BUSN 33946 & ECON 35101
International Macroeconomics and Trade

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Today: Heterogeneous firms

Hallak and Levinsohn:

> *The problem with country-level data, in a nutshell, is that they are not sufficiently informative. Countries do not produce anything and countries do not trade with one another. Firms and consumers do these things. Exactly how one intended or expected to measure the impact of trade on incomes without any reference to firms and/or households is something of a puzzle.*

- Brief introduction to firm-level facts
- Work through Melitz (2003) model
- Quick summaries of heterogeneous-firm papers

Firms in international trade: Overview

Five summary facts about firms in international trade

- Very few firms export: 4% of 5.5 million US firms are exporters
- A few firms dominate exporting: top 10% of exporters account for 96% of exports
- Exporters are bigger than non-exporters: Average exporting firm is twice the size of average non-exporter
- Art Vandelay: More than 50% of importing firms export
- Churning: About 10% start or stop exporting annually

Most manufacturing firms don't export

TABLE 1
FIRM EXPORTING

		Percent of firms (1)	Fraction of firms that export (2)	Mean exports as a share of total shipments (3)
311	Food manufacturing	6.8	0.23	0.21
312	Beverage and tobacco product	0.9	0.30	0.30
313	Textile mills	0.8	0.57	0.39
314	Textile product mills	2.7	0.19	0.12
315	Apparel manufacturing	3.6	0.22	0.16
316	Leather and allied product	0.3	0.56	0.19
321	Wood product manufacturing	4.8	0.21	0.09
322	Paper manufacturing	1.5	0.48	0.06
323	Printing and related support	11.1	0.15	0.10
324	Petroleum and coal products	0.5	0.34	0.13
325	Chemical manufacturing	3.3	0.65	0.23
326	Plastics and rubber products	3.9	0.59	0.11
327	Nonmetallic mineral product	4.3	0.19	0.09
331	Primary metal manufacturing	1.5	0.58	0.31
332	Fabricated metal product	20.6	0.30	0.09
333	Machinery manufacturing	8.7	0.61	0.15
334	Computer and electronic product	3.9	0.75	0.28
335	Electrical equipment, appliance	1.7	0.70	0.47
336	Transportation equipment	3.4	0.57	0.16
337	Furniture and related product	6.5	0.16	0.14
339	Miscellaneous manufacturing	9.3	0.32	0.16
Aggregate manufacturing		100.0	0.35	0.17

Notes: Data are for 2007 and are for firms that appear in both the US Census of Manufactures and the LFTTD. Column 1 summarizes the distribution of manufacturing firms across three-digit NAICS manufacturing industries. Column 2 reports the share of firms in each industry that export. Firm exports are measured using customs information from LFTTD. Column 3 reports mean exports as a percent of total shipments across all firms that export in the noted industry. Percentages in column 1 need not sum exactly to 100 due to rounding.

Bernard, Jensen, Redding, Schott (*JEL*, 2018)

We used to think exporting was rarer; data sources matter.

A few firms dominate exporting

Distribution of Exporters and Export Value by Number of Products and Export Destinations, 2000

A: Share of Exporting Firms

Number of products	*Number of countries* 1	2	3	4	5+	*All*
1	40.4	1.2	0.3	0.1	0.2	**42.2**
2	10.4	4.7	0.8	0.3	0.4	**16.4**
3	4.7	2.3	1.3	0.4	0.5	**9.3**
4	2.5	1.3	1.0	0.6	0.7	**6.2**
5+	6.0	3.0	2.7	2.3	11.9	**25.9**
All	**64.0**	**12.6**	**6.1**	**3.6**	**13.7**	**100**

B: Share of Export Value

Number of products	*Number of countries* 1	2	3	4	5+	*All*
1	0.20	0.06	0.02	0.02	0.07	**0.4**
2	0.19	0.12	0.04	0.03	0.15	**0.5**
3	0.19	0.07	0.05	0.03	0.19	**0.5**
4	0.12	0.08	0.08	0.04	0.27	**0.6**
5+	2.63	1.23	1.02	0.89	92.2	**98.0**
All	**3.3**	**1.5**	**1.2**	**1.0**	**92.9**	**100**

Bernard, Jensen, Redding, Schott (*JEP*, 2007)

Exporters are bigger than non-exporters

Exporter Premia in U.S. Manufacturing, 2002

	Exporter premia		
	(1)	*(2)*	*(3)*
Log employment	1.19	0.97	
Log shipments	1.48	1.08	0.08
Log value-added per worker	0.26	0.11	0.10
Log TFP	0.02	0.03	0.05
Log wage	0.17	0.06	0.06
Log capital per worker	0.32	0.12	0.04
Log skill per worker	0.19	0.11	0.19
Additional covariates	None	Industry fixed effects	Industry fixed effects, log employment

Sources: Data are for 2002 and are from the U.S. Census of Manufactures.
Notes: All results are from bivariate ordinary least squares regressions of the firm characteristic in the first column on a dummy variable indicating firm's export status. Regressions in column 2 include industry fixed effects. Regressions in column 3 include industry fixed effects and log firm employment as controls. Total factor productivity (TFP) is computed as in Caves, Christensen, and Diewert (1982). "Capital per worker" refers to capital stock per worker. "Skill per worker" is nonproduction workers per total employment. All results are significant at the 1 percent level.

Bernard, Jensen, Redding, Schott (*JEP*, 2007)

