Prices, Markups and Quality at the Firm-Product Level

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

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Firm-product data and multi-product firms

- Many datasets recently made available in different countries contain information about which products firms are making, but also about the value and quantity of production (hence information about unit value, a proxy for price)
- Allows researchers to estimate demand elasticity and product quality
- Both for goods produced domestically and for imported/exported goods
- New theories of international trade study the optimal choice of product portfolio and how it varies after trade liberalization (e.g. Bernard, Redding and Schott, 2010, 2011; Mayer, Melitz and Ottaviano, 2011)

Productivity & Quality

- Related debate: can we separate productivity from quality? Our measure of TFP typically contains both!
- Even better: can we measure quality?
- Recent papers try to address this issue (including this one)
  - Aw, Lee and Roberts (2011) and Roberts et al. (2011): Taiwanese and Chinese data
  - Petrin and Warzynski (2011): Danish data

Related Literature

- Roberts and Supina (1996, 2000): US data
- Foster, Haltiwanger and Syverson (2008, 2011): US data
- Kugler and Verhoogen (2011): Colombian data

What we do in this paper/project

- Start by documenting firm-product pricing heterogeneity
- Estimate a firm-product cost function and marginal cost, then document MC heterogeneity
- From the two previous steps: compute a firm-product markup and document heterogeneity
- Estimate demand elasticity and firm-product product quality: document heterogeneity and correlation with other variables
- Estimate a MPPF and get estimates of firm-product TFPR & TFPQ

Empirical methodology, step 1: estimating marginal cost with MP firms (Roberts and Supina, 1996, 2000)

- estimate a cost function: $CT = CT(p_l, p_m, Q, R, D_t)$ where p_l represents the price of labor (average wage), p_M is the price of material (captured by the sector-specific material price index), Q is the output level of the product and R is the deflated value of output of all other products made by the firm. D_t is a vector of year dummies.
- use a translog functional form
- then construct marginal cost
- since we observe price, we can then easily compute the markup

Berry (1994), step 2

- The market share of product j is then

$$s_j(\delta) = \frac{e^{\delta_j}}{\sum_{k=0}^{N} e^{\delta_k}}$$

where $\delta_j = \beta x_j - \alpha p_j + \xi_j$

- we can estimate α (and β) with a simple IV regression:

$$\ln(s_j) - \ln(s_0) = \beta x_j - \alpha p_j + \xi_j$$

where we instrument for price.

Empirical methodology, step 3: estimate MPPF using the approach suggested by Diewert (1973)

- Diewert (1973): under mild regularity conditions, there exists a transformation function that relates the output of any good j to all other goods the firm produces and to aggregate input use
- We add to that setup a productivity term that we call ω_{it} which we assume follows a first-order Markov process and which may be correlated with both inputs and outputs We write the production function for firm i producing good j as

$$q_{ijt} = \beta_0 + \beta l_{it} + \beta_k k_{it} + \beta_m m_{it} + \gamma' q_{it,-j} + \omega_{it} + \eta_{it}$$

  where $q_{it,-j} = (q_{it1}, \ldots, q_{it,j-1}, q_{it,j+1}, q_{itJ})$ is the vector of quantities produced of other goods and η_{it} is an i.i.d. shock to production.
- Holding overall input use constant γ_k is the additional amount of output j that would result from reducing output k by one unit holding input use constant.

Data

- Belgian PRODCOM survey, 1995-2009 (2007?): firm-product level dataset with information about value and physical quantity
- Combined with Central Balance Sheet data (capital, labor, materials) to compute productivity
- Summary statistics
  - Number of firms by year and type of product portfolio (table 1)
  - Average number of products by firm

Table 1 : Structure of the Belgian PRODCOM database

Year	# of firms	Total amount produced (10^6€)	Avg # of prod.	Single product firms		Between 2 and 5 products		Between 6 and 10 products		More than 10 products	
				Share of firms	Share in total prod.	Share of firms	Share in total prod.	Share of firms	Share in total prod.	Share of firms	Share in total prod.
1995	6,066	88,841	2.9	47.3	25.2	40.3	40.9	8.2	15.3	4.2	17.6
1996	6,079	87,765	2.9	47.8	25.5	39.9	41.3	8.4	16.1	3.9	17.2
1997	6,226	95,105	2.8	48.9	25.6	39.8	40.2	8.0	15.3	3.4	18.0
1998	6,292	99,040	2.7	49.7	26.2	39.9	41.5	7.2	15.2	3.2	17.1
1999	6,949	97,810	2.6	50.5	27.8	39.7	41.8	6.9	13.0	2.9	17.4
2000	6,828	110,735	2.6	51.7	27.0	38.6	42.7	7.0	13.4	2.8	16.9
2001	6,861	114,103	2.6	51.4	28.9	39.1	39.6	6.6	16.1	2.9	15.4
2002	6,754	112,118	2.6	51.3	29.4	39.2	38.1	6.5	15.8	2.9	15.7
2003	6,684	115,992	2.6	51.0	29.7	39.7	36.2	6.1	16.1	3.2	18.0
2004	6,333	122,757	2.7	50.8	29.9	39.5	36.4	6.4	13.5	3.2	20.0
2005	6,035	127,022	2.7	49.9	29.8	40.6	40.5	6.3	10.0	3.3	19.7
2006	6,223	140,636	2.7	50.2	28.1	40.6	40.8	6.1	13.6	3.2	17.5
2007	6,157	148,659	2.6	50.7	28.1	40.2	40.5	6.1	13.5	3.0	17.9
2008	4,400	146,269	2.8	49.5	26.3	40.5	41.7	6.4	14.2	3.6	17.9
2009	4,308	116,558	2.7	49.2	28.4	41.2	41.5	6.1	12.1	3.4	18.0
2010	4,022	132,591	2.8	49.3	27.8	41.1	41.2	6.1	12.5	3.5	18.4

