De Loecker, Goldberg, Khandelwal, and Pavcnik

- Been discussing welfare analysis of policy change.
  - Example of hospital mergers: demand model used to estimate supply side (given modeling assumptions)
  - Example of gains from variety, estimate demand elasticities, plus in variety and prices
- Today, talk about a line of literature that uses production side information

Model

- $Q_{fjt} = F_{jt}(V_{fjt,}K_{fjt})\Omega_{ft}$
  - firm f, product j, time t
  - V_{fjt} variable inputs, K_{fjt} fixed inputs facing adjustment costs
  - W^v_{fjt} and W^k_{fjt} price of variable and fixed inputs
- Note Strong Assumptions
  - Production function is product specific
  - F_{jt} twice continuously differentiable...

- Hicks Neutral productivity is log additive and firm specific
- Expenditures on all variable and fixed inputs are attributable to products
- State variables of the firm are $s_{ft}(J_{jf}, K_{j,j=1}, ...K_{f,J_f},,\Omega_{ft}, G_f, r_{fjt})$
- Firms minized short-run costs taking output quantity and input prices are agiven.

Set up Lagrangian

$$\begin{aligned} L(V_{fjt}, K_{fjt}, \lambda_{fjt}) &= \sum_{v=1}^{V} W_{fjt}^{v} V_{fjt}^{f} + \sum_{k=1}^{K} W_{fjt}^{k} K_{fjt}^{k} \\ &+\lambda_{fjt}\left[Q_{fjt} - Q_{fjt}(V_{fjt}, K_{fjt}, \Omega_{fj}\right] \end{aligned}$$

The FONC

$$\frac{\partial L_{fjt}}{\partial V_{fjt}^{v}} = W_{fjt}^{v} - \lambda_{fjt} \frac{\partial Q_{fjt}}{\partial V_{fjt}^{v}} = 0$$

Note λ_{fjt} is the marginal cost of product j to firm j. Rearranging and multplying both sides by $\frac{V_{fjt}}{Q_{fjt}}$ yields

$$\frac{\partial Q_{fjt}}{\partial V_{fjt}^{v}} \frac{V_{fjt}}{Q_{fjt}} = \frac{1}{\lambda_{fjt}}$$

$$\frac{\partial Q_{fjt}}{\partial V_{fjt}^{v}} \frac{V_{fjt}}{Q_{fjt}} = \frac{1}{\lambda_{fjt}} \frac{W_{fjt}^{v} V_{fjt}}{Q_{fjt}}$$

$$= \frac{P_{fjt}}{\lambda_{fjt}} \frac{W^v_{fjt} V_{fjt}}{P_{fjt} Q_{fjt}}$$

Now define:

$$\begin{aligned} markup &: \mu_{fjt} = \frac{P_{fjt}}{\lambda_{it}} \\ output\ elasticity &: \theta^v_{fjt} = \frac{\partial Q_{fjt}}{\partial V^v_{fjt}} \frac{V_{fjt}}{Q_{fjt}} \\ \text{expenditure share} &: \alpha^v_{fjt} = \frac{W^v_{fjt} V_{fjt}}{P_{fjt} Q_{fjt}} \end{aligned}$$

Then

$$\mu_{fjt} = \frac{\theta^v_{fjt}}{\alpha^v_{fjt}}$$

- Builds on Hall (1988), recent treatment of De Loecker and Warzynski (AER 2012), difference here is the j

Say a little bit about De Loecker and Warzynski

- Wanted θ_t^v (note drop the f and j. The j because single product. The f because with the structure it drops out.

$$\begin{aligned} q_{ft} &= f(x_{ft}, ; \beta) + \omega_{ft} + \varepsilon_{ft} \\ &= f(v_{ft}, k_{ft}; \beta) + \omega_{ft} + \varepsilon_{ft} \end{aligned}$$

- If have β can calculate θ_t^v. There are econometric issues in estimating β. Follow Levinsohn and Petrin (2003) and Olley and Pakes and use a control function approach.