Productivity premia

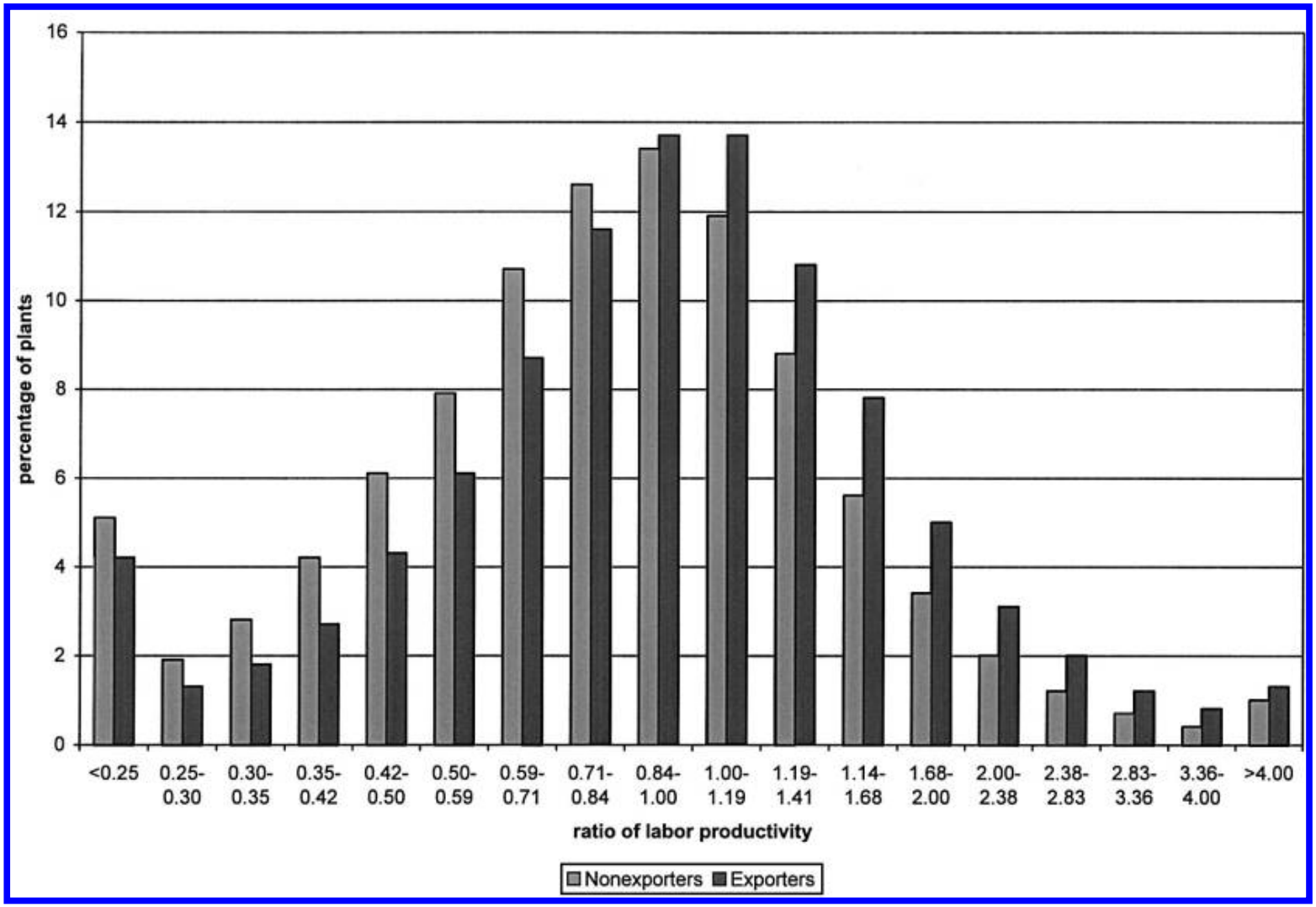


FIGURE 2B. RATIO OF PLANT LABOR PRODUCTIVITY TO 4-DIGIT INDUSTRY MEAN

Bernard, Eaton, Jensen, Kortum (*AER*, 2003)

Importers, exporters, and multinationals

Table 14.1 **Employment at firms engaged in trade**

	Employment (Mill) at trading firms			
	1993		2000	
	Employment	Share (%)	Employment	Share (%)
Firms that trade	38.1	40.0	47.9	41.9
Firms that export	34.6	36.3	45.0	39.4
Firms that import	30.8	32.3	37.7	33.0
Firms that export and import	27.3	28.7	34.8	30.4
Firms that just export	7.3	7.7	10.2	8.9
Firms that just import	3.5	3.7	2.9	2.5

Notes: Table reports the amount of employment (in millions of workers) and share of total civilian U.S. employment at private firms. For a more detailed description of the firm and employment data see section 14.3 and the appendix. The categories are not mutually exclusive, that is, the bottom three rows sum to the first row, as do the second and the sixth, and similarly for the third and fifth rows.

Bernard, Jensen, Schott (*NBER*, 2009)

Importers, exporters, and multinationals

Table 14.13 Employment at multinationals engaged in trade

	Multinational employment (mill)			
	1993		2000	
	Employment	Share[a] (%)	Employment	Share[a] (%)
Multinationals	25.5	26.7	31.3	27.4
– that export to a related party	23.4	24.5	27.5	24.1
– that import from a related party	19.5	20.4	23.3	20.4
– that export to and import from a related party	17.4	18.2	19.4	17.0
– that just export to a related party	6.0	6.3	8.1	7.1
– that just import from a related party	2.1	2.2	3.8	3.3

Notes: Table reports the amount of employment (in millions of workers) at multinational firms in 1993 and 2000. The categories are not mutually exclusive (i.e., the bottom three rows sum to the first row, as do the second and the sixth, and similarly for the third and fifth rows).

[a]Employment shares are with respect to total civilian U. S. employment as reported in the Economic Report of the President.

Bernard, Jensen, Schott (*NBER*, 2009)

Exporting dynamics

- Considerable churning (Alessandria and Choi 2010):

Probability an Establishment Starts or Stops Exporting

	U.S. (1984 to 1992)	Chile (1990 to 2001)
Probability of starting to export in t+1	12%	3.4%
Probability of stopping export in t+1	14%	11.5%

- Future exporters are larger and faster-growing than other non-exporters (Bernard and Jensen *JIE* 1999)
- Exporters are more likely to enter new markets geographically contiguous with current export destinations (Lawless *OER* 2013)
- Sharing a border reduces estimated entry cost for Chilean chemical manufacturers by 20%-40% (Morales et al 2015)

More exporter premia

Exporting firms...

- produce more products (BJRS 2007, BRS 2011)
- pay higher wages (Frias, Kaplan, and Verhoogen 2009)
- use more expensive material inputs (Kugler and Verhoogen 2012)
- innovate more (Aw, Roberts and Xu 2011)

Trade liberalization and reallocation across firms

- Decompose change in aggregate productivity into between- and within-firm components
- Finding that trade liberalization raised shares of more productive firms motived theoretical work on heterogeneous firms
- Measuring firm-level TFP is plagued by simultaneity and selection biases
- Measuring TFP is hard: see recent survey by Jan de Loecker and Penny Goldberg that emphasizes profitability vs productivity, TFPQ vs TFPR, markups, learning by exporting, and so forth
- Pavcnik (2002) is an early and influential paper that applied Olley and Pakes (1996) technique to estimate TFP and assess Chile's 1970s trade liberalization

Pavcnik (2002)

