# Import Competition, Productivity and Multi-Product Firms

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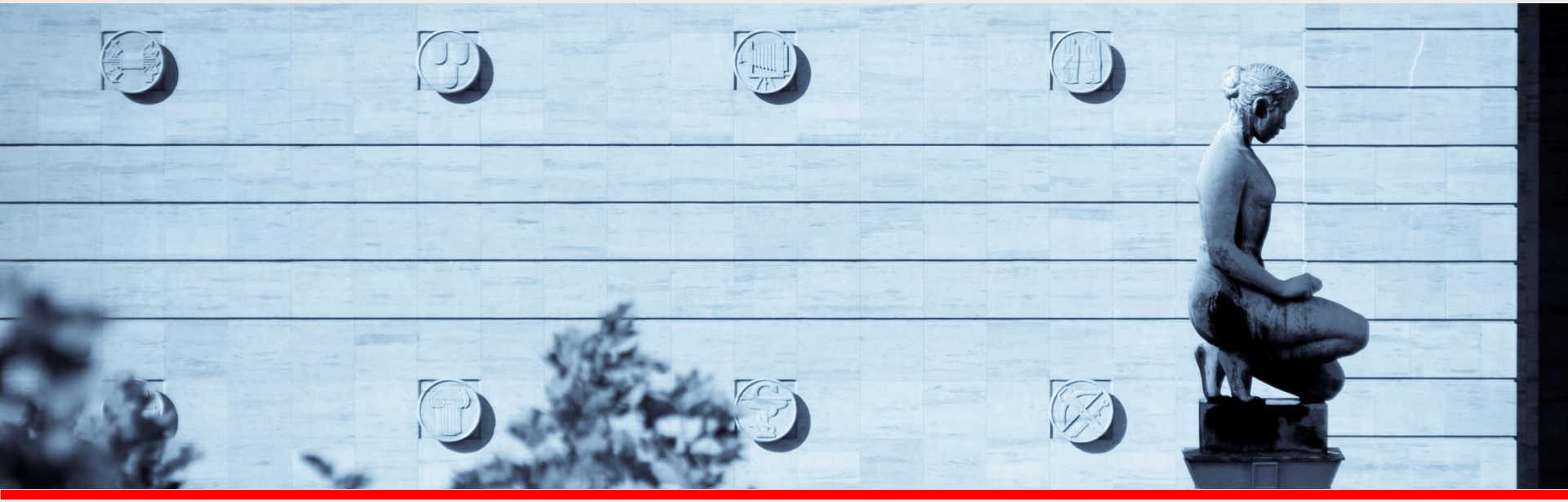



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# Motivation

- Import may affect efficiency in various ways :
  - Improves productivity of importers through sourcing of better and cheaper inputs (see the theoretical model in Antras et al., 2014, and Amiti et al., 2014, for empirical evidence for Belgium)
  - May have spillovers effects on domestic customers of Belgian importers
  - BUT also increases competitive pressures on domestic producers of imported goods
- Product market competition = mechanism to enhance efficiency (Aghion, Howitt, 1996, Holmes, Schmitz, 2010)
- Purpose : Does import competition enhance productivity ?
- To answer this question, one needs a good measure of import competition at the product or firm level and a good measure of productivity at the firm or firm x product level.

# Structure

- The quarterly dataset of Belgian manufacturing firms
- Methodological issues
  - Measuring TFP at the firm and firm x product level
  - Measuring import competition in a small open economy
- Production function estimation using firm and firm x product data – Some results
- TFP responses to changes in import competition
- Some tentative conclusions and avenues for future research

