Import Competition, Productivity and Multi-Product Firms

Emmanuel Dhyne (National Bank of Belgium)
Amil Petrin (University of Minnesota)
Valerie Smeets (Aarhus University)
Frederic Warzynski (Aarhus University)

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Motivation

- How to measure productivity for multi-product (MP) firms ?
- Recent emphasis in trade literature (Eckel-Neary, BRS, MMO,…)
- Idea: Within firms, productivity might vary depending on the rank of the product
- So far: Productivity literature mostly focused on firm-level measures
- This paper: provide a methodology to estimate physical productivity at the firm-product level (addressing pricing heterogeneity bias) for both single and multi-product firms
- Going back to classics in production theory: Diewert (1973) and Lau (1976)

Policy Question

- Old question in economics: link competition-productivity (Olley-Pakes; Pavcnik, etc…)
- This paper: once we have tools to estimate productivity at firm-product level, link with product-level import competition
- Using the most disaggregated/precise measure of product-level import competition available
- How to estimate the effect of competition on multi-product firms (and what they do)? Does the effect depend on the rank?

Main Findings of the Paper

- The level of aggregation matters for productivity estimation
  - Not all products a firm makes are equally productive
  - Productivity and rank are negatively correlated
- Import competition does not affect all products similarly
  - Rank of products matter
  - Competition positively affects the productivity of core products
  - The effect decreases the further away the product is from the core competence of the firm
  - While for the first 3 products, there is a positive effect of competition on productivity, products beyond rank 3 either exhibit no effect or a negative effect of competition

Agenda

1. Literature
2. Productivity and multi-product firms
3. Data
4. Our method: the multi-product transformation function
5. Productivity estimates
6. Link between productivity and import competition
7. Conclusions and future questions

MP Firms: Theory

- Eckel and Neary (2010), Bernard Redding and Schott (2010, 2011), Mayer, Melitz and Ottaviano (2014, 2015)
- Common factor: trade liberalization leads firms to focus on core competence products (reduce the product scope)
- Dhingra (2013): heterogeneous response in terms of product and process innovation following trade liberalization
- Eckel et al. (2015): product innovation depending on type of “competence” (cost based competence vs. quality based competition)

Competition and Productivity

- Very old question in economics
- Not so obvious: Schumpeterian and neo-Schumpeterian view (Aghion-Howitt, etc…)
  - Stealing effect: negative
  - Escaping competition effect: positive
- Recent contributions: Olley-Pakes, Pavcnik, De Loecker, etc…
- See the extensive review by Holmes and Schmitz (2011)

Productivity and Multi-Product Firms

- When estimating TFP, ideally, we should use physical quantity
  - As the production function is about production
- Most researchers use sales (or VA) instead of physical quantity as a measure of output
  - Sales deflated by a common deflator (producer price index at the industry level): leads to a bias (Klette and Griliches; De Loecker)
  - Assume that multi-product firms price their products similarly

Productivity and Multi-Product Firms

- In most cases, firms produce more than one product
  - Around 50% of firms are multi-product firms
- Why not simply use total quantity?
- Issue: hard to get a good measure of quantity
  - How do you add apples and bananas?
  - Or DVD players and aircraft engines?

How to Deal with MP Firms?

- Solutions
  1. Work only with **single product firms** (Foster et al., 2008)
     - If interested by multi-product firms, this will be an issue

How to Deal with MP Firms?

- Solutions
  1. Work only with single product firms (Foster et al., 2008)
  2. Stay at the firm-level and compute a **firm-specific price index** (e.g. Eslava et al., 2004; Smeets and Warzynski, 2013; WP of the paper)
     - Use firm-product level price information to construct a firm-level price index, using products share in firm's sales as weights
     - Deflate sales by the firm price index
     - Advantage: simple, keeps the analysis at the level of the firm, no assumption on input use
     - Advantage: control for different prices among products inside firms
     - Disadvantage: basically a trick to deal with MP firms, does not help understand what happens inside MP firms

