In Search of Trade Frictions

The Frank D. Graham Memorial Lecture

Princeton University
April 2019

Samuel Kortum
Yale University
An exploration based on

- “Firm-to-Firm Trade …”
  - joint with Jonathan Eaton and Francis Kramarz,
    - they’re not responsible for any false claims here!

- Valuable comments
  - Costas Arkolakis, Lorenzo Caliendo, Russell Cooper, Cecilia Fieler, Sharat Ganapati, Rod Ludema, …

- Invaluable research assistance
  - Etienne Guigue and Bella Yao
Gravity for German Exports, 2017

Imports From Germany Divided by GDP of Importer

Distance, in hundreds of kilometers
Basic Questions

- Fraction of n’s spending imported from i (trade share)
  \[
  \frac{X_{ni}}{X_n} = \pi_{ni}
  \]

- Why do trade shares vary so much?

- What type of friction drives that variation?

- Correlation with distance won’t answer this question
Typology of Trade Frictions

- **Type I**: Iceberg costs, Samuelson (1954)
  - freight costs, ad-valorem tariffs, etc.

- **Type II**: Fixed costs of exporting, Melitz (2003)
  - advertising investments, customizing products, etc.

- **Type III**: Search frictions, Chaney (2014)
  - customers (typically firms) ignorant of all that’s available
Bottom Line

- Models with only **Type I** and/or **Type II** frictions come up short

- **Type III** frictions square with new facts on the distribution of customers per French exporter

- Among EU countries, looks like **Type III** frictions could be dominant
Does it Matter?

- Need large Type I frictions to fit an order of magnitude variation in trade shares

- Take trade elasticity of 4, from Simonovska and Waugh (2014), and iceberg cost $d$

\[ 10^{-1} = d^{-4} \text{ implies } d = 1.78 \]

- ... 80% cost increase, inconsistent with data on tariffs, freight rates, or cross-country price differentials for the same good

- Broader interpretation of trade frictions may resolve this tension
Outline of Talk

1. Describe evolution of firm-level trade models, driven by micro data

2. Introduce stripped-down version of firm-to-firm trade model, with search

3. Use it to reveal evidence of Type III frictions

4. Demonstrate the potential importance of such frictions for bilateral trade shares
Part I

• Micro data and evolution of models
  - Implications for trade frictions
Model Evolution

- Eaton, Kortum, and Kramarz (2011)
- Eaton, Kortum, and Kramarz (2019)
Model Evolution

- Eaton, Kortum, and Kramarz (2011)
- Eaton, Kortum, and Kramarz (2019)

All operate in general equilibrium, disciplined by macro trade shares …

\[ \pi_{ni} = \frac{X_{ni}}{X_n} \]
Type I, BEJK (2003)

- Add firms (imperfect competition) to Ricardian model of EK (2002)

\[
\pi_{ni} = \frac{d_{ni}^{-\theta} T_i w_i^{-\theta}}{\sum_{i'} d_{ni'}^{-\theta} T_{i'} w_{i'}^{-\theta}}
\]

Type I friction
Type I, BEJK (2003)

- Add firms (imperfect competition) to Ricardian model of EK (2002)

\[
\pi_{ni} = \frac{d_{ni}^{-\theta}T_i w_i^{-\theta}}{\sum_{i'} d_{ni'}^{-\theta}T_{i'} w_{i'}^{-\theta}}
\]

- Incorporating these trade shares, we can simulate a firm in country i producing some good j
  - will it export? what will it earn? how productive will it be?

