14.582: International Trade II
— Lecture 4: Firm-level Heterogeneity (Empirics I) —

Introduction

- Hallak and Levinsohn (2005): "Countries don't trade. Firms trade."
- Since around 1990, trade economists have increasingly used data from individual firms/plants in order to better understand:
  - Why countries trade.
  - The nature of trade costs.
  - The mechanisms of adjustment to trade liberalization: mark-ups, entry, exit, productivity changes, factor price changes.
  - Who are the winners and losers of trade liberalization (across firms, across workers)?
- This has been an extremely influential development for the field.

Stylized Facts about Trade at the Firm-Level

- Exporting is extremely rare.
- Exporters are different:
  - They are larger.
  - They are more productive.
  - They use factors differently.
  - They pay higher wages.
- We will go through some of these findings first.

Exporting is Rare

- Two papers provide a clear characterization of just how rare exporting activity is among firms:
  1. Bernard, Jensen, Redding and Schott (JEL, forthcoming) on US manufacturing. (See also their 2007 JEP.)
  2. Eaton, Kortum and Kramarz (2011, ECMA) on French manufacturing.
- It was initially hard to match firm-level datasets (which typically contain data on total output/sales, but not sales by destination) to shipment-level trade datasets, but fortunately this can now be achieved in many countries around the world.

Exporting is Rare

BJRS (2017)

NAICS	Industry	(1) Percent of Firms	(2) Fraction of Firms that Export	(3) Mean Exports as a Share of Total Shipments
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	0.35	0.17

Notes: Data are from the 2007 U.S. Census of Manufactures. 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

Exporting is Rare

BJRS (2017)

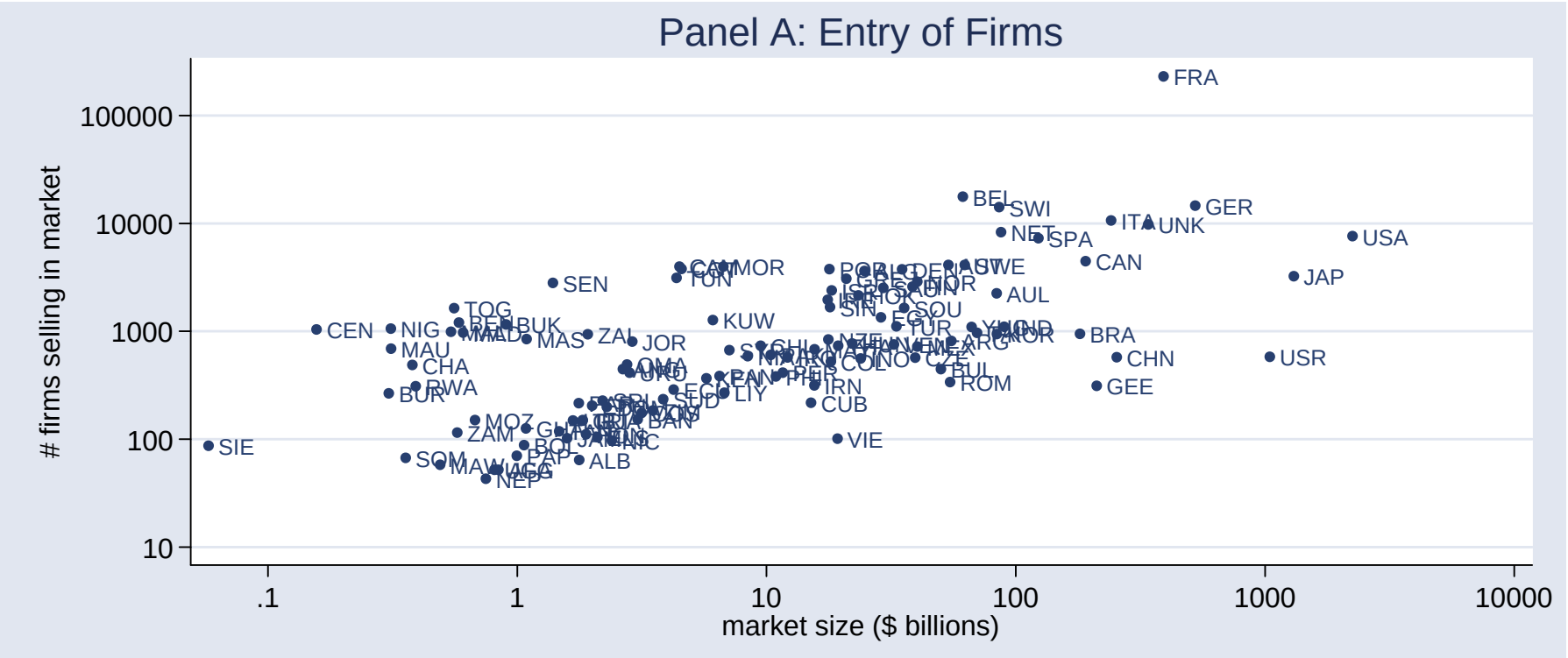
NAICS Industry		(1) Percent of All Firms	(2) Fraction of Firms that Export	(3) Fraction of Firms that Import	(4) Fraction of Firms that Import & Export
311	Food Manufacturing	6.8	0.23	0.15	0.10
312	Beverage and Tobacco Product	0.9	0.30	0.18	0.11
313	Textile Mills	0.8	0.57	0.44	0.37
314	Textile Product Mills	2.7	0.19	0.14	0.09
315	Apparel Manufacturing	3.6	0.22	0.23	0.15
316	Leather and Allied Product	0.3	0.56	0.53	0.40
321	Wood Product Manufacturing	4.8	0.21	0.09	0.06
322	Paper Manufacturing	1.5	0.48	0.25	0.21
323	Printing and Related Support	11.1	0.15	0.05	0.03
324	Petroleum and Coal Products	0.5	0.34	0.18	0.14
325	Chemical Manufacturing	3.3	0.65	0.40	0.36
326	Plastics and Rubber Products	3.9	0.59	0.34	0.29
327	Nonmetallic Mineral Product	4.3	0.19	0.15	0.09
331	Primary Metal Manufacturing	1.5	0.58	0.32	0.29
332	Fabricated Metal Product	20.6	0.30	0.12	0.10
333	Machinery Manufacturing	8.7	0.61	0.30	0.28
334	Computer and Electronic Product	3.9	0.75	0.50	0.47
335	Electrical Equipment, Appliance,	1.7	0.70	0.46	0.41
336	Transportation Equipment	3.4	0.57	0.35	0.31
337	Furniture and Related Product	6.5	0.16	0.12	0.07
339	Miscellaneous Manufacturing	9.3	0.32	0.20	0.17
Aggregate Manufacturing		100	0.35	0.20	0.16

Notes: Data are for 2007 and are for firms that appear in both the U.S. Census of Manufacturers and the LFTTD. Firm exports and imports are measured using customs information from LFTTD. Column (1) summarizes the distribution of manufacturing firms across three-digit NAICS industries. Remaining columns report the percent of firms in each industry that export, import and do both.

Table 3: Firm Importing and Exporting

EKK (2011)

Out of 229,9000 French manufacturing firms, only 34,035 sell abroad (and 523 of them don't sell in France)



Exporters are Different

- The most influential findings about exporting and intra-industry heterogeneity have been related to:
  - Exporters being larger.
  - Exporters being more productive.
- But there are other "exporter premia" too.
- Clearly there is a difficult issue of selection versus treatment here. But for now we'll focus on the raw, descriptive statistics.

Exporter Premia in the United States

BJRS (2017)

	Exporter Premia		
	(1)	(2)	(3)
Log Employment	1.28	1.11	-
Log Shipments	1.72	1.35	0.24
Log Value Added per Worker	0.33	0.19	0.21
Log TFP	0.03	0.04	0.04
Log Wage	0.21	0.09	0.10
Log Capital per Worker	0.28	0.16	0.20
Log Skill per Worker	0.06	0.01	0.11
Additional Covariates	None	Industry Fixed Effects	Industry Fixed Effects, Log Employment

Notes: Notes: Data are for 2007 and are from the U.S. Census of Manufactures. All results are from bivariate OLS regressions of firm characteristic in first column on a dummy variable indicating firm's export status. Firm exports measured using customs information from LFTTD. Columns two and three include industry fixed effects and industry fixed effects plus log firm employment, respectively, as additional controls. Total factor productivity (TFP) is computed as in Caves et al (1982). Capital and skill per worker are capital stock and non-production workers per total employment, respectively. All results are significant at the 1 percent level except the Log Skill per Worker results in column 2 which are not significant at the 10 percent level.

