Productivity and performance of Finnish and Norwegian dairy farms: Does EU membership matter?

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Abstract

Norwegian and Finnish agriculture and agricultural policy have shared several common features in the past. Since 1995 these countries have followed different routes. Finland joined the European Union but Norway decided to stay out of it. Differences in the economic and institutional environment of agriculture may have affected the changes in profitability and productivity of farms directly and/or indirectly via changes in the behavior of farmers.

The objective of this paper is to examine whether the development in profitability and productivity are diverging or converging between Finnish and Norwegian farms since 1991 to 2008. The analysis is based on the decomposition of profitability change into its sources. The results show that technologies are different in the countries…

One of the main analytical challenges of this study is, whether it is possible to isolate the effect of the EU-membership from other influential factors. Are differences, if any, in technological and efficiency change between Finland and Norway really caused by the EU membership and related changes in agricultural policy, or are they caused by other factors like macro-economic conditions? The starting point of the analysis is to estimate the patterns of these profit and total factor productivity growth rates, to find possible differences first and when such differences emerge we search for possible sources for this divergence.)

Keywords: profit, total factor productivity growth, duality, input distance function, Finnish and Norwegian dairy farming.

Introduction (I moved some tex t from the abstract and added some part, look if they are useful or not?)

Norwegian and Finnish agriculture and agricultural policy have shared several common features in the past. Since 1995 these countries have followed different routes. Finland joined the European Union but Norway decided to stay out of it. Although Finland started to follow EU's common agricultural policy, national exceptions have also been allowed. Anyhow, the accession of Finland to EU followed an immediate decrease in product prices and an increase in direct payments. Norway has been able to create her own policy, which has reflections from the CAP and the WTO negotiations. These differences in the economic and institutional environment of agriculture may have affected productivity of farms directly and/or indirectly via changes in the behavior of farmers.

In general, the average farm size in agriculture has been small both in Finland and Norway. In addition to price changes at the time of EU accession, Finnish farmers got access to a relatively generous investment support program with direct investment subsidies and subsidized credits. The motivation has been to speed up the structural change and to improve the competitiveness of farming through increasing scale of production and productivity. The number of dairy farms has diminished rapidly in Finland: in late 1980s there were xx 000 dairy farms when the number in 2011 is close to 10 000. In Norway, the trends are similar:…. Simultaneously the remaining dairy farms have increased in size and specialization of their milk production. Despite, dairy farms are still fairly diversified since most of them produce at least their roughage on the fields in their possession. The field area is also needed for manure spreading.

The relatively small farm size and harsh natural conditions are not the only common features between Finnish and Norwegian dairy farming. In both countries, the milk quota system has been effective since mid 1980s. The binding of the quota system has been relieved in Finland since 1993 but the system still restricts production quantities.

The objective of this paper is to examine whether profitability and productivity have diverged or converged between Finnish and Norwegian farms during the last twenty years. One of the main factors causing possible differences is the Finnish EU accession in 1995. It required considerable strategic adjustments in behavior of Finnish farmers and in the whole food chain. It altered the preconditions of agri-food sector in ways that are expected to have a significant influence on the development of productivity and competitiveness but also farm level profitability. The extent and speed of this change together with long term farm level data provides a unique opportunity for such a comparison.

The paper present at first briefly the analytical framework of profit change which is based on the work of Kumbhakar and Lien (2009). This is followed by the description how the components of profit change can be derived from the IDF and .. In addition to the previous article, we introduce into our model both persistent and time-varying inefficiency suggested by Kumbhakar and Lien in 2011. Thereafter the Finnish and Norwegian data are presented. This section is followed by the results of decomposition and the discussion. The last section concludes.

The analytical framework

The performance and changes in performance is often measured only by physical measures such as partial or total factor productivity (TFP). Examples of TFP growth studies applying a multi-input multi-output technology are for example Brümmer et al. (2002), Karagiannis et al. (2004), Newman and Matthews (2006) and Sipiläinen (2007). If the goal is to maximize productivity then studying TFP is a suitable approach in the sense that the producer with the highest TFP growth will be viewed as the best. However, the objective of a producer is more often to maximize profit or to minimize cost. Increasing productivity coincides with the aim to increase profit or to reduce cost. However, the productivity maximizing point is not necessarily the same as the profit maximizing point.

In the literature several attempts have been made to identify the relationship between productivity change and profit change. For example, Miller and Rao (1989) decomposed profit change into three sources: a price effect, productivity effect, and activity effect. Grifell-Tatjé and Lovell (1999) developed an analytical framework in which profit change over time was first decomposed into price and quantity effects. The quantity effect was then decomposed into productivity and activity effects. The productivity effect was further subdivided into technical efficiency and technical change effects, while the activity effect was subdivided into scale, resource mix and product mix effects. Our study to a large extend follows the approach by Kumbhakar and Lien (2009), where the profitability change over time is measured as a change in profit with respect to total cost. This profitability change can be decomposed into several components:

$$\frac{1}{C}\frac{d\pi}{dt} \quad \dot{Y}_P\left(\frac{R}{C}-1\right)+\frac{\dot{P}R}{C}-\dot{W}+TC+\left[(1-RTS^{-1})\dot{Y}_C\right]+(\dot{Y}_P-\dot{Y}_C)-\frac{du}{dt} \qquad (1)$$