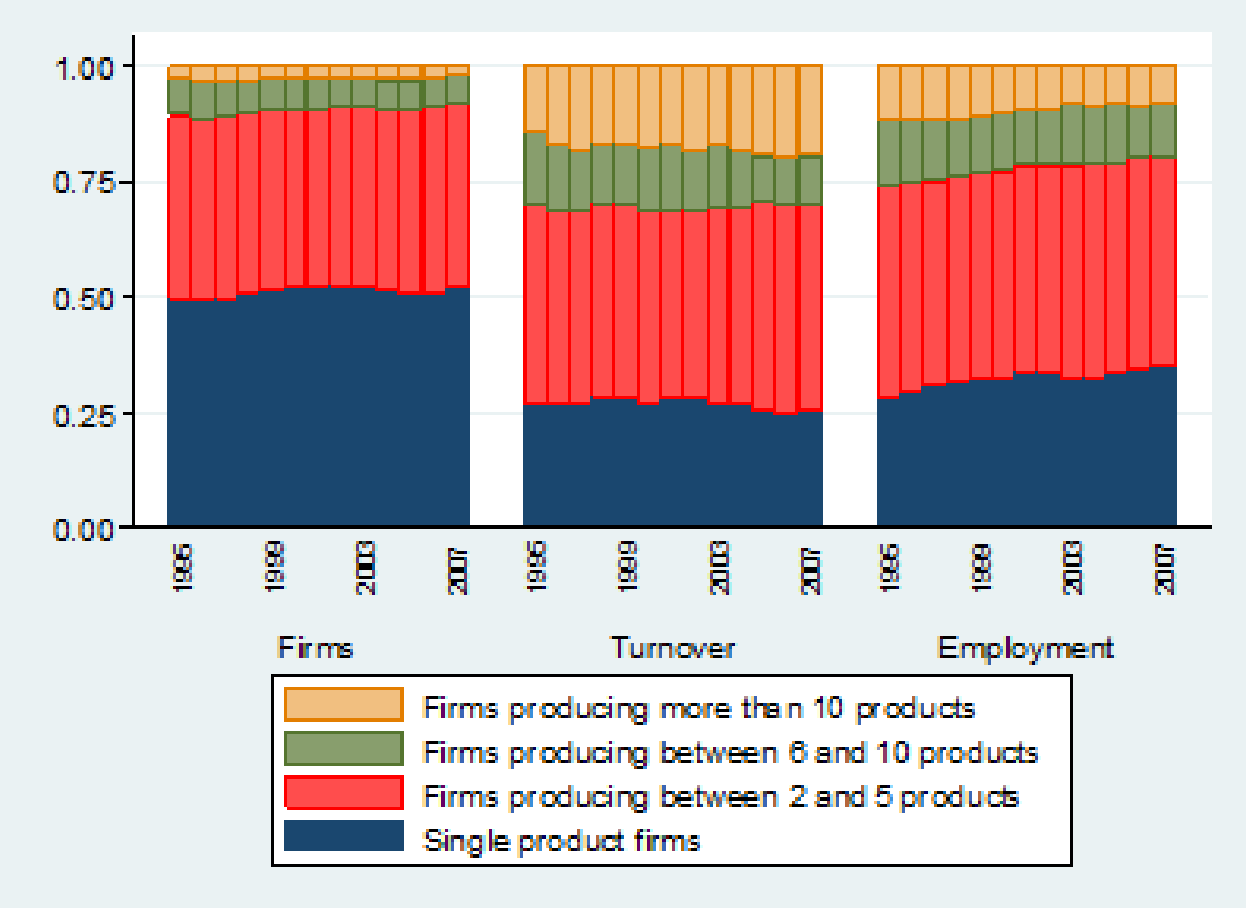
How to Deal with MP Firms?

