Quality and Gravity in International Trade

FIW-Workshop "International Economics"

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- Quality and distance effect on exports?

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This project: Effect of quality differentiation on

- elasticity of trade flows with respect to variable and fixed costs?
- gravity equation of trade?

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Our contribution: Effect of distance on trade lower in industries with high quality differentiation (export flows and extensive margin)

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- **Empirics:** Estimation of gravity equations
  - Aggregate trade data: COMTRADE, NBER-UN $\Rightarrow$ trade flows
  - Firm-level data: Brazil, SECEX $\Rightarrow$ extensive margin

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  - Aggregate trade data: COMTRADE, NBER-UN $\Rightarrow$ trade flows
  - Firm-level data: Brazil, SECEX $\Rightarrow$ extensive margin
- **Parameter estimation:** Effects of trade liberalization
  - With vertical differentiation: effects on exports by 14% lower
  - Heterogeneous effects across industries: reduction between 2% and 31%

Intuition

Firm level: endogenous quality investment

- Increase in demand
- Endogenous sunk costs

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- High quality differentiation $\Leftrightarrow$ high returns on investment
- Highly productive firms: large quality investment

  $\Rightarrow$ Low productivity firms face stronger competition

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Aggregate level: effect of trade liberalization

- Lower trade barrier: entry of low productivity firms
- High quality differentiation: entrants relatively small

  $\Rightarrow$ Smaller effect on extensive margin and export flows

Outline

1. Theoretical model
2. Estimation of gravity equations
3. Parameter estimation
4. Conclusion

Utility function

- N countries, $i \in N$
- Homogenous good $j = 0$, differentiated goods industries with $j \geq 1$
- Upper-tier Cobb-Douglas utility:

$$U = \sum_{j=0}^{J} \beta_j \log X_j, \quad \sum_{j=0}^{J} \beta_j = 1, \beta_j \geq 0 \tag{1}$$

- Sub-utility (CES) for differentiated goods:

$$X_j = \left[\int_{\omega \in \Omega_j} \left(q_j(\omega) x_j(\omega) \right)^{\frac{\sigma_j - 1}{\sigma_j}} d\omega \right]^{\frac{\sigma_j}{\sigma_j - 1}}, \sigma_j > 1, j \geq 1 \tag{2}$$

- $q_j(\omega)$: quality of variety ω; $x_j(\omega)$: quantity of variety ω

Optimal demand

- One factor of production: labor L
  (mobile across industries, immobile across countries)
- Consumption on goods in industry j: $Y_j = \beta_j Y = \beta_j L$
- Homogenous good sector: $w_j = w = 1$
- Demand for one variety ω:

$$x_j(\omega) = A_j q_j(\omega)^{\sigma_j - 1} p_j(\omega)^{-\sigma_j} \quad , A_j = Y_j P_j^{\sigma_j - 1} \tag{3}$$

- Quality-adjusted aggregate price:

$$P_j = \left[\int_{\omega \in \Omega_j} \left(\frac{p_j(\omega)}{q_j(\omega)} \right)^{1-\sigma_j} d\omega \right]^{\frac{1}{1-\sigma_j}} \tag{4}$$

Firm's maximization problem

Quality investment

- Endogenous sunk costs: $f\left[q_j(\omega)\right] = \frac{q_j(\omega)^{\alpha_j}}{\alpha_j}$
- α_j: convexity of investment costs
- Production costs: $l_j(\omega) = f + \frac{q_j(\omega)^{\theta_j}}{\varphi} x_j(\omega)$
- $0 < \theta_j < 1$: sensitivity of marginal costs with respect to quality

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Profits of firm in country i and industry j:

$$\pi_{ij} = \sum_{n=1}^{N} \pi_{nij} = \sum_{n=1}^{N} 1_{\{x_{nij}>0\}} \left[p_{nij} x_{nij} - \tau_{ni} \frac{{q_{nij}}^{\theta_j}}{\varphi} x_{nij} - \frac{1}{\alpha_j} q_{nij}^{\alpha_j} - f_{ni} \right] \quad (5)$$

- $f_{ni} > 0$: export fixed costs, $\tau_{ni} \geq 1$, $\tau_{ii} = 1$

The role of quality differentiation

- Quality-price ratio:

$$\frac{q_{nij}}{p_{nij}} = \left[\left(1-\theta_j\right)^{1-\theta_j} A_{nj}^{1-\theta_j} \left(\frac{\sigma_j-1}{\sigma_j}\right)^{\alpha_j+1-\theta_j} \left(\frac{\varphi}{\tau_{ni}}\right)^{\alpha_j} \right]^{\frac{1}{\alpha_j-\left(\sigma_j-1\right)\left(1-\theta_j\right)}}$$

- Sales relative to marginal exporter: $\frac{s_{nij}(\varphi)}{s_{nij}(\varphi^*_{nij})} = \left(\frac{\varphi}{\varphi^*_{nij}}\right)^{\frac{\alpha_j\left(\sigma_j-1\right)}{\alpha_j-\left(\sigma_j-1\right)\left(1-\theta_j\right)}}$

- Scope for vertical product differentiation: $\frac{\frac{1}{\alpha_j} q_{nij}^{\alpha_j}(\varphi)}{s_{nij}(\varphi)} = \frac{1-\theta_j}{\alpha_j}\frac{\sigma_j-1}{\sigma_j}$

▸ Firm behavior ▸ Derivation

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- Sales relative to marginal exporter: $\frac{s_{nij}(\varphi)}{s_{nij}(\varphi^*_{nij})} = \left(\frac{\varphi}{\varphi^*_{nij}} \right)^{\frac{\alpha_j (\sigma_j - 1)}{\alpha_j - (\sigma_j - 1)(1-\theta_j)}}$

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▸ Firm behavior ▸ Derivation

If scope for vertical differentiation is high (low α), high productivity firms:

- invest relatively more in (price-adjusted) quality,
- are relatively larger compared to low productivity firms.