where π is profit, R is total revenue, C is total cost, $\dot{Y}_P$ is the rate of change in output, weighted on sale price values, $\dot{Y}_C$ is the rate of change in output, weighted on marginal production cost price values, $\dot{P}$ is the rate of change in output price, $\dot{W}$ is the input price change, TC is technical change, RTS is returns to scale, $\frac{du}{dt}$ is the technical inefficiency change, and t is time. With this specification the seven components in equation (1) can be interpreted as:

i. $\dot{Y}_P\left(\frac{R}{C}-1\right)$ is the output growth component

ii. $\frac{\dot{P}R}{C}$ is the output price change component

iii. $\dot{W}$ is the input price change component

iv. TC is the technical change component

v. $[(1-RTS^{-1})\dot{Y}_C]$ is the scale component

vi. $(\dot{Y}_P \quad \dot{Y}_C)$ is the mark-up component

vii. $\frac{du}{dt}$ is the technical inefficiency change component

The specification in equation (1) diverges from the approach by Kumbhakar and Lien (2009) in one way: the technical inefficiency change term has been added. If this inefficiency change term is time-invariant it will affect the decomposition results. Or more precisely, ignoring technical inefficiency change implies that the technical change component capture both technical change and technical inefficiency change, while in this study we decompose these two effects.

As pointed out by Kumbhakar and Lien (2009), the last four components (i-iv) in equation (1) are the typical TFP growth components. With other words, we can obtain TFP change from profitability change measures, but not vice versa.

Implementation

Computations of the output growth component (i), the output price change component (ii), and the input price change component (iii) in equation (1) can be done from observed data in the following way:

I. $(\dot{Y}_P)(R/C-1) = \Sigma_m [P_m Y_m]/((\Sigma_m [P_m Y_m])/(\Sigma_i [W_i X_i]) - 1) = \Sigma_m [0.5(P_1(m,t) + P_1(m,t-$

II. $\dot{P}(R/C) = \Sigma_m [P_m \dot{P}_m]/((\Sigma_m [P_m Y_m])/(\Sigma_i [W_i X_i])) = \Sigma_m [0.5(P_1(m,t) + P_1(m,t-1))0.5(Y_1(m,$

III. $$\dot{W} = \sum_i S_i \dot{W}_i = \sum_i \frac{0.5(W_{i,t} + W_{i,t-1})0.5(X_{i,t} + X_{i,t-1})}{\Sigma_j 0.5(W_{j,t} + W_{j,t-1})0.5(X_{j,t} + X_{j,t-1})} \frac{(W_{i,t} - W_{i,t-1})}{0.5(W_{i,t} + W_{i,t-1})}$$

where P_m is price of output m $(m = 1, \cdots, M)$, Y_m is quantity of output m, W_i is price of input i $(i = 1, \cdots, I)$, and X_i is quantity of input i. Note that the rate of change in variables is calculated with a Tornquist index approach, as is one way to averaging the change between two points of evaluation $(t \text{ and } t-1)$. To keep our analysis time-consistent for "static" variables we follow Nishimizu and Page (1982) by taking simple averages of the consecutive periods $t-1 \text{ and } t$. For example the revenue share above is defined as

$$\frac{R}{C} = \frac{\Sigma_m 0.5(P_{m,t} + P_{m,t-1})0.5(Y_{m,t} + Y_{m,t-1})}{\Sigma_j 0.5(W_{j,t} + W_{j,t-1})0.5(X_{j,t} + X_{j,t-1})}$$

, and then represent the average revenue share between period $t-1$ and period t.

To calculate the technical change component (iv above), the scale component (v), and the mark-up component (vi) require estimates of following unobserved factors: TC, RTS^{-1}, and μ_c. One way to define these factors are $TC = -\frac{\partial C}{\partial t}$, $RTS^{-1} = \sum_m \frac{\partial \ln C}{\partial \ln Y_m}$,

$\dot{Y}_c - RTS \sum_m \frac{\partial lnC}{\partial lnY_m} \dot{Y}_m$, and $-\frac{dc}{dt} = \dot{TF}$, where $RTS = -\frac{1}{\sum_m \frac{\partial lnC}{\partial lnY_m}}$. Estimation that include all these requires in principle econometric estimation of a cost function. Estimation of a cost function requires input price data with sufficient variation. Without price variation, the cost function parameters cannot be estimated. Because there is little to no price variation in our data we cannot estimate the cost function. The solution is to estimate the input distance function (IDF) (Shephard 1953, 1970) and use the duality results. An IDF is used, instead of a output distance function, in our study because the cost function is dual to the IDF, and the IDF representation of the production technology seems to be the most suitable framework to represent the quota-regulated Norwegian and Finnish dairy farming technology. IDF can easily accommodate multiple inputs and multiple outputs and because of the dual relationship we can obtain the required components from the IDF without estimating the cost function.

In the presence of technical inefficiency the IDF is written as $D_I(X,Y,t) \geq 1$, implying that $D_I(X,Y,t)\exp(-u) \; 1$, where $u \geq 0$ is a technical inefficiency indicator measure. Using the homogeneity property we can express the input distance function $D_I(X,Y,t)$[1] as $D_I(X,Y,t)/X_1 \; D_I(\tilde{X},Y,t)$ where $\tilde{X} \; (X_2/X_1, X_3/X_1, \ldots, X_N/X_1)$. Thus allowing for technical inefficiency, $lnD_I(X,Y,t) \; lnX_1 - lnD_I(\tilde{X},Y,t)$. This in turn implies that

$$lnX_1 = lnD_I(\tilde{X},Y,t) \quad u \tag{2}$$

where $lnD_I(X,Y,t) - u \geq 0$.

