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Table 1: Summary statistics on CIP and merged sample - additional information

	1995		2005	
	PPI	CIP	PPI	CIP
Sales in current 1,000 EUR				
25th percentile	1955	340	2827	555
50th percentile	5424	998	8199	1417
75th percentile	20763	3747	25732	5338
Share of sales exported				
25th percentile	19	8	10	7
50th percentile	64	33	50	33
75th percentile	96	88	97	86
Share of sales exported to the UK				
25th percentile	4	2	2	2
50th percentile	14	9	9	8
75th percentile	35	25	24	21
% of imported materials in cost (materials+wages+fuel)				
25th percentile	19	11	15	8
50th percentile	36	27	35	23
75th percentile	55	48	56	46
% of imported materials from the UK in cost (materials+wages+fuel)				
25th percentile	5	2	2	2
50th percentile	14	10	9	8
75th percentile	27	23	21	19
Price-cost margins, distribution across plants				
25th percentile	0.20	0.20	0.22	0.23
50th percentile	0.30	0.31	0.33	0.35
75th percentile	0.42	0.42	0.45	0.47

Note: PPI refers to the sample of CIP plants that participate in the PPI sample. CIP refers to the full sample of plants. Information on imports is based on the roughly 90% of the population of plants for which comparable information is available over the entire time period.

Table 2: Sectoral shares (# plants, share in sales)

		Share of plants				Share of sales			
NACE	Description	1995		2005		1995		2005	
		PPI	CIP	PPI	CIP	PPI	CIP	PPI	CIP
10-14	Mining	2	2	3	4	2	2	1	2
15-16	Food, Bev., Tobac.	22	18	19	14	45	34	25	23
17-19	Textile, App., Leath.	10	9	7	5	2	3	1	1
20	Wood Products	5	5	6	6	2	1	1	1
21-22	Paper, Printing	5	12	7	13	5	7	6	8
24	Chemicals	7	5	7	5	14	15	19	27
25	Rubber, Plastics	5	5	6	6	3	2	2	2
26	Non-metallic min.	7	6	7	8	3	2	3	3
27-28	Metal, Metal prod.	11	12	12	14	3	3	3	3
29	Machinery	6	7	8	6	5	3	4	2
30-33	Electr. machinery	12	9	11	8	14	24	34	26
34-35	Transport equip.	3	3	2	2	2	2	1	1
36	Other manuf.	6	8	6	10	2	2	1	1
	Total	100	100	100	100	100	100	100	100
		# plants				Total sales (Million Euro)			
		666	4643	835	4603	14390	39762	39339	79557

Note: NACE23 excluded to maintain confidentiality.

Table 3: Hierarchical structure of price data

	Plants	Plant-product pairs	Quote-lines	Obs
1995	669	1102	4887	54009
1996	647	1068	4795	52163
1997	627	1040	4658	51022
1998	595	1010	4807	49198
1999	555	947	4174	46327
2000	580	977	4496	46910
2001	653	1074	4929	50017
2002	808	1235	5456	53224
2003	876	1326	5819	59740
2004	852	1295	5368	58658
2005	836	1243	4995	56428
total	1213	1946	12232	577696

Note: These statistics are for the matched plant-price data set. Each column reports the number of distinct values of each category observed in the relevant time-frame. For example, over the course of 1995, we observe prices for 669 distinct plants, though not all of those plants may be observed in any given month of that year.

Table 4: Mean adjustment frequency by export status and currency

	Obs	Invoice Currency					Home Currency	
		unw	wgt	wgt, adj. for exit	wgt inc	wgt dec	unw	wgt
total	545676	0.11	0.16	0.18	0.09	0.07	0.27	0.44
Destination market								
home	354363	0.11	0.19	0.20	0.12	0.06	0.11	0.19
export	191313	0.11	0.15	0.17	0.08	0.07	0.56	0.62
Invoice currency for exports								
IEP/EUR	86665	0.11	0.11	0.13	0.06	0.05	0.11	0.11
STG	60362	0.10	0.16	0.17	0.08	0.08	0.99	1.00
US$	21387	0.11	0.20	0.23	0.10	0.10	1.00	1.00
pre-EUR EU	10917	0.12	0.14	0.16	0.07	0.07	1.00	1.00
post-EUR EU	7988	0.05	0.07	0.09	0.04	0.04	0.11	0.15
other	3994	0.13	0.16	0.18	0.09	0.07	1.00	1.00

Note: The period covered is January 1995 - December 2005. The weighted mean frequency of price adjustment is calculated as $\sum_{t=1}^{T}\sum_i \omega_t^i I_t^i / \sum_{t=1}^{T}\sum_i \omega_t^i N_t^i$ where I_t^i is an indicator variable, equal to 1 if i's price changed at t, and N_t^i equals 1 if i was present in the sample at t, whether or not its price was changed. Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year corresponding to date t. This implies that each month is given equal weight in calculating frequencies. Exit adjustment treats quote-line exit like a price change, i.e. I_t^i is set equal to 1 if the quote-line is no longer present in the sample at date $t+1$.

Table 5: Mean adjustment frequency by month

	Obs	Invoice Currency					Home Currency	
		unw	wgt	wgt, adj. for exit	wgt inc	wgt dec	unw	wgt
January	44194	0.15	0.20	0.22	0.12	0.08	0.31	0.47
February	44525	0.13	0.18	0.19	0.11	0.08	0.30	0.47
March	44573	0.11	0.17	0.18	0.11	0.07	0.27	0.46
April	44741	0.12	0.17	0.18	0.11	0.06	0.28	0.46
May	44831	0.12	0.15	0.16	0.09	0.06	0.28	0.44
June	45148	0.10	0.15	0.17	0.08	0.07	0.26	0.43
July	45808	0.09	0.15	0.15	0.08	0.07	0.26	0.43
August	46158	0.09	0.15	0.17	0.08	0.07	0.25	0.43
September	46079	0.10	0.15	0.15	0.08	0.07	0.25	0.42
October	46601	0.10	0.16	0.17	0.09	0.07	0.27	0.44
November	46570	0.09	0.14	0.16	0.08	0.06	0.26	0.42
December	46448	0.09	0.17	0.29	0.11	0.07	0.25	0.45
total	545676	0.11	0.16	0.18	0.09	0.07	0.27	0.44

Note: The period covered is January 1995 - December 2005. The weighted mean frequency of price adjustment is calculated as $\sum_{t=1}^{T}\sum_i \omega_t^i I_t^i / \sum_{t=1}^{T}\sum_i \omega_t^i N_t^i$ where I_t^i is an indicator variable, equal to 1 if i's price changed at t, and N_t^i equals 1 if i was present in the sample at t, whether or not its price was changed. Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year corresponding to date t. This implies that each month is given equal weight in calculating frequencies. Exit adjustment treats quote-line exit like a price change, i.e. I_t^i is set equal to 1 if the quote-line is no longer present in the sample at date $t+1$.

Table 6: Mean adjustment frequency by type of good, size class, ownership, labour share and quartiles of the producer price index

	Obs	Invoice Currency					Home Currency	
		unw	wgt	wgt, adj. for exit	wgt inc	wgt dec	unw	wgt
Type of product (Vermeulen et al., 2007)								
cons food prod	95320	0.14	0.14	0.16	0.10	0.05	0.25	0.25
cons non-food non durab	48524	0.05	0.06	0.08	0.03	0.03	0.25	0.58
cons durables	57303	0.04	0.06	0.07	0.04	0.02	0.29	0.41
intermediates	252650	0.13	0.17	0.19	0.09	0.08	0.25	0.44
energy	2716	0.48	0.77	0.79	0.47	0.30	0.75	0.85
capital goods	89163	0.07	0.17	0.20	0.08	0.09	0.32	0.67
Type of product (Rauch 1999)								
homogenous	28605	0.29	0.55	0.57	0.32	0.23	0.40	0.66
reference priced	80768	0.12	0.13	0.15	0.09	0.04	0.20	0.30
differentiated	242228	0.10	0.18	0.20	0.10	0.08	0.28	0.50
unclassified	194075	0.08	0.10	0.13	0.05	0.05	0.26	0.51
Plant size								
<20	76117	0.08	0.26	0.27	0.16	0.10	0.14	0.33
20-49	142967	0.11	0.20	0.21	0.11	0.09	0.23	0.31
50-249	250391	0.10	0.19	0.21	0.12	0.07	0.28	0.35
250-500	48391	0.20	0.11	0.13	0.06	0.05	0.44	0.46
500+	27810	0.09	0.16	0.19	0.09	0.08	0.39	0.59
Ownership								
domestic	366071	0.11	0.21	0.23	0.12	0.10	0.24	0.32
foreign	179605	0.10	0.14	0.16	0.08	0.06	0.33	0.51
Quartiles of the labour share in variable cost								
Q1	143913	0.17	0.18	0.21	0.10	0.08	0.31	0.53
Q2	143300	0.10	0.13	0.14	0.07	0.06	0.27	0.44
Q3	134670	0.08	0.12	0.13	0.08	0.03	0.27	0.31
Q4	123793	0.07	0.20	0.21	0.12	0.08	0.22	0.37
Quartiles of the annual producer price index over the period								
Q	130466	0.11	0.15	0.17	0.09	0.06	0.30	0.50
Q2	154196	0.09	0.16	0.18	0.08	0.08	0.28	0.48
Q3	150792	0.11	0.18	0.19	0.11	0.07	0.26	0.38
Q4	110222	0.12	0.17	0.20	0.10	0.06	0.23	0.38

Note: The period covered is January 1995 - December 2005. The weighted mean frequency of price adjustment is calculated as $\sum_{t=1}^{T}\sum_i \omega_t^i I_t^i / \sum_{t=1}^{T}\sum_i \omega_t^i N_t^i$ where I_t^i is an indicator variable, equal to 1 if i's price changed at t, and N_t^i equals 1 if i was present in the sample at t, whether or not its price was changed. Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year corresponding to date t. This implies that each month is given equal weight in calculating frequencies. Exit adjustment treats quote-line exit like a price change, i.e. I_t^i is set equal to 1 if the quote-line is no longer present in the sample at date $t+1$.

Table 7: Size of price changes in invoice currency by export status and currency

	Increases				Decreases			
	Mean	p25	p50	p75	Mean	p25	p50	p75
total	6.13	1.45	3.31	7.41	-5.85	-7.79	-3.85	-1.44
Destination market								
home	5.66	1.73	3.40	7.14	-5.69	-7.74	-3.64	-1.47
export	6.64	1.24	3.22	7.68	-5.94	-7.83	-3.90	-1.43
Invoice currency for exports								
IEP/EUR	6.44	1.64	3.14	6.93	-6.01	-7.39	-3.74	-1.67
STG	4.69	1.12	2.83	5.63	-4.33	-5.56	-2.69	-0.71
US $	8.07	1.38	4.41	10.24	-6.94	-9.39	-5.28	-2.20
pre-EUR EU	4.95	0.01	1.15	4.76	-3.94	-5.61	-1.67	-0.02
post-EUR EU	5.56	0.48	3.92	7.14	-4.81	-5.41	-2.62	-0.50
other	3.18	0.01	0.83	5.10	-4.18	-5.24	-0.88	-0.01

Note: The period covered is January 1995 - December 2005. Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year in question. This implies that each month in the sample is given equal weight in calculating overall frequencies.

Table 8: Size of price changes in invoice currency by month

	Increases				Decreases			
	Mean	p25	p50	p75	Mean	p25	p50	p75
January	6.18	1.19	3.49	7.14	-7.40	-10.12	-4.49	-1.63
February	5.79	1.85	3.89	6.67	-6.09	-8.33	-3.88	-1.31
March	5.56	1.33	2.78	6.84	-4.64	-5.66	-2.86	-0.94
April	5.71	1.55	3.49	7.53	-5.46	-7.36	-3.31	-1.11
May	5.85	1.45	3.00	7.14	-6.59	-8.51	-4.40	-1.58
June	5.71	1.56	3.13	6.50	-7.13	-10.22	-4.38	-2.21
July	5.25	1.56	2.56	5.78	-4.79	-6.64	-3.23	-1.24
August	5.98	1.70	3.85	8.00	-5.98	-8.23	-4.29	-1.59
September	6.21	1.15	3.22	7.52	-5.21	-6.81	-3.57	-1.40
October	6.38	1.41	3.31	7.99	-5.73	-7.91	-3.77	-1.40
November	7.85	1.12	3.08	8.63	-4.82	-6.74	-3.65	-1.57
December	7.15	1.76	4.07	8.35	-6.27	-9.16	-5.22	-1.96
total	6.13	1.45	3.31	7.41	-5.85	-7.79	-3.85	-1.44

Note: Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year in question.