Source : own computation, PRODCOM Survey

Results: pricing

- evolution of price dispersion: more heterogeneity (table 3 and figure 1)
- relationship between price and size (table 4): larger firms have lower prices (except for ready-mix concrete)
- persistence (table 5)

Table 3a: Summary Statistics for Beer Prices

	Average	Median	Std. dev.	Coeff. Var.
1996	1.018	1.008	0.335	0.329
1997	1.081	0.987	0.408	0.377
1998	1.066	0.977	0.438	0.411
1999	1.096	1.022	0.468	0.427
2000	1.124	1.023	0.503	0.447
2001	1.077	1.027	0.456	0.423
2002	1.131	1.055	0.480	0.424
2003	1.149	0.983	0.521	0.454
2004	1.211	1.114	0.601	0.497
2005	1.198	1.221	0.549	0.458
2006	1.200	1.244	0.553	0.461
2007	1.274	1.227	0.626	0.491

Table 3b: Summary Statistics for Ready-mixed Concrete Prices

	Average	Median	Std. dev.	Coeff. Var.
1996	0.0237	0.0241	0.0047	0.201
1997	0.0234	0.0238	0.0045	0.191
1998	0.0233	0.0231	0.0049	0.211
1999	0.0236	0.0239	0.0058	0.247
2000	0.0247	0.0248	0.0084	0.341
2001	0.0249	0.0251	0.0059	0.236
2002	0.0259	0.0260	0.0060	0.233
2003	0.0263	0.0265	0.0061	0.233
2004	0.0267	0.0267	0.0070	0.263
2005	0.0255	0.0260	0.0053	0.207
2006	0.0280	0.0275	0.0119	0.426
2007	0.0288	0.0278	0.0153	0.533

Table 3c: Summary Statistics for Fresh Bread Prices

	Average	Median	Std. dev.	Coeff. Var.
1996	1.422	1.487	0.401	0.282
1997	1.385	1.188	0.464	0.335
1998	1.435	1.186	0.494	0.344
1999	1.398	1.182	0.491	0.351
2000	1.438	1.185	0.492	0.342
2001	1.469	1.205	0.473	0.322
2002	1.485	1.167	0.629	0.424
2003	1.481	1.207	0.558	0.377
2004	1.467	1.190	0.519	0.353
2005	1.498	1.327	0.559	0.373
2006	1.568	1.313	0.627	0.400
2007	1.448	1.149	0.645	0.445

Table 3d: Summary Statistics for Cartons, Boxes, Cases etc. Prices

	Average	Median	Std. dev.	Coeff. Var.
1996	1.096	0.879	0.618	0.564
1997	1.159	0.830	0.825	0.712
1998	1.426	0.808	1.340	0.939
1999	1.345	0.791	1.309	0.974
2000	1.438	0.859	1.582	1.100
2001	1.266	0.883	1.008	0.796
2002	1.266	0.913	0.996	0.787
2003	1.234	0.920	0.977	0.791
2004	1.281	0.955	0.966	0.754
2005	1.217	0.872	0.991	0.815
2006	1.296	0.921	1.103	0.851
2007	1.387	1.030	1.010	0.728

Figure 1a: Distribution of output price (beer made from malt)