[1] The input distance function satisfies the following properties: (i) $D_I(Y, X,t)$ is decreasing in each output level, (ii) $D_I(Y, X,t)$ is increasing in each input level, (iii) $D_I(Y, X,t)$ is homogeneous of degree one in X, and (iv) $D_I(Y, X,t)$ is concave in X.

In the estimation part of this study we follow the approach by Kumbhakar et al. (2011), by including a "true" random farm effect associated with unobserved factors that are not related to inefficiency (μ_i), and decompose the technical inefficiency component (u_{it}) into persistent farm-specific (time-invariant) component (η_i) and a time-varying residual component (u_{it}^{*}). The estimation model is in contrast to models where all time-persistent noise is inefficiency (e.g. Pitt and Lee 1981; Schmidt and Sickles 1984; Kumbhakar 1987) and where no firm-specific effects are inefficiency (e.g., Greene 2005a; 2005b). That the estimation model used here also decomposes the overall technical inefficiency into a persistent component and a residual component may be useful. A high degree of persistent technical efficiency could, for example, be a problem in the long-run. If high degree of persistent technical efficiency a sound focus could be on measures such as encourage to long-term structural adjustment toward fewer larger farms or switches to other production activities.

For a translog input distance function with two output variables (m = 1, …, 2), five input variables (j = 1, 2, ..., 5), a time trend variable (t), one regulatory dummy variable (R_t), and with a independently and identically distributed (iid) random error term $N(0, \sigma_v^2)$ equation (2) for becomes:

$$-\ln X_{1it} = \alpha_0 + \sum_{m=1}^{2} [\beta_m \ln Y_{mit}] + 1/2 \sum_{m=1}^{2}\sum_{n=1}^{2} [\beta_{mn} \ln Y_{mit} \ln Y_{nit}] + \sum_{j=2}^{5} \dots$$

where $\ln\tilde{X}_{jit} = \ln X_{jit} - \ln X_{1it}$ and α, β, δ and ϑ are parameters to be estimated. The symmetry restrictions imply that $\alpha_{jk} = \alpha_{kj}$ and $\beta_{mn} = \beta_{nm}$. Model in equation (3) can be rewritten as

$$\ln X_{1it} = \alpha_0^* + \sum_{m=1}^{2} \beta_m \ln Y_{mit} + 1/2 \sum_{m=1}^{2} \sum_{n=1}^{2} \beta_{mn} \ln Y_{mit} \ln Y_{nit} + \sum_{m=1}^{2} \ldots$$

where $\alpha_0^* = \alpha_0 - E(\eta_i) - E(u_{it}^+)$; $\alpha_i = \mu_i - \eta_i + E(\eta_i)$; and $\varepsilon_{it} = v_{it} - u_{it}^+ + E(u_{it}^+)$. With this specification α_i and ε_{it} have zero mean and constant variance. This model can be estimated in three steps. Since equation (4) is the familiar panel data model, in step 1 the standard random effect panel regression is used to estimate α, β, δ and θ. This procedure also gives predicted values of α_i and ε_{it}, denoted by $\hat{\alpha}_i$ and $\hat{\varepsilon}_{it}$. In step 2, the time-varying technical inefficiency, u_{it}^+, is estimated. Let

$$\hat{\varepsilon}_{it} = \varepsilon_{it} + (\hat{\varepsilon}_{it} - \varepsilon_{it}) = v_{it} - u_{it}^+ + E(u_{it}^+) + (\hat{\varepsilon}_{it} - \varepsilon_{it}) = E(u_{it}^+) + [v_{it} + (\hat{\varepsilon}_{it} - \varepsilon_{it})] - u_{it}^+ \qquad (5)$$

By assuming v_{it} is iid $N(0, \sigma_v^2)$, and u_{it}^+ is iid $N^+(0, \sigma^2)$ and ignoring the $(\hat{\varepsilon}_{it} - \varepsilon_{it})$ term that has zero mean, we can estimate equation (5) using the standard SF technique. This procedure gives estimates of the time-varying residual technical inefficiency components, u_{it}^+, and time-varying residual technical inefficiency $\hat{u}_{it}^+$ which can be used to estimate residual technical efficiency, $RTE = \exp(-\hat{u}_{it}^+)$. In step 3 we estimate η_i, following a similar procedure as in step 2. For this we write:

$$\hat{\alpha}_i = \alpha_i + (\hat{\alpha}_i - \alpha_i) = \mu_i - \eta_i + E(\eta_i) + (\hat{\alpha}_i - \alpha_i) = E(\eta_i) + [\mu_i + (\hat{\alpha}_i - \alpha_i)] - \eta_i \qquad (6)$$

By ignoring the $(\hat{\alpha}_i - \alpha_i)$ term that has a zero mean, and assuming μ_i is iid $N(0, \sigma_\mu^2)$, η_i is iid $N^+(0, \sigma_\eta^2)$; we can estimate equation (6) using the standard pooled normal-half normal SF model to obtain estimates of the persistent technical inefficiency measure, $PTE = \exp(-\hat{\eta}_i)$. Overall technical efficiency (OTE) is then obtained from $OTE = PTE \times RTE$.