- Solutions
  1. Work only with single product firms (Foster et al., 2008)
  2. Compute a firm-level deflator (firm-specific price index)
  3. Estimate **productivity at the firm-product level**
     - Recent models of MP firms consider a firm-product measure of productivity
     - Difficulty: how are inputs allocated between products?
     - De Loecker-Goldberg-Khandelwal-Pavcnick (DLGKP) suggest an algorithm to retrieve the share
     - We suggest another method where the share is not an issue – and with different assumptions
     - Our method allows us to obtain a firm-product level measure of productivity and to allow for economies of scope among products in a flexible way

Data

- Belgium: small open economy
- PRODCOM: firm-level **production**
  - Value and quantity
  - At the 8-digit level (prodcom8)
- **Trade** data: firm-product-country trade flows
  - Value and quantity
  - Also at the product level
  - Used to compute **import competition**
- **Accounting** information (firm-level)
  - Sales, revenues, Labor, materials, capital
- Period: 1997 to 2007, quarterly data

Single and Multiproduct Firms



Product Portfolio
(product is 8-digit prodcom)

	1	2	3	4	5	6+	N
	1.000	0.776	0.704	0.644	0.591	0.491	
		0.224	0.224	0.232	0.231	0.224	
share of product 3			0.072	0.092	0.108	0.119	
share of product 4				0.032	0.051	0.068	
					0.019	0.040	
						0.058	
# firms-quarter	62,069	33,675	16,661	9,975	5,861	13,920	142,161