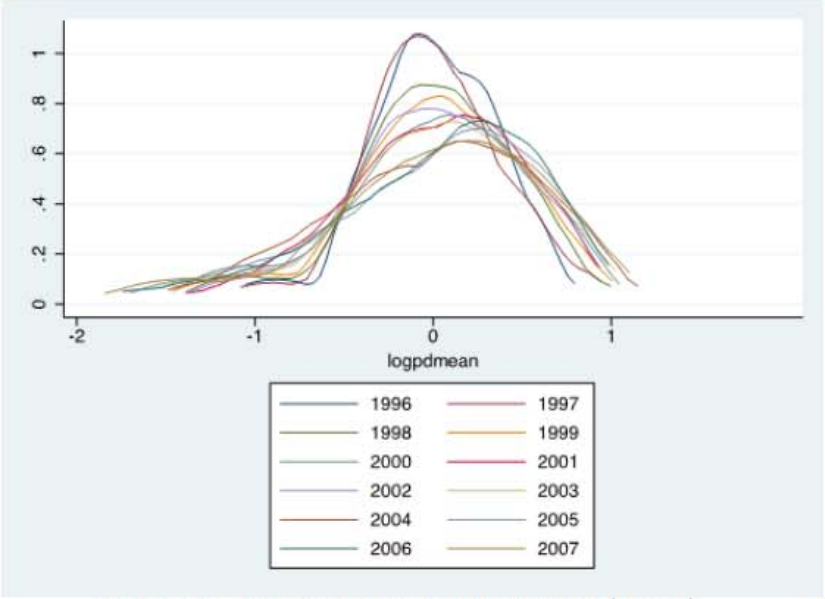


Figure 1b: Distribution of output price (ready-mix concrete)

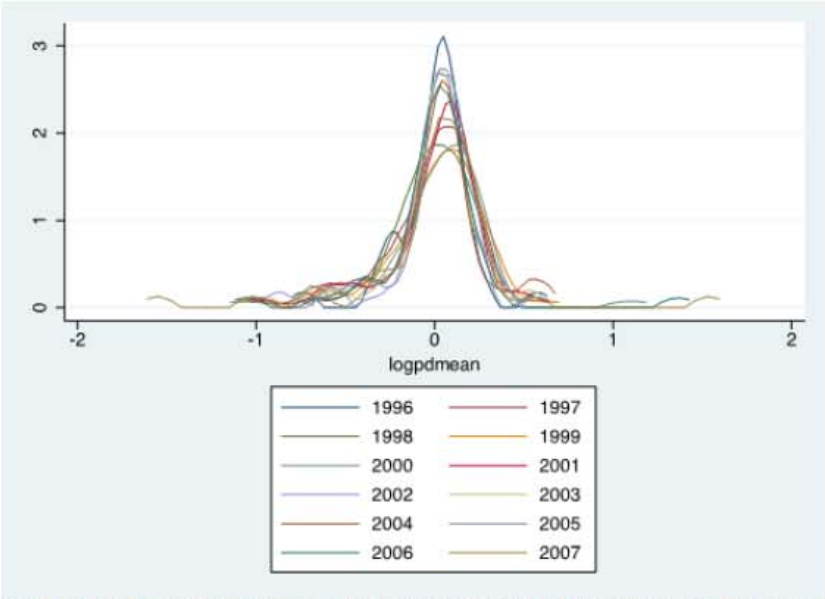


Figure 1c: Distribution of output price (bread)

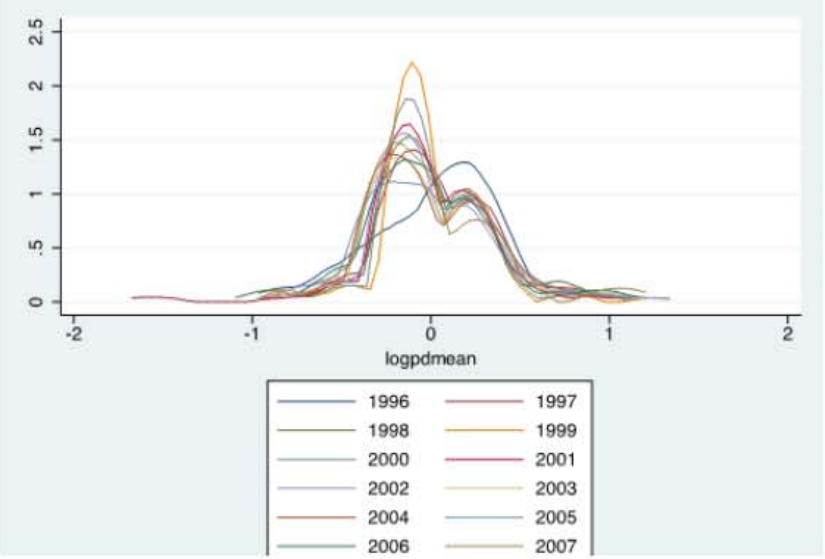


Figure 1d: Distribution of output price (Cartons, boxes and cases)

