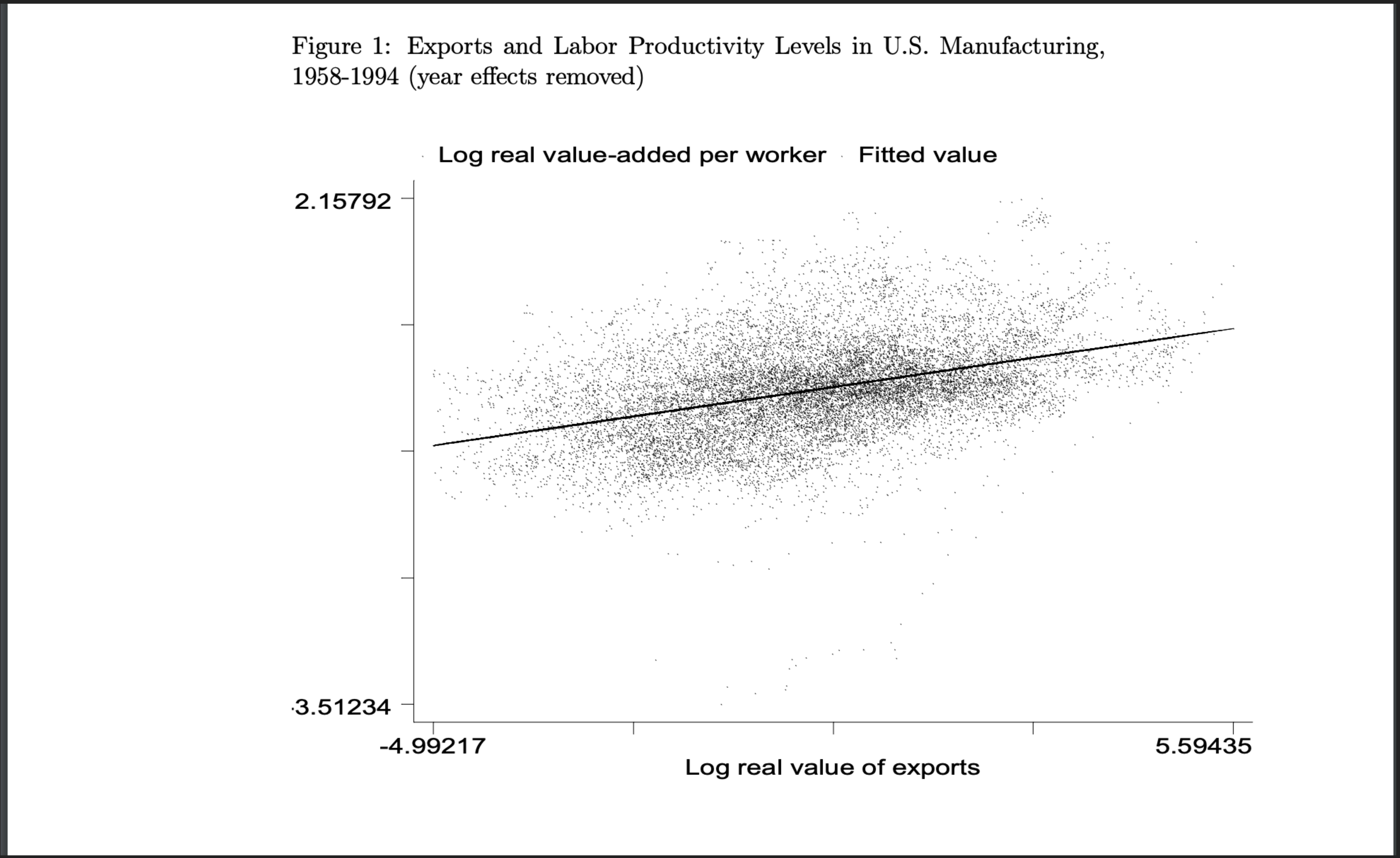
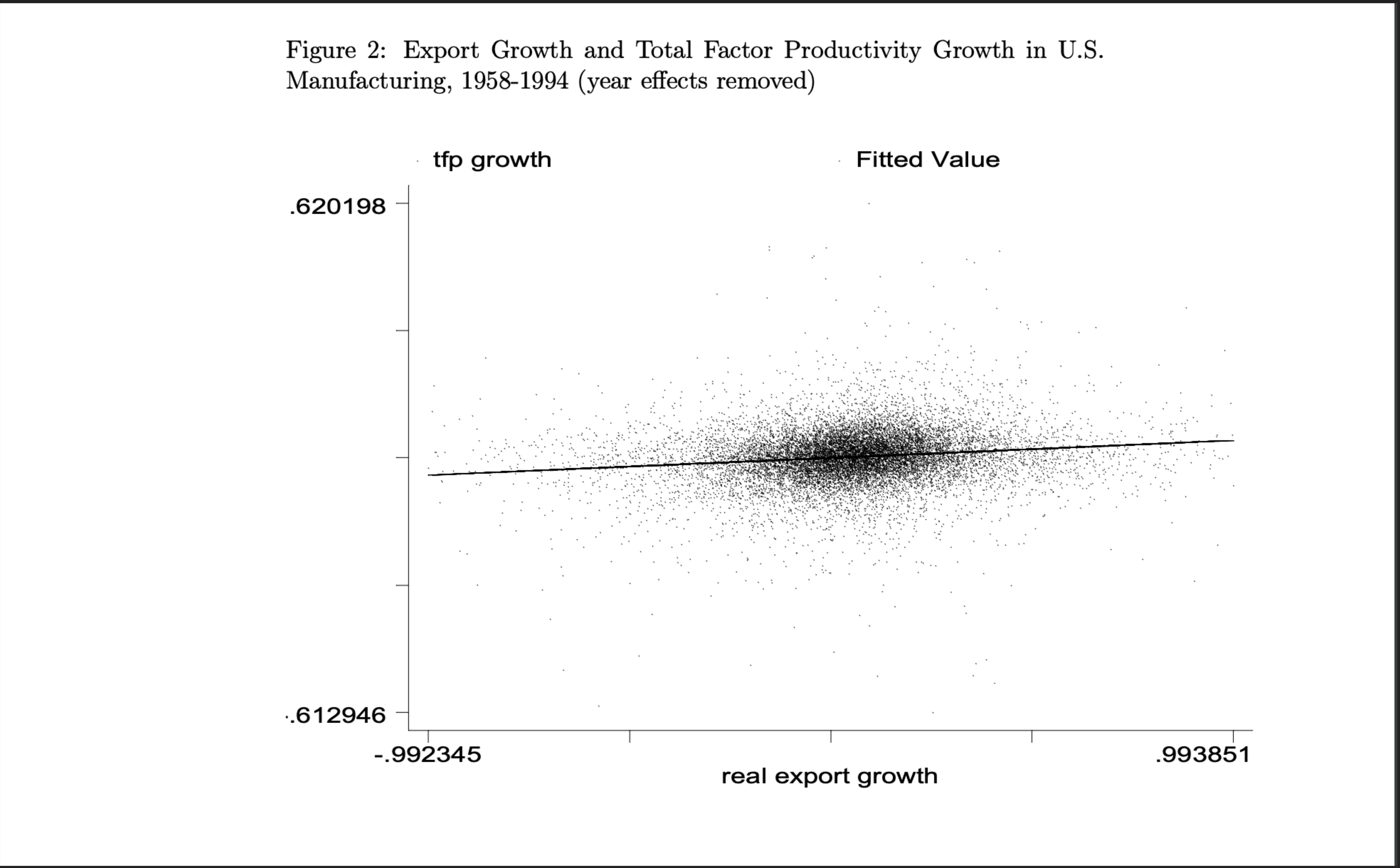
INTERNATIONAL TRADE - ECON 245