- Chile liberalized trade 1974-1979 (tariffs "often surpassing 100% in 1974" reduced to uniform 10%)
- Pavcnik has plant-level panel data for 1979-1986
- No plant-level data on exporting behavior
- Classify industries as import-competing, export-oriented, or non-tradable based on penetration (doesn't use tariff rates)
- Exit is important: 35% of plants exited between 1979 and 1986; exiting plants on average 8% less productive than survivors
- Industry productivity growth decomposed into unweighted average and share-productivity covariance (Table 3) shows 2/3 of aggregate productivity improvement due to between-plant shifts
- Industry productivity regressed on orientation $\times$ year dummies (Table 4) shows substantial productivity increases 1979-1986 for import-competing sectors compared to non-tradables and no such improvements for export-oriented sectors

Melitz (Ecma 2003)

- Melitz (2003) is a model with heterogeneous firms and fixed costs of exporting that can speak to productivity premia and trade liberalization causing intra-industry reallocation
- One of the most cited papers of last 20 years (12k GS)
- Two building blocks:
  1. Krugman (AER 1980): CES preferences, IRS technology, monopolistic competition
  2. Hopenhayn (JPE 1992): equilibrium model of entry and exit
- Are trade-induced reallocations of labor from less to more productive firms a "new" source of gains from trade?

Preferences and production

As in Krugman (1980), representative agent has CES preferences:

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} \mathrm{d}\omega \right]^{\frac{\sigma}{\sigma-1}}$$

Consumption and expenditure on each variety are

$$q(\omega) = Q \left[\frac{p(\omega)}{P} \right]^{-\sigma} \qquad r(\omega) = R \left[\frac{p(\omega)}{P} \right]^{1-\sigma}$$

where $P \equiv \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} \mathrm{d}\omega \right]^{\frac{1}{1-\sigma}}$ and $R \equiv \int_{\omega \in \Omega} r(\omega) \mathrm{d}\omega$

As in Krugman (1980), endowed labor L is only factor of production with wage w and IRS production function has fixed cost and constant marginal cost

$$l = f + q/\varphi \qquad p(\varphi) = \frac{\sigma}{\sigma - 1} \frac{w}{\varphi}$$

$$r(\varphi) = R \left(P \rho \varphi \right)^{\sigma-1} \qquad \pi(\varphi) = \frac{1}{\sigma} r(\varphi) - f$$

Decentralized equilibrium is efficient

See Dixit and Stiglitz (1977) and Dhingra and Morrow (2019)

- Decentralized equilibrium solves revenue maximization:

$$\max_{q_i,n} \int_0^n p_i(q_i) q_i \mathrm{d}i \qquad \text{s.t. } nf + \int_0^n q_i/\varphi_i \mathrm{d}i \leq L$$

- Social planner solves:

$$\max_{q_i,n} \int_0^n q_i^{\frac{\sigma-1}{\sigma}} \mathrm{d}i \qquad \text{s.t. } nf + \int_0^n q_i/\varphi_i \mathrm{d}i \leq L$$

- CES preferences and constant marginal costs make $r(\varphi) \propto \varphi^{\sigma-1}, q(\varphi) \propto \varphi^{\sigma} \Rightarrow p_i(q_i) q_i \propto q_i^{\frac{\sigma-1}{\sigma}}$, so solutions coincide
- Thus, many aggregate properties of Melitz (2003) coincide with those of perfectly competitive models
- As is so often the case, CES is a very special demand system

Aggregate outcomes (closed economy)

- Since all firms with productivity φ charge same price $p(\varphi)$,

$$P \equiv \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma}\mathrm{d}\omega\right]^{\frac{1}{1-\sigma}} = \left[\int_0^{+\infty} p(\varphi)^{1-\sigma} M\mu(\varphi)\mathrm{d}\varphi\right]^{\frac{1}{1-\sigma}}$$

  where M is mass of active firms and $\mu(\varphi)$ conditional pdf of active productivities in equilibrium
- Using $p(\varphi) = \frac{\sigma}{\sigma-1}\frac{w}{\varphi}$, write this as $P = \frac{\sigma}{\sigma-1} w M^{\frac{1}{1-\sigma}} \tilde{\varphi}$

$$\tilde{\varphi} \equiv \left[\int_0^{+\infty} \varphi^{\sigma-1}\mu(\varphi)\mathrm{d}\varphi\right]^{\frac{1}{\sigma-1}}$$

- Similarly, other aggregate variables can be written

$$R = Mr(\tilde{\varphi}) \quad \Pi = M\pi(\tilde{\varphi}) \quad Q = M^{\frac{\sigma}{\sigma-1}} q(\tilde{\varphi})$$

- Aggregates are same as those in a Krugman model with mass M of homogeneous firms with productivity $\tilde{\varphi}$
- But $\tilde{\varphi}$ is endogenous and may depend on trade costs

Entry and exit

To determine equilibrium $\mu(\varphi)$ and $\tilde{\varphi}$, must specify the entry and exit process for firms. Similar to Hopenhayn (1992):

1. There is a large pool of identical potential entrants
2. Entrants pay a fixed cost of entry $f_e > 0$ and draw productivity φ from $G(\cdot)$
3. After observing their φ, firm chooses to produce or exit
4. Active firms exogenously exit with constant probability of death δ

- In stationary equilibrium, active firm earns $\pi(\varphi)$ each period
- There is a unique productivity cutoff φ^* and, given the fixed cost, it is defined by $\pi(\varphi^*) = 0$
- The conditional pdf $\mu(\varphi) = \frac{g(\varphi)}{1-G(\varphi^*)}$ on support $[\varphi^*, \infty)$

Free-entry and zero-cutoff conditions

Free-entry condition

- Entry cost equals expected profits $f_e = \frac{1}{\delta}\frac{\Pi}{M}\left[1 - G(\varphi^*)\right]$
- Free-entry condition is therefore

$$\bar{\pi} \equiv \frac{\Pi}{M} = \frac{\delta f_e}{1 - G(\varphi^*)}$$

- Higher cutoff $\Rightarrow$ entrants need higher average profits for survivors

Zero-cutoff condition

- By definition of $\bar{\pi}$,

$$\bar{\pi} = \pi(\tilde{\varphi}(\varphi^*)) \iff \bar{\pi} = \pi(\varphi) = \frac{1}{\sigma} r(\tilde{\varphi}(\varphi^*)) - f$$

- By definition of φ^*, $\pi(\varphi^*) = 0 \iff r(\varphi^*) = \sigma f$
- Zero-cutoff condition is therefore

$$\bar{\pi} = f\left[\left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} - 1\right]$$