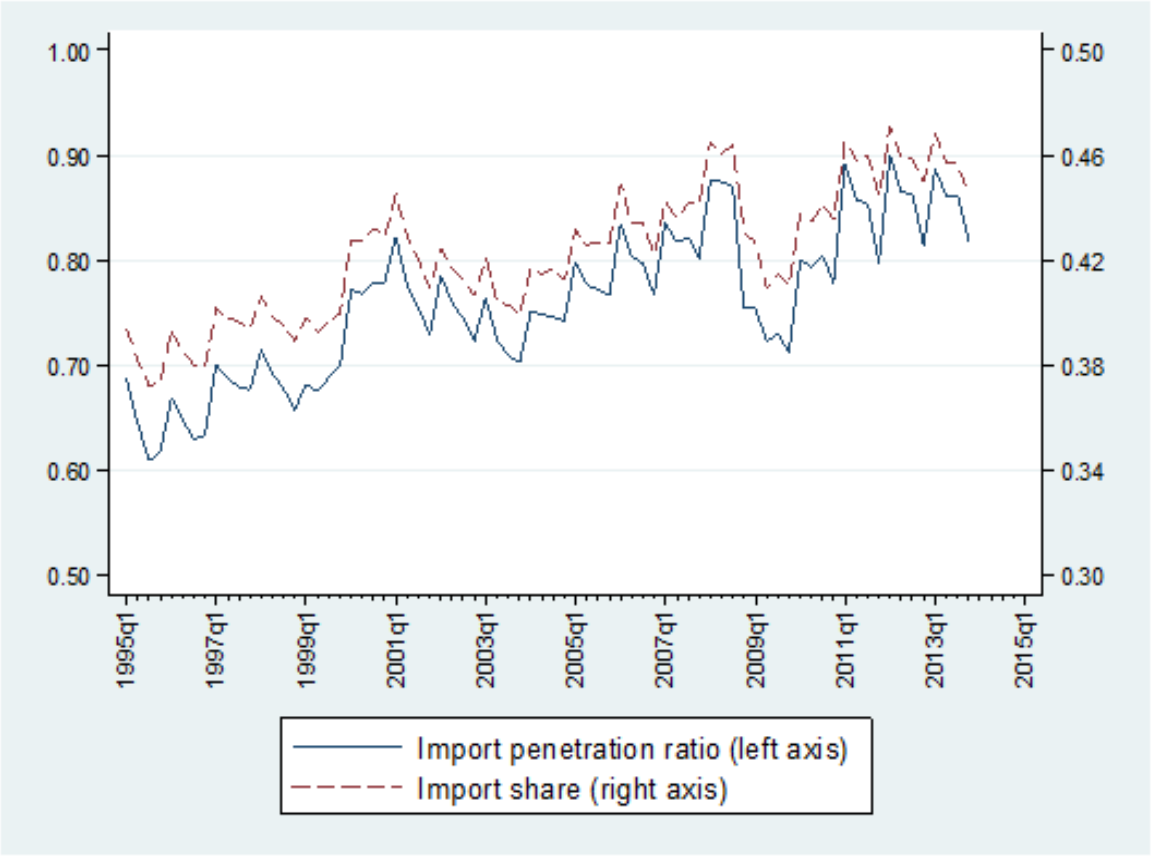
Import Competition

- Proxy import competition with **import share**

- Product-level: import share for a given product g in time t
  1. in value
  2. in quantity
  3. in quantity controlling for re-export

Aggregate Import Competition

a. Total economy



Product-level Import Shares

	Import shares computed in values				
	Mean	25th	Median	75th	N
All products					
1997	0.512	0.230	0.490	0.817	1,784
2007	0.580	0.303	0.590	0.896	1,880
Chemicals					
1997	0.535	0.246	0.501	0.839	355
2007	0.587	0.293	0.589	0.925	407
Food and beverages					
1997	0.473	0.189	0.428	0.753	270
2007	0.527	0.247	0.503	0.853	293
Machinery and equipment					
1997	0.598	0.331	0.647	0.881	276
2007	0.602	0.352	0.642	0.857	242
Fabricated metal products					
1997	0.568	0.257	0.590	0.888	128
2007	0.610	0.323	0.649	0.906	132
Rubber and plastic products					
1997	0.547	0.346	0.481	0.767	107
2007	0.576	0.342	0.552	0.867	107

Multi-product transformation function

- Our approach is based on results from Diewert (1973) and Lau (1976)
  - Diewert (1973) shows that under mild regularity conditions, there will exist a multi-product transformation function that relates the output of any good j to all the other goods a firm produces and to aggregate input use
    - Critical condition: the technology exhibit diminishing marginal rates of transformation of outputs for inputs (i.e., decreasing returns to scale), increasing marginal rates of substitution of outputs for outputs and diminishing marginal rates of substitution of inputs for inputs
  - Lau (1976) allows for more general setting where returns to scale can be overall increasing while allowing for declining marginal rates of transformation among at least some subset of inputs.

Multi-product transformation function

- Used for the joint production of bread and cake in Dhyne, Petrin and Warzynski, 2014
- Two products (bread and cake)

$$\ln q_{iBt} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \gamma_C \ln q_{iCt} + \omega_{iBt} + \eta_{iBt}$$

  - where q_{iBt} and q_{iCt} denote the output quantities of bread and cake respectively

- N products

$$\ln q_{igt} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \gamma_C \ln Q_{i(-g)t} + \omega_{igt} + \eta_{igt}$$

  - where q_{igt} denotes the physical quantity of a good g of firm i at time t and $Q_{i(-g)t}$ denotes a vector of the physical quantity of all the other goods produced by firm i

Multi-product transformation function

- Key advantage: aggregate levels of inputs can be used
- No need to make assumptions on how inputs are distributed among the multiple goods in production
  - As long as Diewert or Lau conditions hold
- We can also potentially test if conditions hold

Multi-product transformation function

$$\ln q_{igt} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \gamma_C \ln Q_{i(-g)t} + \omega_{igt} + \eta_{igt}$$

- Issue: how do we get $Q_{i(-g)t}$?
  - Simply adding a vector of q_s will not work (multidimensionality)
  - Sum the *q's*? Back to the problem to add DVD players and engines together (bread and cake, hats and bikinis)
- Solution 1: use the "pure" Diewert-Lau method (in progress)
  - Look at firms making only 2 products
  - Assess whether solution 1 proxy well for solution 2 for those firms
  - Problem: few environments with enough obs.
- Solution 2: use a hybrid-Diewert method
  - Use for $Q_{i(-g)t}$ the revenue of all the other goods produced by firm i deflated by a firm specific price index for all these other goods produced by the firm
  - Proxy, but allows to have an estimation generalized to more environments