Based on the estimated input distance function parameters, the data and use of the duality results (Karagiannis et al. 2004) we from equation (4) get:

$$TC = -\frac{\partial \ln C}{\partial t} = -\frac{\partial \ln D_I(\tilde{X}, Y, t)}{\partial t} = -\left(\alpha_t + \alpha_{tt} t + \sum_{m=1}^{2} \alpha_{mt} \ln Y_{mit} + \sum_{j=1}^{5} \beta_{jt} \ln \tilde{X}_{jit}\right) \qquad (7)$$

$$\frac{\partial \ln C}{\partial \ln Y_m} = \frac{\partial \ln D_I(\tilde{X}, Y, t)}{\partial \ln Y_{mit}} = \beta_m + \sum_{n=1}^{2} \beta_{mn} \ln Y_{nit} + \sum_{j=1}^{5} \delta_{mj} \ln \tilde{X}_{jit} + \alpha_{mt} t + \theta_m R_i \qquad (8)$$

In other words, equation (7) can be directly used to estimate the technical change component (iv). As we did for three first components (i-iii), technical change is computed in this study by taking the averages of consecutive periods $(t-1)$ and (t). Equation (8) is used in estimation of $\dot{Y}_t$ and RTS and thus in estimation of the scale component (v) and the mark-up component (vi). Thus, if we estimate the input distance function with multiple outputs and use the above results in equation (7) and (8), the three components (iv-vi) in equation (1) can easily be computed because these will be functions of the parameters of the estimated IDF and data. Note also that the expressions in equation (8) reflects the relative importance of output Y_m to the firm.

To estimate the technical inefficiency change component $\left(\frac{du}{dt}\right)$ (vii above) we simply calculate as follows for the overall technical inefficiency measure

$$\frac{du}{dt} = \frac{(OTE_t - OTE_{t-1})}{0.5(OTE_t + OTE_{t-1})}$$

(9)

In addition we report persistent technical efficiency (PTE) scores and residual technical efficiency (RTE) scores (first quartiles, mean, third quartiles) per year in the results section below.

Data description

FINLAND

The same data period is used for Finland, and it includes 6459 observations on 922 dairy farms.

The data source for the Norwegian part is the Norwegian Farm Accountancy Survey. This is farm-level panel data collected by the Norwegian Agricultural Economics Research Institute (NILF). It includes farm production and economic data collected annually from about 1000 farms from different regions, farm size classes, and types of farms. Participation in the survey is voluntary. There is no limit on the number of years a farm may be included in the survey. Approximately 10% of the farms surveyed are replaced every year. The farms are classified according to their main category of farming, defined in terms of the standard gross margins of the farm enterprises. For example, the main share of the total standard gross margin for farms categorized as dairy farms comes from dairy production.

The Norwegian data set used in this analysis is a large unbalanced panel with 7867 observations on 1104 dairy farms observed during 1991 to 2008. Dairy farms could be involved in other farm production activities such as beef, grain, machinery contracting work, etc. We distinguish between two outputs: milk sold measured in liters (Y_1), and other outputs (Y_2). Other outputs represent farm products other than milk, in addition to support payments. Examples of other farm products are livestock products such as beef, pigs, sheep, goats and crop products. The support payments comprise various (more or less) decoupled farm supports, but excluding subsidies related to milk produced. The other outputs variable is first converted from nominal monetary values to real (2000 NOK) values, using a combined (weighted) price index for cattle, crops and subsidies, then converted to the average (of the year 1991-2008) Euro values.

We use the following inputs: land measured in hectare (X_1), purchased feed (X_2), own and hired labor in hours (X_3), other materials (X_4), and capital (X_5). Purchased feed, other materials and capital are all measured in 2000 NOK and then converted to Euro in the same was as for other outputs. Purchased feed is deflated by the purchased feed index, other materials is converted to 2000 values by the price index for other variable costs, cattle capital is deflated by price index for cattle, and other capital is deflated by the price index for other agricultural production, where cattle capital and other capital is merged to one capital variable.

Output prices, P_m, and input prices, W_r, corresponds to the output and input variables. The price information is taken from the farm survey when available (for milk, (rented) land and (rented) labor), and when not, from the agricultural sector of the national accounts.

Table I presents the descriptive statistics of the Finnish and the Norwegian sample. Say something (short) about differences between Finland and Norway, and something about representativeness.

Table I. Descriptive statistic for the Finnish (N = 6459) and Norwegian (N = 7867) samples.