  – Let $m_{ft} = m_t(k_{ft}, \omega_{ft}, z_{ft})$ be demand for materials (z_{ft} include things like input pricess)

– Monotonic under mild conditions, so invert it, to $\omega_{ft} = h_t(m_{ft}, k_{ft}, z_{ft})$, so have

$$q_{ft} = f(v_{ft}, k_{ft}; \beta) + h_t(m_{ft}, k_{ft}, z_{ft}), + \varepsilon_{ft}$$

- Let's use the translog functional form for $f(v_{ft}, k_{ft}; \beta)$, and focus on a value-added version,

$$q_{ft} = \beta_l l_{ft} + \beta_k k_{ft} + \beta_{ll} l_{ft}^2 + \beta_{kk} k_{ft}^2 + \beta_{lk} l_{ft} k_{ft} + \omega_{ft} + \varepsilon_{ft}.$$

- In the first stage run the following nonparametric regression:

$$q_{ft} = \phi_t(l_{ft}, k_{ft}, m_{ft}, z_{ft}) + \varepsilon_{ft}$$

and obtain estimates of expected output $\hat{\phi}_{ft}$ and an estimate for $\varepsilon_{ft.}$. Expected output given by

$$\phi_{ft} = \beta_l l_{ft} + \beta_k k_{ft} + \beta_{ll} l_{ft}^2 + \beta_{kk} k_{ft}^2 + \beta_{lk} l_{ft} k_{ft} + h_t(m_{ft}, k_{ft}, z_{ft})$$

- Note for given values of β can solve out for estimate of $\hat{\omega}_{ft}$

- Second stage uses law of motion for productivity

$$\omega_{ft} = g_t(\omega_{ft-1}) + \xi_{ft}$$

- Orthgonality condition is that the innovation ξ_{ft} is uncorrelated with $t-1$ information.

  - For a given β run nonparametric regression of $\hat{\omega}_{ft}$ on $\hat{\omega}_{ft-1}$ and then construct $\xi_{ft}(\beta)$. Then form moments

$$E\left(\xi_{ft}(\beta)\begin{pmatrix} l_{ft-1} \\ k_{ft} \\ k_{ft}^2 \\ l_{ft-1}k_{ft} \end{pmatrix}\right) = 0$$

- Once have estimate of β, off to the races...

Back to this multi-product firm

- If have inputs (v_{fjt}, k_{fjt}) product by product, then can do same thing (treat each product line as a separate firm)

- But when data not disaggregated that way. Two issues
  - Don't see allocation of inputs across products
  - See expenditures on inputs, not quantities. Use industry wide deflators which is a problem because firms may face different prices, and use different qualities.

- Write output as

$$q_{fjt} = f_j(x_{fjt}, \beta) + \omega_{ft} + \varepsilon_{fjt}$$

- Let x_{fjt} be log input quantity

$$x_{fjt} = \rho_{fjt} + \tilde{x}_{ft} - w^x_{fjt}$$

where

  - ρ_{fjt} is log share of firm input expenditures allocated to product j
  - $\tilde{x}_{ft}$ observed log expenditures of firm f at time t
  - w^x_{fjt} deviation in log price face by firm f

- Substitute into above to get

$$q_{fjt} = f_j(\tilde{x}_{ft}, \beta) + A(\rho_{fjt}, \tilde{x}_{ft}, \beta) + B(w_{fjt}, \rho_{fjt}, \tilde{x}_{ft}, \beta) + \omega_{ft} + \varepsilon_{fjt}$$

Solutions

- Find single product firms to estimate f_j
  - do address selection. Allow differences in ω_{ft} (and can have both selection, as well as a treatment effect)

- Do another control function, modeling input differences, as based on quality.

$$w^x_{ft} = w_t(\nu_{ft}, G_f)$$

where v_{ft} is firm quality and G_f is firm geography. In practice

$$w^x_{ft} = w_t(p_{ft}, ms_{ft}, D_f, G_{f,}, EXP_{ft})$$

where ms_{ft} is marke shares, D_f is product dummies.

- Will be using the estimates firm specific prices to allocate inputs efficiently across the firm.

- Come up with estimates of the parameters, estimates of the inputs, and derives as a bottom line μ_{fjt} .

- Look at estimates

- After all of this stuff is a second paper doing descriptive analysis of the mark-ups.

TABLE I

SUMMARY STATISTICS[a]

Sector	Share of Sample	Single-Product		
	Output (1)	All Firms (2)	Firms (3)	Products (4)
15 Food products and beverages	9%	302	135	135
17 Textiles, apparel	10%	303	161	78
21 Paper and paper products	3%	77	56	32
24 Chemicals	26%	434	194	483
25 Rubber and plastic	5%	139	85	83
26 Nonmetallic mineral products	7%	110	74	60
27 Basic metals	16%	212	115	101
28 Fabricated metal products	2%	74	48	45
29 Machinery and equipment	7%	160	80	186
31 Electrical machinery and communications	5%	89	52	102
34 Motor vehicles, trailers	9%	71	47	95
Total	100%	1970	1047	1400

[a]Table reports summary statistics for the average year in the sample. Column 1 reports the share of output by sector in the average year. Columns 2 and 3 report the number of firms and number of single-product firms manufacturing products in the average year. Column 4 reports the number of products by sector.