Exporter Premia in the United States

BJRS (2017)

	(1)	(2)	(3)
	Exporter Premia	Importer Premia	Exporter & Importer Premia
Log Employment	1.11	1.20	1.39
Log Shipments	0.24	0.32	0.36
Log Value Added per Worker	0.21	0.25	0.28
Log TFP	0.04	0.03	0.03
Log Wage	0.10	0.09	0.11
Log Capital per Worker	0.20	0.28	0.34
Log Skill per Worker	0.11	0.16	0.18

Notes: Data are for 2007 and are for firms that appear in both the U.S. Census of Manufacturers and the LFTTD. All results are from bivariate OLS regressions of a given firm characteristic on the dummy variable noted at the top of each column as well as industry fixed effects. All specifications except for employment also include firm employment as an additional control. Firm exports and imports are measured using customs information from LFTTD. Total factor productivity (TFP) is computed as in Caves et al (1982). Capital and skill per worker are capital stock and non-production workers per total employment, respectively. All results are significant at the 1 percent level.

Table 4: Exporter and Importer Premia

The Exporter Premium: Productivity

Bernard, Eaton, Jensen and Kortum (AER, 2003) for US data

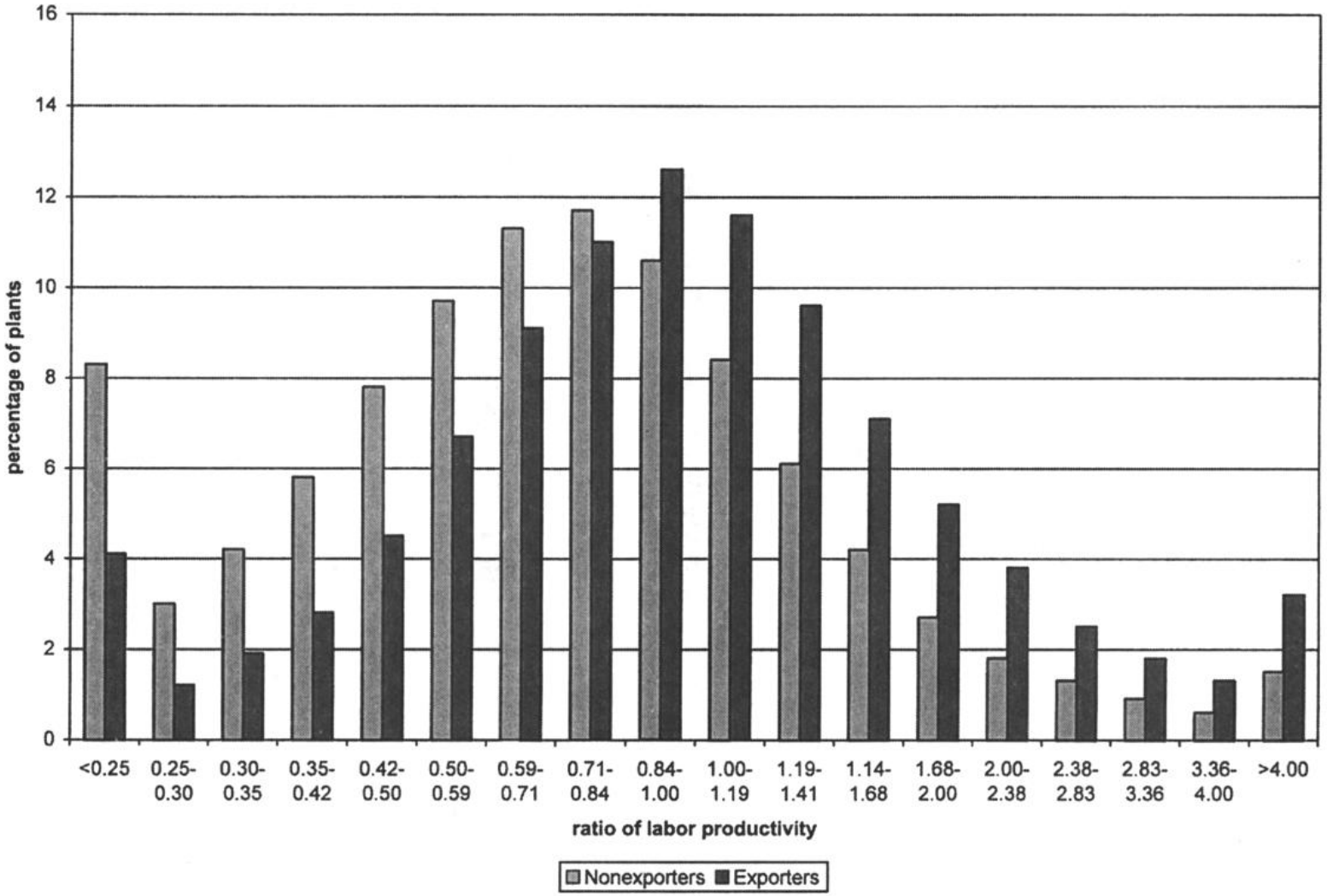


FIGURE 2A. RATIO OF PLANT LABOR PRODUCTIVITY TO OVERALL MEAN

The Exporter Premium: Productivity

Bernard, Eaton, Jensen and Kortum (AER, 2003) for US data

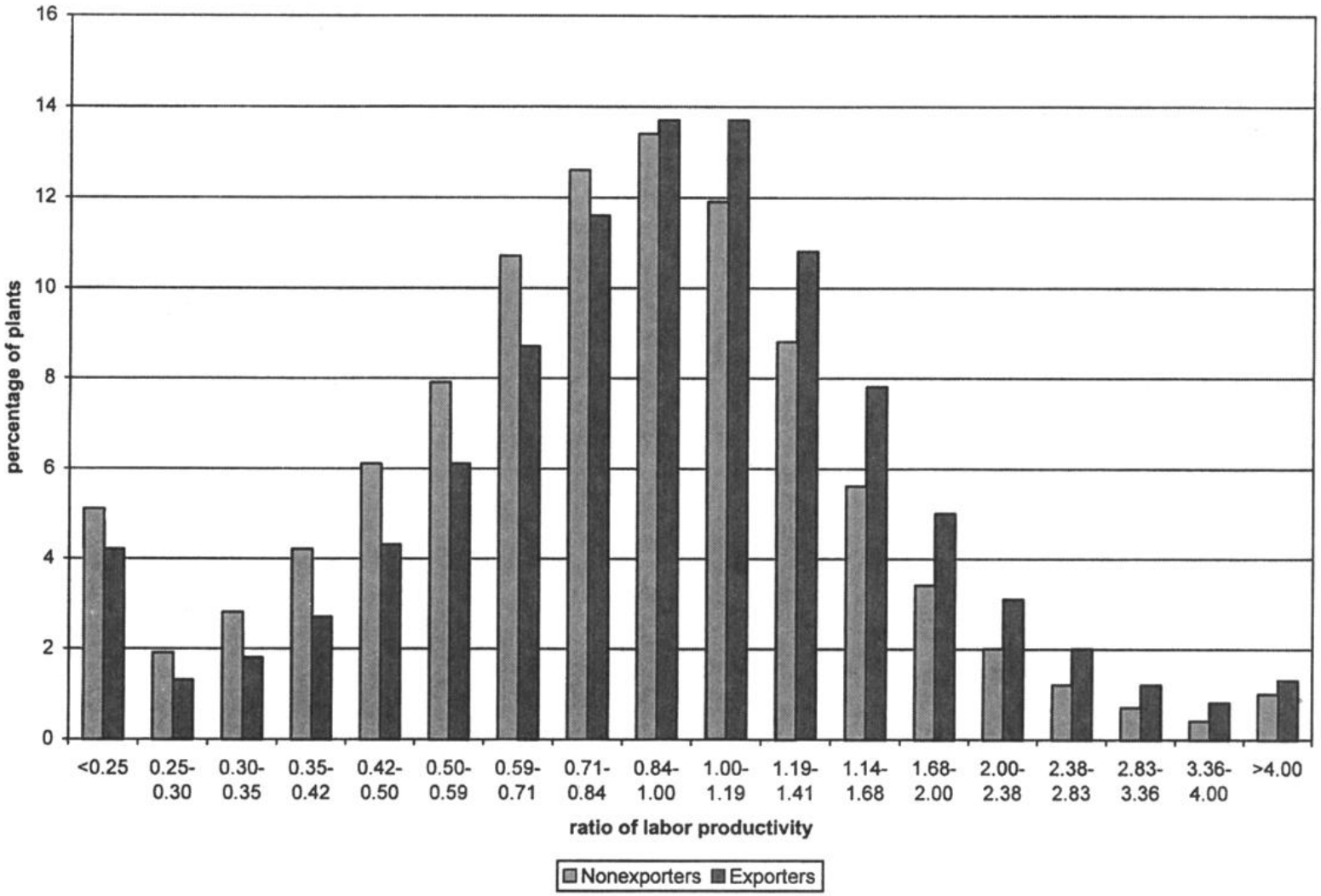
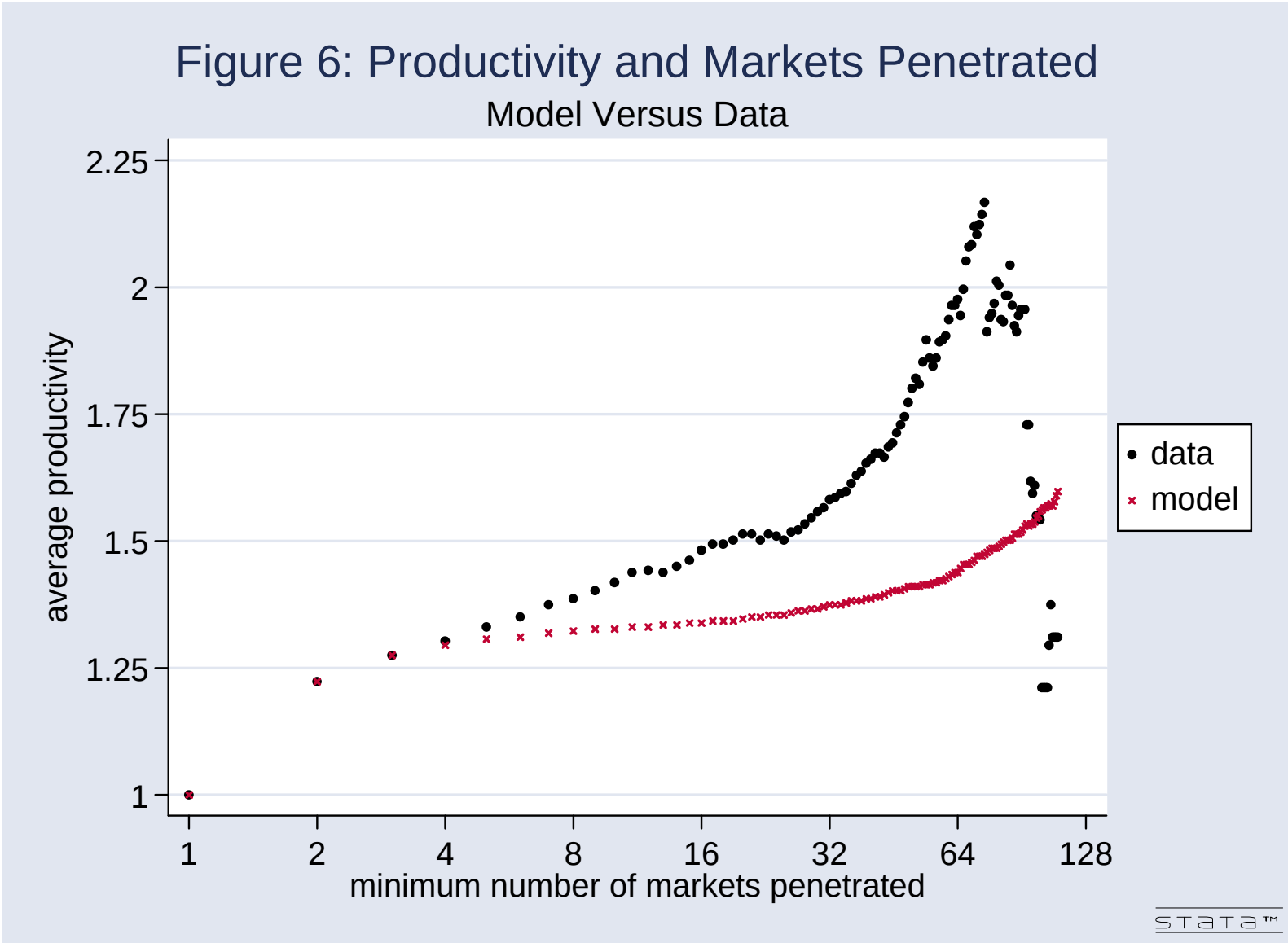


FIGURE 2B. RATIO OF PLANT LABOR PRODUCTIVITY TO 4-DIGIT INDUSTRY MEAN

The Exporter Premium: Productivity

EKK (2011) on France (we'll talk about the model later)



The Exporter Premium: Domestic Sales

EKK (2011) on France

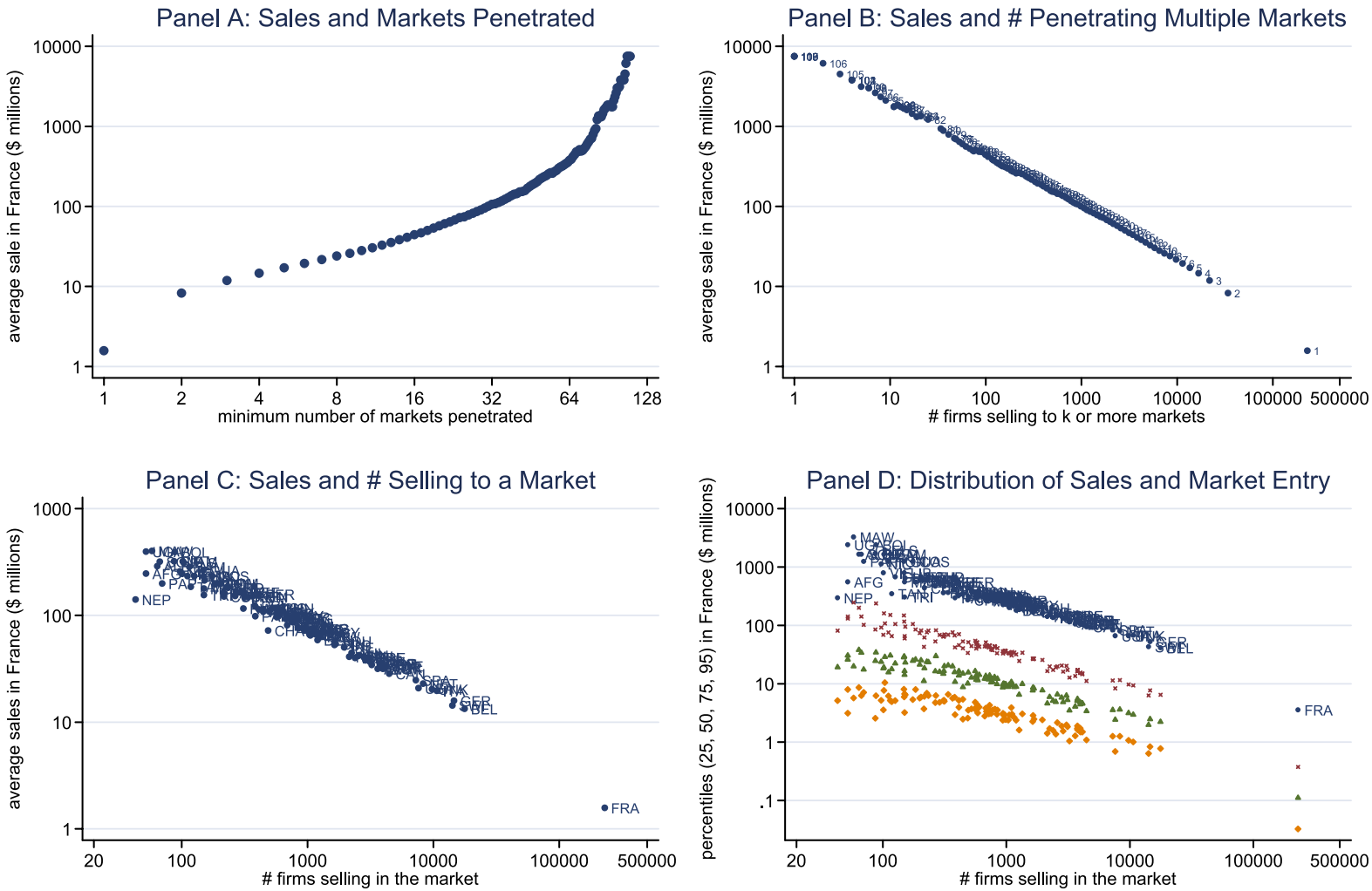


FIGURE 3.—Sales in France and market entry.