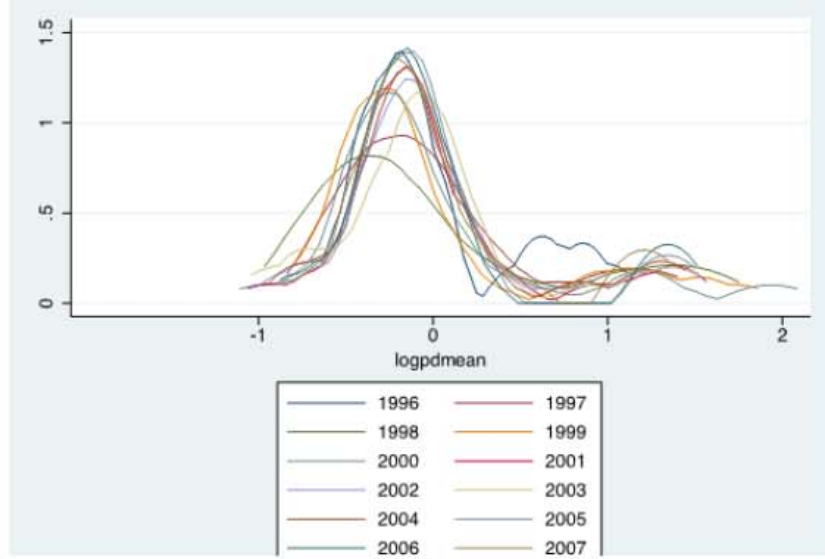


Table 4: Output price differences by size quartile (robust regression)

	Constant	2nd Quartile	3rd Quartile	4th Quartile	# obs.
Beer	0.255*** (0.050)	-0.127*** (0.072)	-0.248*** (0.071)	-0.53*** (0.073)	287
Ready-mixed Concrete	0.022 (0.015)	0.048 (0.021)	0.015 (0.021)	-0.002 (0.021)	594
Bread	0.091*** (0.017)	-0.006 (0.024)	-0.109*** (0.024)	-0.314*** (0.024)	903
Cartons, Boxes and Cases	0.478*** (0.049)	-0.575*** (0.071)	-0.829*** (0.070)	-0.703*** (0.072)	233
Kitchen Furniture	1.31*** (0.118)	-0.739*** (0.165)	-1.655*** (0.164)	-2.816*** (0.166)	403

Table 5: Output price persistence

	HH_price	HM_price	HL_price	MH_price	MM_price	ML_price	LH_price	LM_price	LL_price
Beer	.897	.103	0	.024	.897	.079	0	.094	.906
Ready-Mixed Concrete	.829	.138	.033	.071	.842	.087	.015	.188	.797
Fresh Bread	.888	.106	.006	.081	.779	.140	.016	.270	.714
Cartons, Boxes, Cases, etc.	.933	.067	0	.049	.873	.078	0	.148	.852

Results: marginal cost

- evolution of MC dispersion: more heterogeneity (table 6 and figure 2)
- more heterogeneity on the cost side than on the pricing side (except for cartons, boxes and cases)
- the coefficient of variation is much larger for ready-mixed concrete than for the other three products
- heterogeneity appears to increase for beer and bread, and decrease for ready-mixed concrete and cartons, boxes and cases
- relationship between MC and size (table 7): larger firms have lower MC but the relationship is not linear

Table 6a: Summary Statistics of Marginal Cost Estimates for Beer

	Average	Median	Std. dev.	Coeff. Var.
1996	0.667	0.603	0.300	0.450
1997	0.659	0.568	0.272	0.412
1998	0.643	0.537	0.294	0.458
1999	0.666	0.597	0.287	0.432
2000	0.681	0.615	0.321	0.471
2001	0.668	0.648	0.299	0.447
2002	0.705	0.655	0.335	0.475
2003	0.745	0.637	0.404	0.542
2004	0.761	0.706	0.400	0.526
2005	0.757	0.725	0.440	0.582
2006	0.730	0.718	0.396	0.543
2007	0.788	0.754	0.407	0.517

Table 6b: Summary Statistics of Marginal Cost Estimates for Ready-mixed Concrete

	Average	Median	Std. dev.	Coeff. Var.
1996	0.0304	0.0200	0.0296	0.9750
1997	0.0268	0.0191	0.0199	0.7435
1998	0.0285	0.0194	0.0218	0.7632
1999	0.0302	0.0221	0.0208	0.6895
2000	0.0297	0.0227	0.0201	0.6766
2001	0.0304	0.0221	0.0216	0.7120
2002	0.0306	0.0238	0.0213	0.6963
2003	0.0298	0.0237	0.0194	0.6500
2004	0.0314	0.0238	0.0221	0.7028
2005	0.0328	0.0239	0.0239	0.7293
2006	0.0361	0.0253	0.0266	0.7369
2007	0.0351	0.0245	0.0246	0.7009

Table 6c: Summary Statistics of Marginal Cost Estimates for Fresh Bread

	Average	Median	Std. dev.	Coeff. Var.
1996	1.305	1.148	0.563	0.432
1997	1.188	1.076	0.495	0.416
1998	1.371	1.158	0.794	0.580
1999	1.509	1.270	0.797	0.528
2000	1.418	1.239	0.808	0.570
2001	1.416	1.223	0.779	0.550
2002	1.421	1.236	0.844	0.594
2003	1.384	1.234	0.672	0.485
2004	1.421	1.220	1.066	0.750
2005	1.265	1.185	0.548	0.433
2006	1.325	1.235	0.609	0.460
2007	1.280	1.197	0.661	0.516

Table 6d: Summary Statistics of Marginal Cost Estimates for Cartons, Boxes, Cases etc.