Equilibrium φ^* and $\bar{\pi}$

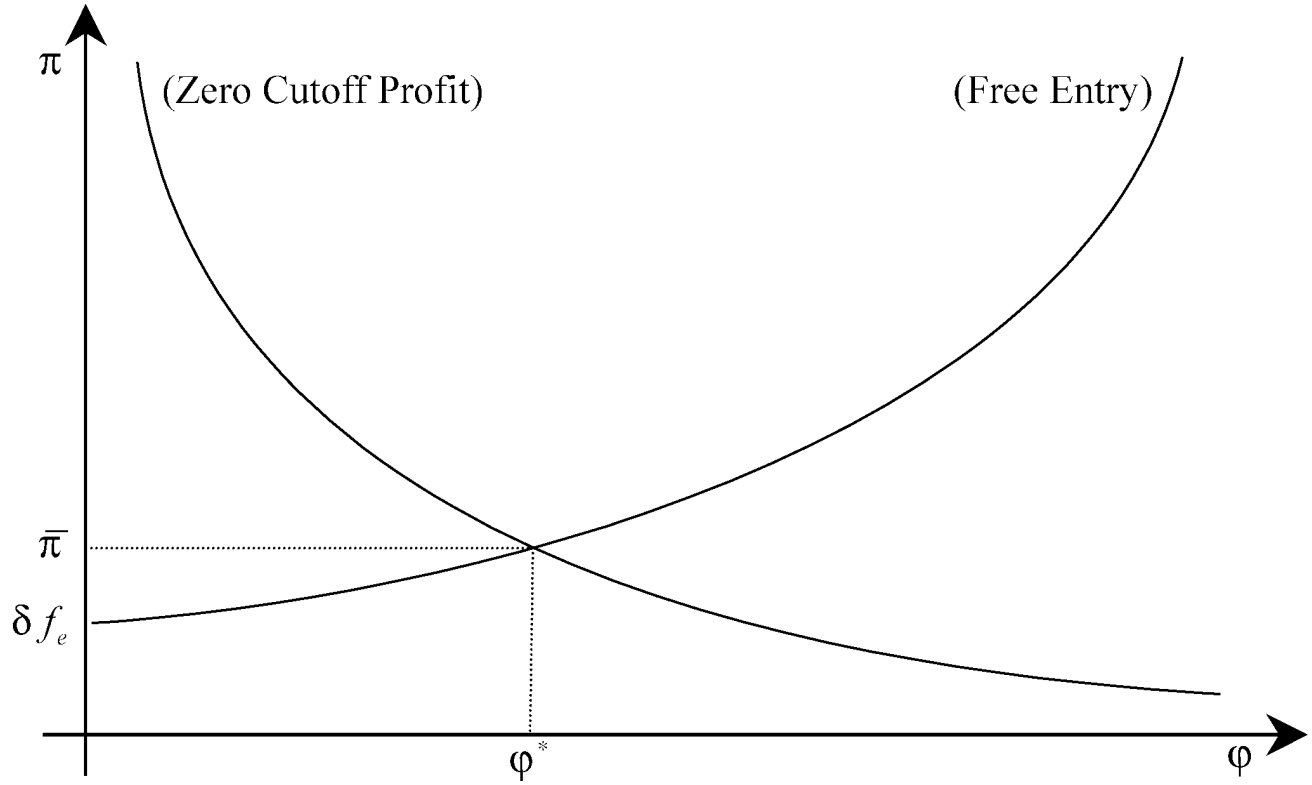


FIGURE 1.—Determination of the equilibrium cutoff φ^* and average profit $\bar{\pi}$.

- Both free-entry and zero-cutoff conditions are independent of L
- Zero-cutoff condition is not necessarily downward sloping
- For Pareto distribution ($1 - G(\varphi) = a\varphi^b$), $\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}$ is constant so ZCP is horizontal

Size, varieties, welfare, and free-trade equilibrium

- Equilibrium still requires determination of M, obtain that from total labor hired, as in Krugman (1980)
- Set wage as numeraire
- Free entry and labor market clearing say $L = R = Mr(\tilde{\varphi})$
  $\Rightarrow M = \frac{1}{\sigma(\bar{\pi}+f)} L$
- Welfare is $U = 1/P = \frac{\sigma-1}{\sigma} M^{\frac{1}{\sigma-1}} \tilde{\varphi}$
- Since $\bar{\pi}$ and φ^* are independent of size, greater size and costless trade are essentially isomorphic, as in Krugman (1980)
- There is no reallocation of market shares across firms when comparing autarky and free trade

Introducing trade costs

- (Assume identical country sizes to shut down terms of trade)
- Iceberg trade costs τ and fixed export cost f_x
- Prices are $p_d(\varphi) = \frac{\sigma}{\sigma-1}\frac{1}{\varphi}$ and $p_x(\varphi) = \frac{\sigma}{\sigma-1}\frac{\tau}{\varphi}$
- Revenues are

$$r_d(\varphi) = R_d\left(P_d\rho\varphi\right)^{\sigma-1} \qquad r_x(\varphi) = \tau^{1-\sigma}R_x\left(P_x\rho\varphi\right)^{\sigma-1}$$

- By symmetry, $P_d = P_x = P$ and $R_d = R_x = R$
- Profits are

$$\pi_d(\varphi) = \frac{1}{\sigma}r_d(\varphi) - f \quad \pi_x(\varphi) = \frac{1}{\sigma}r_x(\varphi) - f_x$$

- Total profits are $\pi(\varphi) = \pi_d(\varphi) + \max\{0, \pi_x(\varphi)\}$
- Cutoffs are now defined as φ^* and φ_x^*
- Assume $\tau^{\sigma-1}f_x > f$ so that there are non-exporters ($\varphi_x^* > \varphi^*$)
- Draw the $\pi_d(\varphi), \pi_x(\varphi)$ functions against $\varphi^{\sigma-1}$

Aggregate outcomes for open economy

- In the open economy, aggregate productivity is now given by

$$\tilde{\varphi}_t = \left\{ \frac{M}{M_t} \tilde{\varphi}^{\sigma-1} + n \frac{M_x}{M_t} (\tilde{\varphi}_x / \tau)^{\sigma-1} \right\}$$

- $M_t \equiv M + nM_x$ is total number of varieties
- $\tilde{\varphi} \equiv \left[\frac{1}{1-G(\varphi^*)} \int_{\varphi^*}^{+\infty} \varphi^{\sigma-1} g(\varphi) \mathrm{d}\varphi \right]^{\frac{1}{\sigma-1}}$ is average of all firms
- $\tilde{\varphi}_x \equiv \left[\frac{1}{1-G(\varphi_x^*)} \int_{\varphi_x^*}^{+\infty} \varphi^{\sigma-1} g(\varphi) \mathrm{d}\varphi \right]^{\frac{1}{\sigma-1}}$ is average of exporters
- We can again write aggregate variables in terms of $\tilde{\varphi}_t$ but this relies heavily on symmetry (welfare depends on productivity of foreign exporters!)