Table 9: Size of price changes in invoice currency by type of good, size class, ownership, labour share and quartiles of the producer price index

	Increases				Decreases			
	Mean	p25	p50	p75	Mean	p25	p50	p75
total	6.13	1.45	3.31	7.41	-5.85	-7.79	-3.85	-1.44
Type of product (Vermeulen et al., 2007)								
cons food prod	5.03	1.49	2.83	5.40	-5.85	-7.43	-3.85	-1.64
cons non-food non durab	7.78	0.01	2.00	7.99	-5.29	-6.66	-0.26	-0.01
cons durables	8.41	2.02	4.85	8.57	-6.12	-9.92	-3.65	-1.18
intermediates	4.84	1.04	2.78	5.71	-4.20	-5.29	-2.48	-0.85
energy	8.87	3.72	7.10	11.82	-8.28	-10.84	-6.44	-3.49
capital goods	7.69	1.49	3.80	9.91	-7.19	-9.39	-5.83	-2.60
Type of product (Rauch, 1999)								
organized exchange	8.65	3.27	6.31	11.25	-7.97	-10.72	-5.94	-2.92
reference priced	4.73	1.35	2.57	4.98	-4.62	-5.65	-3.29	-1.46
differentiated	5.84	1.14	3.02	7.55	-5.69	-8.23	-3.48	-1.19
unclassified	5.94	1.07	2.90	6.11	-5.21	-6.50	-2.86	-0.84
Plant size								
<20	3.19	1.01	2.04	3.88	-3.22	-4.54	-1.99	-0.87
20-49	4.73	1.31	2.86	5.40	-3.93	-4.66	-2.34	-1.07
50-249	6.50	1.76	3.99	8.33	-6.44	-8.88	-4.33	-1.76
250-500	5.54	1.00	2.58	6.15	-4.60	-6.17	-2.38	-0.63
500+	6.41	1.42	3.21	7.27	-6.40	-8.31	-4.38	-2.04
Ownership								
domestic	6.25	1.82	3.78	7.69	-5.44	-7.01	-3.51	-1.48
foreign	6.04	1.32	2.99	7.09	-6.21	-8.34	-4.11	-1.36
Quartiles of the labour share in variable cost (materials+wages+fuel)								
Q1	6.64	1.71	3.69	7.96	-5.98	-8.09	-3.99	-1.73
Q2	4.99	1.25	3.06	6.01	-4.76	-5.81	-2.67	-0.86
Q3	4.58	1.03	2.14	4.96	-5.13	-6.06	-2.01	-0.37
Q4	6.78	1.75	3.99	9.65	-6.68	-9.11	-5.26	-2.08
Quartiles of the annual producer price index over the period								
Q1	6.06	1.32	2.99	6.23	-5.62	-7.02	-3.51	-1.31
Q2	6.40	1.62	3.73	8.18	-6.17	-8.34	-4.32	-1.81
Q3	5.90	1.46	3.21	6.73	-5.69	-7.56	-3.79	-1.46
Q4	6.20	1.47	4.07	8.37	-5.87	-8.22	-3.34	-1.06

Note: The period covered is January 1995 - December 2005. Observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year in question. This implies that each month in the sample is given equal weight in calculating overall frequencies.

Table 10: Invoice currency choice for exports to the UK

	N	IEP/EUR	GBP	Other	Mix of currencies		
		% plants	% plants	% plants	% plants	mean IEP/EUR	mean GBP
all	22128	19.13	45.05	2.42	33.40	38.06	44.36
Euro changeover							
95-97	7942	21.29	54.28	3.30	21.13	38.26	49.97
98-01	6253	17.93	45.13	2.67	34.27	38.51	50.19
02-05	7933	17.91	35.75	1.35	44.99	37.70	38.22
Plant size							
<20	6415	17.79	28.84	0.42	52.95	43.99	31.07
20-49	5841	24.29	49.58	0.96	25.17	36.90	52.09
50-249	7770	17.59	53.86	3.02	25.52	31.22	59.16
250-499	1313	17.44	49.96	7.77	24.83	29.34	51.89
500+	789	9.76	48.42	14.70	27.12	28.59	53.56
Quartiles of the share of exports to the UK							
Q1	5532	31.15	32.86	2.95	33.04	43.40	33.42
Q2	5531	20.79	38.71	3.45	37.05	41.35	43.24
Q3	5533	14.13	46.85	2.11	36.91	34.76	48.37
Q4	5532	10.45	61.79	1.17	26.59	31.41	53.95
Quartiles of the turnover exported to the UK							
Q1	5532	27.68	27.46	0.83	44.03	45.29	29.58
Q2	5532	22.78	40.84	1.81	34.58	40.15	43.75
Q3	5532	16.52	54.01	2.35	27.11	34.60	53.24
Q4	5532	9.54	57.90	4.70	27.86	27.41	59.83
Quartiles of the share of imported materials from the UK in variable cost							
Q1 impuk	5086	24.50	40.25	2.85	32.40	41.08	37.22
Q2	5087	22.17	40.61	4.11	33.10	37.11	41.82
Q3	5086	17.62	49.37	2.03	30.99	36.57	48.22
Q4	5087	15.63	57.11	1.22	26.05	33.88	52.60
Ownership							
domestic	16648	19.07	45.19	0.63	35.12	38.94	44.20
foreign (incl. UK)	5480	19.32	44.64	7.86	28.18	34.74	44.95
UK	906	21.52	52.87	0.99	24.61	45.94	44.49

Note: Information is based on the roughly 95% of plants for which data on the export currency for UK sales is available for each plant-year.

Table 11: Intensive Margin of Price Adjustment I

	$\Delta_{s_t^{ik}} e_t^k$		R^2-adj.	N	f.e.	clust
	β					
Baseline						
All	1.01	(0.09)**	0.67	4212	1047	86
Panel 1						
Median frequency (f) of price adjustment of plant-product pair						
$f < 0.3$	1.07	(0.12)**	0.64	1226	293	68
$0.3 \leq f < 0.5$	0.93	(0.15)**	0.61	1089	313	8
$0.5 \leq f < 0.7$	1.03	(0.33)**	0.67	1269	242	7
$0.7 \geq f$	1.00	(0.39)**	0.69	628	199	5
Time interval between synchronized price changes						
1 mth	0.77	(0.38)**	0.66	748	381	42
2-5 mths	0.93	(0.12)**	0.80	1149	516	46
6-11 mths	0.96	(0.04)**	0.88	1377	578	71
12+ mths	1.03	(0.28)**	0.64	938	441	64
Panel 2						
Type of product (Vermeulen et al. 2007)						
consumer food products	0.91	(0.17)**	0.56	1300	393	20
cons non-food non durab	1.86	(0.60)**	0.43	29	13	6
cons durables	1.06	(0.19)**	0.68	147	28	8
intermediates	1.11	(0.23)**	0.81	1481	404	31
capital goods	1.05	(0.10)**	0.60	1251	207	22
Type of product (Rauch 1999)						
org. exch.	1.03	(0.42)**	0.53	985	292	10
ref. priced	0.87	(0.17)**	0.85	378	146	7
diff.	1.14	(0.15)**	0.56	1666	345	46

Note: Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant (coefficient and s.e. not reported) and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 12: Intensive Margin of Price Adjustment II

	$\Delta_{s_t^{ik}} e_t^k$		R^2-adj.	N	f.e.	clust
	β					
Baseline						
All	1.01	(0.09)**	0.67	4212	1047	86
Panel 1						
Number of employees						
<20	1.25	(0.12)**	0.86	283	98	10
20-29	1.07	(0.23)**	0.67	894	188	24
50-249	1.06	(0.12)**	0.55	2129	477	44
250-499	0.95	(0.17)**	0.61	752	227	7
Panel 2						
Quartiles of share of sales exported to the UK						
Q1	0.73	(0.03)**	0.43	68	25	4
Q2	0.94	(0.05)**	0.78	117	25	11
Q3	1.07	(0.22)**	0.58	1865	378	34
Q4	1.01	(0.11)**	0.71	2162	619	57
Quartiles of share of variable cost imported from the UK						
Q1 & Q2	1.03	(0.26)**	0.63	1334	413	32
Q3	1.03	(0.13)**	0.70	617	170	38
Q4	1.00	(0.07)**	0.67	2213	445	40
Panel 3						
Ownership						
domestic	1.04	(0.13)**	0.57	2842	791	64
foreign	0.96	(0.08)**	0.82	1370	256	24
UK	0.99	(0.01)**	0.96	175	27	8
Quartiles of price-cost margins						
Q1	0.98	(0.17)**	0.61	1757	466	39
Q2	0.92	(0.13)**	0.70	1178	294	38
Q3	1.61	(0.55)**	0.81	951	208	34
Q4	0.99	(0.11)**	0.40	326	79	22
Share of sales to related parties						
None	1.11	(0.26)**	0.58	1731	466	38
Some	1.11	(0.11)**	0.67	438	111	14

Note: Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 13: Extensive Margin of Price Adjustment I

	Probability of a price increase						Probability of a price decrease					
	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust
	$\beta - 1$						$1 - \beta$					
all	0.59	(3.61)	0.00	4873	921	129	1.62	(4.99)	0.00	4564	875	103
Panel 1												
Median frequency (f) of price adjustment of plant-product pair												
$f < 0.3$	3.05	(4.79)	0.00	2517	442	111	-5.53	(5.90)	0.00	2187	378	84
$0.3 \leq f < 0.5$	-1.28	(12.05)	0.00	693	172	10	15.73	(7.26)**	0.01	723	187	10
$0.5 \leq f < 0.7$	-0.90	(6.00)	0.00	1160	174	6	5.61	(2.95)	0.00	1129	171	7
$0.7 \geq f$	-13.97	(12.63)	0.00	503	133	4	21.50	(15.00)	0.01	525	139	4
Age of price at second synchronized price change												
1 mth	-4.53	(7.01)	0.00	2537	495	48	8.50	(7.10)	0.00	2424	478	44
2-5 mths	9.47	(8.19)	0.00	1206	232	65	1.70	(8.06)	0.00	1371	258	56
6-11 mths	2.14	(8.26)	0.00	574	98	59	1.67	(9.05)	0.00	450	82	49
12+ mths	0.29	(5.39)	0.00	556	96	62	-4.50	(7.11)	0.01	319	57	40
Panel 2												
Type of product (Vermeulen et al., 2007)												
(1)	-1.97	(6.57)	0.00	1408	331	27	-5.35	(6.63)	0.00	1380	321	21
(2)	23.14	(24.79)	0.08	101	26	11	54.75	(47.53)	0.12	86	16	10
(3)	-1.44	(9.41)	0.00	357	46	14	26.49	(15.11)*	0.08	178	29	10
(4)	1.20	(6.75)	0.00	1904	376	55	3.71	(9.39)	0.00	1840	370	45
(5)	2.20	(6.55)	0.00	1101	141	22	-0.48	(7.99)	0.00	1078	138	19
Type of product (Rauch, 1999)												
org. exch.	1.24	(11.68)	0.00	1173	274	11	3.02	(7.60)	0.00	1213	280	9
ref. priced	-19.08	(4.81)**	0.02	372	112	13	12.15	(14.27)	0.01	352	105	11
diff.	4.83	(5.43)	0.00	1918	312	66	2.99	(5.65)	0.00	1797	284	54

Note: Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates. Key to Vermeulen categories: (1) Consumer food products, (2) Consumer non-food non-durables, (3) Consumer durables, (4) Intermediates, (5) Capital goods.