Variable	Label	Mean	Std. err.	Min	Max
Finland					
Output quantities					
y_1	Milk yield (liters)	184299	137428	16656	1677813
y_2	Other output (Euro)	30018	25793	1	265151
Output prices					
p_1	Milk (Euro/liters)	0.452	0.051	0.212	1.000
p_2	Other outputs (index)	1.225	0.399	0.866	2.417
Input quantities					
x_1	Land (ha)	41.1	25.6	4.2	278.6
x_2	Purchased feed (Euro)	17398	15036	53	165838
x_3	Labor (hours)	4950	1587	399	16608
x_4	Other materials (Euro)	16968	11686	1215	116502
x_5	Capital (Euro)	29352	26223	1006	273345
Input prices					
w_1	Land (Euro/ha)	116.4	48.5	33.4	266.2
w_2	Purchased feed (feed index)	1.092	0.099	0.957	1.317
w_3	Labor (Euro/hours)	9.513	1.780	3.720	17.485
w_4	Other materials (index)	1.088	0.129	0.942	1.418
w_5	Capital (index)	1.109	0.131	0.929	1.398
Norway					
Output quantities					
y_1	Milk yield (liters)	97438	49291	10859	689501
y_2	Other output (Euro)	43963	22542	8506	477884
Output prices					
p_1	Milk (Euro/liters)	0.517	0.068	0.277	0.902
p_2	Other outputs (index)	1.016	0.057	0.859	1.161
Input quantities					
x_1	Land (ha)	21.8	11.3	3.6	173.8
x_2	Purchased feed (Euro)	15828	9343	163	153780
x_3	Labor (hours)	3662	1127	583	12916
x_4	Other materials (Euro)	10672	5683	294	135038
x_5	Capital (Euro)	26622	13962	1787	174930
Input prices					
w_1	Land (Euro/ha)	128.6	71.9	34.3	548.2
w_2	Purchased feed (feed index)	1.063	0.095	0.990	1.335
w_3	Labor Euro/hours)	14.149	2.542	0.000	19.423
w_4	Other materials (index)	1.036	0.089	0.944	1.270
w_5	Capital (index)	0.984	0.099	0.825	1.166

Results

In Table II we report average values (in addition to standard deviation and quartiles) for the components of profitability, the overall TFP and profit change measures in addition to technical efficiency levels and RTS, for the whole Norwegian and Finnish sample. In Figures XX-XX the temporal or dynamic estimates for selected components are provided.

Table II. Profit change, it's components (in percent) and efficiency and RTS scores.

Components	Mean	Std. err.	Std. dev.	1st quartile	Median	3rd quartile
Finland						
Output growth change	-0.40	0.04	2.67	-1.14	-0.10	0.50
Output price change	-0.70	0.12	9.05	-3.48	0.21	3.56
Input price change	2.25	0.06	4.56	0.95	2.92	4.19
Technical change	1.07	0.01	0.65	0.58	0.99	1.58
Scale	0.89	0.03	1.98	-0.33	0.78	1.97
Technical efficiency change	0.01	0.03	2.12	-1.12	0.03	1.12
Mark-up	2.19	0.09	7.01	-1.42	1.99	5.77
TFP change	4.16	0.13	9.69	-1.21	3.86	9.39
Profit change	0.80	0.12	8.88	-4.34	0.85	6.09
Residual technical efficiency	0.95	0.00	0.02	0.95	0.96	0.96
Persistent technical efficiency	0.93	0.00	0.03	0.91	0.94	0.95
Overall technical efficiency	0.89	0.00	0.04	0.87	0.89	0.91
Return to scale (RTS)	1.41	0.00	0.08	1.36	1.41	1.46
Norway						
Output growth change	-0.18	0.03	2.10	-0.83	-0.06	0.47
Output price change	0.22	0.04	3.22	-1.78	0.11	2.23
Input price change	1.96	0.02	1.73	0.91	1.88	3.00
Technical change	-0.35	0.00	0.20	-0.46	-0.33	-0.22
Scale	0.15	0.01	1.18	-0.44	0.16	0.79
Technical efficiency change	0.00	0.00	0.00	0.00	0.00	0.00
Mark-up	0.45	0.06	4.54	-1.70	0.47	2.53
TFP change	0.25	0.07	5.55	-2.48	0.30	2.98
Profit change	-1.67	0.06	4.94	-4.37	-1.89	0.81
Residual technical efficiency	1.00	0.00	0.00	1.00	1.00	1.00
Persistent technical efficiency	0.95	0.00	0.02	0.94	0.95	0.96
Overall technical efficiency	0.95	0.00	0.02	0.94	0.95	0.96
Return to scale (RTS)	1.29	0.00	0.11	1.22	1.28	1.34

The yearly average profit change was, according to Table II, in Finland 0.8% while in Norway it was -1.67%. There was further a lager variation in profit change in Finland, compared to Norway. By looking at Figure I (lower row) we also observe a weak increasing trend on output growth from about 1995 in Finland, while Norway has during the same period been at about the same level during that period (and also had about the same level as Finland in 1995). We also observe (Figure I, upper row) that Finland on average had a higher TFP growth than Norway during the sample period, and that none of the countries had any increasing or decreasing TFP growth trend during the years after Finland joined EU. This may indicate that the price changes and not technology changes have caused the somewhat better profitability changes in Finnish than Norwegian dairy farming the almost last two decades.

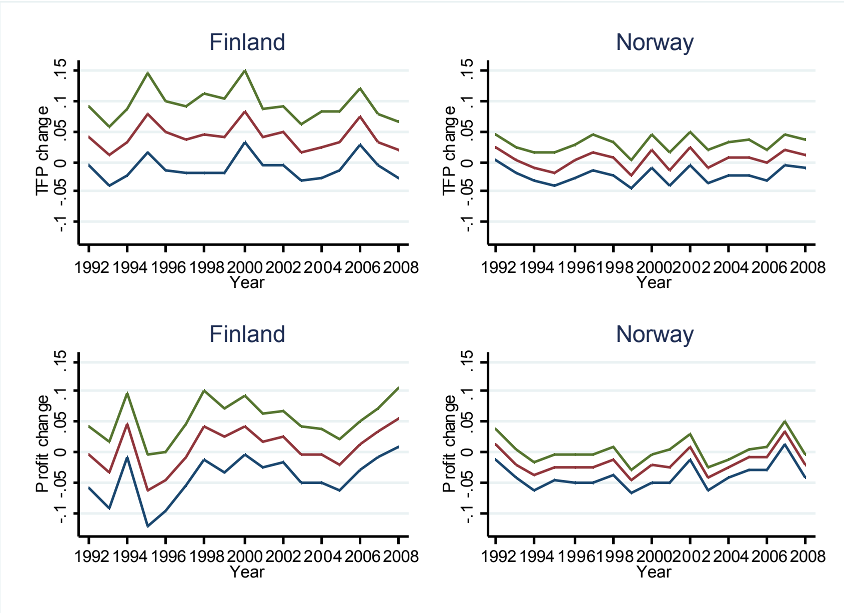

Figure I. T he mean, first and third quartile (middle, bottom and top lines) TFP change (upper row) and profit change (lower row) estimates for the Finnish and Norwegian sample.