$$P = \frac{1}{\rho} M_t^{\frac{1}{1-\sigma}} \tilde{\varphi}_t \quad R = M_t r(\tilde{\varphi}_t) \quad \Pi = M_t \pi(\tilde{\varphi}_t) \quad Q = M_t^{\frac{\sigma}{\sigma-1}} q(\tilde{\varphi}_t)$$

Free-entry and zero-cutoff conditions in open economy

- Free-entry condition is same as before ($\delta f_e = \bar{\pi}[1 - G(\varphi^*)]$), recognizing that $\bar{\pi} = \pi_d(\tilde{\varphi}) + np_x\pi_x(\tilde{\varphi}_x)$ where $p_x = \frac{1-G(\varphi_x^*)}{1-G(\varphi^*)}$.
- Zero-cutoff condition is now derived from $r_d(\varphi^*) = \sigma f$ and $r_x(\varphi_x^*) = \sigma f_x$, which jointly imply

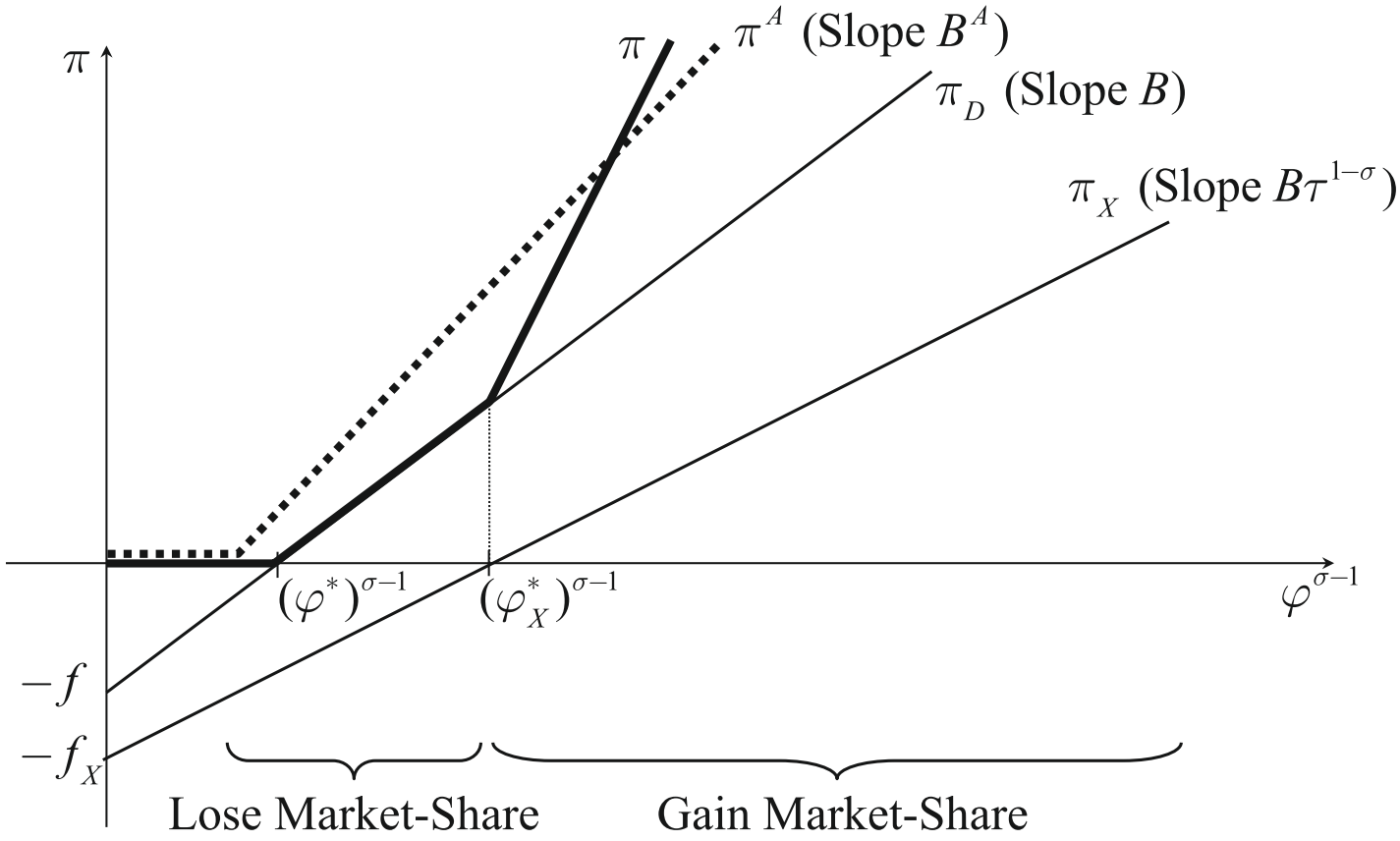
$$\frac{r_x(\varphi_x^*)}{r_d(\varphi^*)} = \frac{f_x}{f} \iff \varphi_x^* = \varphi^*\tau(f_x/f)^{1/(\sigma-1)}$$

- Rearranging $\bar{\pi}$ to be a function of φ^* delivers

$$\bar{\pi} = f\left[\left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} - 1\right] + np_x f_x\left[\left(\frac{\tilde{\varphi}_x(\varphi^*)}{\varphi_x^*(\varphi^*)}\right)^{\sigma-1} - 1\right]$$

- This ZCP has shifted up relative to closed-economy ZCP

The consequences of trade



Melitz and Redding (Handbook 2014), Figure 1.3

Trade (increase in n, decrease in τ or f_x) raises the φ^* cutoff, reallocates input shares to more productive firms, and produces welfare gains

Measuring productivity in Melitz (2003) setting

- With only one input, output quantity per worker is TFPQ

$$\frac{\text{physical output}}{\text{variable workers}} = \frac{\sum_{j=1}^{N} \tau_{ij} x_{ij}(\varphi)}{\sum_{j=1}^{N} l_{ij}^{v}(\varphi)} = \varphi$$

- We often do not see physical output (particularly for differentiated goods). What if we use TFPR?

$$\frac{\text{value of output}}{\text{variable workers}} = \frac{\sum_{j=1}^{N} p_{ij}(\varphi) x_{ij}(\varphi)}{\sum_{j=1}^{N} l_{ij}^{v}(\varphi)} = \frac{\sigma}{\sigma - 1} w_i$$

