Firm-to-Firm Trade:

Imports, Exports, and the Labor Market

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Agenda I

- Most firms do not export, and those that do usually sell to few countries
- This fact fits neatly with theories of firm heterogeneity and trade
- What about imports?
- Imports of one firm (intermediates) should be the exports of another

Agenda II

- How do trade and labor market outcomes interact?
- Firm's labor may be displaced due to outsourcing/offshoring of tasks
- Domestic and imported intermediates compete with labor
- Rethink labor demand in a globalized world
- Implications at the micro **and** macro level

Overview

- Present some motivating facts

- Pursue these two agendas with a single model, capable of guiding empirical work:
  - extending Melitz (2003), Chaney (2008), EKK (2011)
  - introducing buyer-supplier networks as in Oberfield (2013)
  - endogenizing task-level displacement of workers by intermediates

- Simulate some of the GE implications of the model

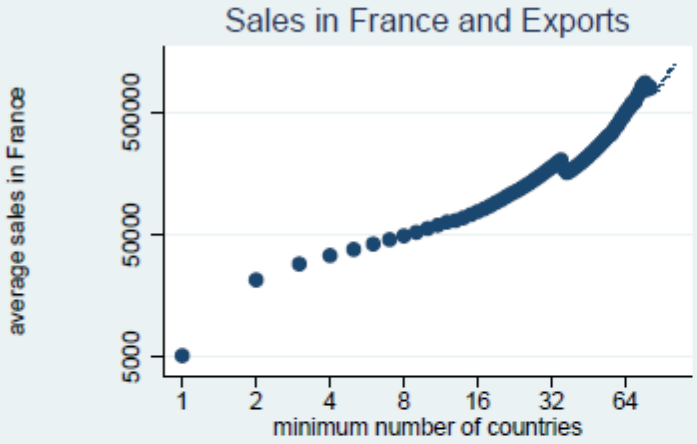
Related Literature

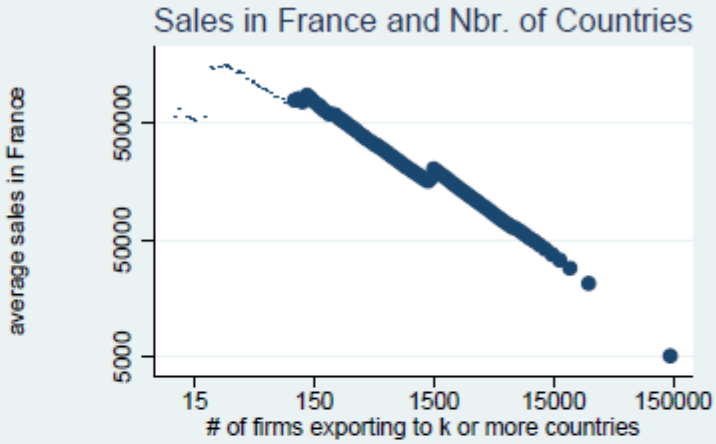
- Theory on exports and labor markets (not on imports): Felbermayr, Prat, and Shmerer (2008), Egger and Kreickemeier (2009), Helpman, Itskhoki, and Redding (2010), Caliendo and Rossi-Hansberg (2012)

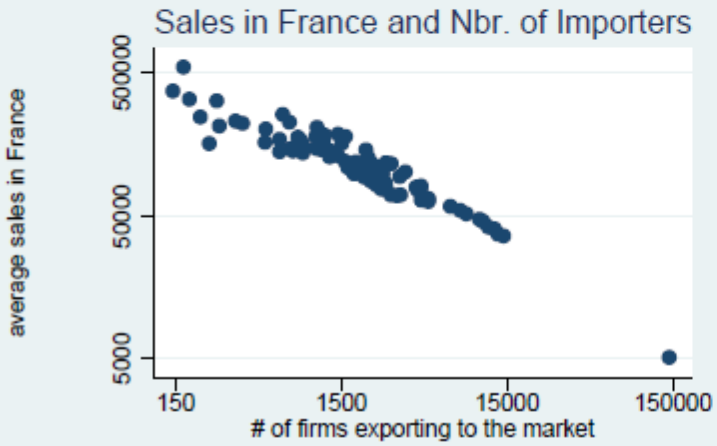
- Theory on purchases and networks: Oberfield (2013), "Business Networks, Production Chains, and Productivity: A Theory of Input-Output Architecture," Revise and Resubmit, *Econometrica*, Lucas (2010), *Economica*, Acemoglu and Autor (2011) in *Handbook of Labor Economics*, Chaney (2013) Garetto (2013), *AEJ*, and Luttmer (2013) both on networks, also Acemoglu, Carvalho... recently in *Econometrica*