TABLE II

EXAMPLE OF SECTOR, INDUSTRY, AND PRODUCT CLASSIFICATIONS[a]

NIC Code		Description
27		Basic metal industries (sector s)
2710		Manufacture of basic iron and steel (industry i)
		Products (j)
	130101010000	Pig iron
	130101020000	Sponge iron
	130101030000	Ferro alloys
	130106040800	Welded steel tubular poles
	130106040900	Steel tubular structural poles
	130106050000	Tube and pipe fittings
	130106100000	Wires and ropes of iron and steel
	130106100300	Stranded wire
2731		Casting of iron and steel (industry i)
		Products (j)
	130106030000	Castings and forgings
	130106030100	Castings
	130106030101	Steel castings
	130106030102	Cast iron castings
	130106030103	Maleable iron castings
	130106030104	S.G. iron castings
	130106030199	Castings, nec

[a]This table is replicated from Goldberg et al. (2010b). For NIC 2710, there are a total of 111 products, but only a subset are listed in the table. For NIC 2731, all products are listed in the table.

TABLE III

AVERAGE OUTPUT ELASTICITIES, BY SECTOR[a]

Sector	Observations in Production Function Estimation (1)	Labor (2)	Materials (3)	Capital (4)	Returns to Scale (5)
15 Food products and beverages	795	0.13	0.71	0.15	0.99
		[0.17]	[0.22]	[0.14]	[0.28]
17 Textiles, apparel	1581	0.11	0.82	0.08	1.01
		[0.02]	[0.04]	[0.08]	[0.06]
21 Paper and paper products	470	0.19	0.78	0.03	1.00
		[0.12]	[0.10]	[0.05]	[0.06]
24 Chemicals	1554	0.17	0.79	0.08	1.03
		[0.08]	[0.07]	[0.06]	[0.08]
25 Rubber and plastic	705	0.15	0.69	−0.02	0.82
		[0.39]	[0.29]	[0.35]	[0.89]
26 Nonmetallic mineral products	633	0.16	0.67	−0.04	0.79
		[0.26]	[0.12]	[0.40]	[0.36]
27 Basic metals	949	0.14	0.77	0.01	0.91
		[0.09]	[0.11]	[0.06]	[0.18]
28 Fabricated metal products	393	0.18	0.75	0.03	0.96
		[0.04]	[0.08]	[0.17]	[0.17]
29 Machinery and equipment	702	0.20	0.76	0.18	1.13
		[0.08]	[0.05]	[0.05]	[0.14]
31 Electrical machinery and communications	761	0.09	0.78	−0.06	0.81
		[0.11]	[0.11]	[0.22]	[0.28]
34 Motor vehicles, trailers	386	0.25	0.63	0.11	1.00
		[0.26]	[0.20]	[0.20]	[0.25]

[a]Table reports the output elasticities from the production function. Column 1 reports the number of observations for each production function estimation. Columns 2–4 report the average estimated output elasticity with respect to each factor of production for the translog production function for all firms. Standard deviations (not standard errors) of the output elasticities are reported in brackets. Column 5 reports the average returns to scale, which is the sum of the preceding three columns.

TABLE IV

MEDIAN OUTPUT ELASTICITIES, BY SECTOR[a]

Sector	Labor (1)	Materials (2)	Capital (3)	Returns to Scale (4)
15 Food products and beverages	0.12	0.75	0.20	1.09
17 Textiles, apparel	0.11	0.82	0.09	1.02
21 Paper and paper products	0.18	0.79	0.03	0.98
24 Chemicals	0.16	0.79	0.06	1.02
25 Rubber and plastic	0.21	0.75	0.04	1.03
26 Nonmetallic mineral products	0.18	0.69	0.04	0.88
27 Basic metals	0.14	0.78	0.02	0.96
28 Fabricated metal products	0.17	0.75	0.02	0.94
29 Machinery and equipment	0.17	0.75	0.16	1.08
31 Electrical machinery and communications	0.10	0.80	0.01	0.91
34 Motor vehicles, trailers	0.23	0.64	0.10	0.97

[a]Table reports the median output elasticities from the production function. Columns 1–3 report the median estimated output elasticity with respect to each factor of production for the translog production function for all firms. Column 4 reports the median returns to scale.