Table 14: Extensive Margin of Price Adjustment II

	Probability of a price increase						Probability of a price decrease					
	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust
	$\beta - 1$						$1 - \beta$					
all	0.59	(3.61)	0.00	4873	921	129	1.62	(4.99)	0.00	4564	875	103
Panel 1												
Plant size												
<20	-12.82	(16.92)	0.01	142	41	13	3.91	(1.89)**	0.00	72	22	7
20-49	4.47	(2.59)*	0.00	1047	164	35	19.96	(10.37)*	0.02	976	155	31
50-249	3.15	(5.07)	0.00	2808	496	68	-2.87	(5.81)	0.00	2586	469	53
250-499	-4.44	(8.03)	0.00	753	187	9	-6.11	(8.15)	0.00	809	196	10
500+	-6.20	(17.20)	0.00	123	33	4	censored to maintain confidentiality					
Panel 2												
Quartiles of share of sales exported to the UK												
Q1	-26.65	(18.32)	0.14	108	21	5	-2.98	(9.63)	0.00	95	18	6
Q2	15.03	(27.09)	0.03	117	22	10	-68.26	(17.52)*	0.08	92	17	6
Q3	-2.85	(4.95)	0.00	2054	336	50	4.89	(5.53)	0.00	1866	321	34
Q4	2.91	(5.70)	0.00	2594	542	86	0.04	(7.58)	0.00	2511	519	78
Quartiles of share of variable cost imported from the UK												
Q1&Q2	-5.30	(7.42)	0.00	1354	321	49	9.70	(8.46)	0.01	1465	335	45
Q3	2.18	(6.11)	0.00	907	160	46	-5.07	(6.94)	0.00	769	141	36
Q4	2.46	(5.63)	0.00	2585	429	61	0.20	(7.50)	0.00	2289	382	48
Panel 3												
Ownership												
home	0.38	(4.29)	0.00	3356	664	95	5.53	(4.42)	0.00	2999	618	74
foreign	0.89	(6.31)	0.00	1517	257	35	-2.18	(8.79)	0.00	1565	257	31
UK	-7.43	(7.83)	0.02	307	44	8	-14.41	(21.83)	0.01	290	39	8
Quartiles of price-cost margins												
Q1	6.71	(9.39)	0.00	1689	376	52	-0.70	(6.75)	0.00	1756	391	46
Q2	-2.68	(6.80)	0.00	1225	233	51	5.66	(8.81)	0.00	1230	222	42
Q3	2.49	(4.64)	0.00	1591	251	54	5.80	(5.31)	0.00	1248	212	41
Q4	-2.62	(9.04)	0.00	355	58	26	-12.52	(6.11)**	0.03	317	48	24
Share of sales to related parties												
None	-3.98	(3.94)	0.00	1975	392	62	8.44	(3.66)**	0.00	1621	339	45
Some	-5.48	(10.87)	0.00	521	76	19	11.96	(13.42)	0.02	494	75	17

Note: Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates.

Table 15: Intensive Margin: Matching on precise item description

$\Delta_{s_t^{ik}} e_t^k$		R^2-adj.	N	f.e.	clust
	β				
1.08	(0.16)**	0.80	2169	1054	54

Note: The match is not on plant-product pairs, but on plant-precise item description pairs, a more demanding criterion. Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant (coefficient and s.e. not reported) and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales at the level of the plant-market. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 16: Extensive Margin: Matching on precise item description

Probability of a price increase						Probability of a price decrease					
$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	f.e.	clust
$\beta - 1$						$1 - \beta$					
-2.70	(4.17)	0.00	987	463	70	6.88	(3.30)**	0.01	864	414	51

Note: The match is not on plant-product pairs, but on plant-precise item description pairs, a more demanding criterion. Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Observations are weighted by sales at the plant-market level. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates.

Table 17: Intensive Margin: Delivery charges

	$\Delta_{s_t^{ik}} e_t^k$	R^2-adj.	N	f.e.	clust			
	β							
Delivery included	1.09	(0.00)	**	0.28	58	34	4
Delivery excluded	1.56	(0.62)	**	0.42	758	205	30

Note: The sample includes only quote-lines from 2003-2005, present in the November 2006 cross-section, for which the "terms of sale" field for November 2006 reports whether delivery charges are included or excluded in the price. Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant (coefficient and s.e. not reported) and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales at the level of the plant-market. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 18: Extensive Margin: Delivery charges

	Probability of a price increase					Probability of a price decrease				
	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	clust	$\Delta_{s_t^{ik}} e_t^k$		ps-R^2	N	clust
	$\beta - 1$					$1 - \beta$				
Delivery inc	Not enough observations to estimate					Not enough observations to estimate				
Delivery excl	18.92	(14.86)	0.02	741	36	-8.40	(8.25)	0.00	603	30

Note: The sample includes only quote-lines from 2003-2005, present in the November 2006 cross-section, for which the "terms of sale" field for November 2006 reports whether delivery charges are included or excluded in the price. Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Observations are weighted by sales at the plant-market level. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates.

Table 19: Intensive Margin: Full set of controls

	coeff	s.e.
$\Delta_{s_t^{ik}} e_t^k$	1.03	(0.14)**
$\Delta_{s_t^{ik}} p_t^{IRL} X_t^{ikIRL}$	-0.45	(1.03)
$\Delta_{s_t^{ik}} p_t^{UK} X_t^{ikUK}$	0.73	(0.90)
$\Delta_{s_t^{ik}} q_t^{IRL} X_t^{ikIRL}$	0.82	(0.76)
$\Delta_{s_t^{ik}} p_t^{UK} X_t^{ikUK}$	-1.36	(1.19)
R^2-adj.	0.66	
N	3325	
# f.e.	802	
# clusters	75	

Note: Sample covers the period 1997-2005. Estimation method is OLS. Dependent variable is log change in home currency price since last price change. Regression includes a constant and an indicator variable for the Irish market, X_t^{ikIRL}, (coefficients and s.e. not reported) and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 20: Extensive Margin: Full set of controls

	Increases		Decreases	
	coeff	s.e.	coeff	s.e.
$\Delta_{s_t^{ik}} e_t^k$	5.78	(4.46)	0.10	(5.39)
$\Delta_{s_t^{ik}} p_t^{IRL} X_t^{ikIRL}$	26.01	(21.02)	-13.48	(24.83)
$\Delta_{s_t^{ik}} p_t^{UK} X_t^{ikUK}$	19.47	(23.82)	-6.07	(21.85)
$\Delta_{s_t^{ik}} q_t^{IRL} X_t^{ikIRL}$	-18.13	(16.46)	38.80	(18.66)**
$\Delta_{s_t^{ik}} p_t^{UK} X_t^{ikUK}$	30.12	(22.61)	-57.79	(26.24)**
pseudo-R^2	0.01		0.01	
N	3899		3711	
# f.e.	719		688	
# clusters	112		94	

Note: Sample covers the period 1997-2005. Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Regression includes an indicator for the Irish market, X_t^{ikIRL} (coefficient estimate and s.e. not reported). Observations are weighted by sales. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates.

Table 21: Intensive Margin: Longer horizons

	$\Delta_{s_t^{ik}} \ln e_t^k$		R^2-adj.	N	f.e.	clust
First and last synch. price changes						
All obs	0.78	(0.51)	0.39	677	116	96
By interval between first and last synch. price changes						
<6 months	1.59	(5.03)	0.16	43	23	20
6-11 months	1.38	(0.88)	0.44	65	27	22
12-23 months	1.81	(1.34)	0.47	141	40	35
24+ months	0.74	(0.61)	0.36	428	75	66
By # of intervening price changes						
<2	0.86	(0.46)*	0.33	400	58	49
≥2	0.76	(0.66)	0.30	277	58	50

Note: Estimation method is OLS. Dependent variable is log change in home currency price between first and last synchronized price change for matched pair of home and UK quotes. All regressions include a constant and the full set of plant-product-month-difference interval fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 22: Intensive Margin: Dynamic adjustment

	coeff	s.e.	coeff	s.e.
$\Delta_{s_t^{ik}} e_t^k$	0.93	(0.08)**	0.94	(0.11)**
$\Delta_{s_t^{ik}} e_{t-s_t^{ik}}^k$	-0.05	(0.11)	-0.05	(0.12)
$\Delta_{s_t^{ik}} e_{t-2s_t^{ik}}^k$			-0.17	(0.23)
R^2-adj.	0.67		0.67	
N	3794		3530	
# f.e.	960		908	
# clusters	67		59	

Note: Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant and the full set of plant-product-month-difference interval fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 23: Intensive margin: All foreign-currency export sales

$\Delta_{s_t^{ik}} \ln e_t^k$		R^2 adj	N	# f.e.	# clust
0.99	(0.07)**	0.67	4687	1178	95

Note: Sample includes all foreign currency export sales. Independent variable is the log change in the exchange rate between the home currency and the invoice currency over the relevant period. Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 24: Extensive margin: All foreign currency export sales

	Increases		Decreases	
	coeff.	s.e.	coeff.	s.e.
$\Delta_{s_t^{ik}} \ln e_t^k$	2.27	(3.26)	-3.52	(4.16)
N	5,458		5,097	
# f.e.	1052		988	
# clusters	151		126	
Pseudo-R^2	0.00		0.00	

Note: Sample includes all foreign currency export sales. Dependent variable is indicator for increase or decrease in invoice currency price. This means in the case of price increases, the indicator equals one if the invoice currency price is increased, equals zero if the invoice currency price remains unchanged or is decreased. The case of price decreases is analogous. Independent variable is the log change in the exchange rate between the home currency and the invoice currency over the relevant period. Estimator is conditional logit, conditioning on plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors in brackets. Standard errors are clustered at the plant level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level. A pseudo-R-squared is reported. The number of fixed effects indicates the number of plant-product-months used to identify the coefficient on exchange rates. The number of clusters indicates the number of plants used to identify the coefficient on exchange rates.

Table 25: Intensive margin, not controlling for costs

$\Delta_{s_t^{ik}} e_t^k$	R^2-adj.	N	f.e.	clust		
0.76	(0.14)	**	0.15	5190	600	162

Note: Sample includes all Sterling-invoiced quote-lines. Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant (coefficient and s.e. not reported) and the full set of quote-line fixed effects. Observations are weighted by sales at the level of the plant-market. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 26: Intensive margin by sign and size of price changes

	$\Delta_{s_t^{ik}} \ln e_t^k$		R^2 adj	N	# f.e.	# clust
$<$-0.05	0.77	(0.38)**	0.66	748	382	42
$\geq$-0.05 & $<$0	0.93	(0.12)**	0.80	1149	517	46
$\geq$0 & $<$0.05	0.96	(0.04)**	0.88	1377	579	71
$\geq$0.05	1.03	(0.28)**	0.64	938	442	64

Note: Dependent variable is log change in home currency price since last price change. All regressions include a constant and the full set of plant-product-month-age-of-price fixed effects. Estimation method is OLS. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 27: Intensive margin - asymmetry

$\Delta_{s_t^{ik}} \ln e_t^{k+}$		$\Delta_{s_t^{ik}} \ln e_t^{k-}$		R^2 adj	N
1.03	(0.08)**	0.97	(0.24)**	0.67	4212

Note: Estimation method is OLS. Dependent variable is log change in home currency price since last price change. All regressions include a constant and the full set of plant-product-month-age-of-price fixed effects. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 28: Intensive margin using forward exchange rates

$\Delta_{s_t^{ik}} \ln f\left(\bar{s}^{ik}\right)_t^k$		R^2 adj	N	# f.e.	# clust
1.01	(0.08)**	0.68	3437	933	58

Note: Dependent variable is log change in home currency price since last price change. Independent variable is the change in the forward exchange rate over the relevant time interval. The horizon for the forward rate is that closest to the median duration of a price for the plant-product pair in question. Only plant-product pairs with similar durations across Irish and UK markets are included in the estimation sample. All regressions include a constant and the full set of plant-product-month-age-of-price fixed effects.Estimation method is OLS. Observations are weighted by sales. Standard errors are clustered at the plant level. Standard errors are in brackets. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 29: Size distribution of synchronized and unsynchronized UK price changes

		All episodes	Synchronized
Increases	Median	3.57	4.17
	Mean	6.04	6.84
	s.d.	9.86	9.52
Decreases	Median	3.00	4.34
	Mean	5.44	5.88
	s.d.	7.27	6.10
All	Median	0.01	0.60
	Mean	1.14	1.12
	s.d.	10.48	10.33

Note: Size distribution is reported for price changes in UK quote-lines which are associated with a home-currency invoiced home market quote-line. Distribution is over occasions of price changes. Episodes are classified as "synchronized" if they are included in the baseline intensive margin analysis.

