Firm-to-Firm Trade:

Imports, Exports, and the Labor Market

Jonathan Eaton, Samuel Kortum, Francis Kramarz, and Raul Sampognaro

CREST, June 2013

Cowles Conference
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


Imports and Sales in France

Sales in France and Imports

Sales in France and # of Partners

Sales in France and # Importers

Distr. of sales in France

- Average sales in France vs. minimum number of sourcing countries
- Average sales in France vs. # firms importing from k or more markets
- Average sales in France vs. # firms importing from the market
- Percentile of sales in France vs. # firms selling to the market
### Distribution of Variables

<table>
<thead>
<tr>
<th></th>
<th>Administrative Labor Costs</th>
<th>Commercial Labor Costs</th>
<th>Engineering/R&amp;D Labor Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1+Total Overhead Labor Costs)</td>
<td>(1+Total Overhead Labor Costs)</td>
<td>(1+Total Overhead Labor Costs)</td>
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<tr>
<td>Q1</td>
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<td>0.0000</td>
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<tr>
<td>P90</td>
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<td>P95</td>
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<table>
<thead>
<tr>
<th></th>
<th>Total Purchases</th>
<th>Total Purchases in France</th>
<th>Total Imports of Goods</th>
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<tr>
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<td>P95</td>
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</table>
### Share of Imports in Total Production Costs

#### Individual Shares

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3 to 4</th>
<th>5 to 8</th>
<th>9 to 16</th>
<th>17 to 32</th>
<th>33 to 64</th>
<th>65 to 128</th>
<th>129 and more</th>
<th>Aggregate (incl. zeroes)</th>
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<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.0647</td>
<td>0.0532</td>
<td>0.0380</td>
<td>0.0253</td>
<td>0.0164</td>
<td>0.0105</td>
<td>0.0062</td>
<td>0.0037</td>
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<tr>
<td><strong>StdDev</strong></td>
<td>0.1358</td>
<td>0.1127</td>
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<td>0.0502</td>
<td>0.0372</td>
<td>0.0256</td>
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<td><strong>Q1</strong></td>
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<tr>
<td><strong>Med</strong></td>
<td>0.0121</td>
<td>0.0102</td>
<td>0.0070</td>
<td>0.0042</td>
<td>0.0023</td>
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<td>0.0006</td>
<td>0.0003</td>
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<tr>
<td><strong>Q3</strong></td>
<td>0.0504</td>
<td>0.0435</td>
<td>0.0293</td>
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<td>0.0103</td>
<td>0.0060</td>
<td>0.0030</td>
<td>0.0016</td>
<td>0.0004</td>
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<tr>
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<td>54,338</td>
<td>117,284</td>
<td>116,830</td>
<td>189,642</td>
<td>127,592</td>
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#### Aggregate Shares

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3 to 4</th>
<th>5 to 8</th>
<th>9 to 16</th>
<th>17 to 32</th>
<th>33 to 64</th>
<th>65 to 128</th>
<th>129 and more</th>
<th>Aggregate (zeroes excl.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.0647</td>
<td>0.1032</td>
<td>0.1248</td>
<td>0.1522</td>
<td>0.1876</td>
<td>0.2234</td>
<td>0.2564</td>
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<tr>
<td><strong>StdDev</strong></td>
<td>0.1358</td>
<td>0.1590</td>
<td>0.1667</td>
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<td><strong>Q1</strong></td>
<td>0.0030</td>
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<td>0.0335</td>
<td>0.0509</td>
<td>0.0734</td>
<td>0.1118</td>
<td>0.1565</td>
<td>0.1877</td>
<td>0.0275</td>
</tr>
<tr>
<td><strong>Med</strong></td>
<td>0.0121</td>
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<td>0.2046</td>
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<td><strong>Q3</strong></td>
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<td>3,844</td>
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### Employment and Labor Costs

