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Are high labour costs destroying the competitiveness of Danish dairy farmers?

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Are high labour costs destroying the competitiveness of Danish dairy farmers? Evidence from an international benchmarking analysis

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Abstract

This paper analysis the competitiveness of Danish dairy farmers relative to dairy farmers in other Northern European countries. We use individual farm accounts data from the European Commission's Farm Accountancy Data Network (FADN) and have an average of 1665 observations per year in the period from 2002 to 2008. In all years, the hourly pay for labour is highest in Denmark and the difference is increasing, especially in 2007 and 2008. We apply Data Envelopment Analysis in a new way to capture the effect on the competitiveness from these differences in labour costs.

We compare the distributions of efficiency scores in different countries to assess their relative competitiveness. To analyze the effect of labour costs we apply two different DEA models; one including the labour input as hours worked and the other including labour costs. This way we capture the effect of labour costs on the differences in average efficiencies between countries.

The results shows that the Danish dairy farmers, on average, were the most economically efficient in Northern Europe in 2007 and 2008. We find that the effect of labour costs for the Danish dairy farmers is decreasing during the study period despite of the salary differences increasing. In 2002 the negative impact of having the highest hourly pay was an average 4.7 percentage points whereas it in 2008 was only 0.6 percentage points.This indicates that the Danish dairy farmers have been highly successful in adapting to having the highest, and increasing, hourly labour costs in Northern Europe.

Keywords: International benchmarking, Data Envelopment Analysis, Agriculture, FADN data.

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1 Introduction

The concept of competitiveness does not have a generally accepted definition in the economic literature, cf. e.g. Sharples (1990) og Ahearn et al. (1990). According to OECD (1994) competitiveness can be understood as "(...) the ability of companies, industries, regions, nations or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis"(p. 4).

Competitiveness depends on multiple factors of which some are controllable by the individual companies, whereas others are not. Amongst the latter are factors such as regulatory conditions and factor prices of which the salary levels are of specific interest to this paper. The paper considers (part of the) results from a large international benchmarking analysis of the primary agricultural production in Europe with particular focus on the danish agricultural sector. The analysis utilizes a large data set from the Farm Accountancy Data Network (FADN) and applies Data Envelopment Analysis (DEA) as the basic analytical method. DEA is well established for analysis of relative performance, also in agricultural production, and we here use standard DEA models to provide efficiency scores for a large representative sample of dairy farms from seven Northern European countries. By comparing the distributions of the efficiency scores for the different countries it is possible to determine which countries outperform others.

A novel approach in the present paper is to compare the results from different DEA models, mainly one that includes labour in terms of the number of hours worked and one including staff costs instead. By comparing the results from these two models we can determine the impact on the relative performance of the differences in the salary levels between the countries. Since the results from these comparisons show that Denmark's performance relative to the other countries is substantially better when labour hours rather than labour costs are considered, we are able to conclude that the high salary level in Denmark is, in fact, detrimental to the country's competitiveness wrt. its agricultural production.

The rest of this paper is structured as follows: A brief review of some of the relevant literature is presented in Section 2 and the DEA methodology is formally introduced in Section 3. The FADN data used in the analysis is described in Section 4 and the results are presented in Section 5. Finally Section 6 provides discussion and conclusions.

2 Literature

Data Envelopment Analysis (DEA) was first proposed by Charnes, Cooper and Rhodes (1978,79), and over the last 30 years there has been a steady stream of contributions extending both the theory of DEA efficiency analysis and the scope of applications. En comprehensive bibliography is Emrouznejad, Parker and Tavares (2008), covering the first 30 years of DEA and identifying more than 4000 published scientific articles and books. An up-to-date textbook is Bogetoft og Otto (2011). Other often applied textbooks are Coelli et al. (2005) and Cooper, Seiford and Tone (2000, 2006).

There is a long tradition of using DEA in the analysis of agricultural production. An early contribution is Fare, Grabowski and Grosskopf (1985) and the above mentioned bibliography covers approximately one hundred papers on DEA and agriculture. The agricultural sector is sometimes used primarily to illustrate a new method, but there is also a large number of papers that use more or less well-known DEA methods to gain insights in the agricultural sector per se. As a consequence of these different reasons for applying DEA in the agricultural sector, papers on DEA and agriculture are published both in general methodological journals like the Journal of Productivity Analysis and journals specifically focused on agriculture, like the European Review of Agricultural Economics and the American Journal of Agricultural Economics. Some recent examples of the latter are Andersen and Bogetoft (2007) and Bogetoft et al. (2007).