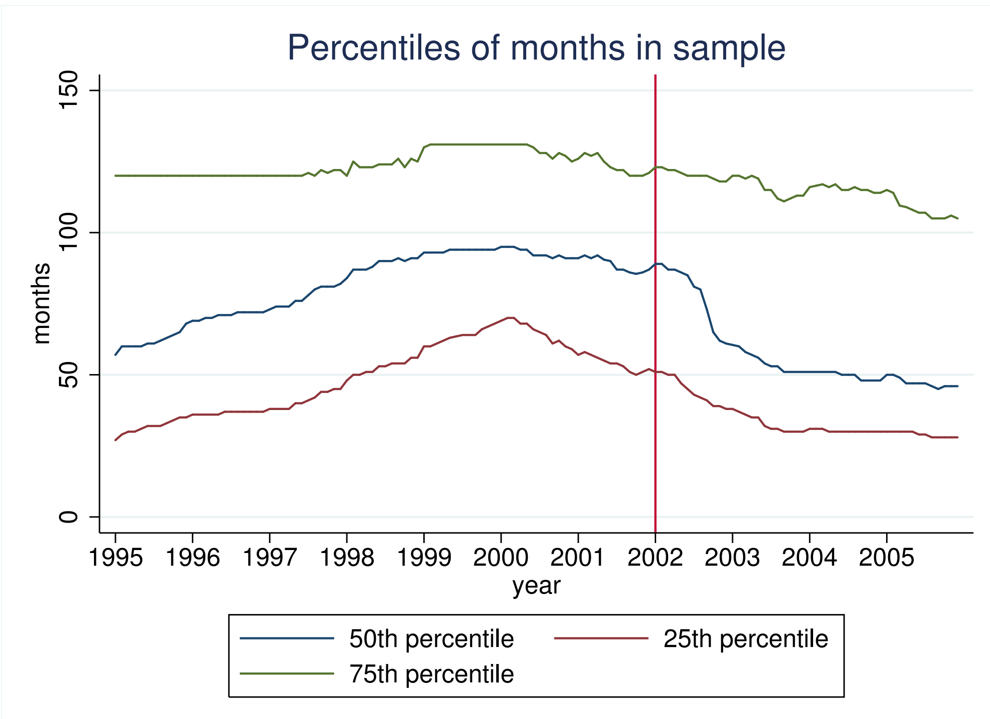

Figure 1: Summary statistics on cross-section distribution of quote-line durations

Note: Each quote-line in the sample has a duration in months. There is censoring of quote-lines at the beginning and end of the sample. The effect of this censorship is most persistent on long duration quote-lines. This figure shows the time series evolution of percentiles of the cross-section distribution of durations for active quote-lines.

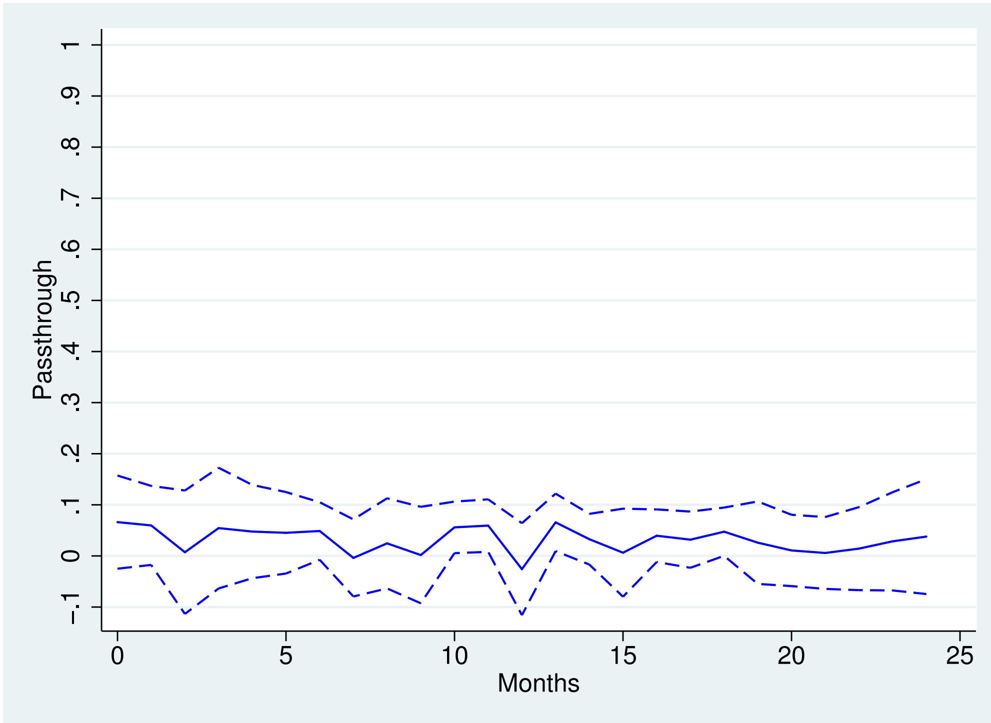

Figure 2: Exchange rate passthrough at different horizons

Note: This is based on estimating the equation $\Delta p_t^{i,UK} = \alpha^i + \sum_{j=0}^{24} \beta_j \Delta e_{t-j}^{UK} + \sum_{j=0}^{24} \gamma_j \pi_{t-j}^{IRL} + \delta \Delta q_t^{UK} + \varepsilon_t^i$ using all Sterling-invoiced export quote-lines. We weight using plant-market sales, and cluster standard errors at the plant level. The reported passthrough is $\sum_{j=0}^{J} \beta_j$ for $J = 0, \ldots, 24$, with the 95% confidence interval also graphed.

3 Additional information on CIP data

Our first data source is the Irish Census of Industrial Production (CIP). This census of manufacturing, mining and utilities takes place annually at both the firm (enterprise) and plant (local unit) level. About 90% of plants belong to firms with only one plant in Ireland, and for these, "enterprise" and "local unit" are synonymous. All local units with 3 or more employees are required to fill in a return. The industries covered are NACE Revision 1.1 (the harmonized European industrial classification system) classes 10 to 41. To maintain confidentiality, we exclude from our analysis local units whose share of total industrial sales in any given year is greater than 4%. We also exclude NACE 2-digit sector 37 (recycling) and sectors 40 and above (electricity, gas and water). The data available to us covers the period 1991 to 2005. Survey forms and methodology documents for this data are available on the web at www.cso.ie.

While data on the turnover of local units is collected by the CSO, it is not reported in the official publication of the Census of Industrial Production. For the micro data turnover is therefore set to zero for some local units (6.5% over the period 1995-2005), in particular in cases where there are multiple local units within an enterprise. As gross output is reported in the official publication this there are a large number of cases where the entry for turnover is zero, but the entry for gross output is positive. In these cases local unit turnover can be calculated in reverse as Turnover from goods produced and industrial services = Gross output + Freight charges for transport of the enterprise's products - Operating subsidies + Excise duty paid or payable on goods produced by the enterprise - End of year stock of work in progress and finished goods + Beginning of year stock of work in progress and finished goods - Value of capitalized work performed by the unit for its own use. For 1.6% of the observations between 1995 and 2005 turnover is still zero after this procedure.

Figures on employment relate to employment in the local unit in the second week of September. In some cases this can result in zero employees in combination with a positive wage bill. Where the average wage is clearly out of line with the local unit's employment history, the figures are adjusted. For example, if employment is zero but the wage bill is positive, employment figures are obtained by averaging the average wage over the previous and the following year and backing out the employment figure closest to the nearest full number from the wage bill for the current year.

Once-off changes in ownership or NACE classification that revert in the following year are ignored.

The share of turnover exported is cleaned from values smaller than zero and values larger than 100 using information from previous and/or later years of the observation in question. From 2001 enterprises are not only asked for the share of turnover they export but also for the value of their exports. Comparing these two figures where available suggests that information based on the share of turnover exported overestimates the true figures by 1-2 percentage points per year on average. From 2001 the share of turnover exported is calculated from the value figures where possible. However, since not all enterprises answer the "value of exports" question, information based on the "share of turnover exported" question is more comprehensive. In years where some of the information for a local unit is imputed or the entire observation is estimated by the CSO, information on exports is adjusted to relate to earlier or later non-imputed/estimated information for the plant rather than to industry averages.

Information on the destination of exports is adjusted to match the figures on the share of turnover exported.

Information on the share of exports to the UK by invoice currency is collected at the enterprise level since 1994, and at the local unit level from 2001. Where possible, pre-2001, the enterprise-level data is merged in at the plant level.

Information on the share of imported materials is collected at the enterprise level since 1994, but at the local unit level from 2001 only. This data as well as the source country information undergoes checking and processing similar to the export information. The CSO changed processing systems for the CIP from 2000 to 2001. This leads to significant changes in the shares of imported materials, in some cases so extreme that we decide not to use this information; in other cases adjustments are made in line with the data collected after 2000.

4 Additional information on PPI Data

The second source of data is the micro data collected for the purpose of constructing the Producer Price Index (PPI). The sampling frame for this data is the population of plants in the CIP. Plants participate in the PPI on a long-term basis, though there is periodic resampling from the CIP to maintain coverage following attrition in the original sample and entry of new plants into the CIP. Participants report prices monthly, and we have access to the data from January 1995 through November 2006. The price data can be linked to the CIP plant data using a unique plant identifier. Survey forms and methodology documents for this data are available at www.cso.ie.

New entrants to the PPI survey are asked to fill out a long form in the first month they participate. They are asked to provide a detailed description of their main products (supplemented e.g. by tariff codes), partially or fully manufactured in Ireland, where the products included should be suitable for pricing every month. Prices provided should be those invoiced for the product satisfying the detailed description on the 15th of the month, excluding value added taxes, before discounts and surcharges are applied, net of direct subsidies (where applicable) and excluding excise duty. There is a separate space on the form for discounts and surcharges to be reported. Both home market prices and export prices (where relevant) are specifically requested. The long form supplied to new participants has explicitly labeled spaces for home sales and export sales within the panel for each separate product. Prices should be reported in the currency in which they are quoted, and there is a space on the form for respondents to report the currency in which the price is quoted, and the relevant units. Respondents are asked to give an approximate breakdown of the relative importance of the different products and markets (home or export) in total sales at the time of entrance to the survey (this information is not systematically supplied by all respondents). Information on "trading terms" (type of customer, order size, delivery terms, currency surcharges etc.) is also requested. For exports, the country of sale is requested.

Continuing respondents are provided with a short form where the product description, terms of sale, discounts and surcharges, currency in which the price is charged, units and previous month's price are already filled in. They are asked to report the price for the current month, and to state the reason for price changes. If products or terms of sale are no longer available or are not representative, replacements are requested, and there is space on the form to fill in the details solicited on the long form described above. In addition, if the firm adds new products or markets, it is asked to fill in the full details of this new quote-line.

Because of data storage restrictions dating back to the early 1990s, the CSO stores time series data on only a limited subset of the variables collected in the survey. For an additional set of variables, data is available for price quotes present in the last cross-section that is collected, but as soon as a price quote exits, this information is lost.

In the form that it reaches us, we have a 4-digit NACE identifier a plant identifier, a product identifier (which allows for matching of products within and across firms, at a sub-NACE 4-digit level, but not exactly lined up with PRODCOM), an item identifier (at a more detailed level of disaggregation than the product identifier, again not exactly lined up with PRODCOM) and for some observations, a within-plant weighting variable that does not change over time (there are many missing values for this variable). For each quote-line in the sample, we have monthly information on the price (in two forms, which we describe below), the invoice currency, the end-of-day exchange rate between the Irish Pound and the invoice currency in question on the date closest to the 15th of the month, and whether the price quote is for a domestic sale or an export sale.

There are two formats for prices: the price level (in domestic currency, Irish Pounds or Euros), and the "price relative." The price level is the price reported by the respondent, adjusted for the reported discounts or surcharges. The price relative is the ratio of the domestic currency price in the current month to the domestic currency price in the previous month (during the Euro changeover, the fixed Euro exchange rates are used to convert the last Irish Pound price to Euros to take this ratio). There are no gaps in the domestic currency price series. That is, if a particular price quote is available at date t and at date t+k, it is available at all dates in between. However there are gaps in the price relative series where the CSO deems there to be problems with the reported home currency price. All of the empirical work is based on the data as presented in price relative form. For prices not quoted in domestic currency, the ratio of the original currency price in the current month to the original currency price in the previous month is backed out using the price relative and the exchange rate series provided with the data. A rounding rule is used to select observations for which there is no change in the original currency price from month to month.

For observations that are present in the last cross-section available to us (November 2006), we additionally observe units, trading terms and destination country, if the respondent has chosen to fill in these fields. The nature of the responses in these fields are at the discretion of the respondent, and they have not been systematically coded. Frequently, the respondent leaves these fields blank, or provides information that is difficult to interpret.

5 Weighting procedure

The fact that we can match price information with plant census data means that we can weight observations at a much greater level of disaggregation than is usual in studies that use micro price data. Within each month, across destination market categories and plants, weights are given by plant-level domestic and export sales as a share of total sales in the CIP for the relevant year. Within plants and destination market categories, we know nothing about the breakdown of sales, so we assign all quotes equal weight. All months in the sample are given equal weight.

