Research at Intersection of Trade and IO

- Countries don't export, plant's export

- Interest in heterogeneous impact of trade policy (some firms win, others lose, perhaps in same industry)

- Closely related to size distribution stuff. (What countries a firm sells to, analogous to how big it is. Get skewed distributions...

- These models relate size distribution of plants to industry parameters, like transportation cost. Then used to talk about micro data, like whether plants export or not.

Eaton Kortum

- Like Dornbusch, Fischer, Samuelson, Ricardian trade with continuum of goods $j \in [0, 1]$

- $z_i(j)$ efficiency in producing good in country i

- c_i is labor cost in country

- Unit cost to produce j in i is $\frac{c_i}{z_i(j)}$

- iceberg cost d_{ni} cost of i to n. $d_{ii} = 1$. $d_{ni} > 1$, $n \neq i$

- Perfect competition

$$p_{ni}(j) = \left(\frac{c_i}{z_i(j)}\right) d_{ni}$$

- Price of good j in country n

$$p_n(j) = \min\{p_{n1}(j); i = 1, ..., N\}$$

- Consumers purchase individual goods in amounts $Q(j)$ to maximize

$$U = \left[\int_0^1 Q(j)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

Technology

- $z_i(j)$ random variable drawn a certain way to make everying work out really easily
  - Frechet (also called Type II extreme value)
  - $F_i(z) = e^{-T_i z^{-\theta}}$
  - T_i is a country specific. Bigger T get better productivity draws
  - θ governs extent of Ricardian comparative advantage. Bigger θ less variability
  - $\log z$ has standard deviation $\frac{\pi}{\theta sqrt(6)}$

- Country i presents country with a distribution of prices

$$\begin{aligned} G_{ni}(p) &= \Pr(P_{ni} \leq p) = 1 - F_i(\frac{c_i d_{ni}}{p}) \\ &= 1 - e^{-T_i (c_i d_{ni})^{-\theta} p^{\theta}} \end{aligned}$$

- Lowest price will be less than p, unless each source's price is greater than p. So $G_n(p) = \Pr(P_n \leq p)$ is

$$\begin{aligned} G_n(p) &= 1 - \prod_{i=1}^{N} (1 - G_{ni}(p)) \\ &= 1 - \prod_{i=1}^{N} e^{-T_i (c_i d_{ni})^{-\theta} p^{\theta}} \\ &= 1 - e^{-\Phi_n p^{\theta}} \end{aligned}$$

for

$$\Phi_n = \sum_{i=1}^{N} T_i \left(c_i d_{ni}\right)^{-\theta}$$

- Price parameter Φ_n.
  - If $d_{ni} = 1$, then Φ_n the same everywhere.
  - $d_{ii} = 1$, $d_{ni} = \infty$, $n \neq i$, the $\Phi_n = T_n c_n^{-\theta}$

- Probability that country i provides a good at the lowest price in country n is

$$\begin{aligned} \pi_{ni} &= \int_0^{\infty} \prod_{s \neq i} \left[1 - G_{ns}\right] dG_{ni}(p) \\ &= \int_0^{\infty} \prod_{s \neq i} e^{-T_s (c_s d_{ns})^{-\theta} p^{\theta}} dG_{ni}(p) \end{aligned}$$

$$
\begin{aligned}
&= \int_0^\infty \prod_{s \neq i} e^{-T_s (c_s d_{ns})^{-\theta} p^\theta} \left[T_i \left(c_i d_{ni} \right)^{-\theta} \theta p^{\theta - 1} \right] e^{-T_i (c_i d_{ni})^{-\theta} p^\theta} dp \\
&= T_i \left(c_i d_{ni} \right)^{-\theta} \int_0^\infty \prod_s e^{-T_s (c_s d_{ns})^{-\theta} p^\theta} \left[\theta p^{\theta - 1} \right] dp \\
&= T_i \left(c_i d_{ni} \right)^{-\theta} \int_0^\infty e^{-\left(\sum_s T_s (c_s d_{ns})^{-\theta} \right) p^\theta} \left[\theta p^{\theta - 1} \right] dp \\
&= T_i \left(c_i d_{ni} \right)^{-\theta} \int_0^\infty e^{-\Phi_n p^\theta} \left[\theta p^{\theta - 1} \right] dp \\
&= T_i \left(c_i d_{ni} \right)^{-\theta} \left[-\frac{1}{\Phi_n} e^{-\Phi_n p^\theta} \right]_0^\infty \\
&= \frac{T_i \left(c_i d_{ni} \right)^{-\theta}}{\Phi_n} = \frac{T_i c_i^{-\theta} d_{ni}^{-\theta}}{\sum T_k c_k^{-\theta} d_{nk}^{-\theta}}
\end{aligned}
$$