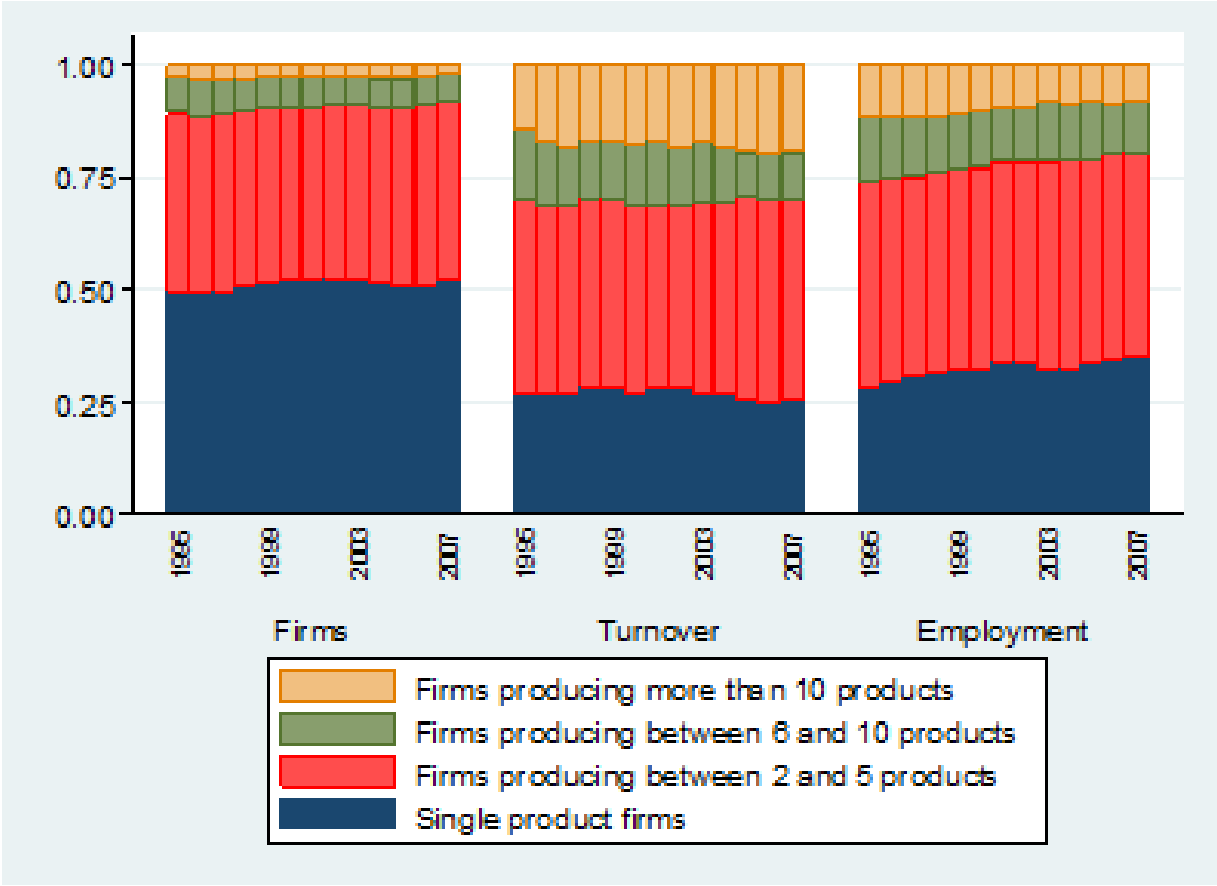
# Quarterly Dataset of Belgian manufacturing firms

- **Based on 5 data sources**
  - Industrial Production Survey (PRODCOM) + Individual VAT declarations + National Social Security declarations + Central Balance Sheet Office + IntraStat and ExtraStat international trade declarations
- Construct **quarterly time series**, at the firm level, for the 1995Q1 – 2007Q4 period
  - **Output variables:** total turnover, production by PRODCOM8 products in monetary and physical units
  - **Prices** : PRODCOM8 product specific unit values, Törnqvist price index
  - **Input variables:** total material inputs consumption, total employment, capital stock (computed using PIM with constant 8 % depreciation rate)
  - **Trade variables:** imports and exports by CN8 products
  - **Other variables:** investments and wages

