# Dynamic Efficiency under Investment Spikes in Lithuanian Cereal and Dairy Farms

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# Contents

# Preliminaries for Dynamic Efficiency

# Dynamic Efficiency

- Production Analysis based on the Revealed Preference Approach (Farrell, 1957; Afriat, 1972).
- Data Envelopment Analysis (Charnes et al., 1978; Fare and Lovell, 1978; Banker et al., 1984).
- Intertemporal dependence of production decisions in DEA:
  - Nemoto and Goto (1999, 2003) – carry-over production factors;
  - **Silva and Stefanou (2003) – dynamic theory of production in the presence of adjustment-cost.**

# Adjustment-cost considerations

- Quasi-fixed factors cannot be adjusted without costs.
- Capital can be treated as quasi-fixed factor.
- Adjustment cost curve defines the level of costs due to (possibly rapid) change in quasi-fixed factors.
- Silva and Stefanou (2003) model the adjustment costs in terms of the properties of representations of the productive technology, e.g. input requirement sets.
- Adjustment costs link the production decisions in time.

# Sources of Adjustment Costs

- Internal adjustment costs:
  - Output-reducing;
  - Arise due to diversion of resources from production to investment activities;
  - **Trade-off between current production and current growth and future production (Silva, Stefanou 2003).**
- External adjustment costs:
  - Arise from market forces, e.g. market power in factor markets;
  - Enter into other costs of the firm.
- Internal adjustment costs are accounted for by manipulating the productive technology.
- Quasi-fixity is due to internal costs.
- Silva et al. (2015) proved the existence of duality between the **dynamic input DDF** and the current value of the optimal value function of the inter-temporal cost minimization problem.

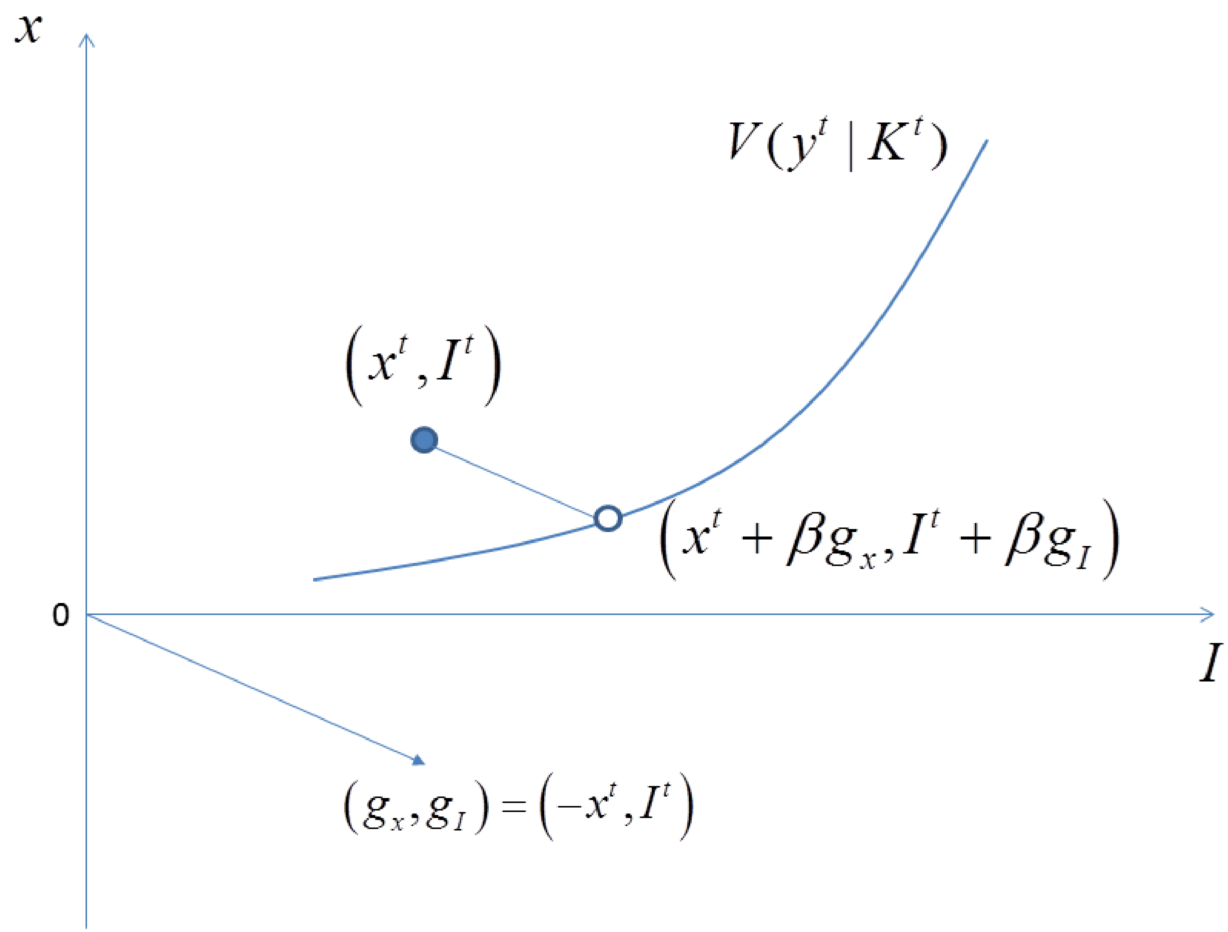
# Productive Technology

- Input requirement set for period *t*:

$$V(y^t \mid K^t) = \left\{(x^t, I^t) : (x^t, I^t) \text{ can produce } y^t \text{ given } K^t\right\}$$