- Successfully matched facts about US exporters
Coming up Short

- BEJK also makes a stark prediction for firms exporting to n from i, as a ratio to market share

\[ \frac{N_{ni}}{\pi_{ni}} = \alpha \]
Coming up Short

- BEJK also makes a stark prediction for firms exporting to \( n \) from \( i \), as a ratio to market share

\[
\frac{N_{ni}}{\pi_{ni}} = \alpha
\]

- Several years later we could evaluate with 1986 data from Francis Kramarz on French exporters
  - ... now, using OECD data for 2012, we can examine other exporting countries too

- Plotting against market size, this ratio is not flat!
French Exporters, 1986

Panel B: Normalized Entry

entry normalized by French market share

market size ($ billions)
German Exporters, 2012

Exports Divided by Market Share ($/\Pi$) vs. Market Size ($\text{billions}$)

[Graph showing the relationship between exports divided by market share and market size for various countries in 2012.]
Lithuanian Exporters, 2012

![Graph showing Lithuanian Exporters with market size on the x-axis and exporters divided by market share on the y-axis. The graph includes various country codes such as LVA, EST, SVN, ROU, GRC, etc.]
Type II, EKK (2011)

- Melitz (2003) model, with fixed costs (Type II frictions) explains why exporters flock to large markets

- Convenient Pareto parameterization of Chaney (2008)

\[ \mu_i^Z(z) = T_i z^{-\theta} \]

- … Type I frictions produce a parallel shift in measure of firms from \( i \) that can supply \( n \) at a cost below \( c \)

\[ \mu_{ni}(c) = d_{ni}^{-\theta} T_i w_i^{-\theta} c^\theta \]
Strengths

- If Type II frictions \( f \) vary only by destination, they drop out of the trade share equation

\[
\pi_{ni} = \frac{\mu_{ni}(c)}{\mu_n(c)} = \frac{d^{-\theta}_n T_i w_i^{-\theta}}{\sum_{i'} d^{-\theta}_{ni'} T_{i'} w_{i'}^{-\theta}}
\]

- Number of exporters by destination

\[
\frac{N_{ni}}{\pi_{ni}} = \frac{X_n}{\alpha \frac{f_n}{f}}
\]

- … increases in market size if \( X/f \) rises with market size
Backing out **Type II Frictions**

- The OECD data show variation in sales per exporter, which the model attributes to **Type II frictions**.
Back out **Type II Frictions**

- The OECD data show variation in sales per exporter, which the model attributes to **Type II frictions**
- We can simply back out these frictions as

\[ f_{ni} = \alpha \frac{X_{ni}}{N_{ni}} \]

- Striking correlation with bilateral trade shares …
Type II Frictions

Graph showing the relationship between bilateral fixed costs (source and destination effects removed) and bilateral trade shares (with source and destination effects removed).
Coming up Short

In this setting, bilateral trade shares become

- ... with CES demand elasticity $\sigma$

\[ \tilde{\theta} = \frac{\theta}{(\sigma - 1)} > 1 \]

\[ \pi_{ni} = \frac{d_{ni}^{-\theta} f_{ni}^{-\tilde{\theta}(\tilde{\theta} - 1)} T_{i} w_{i}^{-\theta}}{\sum_{i'} d_{ni'}^{-\theta} f_{ni'}^{-\tilde{\theta}(\tilde{\theta} - 1)} T_{i'} w_{i'}^{-\theta}} \]

- Now require even more variation in Type I frictions
Type III, EKK (2019)

Granular theory of trade with search frictions, developed throughout the remainder of today’s talk.

- Incorporates Type I and Type III trade frictions
  - eschewing Type II

- Shares the strengths and accounts for the shortcomings of earlier models
  - ... as we’ll see
Part II

- Firm-to-Firm Trade, with Eaton and Kramarz
  - stripped down
Provenance

- Close cousin to recent theories of individuals or firms interacting to exchange goods or technologies
  - Lucas (2009), Lucas and Moll (2014), and Oberfield (2018)

- In the spirit of Arkolakis (2011), with firms reaching individual consumers in foreign markets
  - but here integers are key

- Most like Chaney (2018) and Lim (2018)
  - but no dynamics

- EK and Melitz work together in this model
Motivation via Customer Data

- French exports to 24 other EU countries in 2005
  - and purchases by individual customers (from VAT)