TABLE V

OUTPUT ELASTICITIES, INPUT PRICE VARIATION, AND SAMPLE SELECTION[a]

	Estimates Without Correcting for Input Price Variation				Estimates Without Correcting for Sample Selection			
Sector	Labor (1)	Materials (2)	Capital (3)	Returns to Scale (4)	Labor (5)	Materials (6)	Capital (7)	Returns to Scale (8)
15 Food products and beverages	0.03	0.75	0.82	1.78	0.22	0.63	0.14	1.03
17 Textiles, apparel	−0.07	0.70	−0.07	0.52	0.11	0.83	0.09	1.03
21 Paper and paper products	−0.13	0.23	−0.19	−0.23	0.17	0.77	0.03	0.98
24 Chemicals	0.38	0.69	−0.72	0.26	0.16	0.79	0.04	0.99
25 Rubber and plastic	−0.10	0.30	−0.15	0.21	0.17	0.75	−0.05	0.94
26 Nonmetallic mineral products	0.08	0.64	0.81	1.50	0.12	0.71	0.11	0.93
27 Basic metals	−0.18	1.11	−0.33	0.69	0.12	0.80	0.02	0.94
28 Fabricated metal products	−1.17	−0.28	1.60	0.28	0.15	0.74	0.04	0.95
29 Machinery and equipment	−0.72	1.18	−0.50	−0.10	0.16	0.76	0.15	1.06
31 Electrical machinery and communications	−1.59	0.57	−0.13	−0.47	0.10	0.84	0.02	0.95
34 Motor vehicles, trailers	−0.23	−0.39	1.23	0.44	0.20	0.70	0.04	0.94

[a]Columns 1–4 report the median output elasticities from production function estimations that do not account for input price variation. Columns 5–8 reports the median output elasticities from production function estimations that do not account for sample selection (transition from single-product to multi-product firms).

TABLE VI

MARKUPS, BY SECTOR[a]

Sector	Markups	
	Mean	Median
15 Food products and beverages	1.78	1.15
17 Textiles, apparel	1.57	1.33
21 Paper and paper products	1.22	1.21
24 Chemicals	2.25	1.36
25 Rubber and plastic	4.52	1.37
26 Nonmetallic mineral products	4.57	2.27
27 Basic metals	2.54	1.20
28 Fabricated metal products	3.70	1.36
29 Machinery and equipment	2.48	1.34
31 Electrical machinery and communications	5.66	1.43
34 Motor vehicles, trailers	4.64	1.39
Average	2.70	1.34

[a]Table displays the mean and median markup by sector for the sample 1989–2003. The table trims observations with markups that are above and below the 3rd and 97th percentiles within each sector.