- Relative revenues and relative productivities:

$$\frac{r(\varphi_1)}{r(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma - 1}$$

- Relate this to the productivity-quality isomorphism mentioned in footnote 7 of Melitz (2003)

Bernard, Eaton, Jensen, and Kortum (2003)

- BEJK (2003) introduce firm heterogeneity into a framework close to Eaton and Kortum (2002), analogous to what Melitz (2003) does for Krugman (1980)
- Many countries, many industries, CES preferences
- Many firms within each industry with CRS technologies, iceberg trade costs, and heterogeneous productivities competing on price
- Price charged by least-cost firm in each industry is bounded by the second lowest cost (from same or different country)
- The joint distribution of highest and second-highest productivities is key:

$$F_j(z_1, z_2) = \Pr\left[Z_{1i} \leq z_1, Z_{2i} \leq z_2\right] = \left[1 + T_i\left(z_2^{-\theta} - z_1^{-\theta}\right)\right] \exp\left(-T_i z_2^{-\theta}\right)$$

- Markup $M_n(j) = P_n(j)/C_{1n}(j)$ is random variable M_n drawn from truncated Pareto (truncated by monopolist's markup)

$$H_n(M) = \Pr[M_n < m] = 1 - m^{-\theta} \quad 1 \leq m < \frac{\sigma}{\sigma - 1}$$

Hsieh, Li, Ossa, Yang (2020)

- These 'new' gains... are driven by changes in the set of firms serving a market.
- the import variety gains measured in studies such as Broda and Weinstein (2006) are counteracted by exactly analogous domestic variety losses
- the domestic productivity gains measured in studies such as Trefler (2004) are counteracted by exactly analogous import productivity losses

$$X_{ij} \propto M_{ij} \left(\tilde{p}_{ij}/P_j\right)^{1-\sigma} Y_j, \quad \tilde{p}_{ij} \propto \frac{w_i \tau_{ij}}{\tilde{\varphi}_{ij}}, \quad Y_j \propto w_j L_j$$

Welfare changes are $\Delta \ln W_j = \Delta \ln \left(Y_j/L_j\right) - \Delta \ln P_j$

$$\Delta \ln W_j = \underbrace{\sum_{i=1}^{N} \bar{\lambda}_{ij} \left(\frac{1}{\sigma - 1} \Delta \ln M_{ij} + \left(\Delta \ln \tilde{\varphi}_{ij} - \Delta \ln \tilde{\varphi}_{ij}^{c} \right) \right)}_{\text{'new' gains}}$$

$$+ \underbrace{\sum_{i=1}^{N} \bar{\lambda}_{ij} \left(-\Delta \ln \tau_{ij} + \Delta \ln \tilde{\varphi}_{ij}^{c} + \left(\Delta \ln w_j - \Delta \ln w_i \right) \right)}_{\text{'traditional' gains}}$$

In Melitz (2003) w/ Pareto $G(\varphi)$ (e.g., ACR case), the 'new' gains are exactly zero.

Revisiting many questions with firm heterogeneity

- Multiple factors of production (Bernard Redding Schott 2007)
- Variable markups (Melitz and Ottaviano 2008)
- Trade elasticity (Chaney 2008)
- Gravity regressions (Helpman Melitz Rubinstein 2008)
- Multi-product firms (Bernard Redding Schott 2009)
- Structure of trade costs (Arkolakis 2010, Eaton Kortum Kramarz 2011)
- Export vs FDI (Helpman Melitz Yeaple 2004)

See Melitz and Redding (2014) Handbook of International Economics chapter for overview of extensions

Bernard, Redding, Schott (2007)

- Introduce multiple industries that vary in factor intensity and countries that vary in factor abundance
- Total cost function for firm in i in industry j using skilled S and unskilled U is

$$[f_{ij} + q_{ij}/\varphi]\, w_{Si}^{\beta_j} w_{Ui}^{1-\beta_j}$$

- If $\tau = 1$ and $f_x = 0$, you're in FPE set and four theorems apply straightforwardly
- Absent FPE, trade affects intra-industry reallocation
- Growth of exporters is greater in comparative-advantage sector, so exit by less productive firms is stronger in the comparative-advantage sector
- Race between Stolper-Samuelson force and changes in product variety and average productivity

Melitz and Ottaviano (2008)

- Firm heterogeneity a la Melitz (2003) with quasi-linear quadratic preferences (due to Ottaviano, Tabuchi and Thisse 2002)

$$U = q_0^c + \int_{i\in\Omega} q_i^c \mathrm{d}i - \frac{1}{2}\gamma \int_{i\in\Omega} \left(q_i^c\right)^2 \mathrm{d}i - \frac{1}{2}\eta \left(\int_{i\in\Omega} q_i^c \mathrm{d}i\right)^2$$

- Linear demand delivers variable markups
- Market size affects markups, profits, and productivity cutoff in closed economy
- Asymmetric countries and trade costs analyzed thanks to freely traded outside good that equalizes wages
- Economic mechanisms not new (see Krugman 1979, Venables 1987), but integration of asymmetric countries, variable markups, and heterogeneous firms is novel

Chaney (2008)

- In Krugman (1980, section II), exports from Home to Foreign are

$$\frac{n\tau^{1-\sigma}}{n\tau^{1-\sigma}+n^*}w^*L^* = \frac{n}{n+n^*\tau^{\sigma-1}}w^*L^*$$

- Chaney extends Melitz (2003) to allow asymmetric countries and trade costs by introducing freely traded homogeneous good, fixed set of potential entrants, and a global mutual fund
- Pareto distribution for φ delivers closed-form expressions
- The resulting gravity equation in sector h is

$$X_{ij}^h = \mu_h \frac{Y_i Y_j}{Y}\left(\frac{w_i\tau_{ij}^h}{\theta_j^h}\right)^{-\gamma_h}\left(f_{ij}^h\right)^{[(\sigma_h-1-\gamma_h)/(\sigma_h-1)]}$$

  where θ_j^h is a multilateral-resistance term and γ_h is Pareto shape
- In Krugman (1980), variable trade costs show up in intensive margin of revenues per firm
- In Chaney (2008), both variable and fixed trade costs affect revenues per firm and total number of exporting firms
- With Pareto, variable trade costs do not change average revenue per firm; only extensive margin matters, which depends on γ, not σ

Helpman, Melitz, Rubinstein (2008)

In Krugman, Melitz, and Chaney, bilateral (country-level) exports are always strictly positive. But zeros are pervasive. HMR (2008) do Melitz with truncated Pareto productivity distributions