- From Kramarz, Martin, and Mejean (2015)
  - Bernard, Moxnes, and Ulltveit-Moe (2017) have something similar for Norway
  - Lenoir, Martin, and Mejean (2019) consider the product level as well, interpreted using our firm-to-firm model
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- New concept (for us) relationships

\[ R_{nF} = \bar{b}_{nF} N_{nF} \]
Exporters and Relationships

France

exporter 1

exporter 2

exporter 3

buyers

Germany

Lithuania
Exporters and Relationships

France

exporter 1
exporter 2
exporter 3

buyers

Germany
Lithuania

$N_{GF} = 3$
$R_{GF} = 6$
$\bar{b}_{GF} = 2$

$N_{LF} = R_{LF} = 1$
Basic Regressions

$$\ln N_{nF} = -1.27 + 0.47 \ln X_n + 0.65 \ln \pi_{nF}$$
\[ (0.63) \quad (0.04) \quad (0.11) \]

$$\ln R_{nF} = -2.71 + 0.81 \ln X_n + 1.02 \ln \pi_{nF}$$
\[ (1.06) \quad (0.06) \quad (0.19) \]

$$N = 24, \ R^2 = 0.92$$
Basic Regressions

\[
\ln N_{nF} = -1.27 + 0.47 \ln X_n + 0.65 \ln \pi_{nF}
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(1.06) \quad (0.06) \quad (0.19)
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\[
N = 24, \quad R^2 = 0.92
\]
Overview

- Buyers and sellers meet randomly as in Mortensen and Pissarides (1994)

- **As buyers:** firms seek suppliers to carry out intermediate tasks for production
  - ... or to serve final customers
  - Buy from the lowest cost seller they encounter, and they will always find one

- **As sellers:** firms seek customers, but may fail to find one in any given market
Search Frictions

- Potential exporter in i (cost c) meets buyer in n with intensity

\[ \lambda_{ni}(c) = \lambda_{ni}B_n^{-\phi}S_n(c)^{-\gamma} \]

- B is measure of buyers

- S(c) is the measure of suppliers with cost below c, from anywhere, weighted by inverse Type III frictions
  - Supplier congestion favors low-cost exporters

- Increasing returns in matching if \( \phi + \gamma < 1 \)
Production

- Potential producers in $i$ with efficiency $> z$
  \[ \mu^Z_i(z) = T_i z^{-\theta} \]

- ... who are able to sell in $n$ at cost $< c$
  \[ \mu_{ni}(c) = d_{ni}^{-\theta} T_i \Xi_i c^\theta \]

- Fixed point of firm-to-firm trade
  \[ \Xi_i = \bar{g} \omega_i^{-\theta \beta} \left( \frac{B_i^{-\varphi}}{1 - \gamma} \sum_{i'} \lambda_{ii'} d_{ii'}^{-\theta} T_i \Xi_i \right)^{1 - \beta} \]
Buyer Choosing a Supplier

At any cost \(< c\), the number of suppliers from \(i\) that a buyer meets is Poisson, with mean

\[
\rho_{ni}(c) = \int_0^c \lambda_{ni}(c') d\mu_{ni}(c')
\]
Buyer Choosing a Supplier

- At any cost $< c$, the number of suppliers from $i$ that a buyer meets is Poisson, with mean

$$\rho_{ni}(c) = \int_{0}^{c} \lambda_{ni}(c')d\mu_{ni}(c')$$

- Summing over source-countries $i$, Poisson mean

$$\rho_{n}(c) = \frac{1}{1 - \gamma}B_{n}^{-\phi}S_{n}(c)^{1-\gamma}$$
Buyer Choosing a Supplier

• At any cost \( < c \), the number of suppliers from \( i \) that a buyer meets is Poisson, with mean

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\]

• Summing over source-countries \( i \), Poisson mean

\[
\rho_n(c) = \frac{1}{1 - \gamma} B_n^{-\phi} S_n(c)^{1-\gamma}
\]

• Fraction of suppliers from \( i \) is the trade share

\[
\pi_{ni} = \frac{\rho_{ni}(c)}{\rho_n(c)} = \frac{\lambda_{ni}d_{ni}^{-\theta}T_i\Xi_i}{\sum_{i'} \lambda_{ni'}d_{ni'}^{-\theta}T_{i'}\Xi_i'}
\]
Seller Finding Customers