Most DEA studies focus on the relative efficiency of different farmers in a given country, while we are here concerned with the comparisons of farms in different countries. Amongst the few DEA based cross-country comparisons of agricultural productivity are Coelli and Rao (2005) and O'Donnell (2010) both of whom are mainly concerned with changes in total factor productivity over time. O'Donnell, Prasada Rao and Battese (2008) and Sipilainen, Kuosmanen and Kumbhakar (2008) more directly compare differences between agricultural productivity in different countries, using different methodologies, including DEA. While O'Donnell, Prasada Rao and Battese (2008) include Denmark in their analysis, they only provide country specific results for some of the larger countries in the different regions. Sipilainen, Kuosmanen and Kumbhakar (2008) uses FADN data from 2003 and specifically compare milk producers in Denmark, Sweden and Finland and find Denmark to be the most efficient - a finding we confirm and extend in this paper.

The use of DEA scores to compare the performance of different subgroups within a data set goes back to one of the very first applications of DEA by Charnes, Cooper and Rhodes (1981). This, as well as some subsequent developments like Camanho and Dyson (2006) and Battese, Rao and O'Donnell (2004), considers both group specific and pooled- or meta-frontiers whereby it is possible to distinguish between inter- and intra-group performance. Another strand of the literature, however, estimate the efficiencies for all observations relative to one common meta-frontier and typically compare the average efficiencies within each subgroups relative to this meta-frontier (see e.g. O'Donnell, Prasada Rao and Battese, 2008). Here we also consider only one common meta-frontier (for each year), but look at not just the average efficiencies but also the distributions of the efficiency scores in the groups, c.f. Section 3.2 below.

3 Methodology

3.1 Data Envelopment Analysis

To formally define the DEA methodology used in this study (Charnes, Cooper and Rhodes, 1978, 1979), consider the set of n observed farms across the seven Northern European countries within one of the years $2002, \ldots, 2008$. All the farms are using $k = 1, \ldots, r$ inputs to produce $l = 1, \ldots, s$ outputs, such that the input-output vector for farm i, $(x_i, y_i) \in \mathbf{R}_+^{r+s}$. Let x_i^k denote farm i's consumption of the k'th input and y_i^l its production of the l'th output.

The DEA input efficiency score under variable returns to scale (c.f. Banker, Charnes and Cooper, 1984) for farm i within the given year is estimated by

$$\begin{aligned} \theta_i^* = \quad & \min \theta_i \\ \text{s.t.} \quad & \sum_{j=1}^{n} \lambda_j x_j^k \leq \theta_i x_i^k, k = 1, \ldots, r \\ & \sum_{j=1}^{n} \lambda_j y_j^l \geq y_i^l, l = 1, \ldots, s \\ & \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0, j = 1, \ldots, n. \end{aligned} \tag{1}$$

Here, the $x_j^k, k = 1, \ldots, r$ are the r different inputs used and $y_j^l, l = 1, \ldots, s$ are the s different outputs produced by farm j. We see that the Farrell efficiency of farm i, θ_{i^*}, is the largest possible contraction of all inputs that allows farm i to maintain its present output levels.

For further details on the use of DEA, the reader is referred to the textbooks by e.g. Bogetoft og Otto (2011), Coelli et al. (2005) and Cooper, Seiford and Tone (2000, 2006).

3.2 Presentation and interpretation of results

In order to assess the impact of the differences in salary levels between Denmark and the other Northern European countries, we use a simple approach of comparing the results from two different DEA models: One where the labour input is quantified in terms of the total number of hours worked on the farm and the other where the models incorporate labour costs instead (including also the value of the work effort by the owner and his/her family). It can be argued that the first model implicitly assumes that the salary levels are the same across the farms in different countries, whereas the second one directly acknowledges the differences in salaries by incorporating both direct and indirect labour costs. Thus by comparing the results from these two models we are able to determine the impact of the differences in salary levels on the efficiencies, which in turn indicate the competitiveness.