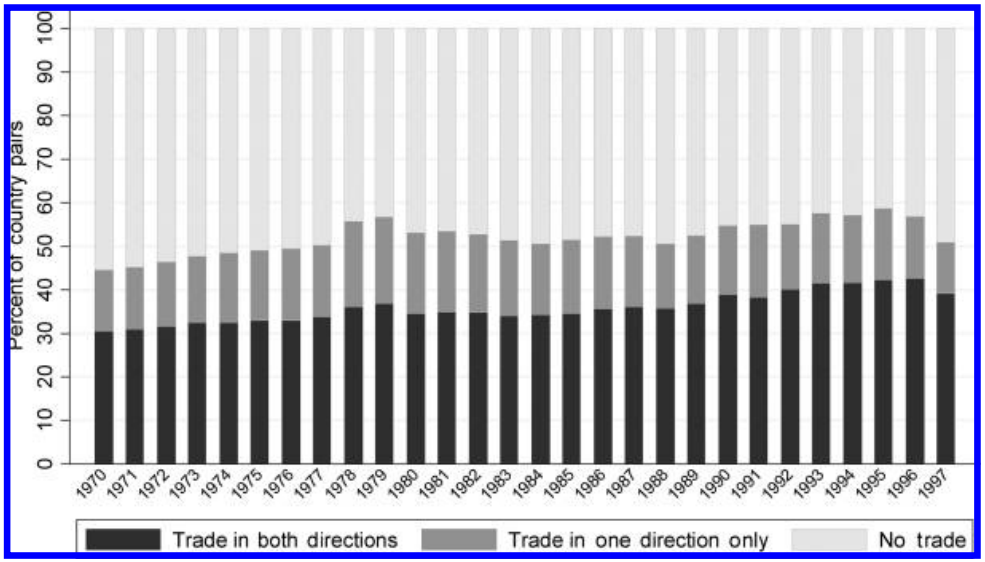


FIGURE I
Distribution of Country Pairs Based on Direction of Trade
Note. Constructed from 158 countries.

- Elasticity of *firm*'s revenue wrt distance suffers OVB: Greater trade cost also reduces number of exporting firms
- Elasticity also suffers selection bias: Non-zero trade flows have lower unobserved trade costs for more distant partners
- Two-step estimation procedure to addresses these biases and exploit both trading and nontrading country pairs (not PPML; Heckman (1979) selection using entry costs or common religion)

Bernard, Redding, Schott (2009)

- Recall 12% of US exporters that sell 5+ products to 5+ destinations account for 92% of export value
- BRS (2009) essentially do two-dimensional Melitz
- Nested CES preferences: CES over products and a continuum of firms supply differentiated varieties within each product
- Each firm draws two stochastic shocks: productivity common to all products and product-specific "product attributes"
- Fixed cost of selling to each market and another product-market fixed cost
- Selection both within and across firms: Within exporters, products with the worst attributes are supplied only to the domestic market, while products with the best attributes are exported to the largest number of markets.
- Trade liberalization causes firms to drop their worst products

Arkolakis (2010)

Melitz's fixed-cost story faces an empirical tension

- Only a small number of firms export, which suggests that fixed exporting costs are large
- Many exporters only export small amounts, which suggests that fixed exporting costs are small
- Arkolakis (2010) extends Chaney (2008) with endogenous marketing costs to explain size distribution of exporters
- Fixed cost of reaching consumers in j with probability x is

$$f_{ij}(x) = f_{ij} \times \left[\frac{1 - (1 - x)^{1-\mu}}{1 - \mu} \right]$$

- Same macro implications are Chaney (2008): Elasticity of aggregate trade flows wrt τ_{ij} is Pareto shape parameter

Eaton, Kortum, Kramarz (2011)

Quantitative exercise to move past Melitz's qualitative match.

Motivating facts:

1. Firms do not enter markets according to an exact hierarchy.
2. Their sales where they do enter deviate from the exact correlations the basic model insists on.
3. Firms that export sell too much in France.
4. In the typical destination, there are too many firms selling small amounts.

Approach:

- Introduce market and firm-specific heterogeneity in entry costs and demand
- Incorporate Arkolakis (2010) formulation of market access costs
- Estimate via SMM: Raw efficiency (Melitz story) explains 57% of variation in extensive margin
- Do a counterfactual cut in trade costs

Helpman, Melitz, Yeaple (2004): Export vs FDI

A firm with productivity φ facing domestic market d and export market x with demands $D_\ell(q_\ell) = B_\ell q_\ell^{\rho-1}$ may choose to export at fixed cost f_x and marginal cost $m/\varphi + m_x$ or it may instead invest at fixed cost f_i and marginal cost m/φ (oversimplify with same MC for domestic and FDI):

$$\pi(\varphi) = \pi_d(\varphi) + \max\{0, \pi_x(\varphi), \pi_i(\varphi)\} \qquad \pi_d(\varphi) = B_d\,(1-\rho)\,\varphi^{\rho/(1-\rho)}$$

$$\pi_x(\varphi) = B_x\,(1-\rho)\left(\frac{\varphi}{1+\varphi m_x}\right)^{\rho/(1-\rho)} - f_x$$