- Number of customers, for seller with cost c from country i, is Poisson with mean

\[ \eta_{ni}(c) = \lambda_{ni}(c)B_ne^{-\rho_n(c)} \]

- Empirical implications flow from this expression
Aggregate

• Measure of exporters

\[ N_{ni} = \int_0^\infty \left( 1 - e^{-n_{ni}(c)} \right) d\mu_{ni}(c) \]
Aggregate

- Measure of exporters

\[ N_{ni} = \int_{0}^{\infty} \left( 1 - e^{-\eta_{ni}(c)} \right) d\mu_{ni}(c) \]

- Measure of relationships

\[ R_{ni} = \int_{0}^{\infty} \eta_{ni}(c) d\mu_{ni}(c) \]
Relationships

- They integrate!

\[ R_{ni} = \pi_{ni} B_n \]

- Theory reproduces a feature of basic relationships regression, with coefficient of 1 on market share
Relationships

\( R_{ni} = \pi_{ni}B_n \)

- They integrate!
- Theory reproduces a feature of basic relationships regression, with coefficient of 1 on market share
  - Coefficient on market size likely reflects increasing returns in matching, but just beginning to formalize that
They integrate!

\[ R_{ni} = \pi_{ni} B_n \]

Theory reproduces a feature of basic relationships regression, with coefficient of 1 on market share

- Coefficient on market size likely reflects increasing returns in matching, but just beginning to formalize that

Exporters are more subtle …
Exporters

- Simplify with a change of variable

\[ N_{ni} = \pi_{ni}B_n \frac{1}{\tilde{\lambda}_{ni}} \int_0^\infty \left( 1 - e^{-\tilde{\lambda}_{ni}\eta(x)} \right) dx = R_{ni}f(\tilde{\lambda}_{ni}) \]

\[ \eta(x) = x^{-\gamma} e^{-\frac{1}{1-\gamma}x^{1-\gamma}} \]

- Scale-adjusted search parameter

\[ \tilde{\lambda}_{ni} = \lambda_{ni}B_n^{1-\varphi/(1-\gamma)} \]
Exporters

- Simplify with a change of variable

\[
N_{ni} = \pi_{ni}B_n \frac{1}{\tilde{\lambda}_{ni}} \int_0^\infty \left( 1 - e^{-\tilde{\lambda}_{ni}\eta(x)} \right) dx = R_{ni}f(\tilde{\lambda}_{ni})
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\[
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\]

- Given R, exporters decline in search parameter
  
  - Globalization and concentration go hand in hand

In Search of Trade Frictions
Customers of an Exporter

• Measure of exporters with exactly k customers in n

\[ N^{(k)}_{ni} = R_{ni} \frac{1}{\tilde{\lambda}_{ni}} \int_0^\infty \frac{1}{k!} \left( \tilde{\lambda}_{ni} \eta(x) \right)^k e^{-\tilde{\lambda}_{ni} \eta(x)} dx \]

• Fraction of exporters with exactly exactly k

\[ P^{(k)}_{ni} = \frac{\int_0^\infty \frac{1}{k!} \left( \tilde{\lambda}_{ni} \eta(x) \right)^k e^{-\tilde{\lambda}_{ni} \eta(x)} dx}{\int_0^\infty \left( 1 - e^{-\tilde{\lambda}_{ni} \eta(x)} \right) dx} \]
Part III

- Evidence of Type III Frictions
  - From 2005 data on customers of French exporters
Backing out Search Frictions

\[ f(\tilde{\lambda}) = \frac{1}{\tilde{\lambda}} \int_{0}^{\infty} \left( 1 - e^{-\tilde{\lambda} \eta(x)} \right) dx \]
Backing out Search Frictions

\[ f(\tilde{\lambda}) = \frac{1}{\tilde{\lambda}} \int_0^\infty \left( 1 - e^{-\tilde{\lambda} \eta(x)} \right) dx \]
Backing out Search Frictions

\[ f(\tilde{\lambda}) = \frac{1}{\tilde{\lambda}} \int_{0}^{\infty} \left( 1 - e^{-\tilde{\lambda} \eta(x)} \right) dx \]
Evaluation on French Data