# Total sample

- Sample coverage : 1995Q1 - 2007Q4
  - **# of firms:** 11,485
  - **# of products :** 3,792
  - **# of firms x products:** 42,568 (avg. 3,7 products per firm)
  - **# of observations:** 925,641 (avg. 21,5 quarters per firm x product)
- Why ending in 2007 ?
  - Revision of NACE classification ⇨ complete revision of PRODCOM classification ⇨ may introduce a major break in the product definitions
  - Revision of PRODCOM reporting threshold ⇨ reduction of the number of sample firms

# Single product and multi product firms



# Measuring total factor productivity

- **Should be easy** : TFP = residuals of production function estimation
- BUT **many** estimation problems (see Griliches, Mairesse, 1995), e. g.
  - **Input endogeneity**
    - Some inputs are correlated with the TFP shock
      ⇨ biased estimates of the production function coefficients
    - Specific estimation procedures: OP, LP, ACF, W-OP or W-LP
  - **Pricing heterogeneity**
    - LHS of production function: revenue or value added at the firm level, deflated using sector-level price deflator
    - Firm-specific relative price changes are included in the TFP shock
    - Solution : use firm-level specific price deflator or output in physical units
  - **How to deal with multi-product firms ?**
    - Is multi-product firms' technology the same as single product firms ? (De Loecker *et al.*, 2012)
    - Inputs allocation to multiple outputs

# Measuring total factor productivity – Our estimation framework

- 2 main specifications of production functions
  - **At the firm level**
    - Traditional Cobb-Douglas production function using deflated revenue as LHS

$$y_{it} = \beta_l \, l_{it} + \beta_k \, k_{it} + \beta_m \, m_{it} + \omega_{it} + \varepsilon_{it}$$

    - Two deflators : sector-level domestic PPI vs Törnqvist firm-level price index
    - Three levels of analysis : Manufacturing, NACE 2 digit, NACE 4 digit
  - At the product x firm level

# Measuring total factor productivity – Our estimation framework

- 2 main specifications of production functions
  - At the firm level
  - **At the product x firm level**
    - Extension of Dhyne, Petrin, Warzynski (2014) : production function for two product firms (Belgian bakeries producing bread and cakes)
    - Use production in physical units at the PRODCOM 8 digit level as LHS, based on Diewert (1973)

$$q_{ijt} = \beta_l \, l_{it} + \beta_k \, k_{it} + \beta_m \, m_{it} + \beta_{-j} \, r_{i,-j,t} + \omega_{ijt} + \varepsilon_{ijt}$$

    - Pooling firm x product data at the PRODCOM 2, 4 and 8 digit levels
    - Needs no explicit assumption on input allocation
    - Controls for the deflated revenue of the other products $r_{i,-j,t}$ , using firm-specific price index based only on the other products or a sectoral deflator
    - Allows to estimate a firm x product specific TFP

# Measuring total factor productivity – Our estimation framework

- Adjusting (W-)OP, (W-)LP to quarterly data
  - To estimate production function at very disaggregated level, one needs large sample
  - Belgian manufacturing firms = small sample for some specific sectors
    ⇨ to increase sample size, we moved from annual to quarterly data
  - Assumption : when making expectations on TFP in *t*, firms used 1 year lagged info, instead of 1 quarter lagged info

$$\mathrm{E}[\omega_t \mid \omega_{t\text{-}4}] = \mathrm{q}(\mathbf{c}(i_{t\text{-}4}, k_{t\text{-}4})'\beta_\omega) \quad \text{or} \quad \mathrm{E}[\omega_t \mid \omega_{t\text{-}4}] = \mathrm{q}(\mathbf{m}(m_{t\text{-}4}, k_{t\text{-}4})'\beta_\omega)$$

  - Wooldridge valid instruments : $k_t$, $k_{t\text{-}4}$, $i_{t\text{-}4}$ or $m_{t\text{-}4}$, $m_{t\text{-}1}$, $l_{t\text{-}1}$
  - For MPPF : add $r_{(\text{-}j)\,t\text{-}1}$ as valid instrument