- $y^t \in \Re^M_{++}$ is a 1 x *M* vector of outputs
- $x^t \in \Re^N_{+}$ is a 1 x *N* vector of inputs
- $K^t \in \Re^F_{++}$ is a 1 x *F* vector of quasi-fixed inputs
- $I^t \in \Re^F_{+}$ is a 1 x *F* vector of gross investments (dynamic factor)

# Dynamic directional input distance function



# Duality issues

- Silva et al. (2015) established a duality between $D(y, K, x, I; g_x, g_y)$ and the following inter-temporal cost minimization problem:

$$W\left(y, K_t, w, c, r, \delta\right) = \min_{x(\cdot), I(\cdot)} \int_t^{+\infty} e^{-r(s-t)}\left[w' x(s) + c' K(s)\right] ds$$

s.t.

$$\dot{K}(s) = I(s) - \delta K(s), K(t) = K_t$$

$$\left(x(s), I(s)\right) \in V\left(y(s) \mid K(s)\right), s \in [t, +\infty)$$

- $t$ is a base period
- $r$ is discount rate
- $\delta$ is depreciation rate

# DEA model for *D*(.)

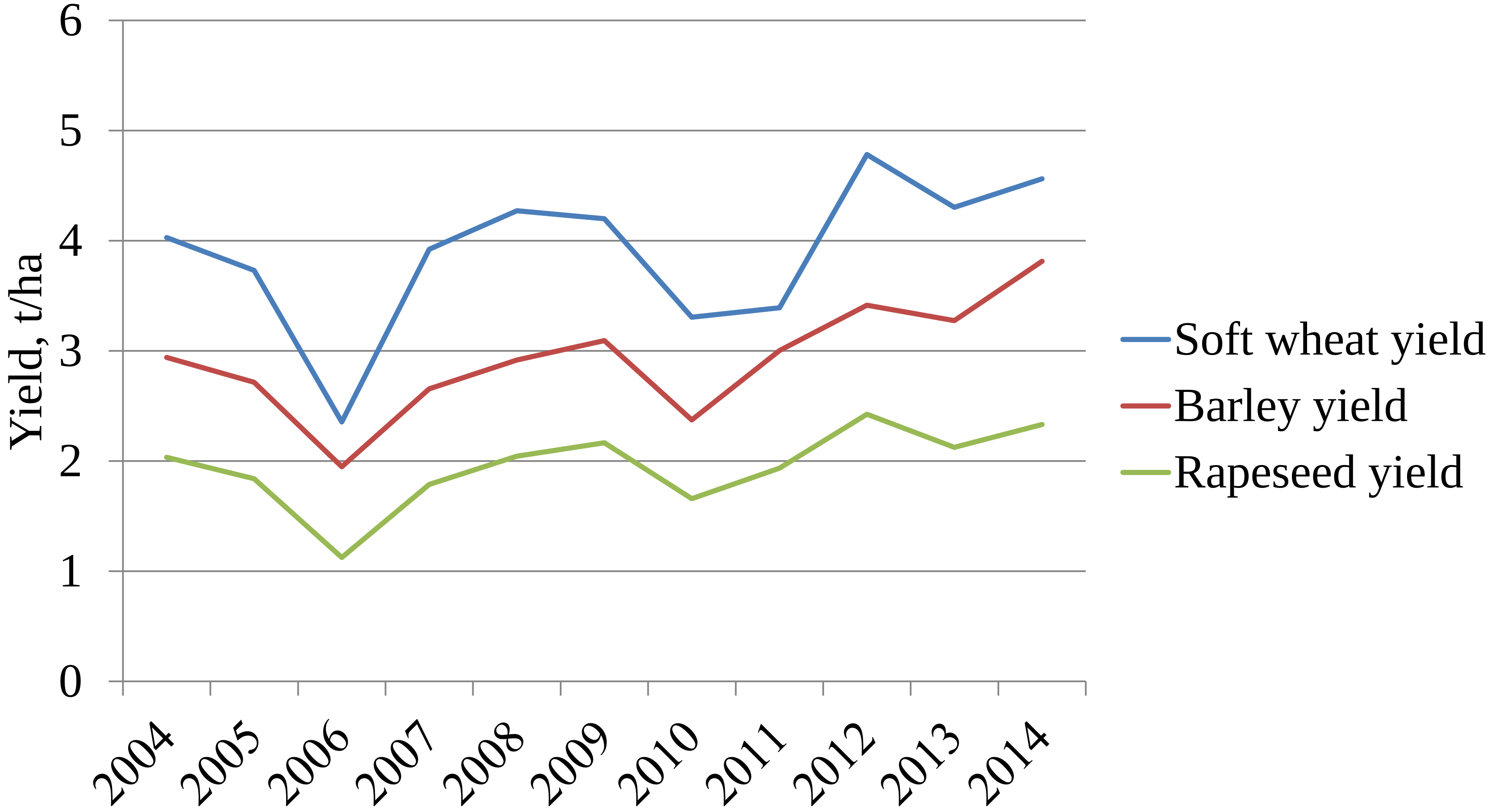
- The following linear programming problem yields the value of the directional distance function:

$$
\begin{aligned}
& D_t(y^t, K^t, x^t, I^t; g_x, g_I) = \max \beta \\
& \text{s.t.} \\
& \sum_{k=1}^{K} \lambda_k y_{m,k}^t \geq y_{m,k'}^t, m = 1,2,\ldots,M; \\
& \sum_{k=1}^{K} \lambda_k x_{n,k}^t \leq x_{n,k'}^t + \beta g_{x,n}, n = 1,2,\ldots,N; \\
& \sum_{k=1}^{K} \lambda_k \left( I_{k,f}^t - \delta_f K_{k,f}^t \right) \geq I_{k',f}^t - \delta_f K_{k',f}^t + \beta g_{I,f}, f = 1,2,\ldots,F; \\
& \lambda_k \geq 0, k = 1,2,\ldots,K
\end{aligned}
$$

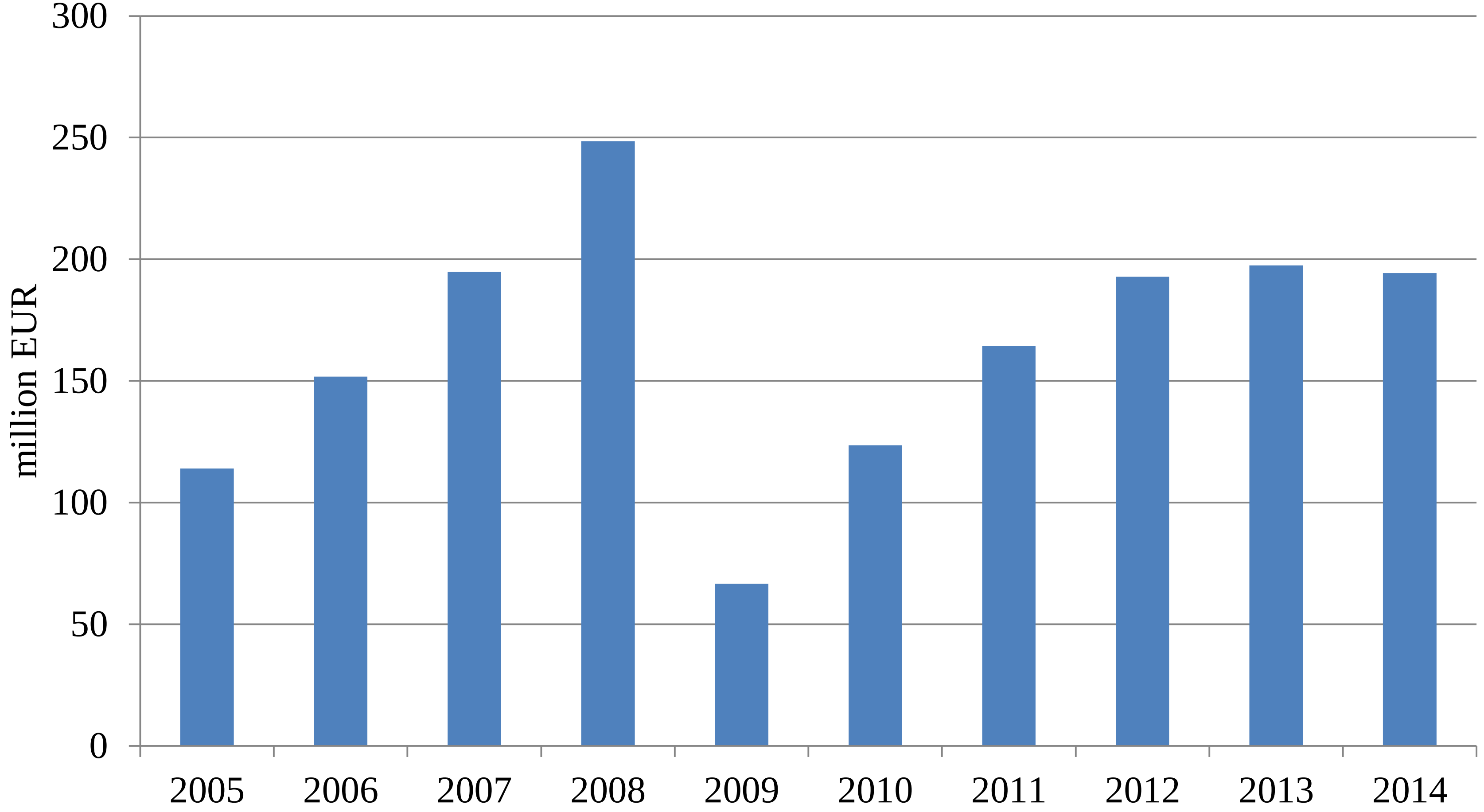
- $\lambda_k$ are intensity variables. CRS technology is presented above.
- We also estimate VRS ($\sum \lambda_k$=1) and NIRS ($\sum \lambda_k$≤1) technologies in order to classify the farms in terms of RTS (Färe et al., 1983; Färe, Grosskopf, 1985; Grosskopf, 1986).