- Conditional distribution of price paid (condition upon country of origin) is same as unconditioned, $G_n(p)$. That is:

$$
G_n(p) = \frac{1}{\pi_{ni}} \int_0^p \Pi_{k \neq i} \left(1 - G_{nk}(c) \right) dG_{ni}(c)
$$

holds for each i. The RHS is distribution of costs conditioned upon actually buying. Now the denominator is the probability of buying from i. With $G_n(p)$, we are looking at the probability cost is less than or equal to p. So on the right side, we want to integrate over every c at i and get the probability of that event (this is $dG_{ni}(c)$, combined with the event that all other locations have a higher cost. So...

$$
\begin{aligned}
& \frac{1}{\pi_{ni}} \int_0^p \Pi_{k \neq i} \left(1 - G_{nk}(c)\right) dG_{ni}(c) \qquad (1) \\
= \ & \frac{1}{\pi_{ni}} \int_0^p \Pi_{k \neq i} e^{-T_k c_k^{-\theta} d_{nk}^{-\theta} c^{\theta}} \theta T_i c_i^{-\theta} d_{ni}^{-\theta} c^{\theta - 1} e^{-T_i d_{ni}^{-\theta} c^{\theta}} dc \\
= \ & \frac{1}{\pi_{ni}} \int_0^p \theta T_i c_i^{-\theta} d_{ni}^{-\theta} c^{\theta-1} e^{-\Phi_n c^{\theta}} dc \\
= \ & \frac{1}{\pi_{ni}} \left[\frac{T_i c_i^{-\theta} d_{ni}^{-\theta}}{-\Phi_n} e^{-\Phi_n c^{\theta}} \right]_0^p \\
= \ & \frac{T_i c_i^{-\theta} d_{ni}^{-\theta}}{\Phi_n} \frac{1}{\pi_{ni}} \left[1 - e^{-\Phi_n p^{\theta}} \right]
\end{aligned}
$$

$$= \quad 1 - e^{-\Phi_n c^\theta} = G_n(p)$$

- .

- Can calculate a price index for the CES objective function $\sigma < 1 + \theta$

$$p_n = \gamma \Phi_n^{-1/\theta}$$

$$\gamma = \left[\Gamma(\frac{\theta + 1 - \sigma}{\theta}) \right]^{-1/(1-\sigma)}$$

Trade Flows

- Average expenditure per good does not vary by source

- Fraction of n's expenditure on goods from country i

$$\frac{X_{ni}}{X_n} = \pi_{ni} = \frac{T_i\left(c_i d_{ni}\right)^{-\theta}}{\Phi_n} = \frac{T_i\left(c_i d_{ni}\right)^{-\theta}}{\sum_{i=1}^{N} T_i\left(c_i d_{ni}\right)^{-\theta}}$$

- Looking like a gravity equation. Try to get it closer. Exporter's total sales

$$\begin{aligned} Q_i &= \sum_{m=1}^{N} X_{mi} = \sum_{m=1}^{N} \pi_{mi} X_m \\ &= \sum_{m=1}^{N} \frac{T_i\left(c_i d_{mi}\right)^{-\theta}}{\Phi_m} X_m \end{aligned}$$

$$= \quad T_i c_i^{-\theta} \sum_{m=1}^{N} \frac{d_{mi}^{-\theta}}{\Phi_m} X_m$$

Or

$$T_i c_i^{-\theta} = \frac{Q_i}{\sum_{m=1}^{N} \frac{d_{mi}^{-\theta}}{\Phi_m} X_m}$$

- Remember that

$$\begin{aligned} p_n &= \gamma \Phi_n^{-1/\theta} \\ p_n^{-\theta} \gamma^{\theta} &= \Phi_n \end{aligned}$$

$$T_i c_i^{-\theta} = \gamma^{\theta} \frac{Q_i}{\sum_{m=1}^{N} \left(\frac{d_m}{p_n}\right)^{-\theta} X_m}$$

- So

$$X_{ni} \quad = \quad \frac{T_i c_i^{-\theta} d_{ni}^{-\theta}}{\Phi_n} X_n$$

$$X_{ni} = \frac{d_{ni}^{-\theta}}{p_n^{-\theta}\gamma^{\theta}}\gamma^{\theta}\frac{Q_i}{\sum_{m=1}^{N}\left(\frac{d_m}{p_n}\right)^{-\theta}X_m}X_n$$

$$= \frac{\frac{d_{ni}^{-\theta}}{p_n^{-\theta}}X_n}{\sum_{m=1}^{N}\left(\frac{d_m}{p_n}\right)^{-\theta}X_m}Q_i$$