FABIAN ECKERT

HETEROGENEOUS FIRMS



Source: Bernard and Jensen 1999



Source: Bernard and Jensen 1999

INTRODUCTION

- Krugman: firms are identical - equilibrium symmetric across firms
  - Mounting evidence on heterogeneity of firms
  - Only subset of firms in an industry actually export
- Marc Melitz' JMP: Krugman 1980 + heterogeneous firms
- In Melitz' work opening to trade has strong selection effects:
  - More productive firms survive trade integration raising average productivity

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#	Year	Title
1	1979	**Sample Selection Bias as a Specification Error.**. (1979). Heckman, James. In: Econometrica. *RePEc:ecm:emetrp:v:47:y:1979:i:1:p:153-61*. Full description at Econpapers || Download paper
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3	1979	**Prospect Theory: An Analysis of Decision under Risk.**. (1979). Kahneman, Daniel ; Tversky, Amos . In: Econometrica. *RePEc:ecm:emetrp:v:47:y:1979:i:2:p:263-91*. Full description at Econpapers || Download paper
4	1980	**A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity.**. (1980). White, Halbert. In: Econometrica. *RePEc:ecm:emetrp:v:48:y:1980:i:4:p:817-38*. Full description at Econpapers || Download paper
5	2003	**The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity**. (2003). Melitz, Marc. In: Econometrica. *RePEc:ecm:emetrp:v:71:y:2003:i:6:p:1695-1725*. Full description at Econpapers || Download paper