The output growth component were, on average, -0. 4% and -0. 18%, respectively, for Finland and Norway (Table II). The negative output growth can (partly) be explained the milk quota regulation that has been in effect during the whole period in both countries. From Figure I I we also observe no effect on output growth in Finland from about 1995 when they entered EU. In Norway there have been an weak decreasing trend in output growth during the period 1992-2008. There also seem, from Figure II, too been a higher variation in output growth over time in Norway, while that not is the case for Finland.

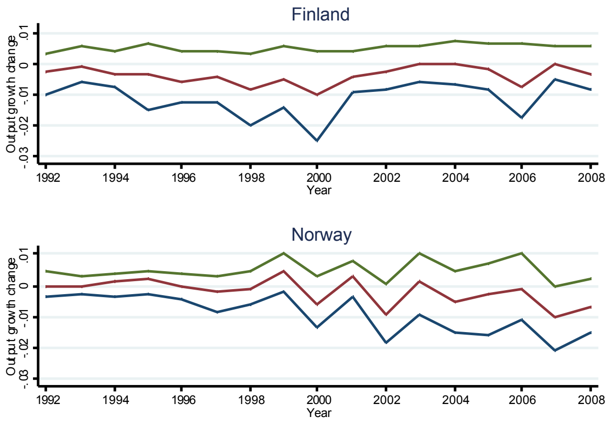

Figure II. The mean, first and third quartile (middle, bottom and top lines) output growth change estimates.

May merge Fig II, III, and IV into one figure?

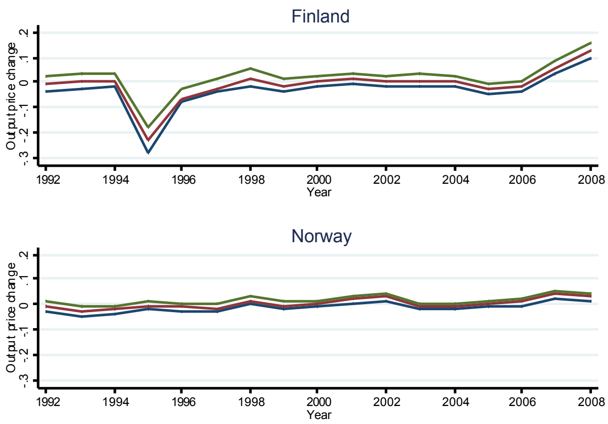

Figure III. The mean, first and third quartile (middle, bottom and top lines) output price change estimates.