# Lithuanian Cereal and Dairy Farms

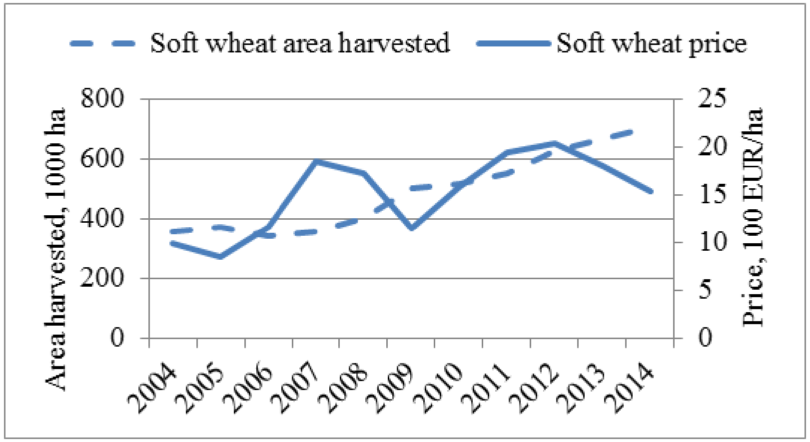
# Dynamics in cereal crop yields in Lithuania, 2004-2014



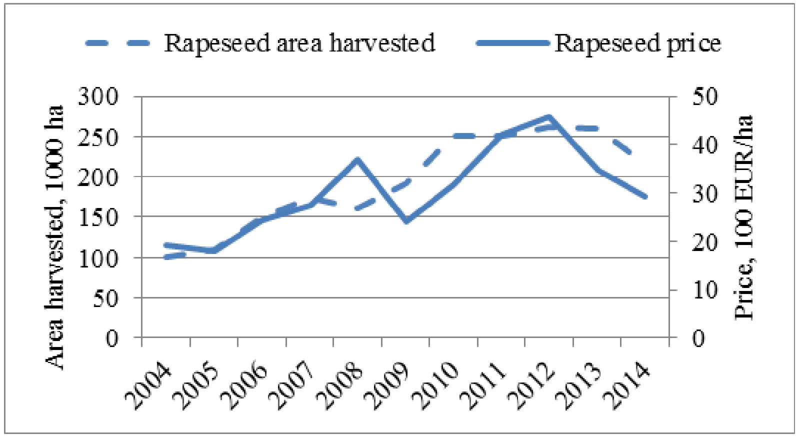
# Credits provided to Lithuanian farms during 2005-2014



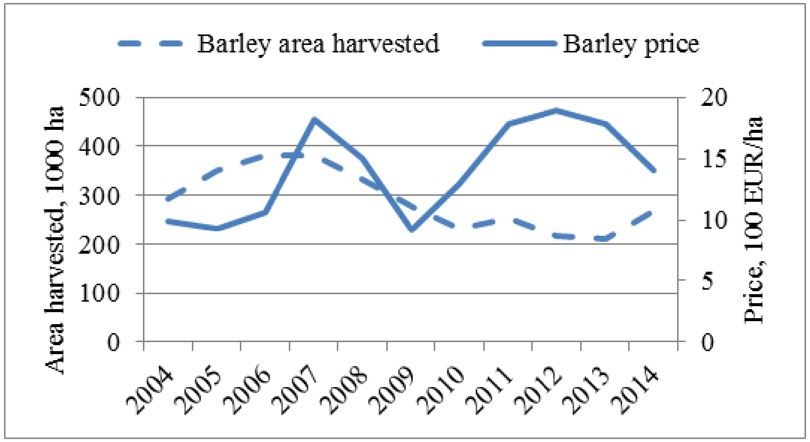
# Cereal area harvested and prices, 2004-2014