# Production function estimation using firm level data

- Estimation by NACE rev 2. 2 digit level
- LHS : quarterly real total turnover (in logs)
- Only present W-OP estimation with firm specific price deflator

| | $\beta_l$ | $\beta_k$ | $\beta_m$ | # obs. |
|---|---|---|---|---|
| Manufacture of food products | 0.126*** | 0.084*** | 0.807*** | 18,613 |
| | (0.00) | (0.01) | (0.00) | |
| Manufacture of beverages | 0.098*** | 0.126** | 0.769*** | 1,636 |
| | (0.01) | (0.05) | (0.01) | |
| Manufacture of textiles | 0.157*** | 0.106*** | 0.775*** | 4,510 |
| | (0.01) | (0.02) | (0.01) | |
| Manufacture of wearing apparel | 0.159*** | 0.011 | 0.812*** | 2,745 |
| | (0.01) | (0.04) | (0.01) | |
| Manufacture of wood and of products of wood and cork | 0.151*** | 0.070*** | 0.769*** | 4,465 |
| | (0.01) | (0.02) | (0.01) | |
| Manufacture of paper and paper products | 0.190*** | 0.108*** | 0.760*** | 3,305 |
| | (0.01) | (0.02) | (0.01) | |
| Printing and reproduction of recorded media | 0.308*** | 0.115*** | 0.607*** | 9,014 |
| | (0.01) | (0.01) | (0.01) | |
| Manufacture of chemicals and chemical products | 0.102*** | 0.089*** | 0.846*** | 5,320 |
| | (0.01) | (0.02) | (0.01) | |
| Manufacture of pharmaceutical products | 0.136*** | 0.076 | 0.815*** | 1,046 |
| | (0.02) | (0.05) | (0.02) | |
| Manufacture of rubber and plastic products | 0.168*** | 0.129*** | 0.753*** | 7,033 |
| | (0.01) | (0.02) | (0.01) | |

| | $\beta_l$ | $\beta_k$ | $\beta_m$ | # obs. |
|---|---|---|---|---|
| Manufacture of other non-metallic mineral products | 0.184*** | 0.059*** | 0.767*** | 8,424 |
| | (0.00) | (0.01) | (0.00) | |
| Manufacture of basic metals | 0.161*** | 0.047 | 0.800*** | 2,861 |
| | (0.01) | (0.03) | (0.00) | |
| Manufacture of fabricated metal products | 0.263*** | 0.100*** | 0.673*** | 21,155 |
| | (0.00) | (0.01) | (0.00) | |
| Manufacture of computer, electronic and optical products | 0.199*** | 0.045 | 0.775*** | 1,341 |
| | (0.02) | (0.05) | (0.01) | |
| Manufacture of electrical equipment | 0.243*** | 0.149*** | 0.740*** | 1,905 |
| | (0.01) | (0.04) | (0.01) | |
| Manufacture of machinery and equipment n.e.c. | 0.279*** | 0.056** | 0.697*** | 7,622 |
| | (0.01) | (0.02) | (0.01) | |
| Manufacture of motor vehicles, trailers and semi-trailers | 0.167*** | 0.031 | 0.795*** | 1,677 |
| | (0.01) | (0.04) | (0.01) | |
| Manufacture of furniture | 0.224*** | 0.116*** | 0.719*** | 6,988 |
| | (0.01) | (0.02) | (0.01) | |
| Other manufacturing | 0.207*** | 0.057 | 0.762*** | 1,911 |
| | (0.01) | (0.04) | (0.01) | |