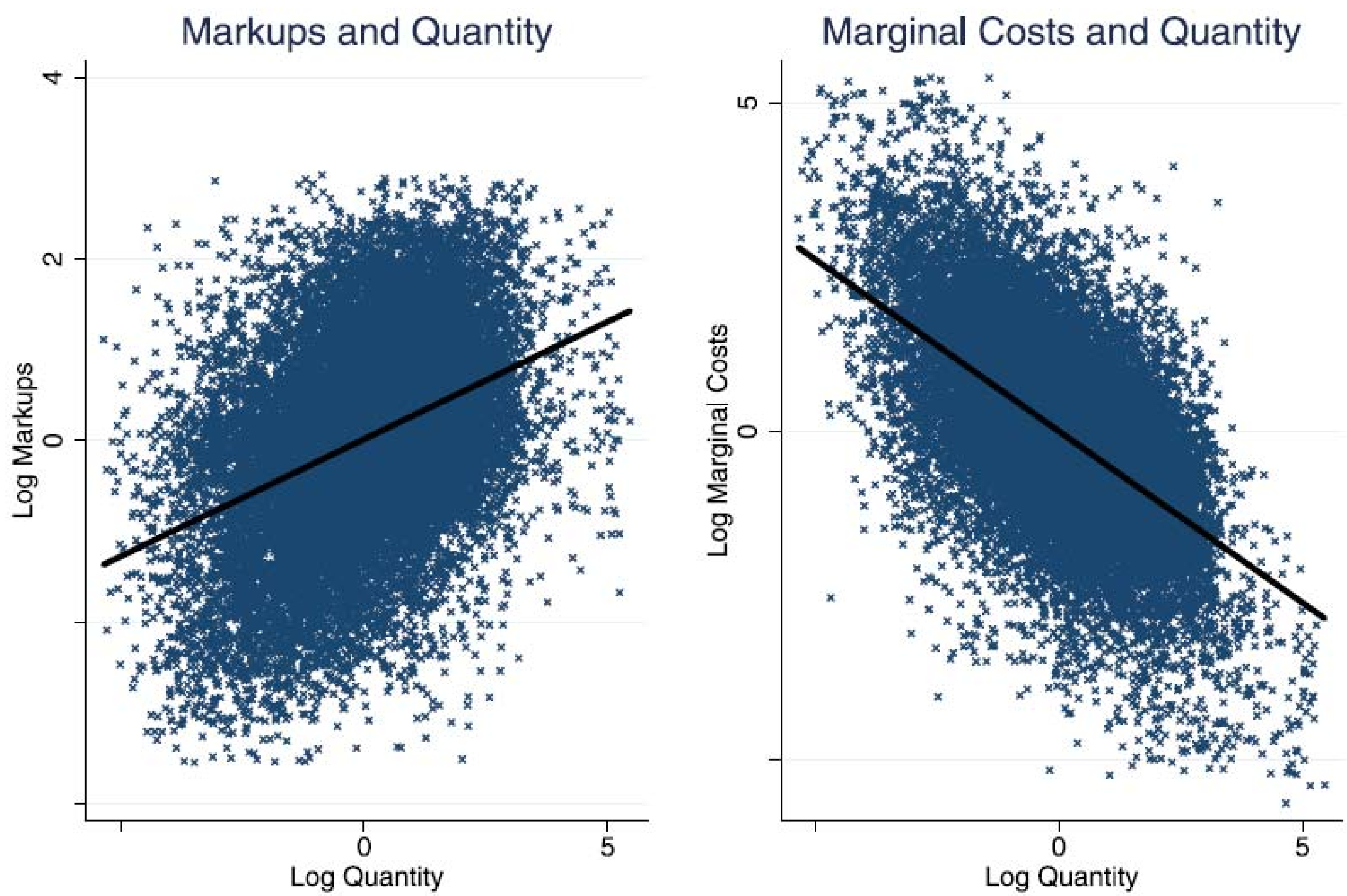

FIGURE 1.—Markups, marginal costs and quantities. Variables de-meaned by product. Markups, cost and quantity outliers are trimmed below and above 3rd and 97th percentiles.