To illustrate, suppose plant i reports $J^i_{h,y,m}$ price quotes in the home market in month m of year y and total home sales of $SALES^i_{h,y}$ in that year. Then the weight for each individual price quote for this plant in the home market at time y, m is given by:

$$w^i_{h,y,m} = \frac{\frac{1}{J^i_{h,y,m}} SALES^i_{h,y}}{\sum_{i=1}^{N_y} \sum_{k=h,e} SALES^i_{k,y}}$$

If this plant reports $J^i_{e,y,m}$ price quotes in the export market, the analogous weight for an export price quote is:

$$w^i_{e,y,m} = \frac{\frac{1}{J^i_{e,y,m}} SALES^i_{e,y}}{\sum_{i=1}^{N_y} \sum_{k=h,e} SALES^i_{k,y}}$$

6 NACE 3-digit industries in 6 groups based on Vermeulen et al. (2007)[1]

I. Consumer food products 151 Production, processing and preserving of meat and meat products 152 Processing and preserving of fish and fish products 153 Processing and preserving of fruit and vegetables 154 Manufacture of vegetable and animal oils and fats 155 Manufacture of dairy products 158 Manufacture of other food products 159 Manufacture of beverages 160 Manufacture of tobacco products **II. Consumer non-food non-durables** 174 Manufacture of made-up textile articles, except apparel 175 Manufacture of other textiles 177 Manufacture of knitted and crocheted articles 181 Manufacture of leather clothes 182 Manufacture of other wearing apparel and accessories 183 Dressing and dyeing of fur; manufacture of articles of fur 191 Tanning and dressing of leather 192 Manufacture of luggage, handbags and the like, saddlery and harness 193 Manufacture of footwear 221 Publishing 222 Printing and service activities related to printing 223 Reproduction of recorded media 244 Manufacture of pharmaceuticals, medicinal chemicals and botanical products 245 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 364 Manufacture of sports goods 365 Manufacture of games and toys 366 Miscellaneous manufacturing n.e.c. **III. Consumer durables** 297 Manufacture of domestic appliances n.e.c. 323 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods 334 Manufacture of optical instruments and photographic equipment 335 Manufacture of watches and clocks 341 Manufacture of motor vehicles 354 Manufacture of motorcycles and bicycles 361 Manufacture of furniture 362 Manufacture of jewelery and related articles 363 Manufacture of musical instruments **IV. Intermediate goods** 132 Mining of non-ferrous metal ores, except uranium and thorium ores 141 Quarrying of stone 142 Quarrying of sand and clay 143 Mining of chemical and fertilizer minerals 145 Other mining and quarrying n.e.c. 156 Manufacture of grain mill products, starches and starch products 157 Manufacture of prepared animal feeds 171 Preparation and spinning of textile fibres 172 Textile weaving 173 Finishing of textiles 176 Manufacture of knitted and crocheted fabrics 201 Sawmilling and planing of wood; impregnation of wood 202 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards 203 Manufacture of builders' carpentry and joinery 204 Manufacture of wooden containers 205 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials 211 Manufacture of pulp, paper and paperboard 212 Manufacture of articles of paper and paperboard 241 Manufacture of basic chemicals 242 Manufacture of pesticides and other agro-chemical products 243 Manufacture of paints, varnishes and similar coatings, printing ink and mastics 246 Manufacture of other chemical products 247 Manufacture of man-made fibres 251 Manufacture of rubber products 252 Manufacture of plastic products 261 Manufacture of glass and glass products 262 Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products 263 Manufacture of ceramic tiles and flags 264 Manufacture of bricks, tiles and construction products, in baked clay 265 Manufacture of cement, lime and plaster 266 Manufacture of articles of concrete, plaster and cement 267 Cutting, shaping and finishing of ornamental and building stone 268 Manufacture of other non-metallic mineral products 271 Manufacture of basic iron and steel and of ferro-alloys 272 Manufacture of tubes 273 Other first processing of iron and steel 274 Manufacture of basic precious and non-ferrous metals 275 Casting of metals 284 Forging, pressing, stamping and roll forming of metal; powder metallurgy 285 Treatment and coating of metals; general mechanical engineering 286 Manufacture of cutlery, tools and general hardware 287

[1]Includes only industries where firms are recorded to be in production in Ireland

Manufacture of other fabricated metal products 312 Manufacture of electricity distribution and control apparatus 313 Manufacture of insulated wire and cable 314 Manufacture of accumulators, primary cells and primary batteries 315 Manufacture of lighting equipment and electric lamps 316 Manufacture of electrical equipment n.e.c. 321 Manufacture of electronic valves and tubes and other electronic components **V. Energy** 101 Mining and agglomeration of hard coal 102 Mining and agglomeration of lignite 103 Extraction and agglomeration of peat 111 Extraction of crude petroleum and natural gas 112 Service activities incidental to oil and gas extraction, excluding surveying 232 Manufacture of refined petroleum products **VI. Capital goods** 281 Manufacture of structural metal 282 Manufacture of tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers 283 Manufacture of steam generators, except central heating hot water boilers 291 Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines 292 Manufacture of other general purpose machinery 293 Manufacture of agricultural and forestry machinery 294 Manufacture of machine tools 295 Manufacture of other special purpose machinery 300 Manufacture of office machinery and computers 311 Manufacture of electric motors, generators and transformers 322 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 331 Manufacture of medical and surgical equipment and orthopaedic appliances 332 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control 333 Manufacture of industrial process control equipment 342 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 343 Manufacture of parts and accessories for motor vehicles and their engines 351 Building and repairing of ships and boats 352 Manufacture of railway and tramway locomotives and rolling stock 353 Manufacture of aircraft and spacecraft 355 Manufacture of other transport equipment n.e.c.

7 Rauch classification at the 2- to 4-digit NACE level

Homogenous 151 Production, processing and preserving of meat and meat products 154 Manufacture of vegetable and animal oils and fats 232 Manufacture of refined petroleum products **Reference priced** 132 Mining of non-ferrous metal ores, except uranium and thorium ores 152 Processing and preserving of fish and fish products 153 Processing and preserving of fruit and vegetables 155 Manufacture of dairy products 156 Manufacture of grain mill products, starches and starch products 157 Manufacture of prepared animal feeds 1583 Manufacture of sugar 1585 Manufacture of macaroni, noodles, couscous and similar farinaceous products 1586 Processing of tea and coffee 1587 Manufacture of condiments and seasonings 1588 Manufacture of homogenized food preparations and dietetic food 1589 Manufacture of other food products n.e.c. 1591 Manufacture of distilled potable alcoholic beverages 1594 Manufacture of cider and other fruit wines 1596 Manufacture of beer 1597 Manufacture of malt 16 Manufacture of tobacco products 1753 Manufacture of non-wovens and articles made from non-wovens, except apparel 1754 Manufacture of other textiles n.e.c. 2121 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard 2411 Manufacture of industrial gases 2412 Manufacture of dyes and pigments 2413 Manufacture of other inorganic basic chemicals 2414 Manufacture of other organic basic chemicals 2415 Manufacture of fertilizers and nitrogen compounds 244 Manufacture of pharmaceuticals, medicinal chemicals and botanical products 247 Manufacture of man-made fibres 274 Manufacture of basic precious and non-ferrous metals **Differentiated** 101 Mining and agglomeration of hard coal 111 Extraction of crude petroleum and natural gas 1411 Quarrying of ornamental and building stone 1412 Quarrying of limestone, gypsum and chalk 1421 Operation of gravel and sand pits 145 Other mining and quarrying n.e.c. 1581 Manufacture of bread; manufacture of fresh pastry goods and cakes 1582 Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes 1598 Production of mineral waters and soft drinks 1751 Manufacture of carpets and rugs 1752 Manufacture of cordage, rope, twine and netting 176 Manufacture of knitted and crocheted fabrics 177 Manufacture of knitted and crocheted articles 18 Manufacture of wearing apparel; dressing and dyeing of fur 19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear 202 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards 203 Manufacture of builders' carpentry and joinery 204 Manufacture of wooden containers 205 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials 211 Manufacture of pulp, paper and paperboard 2122 Manufacture of household and sanitary goods and of toilet requisites 2123 Manufacture of paper stationery 2125 Manufacture of other articles of paper and paperboard n.e.c. 221 Publishing 222 Printing and service activities related to printing 2416 Manufacture of plastics in primary forms 242 Manufacture of pesticides and other agro-chemical products 243 Manufacture of paints, varnishes and similar coatings, printing ink and mastics 245 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 2511 Manufacture of rubber tyres and tubes 2512 Retreading and rebuilding of rubber tyres 252 Manufacture of plastic products 261 Manufacture of glass and glass products 2626 Manufacture of refractory ceramic products 263 Manufacture of ceramic tiles and flags 264 Manufacture of bricks, tiles and construction products, in baked clay 265 Manufacture of cement, lime and plaster 266 Manufacture of articles of concrete, plaster and cement 267 Cutting, shaping and finishing of ornamental and building stone 268 Manufacture of other non-metallic mineral products 281 Manufacture of structural metal products 282 Manufacture of tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers 286 Manufacture of cutlery, tools and general hardware 287 Manufacture of other fabricated metal products 29 Manufacture of machinery and equipment n.e.c. (except NACE 296) 311 Manufacture of electric motors, generators and transformers 313 Manufacture of insulated wire and cable 314 Manufacture of accumulators, primary cells and primary batteries 315 Manufacture of lighting equipment and electric lamps 316 Manufacture of electrical equipment n.e.c. 321 Manufacture of electronic valves and tubes and other electronic components 322 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 323 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods 331 Manufacture of medical and surgical equipment and orthopaedic appliances 332 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment 334 Manufacture of optical instruments and photographic equipment 335 Manufacture of watches and clocks 34 Manufacture of motor vehicles, trailers and semi-trailers 35 Manufacture of other transport equipment 36 Manufacture of furniture; manufacturing n.e.c.

8 Pricing-to-market under flexible and sticky prices

First, we review the dependence of pricing-to-market on the properties of the residual demand in a very general setting with flexible prices. Then we consider two specific examples under flexible prices. Finally we examine these specific examples under Calvo sticky prices. We make particular assumptions about the process for shocks to show how under sticky prices, the frequency of price adjustment, the choice of invoice currency and the process for shocks can matter for pricing-to-market.

General residual demand

Suppose residual demand for firm i in market k at time t takes the form

$$Q_t^{ik} = q\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)$$

where $\mathbf{Z}_t^{ik}$ is a vector of all exogenous factors influencing demand. Suppose that i's marginal cost is the same for all markets (we could generalize by allowing a constant multiplicative difference without affecting the results). The firm's problem at date t takes the form

$$\max_{P_t^{ik*}} \left(E_t^k P_t^{ik*} - C_t^i\right) q\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)$$

and the optimal price expressed in domestic currency can be implicitly defined using:

$$E_t^k P_t^{ik*} = C_t^i \frac{\frac{\partial \ln q\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)}{\partial \ln P_t^{ik*}}}{1 + \frac{\partial \ln q\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)}{\partial \ln P_t^{ik*}}} = C_t^i \frac{\theta_t^{ik}\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)}{\theta_t^{ik}\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right) - 1} = C_t^i \mu_t^{ik}\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)$$

where

$$\theta_t^{ik}\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right) = -\frac{\partial \ln q\left(P_t^{ik*}, \mathbf{Z}_t^{ik}\right)}{\partial \ln P_t^{ik*}}$$

Our interest is in the elasticity of the relative markup between the foreign market and the home market with respect to E_t^k. This can be written:

$$\frac{\partial \ln\left(\mu_t^{ik}/\mu_t^{iH}\right)}{\partial \ln E_t^k} = \frac{\left[\frac{1}{\theta_t^{ik}-1}\right] \frac{\partial \ln \theta_t^{ik}}{\partial \ln P_t^{ik*}}}{\left[1 + \frac{\partial \ln \theta_t^{ik}}{\partial \ln P_t^{ik*}} \frac{1}{\theta_t^{ik}-1}\right]} \left[1 - \frac{\partial \ln C_t^i}{\partial \ln E_t^k}\right] + \frac{\left[\frac{1}{\theta_t^{iH}-1}\right] \frac{\partial \ln \theta_t^{iH}}{\partial \ln P_t^{iH}}}{\left[1 + \frac{\partial \ln \theta_t^{iH}}{\partial \ln P_t^{iH}} \frac{1}{\theta_t^{iH}-1}\right]} \frac{\partial \ln C_t^i}{\partial \ln E_t^k}$$

The elasticity of the (negative of the) price elasticity of demand with respect to price is sometimes referred to as the "super-elasticity" of demand (e.g. Klenow and Willis (2006)). Clearly, if marginal cost is insensitve to exchange rates, under flexible prices, a unitary elasticity of the relative markup with respect to the exchange rate requires that the super-elasticity $\to \infty$.