In the DEA model defined above, best practice is determined by the efficient farms across all the Northern European countries, such that the efficiency scores for all farms in a given year are measured relative to the same efficient frontier. When comparing the overall performance of two countries, here specifically Denmark vs. each of the other Northern European countries in turn, we plot the cumulative distributions of the efficiency scores for each of the two countries. These plots provide a simple way of visualizing the whole distribution of the efficiency scores, rather than considering e.g. just the average efficiencies. If the cumulative distribution for one country consistently lies above the distribution for another, as is the case in Figure 4 below where the cumulative distribution of efficiency scores for Denmark is above that for Germany for all percentiles, this can be viewed as a form of first-order stochastic dominance (c.f. Lehmann, 1955, Karlin, 1960, Hadar and Russell, 1969). This means that the cumulative efficiency score for one of the countries (here Denmark) is at least as high as that of the other country (here Germany), regardless of what percentage of the observations from the two countries is considered, such that Denmark first order stochastically dominates Germany.

If the curves for the cumulative distributions of efficiency scores for the two countries intersect, as in Figure 3, it is no longer possible to use the concept of first order stochastic dominance to determine whether one country outperforms the other. Instead we can consider the area between the two curves for the cumulative distributions. These areas are related to the concept of second order stochastic dominance (c.f. Mas-Colell, Whinston and Green, 1995) and, generally, the bigger the area between the two cumulative distributions where one dominate the other, the better one country is relative to another. But whereas it is straightforward to determine whether or not one country first order stochastically dominates another, it is less obvious how to interpret the absolute size of the area between the two cumulative distributions, which is a topic we leave for future research. So rather than actually calculating these areas we here only use visual inspection of the relevant plots, like those in Figure 3 and Figure 4 where it, without further computations, is clear that the areas between the cumulative distributions are in favor of Denmark, such that Denmark appears to second order stochastically dominate Germany in both models.

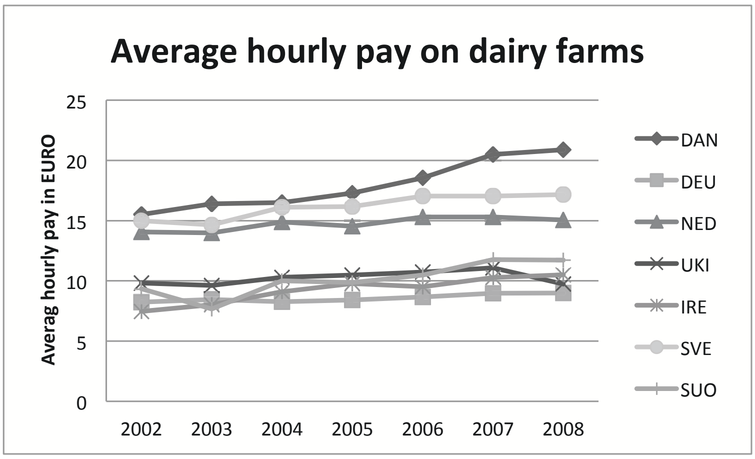

Figure 1: Average hourly pay on dairy farms in different countries, 2002-2008.

4 Data

The data used in the analysis comes from the Farm Accountancy Data Network (FADN) and access was granted as part of a consultancy project for the Danish Ministry of Food, Agriculture and Fisheries. The FADN accounting network, and its underlying data systems, aims at constructing comparable, representative and reliable farm accounting data from the EU agricultural sector. The data has primarily been used for evaluation of the Common Agricultural Policy (CAP) and for analyzing adjustments in the price support levels, but is also used by academics and policy makers e.g. for conducting farm performance studies as in this paper. Assessing the quality of the FADN data is an ongoing research topic, see e.g. FACEPA (2008).

The data used here consist primarily of income and cost figures, for the years 2002-2008, from dairy farms located in seven Northern European countries[1].

First consider the hourly pay 2002-2008 in the countries in the study shown in Figure 1. The average hourly pay is computed from the FADN data as the total wages paid divided by the number of paid labour hours for the dairy farms.

The DEA model considered in the present study includes the input- and output variables shown in Figure 2 below.