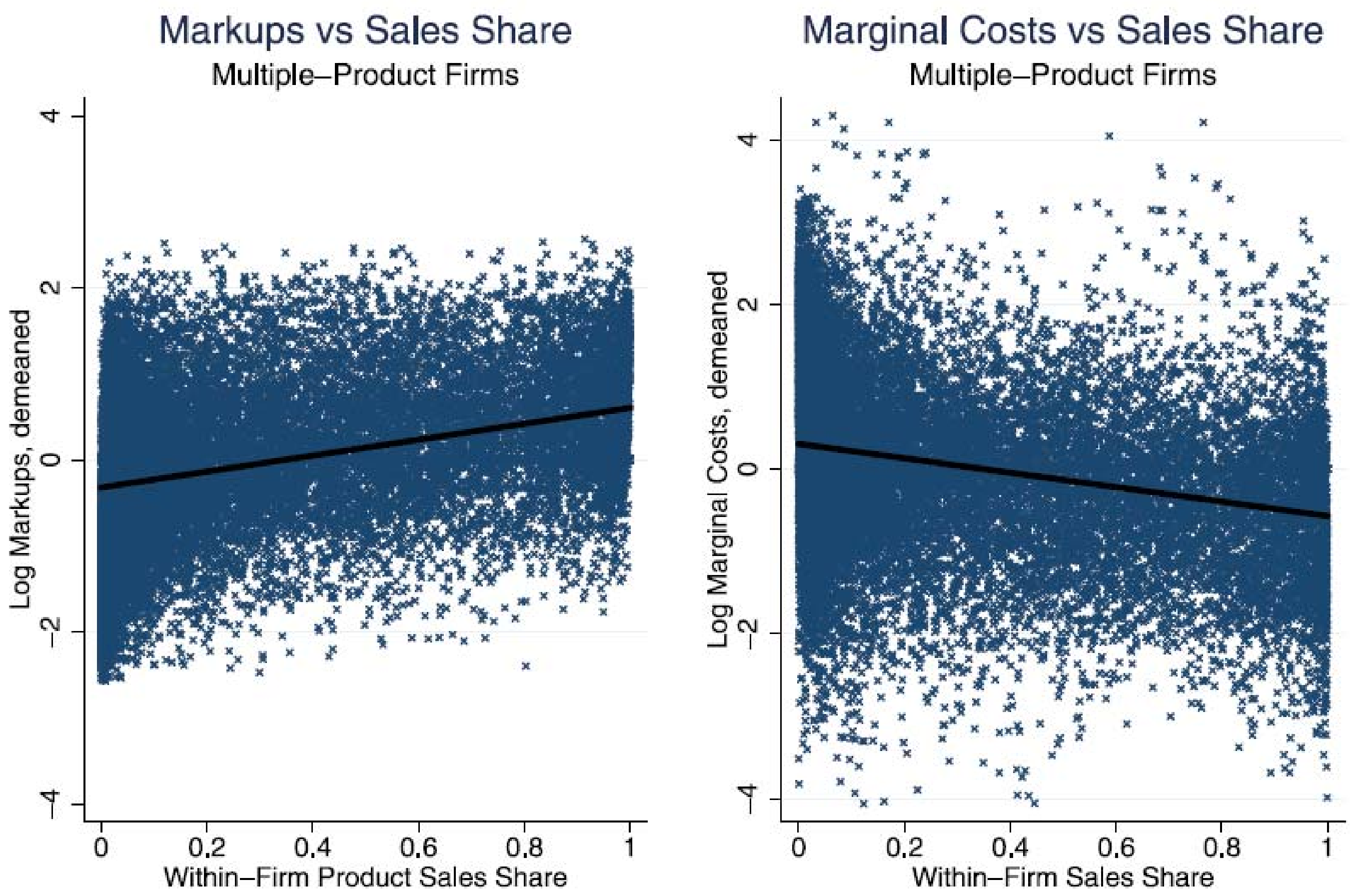

FIGURE 2.—Markups, costs and product sales share. Markups and marginal costs are de-meaned by product–year and firm–year FEs. Markup and marginal cost outliers are trimmed below and above 3rd and 97th percentiles.

Pass Through

$$\ln P_{fjt} = \ln mc_{fjt} + \ln \mu_{fjt}$$

can be written as

$$\ln P_{fjt} = \ln \mu_{ft} + \ln mc_{fjt} + \ln \mu_{fjt} + \left(\ln \mu_{fjt} - \ln \mu_{ft}\right)$$

Suppose run regression

$$\ln P_{fjt} = a_{fj} + \zeta \ln mc_{fjt} + \varepsilon_{fjt}$$

Markups constant $\zeta = 1$ and $\varepsilon_{ijt} = 0$. (But measurement error, etc, so would never get exact fit in reality, but still get $\zeta = 1$)

Incomplete passthrough get $\zeta < 1$.

Check back on

When observing marginal cost, the coefficient ζ reflects markup variability and pass-through. There would be no need to instrument for marginal costs. In fact, instrumenting marginal costs is conceptually incorrect because the correlation between marginal costs and the structural error of the regression (i.e., the markup) is precisely what the coefficient ζ is supposed to capture. However, in our application (and almost every other empirical study), we only observe an estimate of marginal cost, $\ln \widehat{mc}_{fjt} = \ln mc_{fjt} + \sigma_{fjt}$. The pass-through regression becomes

$$\ln P_{fjt} = a_{fj} + \zeta \ln \widehat{mc}_{fjt} + (\varepsilon_{fjt} - \zeta \sigma_{fjt}) = a_{fj} + \zeta \ln \widehat{mc}_{fjt} + u_{fjt}. \tag{36}$$

Measurement error results in a downward bias in the pass-through coefficient ζ, leading us to conclude, potentially erroneously, that pass-through is incomplete. We therefore require instruments to address measurement error in marginal costs. It is important to note that, in this setting, instruments must be uncorrelated with the measurement error, σ_{fjt}. However, we do not require that they are uncorrelated with the part of the error term that reflects the deviation in markup, ε_{fjt}. Indeed, such a condition would be inconsistent with the exercise which is precisely to measure the correlation between marginal cost and markup, that is, the correlation between $\widehat{mc}_{fjt}$ and ε_{fjt}.

We instrument for marginal cost in equation (36) with input tariffs and lagged marginal cost. Both variables are certainly correlated with marginal cost. The former should be uncorrelated with the measurement error in our marginal cost estimate, but input tariffs do not vary at the firm level. The advantage of lagged marginal cost is that it varies at the firm–product–year level. Although lagged marginal costs contain measurement error, we have no reason to expect this measurement error to be serially correlated.

TABLE VII

PASS-THROUGH OF COSTS TO PRICES[a]

	$\ln P_{fjt}$		
	(1)	(2)	(3)
$\ln mc_{fjt}$	0.337***	0.305***	0.406†
	0.041	0.084	0.247
Observations	21,246	16,012	12,334
Within R-squared	0.27	0.19	0.09
Firm–product FEs	yes	yes	yes
Instruments	–	yes	yes
First-stage F-test	–	98	5

[a]The dependent variable is (log) price. Column 1 is an OLS regression on log marginal costs. Column 2 instruments marginal costs with input tariffs and lag marginal costs. Column 3 instruments marginal costs with input tariffs and two-period lag marginal costs. The regressions exclude outliers in the top and bottom 3rd percent of the markup distribution. All regressions include firm–product fixed effects. The regressions use data from 1989–1997. The standard errors are bootstrapped and are clustered at the firm level. Significance: †10.1 percent, *10 percent, **5 percent, ***1 percent.