Productivity Estimations

- **Product-level analysis (using quantity as output)**
  - Pure Diewert-Lau: estimation of q on q (PRODCOM4)
  - Hybrid Diewert-Lau: CN8 products pooled at the 2 digit PRODCOM level (to have enough observations)
  - Multi product firms (using “Diewert adjusted” method)
  - Single product firms

- Use various methods
  - **Focus on the Wooldridge OP estimator**
  - Robust to OLS, OP methods, Wooldridge LP
  - Working on augmented ACF (with input price heterogeneity bias – see DLGKP)

"Pure" Diewert-Lau: MPPF estimation – q_1 on q_2

Combo	L	K	M	Q_{other}	# obs.
2523-2812	0.038	0.387***	0.831***	-0.057***	558
	(0.063)	(0.106)	(0.067)	(0.020)	
1511-1513	0.352***	0.087	0.803***	-0.051***	408
	(0.055)	(0.096)	(0.045)	(0.011)	
2661-2663	0.127	0.563***	0.790***	-0.042***	327
	(0.120)	(0.165)	(0.068)	(0.017)	
2811-2812	0.266***	0.151	0.810***	-0.042***	272
	(0.045)	(0.126)	(0.039)	(0.015)	
3614-3612	0.641***	0.181	0.549***	-0.034***	245
	(0.103)	(0.182)	(0.076)	(0.009)	
1561-1571	0.362***	0.203*	0.554***	-0.120***	218
	(0.101)	(0.122)	(0.053)	(0.015)	

Description of the combo

2523	Manufacture of builders' ware of plastic –
2812	Manufacture of builders' carpentry and joinery of metal
1511	Production and preserving of meat -
1513	Production of meat and poultry meat products
3614	Manufacture of other furniture -
3612	Manufacture of other office and shop furniture
2811	Manufacture of metal structures and parts of structures –
2812	Manufacture of builders' carpentry and joinery of metal
2661	Manufacture of concrete products for construction purposes –
2663	Manufacture of ready-mixed concrete
1561	Manufacture of grain mill products -
1571	Manufacture of prepared feeds for farm animals

"Hybrid" Diewert-Lau: MPPF estimation – q_g on $Q_{i(-g)t}$

	L	K	M	Q_{other}	# obs.
Food products and beverages	0.090***	0.240***	1.280***	-0.570***	36,172
	(0.01)	(0.03)	(0.01)	(0.01)	
Chemicals, chemical products and man-made fibers	-0.186***	0.111	1.288***	-0.377***	9,818
	(0.03)	(0.08)	(0.03)	(0.02)	
Furnitures; other manufactured goods N.E.C.	0.396***	0.384***	1.281***	-0.496***	7,471
	(0.04)	(0.11)	(0.04)	(0.02)	
Rubber and plastic products	0.021	0.132	1.274***	-0.562***	7,238
	(0.04)	(0.08)	(0.03)	(0.02)	
Other non metallic mineral products	0.400***	0.479***	0.782***	-0.474***	6,373
	(0.04)	(0.09)	(0.03)	(0.02)	
Machinery and equipment	0.436***	0.387**	1.203***	-0.682***	5,771
	(0.07)	(0.13)	(0.06)	(0.04)	
Fabricated metal products	0.464***	0.573***	1.049***	-0.601***	8,374
	(0.04)	(0.07)	(0.04)	(0.02)	
Basic metals	-0.013	0.118	1.516***	-0.528***	3,987
	(0.05)	(0.13)	(0.05)	(0.04)	
Textiles	-0.027	0.479***	1.221***	-0.462***	6,458
	(0.03)	(0.08)	(0.03)	(0.02)	
Wearing apparel; fur	0.036	0.141	1.348***	-0.832***	4,688
	(0.04)	(0.15)	(0.08)	(0.09)	
Pulp, paper and paper products	0.151**	0.189	1.056***	-0.386***	3,357
	(0.05)	(0.13)	(0.05)	(0.02)	
Electrical machinery and aparatus N.E.C.	-0.126	0.362*	1.332***	-0.326***	2,278
	(0.10)	(0.16)	(0.08)	(0.04)	