Fixing denominator, X_n sales enter with unit elasticity. So fixing denominator, looks like a standard gravivity model where

$$\ln X_{ni} = f(\text{distance}) + \ln X_n + \ln Q_i$$

Geography Trade and Prices

$$\frac{X_{ni}/X_n}{X_{ii}/X_i} = \frac{\frac{T_i(c_i d_{ni})^{-\theta}}{\Phi_n}}{\frac{T_i(c_i d_{ii})^{-\theta}}{\Phi_i}} = \frac{\Phi_i}{\Phi_n} d_{ni}^{-\theta}$$

$$= \left(\frac{p_i d_{ni}}{p_n}\right)^{-\theta}$$

- Look at symmetric case $d_{ni} = \delta$, $T_i = T$, $c_i = c$, then

$$\frac{X_{ni}/X_n}{X_{ii}/X_i} = \delta^{-\theta}$$

  Can see that decreases in θ. As θ increases, dispersion decreases, so can't offset transportation costs

- Look at figure 1

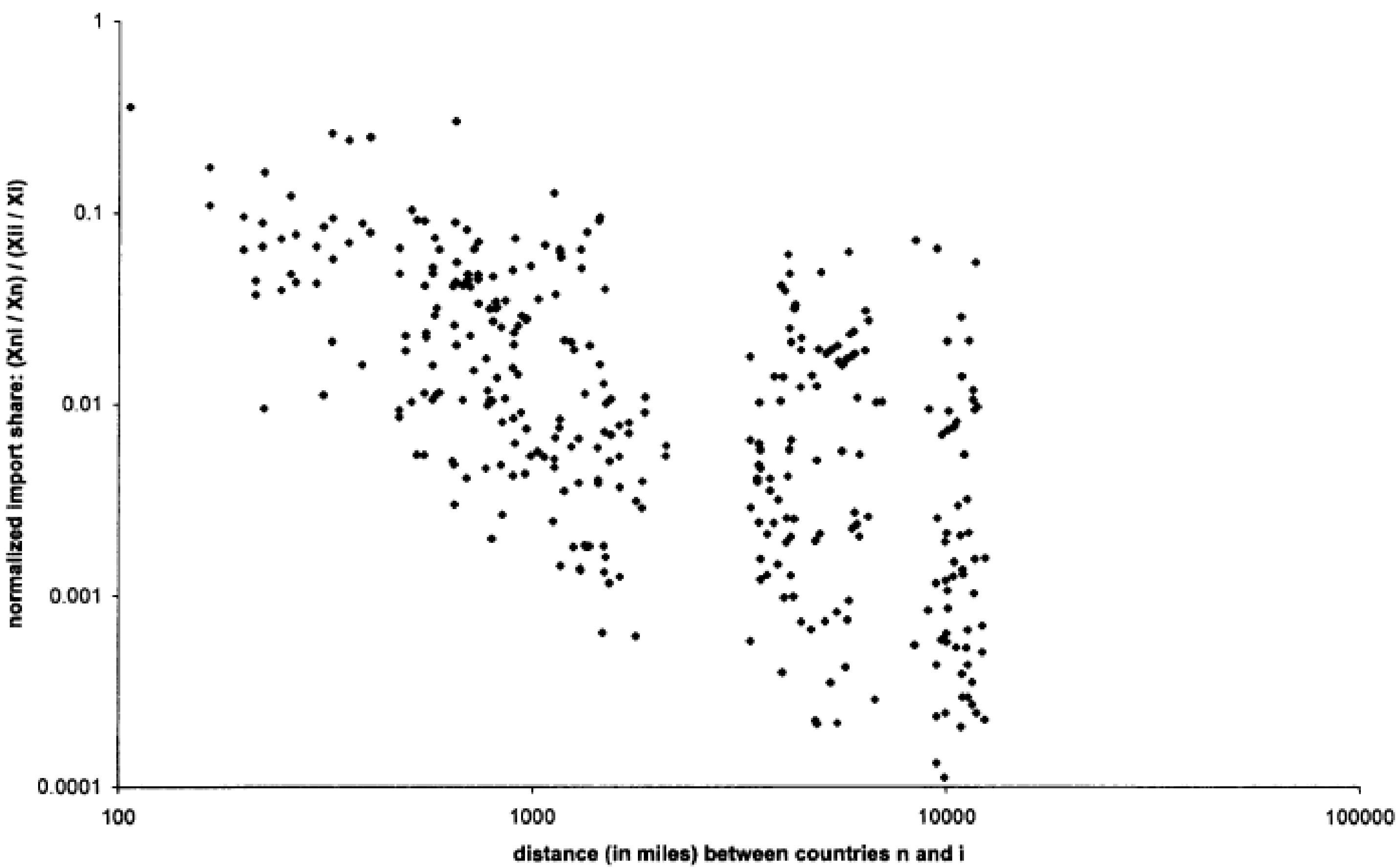


FIGURE 1.—Trade and geography.

- Note identification problem: θ versus d
- Could follow strategies like Hummels to estimate d directly. But physical transportation costs only part of transportation costs
- To identify θ, bring in more data

Price Data

- retail price data for 19 countries for 50 manufacturered products. So $j = 1, ..50$

- $r_{ni}(j) = \ln p_n(j) - \ln p_i(j)$

- Calculate $\ln(p_i/p_n) =$ mean $-r_{ni}(j)$. (Tricky step)

- To get at d_{ni}, $r_{ni}(j)$ bounded above by $\ln d_{ni}$ and bound attained for goods that n imports from i. Every country imports from every other. (Note here the strong assumption comes in that transportation cost is the same for each good.