# Production function estimation using firm level data

- Estimation for 114 NACE rev 2. 4 digit level industries
- LHS : deflated total quarterly income
- Only present W-OP estimation with firm specific price deflator
- Only present sub-sectors of “Manufacture of food products”

| | $\beta_l$ | $\beta_k$ | $\beta_m$ | # obs. |
|---|---|---|---|---|
| **Manufacture of food products** | **0.123*** (0.00)** | **0.084*** (0.01)** | **0.813*** (0.00)** | **16,903** |
| Processing and preserving meat | 0.126*** (0.01) | -0.05 (0.05) | 0.863*** (0.01) | 370 |
| Processing and preserving of poultry meat | 0.103*** (0.01) | 0.127*** (0.04) | 0.873*** (0.01) | 813 |
| Production of meat and poultry meat products | 0.094*** (0.01) | 0.106*** (0.03) | 0.876*** (0.01) | 2,595 |
| Processing and preserving of fish | 0.050** (0.02) | 0.03 (0.04) | 0.910*** (0.010) | 469 |
| Processing and preserving of potatoes | 0.030 (0.05) | -0.057 (0.15) | 0.880*** (0.03) | 386 |
| Processing and preserving of fruits and vegetables | -0.033 (0.02) | -0.037 (0.09) | 0.949*** (0.03) | 671 |
| Manufacture of ice cream | -0.015 (0.07) | 0.455*** (0.14) | 0.828*** (0.03) | 212 |

| | $\beta_l$ | $\beta_k$ | $\beta_m$ | # obs. |
|---|---|---|---|---|
| **Manufacture of food products** | **0.123*** (0.00)** | **0.084*** (0.01)** | **0.813*** (0.00)** | **16,903** |
| Manufacture of grain mill products | 0.121*** (0.02) | 0.095** (0.04) | 0.829*** (0.01) | 439 |
| Manufacture of bread and cake | 0.261*** (0.01) | 0.116*** (0.02) | 0.668*** (0.01) | 5,235 |
| Manufacture of rusks and biscuits | 0.107*** (0.02) | 0.020 (0.03) | 0.851*** (0.01) | 941 |
| Manufacture of cocoa, chocolate and sugar | 0.141*** (0.01) | 0.113*** (0.04) | 0.826*** (0.01) | 1,973 |
| Processing of tea and coffee | 0.071** (0.02) | 0.240*** (0.06) | 0.821*** (0.02) | 313 |
| Manufacture of condiments and seasonings | 0.184*** (0.02) | 0.080 (0.06) | 0.836*** (0.01) | 476 |
| Manufacture of other food products N.E.C | 0.041* (0.02) | 0.136** (0.04) | 0.921*** (0.02) | 656 |

# Production function estimation using firm x product level data

- Pooling of PRODCOM products by PRODCOM 2, 4 or 8 digit level
- LHS : production in physical units (in logs)
- Only pooling products expressed in the same (most common) unit
- Only considering the 3 main products of a firm
- The revenue coming from the remaining products of the firm's product portfolio is deflated using a firm specific price index for the remaining products or the NACE 2 digit PPI
- We only present results for PRODCOM2 digit level
- For more refined level of analysis, estimation is very data demanding ⇨ we only get reasonable estimates for the largest samples at PRODCOM4 or PRODCOM8 level

# Production function estimation using firm x product level data

- Results for PRODCOM2 digit level (W-OP)