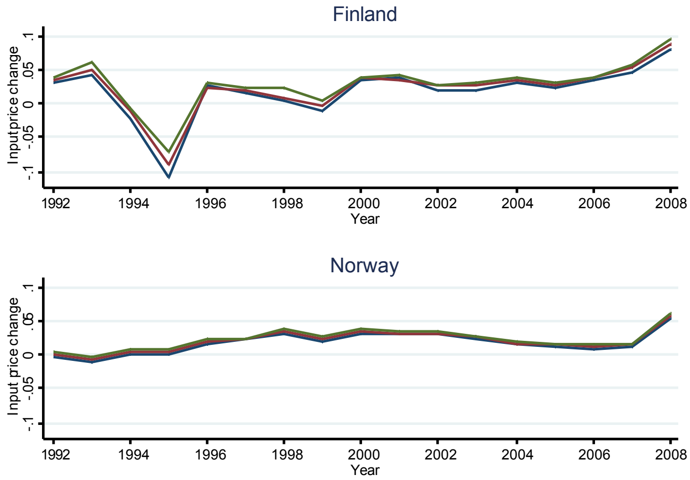

Figure IV. Input price change

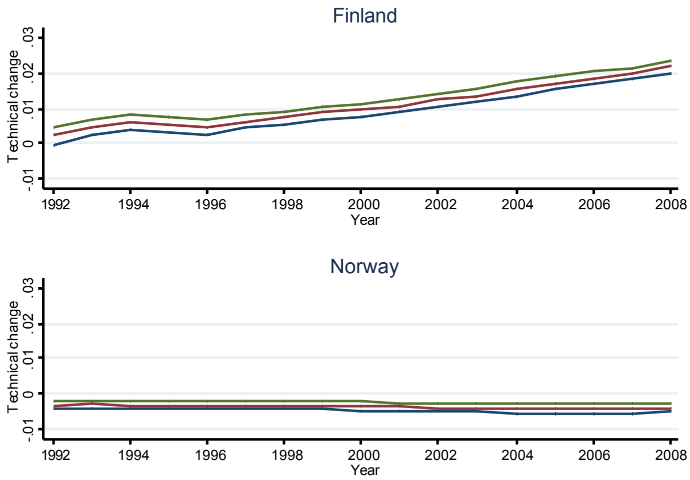

Figure V. Technical change

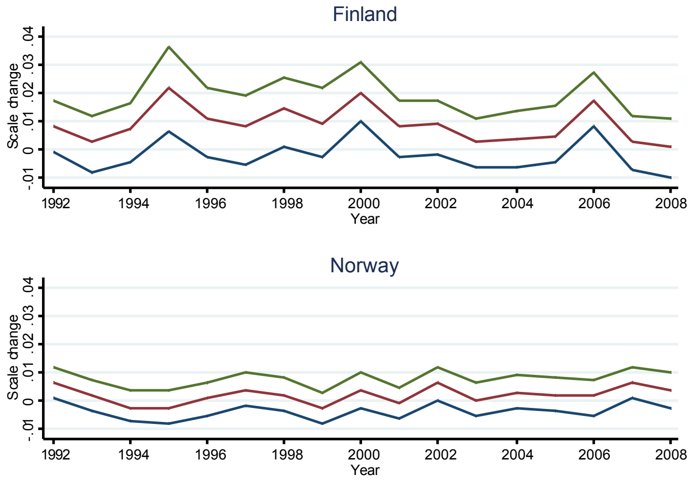

Figure VI. Scale change

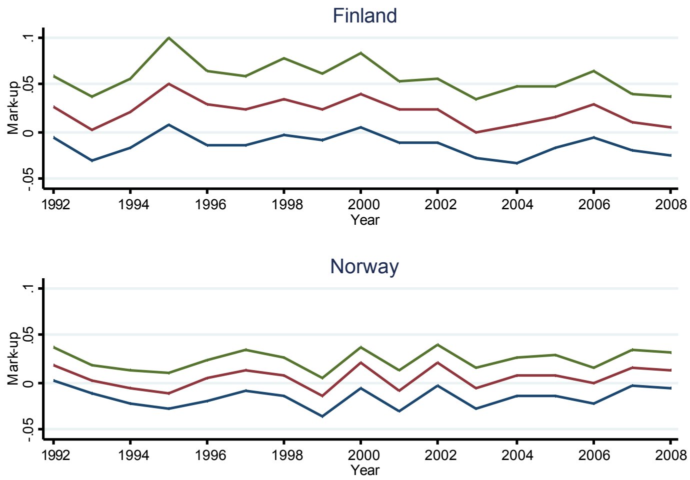

Figure VII. Mark-up

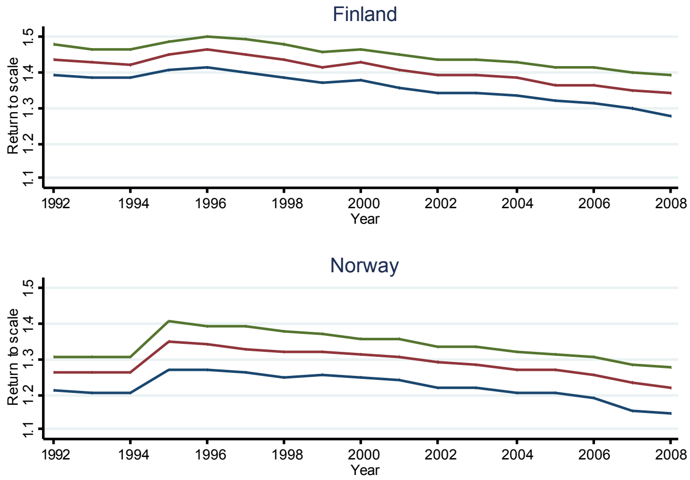

Figure VIII. Return to scale

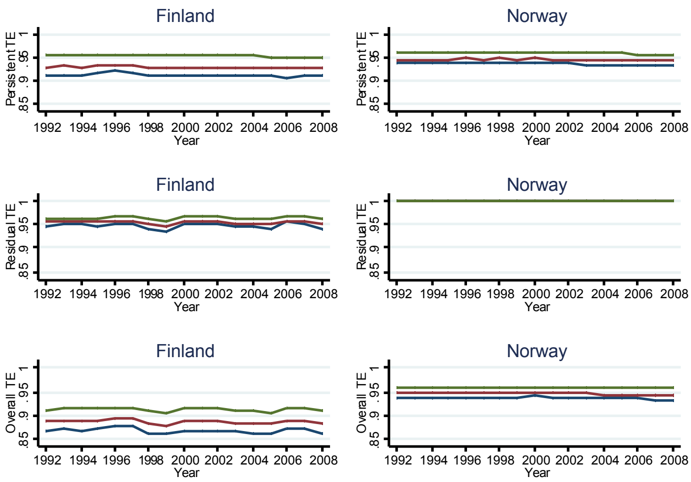

Figure VIII. Persistent, residual and overall technical efficiency (TE)

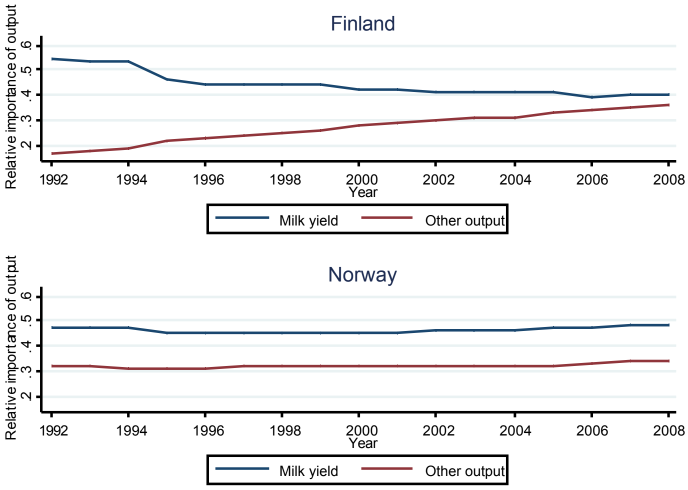

Figure XXXX. The relative importance of output milk yield and other output in Finland and Norway, respectively.