[1] This is but a small subsample of the data provided by FADN which consists of approximately 700000 observations from 18 EU countries in the period 1998 to 2008 with some 1300 variables per observation

Figure 2: Variables in the DEA models: Labour included as either labour costs or hours worked

The variables are defined as:

- Labour:
  - Labour hours: Time worked in hours by total labour input on holding (including owner).
  - Labour costs: Wages and social security charges (and insurance) of wage earners plus an estimated cost of the owner's work effort (number of hours worked times the average salary of the paid workers on the holding). Amounts received by workers considered as unpaid workers (wages lower than a normal wage) are excluded.
- Feed costs: Concentrated feedingstuffs (including mineral licks and preservatives), coarse fodder, expenditure on the use of common grazing land, expenditure on agistment, cost of renting forage land not included in the UAA for equines, cattle, sheep and goats.
- Buildings & machinery costs: Costs of current upkeep of equipment (and purchase of minor equipment), car expenses, current upkeep of buildings and land improvements, insurance of buildings. Major repairs are considered as investments.
- Energy costs: Motor fuels and lubricants, electricity, heating fuels.
- Other costs: Veterinary fees and reproduction costs, milk tests, occasional purchases of animal products (milk, etc.), costs incurred in the market preparation, storage, marketing of livestock products, etc.
- Mortgage costs: Estimated as 4 % of the total fixed assets (value of agricultural land and farm buildings and forest capital + buildings + machinery and equipment + breeding livestock).
- Total value milk: Total value of milk produced. The values are recorded after deduction of the amount of the co-responsibility levy (if any) but before deduction of the amount of the super levy (if any).

Table 1: Number of observations in each country for each year.

	2002	2003	2004	2005	2006	2007	2008
Denmark	341	322	378	322	325	342	424
Germany	441	471	456	458	523	543	622
Holland	138	155	129	118	126	152	157
UK	402	484	410	412	405	407	409
Ireland	161	162	149	145	147	154	1541
Sweden	54	59	50	61	70	84	96
Finland	14	12	17	31	41	52	68
Total	1551	1665	1589	1547	1637	1734	1930

- Total value beef: Total value of beef production + net change in valuation.
- Total value crops: Includes total sale and on-farm use of crops and crop products + net change in valuation.

In Table 1 is shown the number of observations from each country and each year considered in the analysis. The observations are dairy farms with more than 50 dairy cows from the seven Northern European countries considered in this study. By the principles of the FADN accounting framework, the farms included in the study can be considered a random subset of dairy farms from each country. The last row in Table 1 shows the total number of observations in each year, which is used in the estimations of the pooled (annual) frontiers. Thus with over 1500 observations for each estimation, which has to be viewed relative to the dimensionality of the problem (6 inputs and 3 outputs), the size of this data set enables an excellent estimation of the production possibilities and resulting DEA scores.

5 Results

This section presents the results from the analysis of the Danish dairy farms' performance relative to those in the other Northern Europe countries, during the study period of 2002-2008.

5.1 Cumulative distributions of efficiency scores

In this subsection we present selected results of the core elements of the analysis, which are the cumulative distributions of the input efficiency scores. For each of the two DEA models we have, for each of the seven years under analysis, produced six different cumulative distributions for pairwise comparisons of Denmark and each of the other Northern European countries in turn. Thus there is a total of 84 pairwise comparisons of cumulative distributions of efficiency scores. Therefore, we in this section only present (part of) the results for the comparison of Denmark and Germany, specifically the distributions from the

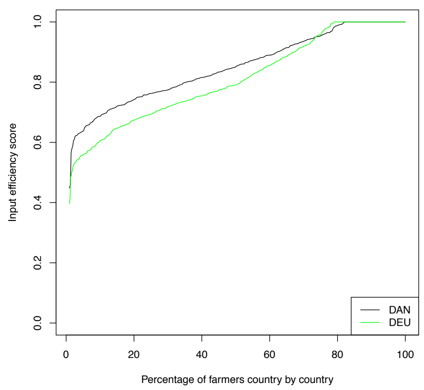

Figure 3: Cumulative distributions for Denmark and Germany, 2008: Labour as costs

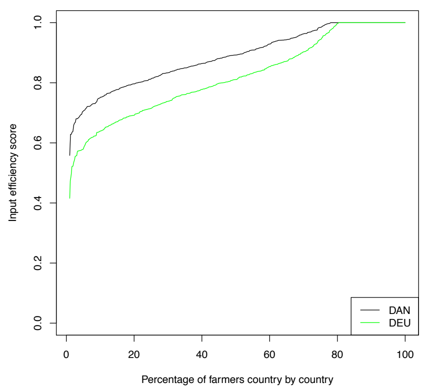

Figure 4: Cumulative distributions for Denmark and Germany, 2008: Labour in hours

last year in the analysis, 2008.

