EU harmonization of regulations, competition and firm-level productivity growth in the Dutch food industry

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December 2009

Motivation

- Previous research has identified the actual trade gains from the EU harmonization of food regulations.
  - Examples include the CEC report, 1997; Henry de Frahan and Vancauteren, 2006; Chevassus-Lozza *et al.*, 2008
- However little is known on how these particular trade liberalization measures may impact productivity?
  - Empirical firm/plant level studies on the *direct* relationship between trade liberalization and productivity offers conflicting answers.
  - Only robust evidence is a positive relationship between export participation and productivity of firms (self-selection).

- to empirically examine the direct and indirect impacts of TBT harmonization on TFPG.
  - the general presumption is that trade liberalization has a positive impact on productivity through the effect of competitive pressures to which domestic firms are exposed
  - *direct*: resource allocation effect
  - *indirect*: resource allocation effect via a mechanism of e.g., market structure
- provide more insights into the empirical tractability of this indirect link
  - Given: empirical work points towards substantial industry/firm and time **variance** of markups: e.g., Diewert and Fox, 2009; De Loecker, 2007, 2009; Botasso et al. 2001; Balk et al., 2009; Kort et al. (2009)
  - Extensions: Bernard et al. (2003); Melitz and Ottaviano (2008) and Baldwin and Forselid (2006); Chen, Imbs and Schott (2009)

- propose using production theory, a theoretically consistent framework
  - a correct estimate of market power based on variable markups and adjusted for variable scale economies (Corsetti et al., 2007)
  - Consistent TFP measure adjusted for markups
- Data: use an unbalanced panel production statistics of 28216 observations spanning over 1979-2005 and 15 Dutch food sectors from the production statistics
- food TBT database
  - further extension/update to a purpose-built database on TBTs at the level of CN 8-digits –
    - inclusion of Commission regulations
    - assign weights to the technical importance by using forward citations (up to 2009) on *counts* (number of directives per product)

Markups, scale economies and TFP growth

Markups

We let each firm (industry) $i \in \{1, ...N)$ face the following production function for period t:

$$y_{it} = a_{it} f_i(\mathbf{x_{it}}) \qquad i = 1, 2, \ldots N \; ; \; t = 0, ..., T, \tag{1}$$

where y_{it} measures firm i's gross output, $\mathbf{x_{it}} \equiv (x_{i1t}, x_{i2t}, \ldots, x_{iJ_it})'$ denotes the vector of J_i non-negative factor inputs, $f_i(\cdot)$ is the core of the (differentiable) production function and a_{it} is TFP measured as Hicks-neutral disembodied technical change.

We can write firm i's profit optimization problem as follows:

$$\max_{y_{it},\, \mathbf{x_{it}}} \; p_{it}(y_{it})\, y_{it} - \mathbf{w_{it}'x_{it}} : y_{it} = a_{it} f_i(\mathbf{x_{it}}) \tag{2}$$

where $\mathbf{w_{it}} \equiv (w_{i1t}, w_{i2t}, \ldots, w_{iJ_it})'$ is the sector's vector of J_i input prices, and $p_{it}(y_{it})$ is the inverse demand function which represents the market price as a function of firm's output.

The first order conditions implied by (2) yield the following equations:

$$p_{it}(y_{it}) + \frac{\partial p_{it}(y_{it})}{\partial y_{it}} y_{it} = c_{it} \text{ and} \tag{3}$$

$$\left[p_{it}(y_{it}) + y_{it} \frac{\partial p_{it}(y_{it})}{\partial y_{it}} \right] \frac{\partial y_{it}}{\partial \mathbf{x_{it}}} = \mathbf{w_{it}}.$$

where c_{it} are the marginal costs.