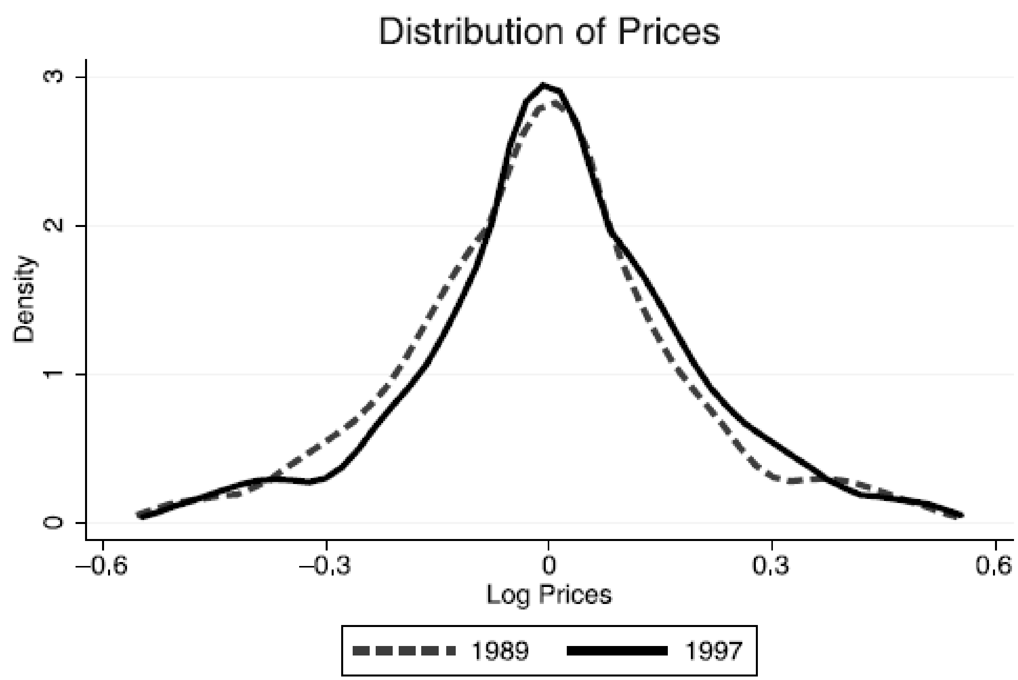

FIGURE 3.—Distribution of prices in 1989 and 1997. Sample only includes firm–product pairs present in 1989 and 1997. Outliers above and below the 3rd and 97th percentiles are trimmed.

TABLE VIII

PRICES AND OUTPUT TARIFFS, ANNUAL REGRESSIONS[a]

	$\ln P_{fjt}$	
	(1)	(2)
$\tau_{it}^{\text{output}}$	0.136**	0.167***
	0.056	0.054
Within R-squared	0.00	0.02
Observations	21,246	21,246
Firm–product FEs	yes	yes
Year FEs	yes	no
Sector–year FEs	no	yes
Overall impact of trade liberalization	−8.4**	−10.4***
	3.4	3.3

[a]The dependent variable is a firm–product's (log) price. Column 1 includes year fixed effects and Column 2 includes sector–year fixed effects. The regressions exclude outliers in the top and bottom 3rd percent of the markup distribution. All regressions include firm–product fixed effects and use data from 1989–1997. Standard errors are clustered at the industry level. The final row uses the average 62% decline in output tariffs from 1989–1997 to compute the mean and standard error of the impact of trade liberalization on prices. That is, for each column the mean impact is equal to the $-0.62 \times 100 \times$ {coefficient on output tariffs}. Significance: *10 percent, **5 percent, ***1 percent.

TABLE IX

PRICES, COSTS, AND MARKUPS AND TARIFFS[a]

	$\ln P_{fjt}$ (1)	$\ln mc_{fjt}$ (2)	$\ln \mu_{fjt}$ (3)
$\tau_{it}^{\text{output}}$	0.156***	0.047	0.109
	0.059	0.084	0.076
τ_{it}^{input}	0.352	1.160**	−0.807‡
	0.302	0.557	0.510
Within R-squared	0.02	0.01	0.01
Observations	21,246	21,246	21,246
Firm–product FEs	yes	yes	yes
Sector–year FEs	yes	yes	yes
Overall impact of trade liberalization	−18.1**	−30.7**	12.6
	7.4	13.4	11.9