- Step 1: Take supplier congestion, common to all destinations, from our earlier estimates $\gamma = 0.4$
- Step 2: Back out scale-adjusted search parameter, to match mean customers per exporter, for each of the 24 EU destinations $\tilde{\lambda}_{nF}$
- Step 3: Compute the distribution of customers per exporter in each of the 24 EU destinations $P_{nF}^{(k)}$
- Plot the Type III frictions, then evaluate fit for distributions of customers per exporter ...
Implied inverse **Type III Frictions**
Customers of French Exporters

Lithuania: \(\gamma = 0.4\)
Customers of French Exporters

Germany: $\gamma = 0.4$

Fraction of exporters with that number of customers vs. Number of customers.
Customers of French Exporters

Fraction of French Exporters with Corresponding Relationships
Part IV

- Contribution of Type III frictions
  - Using 2012 OECD data
Back to the OECD Data

- French data are, of course, limited to $i = F$
- To assess the contribution of Type III frictions, need a matrix across source $i$ and destination $n$
- EU countries in 2012, industry less construction
- Bilateral exporters $N$ and intra-EU exporters $E$ (and matching trade volumes)
Identification Strategy

- No relationships data, so need to estimate

\[ R_{ni} = \pi_{ni} B_n = \pi_{ni} \alpha_0 X_n^{\alpha_1} \]

**Stick with \( \gamma = 0.4 \)**

- Back out **Type III** frictions, just identified given conjectured relationships
  - Model implies **Type I** frictions act only via trade shares
Identification Strategy

- No relationships data, so need to estimate

\[ R_{ni} = \pi_{ni}B_n = \pi_{ni}\alpha_0X_n^{\alpha_1} \]

Stick with \( \gamma = 0.4 \)

- Back out Type III frictions, just identified given conjectured relationships
  - Model implies Type I frictions act only via trade shares

- Identify two remaining parameters by minimizing deviations from intra-EU exporters
Model Equations

- Bilateral exporters

\[
\frac{N_{ni}}{R_{ni}} = \frac{1}{\tilde{\lambda}_{ni}} \int_{0}^{\infty} \left( 1 - e^{-\tilde{\lambda}_{ni} \eta(x)} \right) dx
\]

- Intra-EU exporters

\[
E_i = \int_{0}^{\infty} \left( 1 - e^{-\tilde{\eta}_i(y)} \right) dy
\]

\[
\tilde{\eta}_i(y) = \sum_{n \neq i} \tilde{\lambda}_{ni} \left( \frac{\tilde{\lambda}_{ni}}{R_{ni} y} \right)^{-\gamma} e^{-\frac{1}{1-\gamma} \left( \frac{\tilde{\lambda}_{ni}}{R_{ni} y} \right)^{1-\gamma}}
\]
Preliminary Findings

- Implied measure of buyers (estimate of alpha’s)

\[ B_n = 601.4 \times X_n^{0.639} \]

- How well do we fit bilateral and intra-EU exporters?
German Exporters

![Graph showing German Exporters with countries labeled on the x-axis and y-axis, and a linear trend line]

- Prediction on Intra-EU exporter
- Intra-EU exporters

Countries: Flip, EUS, MLT, CYP, IRL, LTU, EST, LVA, GRC, LUX, SVN, SMK, ESP, GBR, AUT, NLD, NLD

Note: The graph illustrates the relationship between German exporters and other EU countries, with a focus on intra-EU trade volumes.
Lithuanian Exporters

Graph showing the relationship between Intra-EU exporters and prediction on Intra-EU exporter, with a log-log scale.
Decomposition of Trade Frictions

- Recall bilateral trade shares depend on both types of trade frictions

\[ \pi_{ni} = \frac{\tilde{\lambda}_{ni}d_{ni}^{-\theta}T_i\Xi_i}{\sum_{i'} \tilde{\lambda}_{ni'}d_{ni'}^{-\theta}T_{i'}\Xi_{i'}} \]

- Want to distinguish the role of Type III vs. Type I

- Inverse Type III frictions are highly correlated with trade shares, reducing the role of Type I

- Projecting each on source and destination fixed effects …
Type III Frictions (Inverse)
Type III Frictions are Dominant?