*a – Soft wheat*

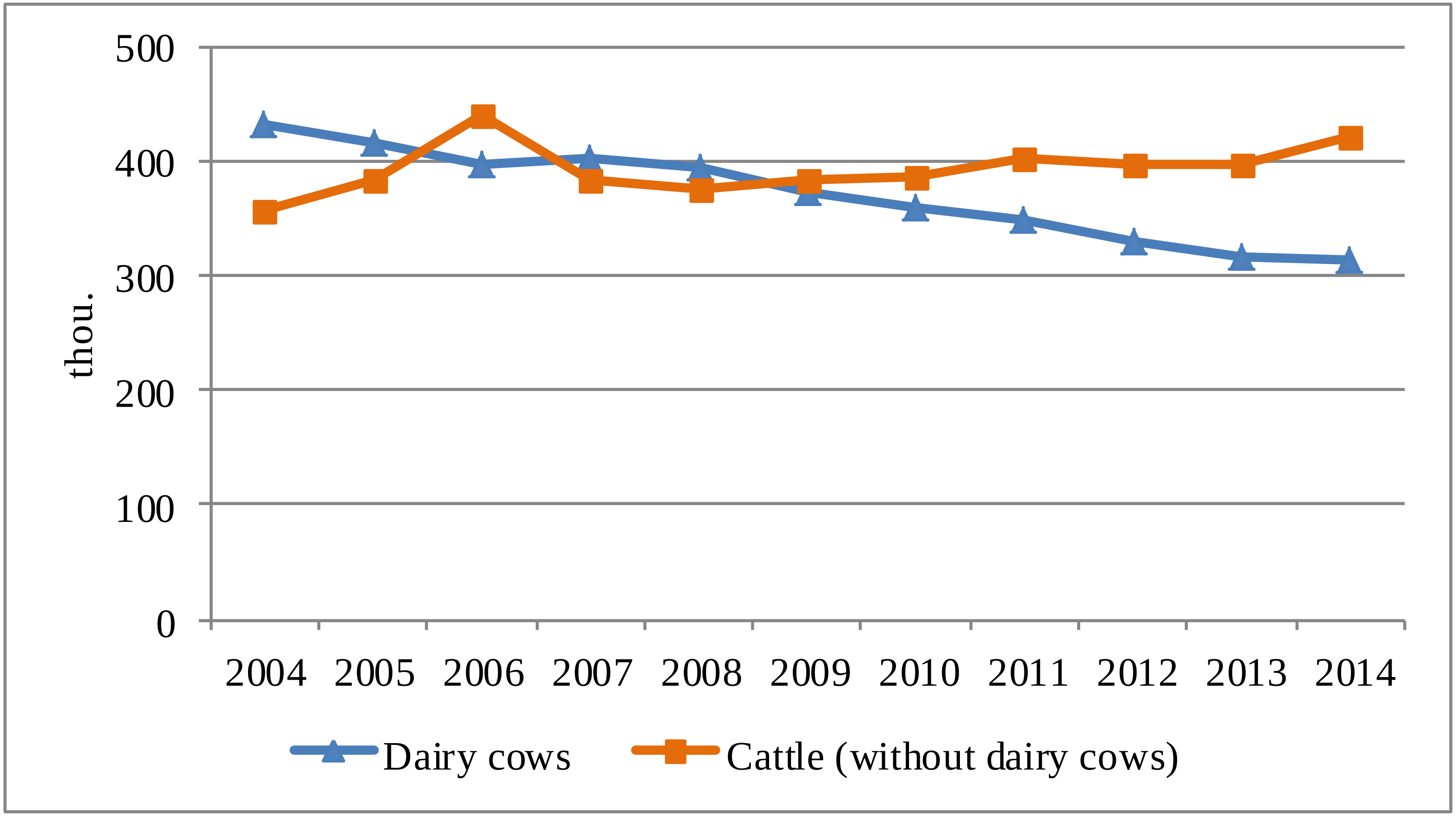



*c – Rapeseed*




*b – Barley*

# Number of cattle in Lithuania, 2004–2014



# Key FADN variables for cereal and dairy farms (Eur/ha), 2004-2013

| Crop farms | Total crops output | Crop-specific costs | Net investment | Average farm capital | Machinery and buildings | Investment support |
|---|---|---|---|---|---|---|
| Denmark | 975 | 311 | 224 | 8942 | 5702 | 2 |
| Latvia | 500 | 207 | 111 | 898 | 530 | 25 |
| **Lithuania** | 530 | 204 | 132 | 1152 | 668 | 57 |
| Poland | 718 | 278 | 39 | 1886 | 1358 | 5 |
| Germany | 1042 | 377 | 82 | 1740 | 1009 | 1 |

| Dairy farms | Total livestock output | Livestock-specific costs | Net investment | Average farm capital | Machinery and buildings | Investment support |
|---|---|---|---|---|---|---|
| Denmark | 1964 | 1106 | 440 | 6525 | 7622 | 2 |
| Latvia | 906 | 569 | 57 | 2381 | 491 | 160 |
| **Lithuania** | 951 | 479 | 136 | 3405 | 1062 | 194 |
| Poland | 1042 | 338 | 79 | 4304 | 3246 | 14 |
| Germany | 1617 | 547 | 7 | 3700 | 2872 | 71 |

