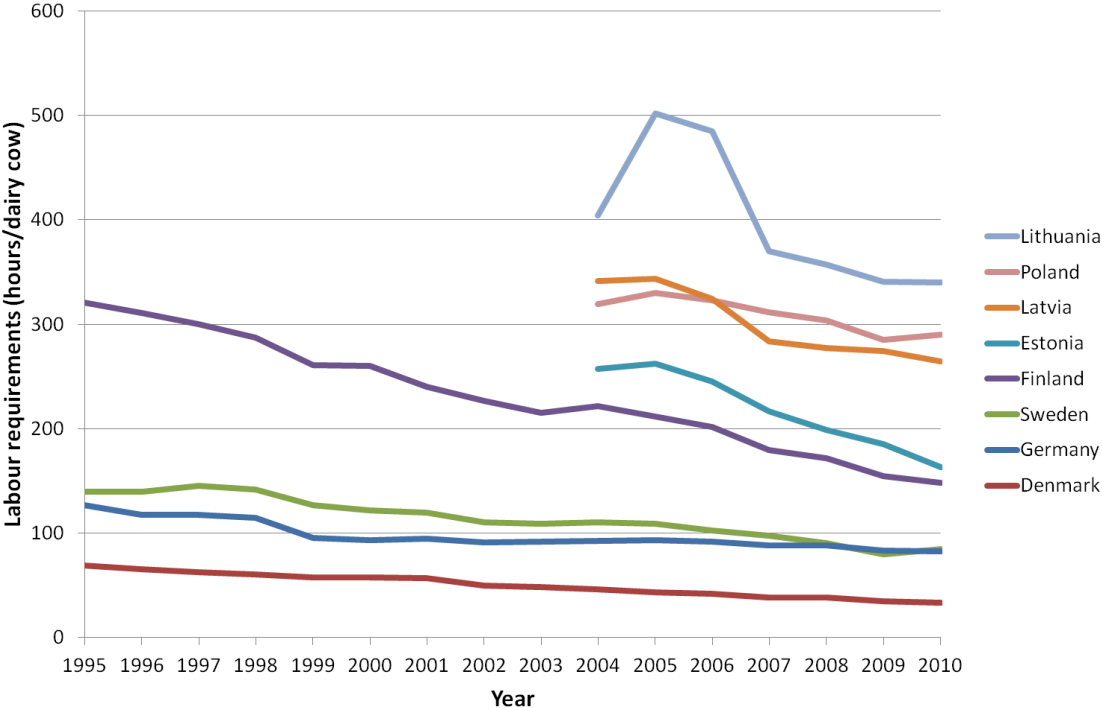

Figure 4. **Evolution of labour requirements per dairy cow**

Expectations concerning the milk farm structure changes suggest that Estonia will overtake Finland in the next few years and will approach Germany and Sweden within 10 to 15 years. Labour productivity of the Polish, Latvian and Lithuanian dairy sectors will continue to rise very slowly, in fact the gap between them and the old member states will most probably widen in the next one or two decades due to the heavy weight of small farms and their relatively slow quitting rates. Concurrently, the quitting rates in the old member states, especially in Sweden and Finland is expected to speed up in the coming years – partly for policy reasons. In Finland, e.g. the age limit of a quitting farmer is planned to be extended from 56 to 59 years and the quitting subsidy eventually phased out. As a result, labour productivity in Finland and Sweden is supposed to set off to a sharper growth than in Germany. However, in exchange for the faster labour productivity growth the quitting wave will also imply a further decline in milk production volumes which the German milk farm sector will not suffer from. Due to an almost complete halt in farm investments in the Danish milk farm sector over the past three years, the labour productivity curve will flat out close to its current level.