<table>
<thead>
<tr>
<th></th>
<th>Employment (in logs)</th>
<th>Average Labor Costs (in logs)</th>
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<tbody>
<tr>
<td><strong>Intercept</strong></td>
<td>-2.5988</td>
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<tr>
<td><strong>Number of imported products (country*8-digit industry):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.0347</td>
<td>0.0106</td>
</tr>
<tr>
<td>2</td>
<td>-0.0055</td>
<td>0.0141</td>
</tr>
<tr>
<td>3 to 4</td>
<td>-0.0048</td>
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</tr>
<tr>
<td>5 to 8</td>
<td>0.0055</td>
<td>0.0112</td>
</tr>
<tr>
<td>9 to 16</td>
<td>0.0663</td>
<td>0.0110</td>
</tr>
<tr>
<td>17 to 32</td>
<td>0.1456</td>
<td>0.0118</td>
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<tr>
<td>33 to 64</td>
<td>0.2456</td>
<td>0.0140</td>
</tr>
<tr>
<td>65 to 128</td>
<td>0.3046</td>
<td>0.0187</td>
</tr>
<tr>
<td>129 and more</td>
<td>0.4993</td>
<td>0.0256</td>
</tr>
<tr>
<td><strong>Number of exported products (country*8-digit industry):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.0723</td>
<td>0.0090</td>
</tr>
<tr>
<td>2</td>
<td>0.1088</td>
<td>0.0119</td>
</tr>
<tr>
<td>3 to 4</td>
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<td>0.0109</td>
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<td>5 to 8</td>
<td>0.2381</td>
<td>0.0109</td>
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<td>0.2617</td>
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<td>0.0124</td>
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<td>33 to 64</td>
<td>0.4663</td>
<td>0.0141</td>
</tr>
<tr>
<td>65 to 128</td>
<td>0.5539</td>
<td>0.0176</td>
</tr>
<tr>
<td>129 and more</td>
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<tr>
<td>engineering share in overhead labor</td>
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<tr>
<td>marketing share in overhead labor</td>
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<td>0.0055</td>
</tr>
<tr>
<td>log of French sales</td>
<td>0.6816</td>
<td>0.0016</td>
</tr>
</tbody>
</table>

**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: 1

- 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 \( \mu_i(z) = T_i z^{-\theta}, \theta > \sigma - 1 \)

- 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 \( c^\theta \)

- 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 \( \bar{c}_n \) 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 $k = 1, \ldots, K$
   - 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 $\beta_k$ 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:

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

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

- Hence, given $p$, the measure of firms in $n$ from $i$ with cost below $c$ is

$$\mu_{ni}(c|p) = T_i \left[ d_{ni} b_i(p) \right]^{-\theta} c^{\theta}$$

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

- We will show that \( F_i(p) = \left( \frac{p}{\bar{c}_i} \right)^\theta \), for \( p \leq \bar{c}_i \)
Hence $G_{k,i}(w_{k,i}) = 1 - e^{-\gamma_{k,i}w_{k,i}^\theta}$ is the probability of replacing task $k$ workers at wage $w_{k,i}$ with $\gamma_{k,i} = \lambda_{k,i}\bar{c}_i^{-\theta}$ capturing the strength of the outsourcing option.
Cost Distribution of Firms: 1

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

$$
\mu_{ni}(c) = \int_0^\infty \cdots \int_0^\infty \mu_{ni}(c \mid p) dG_{1,i}(p_{1,i}) \cdots dG_{K,i}(p_{K,i})
$$

$$
= T_i d_{ni} c^{\theta} \prod_{k=1}^{K} \left( \int_0^\infty \min \left\{ w_{k,i}, p_{k,i} \right\}^{-\theta \beta_k} dG_{k,i}(p_{k,i}) \right).
$$
Cost Distribution of Firms: II

- Assume $c_i \geq \max_k \{w_{k,i}\}$, so firms may pass on the option to outsource.

- Then, integral can be solved as:

$$\int_0^\infty \min \{w_{k,i}, p_{k,i}\}^{-\theta_k} e^{-\gamma_{k,i}w_{k,i}} dG_{k,i}(p_{k,i})$$

$$= w_{k,i}^{-\theta_k} e^{-\gamma_{k,i}w_{k,i}} + \Gamma_{k,i}^{\beta_k} \gamma(1 - \beta_k, \gamma_{k,i}w_{k,i})$$

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:

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

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

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

- The term $\Xi_i$ captures the cost-reducing effects of firm-to-firm trade

- In EKK, $\Xi_i = 1$ because $\gamma_{k,i} = 0$
Circling the Circle

- Assume intermediates are priced at marginal cost. Then,

\[
\mu_n(c) = \sum_{i=1}^{N} \mu_{ni}(c) = c^\theta \sum_{i=1}^{N} T_i d_{ni}^{-\theta} w_i^{-\theta} \Xi_i
\]

\[= \gamma_n c^\theta\]

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

\[
F_n(p) = \frac{\mu_n(p)}{\mu_n(\bar{c}_n)} = \left( \frac{p}{\bar{c}_n} \right)^\theta,
\]

- The cost threshold \( \bar{c}_n \) 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:

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

- So that \( \gamma_i = \frac{\gamma_{k,i}}{\bar{\lambda}_{k,i}} \) which satisfies a (well behaved) fixed point:

\[
\gamma_n = \sum_{i=1}^{N} T_i d_{ni}^{-\theta} w_i^{-\theta} \\
\prod_{k=1}^{K} \left[ e^{-\gamma_i \bar{\lambda}_{k,i} w_{k,i}^\theta} + (\gamma_i \bar{\lambda}_{k,i} w_{k,i}^\theta)^{\beta_k} \gamma (1 - \beta_k, \gamma_i \bar{\lambda}_{k,i} w_{k,i}^\theta) \right]
\]
Furthermore, denoting consumption of final goods $X_n^C$, the price index is:

$$P_n = \tilde{m} \left[ \frac{\theta}{\theta - (\sigma - 1)} \left( \frac{\sigma E_n}{X_n^C} \right)^{1-\theta/(\sigma-1)} \gamma_n \right]^{-1/\theta}$$
Micro and Macro Labor Share

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

$$1 - G_{k,i}(w_{k,i}) = \exp \left( -\gamma_i \lambda_{k,i} w_{k,i}^\theta \right)$$

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

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

$$\beta_i^M = \sum_{k=1}^{K} \beta_k \exp \left( -\gamma_i \lambda_{k,i} w_{k,i}^\theta \right)$$
• The share of labor payments to workers at task $k$ is:

$$s_{k,i} = \frac{\beta_k \exp \left( -\tau_i \bar{\lambda}_{k,i} \omega^\theta_{k,i} \right)}{\sum_{k'=1}^K \beta_{k'} \exp \left( -\tau_i \bar{\lambda}_{k',i} \omega^\theta_{k',i} \right)}$$
Trade Shares

- Having solved for the $\Xi_i$ we can then write

$$\gamma_n = \sum_{i=1}^{N} T_i (\bar{w}_i d_{ni})^{-\theta} \Xi_i$$

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

$$\pi_{ni} = \frac{\mu_{ni}(\bar{c}_n)}{\mu_n(\bar{c}_n)} = \frac{\Xi_i T_i (\bar{w}_i d_{ni})^{-\theta}}{\gamma_n}$$

$$= \frac{\Xi_i T_i (\bar{w}_i d_{ni})^{-\theta}}{\sum_{i'=1}^{N} \Xi_{i'} T_{i'} (\bar{w}_{i'} d_{ni'})^{-\theta}}.$$  

- Again, the term $\Xi_i$ 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, \( \Pi_i \) is profit. \( M \) stands for mfg workers engaged in production, \( F \) for fixed cost workers, \( N \) for non mfg workers

Denoting \( \alpha \) the share of GDP going to manufactures, then

\[ w_i^N L_i^N = (1 - \alpha)Y_i^A, \quad X_i^C = \alpha Y_i^A \]
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:

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

• 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*

**Outcomes**

<table>
<thead>
<tr>
<th></th>
<th>country 1</th>
<th>country 2</th>
<th>country 1</th>
<th>country 2</th>
<th>country 1</th>
<th>country 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>wage bill in mfg / total production cost</td>
<td>0.54</td>
<td>0.54</td>
<td>0.37</td>
<td>0.45</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>wage bill in mfg / GDP</td>
<td>0.23</td>
<td>0.23</td>
<td>0.22</td>
<td>0.23</td>
<td>0.22</td>
<td>0.23</td>
</tr>
<tr>
<td>wage bill in task 1 / wage bill in mfg</td>
<td>0.019</td>
<td>0.019</td>
<td>0.027</td>
<td>0.022</td>
<td>0.092</td>
<td>0.084</td>
</tr>
</tbody>
</table>

**Simulations**

<table>
<thead>
<tr>
<th></th>
<th>$d_{ni}=3.0; \lambda_{n,k}=0.5$</th>
<th>$d_{ni}=1.5; \lambda_{n,k}=0.5$</th>
<th>$d_{ni}=3.0; \lambda_{n,k}=0.7$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>country 1</td>
<td>country 2</td>
<td>country 1</td>
</tr>
<tr>
<td>wage bill in mfg / total production cost</td>
<td>0.51</td>
<td>0.54</td>
<td>0.11</td>
</tr>
<tr>
<td>wage bill in mfg / GDP</td>
<td>0.21</td>
<td>0.24</td>
<td>0.06</td>
</tr>
<tr>
<td>wage bill in task 1 / wage bill in mfg</td>
<td>0.020</td>
<td>0.019</td>
<td>0.090</td>
</tr>
</tbody>
</table>

**Endogenous wage**
*(no trade in non-mfg; no deficit in mfg)*

**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)*
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 Production Labor in Total Variable Cost

- **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