| | $\beta_l$ | $\beta_k$ | $\beta_m$ | $\beta_{-j}$ | # obs. |
|---|---|---|---|---|---|
| Food products and beverages | 0.211*** | 0.115*** | 1.192*** | -0.534*** | 17,565 |
| | (0.02) | (0.04) | (0.02) | (0.02) | |
| Textiles | -0.041 | 0.421*** | 1.391*** | -0.451*** | 1,656 |
| | (0.05) | (0.12) | (0.07) | (0.03) | |
| Wearing apparel; fur | 0.343** | 0.114 | 1.230*** | -0.714*** | 1,249 |
| | (0.11) | (0.23) | (0.15) | (0.17) | |
| Pulp, paper and paper products | 0.015 | 0.158 | 1.003*** | -0.375*** | 1,568 |
| | (0.07) | (0.15) | (0.06) | (0.03) | |
| Chemicals, chemical products and man-made fibers | 0.045 | 0.170* | 1.491*** | -0.444*** | 3,905 |
| | (0.05) | (0.08) | (0.05) | (0.03) | |
| Rubber and platic products | 0.098 | 0.372*** | 1.267*** | -0.563*** | 3,982 |
| | (0.06) | (0.11) | (0.06) | (0.04) | |
| Other non metallic mineral products | 0.271*** | 0.376*** | 0.775*** | -0.399*** | 3,875 |
| | (0.06) | (0.10) | (0.05) | (0.02) | |
| Basic metals | 0.185** | 0.125 | 1.501*** | -0.741*** | 1,935 |
| | (0.07) | (0.17) | (0.07) | (0.06) | |
| Fabricated metal products | 0.906*** | 0.447*** | 0.458*** | -0.543*** | 3,456 |
| | (0.07) | (0.13) | (0.05) | (0.03) | |
| Machinery and equipment | 0.082 | 0.981*** | 1.232*** | -0.455*** | 1,204 |
| | (0.12) | (0.19) | (0.07) | (0.07) | |
| Electrical machinery and aparatus N.E.C. | -0.422 | 0.122 | 1.590*** | -0.268* | 643 |
| | (0.24) | (0.14) | (0.25) | (0.14) | |
| Furnitures; other manufactured goods N.E.C. | 0.770*** | 1.014*** | 1.001*** | -0.439*** | 4,147 |
| | (0.07) | (0.12) | (0.07) | (0.03) | |

# Measuring import competition in a small open economy

- How to measure import competition ?
  - $IPR_t = \frac{M_t}{Y_t + M_t - X_t}$ or $IS_t = \frac{M_t}{Y_t + M_t}$
    - Macro IPR OK but product specific IPR noisy (IPR < 0, |IPR| >>>0)
    - IS always between 0 and 1

