Firm Flexibility in the EU Dairy Processing Industry

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1 Introduction

The ability to adjust to changing economic conditions is a crucial firm asset. Particularly production flexibility, i.e. firms` capability to adapt output under constant average costs, is an important factor for firms` competitiveness in dynamic environments. This is particularly relevant for the EU food industry, a sector characterized by high saturation, strong downstream bargaining power, and fluctuating input prices (Banterle et al. 2013).

The dairy processing sector is chosen as it is characterized by strong fluctuations in market environments, e.g., the end of the quota system, rapid changes in consumers' preferences and the Russian ban on EU food (Hirsch and Hartmann 2014)

2 Objectives

- Derive measures of firm flexibility and to reveal how flexibility varies over time as well as across EU member states.
- Assess whether a trade-off between production flexibility and technical efficiency exists.
- Test if firm-specific characteristics such as firm size, financial risk, age, or capital intensity impact flexibility.
- Assess if flexibility can sustain profitability during economic crises.

3 Method

Stigler (1939) defines flexibility as an attribute of a firm`s production technology to handle output variations at lower costs. Empirically this can be measured by the curvature –i.e. the second derivative– of a firm`s average variable cost (AVC) curve:

$$Flex = \partial^2 AVC \big/ \partial y^2 = 1\big/ y^3 (VC_{yy} y^2 - 2VC_y y + 2VC)$$

The lower (larger) the curvature of the AVC curve, the more (less) flexible a firm`s production technology (Renner et al. 2014).

- ➢ Problem: cost functions rely on input prices which are usually not available.
- ➢ Alternative approach: derive a flexibility measure based on input-distance functions (D) and the duality theorem (Renner et al. 2014):

$$Flex = 1\big/ y^3 \left(1\Big/ \sum_n D_{Xn} \left(D_y^2 + \mathbf{D_{yx}} (\mathbf{D_{xx}} + \mathbf{D_x} \mathbf{D'_x})^{-1} \mathbf{D_{xy}} + D_{yy}\right) y^2\right) + 2(D_y y + 1)\Big/ \sum_n D_{Xn}$$

where *D..* and **D..** are (matrices of) first and second derivatives of the input-distance function $D(\mathbf{x},k,y)$ w.r.t. inputs **x,** k and output y.

$D(\mathbf{x},y)$ can be empirically estimated using stochastic frontier analysis:

$$\ln D(\mathbf{x}, y) = \beta_0 + \beta_1 \ln(y) + \sum_{n=1}^{N} \beta_n \ln(x_n) + \sum_{m=1}^{M} \beta_m \ln(k_m) + 0.5\beta_2 (\ln(y)^2) + 0.5\sum_{n}^{N}\sum_{l}^{L} \beta_{nl} \ln(x_n)\ln(x_l) + 0.5\sum_{m=1}^{M}\sum_{k=1}^{K} \beta_{mk} \ln(k_m)\ln(k_k) + \sum_{n=1}^{N} \beta_{ny} \ln(x_n)\ln(y) + \sum_{m=1}^{M} \beta_{my} \ln(k_m)\ln(y) + \sum_{n=1}^{N}\sum_{m=1}^{M} \beta_{nm} \ln(x_n)\ln(k_m) + \sum_{n=1}^{N} \phi_t$$

Determination of flexibility drivers using a dynamic panel model:

$$Flex_{i,t} = \beta_0 + \beta_1 Flex_{i,t-1} + \sum_n \beta_n x_{n,i,t} + \phi_C + \mu_i + \varepsilon_{i,t}$$

4 Data

- Accounting data of dairy processors provided by the AMADEUS database, a trans-European database of financial information (Hirsch and Hartmann 2014).
- AMADEUS comprises firms of all legal forms and size classes.
- Operating revenue is used as the output measure (y). Material- and staff costs are used as variable inputs (x). Fixed assets are used as a quasi-fixed input (k).
- Focus on seven countries, including 2767 dairy processors: France, Germany, Italy, Poland, Portugal, Romania, and Spain.
- Period 2006-2014.

5 Results and discussion

Median *Flex* and technical efficiency (2006-2014)

	France	Germany	Italy	Poland	Spain
Flex	-135.167 (2032.280)	-4153.708 (6954.430)	-104.007 (930.620)	-92.401 (1555.560)	-122.109 (1857.900)
Technical Efficiency	0.948	0.890	0.924	0.998	0.922
Correlation[a]	0.432***	0.686***	0.617***	0.549***	0.261***

Note: Standard deviations in parentheses; Values for technical efficiency close to 1 indicate high efficiency
*** significant at the 1%-level; [a]Spearman`s rho

- Less flexible production systems prevail in Italy and Poland while flexibility is highest in France and Germany.
- Negative correlation between flexibility and technical efficiency. This trade-off between flexibility and efficiency reveals that a sole focus on firm efficiency would be misleading. In contrast, firms' ability to adjust to shocks needs to be explicitly considered.

GMM dynamic panel model results

	Constant	$Flex_{t-1}$	Firm size	Gearing	Firm age	Capital intensity
Coefficients	2927.294*** (746.612)	0.419*** (0.169)	-349.918*** (78.032)	0.584 (0.456)	4.821* (2.532)	-506.931 (533.846)
Wald	$\chi^2_{(9)} = 247.92$*** p=0.000					

Note: Robust standard errors in parentheses; *** significant at the 1%-level; Country & legal form dummies included
AR(2): z = 0.84 p=0.402
Sargan-Hansen: $\chi^2_{(130)} = 140.28$ p=0.254

- AR coefficient confirms the dynamic structure and indicates that flexibility is persistent over time.
- Firm size significantly increases production flexibility.
- Firm age has a negative impact on production flexibility.

To assess whether flexibility can help firms to remain competitive during economic crisis

- we used Propensity Score Matching to derive comparable samples of high/low flexibility firms regarding size, age, gearing & capital intensity.
- Those samples can be compared regarding ROA growth during 2008/2009.

Median ROA growth between 2008/09 for high and low flexibility firms

	France	Germany	Italy	Poland	Spain
Low flexibility	0.008	-0.163	-0.063	-0.480	-0.154
High flexibility	0.136	0.095	0.042	-0.163	-0.127

- ROA growth rates of high flexibility firms are less affected by the economic crisis

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