Other Exporter Premia

- Examples of other exporter premia seen in the data (and there are many more):
  - Produce more products: BJRS (2007) and Bernard, Redding and Schott (QJE, 2011)
  - Higher Wages: Frias, Kaplan and Verhoogen (2011 wp) using employer-employee linked data from Mexico (i.e., when a given worker moves from a purely domestic firm to an exporting firm, his/her wage rises).
  - More expensive (potentially indicating higher quality) material inputs: Kugler and Verhoogen (REStud, 2012) using very detailed data on inputs used by Colombian firms.
  - Innovate more: Aw, Roberts and Xu (AER, 2011).
  - Pollute less: Holladay (2015)

Eaton, Kortum and Kramarz (ECMA, 2011)

- EKK (2011) construct a Melitz (2003)-like model in order to try to capture key features of French firms' exporting behavior:
  - Whether to export at all. (Simple extensive margin).
  - Which countries to export to. (Country-wise extensive margins).
  - How much to export to each country. (Intensive margin).

- They uncover some striking regularities in the firm-wise sales data in (multiple) foreign markets.
  - These 'power law' like relationships occur in many settings (e.g. Gabaix (ARE, 2009; JEP, 2016)).
  - Most famously, they occur for domestic sales within one market.
  - In that sense, perhaps it's not surprising that they also occur market by market abroad. (Since scale invariance is at the heart of power laws.)

- They then (very nicely) show how these moments can be used to estimate a quantitative Melitz-like model and use the estimated model to answer counterfactual questions.

EKK (2011): Stylised Fact 1: Market Entry (averages across countries)

'Normalization' in Panel B: $N_{nF}/(X_{nF}/X_n)$

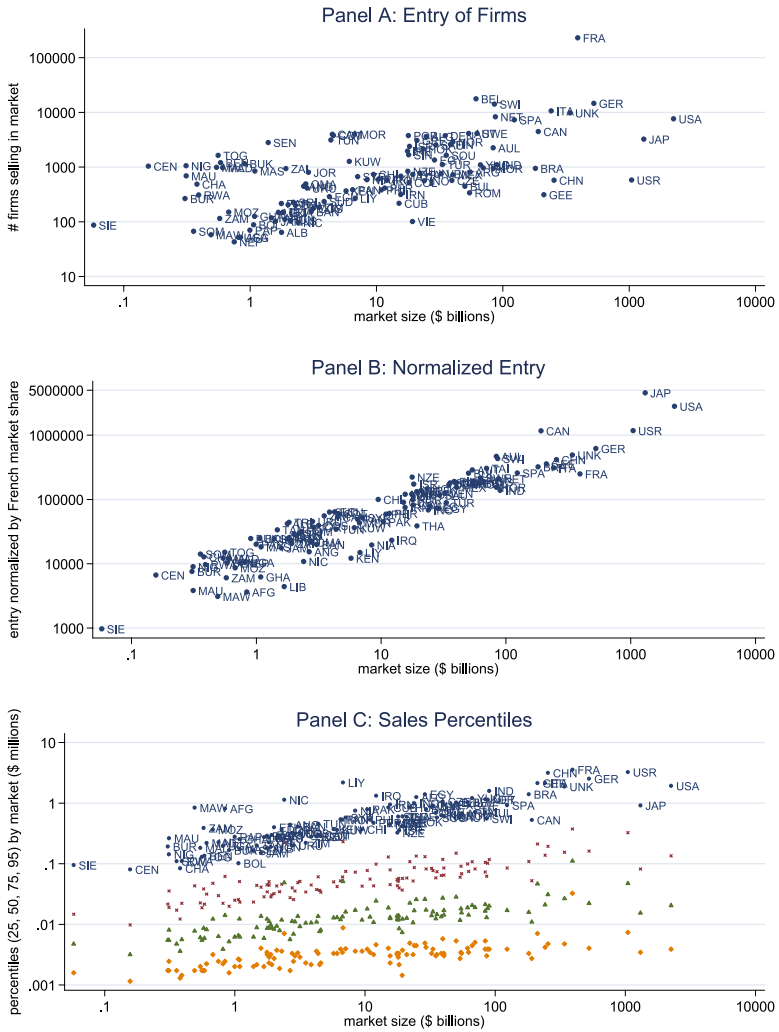


FIGURE 1.—Entry and sales by market size.

EKK (2011): Stylised Fact 1: Market Entry (averages across countries)

All exporters export to at least one of these 7 places. But it's not a strict hierarchy as one would see in pure Melitz (2003) model.

TABLE I

FRENCH FIRMS EXPORTING TO THE SEVEN MOST POPULAR DESTINATIONS

Export Destination	Number of Exporters	Fraction of Exporters
Belgium[a] (BE)	17,699	0.520
Germany (DE)	14,579	0.428
Switzerland (CH)	14,173	0.416
Italy (IT)	10,643	0.313
United Kingdom (UK)	9752	0.287
Netherlands (NL)	8294	0.244
United States (US)	7608	0.224
Any destination (all French exporters)	34,035	

EKK (2011): Stylised Fact 1: Market Entry (averages across countries)

For 27% of exporters, a strict hierarchy is observed over these 7 destinations.

TABLE II

FRENCH FIRMS SELLING TO STRINGS OF TOP-SEVEN COUNTRIES

	Number of French Exporters		
Export String[a]	Data	Under Independence	Model
BE[a]	3988	1700	4417
BE–DE	863	1274	912
BE–DE–CH	579	909	402
BE–DE–CH–IT	330	414	275
BE–DE–CH–IT–UK	313	166	297
BE–DE–CH–IT–UK–NL	781	54	505
BE–DE–CH–IT–UK–NL–US	2406	15	2840
Total	9260	4532	9648

[a]The string BE means selling to Belgium but no other among the top 7; BE–DE means selling to Belgium and Germany but no other, and so forth.

EKK (2011): Stylised Fact 2: Sales Distributions (across all firms)

Surprisingly similar shape (with 'mean' shift) in each destination market (including home). Power laws (at least in upper tails—upper left, here).

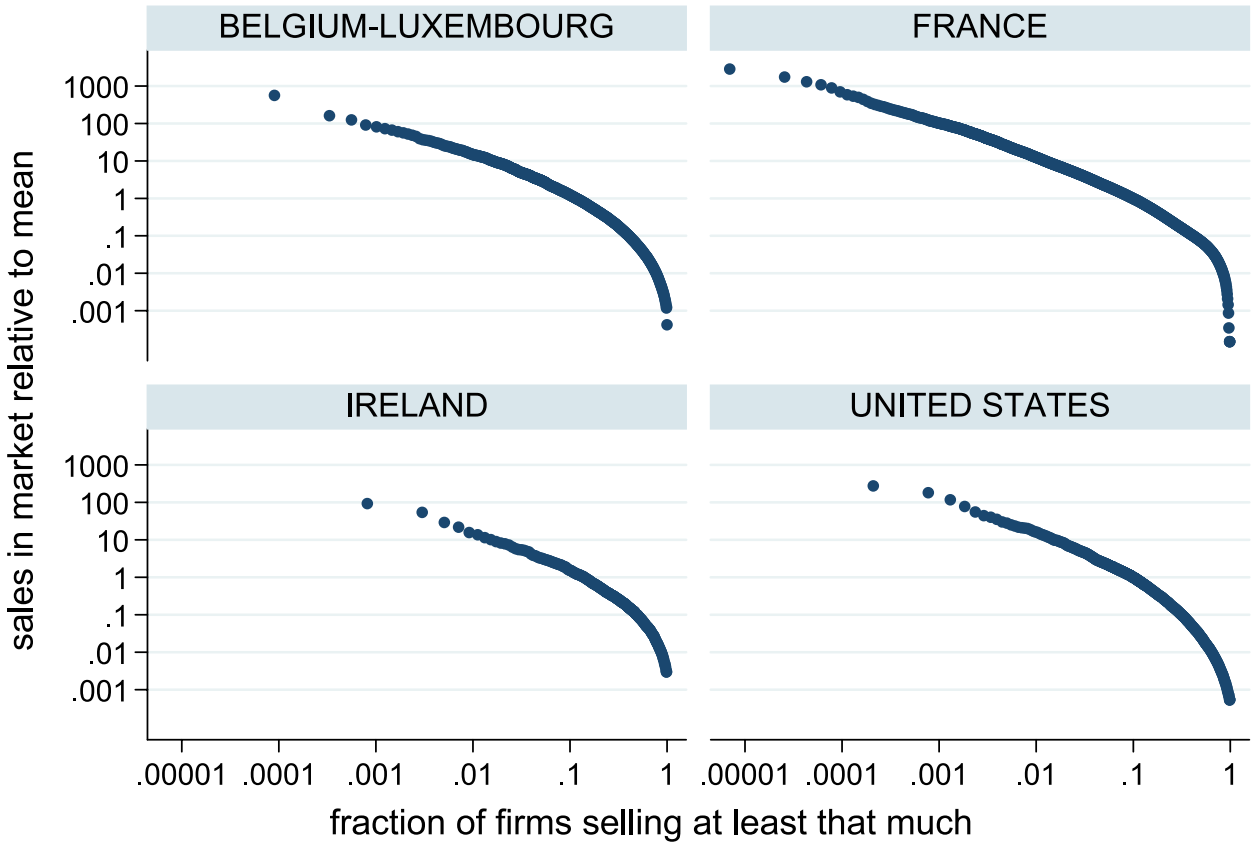


FIGURE 2.—Sales distributions of French firm: Graphs by country.