The impact of trade on intra-industry reallocations and aggregate industry productivity

Full View

MJ Melitz - econometrica, 2003 - Wiley Online Library

This paper develops a dynamic industry model with heterogeneous firms to analyze the intra-industry effects of international trade. The model shows how the exposure to trade will induce only the more productive firms to enter the export market (while some less productive …

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KEY DIFFICULTY

- In Krugman: zero profit condition meant in equilibrium no firm made profits
- How can zero profit restriction (implied by free entry) work once firms differ in their productivity?
  - If some firms make zero profits other should still make positive profits?
- First generation of models needed Dixit+Stiglitz Monop competition
- Second generation of models needed Hopenhayn (1992)
  - Hopenhayn (1992) presented a dynamic GE model of firm entry and exit

THE RESOLUTION: PROBABILISTIC TWO STEP FORMULATION

- Now **two** fixed cost payments associated with entry:
  - One to learn productivity, one to actually produce using that productivity
- Now two free entry conditions in Melitz
  1. *Before drawing productivity:* expected profits must be non-negative
  2. *After drawing productivity:* only produce if its profitable
- So some firms pay fixed cost to draw productivity, discover they are not productive enough, and exit again

RELATION TO THEORETICAL LITERATURE

- Dynamic industry models of heterogeneous firms under perfect competition
  - Jovanovic 1982 (learning prod over time), Hopenhayn 1992 (stochastic shocks to productivity)
- Models of trade under imperfect competition: Krugman 1980
- Other framework for modeling firm heterogeneity
  - Bernard Eaton Jensen Kortum (2003), Yeaple (2003)

RELATION TO EMPIRICAL LITERATURE

- Literature on heterogeneous productivity, entry and exit
  - Davis Haltiwanger (1991), Dunne Roberts Samuelson (1989), Bertelsman Doms (2000)
- Literature on exports and productivity
  - Bernard Jensen (1995, 1999), Roberts Tybout (1996, 1997)
- Literature on trade liberalization
  - Levinsohn (1999), Pavcnik (2002), Tybout Westbrook (1995)

MELITZ (2003)

AUTARKY EQUILIBRIUM

INTRODUCTION

- Setup same as basic Krugman with two key additions
  - Two fixed costs:
    - f_e fixed cost to draw a productivity
    - f_d fixed cost for domestic production
  - Firms differ in productivities φ, density $g(\varphi)$ and CDF $G(\varphi)$
- Again start by considering **autarky**, i.e., single country case

DEMAND

- The CES demand function we derived is still valid:

$$c(\omega) = [p(\omega)/P]^{-\sigma} w/P$$

where $X = w$ is the income of an individual worker

- Conventions:
  - We normalize the wage to 1 throughout, i.e., $w = 1$ [WLOG]
  - We index goods by the productivity of the firm producing it (φ) rather than the variety they produce (ω) [WLOG - why?]
  - Index endogenous variables by subscript a for $a$utarky

FIRMS

- Profits of a domestic firm with productivity φ:

$$\pi_a(\varphi) = p(\varphi)q(\varphi) - \frac{q(\varphi)}{\varphi} - f_d = \frac{q(\varphi)}{\varphi(\sigma - 1)} - f_d$$

where we used the optimal pricing rule derived last time ($p = (\sigma/(\sigma - 1))w/\varphi$)

GOODS MARKET CLEARING

- Total demand for a given variety: $Lc(\varphi) = Lp(\varphi)^{-\sigma}/P_a^{1-\sigma}$
- Goods market clearing implies:

$$q(\varphi) = Lc(\varphi) = L/P_a^{1-\sigma}[\frac{\sigma}{\varphi(\sigma-1)}]^{-\sigma}$$

- Substituting into the equation for profits:

$$\pi_a(\varphi) = \frac{L/P_a^{1-\sigma}[\frac{\sigma}{\varphi(\sigma-1)}]^{-\sigma}}{\varphi(\sigma-1)} - f_d = \frac{L\sigma^{-\sigma}}{P_a^{1-\sigma}(\sigma-1)^{1-\sigma}}\varphi^{\sigma-1} - f_d \equiv B_a\varphi^{\sigma-1} - f_d$$