The cumulative distributions of efficiency scores from 2008 for Denmark are compared to those for Germany in Figure 3 and Figure 4, where the labour input is included as costs and as hours respectively. Both figures include scores from 424 Danish and 622 German dairy farmers which have all been estimated relative to best practice defined by the 1930 dairy farmers across all of the seven Northern European countries in 2008.

In Figure 3 we see that the cumulative distributions intersect, so there is no first order stochastic dominance between Denmark and Germany in this model. Although a higher percentage of the German farmers are 100% efficient, the Danish dairy farmers perform better than the German for the most part. This is also evident from the area between the two curves, where the curve for the cumulative distribution for Denmark for most parts lies clearly above that for Germany, which could indicate that Denmark second order stochastically dominates Germany. In fact the Danish farmers are on average 4% more input efficient than their German counterparts.

In Figure 4 we have a more unambiguous result where the two cumulative distributions do not intersect. Therefore, it is clear that Denmark is performing better than Germany and this may be considered a situation where Denmark first order stochastically dominates Germany. On average the Danish farmers have 6.7% higher input efficiency than the German farmers in this model.

Finally, by comparing Figure 3 and Figure 4 we can see that the Danish farmers are performing relatively worse compared to Germany when labour costs rather than labour hours are included. Besides the fact that there is only first order stochastic dominance in the model with labour hours (c.f. Figure 4), for all percentiles (all values on the horizontal axis) the distance between the cumulative distribution for Denmark and that for Germany is smaller in the model with labour costs than in that with labour hours. Thus, while Denmark quite clearly outperforms Germany in the model with labour hours, the difference is smaller and the conclusion perhaps less clear in the model with labour costs. Finally, the difference in average efficiency between Denmark and Germany is 4% in the model with labour costs as opposed to 6.7% in the model with labour hours. The difference of 2.7% between these two values, is the impact of including labour costs rather than labour hours in the models and can be viewed as a measure of the indirect cost of having a higher hourly pay in Denmark than in Germany in 2008 (c.f. also Figure 1).

In the following we report only the differences in average input efficiency for the different pairwise comparisons with the Danish dairy farmers.

5.2 Average efficiency scores

In this subsection we look at the average input efficiency scores for each of the countries in each of the seven years (2002-2008) considered in this study. The differences between the average scores for Denmark and those for each of the other Northern European countries in each year are presented in Figure 5 and Figure 6 below, where the former includes the labour input as costs and the latter includes labour as hours. The figures show the differences between the average scores for Denmark and those for each of the other countries, such that a value above zero means that Denmark has a higher average efficiency score than the country it is being compared to. Note that the two averages from the cumulative distributions shown in Figure 3 provides one data point in Figure 5 below, specifically the value of the difference between the average efficiency scores in Denmark and Germany in 2008 of 4%. Similarly for the model with labour included as hours, the detailed information presented in Figure 4 is condensed into one single point in Figure 6, namely a 6.7 % difference between the average efficiency scores for Denmark and Germany in 2008.

Note while the observations from Finland are included in the actual analysis, they are not shown in Figure 5 and Figure 6 below, since their differences to Denmark are so much higher (with Finland being clearly dominated) than those for the other countries that they distort the illustration. This could partly be due to the small sample size for Finland, c.f. Table 1, which creates more uncertainty on the average scores for Finland.

In Figure 5 we see that the differences for all countries are above zero in both 2007 and 2008, which shows that Denmark had the most efficient dairy farmers in Northern Europe in those years, even in the model considering labour costs. This also has to be viewed relative to the fact that the hourly pay on the farms in Denmark not only were higher than that in all the other countries, but with

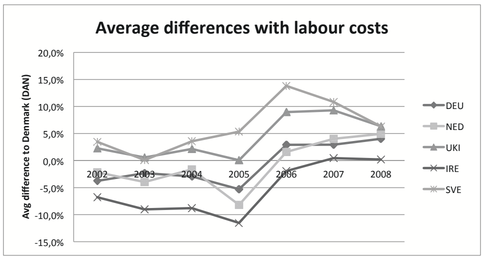

Figure 5: Average difference to Denmark: Labour as costs

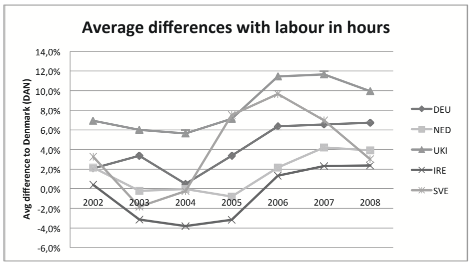

Figure 6: Average difference to Denmark: Labour in hours

the difference in pay levels also increasing in 2007 and 2008, as is evident from Figure 1. For the years up till 2006, Holland, Germany and in particular Ireland performed better than Denmark, which can be seen from the values below zero in Figure 5. It appears that Denmark has become relatively more efficient than Ireland, Germany and Holland over time, whereas Sweden and UK have been catching up relative to Denmark in 2007 and 2008. Also it seems like all countries, apart from Ireland, in 2008 had reached a similar average efficiency level which was 5% less than Denmark's.