EKK (2011): Stylised Fact 3: Export Participation and Size in France

Big firms at home are multi-destination exporters.

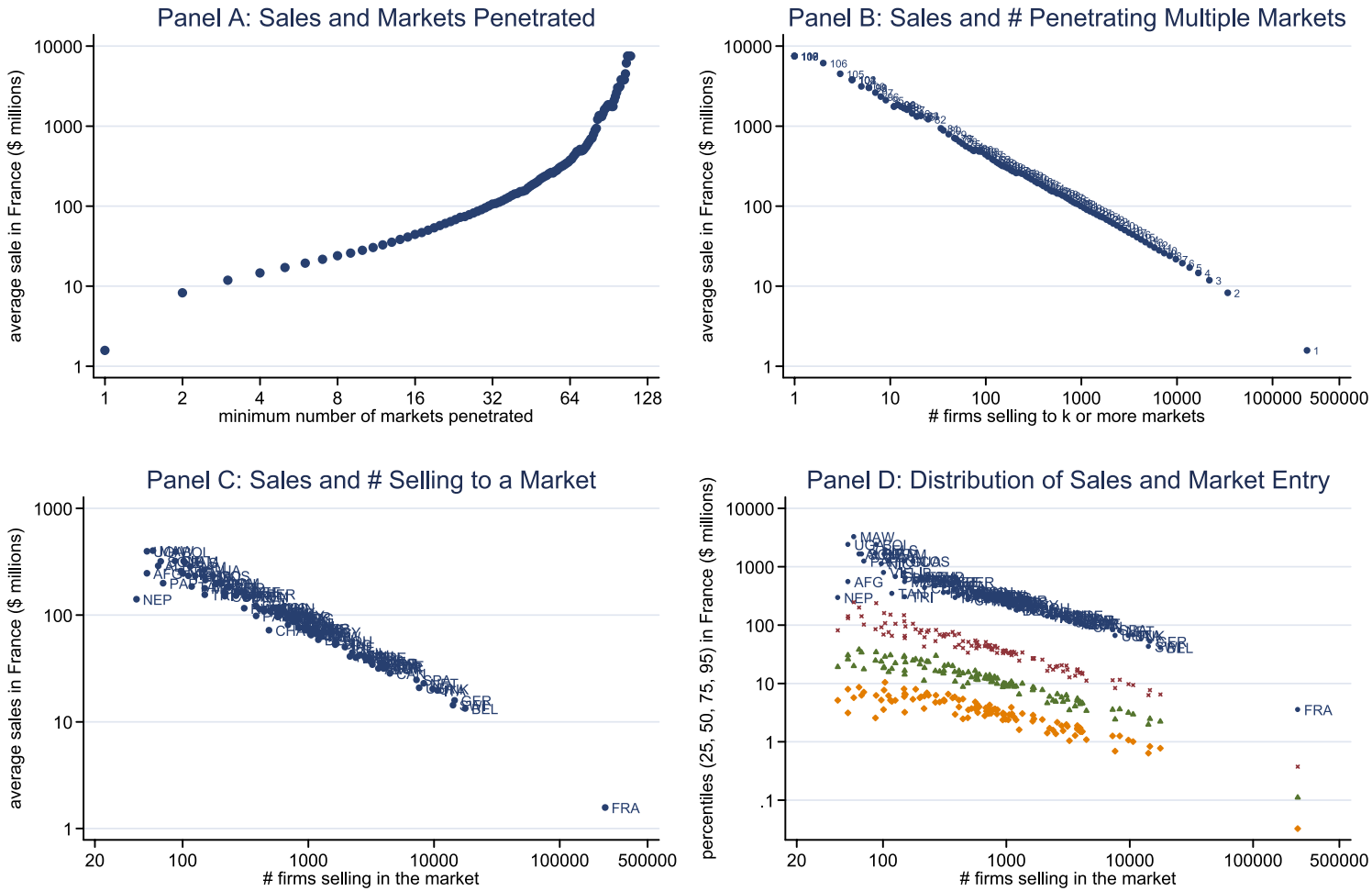


FIGURE 3.—Sales in France and market entry.

EKK (2011): Stylised Fact 4: Export Intensity

Firm-level ratio of sales at home to abroad $(X_{nF}(j)/X_{FF}(j))$ relative to the average $(\bar{X_{nF}}/\bar{X_{FF}})$. Characteristics of distribution across j's plotted here.

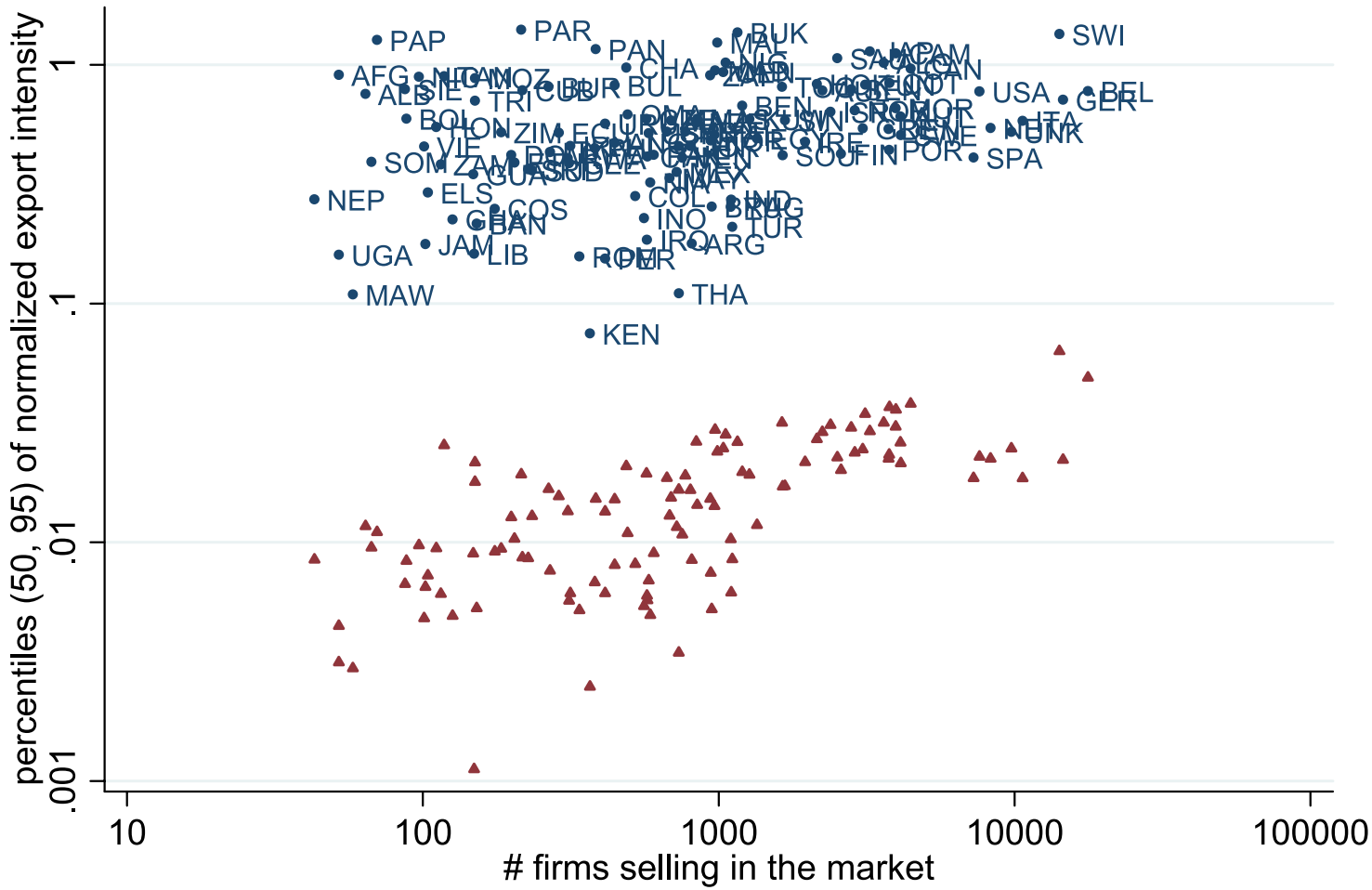


FIGURE 4.—Distribution of export intensity, by market.