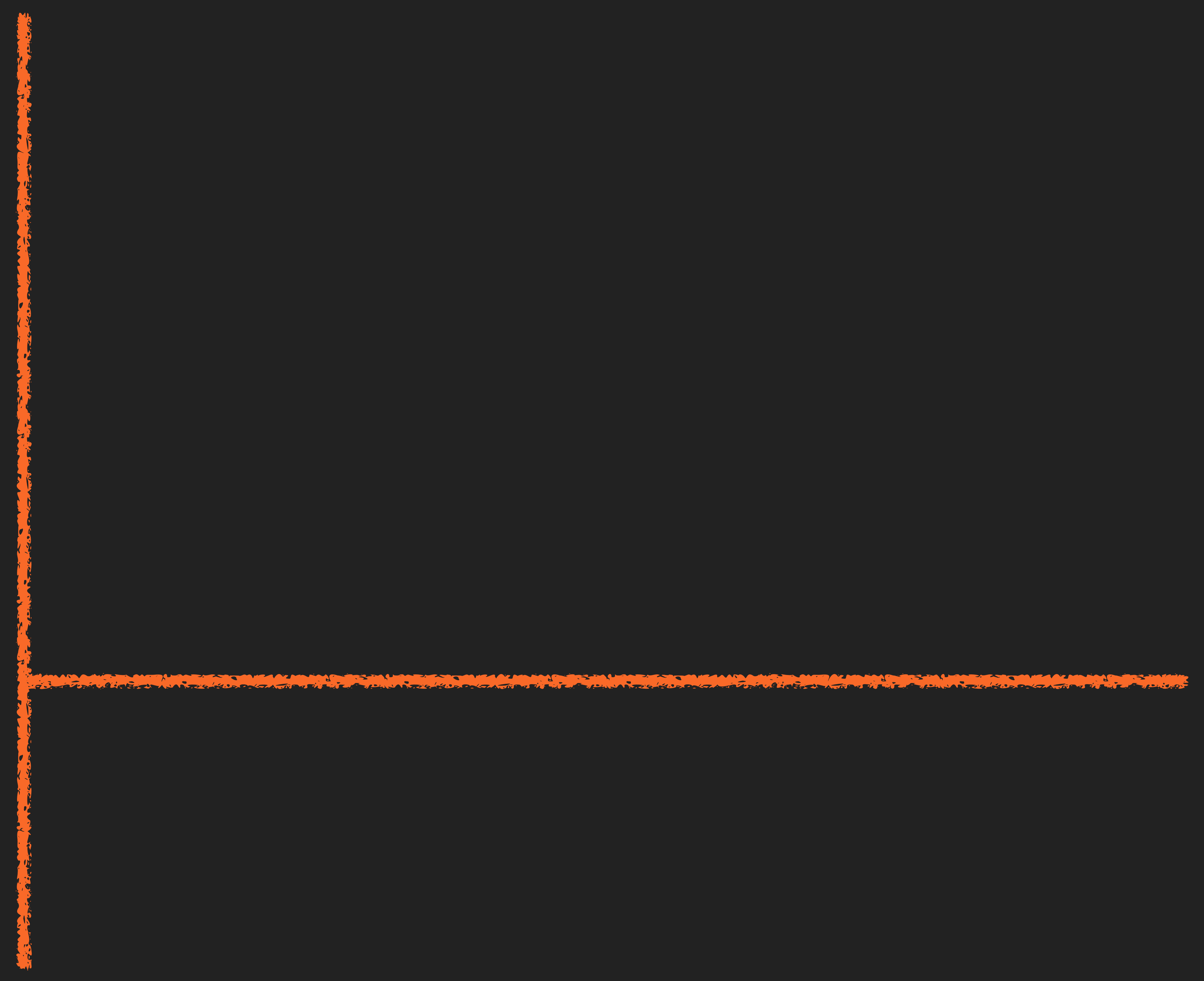
- Expression for profits: result of profit maximization and market clearing.