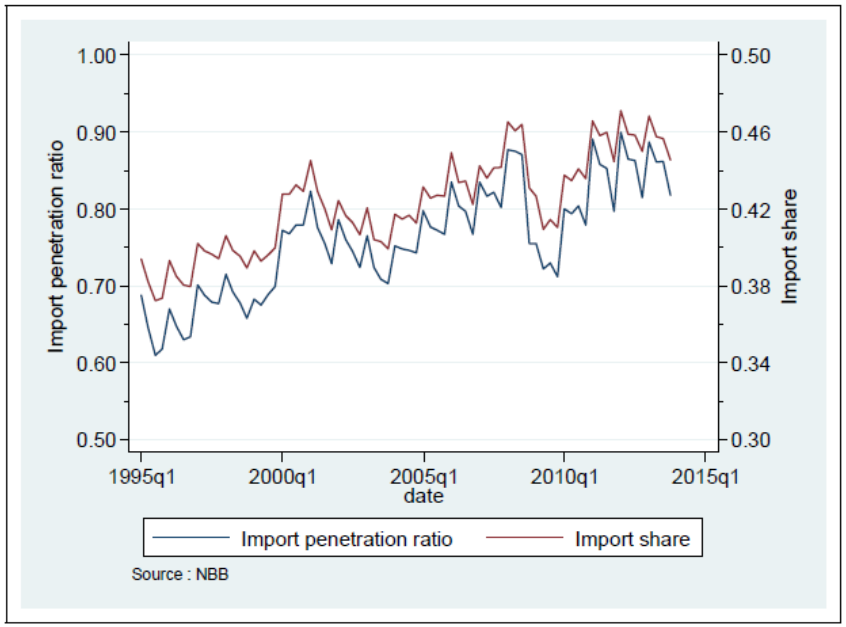



Figure 2: Belgium macroeconomic import competition index

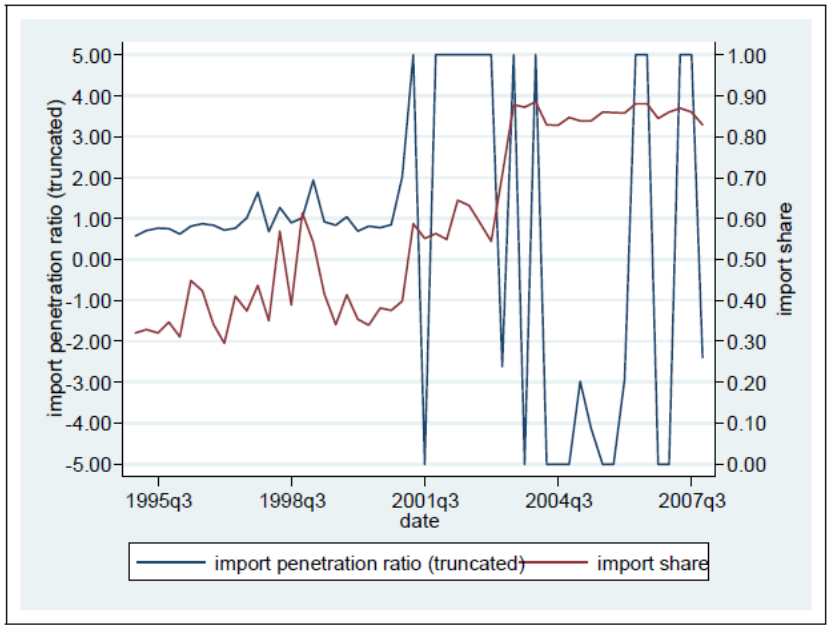



Figure 3: Import competition index for shampoos

# Measuring import competition in a small open economy

## ► Import competition in a small open economy

- Belgium = small economy with a world class harbor
- Belgium = entry into EU => large share of imports are re-exported
- Need to correct for re-export : net imports at the product x firm level

$$\sum_i Max\{M_{ijt} - X_{ijt}, 0\}$$

controlling for transfer pricing

⇨ 3 measures of import shares at the product level :

- using imports in monetary units (IS1) or physical units (IS2)
- using net imports in physical units (IS3) (**our preferred measure**)

- Import competition at the firm level
  - weighted average of product specific import shares using the product portfolio of the firm

# Production efficiency and import competition

- Production efficiency and firm-specific import competition
  - Only select firms with positive import shares for all the products in their product mix
  - Cleaning of TFP outliers (Q2 +/- 3 IQR) by NACE 4 digit industries
  - $\omega_{it} = \delta_{jt} + \gamma\, IS_{i,t-4} + \epsilon_{it}$ or $\omega_{it} = \delta_{jt} + \gamma\, IS_{i,t-4} + \rho\, \omega_{i,t-4} + \epsilon_{it}$
  - Results presented for firm-level TFP based on W-OP
  - Only considering NACE rev. 2 industries with positive coef. for 3 inputs + return to scale between 0.7 and 1.4

| | Import share in value (IS1) | | | | Net import share in quantities (IS3) | | | |
|---|---|---|---|---|---|---|---|---|
| | NACE 2 digit | | NACE 4 digit | | NACE 2 digit | | NACE 4 digit | |
| L4.ISx | 0.043*** | 0.009 | 0.087*** | 0.026*** | 0.033*** | 0.008 | 0.082*** | 0.024*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| L4.TFP | | 0.593*** | | 0.656*** | | 0.593*** | | 0.656*** |
| | | (0.00) | | (0.00) | | (0.00) | | (0.00) |
| Nobs | 53,901 | 38,893 | 46,090 | 33,169 | 53,901 | 38,893 | 46,090 | 33,169 |
| R-sq | 0.895 | 0.938 | 0.973 | 0.986 | 0.895 | 0.938 | 0.973 | 0.986 |