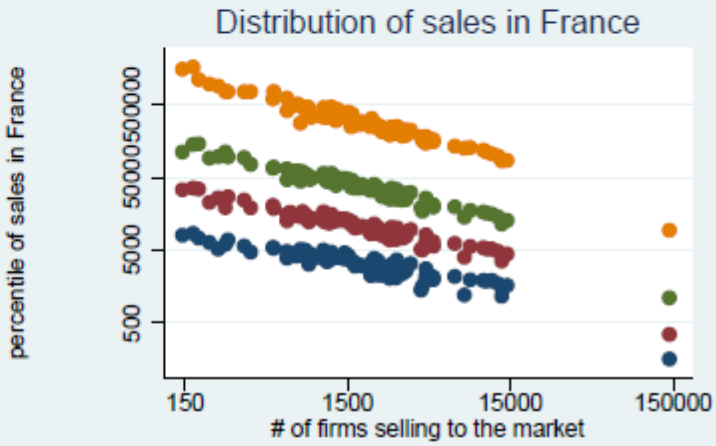
- Quantitative (most on exports and labor markets, some on imports and labor markets): Biscourp and Kramarz (2007), Hummels, Jorgenson, Munch, and Xiang (2011), Irarrazabal, Moxnes, and Ulltveit-Moe (2010), Klein, Moser, and Urban (2010), Frias, Kaplan, and Verhoogen (2010), Kramarz (2009), Caliendo, Monte, and Rossi-Hansberg (2013), Blaum, Lelarge, and Peters (2013), Helpman, Itskhoki, Muendler, and Redding (2013), also here in this conference...

Exports and Sales in France

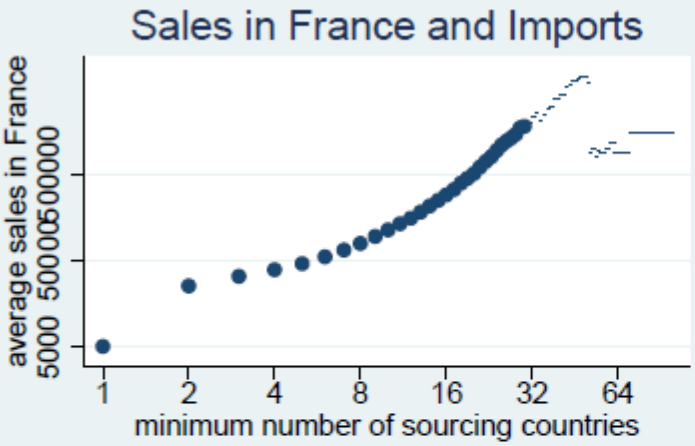


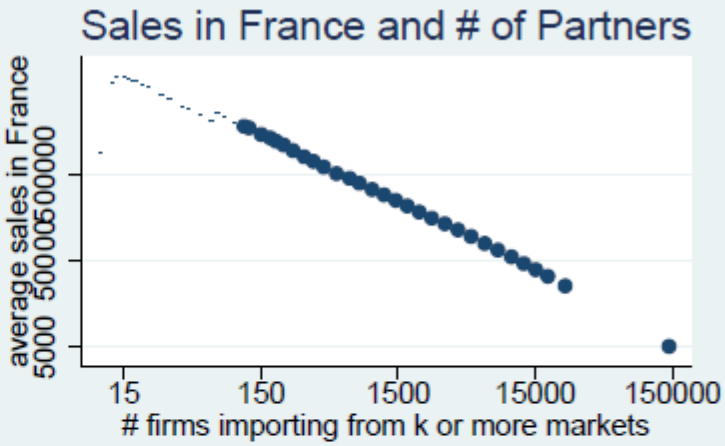


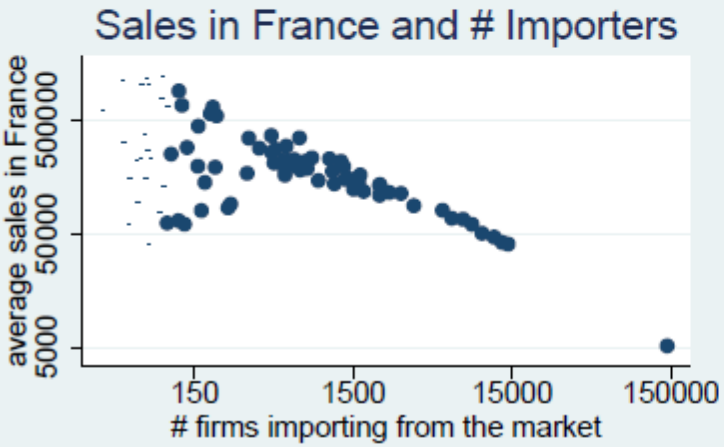


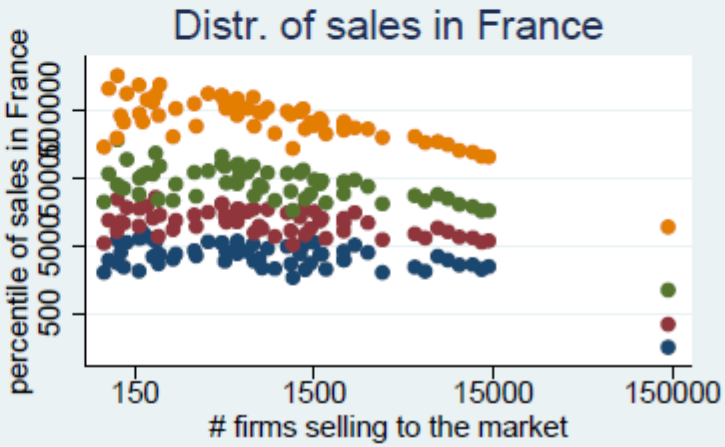


Imports and Sales in France









Distribution of Variables

	Administrative Labor Costs (1+Total Overhead Labor Costs)	Commercial Labor Costs (1+Total Overhead Labor Costs)	Engineering/R&D Labor Costs (1+Total Overhead Labor Costs)
Q1	0.0000	0.0000	0.0000
Median	0.3660	0.0000	0.0000
Q3	0.9047	0.1916	0.1282
P90	0.9815	0.9314	0.7421
P95	0.9957	0.9329	0.9809