Specific examples: Flexible prices

CES

Suppose demand for firm i in market k at time t takes the CES form:

$$Q_t^{ik} = \left(\frac{P_t^{ik*}}{P_t^{k*}}\right)^{-\eta} Q_t^k$$

If prices are fully flexible, the optimal price (converted to domestic currency) is given by:

$$E_t^k P_t^{ik*} = \frac{\eta}{\eta - 1} C_t^i$$

The optimal markup is constant and hence $\frac{\partial \ln\left(\mu_t^{ik}/\mu_t^{iH}\right)}{\partial \ln E_t^k} = 0$.

Linear demand

Now suppose that firm i in market k at time t faces the following linear demand (scaled by the size of the market):

$$Q_t^{ik} = Q_t^k \left[\alpha - \delta P_t^{ik*} + \gamma \delta P_t^{k*}\right]$$

In this case

$$\theta_t^{ik} = \frac{\delta P_t^{ik*}}{\alpha - \delta P_t^{ik*} + \gamma \delta P_t^{k*}}$$

and

$$\frac{\partial \ln \theta_t^{ik}}{\partial \ln P_t^{ik*}} = \theta_t^{ik} + 1$$

so if costs are insensitive to E_t^k, the relative markup elasticity is given by

$$\frac{\partial \ln\left(\mu_t^{ik}/\mu_t^{iH}\right)}{\partial \ln E_t^k} = \frac{\left[\frac{1}{\theta_t^{ik}-1}\right]\frac{\partial \ln \theta_t^{ik}}{\partial \ln P_t^{ik*}}}{\left[1 + \frac{\partial \ln \theta_t^{ik}}{\partial \ln P_t^{ik*}}\frac{1}{\theta_t^{ik}-1}\right]} = \frac{\theta_t^{ik}+1}{2\theta_t^{ik}} = \frac{2\mu_t^{ik}-1}{2\mu_t^{ik}}$$

Plugging in for plausible values of the gross markup (e.g. 1.05-1.5) yields elasticities in the range 0.52-0.67.

Specific examples: Calvo sticky prices

CES demand

Suppose that in the context of the model presented in the paper, $F_t^{ik} = 0$ with probability $1-\lambda$ and equals infinity otherwise, and that F_t^{ik} is perfectly correlated across markets within a firm (Calvo sticky prices with perfectly synchronized price setting within the plant-product pair). Suppose that demand takes the form:

$$Q_t^{ik} = \left(\frac{P_t^{ik*}}{P_t^{k*}}\right)^{-\eta} Q_t^k$$

Assume that firms discount the future at constant rate β.

If the firm sets prices in local currency and gets the signal to change prices at t, its problem in choosing the optimal reset price in market k is:

$$\max_{\hat{P}_t^{ik*}} \mathbb{E}_t \sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \left[\frac{E_s^k \hat{P}_t^{ik*} - C_s^i}{P_s^H}\right] \left(\frac{\hat{P}_t^{ik*}}{P_s^{k*}}\right)^{-\eta} Q_s^k$$

where $\tilde{\beta} = \lambda\beta$. The optimal reset price is:

$$\hat{P}_t^{ik*} = \left(\frac{\eta}{\eta-1}\right) \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} Q_s^k C_s^i / P_s^H\right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} Q_s^k E_s^k / P_s^H\right]}$$

If the firm sets prices in home currency, its problem in choosing the optimal reset price is:

$$\max_{\hat{P}_t^{ik}} \mathbb{E}_t \sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \left[\frac{\hat{P}_t^{ik} - C_s^i}{P_s^H} \right] \left(\frac{\hat{P}_t^{ik}}{E_s^k P_s^{k*}} \right)^{-\eta} Q_s^k$$

and the optimal reset price is:

$$\hat{P}_t^{ik} = \left(\frac{\eta}{\eta - 1} \right) \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} E_s^{k\eta} Q_s^k C_s^i / P_s^H \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} E_s^{k\eta} Q_s^k / P_s^H \right]}$$

This implies that in the case of local currency invoicing and perfectly synchronized price setting, the optimal reset price in the foreign market relative to the optimal reset price in the home market, expressed in domestic currency, on the date at which the firm changes the price in both markets, is given by:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = E_t^k \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} Q_s^k C_s^i / P_s^H \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{H\eta-1} Q_s^H C_s^i \right]} \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{H\eta-1} Q_s^H \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} Q_s^k E_s^k / P_s^H \right]} \quad (1)$$

In contrast, in the case of home currency invoicing, this object is given by:

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} E_s^{k\eta} Q_s^k C_s^i / P_s^H \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{H\eta-1} Q_s^H C_s^i \right]} \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{H\eta-1} Q_s^H \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \left[P_s^{k*\eta} E_s^{k\eta} Q_s^k / P_s^H \right]} \quad (2)$$

By definition, the relative reset price is equal to the relative reset markup given that cost is assumed the same across markets. To show how the relative reset markup depends on the current nominal exchange rate, and how this dependence is a function of price stickiness, invoice currency and the process for shocks, suppose that costs, home and foreign aggregate prices and aggregate demand are constant: $\bar{P}^{k*}$, $\bar{P}^H$, $\bar{Q}^k$, $\bar{Q}^H$, $\bar{C}^i$.[2] Suppose that the nominal exchange rate follows a random walk in logs:[3]

$$\ln E_t^k = \rho \ln E_{t-1}^k + \varepsilon_t^k$$

for some $\rho \in [0, 1]$, where

$$\varepsilon_t^k \sim N\left(0, \sigma^2\right)$$

Then in the case of local currency invoicing and perfectly synchronized price setting, the optimal reset price in the foreign market relative to the optimal reset price in the home market, expressed in domestic currency, on the date at which the firm changes the price in both markets, is given by:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = \frac{\hat{\mu}_t^{ik}}{\hat{\mu}_t^{iH}} = \frac{E_t^k}{\left(1 - \tilde{\beta}\right) \left[E_t^k + \sum_{s=1}^{\infty} \tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2} \left[\frac{1-\rho^{2s}}{1-\rho^2} \right] \right) \right]}$$

[2]These assumptions are made for illustrative purposes only, to show how pricing-to-market depends on the process for shocks in the simplest possible setting. In general equilibrium, the structure of the model dictates how the behavior of these variables depends on the nominal exchange rate.

[3]It is natural to specify a random walk in log terms, as this guarantees that the level of the exchange rate is always positive and greater than zero.

where $\hat{\mu}$ indicates the markup implied by the reset price - we will refer to this as the reset markup. It is clear that the degree of price stickiness as captured by $\tilde{\beta}$, and ρ, the persistence of the exchange rate process, and σ^2, the variation of the innovation, will matter for the relationship between relative reset markups and the current nominal exchange rate:

$$\frac{\partial \ln \left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = \frac{\sum_{s=1}^{\infty} \tilde{\beta}^s \left(1-\rho^s\right) \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}{E_t^k + \sum_{s=1}^{\infty} \tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}$$

In the special case where $\rho = 0$, we have:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = \frac{E_t^k}{\left[\left(1-\tilde{\beta}\right) E_t^k + \tilde{\beta} \exp\left(\frac{\sigma^2}{2}\right)\right]}$$

so

$$\frac{\partial \ln \left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = \frac{\tilde{\beta} \exp\left(\frac{\sigma^2}{2}\right)}{\left(1-\tilde{\beta}\right) E_t^k + \tilde{\beta} \exp\left(\frac{\sigma^2}{2}\right)}$$

while if $\rho = 1$ (i.e. log exchange rate is a random walk), we have:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = \frac{1-\tilde{\beta} \exp\left(\frac{\sigma^2}{2}\right)}{\left(1-\tilde{\beta}\right)}$$

so

$$\frac{\partial \ln \left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = 0$$

In the case of home currency invoicing and perfectly synchronized price setting, the optimal reset price in the foreign market relative to the optimal reset price in the home market, expressed in domestic currency, on the date at which the firm changes the price in both markets, is given by:

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t E_s^{k\eta}}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t E_s^{k\eta}} = 1$$

So in this case, there is no pricing-to-market, independent of the exchange rate process.

Note that given CES demand, the degree of pricing-to-market conditional on price adjustment is independent of the size of the gross markup $\mu = \eta/\left(\eta-1\right)$.

Linear demand

We maintain the Calvo assumption about price stickiness along with synchronized price changes across markets and constant discounting at rate β, but now suppose that demand is linear:

$$Q_t^{ik} = Q_t^k \left[\alpha - \delta P_t^{ik*} + \gamma \delta P_t^{k*}\right]$$

In the case of local currency invoicing, the firm's problem in choosing its optimal reset price in market k is:

$$\max_{\hat{P}_t^{ik*}} \mathbb{E}_t \sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \left[\frac{E_s^k \hat{P}_t^{ik*} - C_s^i}{P_s^H} \right] Q_s^k \left[\alpha - \delta \hat{P}_t^{ik*} + \gamma \delta P_s^{k*} \right]$$

and the optimal reset price is:

$$\hat{P}_t^{ik*} = \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{E_s^k Q_s^k}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^{k*} + \left(C_s^i / E_s^k \right) \right] \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{E_s^k Q_s^k}{P_s^H}}$$

In the case of home currency invoicing, the firm's problem is

$$\max_{\hat{P}_t^{ik}} \mathbb{E}_t \sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \left[\frac{\hat{P}_t^{ik} - C_s^i}{P_s^H} \right] Q_s^k \left[\alpha - \delta \left(\hat{P}_t^{ik} / E_s^k \right) + \gamma \delta P_s^{k*} \right]$$

and the optimal reset price is:

$$\hat{P}_t^{ik} = \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^k}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^{k*} + \left(C_s^i / E_s^k \right) \right] \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^k}{E_s^k P_s^H}}$$

This implies that in the case of local currency invoicing and perfectly synchronized price setting, the optimal reset price in the foreign market relative to the optimal reset price in the home market, expressed in domestic currency, on the date at which the firm changes the price in both markets, is given by:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = E_t^k \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{E_s^k Q_s^k}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^{k*} + \left(C_s^i / E_s^k \right) \right] \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^H}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^H + C_s^i \right] \right]} \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^H}{P_s^H}}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{E_s^k Q_s^k}{P_s^H}} \tag{3}$$

In contrast, in the case of home currency invoicing, this object is given by:

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^k}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^{k*} + \left(C_s^i / E_s^k \right) \right] \right]}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^H}{P_s^H} \left[\frac{1}{2} \left[(\alpha/\delta) + \gamma P_s^H + C_s^i \right] \right]} \frac{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^H}{P_s^H}}{\sum_{s=t}^{\infty} \tilde{\beta}^{s-t} \mathbb{E}_t \frac{Q_s^k}{E_s^k P_s^H}} \tag{4}$$

Assuming again that costs, home and foreign aggregate prices and aggregate demand are constant: $\bar{P}^{k*}$, $\bar{P}^H$, $\bar{Q}^k$, $\bar{Q}^H$, $\bar{C}^i$, and that the nominal exchange rate follows a random walk in logs, we can illustrate how the behavior of the relative reset prices depends on the nominal exchange rate process and other primitives of the firm's problem. However in the case of linear demand, we must do a little more work. Suppose that there is no cost heterogeneity. Then the steady state price in the home market is given by:

$$\bar{P}^H = \frac{1}{2} \left[\alpha/\delta + \gamma \bar{P}^H + \bar{C} \right]$$

so

$$\bar{P} = \frac{1}{2 - \gamma} \left[\alpha/\delta + \bar{C} \right]$$

and making use of $\bar{P}^H/\bar{C} = \mu^H$ we get

$$\bar{C} = \frac{\alpha/\delta}{\mu^H (2-\gamma) - 1}$$

and normalizing $\bar{C} = 1$, then

$$\mu^H (2-\gamma) - 1 = \alpha/\delta$$

and we get

$$\alpha/\delta + \gamma\bar{P}^H + \bar{C} = 2\mu^H$$

Suppose we assume the same parameters in the foreign as in the home market, $\mu = \mu^H$, and also assume $\bar{P}^{k*} = \bar{P}^H$. Then

$$\alpha/\delta + \gamma\bar{P}^{k*} = 2\mu - 1$$

Then under local currency invoicing, we have:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = \frac{\hat{\mu}_t^{ik}}{\hat{\mu}_t^{iH}} = E_t^k \frac{[2\mu - 1]\left(1-\tilde{\beta}\right)\left[E_t^k + \sum_{s=1}^{\infty}\tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)\right] + 1}{2\mu\left(1-\tilde{\beta}\right)\left[E_t^k + \sum_{s=1}^{\infty}\tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)\right]}$$

so

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} =$$

$$1 - \frac{\left[E_t^k + \sum_{s=1}^{\infty}\tilde{\beta}^s \rho^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)\right]}{[2\mu - 1]\left(1-\tilde{\beta}\right)\left[E_t^k + \sum_{s=1}^{\infty}\tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)\right]^2 + \left[E_t^k + \sum_{s=1}^{\infty}\tilde{\beta}^s \left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)\right]}$$