- Regress \( \ln \tilde{\lambda}_{ni} \) on \( \ln \pi_{ni} \)
  - including a full set of source and destination-country effects

- Amounts to regressing \( \ln \lambda_{ni} \) on \( \ln \lambda_{ni} d_{ni}^{-\theta} \)

- OLS slope coefficient:

\[
\hat{\beta} = \frac{\text{Var}(\ln \lambda_{ni}) + \text{Cov}(\ln \lambda_{ni}, \ln d_{ni}^{-\theta})}{\text{Var}(\ln \lambda_{ni}) + \text{Var}(\ln d_{ni}^{-\theta}) + 2\text{Cov}(\ln \lambda_{ni}, \ln d_{ni}^{-\theta})}
\]

- Ignoring the covariance, a slope close to 0 means Type I frictions dominate; a slope close to 1 means Type III frictions dominate

- Regression Table 1 …
# Regression Table 1

<table>
<thead>
<tr>
<th></th>
<th>Log($\hat{\lambda}_{ni}$)</th>
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<tbody>
<tr>
<td>Log($\pi_{ni}$)</td>
<td><strong>1.04</strong>*</td>
<td><strong>0.99</strong>*</td>
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<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
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<tr>
<td>Log(Distance)</td>
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<td>-1.41***</td>
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<td>0.69***</td>
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<td></td>
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<td>(0.10)</td>
<td>(0.14)</td>
<td>(0.09)</td>
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<tr>
<td>Constant</td>
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<td><strong>8.86</strong>*</td>
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<td><strong>10.06</strong>*</td>
<td><strong>7.89</strong>*</td>
<td><strong>6.11</strong>*</td>
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<tr>
<td></td>
<td>(0.47)</td>
<td>(0.22)</td>
<td>(0.92)</td>
<td>(0.82)</td>
<td>(0.64)</td>
<td>(0.42)</td>
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<td>Observations</td>
<td>575</td>
<td>90</td>
<td>575</td>
<td>90</td>
<td>575</td>
<td>90</td>
</tr>
<tr>
<td>Dest. and source F.E.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Selected markets</td>
<td>All¹</td>
<td>10 largest</td>
<td>All¹</td>
<td>10 largest</td>
<td>All¹</td>
<td>10 largest</td>
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<tr>
<td>$R^2$</td>
<td>0.86</td>
<td>0.99</td>
<td>0.63</td>
<td>0.93</td>
<td>0.87</td>
<td>0.99</td>
</tr>
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</table>

¹ We drop 25 observations where we do not fit bilateral exporters $N_{ni}$.

OECD data 2012; Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.  

---
A More Nuanced Picture

› If Type III frictions are dominant
  - our estimates of them are noisy!

› We haven’t killed distance, yet, but progress
  - when we limit the sample to the 10 largest economies

› Regression Table 2 …
## Regression Table 2

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<td>$R^2$</td>
<td>0.94</td>
<td>0.98</td>
<td>0.91</td>
<td>0.93</td>
<td>0.97</td>
<td>0.99</td>
</tr>
</tbody>
</table>

1 We drop 25 observations where we do not fit bilateral exporters $N_{ni}$.

OECD data 2012; Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. 
Conclusion

- **Type III** search frictions account for new facts
  - and appear to play a critical role in aggregate patterns of bilateral trade

- The stripped-down model of search frictions can be extended in many directions to ask new questions

- Jonathan Eaton, Francis Kramarz, and I are doing that in