	Total Purchases (Production labor costs+Total Purchases)	Total Purchases in France (Production labor costs+Total Purchases)	Total Imports of Goods (Production labor costs+Total Purchases)
Q1	0.7550	0.7082	0.0000
Median	0.8523	0.8142	0.0000
Q3	0.9376	0.9091	0.0000
P90	1.0000	1.0000	0.1402
P95	1.0000	1.0000	0.3015

Share of Imports in Total Production Costs

	Product*country level number of products*country									
	1	2	3 to 4	5 to 8	9 to 16	17 to 32	33 to 64	65 to 128	129 and more	Aggregate (incl. zeroes)
Individual Shares										
Mean	0.0647	0.0532	0.0380	0.0253	0.0164	0.0105	0.0062	0.0037	0.0015	0.0357
StdDev	0.1358	0.1127	0.0901	0.0671	0.0502	0.0372	0.0256	0.0176	0.0098	0.1114
Q1	0.0030	0.0022	0.0015	0.0009	0.0005	0.0003	0.0001	0.00005	0.000007	0.0000
Med	0.0121	0.0102	0.0070	0.0042	0.0023	0.0013	0.0006	0.0003	0.00006	0.0000
Q3	0.0504	0.0435	0.0293	0.0181	0.0103	0.0060	0.0030	0.0016	0.0004	0.0000
Number of observations	4,097	5,027	11,510	26,458	54,338	90,508	117,284	116,830	189,642	127,592
	Firm-level number of products*country									
	1	2	3 to 4	5 to 8	9 to 16	17 to 32	33 to 64	65 to 128	129 and more	Aggregate (zeroes excl.)
Aggregate Shares										
Mean	0.0647	0.1032	0.1248	0.1522	0.1876	0.2234	0.2564	0.3074	0.3593	0.1696
StdDev	0.1358	0.1590	0.1667	0.1740	0.1887	0.1957	0.1906	0.1926	0.2054	0.1906
Q1	0.0030	0.0090	0.0196	0.0335	0.0509	0.0734	0.1118	0.1565	0.1877	0.0275
Med	0.0121	0.0366	0.0568	0.0841	0.1237	0.1604	0.2046	0.2695	0.3321	0.0977
Q3	0.0504	0.1225	0.1571	0.2075	0.2587	0.3170	0.3540	0.4146	0.4978	0.2476
Number of observations	4,097	2,496	3,306	4,135	4,465	3,844	2,536	1,284	684	26,847

Employment and Labor Costs

	Employment (in logs)		Average Labor Costs (in logs)	
	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	-2.5988	0.0096	2.7757	0.0063
*number of imported products (country*8-digit industry):*				
1	0.0347	0.0106	0.0183	0.0069
2	-0.0055	0.0141	0.0007	0.0092
3 to 4	-0.0048	0.0124	-0.0227	0.0081
5 to 8	0.0055	0.0112	-0.0547	0.0073
9 to 16	0.0663	0.0110	-0.0953	0.0072
17 to 32	0.1456	0.0118	-0.1275	0.0077
33 to 64	0.2456	0.0140	-0.1768	0.0092
65 to 128	0.3046	0.0187	-0.1999	0.0122
129 and more	0.4993	0.0256	-0.2659	0.0168
*number of exported products (country*8-digit industry):*				
1	0.0723	0.0090	0.0577	0.0059
2	0.1088	0.0119	0.0555	0.0078
3 to 4	0.1589	0.0109	0.0534	0.0071
5 to 8	0.2381	0.0109	0.0434	0.0071
9 to 16	0.2617	0.0112	0.0733	0.0074
17 to 32	0.3808	0.0124	0.0843	0.0081
33 to 64	0.4663	0.0141	0.1243	0.0092
65 to 128	0.5539	0.0176	0.1598	0.0115
129 and more	0.6597	0.0211	0.2190	0.0138
engineering share in overhead labor	0.2704	0.0076	0.1519	0.0050
marketing share in overhead labor	0.2062	0.0055	-0.2183	0.0036
log of French sales	0.6816	0.0016	0.1021	0.0011
R-square	0.7859		0.1738	
Number of Observations	122,406		122,401	

Notes: "Overhead Labor Costs" equal total labor costs minus labor costs for production workers. Sources: DADS (exhaustive), Ficus, Customs. Year 2004. An exported or imported product denotes an 8-digit product for (from) a given country.