In the special case where $\rho = 0$ we get:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = E_t^k \frac{[2\mu - 1]\left[\left(1-\tilde{\beta}\right)E_t^k + \tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right] + 1}{2\mu\left[\left(1-\tilde{\beta}\right)E_t^k + \tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right]}$$

so

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = 1 - \frac{E_t^k\left(1-\tilde{\beta}\right)}{(2\mu - 1)\left[\left(1-\tilde{\beta}\right)E_t^k + \tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right]^2 + \left[\left(1-\tilde{\beta}\right)E_t^k + \tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right]}$$

while if $\rho = 1$ we get:

$$\frac{E_t^k \hat{P}_t^{ik*}}{\hat{P}_t^{iH}} = \frac{[2\mu - 1]\left(1-\tilde{\beta}\right)E_t^k\left[1-\tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right] + 1}{2\mu\left(1-\tilde{\beta}\right)\left[1-\tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right]}$$

so

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = \frac{E_t^k\,[2\mu - 1]\left(1-\tilde{\beta}\right)\left[1-\tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right]}{E_t^k\,[2\mu - 1]\left(1-\tilde{\beta}\right)\left[1-\tilde{\beta}\exp\left(\frac{\sigma^2}{2}\right)\right] + 1}$$

Under home currency invoicing, we have

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{\hat{\mu}_t^{ik}}{\hat{\mu}_t^{iH}} = \frac{(2\mu-1) + \left(1-\tilde{\beta}\right)\left[\frac{1}{E_t^k} + \sum_{s=1}^{\infty}\tilde{\beta}^s \frac{1}{\left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}\right]}{2\mu\left(1-\tilde{\beta}\right)\left[\frac{1}{E_t^k} + \sum_{s=1}^{\infty}\tilde{\beta}^s \frac{1}{\left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}\right]}$$

and

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} =$$

$$\frac{[2\mu-1]\left[\frac{1}{E_t^k} + \sum_{s=1}^{\infty}\tilde{\beta}^s \rho^s \frac{1}{\left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}\right]}{(2\mu-1)\left[\frac{1}{E_t^k} + \sum_{s=1}^{\infty}\tilde{\beta}^s \frac{1}{\left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}\right] + \left(1-\tilde{\beta}\right)\left[\frac{1}{E_t^k} + \sum_{s=1}^{\infty}\tilde{\beta}^s \frac{1}{\left(E_t^k\right)^{\rho^s} \exp\left(\frac{\sigma^2}{2}\left[\frac{1-\rho^{2s}}{1-\rho^2}\right]\right)}\right]^2}$$

so in the special case where $\rho = 0$ we have:

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{2\mu - 1 + \left[\left(1-\tilde{\beta}\right)\frac{1}{E_t^k} + \tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right]}{2\mu\left[\left(1-\tilde{\beta}\right)\frac{1}{E_t^k} + \tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right]}$$

and

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = \frac{[2\mu-1]\left(1-\tilde{\beta}\right)\frac{1}{E_t^k}}{(2\mu-1)\left[\left(1-\tilde{\beta}\right)\frac{1}{E_t^k} + \tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right] + \left[\left(1-\tilde{\beta}\right)\frac{1}{E_t^k} + \tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right]^2}$$

while in the special case where $\rho = 1$ we have:

$$\frac{\hat{P}_t^{ik}}{\hat{P}_t^{iH}} = \frac{(2\mu-1)E_t^k\left[1-\tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right] + \left(1-\tilde{\beta}\right)}{2\mu\left(1-\tilde{\beta}\right)}$$

so

$$\frac{\partial \ln\left(\hat{\mu}_t^{ik}/\hat{\mu}_t^{iH}\right)}{\partial \ln E_t^k} = \frac{(2\mu-1)\left[1-\tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right]E_t^k}{(2\mu-1)E_t^k\left[1-\tilde{\beta}\exp\left(-\frac{\sigma^2}{2}\right)\right] + \left(1-\tilde{\beta}\right)}$$

Comovement between relative reset prices and E_t^k (and hence pricing-to-market) depends on the properties of the nominal exchange rate process, on the level of markups μ, and on the frequency of price adjustment. This dependence differs across the two cases of local currency invoicing and home currency invoicing. Table 30 provides some illustrative numbers for the different cases, evaluated at $E_t^k = 1$. Note that when prices are flexible ($\tilde{\beta} = 0$), evaluating at $E_t^k = 1$ returns the flexible-price relative markup elasticity, which depends only on μ.

Table 30: Markup elasticity under linear demand

		values of $1-\lambda$; $\mu=1.25$, $\sigma^2=0.1$									
inv. curr.	ρ	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Local	0	0.98	0.96	0.94	0.92	0.90	0.89	0.87	0.85	0.83	0.81
Local	1	0.00	0.01	0.02	0.05	0.08	0.11	0.14	0.18	0.22	0.26
Home	0	0.03	0.07	0.10	0.13	0.16	0.19	0.22	0.25	0.28	0.31
Home	1	0.74	0.68	0.66	0.64	0.63	0.63	0.62	0.62	0.61	0.61
		values of μ; $1-\lambda=0.15$, $\sigma^2=0.1$									
inv. curr.	ρ	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
Local	0	0.93	0.93	0.94	0.94	0.94	0.94	0.95	0.95	0.95	0.95
Local	1	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Home	0	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.11	0.11
Home	1	0.58	0.60	0.62	0.64	0.66	0.67	0.68	0.70	0.71	0.72
		values of σ^2; $\mu=1.25$; $1-\lambda=0.15$									
inv. curr.	ρ	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Local	0	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.96	0.96
Local	1	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.02
Home	0	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12
Home	1	0.63	0.66	0.68	0.70	0.71	0.73	0.74	0.75	0.76	0.77

Summing up

These special cases are not designed to match our findings, but illustrate several points that are useful in interpreting our empirical results. First, simply conditioning on price changes does not eliminate the effect of stickiness on reset prices. The fact that prices are sticky means that even when producers do change their prices, their behavior may differ from what it would be if prices were not sticky. This does not rely on strategic complementarities in pricing across firms, as we abstract from these considerations in these special cases. Second, it is reasonable to expect behavior conditional on price adjustment to vary systematically with the choice of invoice currency. Third, when prices are sticky, the degree of stickiness and expectations about the joint process for shocks matter for the behavior of reset prices. We focus on shocks to the nominal exchange rate to illustrate this dependence, but more generally, the behavior of reset prices depends on the joint process for shocks to all variables.

9 Interpreting the extensive margin results

Frequency analysis

In this note, we illustrate some aspects of the raw data that underlies our extensive margin finding that we cannot reject $\beta_e^k = 1$. We focus on plant-product pairs and months where there is at least one quote-line in the Irish market and at least one quote-line in the UK market, and where the last price change was synchronized across at least one quote-line in each market. We look only at cases where the last price change was synchronized. Let s_t^i be the number of periods since prices were last changed. Now suppose $\Delta_{s_t^i} e_t^{UK} > 0$. We can classify the cases where the direction of price changes at t tells us that the producer is leaning against the default drift in relative markups, exacerbating the default drift in relative markups, and where the direction of price changes is uninformative, as follows. The final column reports the frequency of the different types of episode:

$\Delta_{s_t^i} e_t^{UK} > 0$			
	UK prices	Irish prices	freq.
Lean against	all ↓ or ↓ and 0	0	76
	all ↓ or ↓ and 0	all ↑ or ↑ and 0	33
	0	all ↑ or ↑ and 0	50
Uninformative	all ↓ or ↓ and 0	all ↓ or ↓ and 0	127
	all ↑ or ↑ and 0	all ↑ or ↑ and 0	210
	0	0	6184
	↑ and ↓	↑ and ↓	163
Exacerbate	all ↑ or ↑ and 0	0	94
	all ↑ or ↑ and 0	all ↓ or ↓ and 0	26
	0	all ↓ or ↓ and 0	48

Now suppose $\Delta_{s_t^i} e_t^{UK} < 0$. Again, we can classify the cases where the direction of price changes at t tells us that the producer is leaning against the default drift in relative markups, exacerbating the default drift in relative markups, and where the direction of price changes is uninformative, as follows:

$\Delta_{s_t^i} e_t^{UK} < 0$			
	UK prices	Irish prices	freq.
Lean against	all ↑ or ↑ and 0	0	51
	all ↑ or ↑ and 0	all ↓ or ↓ and 0	20
	0	all ↓ or ↓ and 0	33
Uninformative	all ↓ or ↓ and 0	all ↓ or ↓ and 0	103
	all ↑ or ↑ and 0	all ↑ or ↑ and 0	149
	0	0	3638
	↑ and ↓	↑ and ↓	149
Exacerbate	all ↓ or ↓ and 0	0	37
	all ↓ or ↓ and 0	all ↑ or ↑ and 0	26
	0	all ↑ or ↑ and 0	46

We can summarize these findings by looking at the overall frequency of "lean against," "uninformative" and "exacerbate." Here, we condition on at least one price changing:

Frequency conditional on at least one change			
	$\Delta_{s_t^i} e_t^{UK} > 0$	$\Delta_{s_t^i} e_t^{UK} < 0$	total
Lean against	159	104	263
Undetermined	500	401	901
Exacerbate	168	109	277

From this table, it is apparent that the number of episodes where the direction of price changes is consistent with a desire to lean against the default markup drift (i.e. $\beta_e^{UK} < 1$)

is approximately equal to the number of episodes where the direction of price changes is consistent with a desire to exacerbate the default markup drift (i.e. $\beta_e^{UK} > 1$). This one way to illustrate why our more formal treatment (the conditional logit estimations) cannot reject the null hypothesis of $\beta_e^{UK} = 1$. The more formal estimation strategy has the advantage that it can take into account the magnitude of the exchange rate change, which this analysis does not.

Interpretation of coefficients in conditional logit

In our baseline conditional logit exercises, our estimate of the coefficient on exchange rate changes since the last price change is not significantly different from zero. But does this indicate a true zero, or just a very imprecisely estimated coefficient? To do better at interpreting the results, it is necessary to transform the point estimates into a form that is easier to interpret. Remember that the estimating equations are

$$\Pr[\text{increase}] = \Lambda\left(\psi^i_{t,s_t^{ik}} + \left(\beta_e^k - 1\right)\Delta_{s_t^{ik}} e_t^k\right)$$

$$\Pr[\text{decrease}] = \Lambda\left(\phi^i_{t,s_t^{ik}} - \left(\beta_e^k - 1\right)\Delta_{s_t^{ik}} e_t^k\right)$$

where $\Lambda(x) = 1/(1+e^{-x})$. The conditional logit estimator conditions on $\psi^i_{t,s_t^{ik}}$ and $\phi^i_{t,s_t^{ik}}$, it does not estimate them. So to benchmark values for these, we use the unconditional probability of price increases and price decreases. The unconditional probability of a price change is approximately 0.16, while increases make up about 2/3 of price changes and decreases make up about 1/3. As a result, we solve out for ψ and ϕ using

$$0.16 * 0.67 = 1/\left(1+e^{-\psi}\right)$$

$$0.16 * 0.33 = 1/\left(1+e^{-\phi}\right)$$

implying $\psi = -2.12$ and $\phi = -2.89$. The "increases" equation is identified off a range of $\Delta_{s_t^{ik}} e_t^k \in [-0.13, 0.18]$. The coefficient estimate is 0.59. Substituting in the benchmark ψ, this implies $\Pr[\text{increase}] \in [0.10, 0.12]$. So the difference between a 13% appreciation and a 18% depreciation implies an increase in the probability of a price increase from 0.10 to 0.12. The "decreases" equation is identified off the range of $\Delta_{s_t^{ik}} e_t^k \in [-0.11, 0.18]$. The coefficient estimate is 1.62. Substituting in the benchmark ϕ, this implies $\Pr[\text{decrease}] \in [0.04, 0.07]$. We conclude that large differences in exchange rate movements imply modest absolute changes in the probability of observing price increases or decreases, and in this sense, we really are estimating effects that are close to zero rather than just very imprecisely estimated.