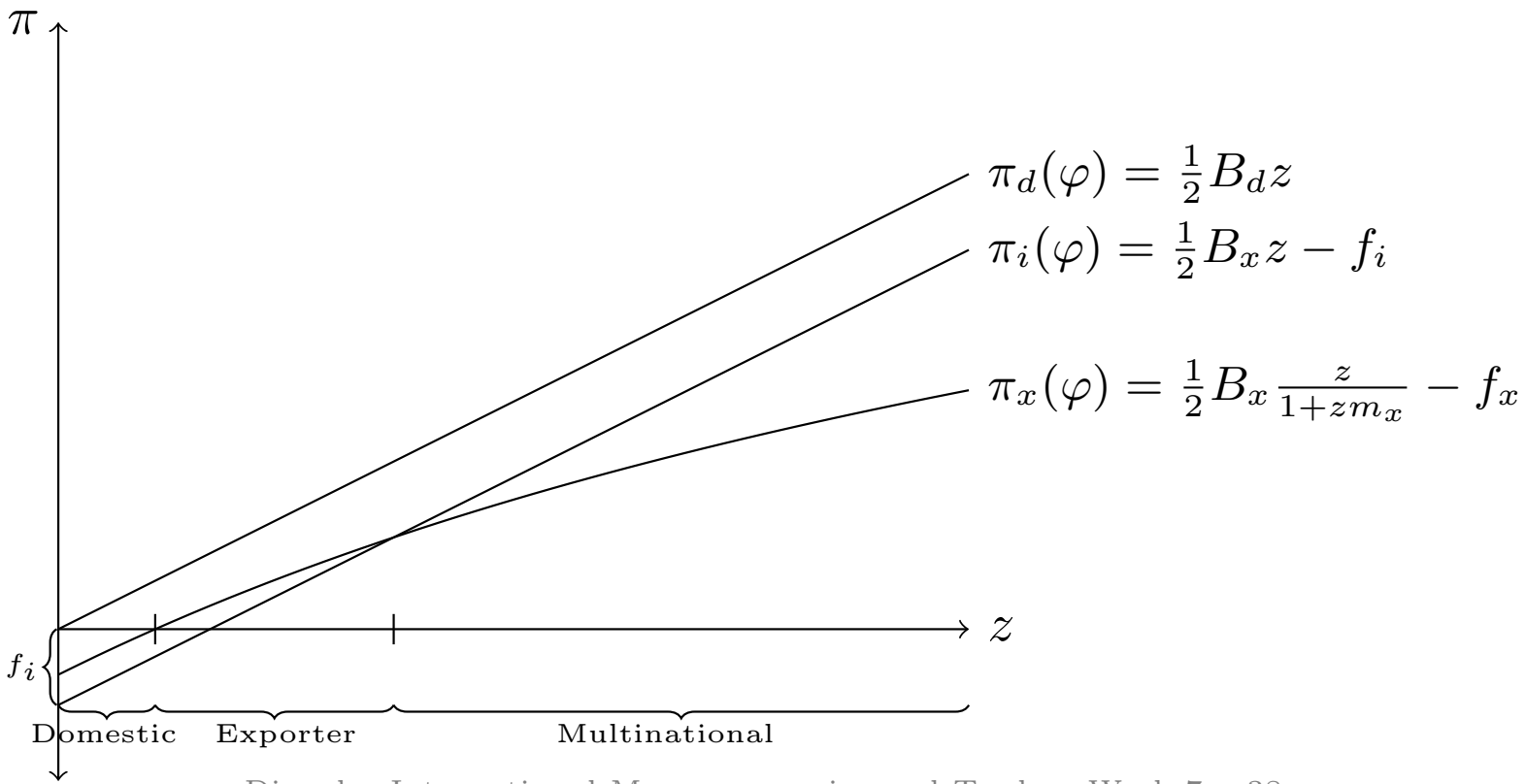
$$\pi_i(\varphi) = B_x\,(1-\rho)\,\varphi^{\rho/(1-\rho)} - f_i$$

To decide between exporting and investing, compare π_x and π_i

Proximity-concentration tradeoff

- If $f_i \leq f_x$, horizontal FDI is cheaper than exporting in both fixed costs ($f_i \leq f_x$) and marginal costs ($m < m + m_x$)
- If $f_i > f_x$, there is a proximity-concentration tradeoff because FDI involves *higher* fixed cost and *lower* marginal cost

To illustrate, let $\rho = \frac{1}{2}$ and $B_d = B_x$



Comparative statics

For a firm comparing exporting and investing:

- Higher productivity (higher z) makes investment relatively more attractive
- Higher trade costs (higher m_x or f_x) make investment relatively more attractive
- Higher plant fixed costs (higher f_i) make investment less attractive
- Higher demand (higher B_x) makes investment more attractive

Trade and firm-level innovation

So far, firm's productivity φ is a (randomly drawn) fixed characteristic

- Melitz and Trefler (JEP 2012) discuss gains from variety, reallocation of resources, and trade-induced innovation
- Trade has a market-size effect on R&D decisions (Schmookler 1954) [same logic as proximity-concentration tradeoff]
- Verhoogen (*QJE*, 2008) finds that '94 peso devaluation increased Mexican plants' exports and ISO-9000 certification
- Lileeva and Trefler (*QJE* 2010): Canadian firms that experienced larger tariff cuts under the US-Canadian FTA had greater labor productivity increases, engaged in more production innovation, and had higher adoption rates for advanced manufacturing technologies.
- Atkin, Khandelwal, Osman (*QJE* 2017): Treated firms produce (fewer) higher-quality rugs. They have higher quality after controlling for specifications; perform better when asked to produce identical rugs; exhibit learning curves; and improve quality most along dimensions in which buyers and intermediary shared info.

Atkeson and Burstein (2010)

The argument

- Changes in trade costs can have large effects on individual firms' innovation decisions without affecting aggregate welfare

The model

- Heterogeneous firms produce differentiated CES products incurring fixed and variable export costs as in Melitz (2003)
- Model of innovation builds on Griliches (1979)
- Firms profit opportunities determined by firm-specific factor (productivity)
- *Process* innovation: Increase stock of specific factor in existing firm
- *Product* innovation: Create new firms with new initial stock of factor

Atkeson and Burstein (2010)

What is the effect of a change in marginal trade costs on aggregate productivity?

- *Direct effect* is change in aggregate productivity holding fixed firms' exit, export, process, and product innovation decisions
- *Indirect effect* is changes in firms' exit, export, process, and product innovation decisions caused by the change in trade costs
- Krugman (1980) has only the product innovation margin
- Main result: Adding firm heterogeneity and process innovation changes consequences for aggregate productivity little because the increase in productivity of average firm from changes in exit and export decisions and reallocation of process innovation from non-exporters to exporters is offset by production innovation
- The logic: Firms' free-entry condition constrains the overall response of aggregate productivity to changes in trade costs
- Lower trade costs raise innovation by current and prospective exporters, but this also reduces entrants' expected profits

Atkeson and Burstein (2010)

Innovation requires employing the research good

- Process innovation: Invest $\exp(z)c(q)$ units to have $\exp(z+\Delta_z)^{1/(\rho-1)}$ with probability q and $\exp(z-\Delta_z)^{1/(\rho-1)}$ with probability $1-q$ with $c', c'' > 0$
- Product innovation: Invest n_e units to produce new firm in $t+1$ with state variable s drawn from G

Special case 1: All firms export ($n_x = 0$)

- Absent fixed costs of exporting, a decline in the marginal cost of exporting affects all (active) firms' profits proportionally.
- Free-entry condition requires this increase in profits be exactly offset by increase in cost of research good that produces both innovations.
- The indirect effect corresponds entirely to a change in product innovation.

See paper for calibration and numerical results for $n_x > 0$ case

Coming up next

In the next three weeks, we will turn to economic geography, including intranational trade

- Week 8: We introduce local increasing returns (agglomeration)
- Week 9: We introduce models in which monopolistic competition, trade costs, and mobile labor drive agglomeration
- Week 10: Economic geography with heterogeneous skills