PF estimation- Single product firms

	L	K	M	N
Fabricated metal products	0.247***	0.037	0.768***	8,723
	(0.03)	(0.07)	(0.03)	
Food products and beverages	0.168***	0.336***	0.657***	5,681
	(0.02)	(0.05)	(0.02)	
Other non metallic mineral products	-0.023	0.013	0.773***	5,374
	(0.02)	(0.06)	(0.02)	
Furnitures; other manufactured goods N.E.C.	-0.027	0.695***	0.471***	3,759
	(0.05)	(0.03)	(0.12)	
Chemicals, chemical products and man-made fibers	0.084	0.271***	0.676***	2,093
	(0.05)	(0.09)	(0.04)	
Textiles	-0.125***	0.176*	0.909***	4,071
	(0.04)	(0.10)	(0.03)	
Rubber and plastic products	-0.299***	0.082	1.160***	3,235
	(0.06)	(0.13)	(0.05)	

Link TFP-Import Share, Product

- Baseline

$$\omega_{igt} = \beta_1 IS_{g(t-4)} + \delta_t + \nu_g$$

- Add more controls (past productivity, rank of the product)

$$\omega_{igt} = \beta_1 IS_{g(t-4)} + \beta_2 \omega_{ig(t-4)} + \beta_3 rank_{igt} + \beta_4 IS_{g(t-4)} * rank_{igt} + \delta_t + \nu_g$$

Link TFPQ-Import Share, Multi product firms

	(1)	(2)	(3)
Import share defined in value			
Import share (t-4)	0.239***	0.244***	0.284***
	(0.026)	(0.026)	(0.029)
Productivity (t-4)	0.876***	0.849***	0.850***
	(0.002)	(0.002)	(0.002)
2nd product		-0.087***	-0.078***
		(0.005)	(0.008)
3rd product		-0.228***	-0.202***
		(0.007)	(0.012)
Higher than 3rd product		-0.348***	-0.297***
		(0.009)	(0.015)
Import share*2nd product			-0.032
			(0.021)
Import share*3rd product			-0.080***
			(0.028)
Import share*Higher than 3rd			-0.146***
			(0.033)
N	65,167	65,167	65,167
Adj. R^2	0.991	0.991	0.991

Link TFPQ-Import Share, Single product firms

Import share defined in quantity controlling for net imports

Dep. var.: Productivity	(1)	(2)
Import share (t-4)	0.027	0.110***
	(0.057)	(0.035)
Productivity (t-4)		0.716***
		(0.004)
N	24,183	24,183

“Robustness” Checks

- Translog specification: Wooldridge and ACF
  - with ACF: including import share in the law of motion of productivity (as suggested by DL)
  - also dealing with potential input price heterogeneity bias (see DLGPW)
- The pure Diewert: q1 on q2
  - More checks at the 4-digit (ACF etc…)
  - also trying at the 8-digit (constraint with # of obs.)

Conclusions

- Develop a new method (Hybrid Diewert) to estimate TFP with multi-product firms and pricing heterogeneity
- Policy question: link TFP and import competition
- Key results:
  - Import competition has a positive effect on firm-level productivity
  - The effect on firm-product-level productivity is not homogeneous
  - Rank of products matter
  - Competition positively affects the productivity of core products
  - The effect decreases the further away the product is from the core competence of the firm

Future Work

- Product dropping
  - Less productive products are more likely to be dropped
  - Non core products are more likely to be dropped
  - Import competition weakly increases dropping

Dep. Var: Product Dropping	(1)	(2)
TFPQ	-0.009***	-0.009***
	(0.00)	(0.00)
MS	0.016*	0.010
	(0.01)	(0.01)
Core product	-0.040***	-0.040***
	(0.01)	(0.01)
Product dummies	YES	YES
Quarter dummies	NO	YES
# obs.	44,776	44,776
Adj. R2	0.051	0.057