- Take second highest vlue of r_{ni} across commodities to obtain a measure of $\ln d_{ni}$

$$D_{ni} = \frac{\max 2_j \left\{ r_{ni}(j) \right\}}{\frac{\sum_{j=1}^{50} [r_{ni}(j)]}{50}} \approx \ln \left(\frac{p_i d_{ni}}{p_n} \right)$$

- So have a price measure $\exp D_{ni}$,

- Look at figure Table II and Figure 2. Get slope of 8.28, an estimate of θ.

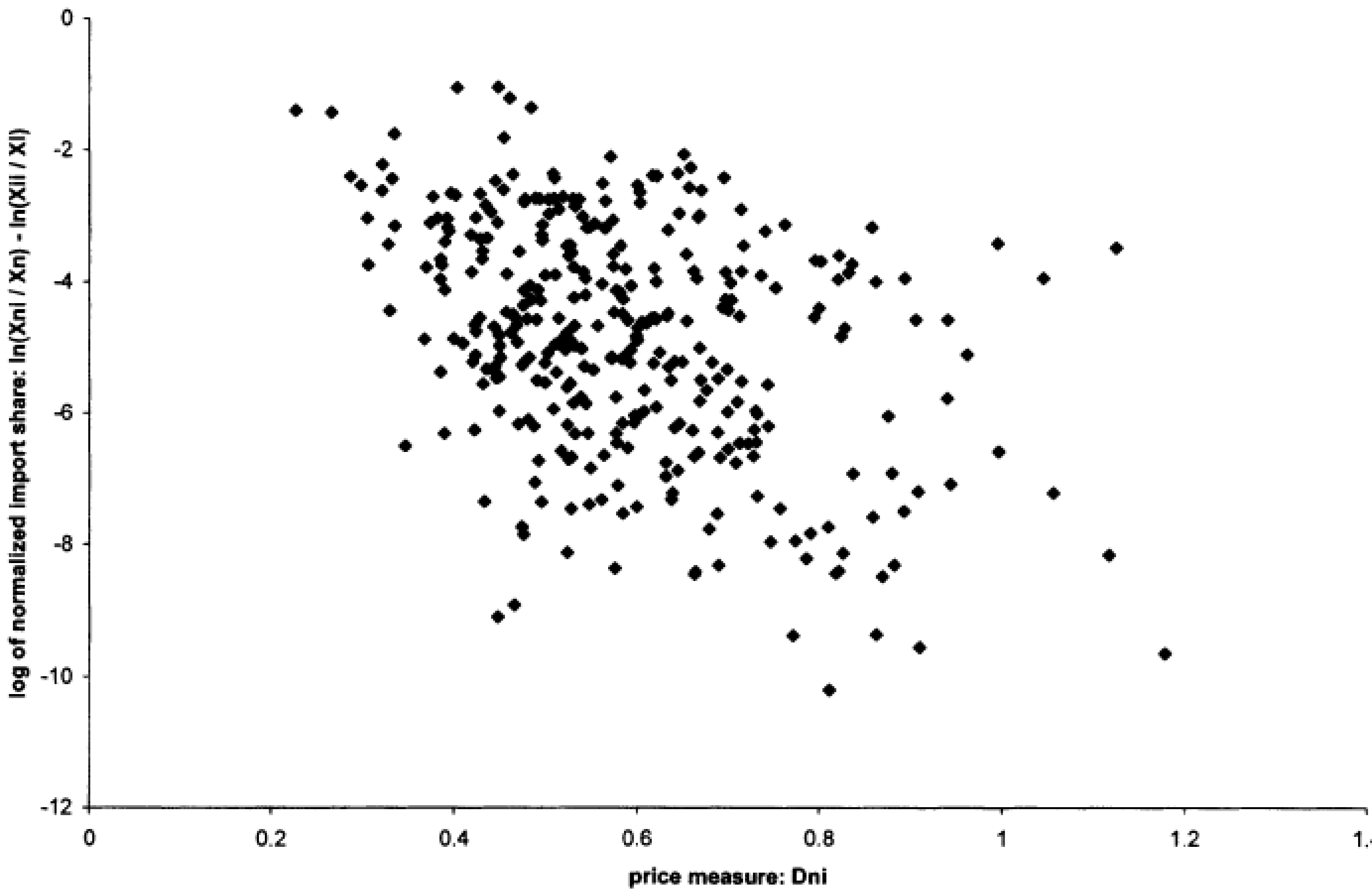


FIGURE 2.—Trade and prices.