	Average	Median	Std. dev.	Coeff. Var.
1996	0.714	0.667	0.343	0.481
1997	0.721	0.604	0.408	0.566
1998	0.838	0.645	0.562	0.670
1999	0.749	0.628	0.550	0.734
2000	0.780	0.686	0.476	0.610
2001	0.739	0.658	0.417	0.565
2002	0.764	0.677	0.436	0.570
2003	0.798	0.700	0.441	0.552
2004	0.831	0.697	0.438	0.526
2005	0.914	0.775	0.471	0.516
2006	0.884	0.778	0.380	0.430
2007	0.916	0.798	0.446	0.487

Figure 2a: Distribution of marginal cost (beer made from malt)

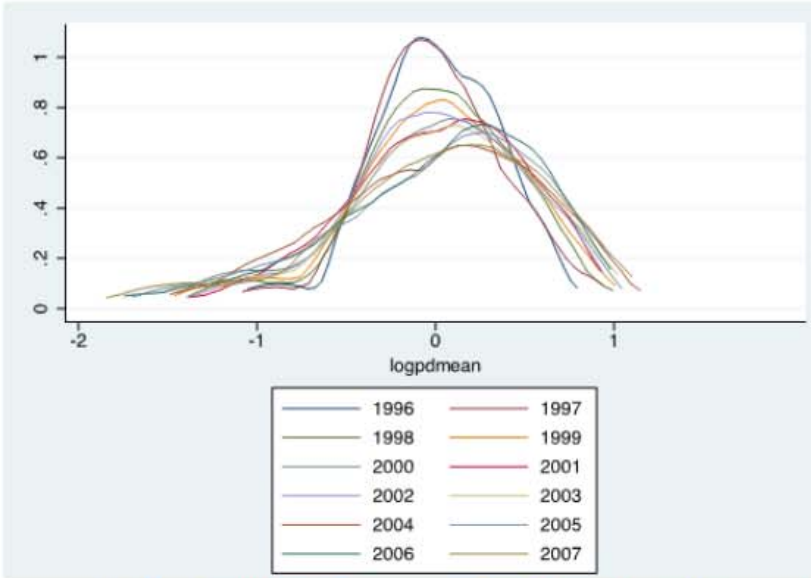


Figure 2b: Distribution of marginal cost (ready-mix concrete)

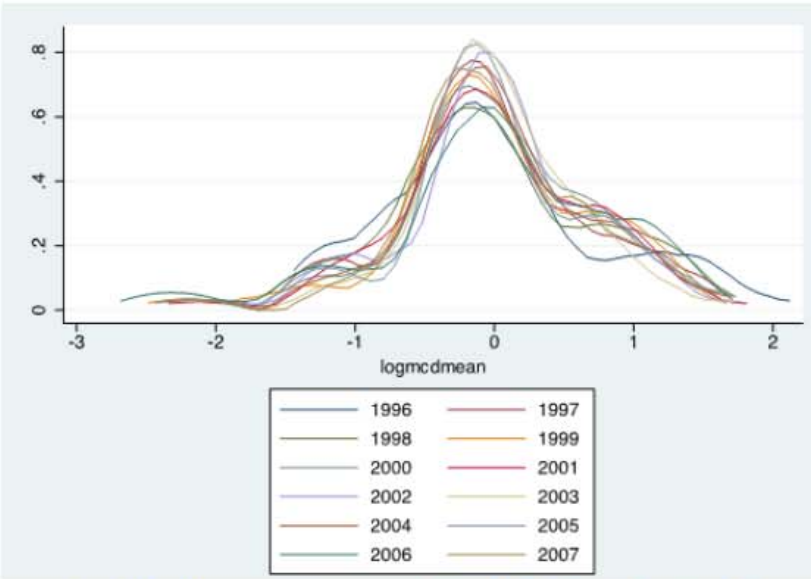


Figure 2c: Distribution of marginal cost (bread)