EKK (2011): Model

- The above relationships fit the Melitz (2003) model (with $G(.)$ being Pareto) in some regards, but not all.
- EKK (2011) therefore add some features to Melitz (2003) in order to bring this model closer to the data.
- Most of these will take the flavor of 'firm-specific shocks/noise'.
  - The shocks smooths things out and allow for unobserved heterogeneity.

EKK (2011) Model

- Shocks:
  - Firm (i.e. j)-specific productivity draws (in country i): $z_i(j)$. (Like in Melitz, 2003.) This is Pareto with parameter θ.
  - Firm-specific demand draw $\alpha_n(j)$. The demand they face in market n (if they sell at p there) is thus: $X_n(j) = \alpha_n(j) f X_n \left(\frac{p}{P_n}\right)^{-(\sigma-1)}$, where f will be defined shortly.
  - Firm-specific fixed entry costs $E_{ni}(j) = \varepsilon_n(j) E_{ni} M(f)$, where $\varepsilon_n(j)$ is a firm-specific "fixed exporting cost shock", E_{ni} is the fixed exporting term that appears in Melitz (2003) (i.e. constant across firms). And $M(f) = \frac{1-(1-f)^{1-1/\lambda}}{1-1/\lambda}$, which, following Arkolakis (JPE, 2010), is a micro-founded "marketing" function that captures how much firms have to pay to "access" f consumers (this is a choice variable).
  - EKK allow for $g(\alpha, \varepsilon)$ to take any form, but it needs to be the same across countries n, iid across firms, and within firms independent from the Pareto distribution of z. (In practice, they use a bivariate log-normal distribution.)

EKK (2011) Model: Entry

- The entry condition is similar to Melitz (2003). Enter if cost $c_{ni}(j) = \frac{w_i \tau_{ij}}{z_i(j)}$ satisfies:

$$c \leq \bar{c}_{ni}(\eta) \equiv \left(\frac{\eta X_n}{\sigma E_{ni}} \right)^{1/(\sigma-1)} \frac{P_n}{\bar{m}} \tag{1}$$

  - Here $\eta_n(j) \equiv \frac{\alpha_n(j)}{\varepsilon_n(j)}$.
  - And X_n is total sales in n, P_n is the price index in n, and $\bar{m}$ is the (constant) markup.

- Integrating this over the distribution $g(\eta)$ we can solve for how much entry (measure of firms) there is:

$$J_{ni} = \frac{\kappa_2}{\kappa_1} \frac{\pi_{ni} X_n}{\sigma E_{ni}} \tag{2}$$

- This therefore agrees well with Fact 1 (normalized entry is linear in X_n), provided that E_{ni} is a linear function of X_n). See Fig 1 (B).

EKK (2011): Stylised Fact 1: Market Entry (averages across countries)

'Normalization': $N_{nF}/(X_{nF}/X_n)$

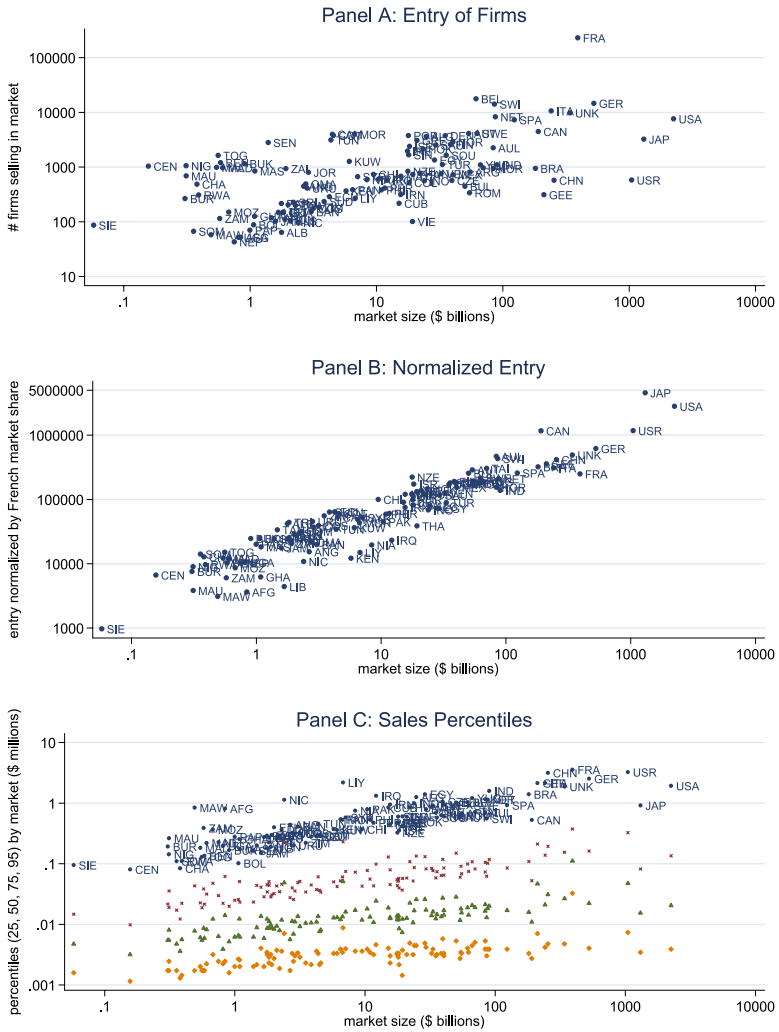


FIGURE 1.—Entry and sales by market size.

EKK (2011) Model: Firm Sales

- The firm sales (conditional on entry) condition is similar to Arkolakis (2010):

$$X_{ni}(j) = \varepsilon \left[1 - \left(\frac{c}{\bar{c}_{ni}(\eta)}\right)^{\lambda(\sigma-1)}\right] \left(\frac{c}{\bar{c}_{ni}(\eta)}\right)^{-(\sigma-1)} \sigma E_{ni}. \quad (3)$$

- For low-cost firms ($c << \bar{c}_{ni}(\eta)$), this will be a Pareto distribution (c is Pareto, so c to any power is also Pareto) in each market (as in Figure 2).
- But the $\left[1 - \left(\frac{c}{\bar{c}_{ni}(\eta)}\right)^{\lambda(\sigma-1)}\right]$ will cause the sales distribution to deviate from Pareto in the lower tail (also as in Figure 2).

EKK (2011): Stylised Fact 2: Sales Distributions (across all firms)

Surprisingly similar shape (with 'mean' shift) in each destination market (including home). Power laws (at least in upper tails—top left, here).