TABLE II

PRICE MEASURE STATISTICS

Country	Foreign Sources		Foreign Destinations	
	Minimum	Maximum	Minimum	Maximum
Australia (AL)	NE (1.44)	PO (2.25)	BE (1.41)	US (2.03)
Austria (AS)	SW (1.39)	NZ (2.16)	UK (1.47)	JP (1.97)
Belgium (BE)	GE (1.25)	JP (2.02)	GE (1.35)	SW (1.77)
Canada (CA)	US (1.58)	NZ (2.57)	AS (1.57)	US (2.14)
Denmark (DK)	FI (1.36)	PO (2.21)	NE (1.48)	US (2.41)
Finland (FI)	SW (1.38)	PO (2.61)	DK (1.36)	US (2.87)
France (FR)	GE (1.33)	NZ (2.42)	BE (1.40)	JP (2.40)
Germany (GE)	BE (1.35)	NZ (2.28)	BE (1.25)	US (2.22)
Greece (GR)	SP (1.61)	NZ (2.71)	NE (1.48)	US (2.27)
Italy (IT)	FR (1.45)	NZ (2.19)	AS (1.46)	JP (2.10)
Japan (JP)	BE (1.62)	PO (3.25)	AL (1.72)	US (3.08)
Netherlands (NE)	GE (1.30)	NZ (2.17)	DK (1.39)	NZ (2.01)
New Zealand (NZ)	CA (1.60)	PO (2.08)	AL (1.64)	GR (2.71)
Norway (NO)	FI (1.45)	JP (2.84)	SW (1.36)	US (2.31)
Portugal (PO)	BE (1.49)	JP (2.56)	SP (1.59)	JP (3.25)
Spain (SP)	BE (1.39)	JP (2.47)	NO (1.51)	JP (3.05)
Sweden (SW)	NO (1.36)	US (2.70)	FI (1.38)	US (2.01)
United Kingdom (UK)	NE (1.46)	JP (2.37)	FR (1.52)	NZ (2.04)
United States (US)	FR (1.57)	JP (3.08)	CA (1.58)	SW (2.70)

Notes: The price measure D_{ni} is defined in equation (13). For destination country n, the minimum Foreign Source is $\min_{i \neq n} \exp D_{ni}$. For source country i, the minimum Foreign Destination is $\min_{n \neq i} \exp D_{ni}$.

AER piece

- Look at facts in paper.

- Extension of the model. Each country gets two draws rather than one, rather than one of same thing. Then Bertrand competition.

- Let $C_{kni}(j)$ be the cost of supplier rank k to n from i

$$C_{kni}(j) = \left(\frac{c_i}{z_{ki}(j)} \right) d_{ni}$$

- The lowest cost is

$$C_{1n}(j) = \min_i \{ C_{1ni}(j) \}$$

- The lowest cost can't charge more than then the second lowest cost

$$C_{2n}(j) = \min \left\{ C_{2ni^*}(j), \min_{i \neq i^*} \{C_{1ni}(j)\} \right\}$$

- But won't want to charge more than a markup $\bar{m} = \frac{\sigma}{\sigma - 1}$. So

$$P_n(j) = \min \{C_{2n}(j), \bar{m} C_{1n}(j)\}$$

- Distribution of z_1, z_2 in any country

$$\begin{aligned} F_i(z_1, z_2) &= \Pr(Z_{1i} \leq z_1, Z_{2i} \leq z_2) \\ &= \left[1 + T_i \left(z_2^{-\theta} - z_1^{-\theta}\right)\right] e^{-T_i z_2^{-\theta}} \end{aligned}$$

Results

- 1. Probability country i exports j to n is

$$\pi_{ni} = \frac{T_i \left(c_i d_{ni}\right)^{-\theta}}{\Phi_n}$$

- Conditional distribution of costs (given sell) same for all countries, everything at extensive margin

- Get distribution of prices with truncation

- Get exact price index, formula has same shape as before $p_n = \gamma \Phi^{-\frac{1}{\theta}}$ (but γ has a new definition)

- $\frac{x_{ni}}{x_n} = \pi_{ni}$

Implications for Productivity, Exporting, and Size

- Productivity, value of output divided by input

$$\frac{(1+m)\,\frac{c}{z}x}{\frac{c}{z}x} = 1+m$$

where m actual markup. So actually a measure of markup (here at least)

- Markup is drawn from Pareto truncated at monopoly markup

$$\begin{aligned} H_n(m) &= 1 - m^{-\theta},\, 1 \leq m < \bar{m} \\ &= 1,\ m \geq \bar{m} \end{aligned}$$

- Have a distribution of $m|z$ (

$$\begin{aligned} H_n(m|z_1) &= 1 - e^{-\phi_n c_n^{\theta} z_1^{-\theta}\left(m^{\theta}-1\right)}\ ,1 \leq m < \overline{m} \\ &= 1,\, m \geq \bar{m} \end{aligned}$$

- So higher z, higher m (stochastically dominant sense)