ZERO PROFIT CONDITION (ZCP)

- Zero cut-off profit (ZCP) condition

$$\pi_a(\varphi) = B_a \varphi^{\sigma-1} - f_d = 0 \Rightarrow \varphi_a^{\sigma-1} = \frac{f_d}{B_a}$$

- φ_a is the "ZCP" level of productivity
  - Firms with $\varphi > \varphi_a$ earn positive profits
  - Firms with $\varphi < \varphi_a$ exit right after learning their productivity
- Selection! "Incumbents" more productive than entrants



FREE ENTRY CONDITION (FE)

- Expression for φ_a contains price index – so did not yet solve for φ_a
- A second condition is needed to pin down productivity threshold φ_a
  - Free Entry [FE] condition
    - FE: *expected* profits of entry must be zero
- Firms pay f_e to receive a productivity draw from $g(\varphi)$
- Note: in Krugman Zero Profit = Free Entry

FREE ENTRY CONDITION

- Firms only produce if their draw φ is such that $\varphi > \varphi_a$
- Free entry = expected value of entry must offset entry cost f_e:

$$\int_0^\infty \pi_a(\varphi)g(\varphi)d\varphi = f_e$$

- Combine ZCP and FE conditions by noticing:

$$\pi_a(\varphi) = B_a\varphi^{\sigma-1} - f_d = (\varphi/\varphi_a)^{\sigma-1}B_a\varphi_a^{\sigma-1} - f_d = [(\varphi/\varphi_a)^{\sigma-1} - 1]f_d$$

- Plugging this into FE condition:

$$f_e = \int_0^\infty \pi_a(\varphi)g(\varphi)d\varphi = \int_{\varphi_a}^\infty [(\varphi/\varphi_a)^{\sigma-1} - 1]f_d g(\varphi)d\varphi \equiv J(\varphi_a)f_d$$

FREE ENTRY CONDITION

- The function $J(\varphi_a) > 0$ is monotonically decreasing in φ_a
  - There exist a unique value of φ_a that solves FE and ZCP conditions simultaneously
- All other variables in the model can be described as a function of φ_a and are hence pinned down
  - Productivity distribution of surviving firms: $g(\varphi)/[1 - G(\varphi_a)]$

SOLVING FOR THE MASS OF FIRMS

- Still need to solve for the mass of firms, in fact, two masses of firms:
  - M_e firms pay to draw a productivity
  - M_a firms operate in equilibrium
- The two are related as follows [so just need to solve for one]:

$$M_a = M_e[1 - G(\varphi_a)]$$

- Also need expression for average profits of surviving firms:

$$\bar{\pi}(\varphi_a) = \int_{\varphi_a}^{\infty} \pi_a(\varphi) \frac{g(\varphi)}{1 - G(\varphi_a)} d\varphi = \frac{f_e}{1 - G(\varphi_a)}$$

SOLVING FOR THE MASS OF FIRMS

- Like Krugman labor market clearing condition can be solved for mass of firms:

$$L = M_a \int_{\varphi_a}^{\infty} [\frac{q(\varphi)}{\varphi} + f_d] \frac{g(\varphi)}{1 - G(\varphi_a)} d\varphi + M_e f_e$$

$$= M_a \int_{\varphi_a}^{\infty} [(\sigma - 1)\pi_a(\varphi) + \sigma f_d] \frac{g(\varphi)}{1 - G(\varphi_a)} d\varphi + \frac{f_e M_a}{1 - G(\varphi_a)}$$

$$= M_a[(\sigma - 1)\bar{\pi}(\varphi_a) + \sigma f_d] + M_a \bar{\pi}(\varphi_a)$$

$$= M_a \sigma[\bar{\pi}(\varphi_a) + f_d]$$

- So that we can solve:

$$M_a = \frac{L}{\sigma[\bar{\pi}_a(\varphi) + f_d]} = \frac{L}{\sigma(\frac{f_e}{1 - G(\varphi_a)}) + f_d}$$

TRADE EQUILIBRIUM

INTRODUCING TRADE

- Introduce a second symmetric country
  - Wage still normalized at 1, and equal in both
- To export, firms have to pay another fixed cost f_x
  - Can no longer use trick of "doubling population" to analyze trade eq.
- Iceberg trade costs as before: ship $\tau > 1$ for 1 unit to arrive
- *Key change*: Endogenous second cutoff φ_x above which firms profitably **export**

ZERO CUTOFF PROFITS WITH TRADE

- Domestic ZCP is still given as:

$$\pi_d(\varphi_d) = B_d\varphi_d^{\sigma-1} - f_d = 0 \Rightarrow \varphi_d^{\sigma-1} = \frac{f_d}{B_d} = \frac{f_d\sigma^\sigma}{LP_d^{\sigma-1}(\sigma-1)^{\sigma-1}}$$