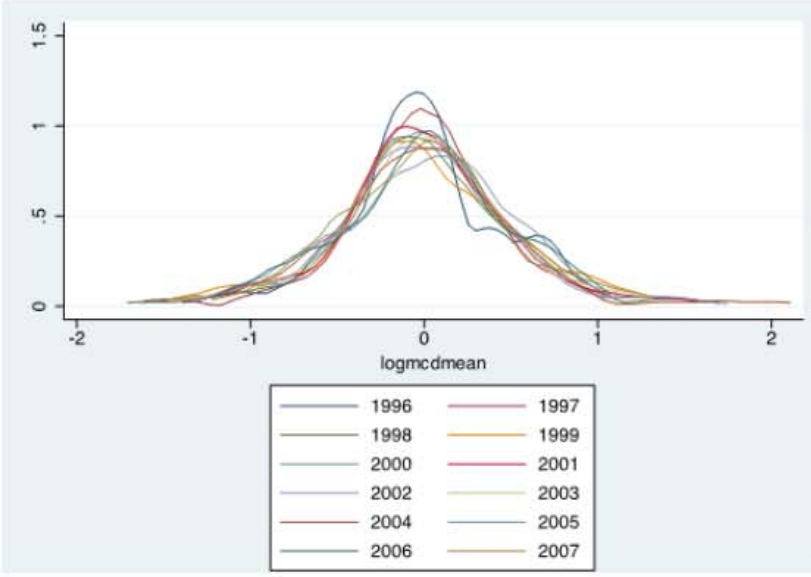


Figure 2d: Distribution of marginal cost (Cartons, boxes and cases)

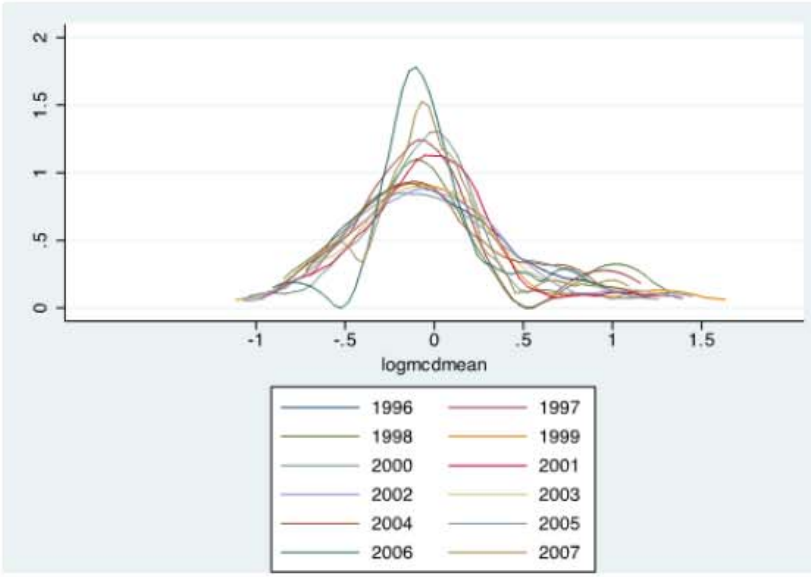


Table 7: Marginal Cost Differences by Size Quartile

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	# obs.
Beer	0.115*** (0.052)	-0.029 (0.075)	-0.092 (0.074)	-0.339*** (0.076)	287
Ready-mixed Concrete	0.379*** (0.049)	-0.428*** (0.071)	-0.612*** (0.071)	-0.405*** (0.071)	594
Bread	0.355*** (0.024)	-0.264*** (0.034)	-0.449*** (0.034)	-0.761*** (0.034)	903
Cartons, boxes and cases	0.195*** (0.045)	-0.297*** (0.065)	-0.452*** (0.064)	-0.134*** (0.066)	233

Results: markup

- markups are decreasing, except for bread (table 8)
- standard deviation appears to increase, except for ready-mixed concrete
- table 9: the log demeaned markup increases with firm size for two of our products (ready-mixed concrete and bread), as the sensitivity of marginal cost with respect to size is larger than for price; but it decreases with firm size for the other two (beer and boxes) for the opposite reason.
- again: the relationship is not always linear (only for the last two products).

Table 8a: Average Markups for Beer

	Average	Median	Std. dev.
1996	1.523	1.385	0.475
1997	1.425	1.400	0.538
1998	1.567	1.413	0.748
1999	1.699	1.761	0.684
2000	1.575	1.481	0.775
2001	1.545	1.513	0.763
2002	1.546	1.463	0.806
2003	1.569	1.558	0.800
2004	1.561	1.620	0.727
2005	1.574	1.544	0.770
2006	1.537	1.424	0.783
2007	1.404	1.367	0.731

Table 8b: Average Markups for Ready-mixed Concrete

	Average	Median	Std. dev.
1996	1.384	1.210	1.042
1997	1.306	1.184	0.895
1998	1.327	1.201	0.982
1999	1.173	1.031	0.798
2000	1.217	1.234	0.825
2001	1.260	1.189	0.903
2002	1.275	1.145	0.889
2003	1.237	1.129	0.788
2004	1.285	1.146	0.893
2005	1.203	1.064	0.862
2006	1.469	1.025	1.811
2007	1.114	1.052	0.696

Table 8c: Average Markups for Fresh Bread

	Average	Median	Std. dev.
1996	1.160	1.191	0.245
1997	1.267	1.249	0.510
1998	1.210	1.171	0.510
1999	1.087	1.080	0.423
2000	1.175	1.151	0.480
2001	1.181	1.199	0.413
2002	1.191	1.179	0.514
2003	1.181	1.145	0.376
2004	1.208	1.175	0.405
2005	1.289	1.245	0.409
2006	1.289	1.211	0.400
2007	1.242	1.225	0.410

Table 8d: Average Markups for Cartons, Boxes, Cases, etc.