# Dynamic Efficiency of Lithuanian Cereal and Dairy Farms

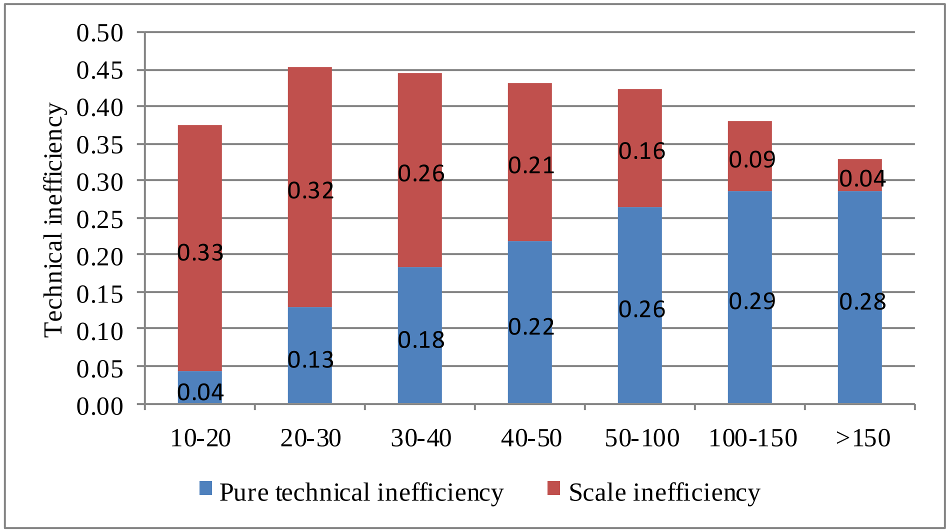
# Data Used

- Farm-level FADN data for 2004-2015.
- Three variable inputs:
  - land,
  - labour,
  - intermediate consumption.
- A quasi-fixed input - capital assets.
- A dynamic factor - gross investments.
- An output - total agricultural output.
- Törnqvist price indices were applied to derive implicit quantities of capital assets, investments and agricultural output.
- The outliers were identified following P. C. Geylani and S. E. Stefanou (2013).
- Also, observations with negative gross investments were omitted.
- 3671 cereal farm and 2782 dairy farm observations are considered.
- Directional vector is set to be equal to negated input quantities and 20% of capital assets
- Investment spikes (Geylani and Stefanou, 2013): investments exceeding the 2.5 median values of the investment-to-asset ratio.

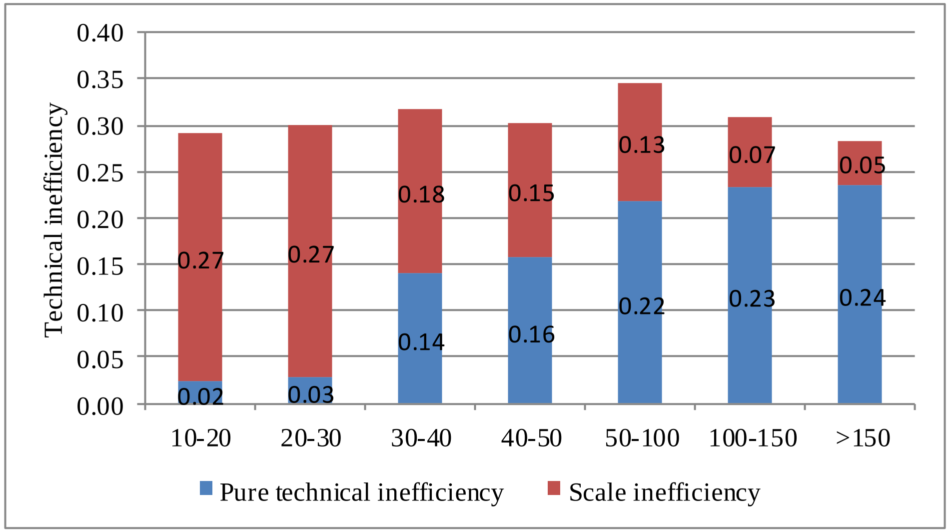
# Investment spike characteristics in Lithuanian cereal and dairy farms

| Indicator | Cereal farms | Dairy farms |
|---|---|---|
| Percentage of observations in data set with spikes | 51 | 50 |
| Percentage of total sample investment accounted for by spikes | 70 | 74 |
| Number of investment spikes and the percentage of farms in each group | | |
| 1–2 | 84 | 80 |
| 3–4 | 13 | 18 |
| 5–6 | 3 | 2 |