Efficiency in Exporting

- Selling at home need

$$z_{1i}(j) \geq z_{1k}(j)\frac{c_i}{c_k d_{ik}} \text{ for all } k \neq i$$

- Selling some other market n

$$z_{1i}(j) \geq z_{1k}(j)\frac{c_i d_{ni}}{c_k d_{nk}} \text{ for all } k \neq i$$

  Higher hurdle (have triangle inequality)

- Plants export more likely to have higher measured efficiency

- Compare with Melitz model. Suppose two countries and a fixed cost to export. Suppose have parameter θ that leads to multiplicative scaling up of profits. (Or θ^γ, whatever...). Let λ be fixed cost to export. Then profits are (where π_k is profits in market k when $\theta = 1$)

$$\begin{aligned} \text{no export} &: \quad \theta\pi_{Dom} \\ \text{export} &: \quad \theta\pi_{Dom} + \theta\pi_{Foreign} - \lambda \end{aligned}$$

Will export if

$$\begin{aligned} \theta\pi_{Foreign} - \lambda &\geq 0 \\ \theta &\geq \hat{\theta} = \frac{\lambda}{\pi_{Foreign}} \end{aligned}$$

Efficiency and Size

- Why would exporting plants have higher domestic sales? (First, if we just ask about all sales, easy, if export, should be bigger for one obvious reason, make it harder. Why if export, do you sell more locally?)

- $\sigma > 1$, then easy, efficient, then lower price to sell more

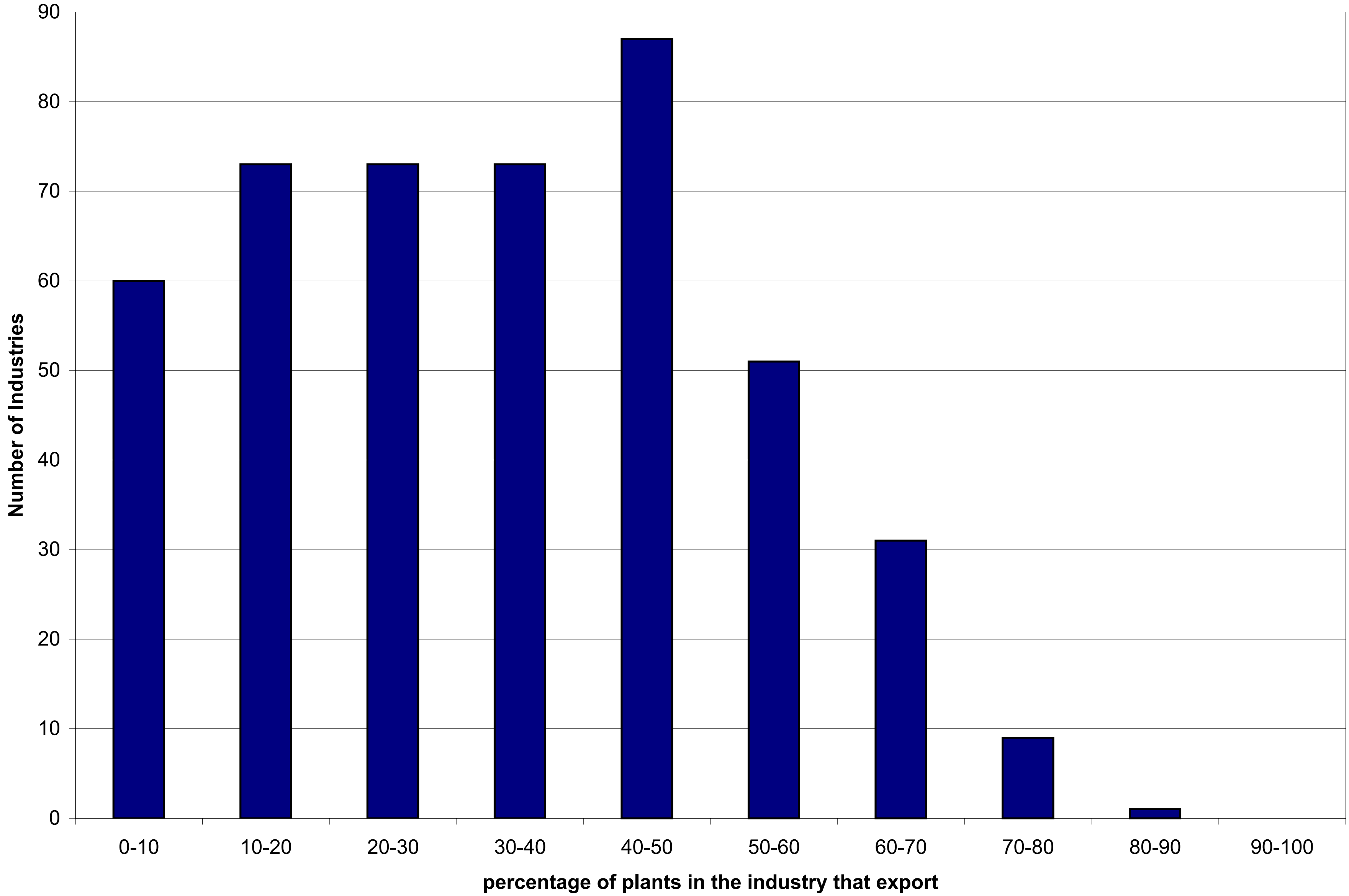
- $\sigma < 1$. Tricky. More efficient, on average have more efficient rivals, so sell more, but then revenues....