Basic Model: I

- Countries (source, destination): $i, n = 1, ..., N$
- Continuum of goods j and CES preferences with $\sigma > 1$
- Firm j producing in i has efficiency $z_i(j)$ in serving any destination n
- Measure of firms in i with efficiency above z is $\mu_i^z(z) = T_i z^{-\theta}$, $\theta > \sigma - 1$
- Wage w_i, intermediates price index P_i, and iceberg trade costs d_{ni}

Basic Model: II

- Unit production cost for firm from i with efficiency z selling in n is: $c_{ni} = d_{ni}\left(w_i^{\beta} P_i^{1-\beta}\right)/z$
- Hence, measure of firms with cost below c is proportional to c^{θ}
- Charging $p_n = \frac{\sigma}{\sigma-1} c_{ni}$ in market n, sells $x_n(j) = X_n \left(\frac{p_n}{P_n}\right)^{-(\sigma-1)}$
- Fixed entry cost of selling there is E_n, paid in (overhead) labor in n
- Cost threshold $\overline{c}_n$ to sell in market n

Two Changes to the Basic Model

1. Intermediates supplied by individual local or foreign firms, not a composite good

   - generates a network of buyers and sellers

2. Inputs replace workers doing various firm-level tasks $k = 1, ..., K$

   - induces heterogeneous and endogenous labor shares

A Model of Firm-to-Firm Trade

- Firm performs each task k using either its workers or intermediates purchased from another firm
- Each task k contributes a Cobb-Douglas share β_k to CRS production
- Worker in i performing task k has an opportunity cost $w_{k,i}$
- Firm may replace worker for task k with an intermediate at price $p_{k,i}$

Cost Function

- Given wages and prices of intermediates available to the firm in i, an input bundle costs:

$$b_i(\boldsymbol{p}) = \prod_{k=1}^{K} \min\left\{w_{k,i}, p_{k,i}\right\}^{\beta_k}$$

- With efficiency z, firm's unit cost of production for delivery to n is: $c_{ni} = d_{ni} b_i(\boldsymbol{p})/z$

- Hence, given $\boldsymbol{p}$, the measure of firms in n from i with cost below c is $\mu_{ni}(c|\boldsymbol{p}) = T_i \left[d_{ni} b_i(\boldsymbol{p})\right]^{-\theta} c^{\theta}$

- An entry threshold $\overline{c}_n$ on costs is determined by entry as in Basic Model

Prices of Intermediates

- Firm in i encounters $h_{k,i}$ intermediate price quotes for task k from any country, distributed Poisson with parameter $\lambda_{k,i}$

- Each price is drawn from a distribution $F_i(p)$

- The distribution of the low-cost intermediate is thus:

$$G_{k,i}(p) = \mathsf{Pr}(p_{k,i} \leq p) = 1 - e^{-\lambda_{k,i} F_i(p)}$$

- We will show that $F_i(p) = \left(\frac{p}{\overline{c}_i}\right)^{\theta}$, for $p \leq \overline{c}_i$

- Hence $G_{k,i}(w_{k,i}) = 1 - e^{-\Upsilon_{k,i} w_{k,i}^{\theta}}$ is the probability of replacing task k workers at wage $w_{k,i}$ with $\Upsilon_{k,i} = \lambda_{k,i} \bar{c}_i^{-\theta}$ capturing the strength of the outsourcing option

Cost Distribution of Firms: I

- Firm draws a low-cost price $p_{k,i}$ from $G_{k,i}$ for each of its $k = 1, ..., K$ tasks

- Decides whether to carry out each task with that input or with its own employees

- Taking account of the outsourcing option, measure of firms from i in n with cost below c is:

$$\begin{aligned}\mu_{ni}(c) &= \int_0^\infty ... \int_0^\infty \mu_{ni}(c|\boldsymbol{p}) dG_{1,i}(p_{1,i}) ... dG_{K,i}(p_{K,i}) \\ &= T_i d_{ni}^{-\theta} c^\theta \prod_{k=1}^{K} \left(\int_0^\infty \min\left\{w_{k,i}, p_{k,i}\right\}^{-\theta\beta_k} dG_{k,i}(p_{k,i}) \right).\end{aligned}$$

Cost Distribution of Firms: II

- Assume $\overline{c}_i \geq \max_k \left\{ w_{k,i} \right\}$, so firms may pass on the option to outsource.

- Then, integral can be solved as:

$$\begin{aligned} & \int_0^{\infty} \min \left\{ w_{k,i}, p_{k,i} \right\}^{-\theta\beta_k} dG_{k,i}(p_{k,i}) \\ = \; & w_{k,i}^{-\theta\beta_k} e^{-\Upsilon_{k,i} w_{k,i}^{\theta}} + \Upsilon_{k,i}^{\beta_k} \gamma(1-\beta_k, \Upsilon_{k,i} w_{k,i}^{\theta}) \end{aligned}$$

  with $\gamma(1-\beta, x) = \int_0^x y^{-\beta} e^{-y} dy$ the incomplete gamma function