	Average	Median	Std. dev.
1996	1.555	1.630	0.429
1997	1.569	1.511	0.400
1998	1.694	1.503	0.997
1999	1.787	1.512	0.910
2000	1.738	1.408	0.966
2001	1.711	1.458	0.768
2002	1.657	1.531	0.718
2003	1.592	1.395	0.727
2004	1.570	1.464	0.626
2005	1.366	1.284	0.664
2006	1.397	1.234	0.644
2007	1.537	1.351	0.682

Table 9: Markup differences by size quartile

	1st quartile	2nd quartile	3rd quartile	4th quartile	# obs.
Beer	0.125** (0.021)	-0.084*** (0.030)	-0.258*** (0.029)	-0.167*** (0.030)	287
Ready-mixed Concrete	-0.382*** (0.056)	0.496*** (0.080)	0.621*** (0.080)	0.466*** (0.080)	594
Bread	-0.229*** (0.017)	0.231*** (0.024)	0.350*** (0.024)	0.415*** (0.024)	903
Cartons, Boxes, Cases, etc.	0.425*** (0.023)	-0.263*** (0.034)	-0.513*** (0.034)	-0.701*** (0.035)	233

Results: demand estimation

- Table 10: Yields sensible demand elasticity between -1 and -2 (except one product)
- Also generates a distribution of firm-product quality (time varying) that we use next to look at product upgrading

Table 10: Demand Estimation

Dep. var.: lnsj-lns0	Beer	Ready-mix concrete	Bread	Cartons, Boxes, Cases, etc.
α	-1.54*** (0.18)	-11.51*** (4.97)	-1.20*** (0.09)	-0.94*** (0.08)
Average elasticity	-1.79	-0.3	-1.77	-1.2
Median elasticity	-1.59	-0.29	-1.59	-0.82
# obs.	287	594	903	233

Results: MPPF estimation (bread)

- estimate a production function for one sector where most firms produce exactly two products: bread and cake
- also testing more general specifications
- generates estimates of TFPQ and TFPR (see table 11 and Fig. 5-6)
- how does the distribution compare with quality? More heterogeneity in quality, then TFPQ, then TFPR (Figure 4)

Table 5 - Production function estimates

	Bread : $logQ_{bread}$		Cake : $logQ_{cake}$	
	Two products firms (1)	Single product firms (2)	Two products firms (3)	Single product firms (4)
logL	0.357***	0.599***	0.560***	0.564
	(0.075)	(0.134)	(0.120)	(0.354)
logMat	0.669***	0.256**	0.684***	0.765***
	(0.055)	0.112	(0.095)	(0.276)
$logQ_{bread}$	-	-	-0.084	-
			(0.066)	
$logQ_{cake}$	-0.026	-	-	-
	(0.025)			
logK	0.077	0.317	0.296*	0.712
	(0.113)	(0.602)	(0.181)	(0.887)
Const.	1.838	-73.737	10.944	326.214***
	(5.269)	(88.964)	8.416	(95.912)
N	748	174	748	244

Table 11: Standard Deviations of TFPQ and TFPR Estimates (Bread)

	TFPQ	TFPR
1996	0.270	0.169
1997	0.409	0.462
1998	0.519	0.483
1999	0.473	0.426
2000	0.502	0.460
2001	0.472	0.433
2002	0.476	0.487
2003	0.394	0.300
2004	0.418	0.312
2005	0.412	0.272
2006	0.428	0.263
2007	0.467	0.322

Table 12: Correlation Between Price, Marginal Cost, Markup and TFP Estimates - Bread

	p	mc	μ	TFPQ	TFPR
p	1				
mc	0.5797	1			
μ	0.0604	-0.5499	1		
TFPQ	-0.4695	-0.8679	0.7508	1	
TFPR	0.1223	-0.457	0.7644	0.6499	1