For firm i the first order condition (F.O.C.) implied by the solution of (3) can be rewritten as:

$$\frac{p_{it}(y_{it}) - c_{it}}{p_{it}(y_{it})} = -\frac{\partial p_{it}(y_{it})}{\partial y_{it}} \frac{y_{it}}{p_{it}}, \tag{4}$$

or the Lerner index as a measure of a monopolist's market power is inversely related to the price elasticity of market demand,

$$L_{it} = \frac{1}{\varepsilon_{it}}, \tag{5}$$

where $\varepsilon_{it} \equiv -\frac{\partial y_{it}}{\partial p_{it}(y_{it})} \frac{p_{it}(y_{it})}{y_{it}}$ is firm i's elasticity of demand with respect to price[1] and $L_{it} \equiv \frac{p_{it}(y_{it}) - c_{it}}{p_{it}(y_{it})}$ is firm i's Lerner index or Price Cost Margin (PCM).

[1] The larger the elasticity of demand in absolute terms, the smaller the monopolistic firm's market power.

From (4) and (5) we obtain that the second F.O.C. in (3) can be rewritten as:

$$\mathbf{w_{it}} = \frac{\partial y_{it}}{\partial \mathbf{x_{it}}} p_{it}(y_{it})[1 - L_{it}],$$

or for any individual input factor $k \; \epsilon \; J_i$:

$$\frac{\partial \ln y_{it}}{\partial \ln x_{ikt}} \frac{y_{it}}{x_{ikt}} p_{it}(y_{it})[1 - L_{it}] = w_{ikt} : k = 1, 2, \ldots, J_i \; ; \; t = 0, ..., T \quad (6)$$

$$\frac{\partial \ln y_{it}}{\partial \ln x_{ikt}} = \frac{1}{[1 - L_{it}]} \frac{w_{ikt} x_{ikt}}{y_{it} p_{it}(y_{it})} = \mu_{it} s_{ikt},$$

where s_{ikt} denotes the share of input k in the total production value of firm i, or $s_{ikt} \equiv w_{ikt} x_{ikt} / \left[y_{it} p_{it}(y_{it}) \right]$, so that firm i's factor input share can be written as

$$s_{it} = \sum_{k=1}^{J_i} s_{ikt} = \mathbf{w'_{it}} \mathbf{x_{it}} / \left[y_{it} p_{it}(y_{it}) \right]. \quad (7)$$

The time-varying markup in (**??**) can be rewritten as,

$$\mu_{it} = \frac{y_{it} p_{it}(y_{it})}{\mathbf{w}'_{\mathbf{it}} \mathbf{x}_{\mathbf{it}}} \theta_{it} \tag{8}$$

where $\theta_{it} \equiv \sum_{k=1}^{J_i} \frac{\partial y_{it}}{\partial \mathbf{x}_{ikt}} \frac{\mathbf{x}_{ikt}}{y_{it}} = \sum_{k=1}^{J_i} \theta_{ikt}$.

- For simplicity, we assume that $\mu_{it} = \mu_t$; equivalent to assuming that the firm i's elasticity of demand with respect to price do not vary substantially across firms within the same sector.
  - Basus (2002); Diewert and Fox (2009), De Loecker (2007,2009), Botasso et al. (2001)
  - Alternatively, interactions with other firm specific variables (e.g., Konings et al. 2005; Bellone et al. 2005)
- In line with Basu and Fernald (2002), the correlation between economies of scale and markups, which is obviously also implied by (8), simply state that firms with increasing returns to scale, $\theta_{it} > 1$, must charge markups to cover their costs; on the hand, if profits are small, $\frac{y_{it} p_{it}(y_{it})}{\mathbf{w}'_{\mathbf{it}} \mathbf{x}_{\mathbf{it}}} \equiv 1$, μ_{it} and θ_{it} are similar.

Total Factor Productivity Growth

We now have the full ingredients to define productivity, relating differences in production between period t and some base period 0 as

$$\begin{aligned} \Delta \ln y_{it} &\equiv \ln y_{it} - \ln y_{i0} \\ &\equiv \ln f_i(\mathbf{x_{it}}) - \ln f_i(\mathbf{x_{i0}}) + \Delta \ln a_{it} \\ &= \frac{1}{2} \sum_k \left[\frac{\partial \ln f_i(\mathbf{x_{it}})}{\partial \ln x_{ikt}} + \frac{\partial \ln f_i(\mathbf{x_{i0}})}{\partial \ln x_{ikt}} \right] [\ln x_{ikt} - \ln x_{ik0}] \\ &\quad + \Delta \ln a_{it} \end{aligned} \tag{9}$$

Substituting the last equality of equation (6) in equation (9) yields:

$$\Delta \ln y_{it} \equiv \ln y_{it} - \ln y_{i0} = \frac{1}{2} \sum_k [\mu_{it} s_{ikt} + \mu_{i0} s_{ik0}] [\ln x_{ikt} - \ln x_{ik0}] + \Delta \ln a_{it}, \tag{10}$$

where the markup ratio, μ_{it}, may vary over time.