Figure 6 shows the differences between the average efficiency scores in Denmark and in each of the other countries, based on the model where labour is included as the number of hours worked. This corresponds to an implicit assumption of the farmers in all countries facing the same hourly pay. In this figure only Ireland and Sweden between 2003 and 2005 have negative values, which reflects situations where those countries have a higher average efficiency score than Denmark. Otherwise the differences between Denmark and the other countries are positive, indicating higher average efficiencies in Denmark, possibly a tendency of increasing values over time, and absolute levels of the differences in 2008 between 2% and 10% (in favor of Denmark).

Altogether we have that the Danish dairy farmers have become relatively more competitive during the period from 2002 to 2008, compared to their Northern European counterparts. In spite of having the highest and relatively increasing hourly salary levels (c.f. Figure 1), the Danish dairy farmers are, on average, the most efficient in 2007 and 2008, even in the model explicitly incorporating the salary levels by including labour costs. And the relative superiority of Denmark is even higher in the model including labour as hours worked, thus implicitly assuming similar salary levels across the countries. So while the relative performance of Denmark suffers due to the high salary levels, as seen from the difference between the results in Figure 3 and Figure 4 (specifically comparing against Germany in 2008) and again between Figure 5 and Figure 6 (more generally), the Danish dairy farmers still come out as the top performers in Northern Europe.

As presented above, comparing Figure 5 and Figure 6 reveals that Denmark is relatively more efficient in the latter with labour in hours. In the next subsection we look deeper into the impact of the higher salary levels in Denmark through further comparisons of the results from the two models.

5.3 Comparisons of differences between average efficiency scores in the two models

This subsection considers the impact on the average efficiencies arising from the differences in labour costs, that is the difference between the results from the two (sets of) models including the labour input as costs and in hours respectively. Table 2 shows the differences between the results presented in Figure 5 and in Figure 6, which is the differences between the models between the differences in the average efficiency scores for Denmark and each of the other countries in each of the years. That is, each value in Table 2, for example the 2.7 for Germany in 2008 is calculated by subtracting the difference between the average efficiency score in Denmark and the average score in Germany in 2008 in the model with labour as costs (which Figure 5 showed to be 4%) from the difference between the average efficiency score in Denmark and the average score in Germany in 2008 in the model with labour as hours (which Figure 6 showed to be 6.7%). These 2.7 percentage points is an indirect measure of the cost, in terms of efficiency, from having significant higher hourly payments. A fairly similar result is present for UK and Ireland in 2008, with 3.6 and 2.2 percentage points respectively. Since the average hourly payment in 2008 was 20.9 EURO in Denmark and respectively 9, 9.7 and 10.5 EURO in Germany, UK and Ireland, we conclude that Denmark has successfully adapted to the higher labour costs, since the impact of these costs have generally decreased during the study period to having a limited the effect on efficiency in 2008.

While it may be tempting to use simple t-tests to assess the significances of the differences in Table 2, it is worth noting that this would be theoretically incorrect since the efficiency scores underlying the averages and differences are neither normal distributed nor independent. We therefore use the non-parametric Kruskal-Wallis test (Kruskal and Wallis, 1952) for comparisons between countries of the mean of the rankings of efficiency differences between the models. The results in Table 2 are in brackets in the few cases where the Kruskal-Wallis test shows NO significant difference between Denmark and the country in question on a 5% significance level. The detailed test results are shown in Table 3 in the appendix.

Table 2 show the differences on the relative performance of the countries in the two different models or, in other words, the size and significance of the salary levels' impact on Denmark's performance relative to the other countries. The results show that the effect of relative increasing labour costs (see Figure 1) has become less important. In 2002 the cost of having the highest hourly

Table 2: The effect from salary in percentage points.