Could the extensive margin results be a Type II error?

We have undertaken the following Monte Carlo exercise to examine whether for $\beta \neq 1$, the extensive margin exercise is able to reject the null of $\beta = 1$, with realistic idiosyncratic shocks. The exercise is based on assuming that the true process for the month-on-month log change in the optimal reset price (expressed in foreign currency) for firm i, in market k at time t is given by:

$$\Delta \hat{p}_t^{ik*} = \theta_t^i + (\beta - 1)\,\Delta e_t^k + \eta_t^{ik}$$

where $\theta_t^i \sim_{iid} N\left(\mu_\theta, \sigma_\theta^2\right)$ and $\eta_t^{ik} \sim_{iid} N\left(0, \sigma_\eta^2\right)$. We choose μ_θ, σ_θ^2 and σ_η^2 (presently we describe how we choose these). We take the observed Δe_t^k for the Euro-Sterling exchange rate each month over the period February 1995-December 2009. Then we take draws of θ_t^i and η_t^{ik} for 200 "firms" in the "Irish" and "UK" markets for the time-period February 1995-December 2009. We use

$$\Delta \hat{p}_t^{iIRL*} = \theta_t^i + \eta_t^{iIRL}$$

to construct the log change in the optimal reset price for firm i in the Irish market, and

$$\Delta \hat{p}_t^{iUK*} = \theta_t^i + (\beta - 1)\,\Delta e_t^{UK} + \eta_t^{iUK}$$

to construct the log change in the optimal reset price for firm i in the UK market. We then adopt the following rule for the timing of price changes. We assume that with probability 0.1, firm i gets to change its price in both markets. With probability 0.05, it gets to change its price only in the Irish market. With probability 0.05 it gets to change its price only in the UK market. These probabilities are independent across firms and over time. This is chosen to approximately match the fact that for plants with price quotes in both the UK and Irish markets, 20% of the time, at least one price changes, while of of episodes where at least one price changes, 30% do not involve synchronization, 30% involve perfect synchronization, and the remainder involve partial synchronization. For plants and markets for which a price change is indicated, we construct the realized price change as:

$$\Delta_{s_t^{ik}} p_t^{ik*} = \sum_{\tau = t - s_t^{ik} + 1}^{t} \Delta \hat{p}_\tau^{ik*}$$

and the corresponding exchange rate change as

$$\Delta_{s_t^{ik}} e_t^k = \sum_{\tau = t - s_t^{ik} + 1}^{t} \Delta e_\tau^k$$

This gives us a distribution of $\Delta_{s_t^{ik}} p_t^{ik*}$ and $\Delta_{s_t^{ik}} e_t^k$. We choose $\mu_\theta = 0.004$, $\sigma_\theta^2 = 0.02$ and $\sigma_\eta^2 = 0.02$ to approximately match the observed relative frequency of increases vs decreases (there are 74% as many decreases as increases in the data, and 78% in our simulation) and the observed size distribution of invoice currency price changes. These values also match the fact that the observed distribution of $\Delta_{s_t^{ik}} p_t^{ik*}$ has a higher standard deviation than the observed distribution of $\Delta_{s_t^{ik}} e_t^k$.

Table 32: Results of Monte Carlo simulation

	Increases: $\beta - 1$		Decreases: $1 - \beta$	
	% signif. pos	% signif. neg	% signif. pos	% signif. neg
$\beta = 1.25$	100	0	0	100
$\beta = 1.10$	87	0	0	35
$\beta = 1.05$	66	0	1	6
$\beta = 1.00$	19	0	9	0
$\beta = 0.95$	1	4	45	0
$\beta = 0.90$	0	11	88	0
$\beta = 0.75$	0	94	100	0

Note: The critical value chosen for determining significance is a t-stat of 1.96.

Table 31: Size of price changes: Data and Monte Carlo

	Increases				Decreases			
	Mean	p25	p50	p75	Mean	p25	p50	p75
Data	6.13	1.45	3.31	7.41	-5.85	-7.79	-3.85	-1.44
Monte Carlo	6.61	2.17	4.77	9.06	-4.16	-5.71	-3.06	-1.38

Note: Moments refer to invoice currency price changes. To calculate moments for the data, price change observations are weighted by the relevant plant's sales in the relevant market (home or export) expressed as a share of total within-sample sales in the year in question. The statistics for the Monte Carlo refer to the case where $\beta = 1$ and where we simulate 20,000 firms in the two markets for the sample period.

We then use the panel of simulated data to implement the same conditional logit regressions as we implement using the actual data:

$$\Pr[\text{increase}] = \Lambda\left(\psi^i_{t,s^{ik}_t} + \left(\beta^k_e - 1\right)\Delta_{s^{ik}_t} e^k_t\right) \tag{5}$$

$$\Pr[\text{decrease}] = \Lambda\left(\phi^i_{t,s^{ik}_t} - \left(\beta^k_e - 1\right)\Delta_{s^{ik}_t} e^k_t\right) \tag{6}$$

For each value of β we examine, we create 100 panels of 200 firms of length $T = 179$ (corresponding to the number of months for which we have the change in the exchange rate). and we record the distribution of the estimates of $\beta - 1$ and the relevant standard errors from both the increases equation and the decreases equation in each case. We find that when the true $\beta = 0.75$ (or 1.25), this test has no difficulty rejecting the null of $\beta = 1$, in the sense that the results of the increases equation and the decreases equation point in the same direction. For values of β quite close to 1 (such as 0.9, 0.95, 1.05 or 1.1), the results of the test are somewhat ambiguous.

10 Selection bias

In this note, we address the possibility of a bias in the intensive margin estimates that may arise from a form of selection that operates within plant-product pairs and markets. Remember that the intensive margin exercise makes use only of episodes where there is an invoice currency price change. Suppose that price setting is state-dependent, and that as outlined in Section 4.2, invoice currency price increases and price decreases are observed as follows:

$$\Delta_{s_t^{ik}} p_t^{ik*} > 0 \quad \text{if} \quad \eta_{t,s_t^{ik}}^{ik} > \bar{\rho}_t^i - \theta_{t,s_t^{ik}}^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$$

$$\Delta_{s_t^{ik}} p_t^{ik*} < \quad \text{if} \quad \eta_{t,s_t^{ik}}^{ik} < \underline{\rho}_t^i - \theta_{t,s_t^{ik}}^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$$

Remember that the intensive margin estimating equation is

$$\Delta_{s_t^{ik}} p_t^{ik} = \theta_{t,s_t^{ik}}^i + \beta_e^k \Delta_{s_t^{ik}} e_t^k + \eta_{t,s_t^{ik}}^{ik}$$

The problem in estimating the intensive margin is that by conditioning on observing invoice currency price changes, we potentially induce a dependence of $\eta_{t,s_t^{ik}}^{ik}$ on $\Delta_{s_t^{ik}} e_t^k$ and $\theta_{t,s_t^{ik}}^i$. For simplicity, we ignore the dependence on $\theta_{t,s_t^{ik}}^i$ and focus on potential biases in the intensive margin estimates of the coefficient on $\Delta_{s_t^{ik}} e_t^k$.[4] Because $\beta_e^k - 1$ shows up in the selection equation, the way in which the distribution of $\eta_{t,s_t^{ik}}^{ik}$ depends on $\Delta_{s_t^{ik}} e_t^k$ is mediated by the true value of $\beta_e^k - 1$. There are three possible cases, $\beta_e^k - 1 > 0$, $\beta_e^k - 1 = 0$ and $\beta_e^k - 1 < 0$. We now consider each in turn.

Case 1: $\beta_e^k - 1 > 0$

If $\Delta_{s_t^{ik}} e_t^k$ is positive and large, then $\bar{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is low, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)$ is low. Conversely, if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then $\bar{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is high, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)$ is high. So $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)\right) < 0$. If $\Delta_{s_t^{ik}} e_t^k$ is positive and large, $\eta_{t,s_t^{ik}}^{ik} < \underline{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is low, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)$ is low. Conversely, if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then $\eta_{t,s_t^{ik}}^{ik} < \underline{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is high, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)$ is high. So $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)\right) < 0$. However, if $\Delta_{s_t^{ik}} e_t^k$ is positive and large, this also makes invoice currency price increases more likely than price decreases, so overall, $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right) > 0$. And if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then invoice currency price decreases are more likely than increases, so overall $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right) < 0$. This implies that $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right)\right) > 0$. It follows that if we estimate the intensive margin equation separately conditioning on invoice currency price increases or invoice currency price decreases, our estimate of β_e^k will be biased in one direction. However if we pool invoice currency price increases and invoice currency price decreases, the bias will go in the other direction. We have confirmed this using Monte Carlo simulation.

[4] The issue is further complicated by the fact that there may be a relationship between $\theta_{t,s_t^{ik}}^i$ and $\Delta_{s_t^{ik}} e_t^k$, but again we ignore this.

Case 2: $\beta_e^k - 1 < 0$

If $\Delta_{s_t^{ik}} e_t^k$ is positive and large, then $\bar{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is high, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)$ is high. Conversely, if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then $\bar{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is low, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)$ is low. So $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} > 0\right)\right) > 0$. If $\Delta_{s_t^{ik}} e_t^k$ is positive and large, $\eta_{t,s_t^{ik}}^{ik} < \underline{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is high, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)$ is high. Conversely, if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then $\eta_{t,s_t^{ik}}^{ik} < \underline{\rho}_t^i - \left(\beta_e^k - 1\right) \Delta_{s_t^{ik}} e_t^k$ is low, and $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)$ is low. So $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} < 0\right)\right) > 0$. However, if $\Delta_{s_t^{ik}} e_t^k$ is positive and large, this also makes invoice currency price decreases more likely than price increases, so overall, $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right) < 0$. And if $\Delta_{s_t^{ik}} e_t^k$ is very negative, then invoice currency price increases are more likely than decreases, so overall $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right) > 0$. This implies that $Corr\left(\Delta_{s_t^{ik}} e_t^k, \mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right)\right) < 0$. It follows that if we estimate the intensive margin equation separately conditioning on invoice currency price increases or invoice currency price decreases, our estimate of β_e^k will be biased in one direction. However if we pool invoice currency price increases and invoice currency price decreases, the bias will go in the other direction. We have confirmed this using Monte Carlo simulation.

Case 3: $\beta_e^k - 1 = 0$

In this case, the probability of observing a price change does not depend on $\Delta_{s_t^{ik}} e_t^k$. As a result, there is no induced dependence of $\mathbb{E}\left(\eta_{t,s_t^{ik}}^{ik} | \Delta_{s_t^{ik}} p_t^{ik*} \neq 0\right)$ on $\Delta_{s_t^{ik}} e_t^k$.

Testing for selection bias

Based on what we have outlined here, one way to assess whether or not there is a bias in our intensive margin estimates of β_e^k due to the kind of selection we have outlined is to estimate the equation separately (a) pooling across invoice currency increases and invoice currency decreases, (b) making use only of cases with invoice currency increases and (c) making use only of cases with invoice currency decreases. Irrespective of the true value of β_e^k, we would expect that either the estimates from (a) are higher than the estimates from (b) and (c), or vice versa. In Table 33 we report the results from precisely this exercise. The coefficient estimates from (a), (b) and (c) are not significantly different from each other, and not significantly different from 1. This suggests to us that if indeed pricing is state-dependent, we may be in Case 3, and that the type of selection described in this note does not induce a bias in our intensive margin estimate of β_e^k.

Table 33: Is there selection bias in the intensive margin estimates?

	$\Delta_{s_t^{ik}} \ln e_t^k$		R^2-adj.	N	f.e.	clust
	β					
All episodes	1.01	(0.09)**	0.67	4212	1047	86
$\Delta_{s_t^{ik}} p_t^{ik*} > 0$	1.03	(0.07)**	0.75	2315	776	82
$\Delta_{s_t^{ik}} p_t^{ik*} < 0$	0.82	(0.20)**	0.69	1897	689	59