Estimation of Scale Elasticities

The translog assumption of the production form fits the index number approach developed in Nakajima *et al.* (1998, 2002, 2007) and Diewert and Fox (2009) for estimating the returns to scale parameter θ_t. The authors derive the following simple equation,

$$\Delta \ln y_{it} = tc_t + \theta_t \ln Q^T(\mathbf{w}_{i0}, \mathbf{w}_{it}, \mathbf{x}_{i0}, \mathbf{x}_{it}) + \varepsilon_{it}, \qquad i = 1, 2, \ldots N; \;\; t = 1, 2, .. \tag{11}$$

where $Q_T(\cdot)$ is the Tornqvist *aggregated* input quantity index (k_{it}, l_{it}, and m_{it}), θ_t is the estimate for the returns of scale parameter, tc_t measures technical change, and ε_{it} is the error term.

Sector	Firm-years	Elasticity of scale, (yearly regressions)	Elasticity of scale, (yearly reverse regressions)	Elasticity of scale, (panel regression)	Elasticity of scale, (panel regression)
		I	II	III	IV
Prod., preserving of meat (1511)	1705	0.998 (4, 20, 3)b	1.145 (1,17,9)	1.000 (0.009)c	1.157 (0.000)
Prod., preserving of poultry meat (1512)	934	1.023 (3,18,6)	1.037 (3,18,6)	0.999 (0.012)	0.965 (0.028)
Processing meat (1513)	2222	1.083 (4,16,7)	1.125 (2,15,10)	1.045 (0.041)	1.107 (0.000)
Proc. and pres. fish (152)	955	1.052 (6,15,6)	1.061 (4,21,2)	0.931 (0.000)	0.946 (0.000)
Proc. and pres. fruits & veget. (153)	1377	0.971 (2,23,2)	1.090 (9,17,1)	1.014(0.035)	0.900 (0.000)
Oils & fats (154)	318	0.964 (3, 21,3)	1.029 (0,19,8)	0.984 (0.147)	0.991 (0.442)
Dairy prod. (155)	1315	0.932 (9,18,0)	1.046 (5,20,2)	0.954 (0.000)	0.965 (0.000)
Grain mill prod. (156)	434	0.998 (6,19,2)	1.095 (5,21,1)	1.001 (0.096)	0.951 (0.000)
Prep. animal feed (157)	2363	0.971 (3,23,1)	1.049 (6,18,3)	0.983 (0.019)	0.943 (0.000)
Bread, fresh pastry & cakes, (1581)	10340	0.954 (14,10,3)	1.140 (16,10,1)	1.026 (0.000)	0.939 (0.000)
Biscuits, pres. Pastry & cakes (1582)	1686	0.971 (5,19,2)	1.016 (9,15,1)	0.998 (0.001)	0.894 (0.000)
Sugar (1583) + sugar conf., choc., cocoa (1584)	1286	0.957 (5,20,2)	1.066 (5,21,1)	0.984 (0.022)	0.954 (0.000)
Tea & coffee (1586)	1231	1.123 (0,19,8)	1.125 (2,17,8)	1.071 (0.001)	1.095 (0.000)
Condiments (1587)	1320	0.981 (5,19,3)	1.123 (5,16,6)	1.012 (0.042)	1.056 (0.071)
Other food prod. (1589)	730	0.986 (5,21,1)	1.061 (6,18,3)	0.984 (0.081)	0.974 (0.022)