4.2. Total Factor productivity

Concerning the TFP growth analysis, we start with a growth accounting exercise focusing on the old EU member states. Figure 5 demonstrates graphically that in all four countries productivity of dairy farms has increased significantly from 1995 to 2010, with the total increase ranging from 43% for Germany and Sweden to almost 60% for Finland. Although, overall, Finland displays the largest rise in TFP, differences among the four countries are small and vary from year to year, so that not too much should be read from the final ranking. In particular, we note that the increase in productivity in Finland has been very comparable to that in Denmark, and that in the last two years of the study period (from 2008 to 2010) Finland moved from third to first in terms of overall increase in TFP. Thus, TFP growth has been roughly comparable in the four countries considered here. Although dairy farms in Sweden and Denmark have experienced a sharp decrease in TFP in year 2010, the analysis suggests that this is only a temporary phenomenon. However, only the addition of more recent data will permit to check the validity of that conjecture.
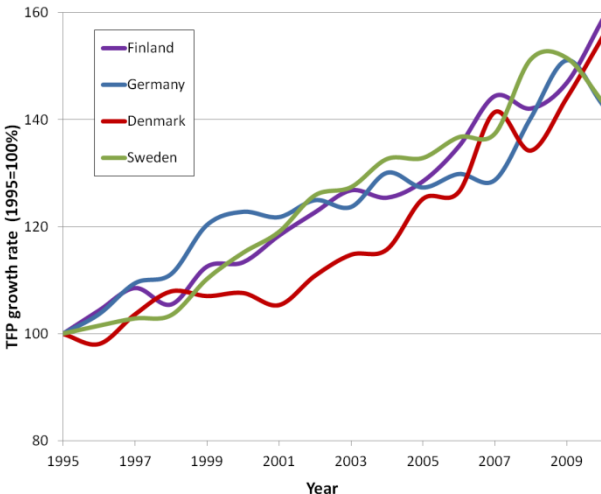

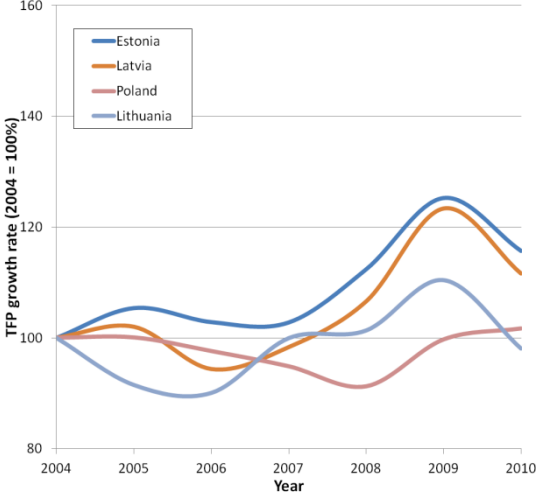**Figure 5.   TFP growth in Finland, Sweden, Germany and Denmark (1995-2010)**

Figure 6.   TFP growth in Estonia, Latvia, Lithuania and Poland (2004-2010)

Table 2 provides the full growth accounting results, from which it is clear that productivity growth in the four countries, although of a similar magnitude, has been achieved through different channels. Output per farm has expanded in all four countries, but the annual growth rate for Denmark (10.4%) stands out as particularly high (the corresponding rate for Finland is only 6.4%). We also note that growth in milk production in Finland accounts for a much larger share of total output growth than in the other countries (87% versus 64% for Sweden for instance). Thus, dairy farms in Finland are becoming relatively more specialised than those in the other three countries.

The input side section of Table 2 reveals that a large share of the growth in output has been achieved by increasing the quantities of production factors, at an annual rate varying from 3.1% for Germany to 7.2% for Denmark. The countries with the highest output growth rates are also those with the highest input growth rates and there is therefore no "miracle growth". In all countries, other inputs are substituted for labour, but the relative contributions of feeds and capital to input growth vary. For instance, the contribution of capital investments to input growth is much larger in Finland than in Sweden, where the increase in feeds has played a quantitatively larger role. Denmark stands out by the importance of capital to input growth, which reflects the high level of investment by Danish dairy farms over the last two decades.

Table 2.   Growth accounting and TFP growth for milk farms, 1995-2010

Country	Annual output growth (%)				Annual Input growth (%)					TFP growth (%)
	TOTAL	Milk	Crop	Livestock	**TOTAL**	Feeds	Capital	Labour	Other	
1995-2010										
Germany	**5,6**	4,4	0,8	0,4	**3,1**	1,0	1,1	0,2	0,7	**2,4**
Sweden	**7,4**	4,8	1,9	0,6	**4,9**	2,2	1,3	0,9	0,4	**2,4**
Denmark	**10,4**	7,3	2,4	0,5	**7,2**	2,9	3,1	0,5	0,4	**3,0**
Finland	**6,4**	5,6	0,5	0,3	**3,2**	1,1	1,8	-0,1	0,3	**3,1**
2004-2010										
Germany	**5,7**	4,0	1,2	0,4	**4,0**	1,6	0,8	0,5	1,1	**1,6**
Denmark	**13,7**	7,1	5,5	0,6	**7,9**	5,1	1,7	0,5	0,5	**5,8**
Sweden	**4,5**	4,4	0,0	0,1	**3,2**	1,4	1,1	0,5	0,2	**1,3**
Finland	**6,7**	5,9	0,6	0,1	**2,6**	1,1	1,3	-0,4	0,5	**4,1**
Estonia	**6,1**	4,5	1,2	0,4	**3,6**	2,7	1,6	-1,1	0,4	**2,5**
Latvia	**0,8**	2,6	-1,4	-0,4	**-1,0**	0,1	0,3	-0,8	-0,6	**1,8**
Lithuania	**7,3**	4,1	1,7	1,4	**7,7**	1,0	5,9	0,5	0,1	**-0,3**
Poland	**3,8**	2,5	0,3	1,0	**3,5**	1,1	1,8	0,2	0,4	**0,3**