- $B_d \neq B_a$ due to a changed price index P_d in the presence of trade!
    - Note if $P_d < P_a$ [i.e., if gains from trade>0] then $\varphi_d > \varphi_a$

PROFITS FROM EXPORTING

- Firms charge $p_x = [\sigma/(\sigma-1)]\tau$ per unit of their good in foreign country
- Profits from export market are hence:

$$\pi_x(\varphi) = p_x(\varphi)q_x(\varphi) - \frac{\tau q_x(\varphi)}{\varphi} - f_x = \frac{\tau q_x(\varphi)}{\varphi(\sigma-1)} - f_x$$

- Same steps but using foreign demand and price charged abroad:

$$\pi_x(\varphi) = \frac{\tau^{1-\sigma} L \sigma^{-\sigma}}{P_d^{1-\sigma}(\sigma-1)^{1-\sigma}} \varphi^{\sigma-1} - f_x \equiv B_x \varphi^{\sigma-1} - f_x$$

PROFITS FROM EXPORTING

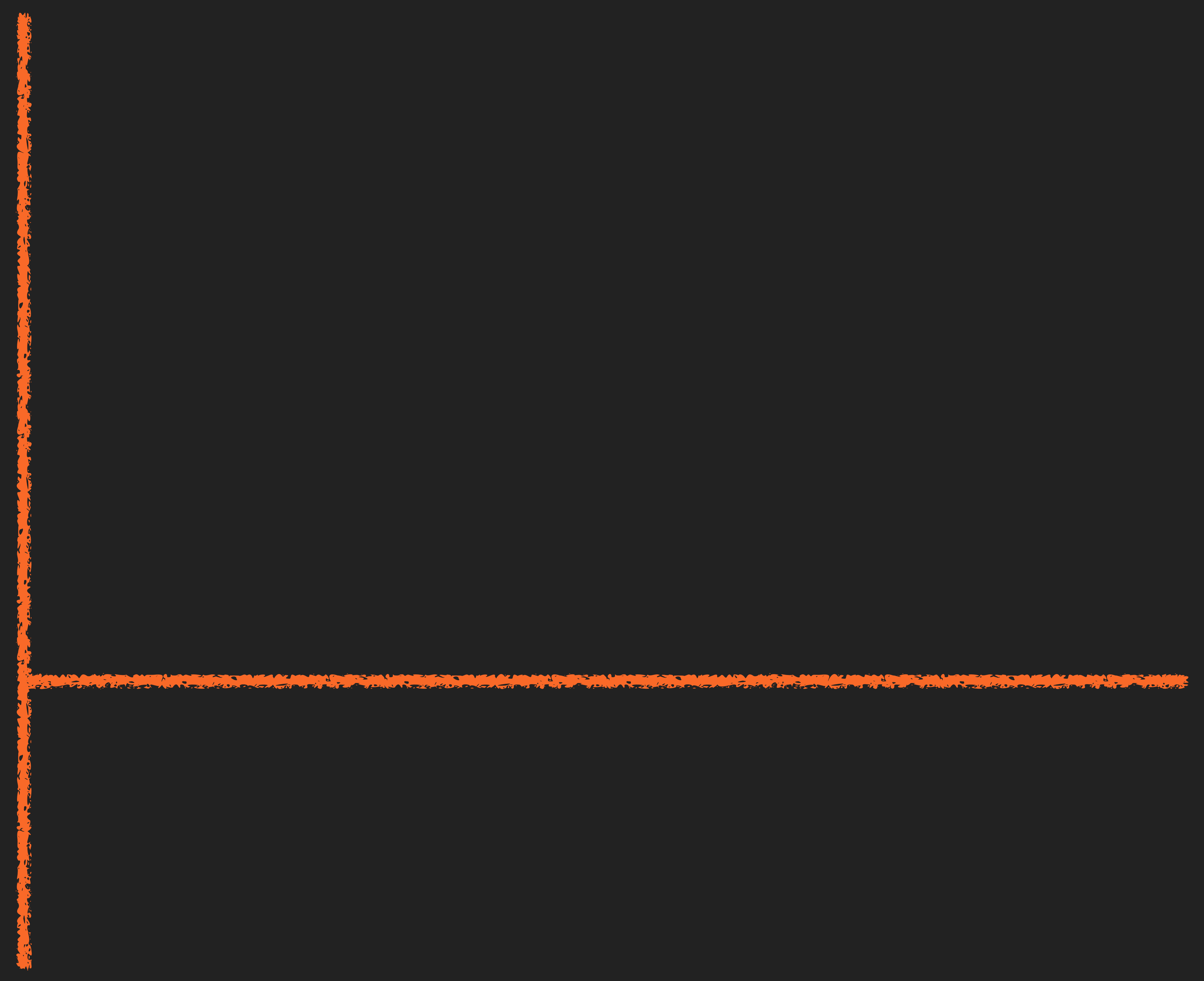
- ZCP in export market:

$$\pi_x(\varphi_x) = B_x \varphi_x^{\sigma-1} - f_x = 0 \Rightarrow \varphi_x^{\sigma-1} = \frac{f_x}{B_x} = \frac{f_x \tau^{\sigma-1} \sigma^{\sigma}}{L P_d^{\sigma-1} (\sigma-1)^{\sigma-1}}$$

- Dividing by expression for φ_d:

$$(\varphi_x / \varphi_d)^{\sigma-1} = f_x \tau^{\sigma-1} / f_d$$

- So that $\varphi_x > \varphi_d$ if $f_x \tau^{\sigma-1} > f_d$ which we assume



FREE ENTRY CONDITION WITH EXPORTING

- To pin down cutoff use again FE condition:

$$f_e = \int_0^\infty [\pi_d(\varphi) + \pi_x(\varphi)]g(\varphi)d\varphi$$

$$= \int_{\varphi_d}^\infty (B_d\varphi^{\sigma-1} - f_d)g(\varphi)d\varphi + \int_{\varphi_x}^\infty (B_x\varphi^{\sigma-1} - f_x)g(\varphi)d\varphi$$

$$\equiv J(\varphi_d)f_d + J(\varphi_x)f_x$$

- $J(\cdot)$ monotonically decreasing.
  - Since $\varphi_x > \varphi_d$ this must imply $\varphi_x > \varphi_d > \varphi_a$
  - This in turn proves that $P_d < P_a$ so that there are gains from trade!

GAINS FROM TRADE

- Since expected profits are zero – there are no profits redistributed in equilibrium.
- Each worker/consumer earns w and buys a CES bundle at price index P
  - If normalize wage to unity welfare is simply inverse price index
- CES price index in free trade case [change of variable from ω to φ]

$$P_d = \left[M_d \int_{\varphi_d}^{\infty} p(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi + M_x \int_{\varphi_x}^{\infty} p_x(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_x)} d\varphi \right]^{\frac{1}{1-\sigma}}$$

GAINS FROM TRADE

$$P_d = \left[M_d \int_{\varphi_d}^{\infty} p(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi + M_x \int_{\varphi_x}^{\infty} p_x(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_x)} d\varphi \right]^{\frac{1}{1-\sigma}}$$

- Three potential sources of gains from trade:
  - [FIRST] Second term only shows up with trade and c.p. lowers P_d: positive effect of increased import variety on welfare

GAINS FROM TRADE

$$P_d = \left[M_d \int_{\varphi_d}^{\infty} p(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi + M_x \int_{\varphi_x}^{\infty} p_x(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_x)} d\varphi \right]^{\frac{1}{1-\sigma}}$$

- Three potential sources of gains from trade:
  - [SECOND] M_d falls as home opens to trade raising P_d: negative effect of reduced domestic varieties on welfare
    - Due to import competition which lowers demand for domestic firms and forces least productive firms to exit
    - Alternative explanation: rise in wages makes least productive firms non-profitable

GAINS FROM TRADE

$$P_d = \left[M_d \int_{\varphi_d}^{\infty} p(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_d)} d\varphi + M_x \int_{\varphi_x}^{\infty} p_x(\varphi)^{1-\sigma} \frac{g(\varphi)}{1 - G(\varphi_x)} d\varphi \right]^{\frac{1}{1-\sigma}}$$

- Three potential sources of gains from trade:
  - [THIRD] The exit of less productive firms raises φ_d in the first integral and induces a selection effect, making the average product from home cheaper (c.p.)

WHAT DID WE LEARN?