Table 2: TFP growth and markups in the Dutch Food Processing Industry, 1979-2005

Sector	Markups	Markups1	TFPG (%)	TFPG1 (%)	TFPG2 (%)
Prod., preserving of meat (1511)	1.043 (.098)	1.228 (.167)	-1.825 (.099)	-1.525 (.102)	-.825 (.095)
Prod., preserving of poultry meat (1512)	1.022 (.068)	1.086 (.071)	-.625 (.050)	-.825 (.049)	-.212 (.047)
Processing meat (1513)	1.083 (.070)	1.205 (.094)	-.182 (.071)	-.321 (.077)	.421 (.078)
Proc. and pres. fish (152)	1.071 (.099)	1.156 (.106)	-.984 (.087)	-.912 (.097)	-1.104 (.088)
Proc. and pres. fruits & veget. (153)	1.062 (.085)	1.261 (.133)	.531 (.084)	.412 (.084)	.092 (.081)
Oils & fats (154)	1.034 (.074)	1.112 (.099)	-.106 (.047)	-.113 (.051)	-.091 (.049)
Dairy prod. (155)	1.023 (.118)	1.221 (.132)	1.000 (.034)	1.715 (.041)	2.041 (.037)
Grain mill prod. (156)	1.075 (.154)	1.231 (.187)	.758 (.031)	1.023 (.045)	1.427 (.036)
Prep. animal feed (157)	1.012 (.041)	1.101 (.048)	-.144 (.029)	.080 (.031)	-.227 (.031)
Bread, fresh pastry & cakes, (1581)	1.064 (.149)	1.353 (.133)	.489 (.041)	.924 (.053)	.741 (.048)
Biscuits, pres. Pastry & cakes (1582)	1.112 (.128)	1.187 (.127)	.585 (.038)	.483 (.042)	.574 (.044)
Sugar (1583) + sugar conf., choc., cocoa (1584)	1.031 (.109)	1.165 (.149)	.328 (.041)	-.198 (.044)	.208 (.043)
Tea & coffee (1586)	1.076 (.086)	1.185 (.196)	.826 (.037)	.709 (.038)	-.177 (.042)
Condiments (1587)	1.017 (.190)	1.352 (.362)	-.912 (.095)	-.692 (.087)	-.843 (.083)
Other food prod. (1589)	1.064 (.132)	1.281 (.279)	-.633 (.063)	-.543 (.090)	-.559 (.068)

EU harmonization of food regulations and productivity

$$
\begin{aligned}
TFP_{it} \quad = \quad & \overbrace{\alpha_0 + \sum_{\delta=t}^{T} \delta_t D_t^{TIME} + \sum_{\sigma=s}^{S} \sigma_s D_s^{SECTOR} + \tau HARM_{it}}^{Baseline} \\
& + \epsilon D_{it}^{EXP} \\
& + \kappa \mu_{st} + \pi(\mu_{st} HARM_{it}) + \nu_{it}
\end{aligned} \tag{12}
$$

with i, s and t indexing firm, sector and period respectively.
estimating parameters $\delta_t, \sigma_s, \tau, \epsilon, \kappa, \pi$
D^{TIME} = time dummies, D^{SECTOR} = sector dummies, D_{it}^{EXP} =dummy if firm i = exports
$HARM_{it}$ = export-citation weighted coverage ratio of TBT harmonization counts
μ_{st} = markup

- we propose a "fixed-effect" adjustment of the number of forward citation per regulation/Directive.
- we do so by dividing the number of forward citations of each individual regulation/directive with the average number of forward citations of the same publication year.
- For each firm we than compute the average of the "fixed effect" adjusted number of forward citations of the regulations/directives
- In order to minimize further the problem of truncation, we restrict our analysis to directives/regulations issued up to the year 2005 with forward citations of the most recent directives/regulations

Conclusion

- developed a framework where we integrate the impact of TBT liberalization on TFPG acounting for markups.
- Applying this analysis to thirteen industries in Dutch manufacturing and services for the period 1988-2006, we found that:
  - A majority of Dutch food industries are characterized by an oligopolistic structure.
  - The variation of market power within sectors over time is present
- When the adjustment of market power is made in addition to scale economies, the new TFPG rates vary according to both the competition measure and the industry
- Extension:
  - find an augmented measure of competition cleaned from a set of other alternatives (profit elasticity; Herfindahl)
  - link to an EU productivity database?