# Production efficiency and import competition

- Does the firms' response to increased foreign competition vary according to relative importance of the products in product mix ?
- TFP at the firm x product level and product specific import competition
  - Only consider 3 main products at the firm level
  - Cleaning of TFP outliers (Q2 +/- 3 IQR) by product
  - 6 specifications
    - $\omega_{jit} = \delta_j + \delta_t + \gamma_1 \, IS_{j,t-4} + \epsilon_{jit}$
    - $\omega_{jit} = \delta_j + \delta_t + \delta_k + \gamma_1 \, IS_{j,t-4} + \epsilon_{jit}$
    - $\omega_{jit} = \delta_j + \delta_t + \gamma_1 \, IS_{j,t-4} + \rho \, \omega_{ji,t-4} + \epsilon_{jit}$
    - $\omega_{jit} = \delta_j + \delta_t + \delta_k + \gamma_1 IS_{j,t-4} + \rho \, \omega_{ji,t-4} + \epsilon_{jit}$
    - $\omega_{jit} = \delta_j + \delta_t + \gamma_1 IS_{j,t-4} + \sum_{k=2}^{3} \gamma_k IS_{j,t-4} \times \left(Rank_{ji,t-4} = k\right) + \rho \, \omega_{ji,t-4} + \epsilon_{jit}$
    - $\omega_{jit} = \delta_j + \delta_t + \delta_k + \gamma_1 IS_{j,t-4} + \sum_{k=2}^{3} \gamma_k IS_{j,t-4} \times \left(Rank_{ji,t-4} = k\right) + \rho \, \omega_{ji,t-4} + \epsilon_{jit}$

(i = firm, j = product, t = time, k =product rank)

# Production efficiency and import competition

- Results presented for firm-level TFP based on W-OP
- Only considering estimation at the PRODCOM2 digit level, with positive coef. for the 3 inputs + return to scale between 0.7 and 1.4

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| IS1 | | | | | | |
| Import share (t-4) | -0.348*** | -0.298*** | 0.068 | 0.074 | 0.259*** | 0.165*** |
| | (0.086) | (0.081) | (0.049) | (0.048) | (0.050) | (0.051) |
| Productivity (t-4) | | | 0.889*** | 0.869*** | 0.872*** | 0.868*** |
| | | | (0.003) | (0.003) | (0.003) | (0.003) |
| 2nd product | | -0.400*** | | -0.076*** | | -0.035*** |
| | | (0.011) | | (0.006) | | (0.010) |
| 3rd product | | -0.977*** | | -0.211*** | | -0.175*** |
| | | (0.018) | | (0.010) | | (0.018) |
| Import share*2nd product | | | | | -0.256*** | -0.168*** |
| | | | | | (0.021) | (0.033) |
| Import share*3rd product | | | | | -0.570*** | -0.151*** |
| | | | | | (0.030) | (0.053) |
| $R^2$ | 0.981 | 0.983 | 0.997 | 0.997 | 0.997 | 0.997 |
| IS3 | | | | | | |
| Import share (t-4) | -0.386*** | -0.330*** | 0.012 | 0.014 | 0.201*** | 0.079* |
| | (0.073) | (0.068) | (0.042) | (0.041) | (0.044) | (0.046) |
| Productivity (t-4) | | | 0.896*** | 0.873*** | 0.880*** | 0.872*** |
| | | | (0.003) | (0.004) | (0.003) | (0.004) |
| 2nd product | | -0.366*** | | -0.065*** | | -0.046*** |
| | | (0.011) | | (0.006) | | (0.009) |
| 3rd product | | -1.015*** | | -0.201*** | | -0.175*** |
| | | (0.017) | | (0.010) | | (0.015) |
| Import share*2nd product | | | | | -0.232*** | -0.103*** |
| | | | | | (0.024) | (0.035) |
| Import share*3rd product | | | | | -0.558*** | -0.131*** |
| | | | | | (0.034) | (0.050) |
| $R^2$ | 0.934 | 0.942 | 0.988 | 0.988 | 0.988 | 0.988 |

# Main conclusions and implications

- Multiple products matter
- Product level seems to be the correct level of analysis
- Allows to disentangle the various effects of import competition on the firm's efficiency.
- Increasing foreign competition in the core product of the firm seems to increase efficiency
- But increasing foreign competition in the non core products may have a negative impact in the efficiency of production of those non core products

# Steps for future research

- What is the impact of import competition on other key variables ?
  - Prices
  - # of products, product entry / exit
  - Diversification of the product portfolio
  - Quality of the products
  - Mark-ups and marginal costs

**Thanks for your attention**