	2002	2003	2004	2005	2006	2007	2008	Avg
Germany	5.8	5.7	3.4	8.7	3.5	3.6	2.7	4.8
Holland	4.3	3.7	1.6	7.4	(0.6)	(0.2)	-1.0	2.4
UK	4.7	5.4	3.5	7.1	2.5	2.4	3.6	4.2
Ireland	7.2	5.9	5.0	8.4	3.3	1.9	2.2	4.8
Sweden	(-0.2)	(-1.9)	-3.8	2.2	-4.1	-3.9	-3.3	-2.2
Finland	6.6	7.2	4.8	8.4	3.3	1.9	(-0.8)	4.5
Avg	4.7	4.3	2.4	7.0	1.5	1.0	0.6	n/a

pay was 4.7 percentage points and in 2008 it was only 0.6 percentage points on average across the different countries. Sweden is the only country that is more burdened by labour costs than to Denmark.

6 Discussion and conclusion

In this paper we have analyzed the effect of the high and relatively more increasing labour costs on dairy farms in Denmark compared to six other North European countries.

The results show that the Danish dairy farmers have, on average, become the most economically efficient farmers in Northern Europe in 2007 and 2008. By implicitly assuming same hourly pay for all farmers we show that the effect of labour costs has become less important for the Danish dairy farmers during the analyzed period, which is in contrast to the increasing hourly pay. In 2002 the cost of having the highest hourly pay was, on average, 4.5 percentage points whereas it in 2008 was only 0.6 percentage points on average. Behind this general trend, the result shows large differences between countries and across time. The lost competitiveness from higher hourly pay is largest relative to Germany, UK and Ireland with more than 4 percentage points on average across time. Nevertheless, we conclude that the Danish dairy farmers has been highly successful in adapting to the highest and relatively more increasing hourly labour costs in Northern Europe.

There are many possible explanations for this successful adaption to higher labour costs, two of which may be simply higher prices for milk or successful investments in assets that substitute labour. We have, similarly to the consideration of salary levels, analyzed the impact of the different sales prices for milk and differences in the levels of capital investments, in order to provide some insights into these possible explanations.

The effect of differences in milk prices has been analyzed in the same way as the analysis of the effect of labour, with the two models considering milk as output in either quantities or monetary measures. The results are ambiguous wrt. both country differences and changes over time. As an example, in 2008 Denmark seemingly had an advantage of relatively higher payments for milk compared to Holland and Sweden, whereas the remaining countries on average seemed to have the advantage over Denmark from higher payments for milk. Thus there is no evidence that higher output prices are the reason for the relatively good performance of the Danish dairy farmers in the previous.

The effect of capital is analyzed by comparing DEA models with and without capital costs. This is a slightly different to the analysis of labour costs, since there is a different number of variables in the two models. Theoretically, the model with fewer variables will have higher efficiency scores, but the results show that the sizes of the increases in efficiency scores from omitting the capital variable divide the countries into two groups: Holland and Ireland with a negligible effect relative to Denmark from excluding capital and Germany, UK, Sweden and Finland with differences relative to Denmark of 3.9 to 6.4 % on average across 2002-2008 from excluding capital. Together with the overall economic efficiency, this may indicate that the Danish diary farmers have been successful in substituting away from the increasingly expensive labour through capital investments.

References

Ahearn, M., Culver, D. and Schoney, R. (1990), Usefulness and limitations of COP estimates for evaluating international competitiveness: a comparison of Canadian and U.S. wheat, American Journal of Agricultural Economics, 72 (5), pp. 1283-1291.

Andersen, J.L. and Bogetoft, B. (2007), Gains from quota trade: theoretical models and an application to the Danish fishery, European Review of Agricultural Economics, 34(1), pp. 105-127.

Banker, R.D., Charnes, A. and Cooper, W.W. (1984), Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, Management Science, 30, pp. 1078-1092.

Battese, G.E., Rao, D.S.P. and O'Donnell, C.J. (2004), A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies, Journal of Productivity Analysis, 21, pp. 91-103.

Bogetoft, P., Boye, K., Neergaard-Petersen, H. and Nielsen, K. (2007), Reallocating Sugar Beet Contracts: Can Sugar Production Survive in Denmark?, European Review of Agricultural Economics, 34(1), pp. 1-20.

Bogetoft, P. and Otto, L. (2011), Benchmarking with DEA, SFA, and R, Springer.