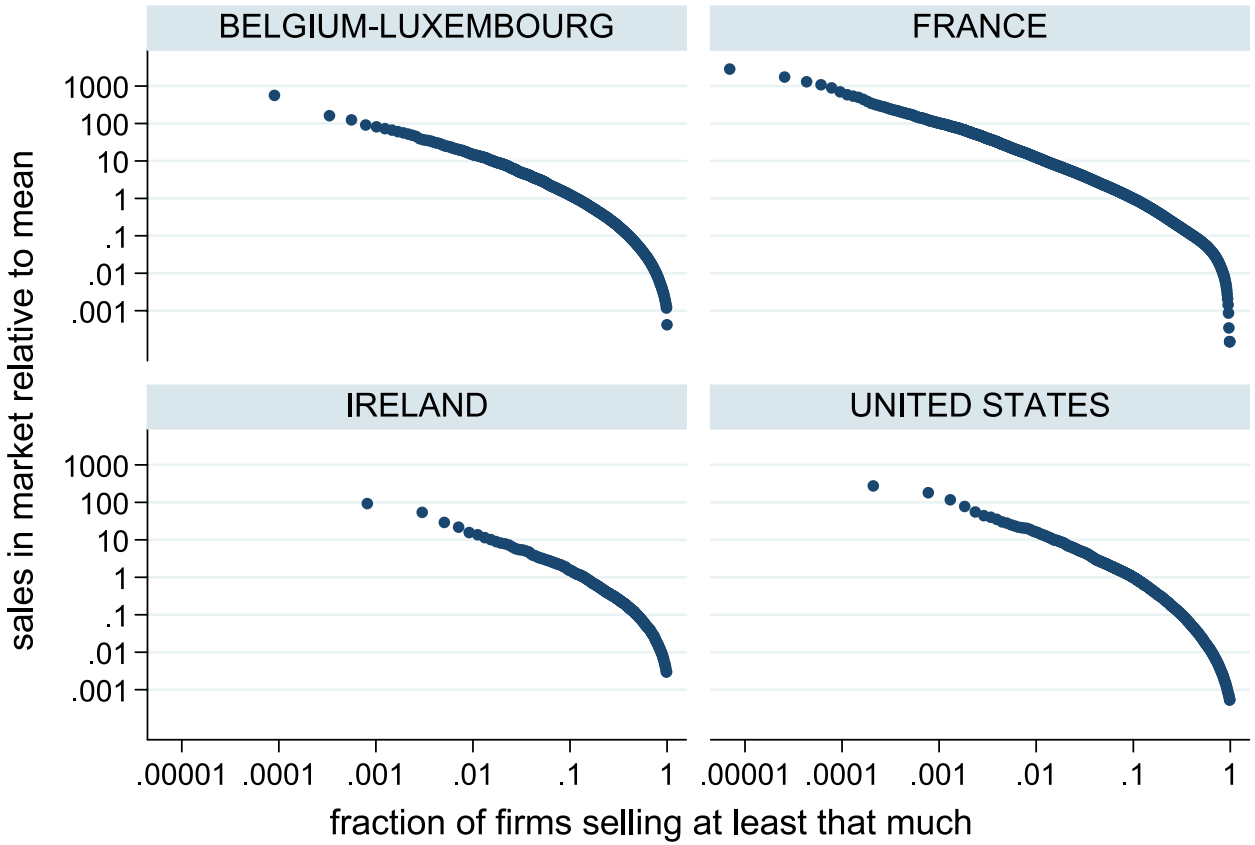


FIGURE 2.—Sales distributions of French firm: Graphs by country.

EKK (2011) Model: Sales in France Conditional on Foreign Entry

- The amount of sales in France conditional on entering market n can be shown to be (where $v_{nF}(j) \equiv (c/\bar{c}_{ni}(\eta))^{1/\theta}$):

$$\begin{aligned} X_{FF}(j)|_n &= \frac{\alpha_F(j)}{\eta_n(j)} \left[1 - v_{nF}(j)^{\lambda/\widetilde{\theta}} \left(\frac{N_{nF}}{N_{FF}} \right)^{\lambda/\widetilde{\theta}} \left(\frac{\eta_n(j)}{\eta_F(j)} \right)^{\lambda} \right] \\ &\times \quad v_{nF}(j)^{-1/\widetilde{\theta}} \left(\frac{N_{nF}}{N_{FF}} \right)^{-1/\widetilde{\theta}} \frac{\kappa_2}{\kappa_1} \bar{X}_{FF}. \end{aligned}$$

- Since N_{nF}/N_{FF} is close to zero (everywhere but in France) the dependence of this on N_{nF} is Pareto with slope $-1/\widetilde{\theta}$ (and $\widetilde{\theta} \equiv \frac{\theta}{\sigma-1}$). As in Figure 3 (C).

EKK (2011): Stylised Fact 3: Export Participation and Size in France

Big firms at home are multi-destination exporters.

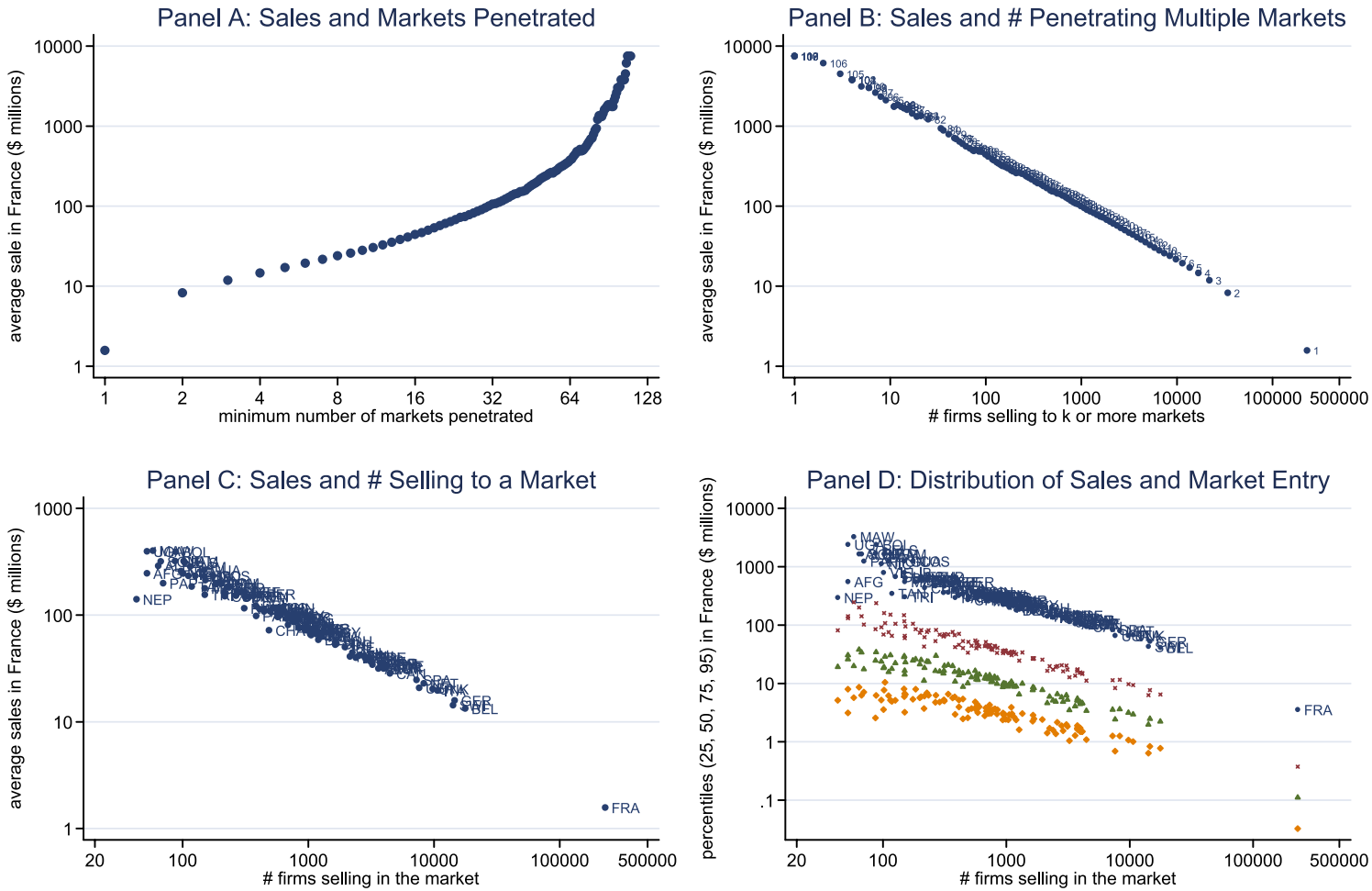


FIGURE 3.—Sales in France and market entry.

EKK (2011) Model: Normalized Export Intensity

- This can can be shown to be:

$$\frac{X_{nF}(j)}{X_{FF}(j)} \Big/ \frac{\bar{X}_{nF}}{\bar{X}_{FF}} = \frac{\alpha_n(j)}{\alpha_F(j)} \left[\frac{1 - v_{nF}(j)^{\lambda/\widetilde{\theta}}}{1 - v_{nF}(j)^{\lambda/\widetilde{\theta}} \left(\frac{N_{nF}}{N_{FF}} \right)^{\lambda/\widetilde{\theta}} \left(\frac{\eta_n(j)}{\eta_F(j)} \right)^{\lambda}} \right] \left(\frac{N_{nF}}{N_{FF}} \right)^{1/\widetilde{\theta}}$$

- Since N_{nF}/N_{FF} is close to zero (everywhere but in France) the dependence of the square bracket on N_{nF} is negligible. So we are left with the dependence driven by the term outside the square bracket, i.e. Pareto with slope $1/\widetilde{\theta}$. As in Figure 4.

EKK (2011): Stylised Fact 4: Export Intensity

Firm-level ratio of sales at home to abroad $(X_{nF}(j)/X_{FF}(j))$ relative to the average $(\bar{X_{nF}}/\bar{X_{FF}})$. Characteristics of distribution across j's plotted here.