Cost Distribution of Firms: III

- The measure of firms from i in n with cost below c is thus:

$$\mu_{ni}(c) = c^{\theta} T_i d_{ni}^{-\theta} \overline{w}_i^{-\theta} \Xi_i,$$

with $\overline{w}_i = \prod_{k=1}^{K} \left(w_{k,i}\right)^{\beta_k}$ and

$$\Xi_i = \prod_{k=1}^{K} \left[e^{-\Upsilon_{k,i} w_{k,i}^{\theta}} + \left(\Upsilon_{k,i} w_{k,i}^{\theta}\right)^{\beta_k} \gamma(1-\beta_k, \Upsilon_{k,i} w_{k,i}^{\theta}) \right]$$

- The term Ξ_i captures the cost-reducing effects of firm-to-firm trade

- In EKK, $\Xi_i = 1$ because $\Upsilon_{k,i} = 0$

Circling the Circle

- Assume intermediates are priced at marginal cost. Then,

$$\begin{aligned}\mu_n(c) &= \sum_{i=1}^{N} \mu_{ni}(c) = c^{\theta} \sum_{i=1}^{N} T_i d_{ni}^{-\theta} \overline{w}_i^{-\theta} \Xi_i \\ &= \Upsilon_n c^{\theta}\end{aligned}$$

  the price distribution of an intermediate is (as assumed above):

$$F_n(p) = \frac{\mu_n(p)}{\mu_n(\overline{c}_n)} = \left(\frac{p}{\overline{c}_n}\right)^{\theta},$$

- The cost threshold $\overline{c}_n$ is nailed down by the entry condition in n with fixed cost E_n

The Value of Outsourcing

- Assume the number of intermediate goods sampled by a buyer rises with the measure of entrants:

$$\lambda_{k,i} = \bar{\lambda}_{k,i}\mu_i(\overline{c}_i)$$

- So that $\Upsilon_i = \Upsilon_{k,i}/\bar{\lambda}_{k,i}$ which satisfies a (well behaved) fixed point:

$$\begin{aligned}\Upsilon_n &= \sum_{i=1}^{N} T_i d_{ni}^{-\theta}\overline{w}_i^{-\theta} \\ &\quad \prod_{k=1}^{K}\left[e^{-\Upsilon_i\bar{\lambda}_{k,i}w_{k,i}^{\theta}} + \left(\Upsilon_i\bar{\lambda}_{k,i}w_{k,i}^{\theta}\right)^{\beta_k}\gamma(1-\beta_k, \Upsilon_i\bar{\lambda}_{k,i}w_{k,i}^{\theta})\right]\end{aligned}$$

- Furthermore, denoting consumption of final goods X_n^C, the price index is:

$$P_n = \bar{m} \left[\frac{\theta}{\theta - (\sigma - 1)} \left(\frac{\sigma E_n}{X_n^C} \right)^{1-\theta/(\sigma-1)} \Upsilon_n \right]^{-1/\theta}$$

Micro and Macro Labor Share

- The probability of a firm in i of not outsourcing task k is:

$$1 - G_{k,i}(w_{k,i}) = \exp\left(-\Upsilon_i \bar{\lambda}_{k,i} w_{k,i}^{\theta}\right)$$

- Thus the labor share of production costs is random at the firm level

- At aggregate level the labor share is non-stochastic, but endogenous

$$\beta_i^M = \sum_{k=1}^{K} \beta_k \exp\left(-\Upsilon_i \bar{\lambda}_{k,i} w_{k,i}^{\theta}\right)$$

- The share of labor payments to workers at task k is:

$$s_{k,i} = \frac{\beta_k \exp\left(-\Upsilon_i \bar{\lambda}_{k,i} w_{k,i}^{\theta}\right)}{\sum_{k'=1}^{K} \beta_{k'} \exp\left(-\Upsilon_i \bar{\lambda}_{k',i} w_{k',i}^{\theta}\right)}$$

Trade Shares

- Having solved for the Ξ_i we can then write

$$\Upsilon_n = \sum_{i=1}^{N} T_i \left(\overline{w}_i d_{ni}\right)^{-\theta} \Xi_i$$

- Hence, the share of country n spending on imports from i is:

$$\begin{aligned} \pi_{ni} &= \frac{\mu_{ni}(\overline{c}_n)}{\mu_n(\overline{c}_n)} = \frac{\Xi_i T_i \left(\overline{w}_i d_{ni}\right)^{-\theta}}{\Upsilon_n} \\ &= \frac{\Xi_i T_i \left(\overline{w}_i d_{ni}\right)^{-\theta}}{\sum_{i'=1}^{N} \Xi_{i'} T_{i'} \left(\overline{w}_{i'} d_{ni'}\right)^{-\theta}}. \end{aligned}$$

- Again, the term Ξ_i serves to augment country i's technology

General Equilibrium I

- The model has a mfg and a non-mfg sector:

$$Y_i^A = w_i^M L_i^M + w_i^F L_i^F + w_i^N L_i^N + \Pi_i.$$

with Y_i^A is GDP, Π_i is profit. M stands for mfg workers engaged in production, F for fixed cost workers, N for non mfg workers