[a]The dependent variable is noted in the columns. The sum of the coefficients from the markup and marginal costs regression equals their respective coefficient in the price regression. The regressions exclude outliers in the top and bottom 3rd percent of the markup distribution, and include firm–product fixed effects and sector–year fixed effects. The final row uses the average 62% and 24% declines in output and input tariffs from 1989–1997, respectively, to compute the mean and standard error of the impact of trade liberalization on each performance measure. That is, for each column the mean impact is equal to the $-0.62 \times 100 \times$ {coefficient on output tariff} $\pm\, 0.24 \times 100 \times$ {coefficient on input tariff}. The regressions use data from 1989–1997. The table reports the bootstrapped standard errors that are clustered at the industry level. Significance: ‡11.3 percent, *10 percent, **5 percent, ***1 percent.

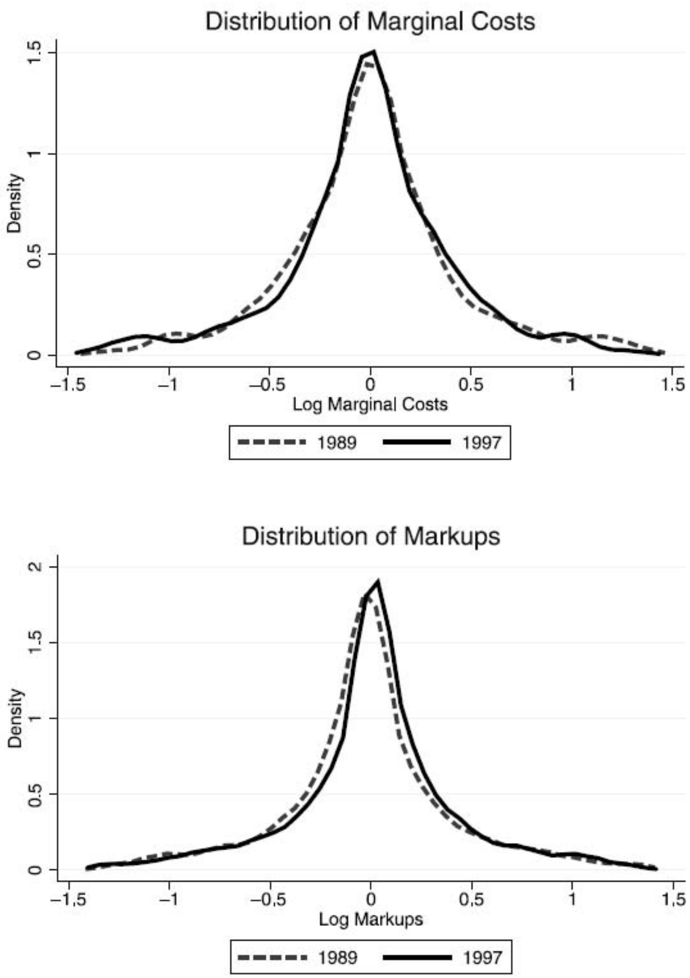

FIGURE 4.—Distribution of marginal costs and markups in 1989 and 1997. Sample only includes firm–product pairs present in 1989 and 1997. Outliers above and below the 3rd and 97th percentiles are trimmed.

TABLE X

PRO-COMPETITIVE EFFECTS OF OUTPUT TARIFFS[a]

	$\ln \mu_{fjt}$			
	(1)	(2)	(3)	(4)
$\tau_{it}^{\text{output}}$	0.143***	0.150**	0.129**	0.149**
	0.050	0.062	0.052	0.062
$\tau_{it}^{\text{output}} \times \text{Top}_{fp}$			0.314**	0.028
			0.134	0.150
Within R-squared	0.59	0.65	0.59	0.65
Observations	21,246	16,012	21,246	16,012
Second-order polynomial of marginal cost	yes	yes	yes	yes
Firm–product FEs	yes	yes	yes	yes
Sector–year FEs	yes	yes	yes	yes
Instruments	no	yes	no	yes
First-stage F-test	–	8.6	–	8.6

[a]The dependent variable is (log) markup. All regressions include firm–product fixed effects, sector–year fixed effects and a second-order polynomial of marginal costs (these coefficients are suppressed and available upon request). Columns 2 and 4 instrument the second-order polynomial of marginal costs with second-order polynomial of lag marginal costs and input tariffs. Columns 3 interacts output tariffs and the second-order marginal cost polynomial with an indicator if a firm–product observation was in the top 10 percent of its sector's markup distribution when it first appears in the sample. The regressions exclude outliers in the top and bottom 3rd percent of the markup distribution. The table reports the bootstrapped standard errors that are clustered at the industry level. Significance: *10 percent, **5 percent, ***1 percent.