The development of production costs in dairy farms using panel data

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Contents

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  – structural change and projections
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  – development of costs

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Introduction structural change and projections

Farms

- Dairy Farms
- Cattle Farms
- Sheep and Goats
- Pig farms

-57%
-50%
-67%
+31%
Introduction number of cattle 2000–2013

Animals, thousands

- Dairy cows
- Suckler cows
- Bulls 1 year and over
- Heifers
- Calves under 1 year

-18%
-22%
-13%
-5%
+106%
Introduction

- The structure of agriculture has changed rapidly. Number of dairy farms has dropped by 57%, but the number of cows only by 22%.
- Average farm size has grown.
  - Farms have more animals and more arable land (hectares).
- The goal of this study was to study how the production costs in Finnish dairy farms have developed in 2000s taking into account farm-level information and time effect by observing the same farms for several years.
  - Farm-level information was location, economic size and number of cows.
  - Analyzed interindividual differences in intraindividual changes over time.
Introduction prices have increased in the 2000s

Data source: Statistics Finland.
Introduction production costs in animal farming

€

Dairy farms 160%
Suckler cow farms 123%
Sheep production 211%
Piglet production 377%
Pork production 199%
Combined pig production 161%
DATA: dairy farms
Dairy farms participating in Luke profitability bookkeeping were studied for the years 2000–2011.

The data set was formed as panel. Each farm was repeatedly measured in one year intervals.

There were 4205 observations from 633 different farms and on average 350 different farms every year.

Data set was unbalanced. This is due to the fact that it is voluntary to participate in Luke bookkeeping activities and, on the other hand, some farms had exited the business.
Data  farm level panel data 2000-2011

- The unit production costs were studied (continuous variable).
- The total production cost is sum of following components:
  material, livestock, machinery, building, wages and interest costs.
- The production costs were deflated by using Consumer price indices year to 2011 prices (2000=100).
- The farm-level data were weighted with weight factors calculated individually for each farm for every year taking into account
  - the type of operations, economic size and location by support areas.
  - Weights were calibrated taking into account the total arable land in Finland.
- The unit costs of dairy farms were obtained by dividing the total production costs by the amount of produced milk (eurocent per litre).

Total cost has increased over time meaning that prices have grown and dairy farms are larger. However, it seems that the unit cost has remained the same.
Model for production costs
Model specification for unit cost

Linear mixed model
Production cost per litre of milk

Fixed effects
- Continuous
  - Intercept
  - Time
  - Cow
  - Weight
  - Support area
  - Standard output

Random effects
- Unstructured covariance matrix
- Autoregressive residual matrix
  - Intercept
  - Time

Data used, Luke profitability bookkeeping panel data.
Method  linear mixed model

- A linear mixed model includes both fixed and random effects.
- The linear mixed model for an individual farm, \( i \), was defined as followed:

\[
\begin{align*}
\mathbf{y}_i &= \mathbf{X}_i\mathbf{\beta} + \mathbf{Z}_i \mathbf{b}_i + \mathbf{\epsilon}_i \\
\mathbf{b}_i &\sim N(\mathbf{0}, \mathbf{D}) \\
\mathbf{\epsilon}_i &\sim N(\mathbf{0}, \mathbf{R}_i) \\
\mathbf{b}_1, \ldots, \mathbf{b}_n, \mathbf{\epsilon}_1, \ldots, \mathbf{\epsilon}_n &\text{ independent}
\end{align*}
\]
Method covariance structure for random effects

- Unstructured (UN) covariance structure was chosen for random effects in the model since it is suitable for longitudinal data.
- Random effects were defined over farm register number (observation unit \( i \)).
- The unstructured \( 2 \times 2 \) covariance matrix for the random effects (intercept and time) is denoted as followed:

\[
D = \text{Var}(b_i) = \begin{pmatrix} \sigma_{b0}^2 & \sigma_{b0,b1} \\ \sigma_{b0,b1} & \sigma_{b1}^2 \end{pmatrix}
\]

- where three parameters, \( b0 \) variance, \( b1 \) variance, \( b0 \) and \( b1 \) covariance, are denoted as UN(1,1), UN(2,2) and UN(2,1), respectively.
Method covariance structure for residual random effects

• For residual random effects first-order autoregressive (AR1) covariance structure was chosen because it is suitable for data containing sequential observations and correlations declining exponentially with time.

• The first-order autoregressive covariance matrix for residual is denoted:

\[
R_i = \text{Var}(\epsilon_i) = \begin{pmatrix}
\sigma^2 & \sigma^2 \rho & \ldots & \sigma^2 \rho^{n_i-1} \\
\sigma^2 \rho & \sigma^2 & \ldots & \sigma^2 \rho^{n_i-2} \\
\vdots & \vdots & \ddots & \vdots \\
\sigma^2 \rho^{n_i-1} & \sigma^2 \rho^{n_i-2} & \ldots & \sigma^2 
\end{pmatrix}
\]
Results
Results of linear mixed model explaining the unit cost

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<th>Estimate</th>
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<th>Sig.</th>
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<th>CI 95% Up</th>
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Results

• Costs increase year-to-year.
• The unit cost decreased as the number of cows increased.
  – To compensate annual cost increase farms should be expanded with two cows every year.
• Small farms had higher unit cost and annual variation than medium-sized and large farms.
  – Finnish dairy farms have developed fast and the benefits of scale may not have yet been accomplished.
• The farm location by support areas explains only slightly the unit cost.
• Productions costs change at different pace between farms.
## Unit cost of milk

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Thank you!

Alina Sinisalo
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alina.sinisalo@luke.fi