Denoting α the share of GDP going to manufactures, then

$$w_i^N L_i^N = (1-\alpha) Y_i^A, \; X_i^C = \alpha Y_i^A$$

General Equilibrium II

- Firms selling in i pay fixed costs:

$$w_i^F L_i^F = E_i \mu_i(\bar{c}_i) = \frac{\theta - (\sigma - 1)}{\theta \sigma} X_i^C$$

- The manufacturing wage bill is:

$$w_i^M L_i^M = \beta_i^L \sum_{n=1}^{N} \pi_{ni} \left[\frac{\sigma - 1}{\sigma} X_n^C + \frac{1 - \beta_n^L}{\beta_n^L} w_n^M L_n^M \right]$$

- Finally, profits are:

$$\Pi_i = \sum_{n=1}^{N} \pi_{ni} \frac{\sigma - 1}{\theta \sigma} X_n^C$$

Simulations

- Some experiments: computing the equilibrium of this model of international firm-to-firm trade

- Task 1 (among 10 tasks) cannot be outsourced, $\beta_1 = 0.01$

- With different assumptions on closing the model:

  1. Non-mfg not tradeable, hence wage is endogenous, no deficit in mfg

  2. Non-mfg costlessly traded, hence wage determined by non-mfg productivity, (potential) deficit in mfg

Setting:

10 tasks

task 1 cannot be outsourced (share $\beta = 0.01$)