TABLE 1—PLANT-LEVEL EXPORT FACTS

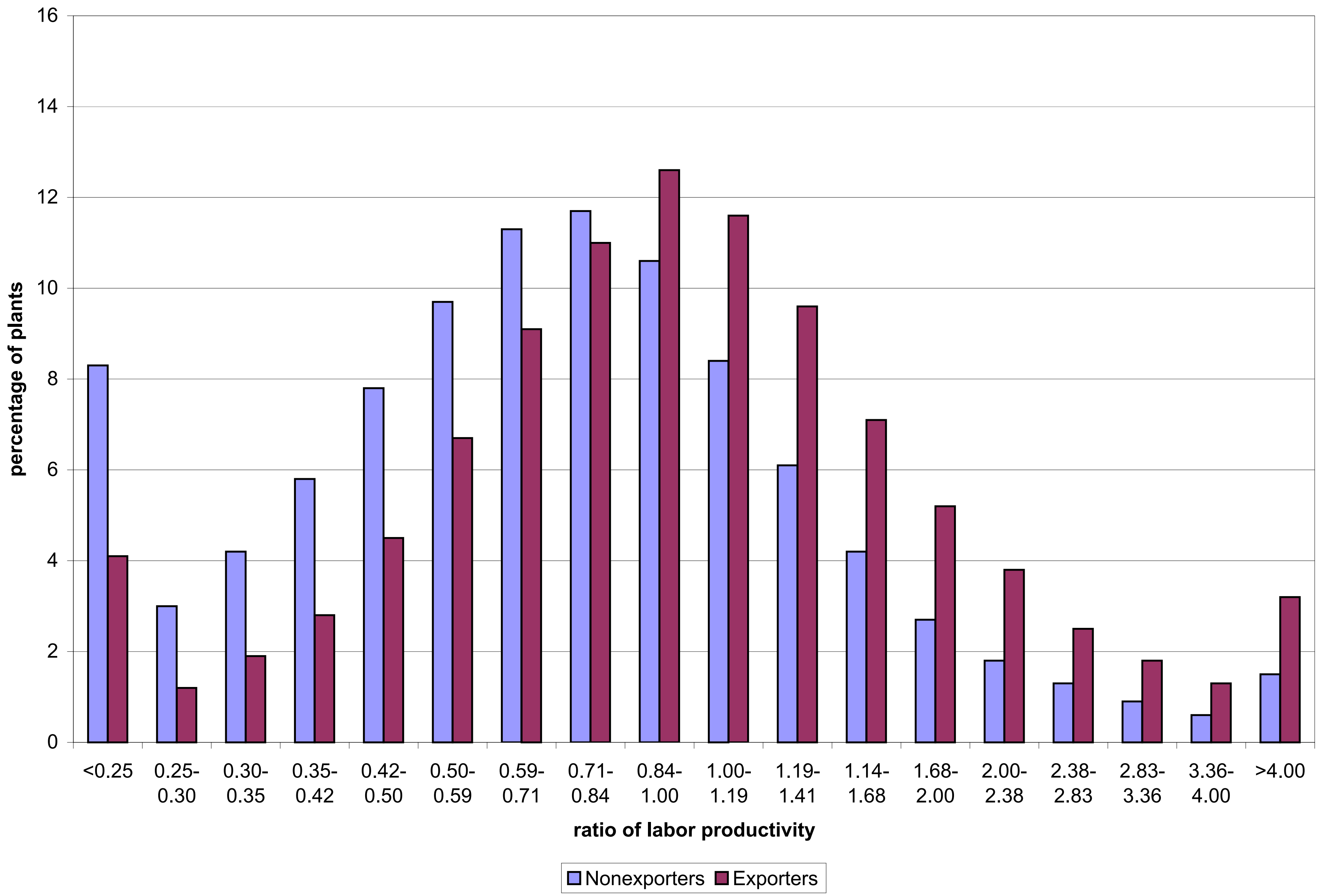
Export status	Percentage of all plants
No exports	79
Some exports	21

Export intensity of exporters (percent)	Percentage of exporting plants
0 to 10	66
10 to 20	16
20 to 30	7.7
30 to 40	4.4
40 to 50	2.4
50 to 60	1.5
60 to 70	1.0
70 to 80	0.6
80 to 90	0.5
90 to 100	0.7