Concluding remarks

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Appendix I Parameter estimates (of equation 4)

Parameter	Variable	Finland			Norway		
		Coeff.	St. error	*t*-value	Coeff.	St. error	t-value
β_1	Milk	0.133	0.239	0.56	0.715	0.435	1.64
β_2	Ot. outp.	-1.072	0.178	-6.03	0.075	0.358	0.21
β_{11}	$(\text{Milk})^2$	-0.112	0.028	-4.03	-0.045	0.058	-0.77
β_{12}	Milk * Ot. outp	0.084	0.017	5.01	-0.039	0.036	-1.07
β_{22}	$(\text{Ot. outp})^2$	-0.053	0.005	-9.74	-0.030	0.036	-0.82
δ_{12}	Milk * Feed	-0.025	0.014	-1.81	0.042	0.027	1.59
δ_{13}	Milk * Labor	0.027	0.019	1.41	-0.026	0.046	-0.56
δ_{14}	Milk * Ot. mat.	-0.031	0.020	-1.56	-0.007	0.046	-0.16
δ_{15}	Milk * Capital	0.006	0.017	0.33	-0.051	0.029	-1.78
δ_{22}	Ot. outp. * Feed	0.001	0.011	0.12	-0.016	0.021	-0.76
δ_{23}	Ot. outp. * Labor	0.069	0.017	3.97	0.025	0.034	0.73
δ_{24}	Ot. outp. * Ot. mat.	-0.004	0.018	-0.24	-0.035	0.036	-0.98
δ_{25}	Ot. outp. * Capital	0.016	0.015	1.01	0.075	0.028	2.67
α_2	Feed	0.091	0.175	0.52	-0.369	0.283	-1.3
α_3	Labor	-0.744	0.335	-2.22	0.584	0.385	1.52
α_4	Other materials	0.241	0.308	0.78	0.378	0.325	1.16
α_5	Capital	-0.260	0.187	-1.39	-0.211	0.322	-0.66
α_{22}	$(\text{Feed})^2$	0.077	0.014	5.32	0.102	0.009	11.13
α_{23}	Feed * Labor	-0.037	0.019	-1.97	-0.035	0.022	-1.61
α_{24}	Feed * Ot. mat.	-0.009	0.015	-0.59	0.045	0.025	1.8
α_{25}	Feed * Capital	0.022	0.011	1.93	-0.064	0.018	-3.52
α_{33}	$(\text{Labor})^2$	0.173	0.038	4.51	0.098	0.035	2.78
α_{34}	Labor * Ot. mat.	-0.072	0.027	-2.7	-0.077	0.033	-2.35
α_{35}	Labor * Capital	-0.016	0.018	-0.91	-0.022	0.024	-0.93
α_{44}	$(\text{Other materials})^2$	0.084	0.021	3.94	0.083	0.032	2.61
α_{45}	Ot. mat * Capital	0.027	0.017	1.6	-0.030	0.023	-1.31
α_{55}	$(\text{Capital})^2$	-0.007	0.020	-0.35	0.122	0.029	4.27
α_t	Time trend	0.018	0.023	0.77	-0.034	0.024	-1.41
α_{tt}	$(\text{Time trend})^2$	0.001	0.000	5.77	0.000	0.000	-0.45
α_{1t}	Milk * Time	0.007	0.002	3.38	-0.001	0.003	-0.34
α_{2t}	Ot. output * Time	-0.008	0.002	-3.83	0.001	0.002	0.45
β_{2t}	Feed * Time	0.001	0.002	0.44	0.005	0.002	2.81
β_{3t}	Labor * Time	-0.004	0.002	-1.93	-0.002	0.002	-0.79
β_{4t}	Ot. mat. * Time	0.003	0.002	1.43	0.002	0.002	0.85
β_{5t}	Capital * Time	-0.005	0.002	-3.21	0.000	0.002	-0.06
θ_0	EU dummy	0.464	0.227	2.05	-0.353	0.203	-1.74
θ_{y1}	Milk * EU dum.	0.007	0.019	0.35	0.027	0.022	1.19
θ_{y2}	Ot. out * EU dum.	-0.008	0.014	-0.55	0.017	0.020	0.85
θ_{x2}	Feed * EU dum.	-0.052	0.011	-4.63	-0.062	0.012	-5.1
θ_{x3}	Labor * EU dum.	-0.015	0.019	-0.78	0.054	0.018	2.97
θ_{x4}	Ot. mat. * EU dum.	-0.024	0.017	-1.43	-0.001	0.018	-0.06
θ_{x5}	Capital * EU dum.	0.023	0.015	1.54	-0.003	0.014	-0.24
α_0	Constant	4.511	1.861	2.42	-5.841	2.824	-2.07