# Pure technical and scale inefficiencies for Lithuanian cereal farms

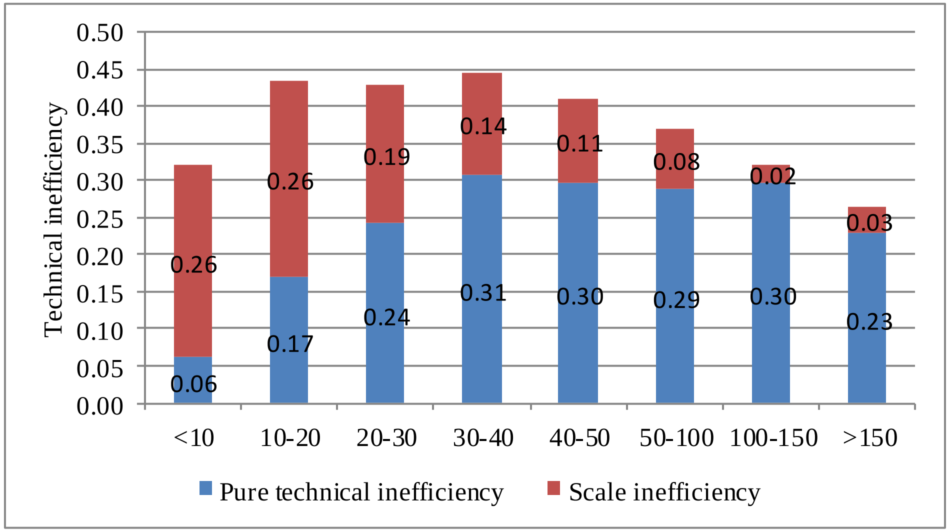



Farms without investment spikes

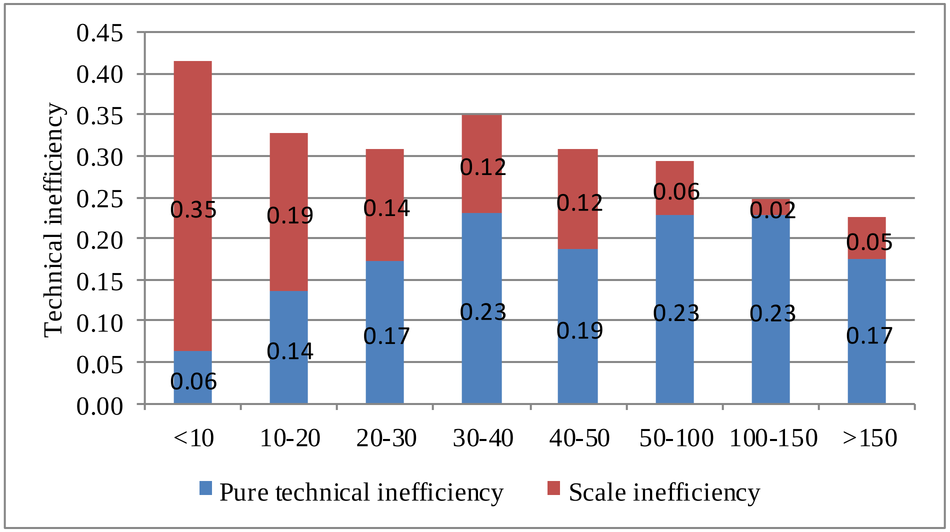



Farms with investment spikes

# Pure technical and scale inefficiencies for Lithuanian dairy farms

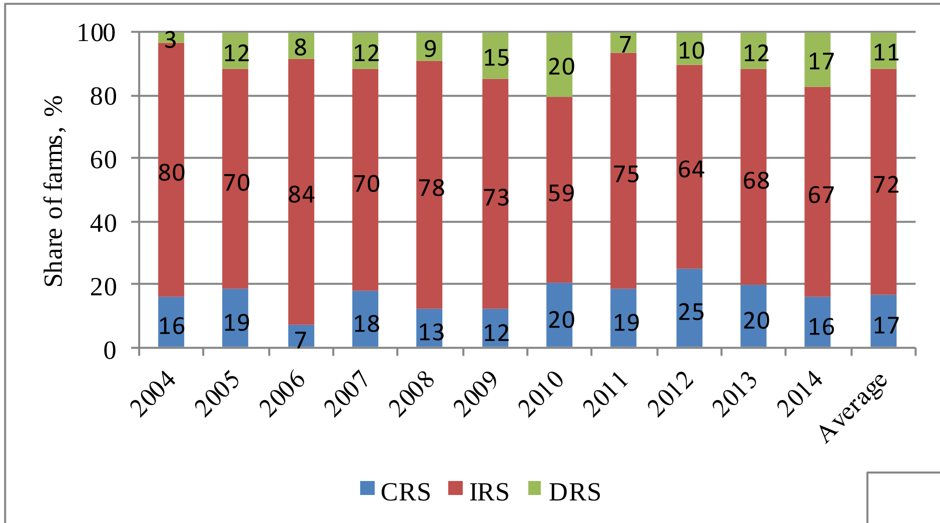



Farms without investment spikes

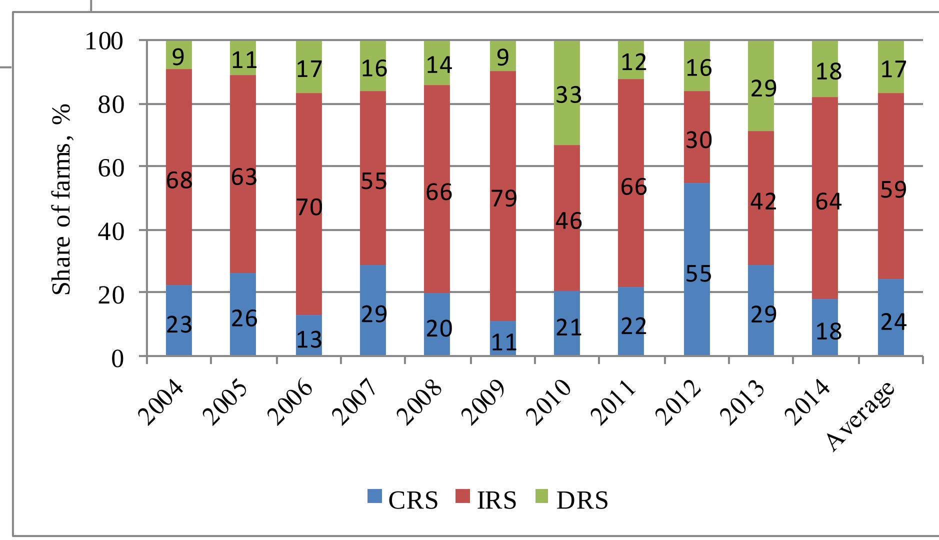



Farms with investment spikes

# The structure of Lithuanian cereal farms in terms of RTS

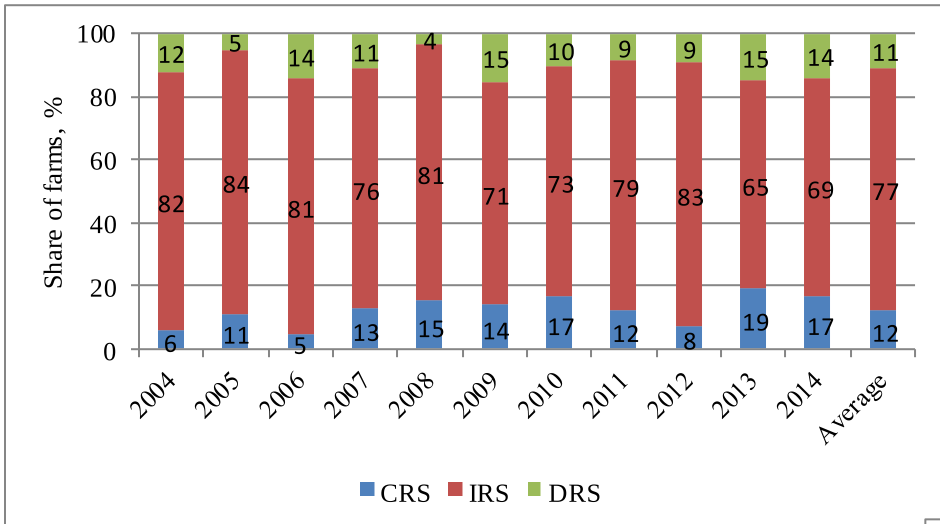



Farms without investment spikes

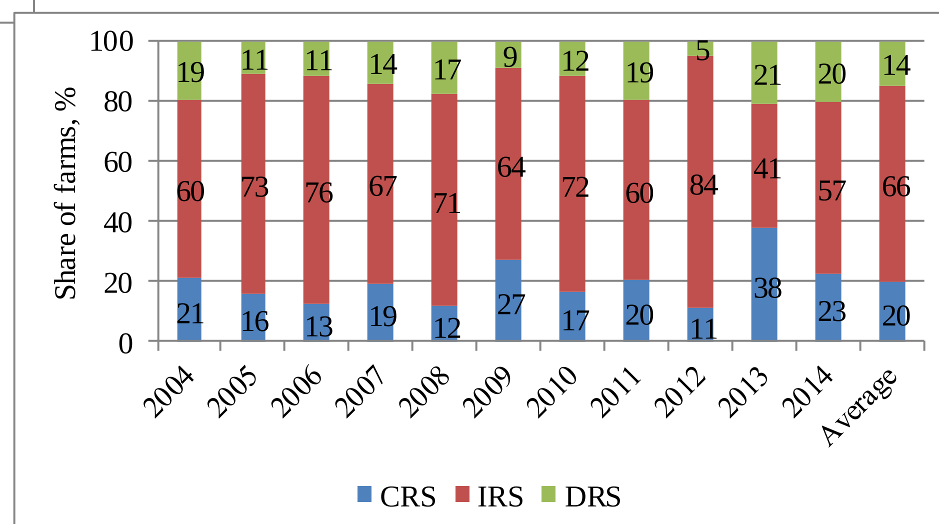



Farms with investment spikes

# The structure of Lithuanian dairy farms in terms of RTS




Farms without investment spikes




Farms with investment spikes

# Conclusions

- The results showed the support payments under the EU policies enabled Lithuanian farmers actively invest in modernization of agricultural holdings. Farms with investment spikes constituted around the half of the investigated farms. Furthermore, these investments accounted for a rather high share of overall investments in the sample (70% and 74% for cereal and dairy farms, respectively).
- The patterns of inefficiencies for farms without investment spikes were almost identical to those for farms with investment spikes. In case of cereal farms, the small farms appeared as those exhibiting the highest level of technical efficiency, while large farms were the least efficient. The results of dairy farms were somewhat different. The small farms remained the most technically efficient farms; however, the middle-sized farms were the least efficient. In all cases the inefficiency of scale was inversely related to farm size. Both cereal and dairy farms showed lower inefficiency in the presence of investment spikes, which indicates improvements in productivity due to investments.
- In all cases, most of farms operated below the optimal scale. The farms operating in the region of increasing returns to scale could increase productivity by increasing their input and investments. However, it is important to avoid excessive investments by maintaining the balance between output growth and investments. One possible solution for reducing technical and scale inefficiency of Lithuanian cereal and dairy farms is to find a balance between supporting small and large farms.

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