Policy question: liberalization of the price of bread in 2004

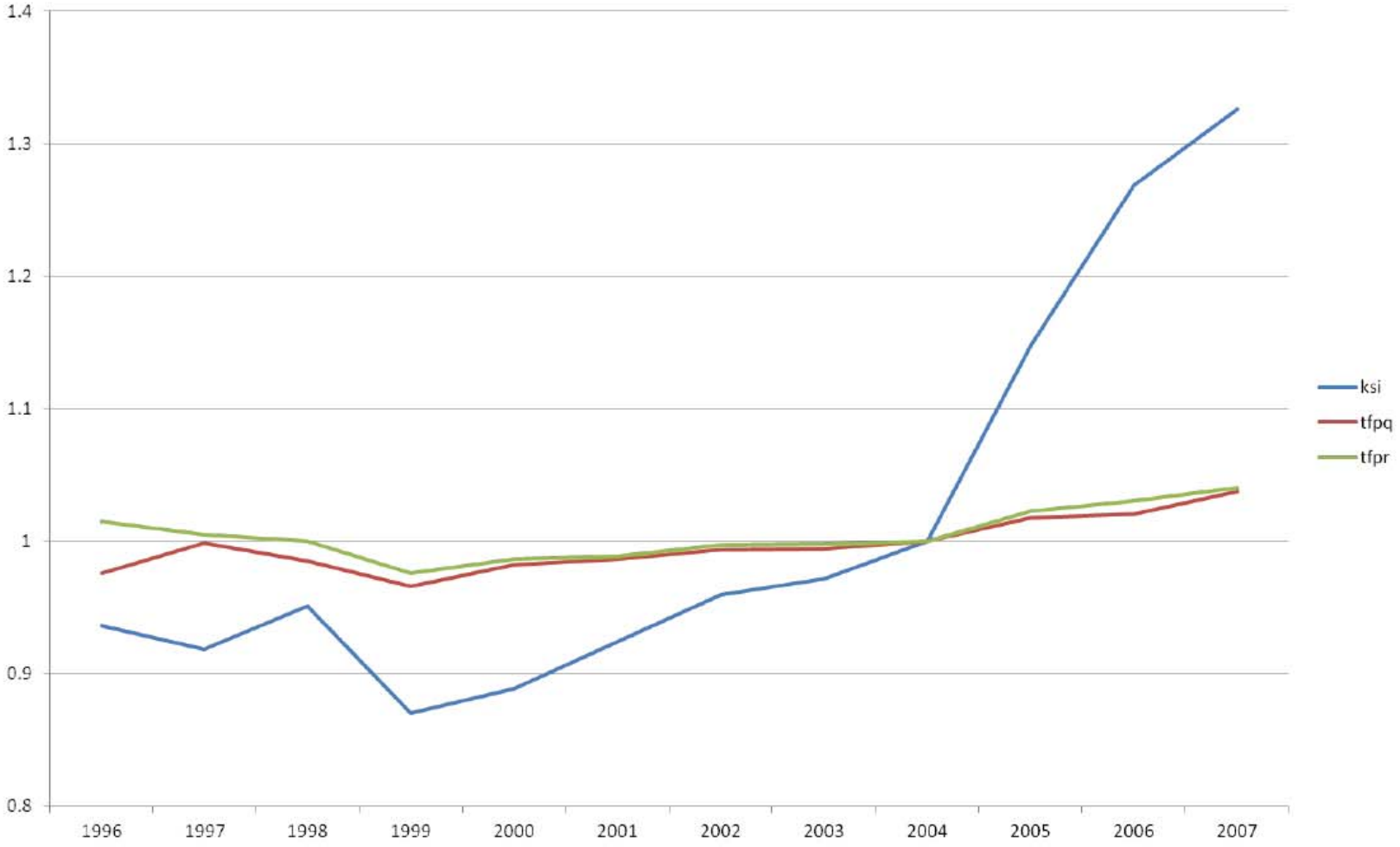
Dhyne, Petrin, Warzynski (2012): Deregulation and Spillovers in Multi-Product Production Settings: The Case of Belgian Bakeries

- In 2004, the Belgian government decided to liberalize the price of bread
- Consequences on price and markups: both went up (hence complaints from consumers)
- Effect on productivity &quality? See figure 7
- TFP grew moderately, but quality increased dramatically!
- Evidence of product upgrading?

Table 6 : Evolution of TFP and quality (ξ) for bread and cakes

	Bread		Cake	
	TFP	ξ	TFP	ξ
1999	-0.354	-2.561	-8.491	-3.406
2000	-0.360	-2.669	-8.464	-3.446
2001	-0.357	-2.484	-8.490	-3.177
2002	-0.347	-2.531	-8.581	-3.294
2003	-0.343	-2.338	-8.562	-2.998
2004	-0.357	-2.417	-8.741	-3.101
2005	-0.352	-2.125	-8.949	-2.656
2006	-0.347	-2.102	-9.042	-2.648
2007	-0.344	-1.915	-8.944	-2.288
2008	-0.364	-1.690	-9.444	-2.089

Figure 7: Evolution of average quality and efficiency: Bread



Conclusion

- Suggest a new methodology combining estimation of cost, demand and production functions to analyze pricing, quality and productivity evolution in Belgian manufacturing
- Approach yields sensible results
- Future work: more on product upgrading and product switching, in particular:
  - role of increased competition (direct or indirect measures? Use trade data?) See Amiti and Khandelwal (forthcoming)
  - role of IT and R&D