Camanho, A.S. and Dyson, R.G. (2006), Data envelopment analysis and Malmquist indices for measuring group performance, Journal of Productivity Analysis, 26, pp.35-49.

Charnes, A., Cooper, W.W. and Rhodes, E. (1981), Evaluating program and managerial efficiency: an application of data envelopment analysis to program followthrough, Management Science 27(6), pp. 668-697.

Charnes, A., Cooper, W.W. and Rhodes, E. (1979), Short Communication: Measuring the Efficiency of Decision Making Units, European Journal of Operational Research, 3(4), p. 339.

Charnes, A., Cooper, W.W. and Rhodes, E. (1978), Measuring the Efficiency of Decision Making Units, European Journal of Operational Research, 2, pp. 429-444.

Coelli, T.J. and Rao, D.S.P. (2005), Total factor productivity growth in agriculture: a Malmquist index analysis of 93 countries, 1980-2000, Agricultural Economics, 32 (s1): 115-134.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and Battese, G. (2005), An introduction to efficiency and productivity analysis, 2nd edition, Springer, New York.

Cooper, W.W., Seiford, L.M. and Tone, K. (2006), Introduction to Data Envelopment Analysis And Its Uses: With DEA-Solver Software And References, Birkhauser.

Cooper, W.W., Seiford, L.M. and Tone, K. (2000), Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References, and DEA-Solver Software, Springer.

Emrouznejad, A., Parker, B.R. and Tavares, G. (2008), Evaluation of research in efficiency and productivity: A survey and analysis of the first 30 years of scholarly literature in DEA, Socio-Economic Planning Sciences, 42, 151- 157.

FACEPA (2008), Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture (http://www2.ekon.slu.se/facepa/index.html)

Fare, R., Grabowski, R. and Grosskopf, S. (1985), Technical Efficiency of Philippine Agriculture, Applied Economics, 17 (2), pp. 205-214.

Hadar, J. and Russell, W.R. (1969), Rules for Ordering Uncertain Prospects, American Economic Review 59, pp. 25-34.

Karlin, S. (1960), Dynamic inventory policy with varying stochastic demands, Management Science, 6, pp. 231-258

Kruskal, W.H. and Wallis, W.A. (1952), Use of ranks in one-criterion variance analysis, Journal of the American Statistical Association 47(260), pp. 583-621.

Lehmann, E.L. (1955), Ordered families of distributions, Annals of Mathematical Statistics, 26, pp. 399-419.

Mas-Colell, A., Whinston, M.D. and Green, J.R. (1995), Microeconomic Theory, Oxford University Press.

O'Donnell, C.J. (2010), Measuring and decomposing agricultural productivity and profitability change, Australian Journal of Agricultural and Resource Economics, 54, pp. 527-560.

O'Donnell, C.J., Prasada Rao, D.S. and Battese, G.E. (2008), Metafrontier frameworks for the study of firm-level efficiencies and technology ratios, Empirical Economics (34), pp. 231-255.

OECD (1994), Framework Conditions for Industrial Competitiveness: the OECD Industry Committee Project, DSTI/IND (94).

Sharples, J. (1990), Cost of production and productivity in analyzing trade and competitiveness, American Journal of Agricultural Economics, 72 (5), pp. 1278-1282.

Sipilainen T., Kuosmanen T. and Kumbhakar S.C. (2008), Measuring productivity differentials - An application to milk production in Nordic countries, 12th Congress of the European Association of Agricultural Economics, (EAAE 2008).

Appendix: Kruskal-Wallis tests of the significances of the effects from salary

Table 3: Kruskal-Wallis test of significant effect from salary.

		2002	2003	2004	2005	2006	2007	2008
Germany	KW value	192.6	151.3	99.1	206.7	63.2	72.4	39.6
	p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Holland	KW value	41.4	43.9	18.2	74.9	0.89	0.29	6.01
	p value	0.000	0.000	0.000	0.000	0.345	0.592	0.014
UK	KW value	170.6	242.8	191.2	197.5	52.7	77.6	101.4
	p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ireland	KW value	179.1	137.6	151.4	158.4	48.3	31.1	20.6
	p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sweden	KW value	0.74	1.50	4.98	8.37	14.1	12.2	17.3
	p value	0.388	0.220	0.026	0.004	0.000	0.001	0.000
Finland	KW value	21.7	20.1	23.1	39.8	13.3	4.11	3.33
	p value	0.000	0.000	0.000	0.000	0.000	0.043	0.068