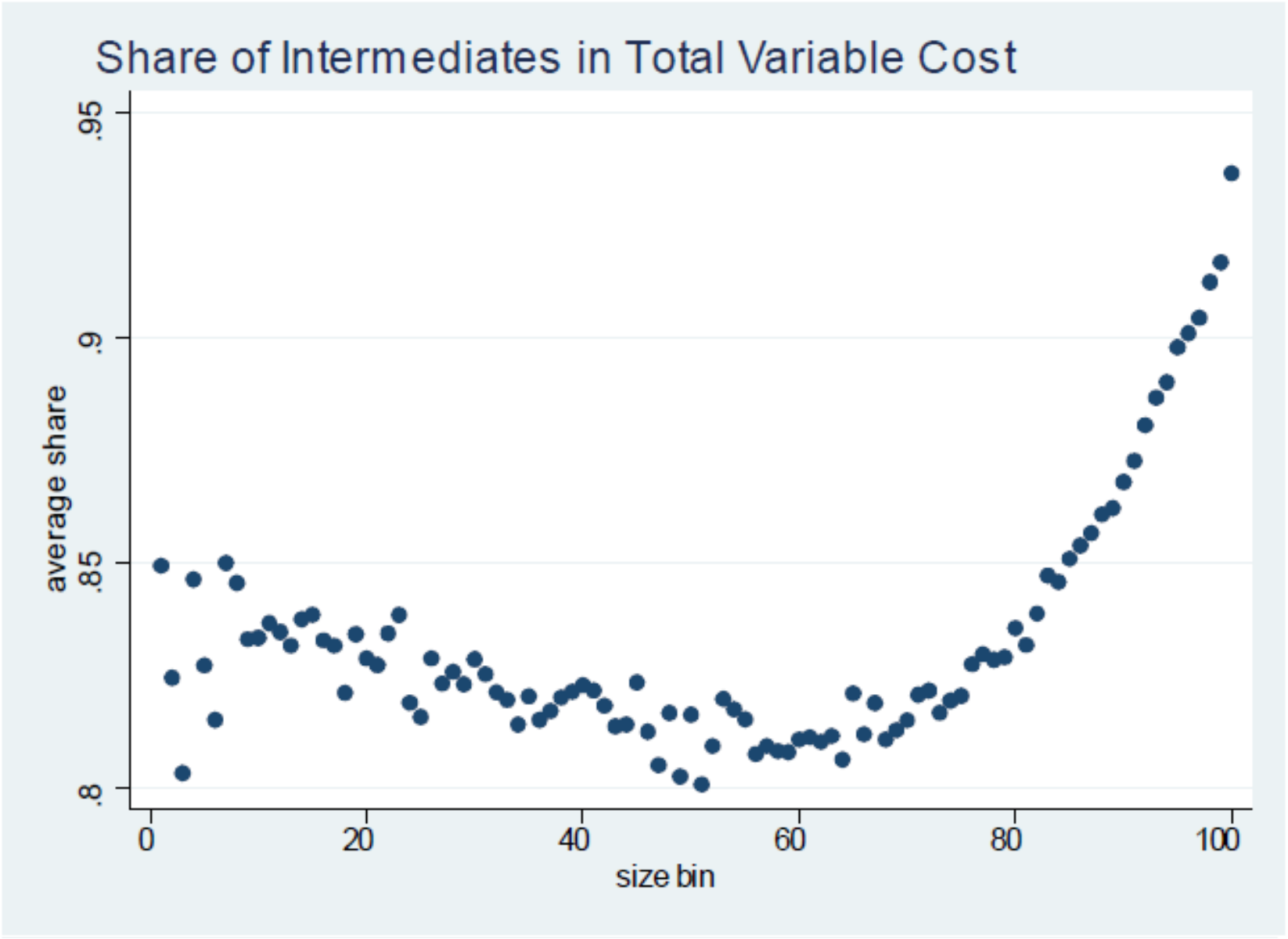
Country 1 is half size of country 2

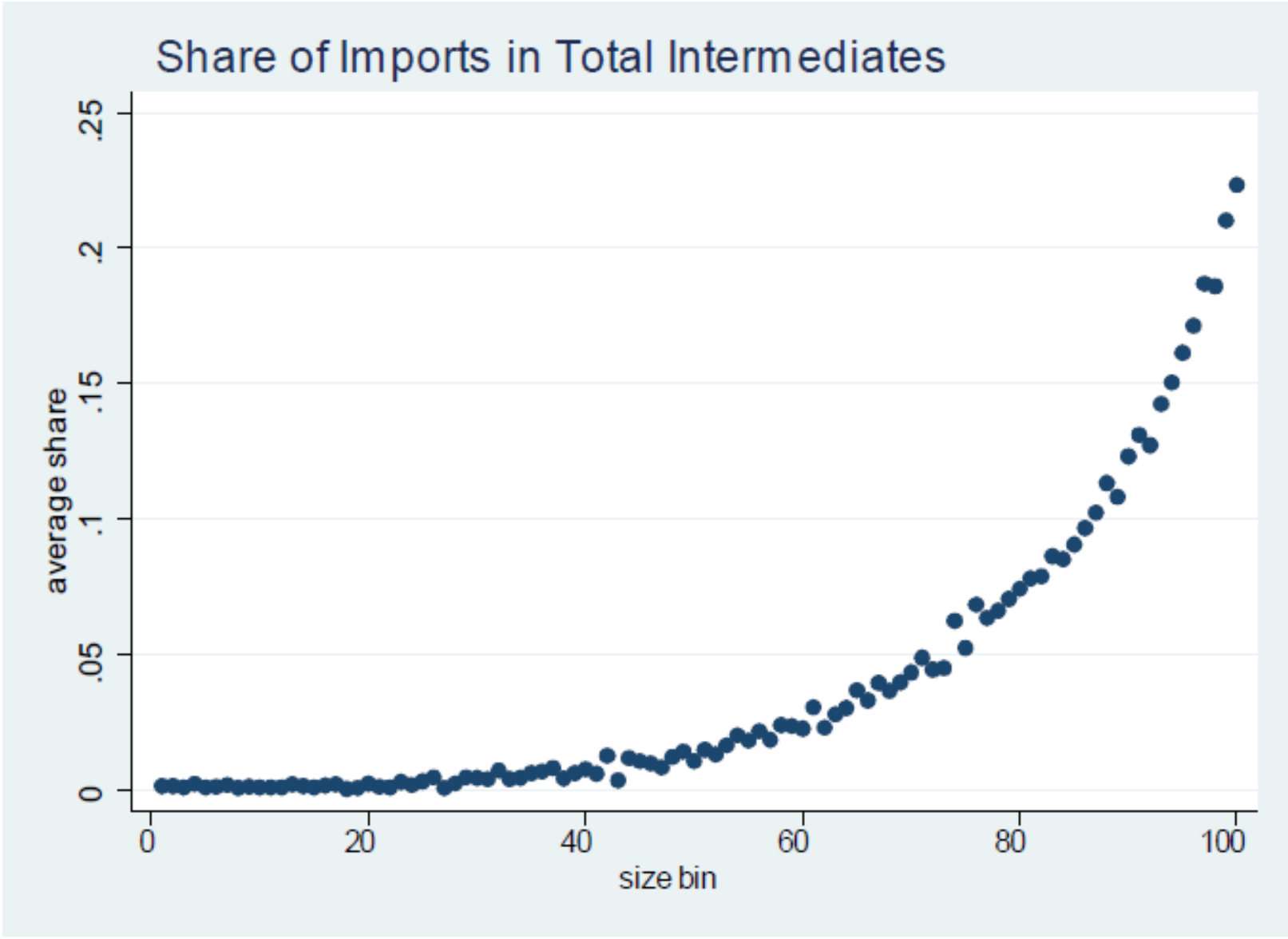
Simulations

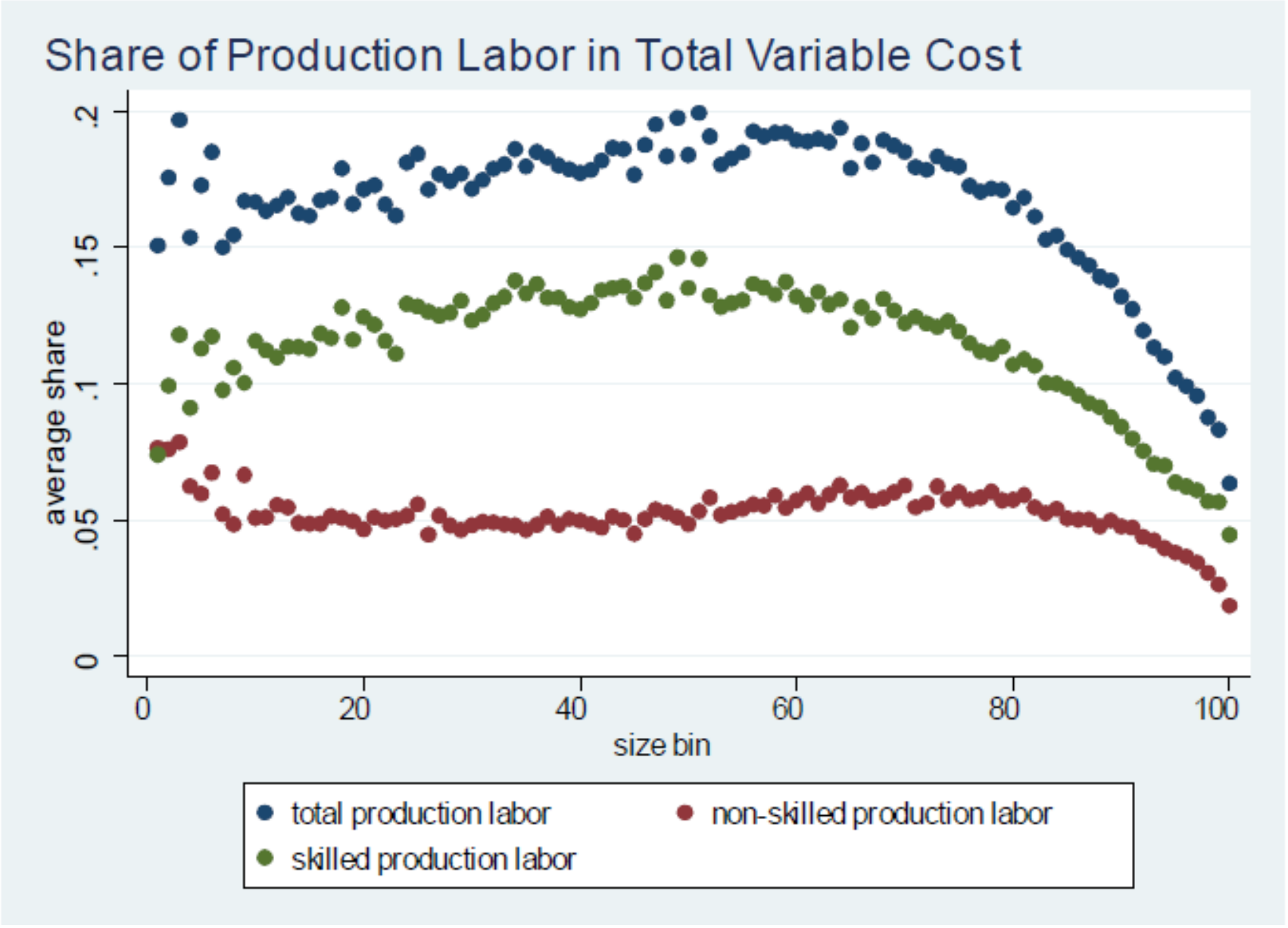
Outcomes	d_{ni}= 3.0; $\lambda_{n,k}$=0.5		d_{ni}= 1.5; $\lambda_{n,k}$=0.5		d_{ni}= 3.0; $\lambda_{n,k}$=0.7	
Endogenous wage	*country 1*	*country 2*	*country 1*	*country 2*	*country 1*	*country 2*
(no trade in non-mfg; no deficit in mfg)						
wage bill in mfg / total production cost	0.54	0.54	0.37	0.45	0.11	0.12
wage bill in mfg / GDP	0.23	0.23	0.22	0.23	0.22	0.23
wage bill in task 1 / wage bill in mfg	0.019	0.019	0.027	0.022	0.092	0.084
Exogenous wage						
(pinned down by productivity in non-manufacturing, with deficit in manufacturing: productivity in country 1 is 1.5 times that in country 2)						
wage bill in mfg / total production cost	0.51	0.54	0.11	0.5	0.05	0.13
wage bill in mfg / GDP	0.21	0.24	0.06	0.35	0.14	0.29
wage bill in task 1 / wage bill in mfg	0.020	0.019	0.090	0.020	0.210	0.078

Embellishments

- Ultimately, we want to estimate parameters from micro data
- ... and calibrate to aggregate data, such as trade shares
- Successes:
  - Distribution of purchases over total production (variable) costs
  - Distribution of imports over total production costs
  - Shape of imports similar to that of exports (through size/efficiency)


Share of Intermediates in Total Variable Cost
average share
.8
.85
.9
.95
0
20
40
60
80
100
size bin


Share of Imports in Total Intermediates
average share
0
.05
.1
.15
.2
.25
0
20
40
60
80
100
size bin


Share of Production Labor in Total Variable Cost
average share
0
.05
.1
.15
.2
0
20
40
60
80
100
size bin
total production labor
non-skilled production labor
skilled production labor

- Failures:
  - Large firms tend to purchase more intermediates (as a share of prod. costs)
  - Large firms tend to import more (as a share of intermediates)
  - Individual purchases (imports) as a share of prod. costs fall with number of suppliers
  - Large firms are more complex, with more skilled overhead...

- Potential solutions; Introduce firm types:
  - Type 1: small number of tasks limited to local suppliers, Low Fixed Costs

- Type 2...
- Type 73: large number of tasks buying potentially from everywhere, High Fixed Costs