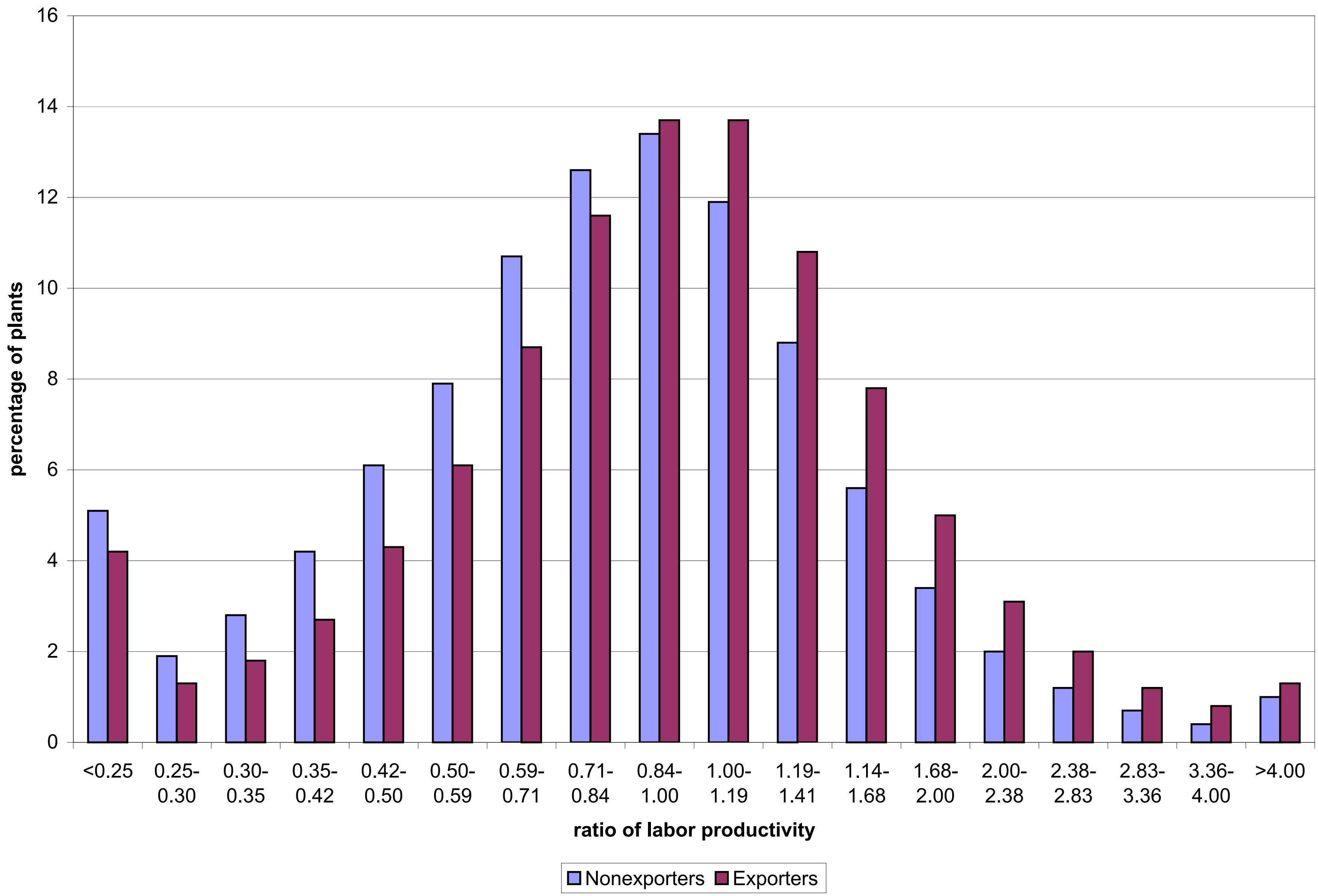
Note: The statistics are calculated from all plants in the 1992 Census of Manufactures.



90
80
70
60
50
40
30
20
10
0
Number of Industries
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
percentage of plants in the industry that export



16
14
12
10
8
6
4
2
0
percentage of plants
<0.25
0.25-0.30
0.30-0.35
0.35-0.42
0.42-0.50
0.50-0.59
0.59-0.71
0.71-0.84
0.84-1.00
1.00-1.19
1.19-1.41
1.14-1.68
1.68-2.00
2.00-2.38
2.38-2.83
2.83-3.36
3.36-4.00
>4.00
ratio of labor productivity
Nonexporters
Exporters



percentage of plants
16
14
12
10
8
6
4
2
0
<0.25
0.25-0.30
0.30-0.35
0.35-0.42
0.42-0.50
0.50-0.59
0.59-0.71
0.71-0.84
0.84-1.00
1.00-1.19
1.19-1.41
1.14-1.68
1.68-2.00
2.00-2.38
2.38-2.83
2.83-3.36
3.36-4.00
>4.00
ratio of labor productivity
Nonexporters
Exporters