We now present the results of the growth accounting exercise for the four new entrants over the period 2004-2010. The evolution of the TFP index presented graphically in Figure 6, which indicates that the situation for those countries is not very stable, with important year-to-year variations in the productivity of dairy farms. The shock of entry into the EU was followed by a decline in productivity, which stopped between 2006 and 2008, followed by some productivity growth, but TFP actually decreased again in three countries in year 2010. The frustratingly short time series make it difficult to infer long-term trends.

Table 2 also presents the full growth accounting results for all eight countries from 2004 to 2010. Over that period, Finland had the second highest TFP growth rate, with farm productivity growing faster only in Denmark. These TFP growth rates were significantly larger than in the four newer EU members, and there is therefore no evidence that those countries are catching up in terms of TFP, as could have been thought at least for Estonia by focusing on partial productivity indicators.

5. Conclusions

Dairy farms in the new EU members of the Baltic Sea region have lower levels of labour productivity than farms in the old EU member sates, but Estonian farms outperform Latvian, Lithuanian, and Polish farms by a large margin on the basis of that indicator. Indeed, productivity of labour on Estonian farms is now only 20% less than productivity of labour on Finnish farms. Cross-country differences in farm labour productivity are driven primarily by differences in labour requirements per cow, while differences in milk yields account for a much smaller share of the difference. This suggests that the key to high labour productivity in dairy is the farm structure and the adoption of mechanical innovations, while differences in adoption of biological innovations (e.g., genetic improvement, feeds) are relatively less important. This is reinforced by the finding that yield growth has been relatively slow in the old EU members and appears to become increasingly difficult.

Concerning the old member states, Finland has matched Denmark and outperformed Germany and Sweden in terms of both labour productivity growth and TFP growth over the entire 1995-2010 period. It is worth noting that although the TFP index is normalized at 100 in the first year of the study for all countries, this does not mean that productivity levels were equal across countries at the time. Indeed, Sipiläinen et al. (2008) showed that, in year 2003, Finnish dairy farms lagged both their Swedish and Danish equivalents by a significant margin. Eventually differences in rates of growth were small and the competitive positions of those four countries have not changed dramatically over the 15 years of the study period.

TFP growth has been faster in the old member states, particularly in the Finnish and Danish farms than on farms of the new EU members over the 2004-2010 period. Hence, the high rates of growth in labour productivity calculated for Estonian and, to a lesser extent, Latvian farms, have been driven more by substitutions of other inputs for labour rather than real efficiency gains. Productivity of Polish and Lithuanian dairy farms has yet to really take off. Hence, at farm level, TFP in the new EU countries is not converging to its level in the old EU members. Transferring technologies from the productivity leaders to the productivity laggards appears difficult in the primary sector, maybe due to the relatively small size of firms and importance of country-specific agro-ecological conditions.

An opposite tendency was found for the TFP growth in the dairy industries, although those findings are not subject of the current study. A growth accounting exercise establishes that cross-country convergence is occurring in terms of TFP in dairy processing – the new EU members, primarily Poland and Lithuania are catching up the old EU members in terms of productivity of their dairy manufacturing sectors. These findings suggest that the transfer of technologies and management techniques is easier in the industrial sector where company size and industrial concentration is considerably larger than in the farm sector.

Besides productivity development, the competitiveness of the dairy supply chain is determined by a number of factors, the farm and industry structure within the chain, the transactions among actors in the chain, growth on the domestic and export markets and innovation. One of the key factors to determine future competitiveness of a country's dairy chain is the growth potential of milk production. In the past milk production has increased in most of the countries except for Sweden and Finland. Sufficient raw material supply is a basic condition for dairy processors' growth, which will ultimately contribute to the competitiveness of national dairy supply chains.

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