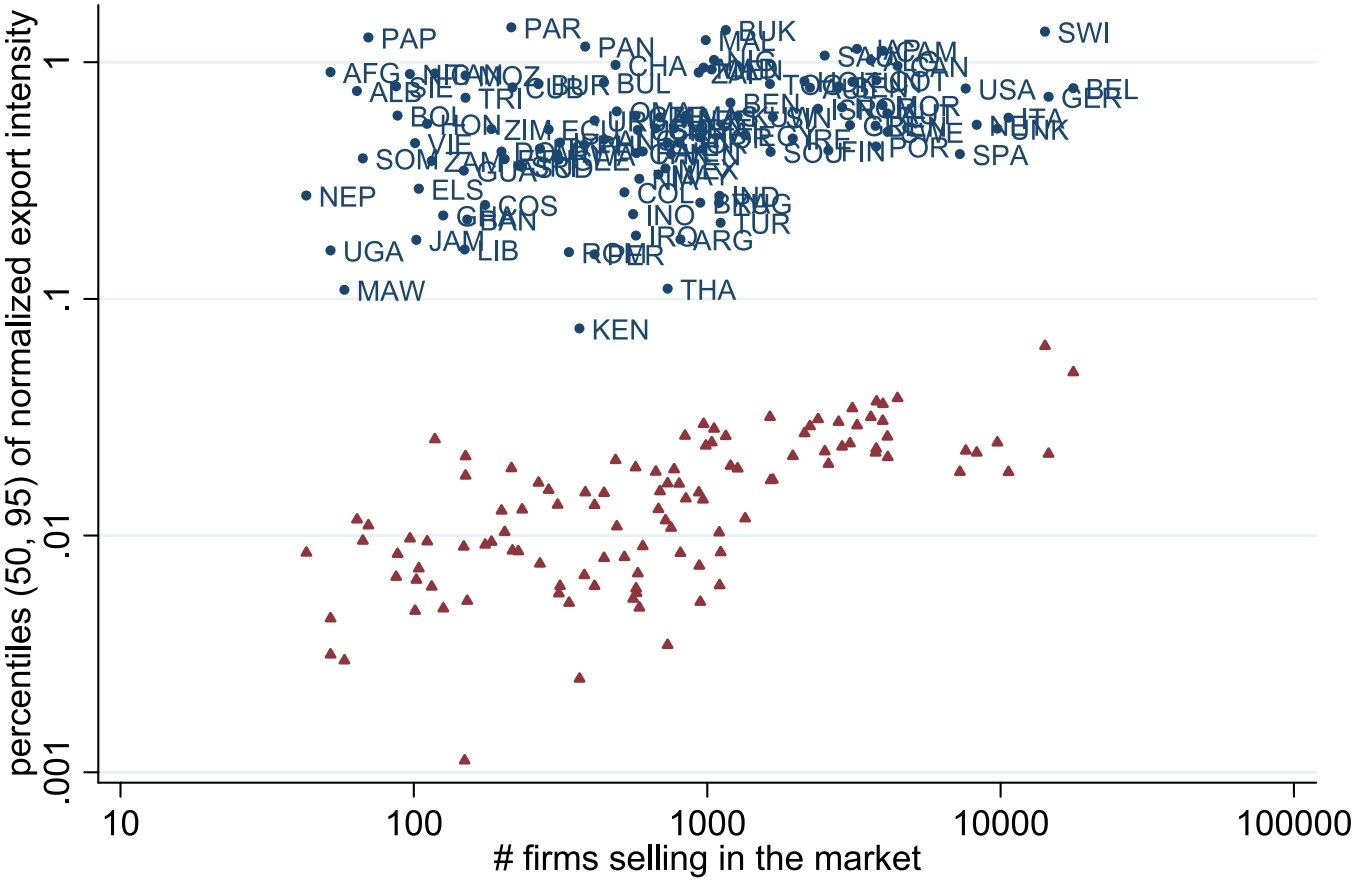


FIGURE 4.—Distribution of export intensity, by market.

EKK (2011): Estimation

- Use simulated method of moments (SMM).
- Basic idea:
  - Guess a candidate value of the model parameters Θ: θ, covariance matrix of (α, η) joint log-normal distribution, λ, σ
  - Draw S values of c from Pareto (θ) distribution, $S \times C$ values of and (α, η) from a joint log-normal distribution. (S is number of firms in simulated economy; C is number of destination countries.)
  - Calibrate σE_{in} to Figure 1(C) fit
  - Calculate value of each simulated firm's sales to each destination market (including exit).
  - Hence calculate any moment in the model (at the candidate Θ) that could be computed in the firm-level data
  - Calculate distance between this simulated set of moments and a chosen set of data moments
  - Iterate over Θ space to find parameter values with shortest moment distance.
- Moments chosen relate strongly to the four figures we saw earlier

EKK (2011): Results

- Parameter estimates (bootstrapped SEs):
  - $\widetilde{\theta} = 2.46(0.10)$—implies that on average 59% of gross profits are dissipated by fixed costs of entry in an average market
  - $\lambda = 0.91(0.12)$—close to 1 so allows for lots of small firms to be entrants but not sell much
  - $\sigma_\alpha = 1.69(0.03)$—huge shock to demand
  - $\sigma_\eta = 0.34(0.01)$—comparatively smaller shock to entry costs
  - $\rho = -0.65(0.03)$—rationalizes large variance of sales, across firms, within average destination markets

EKK (2011): General Equilibrium

- So far, the model estimation procedure took macro aggregates (X_{ni}, w_i) as given.
- Now add GE features. For each country in the world:
  - Unit input bundle $w_i = W_i^{\beta} P_i^{1-\beta}$ where W_i is the wage.
  - Nonmanufacturing goods (not traded) and manufacturing goods (above model) combine via Cobb-Douglass preferences (with share γ).
  - Fixed costs of entry incur labor costs in the destination country
  - Countries run trade (net) deficits exogenously given by D_i (chosen to match data)
- Counterfactuals:
  - Consider shock to, say, variable trade costs
  - Solve (a la Dekle, Eaton and Kortum, 2007) for the change in all aggregate variables (W_i, P_i, X_{ni}, N_{ni})
  - Then feed these macro aggregates into the firm-level simulation to see firm-level consequences.

EKK (2011): "Globalization" Counterfactual

A drop in all international trade costs, worldwide, of 10%

TABLE V

COUNTERFACTUALS: FIRM ENTRY AND EXIT BY INITIAL SIZE

	All Firms			Exporters		
		Counterfactual			Counterfactual	
Initial Size Interval (percentile)	Baseline No. of Firms	Change From Baseline	Change (%)	Baseline No. of Firms	Change From Baseline	Change (%)
Not active	0	1118	—	0	1118	—
0 to 10	23,140	−11,551	−49.9	767	15	2.0
10 to 20	23,140	−5702	−24.6	141	78	55.1
20 to 30	23,140	−3759	−16.2	181	192	106.1
30 to 40	23,140	−2486	−10.7	357	357	100.0
40 to 50	23,140	−1704	−7.4	742	614	82.8
50 to 60	23,138	−1141	−4.9	1392	904	65.0
60 to 70	23,142	−726	−3.1	2450	1343	54.8
70 to 80	23,140	−405	−1.8	4286	1829	42.7
80 to 90	23,140	−195	−0.8	7677	2290	29.8
90 to 99	20,826	−38	−0.2	12,807	1915	15.0
99 to 100	2314	0	0.0	2169	62	2.8
Total	231,402	−26,589		32,969	10,716	

EKK (2011): "Globalization" Counterfactual

A drop in all international trade costs, worldwide, of 10%

TABLE VI

COUNTERFACTUALS: FIRM GROWTH BY INITIAL SIZE

	Total Sales			Exports		
		Counterfactual			Counterfactual	
Initial Size Interval (percentile)	Baseline ($ millions)	Change From Baseline	Change (%)	Baseline ($ millions)	Change From Baseline	Change (%)
Not active	0	3	—	0	3	—
0 to 10	41	−24	−58.0	1	2	345.4
10 to 20	190	−91	−47.7	1	2	260.3
20 to 30	469	−183	−39.0	1	3	266.7
30 to 40	953	−308	−32.3	2	7	391.9
40 to 50	1793	−476	−26.6	6	18	307.8
50 to 60	3299	−712	−21.6	18	48	269.7
60 to 70	6188	−1043	−16.9	58	130	223.0
70 to 80	12,548	−1506	−12.0	206	391	189.5
80 to 90	31,268	−1951	−6.2	1085	1501	138.4
90 to 99	148,676	4029	2.7	16,080	11,943	74.3
99 to 100	230,718	18,703	8.1	56,301	20,486	36.4
Total	436,144	16,442		73,758	34,534	

A Selection of Related Work

- Blaum, Lelarge and Peters (2017): similar to EKK (2011) but looking at import sourcing behavior of French firms
- Antras, Fort and Tintelnot (AER, 2017): model of "global sourcing" (combinations of inputs from around the world)
- Armenter and Koren (AER, 2014): A "balls and bins" model of trade. Asking how much of the extensive margin patterns of trade (across firms, countries, products, etc) could arise from a purely probabilistic model. Large scope for this given the highly sparse nature of the data in this regard.
- Armenter and Koren (JEEA, 2015): Asks how much of the exporter premium and exporting firm share can be explained by firm size (and hence IRTS).