- Market Integration (trade) leads to reallocation of resources across firms within industries:
  - Low productivity firms exit
  - Intermediate productivity surviving firms contract
  - High productivity surviving firms enter export markets and expand
- Sales-weighted industry productivity rises due to this selection effect
- *Missing*: Selection does not feed back into changes in firm-level productivity

CHANEY (2008)

THE DISTRIBUTIONAL ASSUMPTION

- Chaney assumes that the distribution of productivities across firms follows a Pareto distribution:

$$G(\varphi) = 1 - \varphi^{-\theta} \quad \text{for} \quad \varphi \geq 1 \quad \text{and} \quad \theta > \sigma - 1 > 0$$

- This allows us to compute closed form expressions for various objects:

$$J(\varphi_a) = \frac{\sigma - 1}{\theta - \sigma + 1}(1 - G(\varphi_a))$$

CLOSED FORM FOR MASS FOR FIRMS UNDER AUTARKY

- Using this expression others start looking “nice” too:

$$M_a = \frac{\theta - \sigma + 1}{\sigma\theta}\frac{L}{f_d} \quad \text{and} \quad M_e = \frac{\sigma - 1}{\sigma\theta}\frac{L}{f_e}$$

- *Under autarky,* the number of products available to consumers is proportional to the size of the country - similar to Krugman.
  - Similarly for the mass of *entering* firms

MASS FOR FIRMS UNDER FREE TRADE

- Under free trade the mass of entering firms continues to be

$$M_e = \frac{\sigma - 1}{\sigma\theta}\frac{L}{f_e}$$

- It follows directly from the full employment condition
- Recall that the mass of producing firms is: $M_d = M_e[1 - G(\varphi_a)]$
    - So opening to trade *reduces* the number of *available* varieties/firms
- It turns out that with Pareto-distributed productivity, the welfare effect from the decline in home varieties is offset exactly by increase in foreign varieties
    - Only the selection effect remains

GRAVITY EQUATION

- With Chaney's distributional assumption the Melitz model yields a gravity equation similar to the homogeneous firm cases (Krugman, Armington)
  - But different interpretations of the coefficients
- Generalize earlier exposition to allow for multiple countries:
  - M_e^i are entrants in country i
  - φ^{ij} is the zero cutoff profit value of productivity for selling from i to j
  - Allow wages to differ across countries, w^i

GRAVITY EQUATION

- We then obtain the following trade shares:

$$\lambda_{ij} = \frac{X^{ij}}{X^j} = \frac{M_e^i \int_{\varphi^{ij}}^{\infty} p^{ij}(\varphi)^{1-\sigma} g(\varphi) d\varphi}{\sum_k M_e^k \int_{\varphi^{kj}}^{\infty} p^{kj}(\varphi)^{1-\sigma} g(\varphi) d\varphi} = \frac{M_e^i (w^i \tau^{ij})^{-\theta} (w^i f^{ij})^{1-\frac{\theta}{\sigma-1}}}{\sum_k M_e^k (w^k \tau^{kj})^{-\theta} (w^k f^{ij})^{1-\frac{\theta}{\sigma-1}}}$$

- Can redefine a bilateral resistance term $T_{ij} \equiv (\tau_{ij})^{-\theta} (f^{ij})^{1-\frac{\theta}{\sigma-1}}$
    - This now captures both iceberg trade costs and fixed cost of selling to a destination
- Can solve for wage vector similarly to Armington model!

GAINS FROM TRADE

- The elasticity of trade flows to distance is governed by the term $-\theta$
  - Very different from Krugman 1980 and Armington where the iceberg trade costs were raised to the power of $1-\sigma<0$
  - σ is a preference parameter, θ a technology parameter
- Similar to before it is possible to show that the welfare impact moving from autarky to free trade is given by

$$\hat{W}_i = \lambda_{ii}^{-1/\theta}$$

EX-ANTE GAINS FROM TRADE: KRUGMAN VS MELITZ

- Do the different models predict *different* gains from trade?
- In Melitz model we impose $\theta > \sigma - 1 > 0$ so that one could think comparing gains from trade in Krugman and Melitz: $\lambda_{ii}^{-1/\theta} < \lambda_{ii}^{-1/(\sigma-1)}$
- Melitz and Redding (2014) compare these models
  - When calibrate so that average firm productivities in autarky are the same, GFT are larger in Melitz model
    - Heterogeneous agent models allow for greater expansion of output as production gets transferred to more productive firms (lower value of λ_{ii} in Melitz)
    - This is enough to counteract the parameter restrictions

EX-POST GAINS FROM TRADE: KRUGMAN VS MELITZ

- What about *ex-post* gains from trade when we take λ_{ii} from the data
- Simonovska and Waugh (2014) present a gravity equation based estimator for the distance elasticity (also know as "trade elasticity")
  - They find that $\theta < \sigma - 1$ so that the ex-post gains are also larger using the Melitz model with the appropriately estimated trade elasticity
  - This does not violate our parameter restriction since the estimates are obtained by estimating *different* models