$\Rightarrow$ Low productivity firms face stronger competition

Gravity equation

- Gravity equation:

$$S_{nij} = \frac{1 - G_{ij}\left(\varphi^*_{nij}\right)}{1 - G_{ij}\left(\varphi^*_{iij}\right)} M_{ij} \int_{\varphi^*_{nij}}^{\infty} s_{nij}(\varphi) \frac{g_{ij}(\varphi)}{1 - G_{ij}\left(\varphi^*_{nij}\right)} d\varphi \qquad (6)$$

- Pareto distribution of productivity: $g_{ij}(\varphi) = \xi_j \varphi^{-\xi_j - 1}$

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- Pareto distribution of productivity: $g_{ij}(\varphi) = \xi_j \varphi^{-\xi_j - 1}$
- Gravity equation with Pareto distributed productivity:

$$S_{nij} = \frac{S_{ij}}{\Xi_{ij}} \left(\frac{Y_n}{P_n^{1-\sigma_j}} \right)^{\frac{\xi_j}{\sigma_j - 1}} \tau_{ni}^{-\xi_j} f_{ni}^{\frac{\alpha_j\left(\sigma_j - 1\right) - \xi_j\left[\alpha_j - \left(\sigma_j - 1\right)\left(1 - \theta_j\right)\right]}{\alpha_j\left(\sigma_j - 1\right)}} \tag{7}$$

- Exporter-industry FE: $\frac{S_{ij}}{\Xi_{ij}}$; Importer-industry FE: $\left(\frac{Y_n}{P_n^{1-\sigma_j}} \right)^{\frac{\xi_j}{\sigma_j - 1}}$

▸ Gravity ▸ Estimation

Prediction 1

- Effect of fixed trade costs on aggregate trade flows:

$$\frac{d \ln S_{nij}}{d \ln f_{ni}} = \underbrace{1 - \frac{\xi_j}{\sigma_j - 1}}_{\text{Chaney (2008)}} + \underbrace{\frac{\xi_j \left(1 - \theta_j\right)}{\alpha_j}}_{\text{Quality effect}} \tag{8}$$

- Scope for vertical product differentiation:

$$\frac{\frac{1}{\alpha_j} q_{nij}^{\alpha_j}(\varphi)}{s_{nij}(\varphi)} = \frac{1 - \theta_j}{\alpha_j} \frac{\sigma_j - 1}{\sigma_j}$$

Prediction 1: The elasticity of trade flows with respect to fixed trade costs is lower in industries with high scope for vertical differentiation.

Prediction 2

- Effect of fixed trade costs on share of exporters:

$$\frac{d \ln \gamma_{nij}}{d \ln f_{ni}} = \underbrace{-\frac{\xi_j}{\sigma_j - 1}}_{\text{Chaney (2008)}} + \underbrace{\frac{\xi_j \left(1 - \theta_j\right)}{\alpha_j}}_{\text{Quality effect}} \tag{9}$$

- Scope for vertical product differentiation: Back to data

$$\frac{\frac{1}{\alpha_j} q_{nij}^{\alpha_j}(\varphi)}{s_{nij}(\varphi)} = \frac{1 - \theta_j}{\alpha_j} \frac{\sigma_j - 1}{\sigma_j}$$

Prediction 2: The elasticity of the share of exporters with respect to fixed trade costs is lower in industries with high scope for vertical differentiation.

Data sources

1. Trade data
   - Aggregate data: Bilateral world trade flows by SITC 4-digit from COMTRADE and NBER-UN
   - Brazilian firm-level data from SECEX (Foreign Trade Secretariat)

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   - Aggregate data: Bilateral world trade flows by SITC 4-digit from COMTRADE and NBER-UN
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2. Industry-level degree of quality differentiation (4-digit)
   - "Quality ladder" from Khandelwal (2010) ▸ Quality ladder
     - "*ladder* increases if price can rise without losing market share."
   - R&D intensity from Kugler & Verhoogen (2012) ▸ R&D intensity
   - Gollop-Monahan (1991) index: horizontal differentiation ▸ Gollop Index

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3. Variable and fixed trade costs
   - Variable: Tariff data from TRAINS-WTI
   - Fixed: Bilateral distance and language from CEPII and administrative barriers from WB "Trading Across Borders".

Summary statistics

Table: Summary statistics

Variable	Obs	Mean	Std. Dev.
Sample for the analysis using bilateral world trade data, year 2000			
$\ln S_{nij}$	420,849	6.903	1.744
$\ln Dist_{ni}$	420,849	8.132	1.103
$Language_{ni}$	420,849	0.154	0.361
$ladder_j$	420,849	1.904	0.701
R&D intensity	88,789	0.031	0.022
Gollop Monahan (GM) index	88,789	0.492	0.137
$\ln t\_border_{ni}$	374,349	3.777	1.41
$\ln t\_doc_{ni}$	425,407	2.771	1.721
Sample for the analysis of the share of Brazilian firms, year 2000			
Share of firms γ_{nj}	60,029	0.126	0.113
$\ln Dist_n$	60,029	8.603	0.751
$ladder_j$	60,029	1.756	0.625
R&D intensity	14,333	0.028	0.016
GollopMonahan index	14,333	0.51	0.103

Empirical strategy

Log-linearized gravity equation: ▸ Gravity

$$\ln S_{nij} = -\xi_j \ln \tau_{ni} + \left[1 - \frac{\xi_j}{\sigma_j - 1} + \frac{\xi_j(1-\theta_j)}{\alpha_j}\right] \ln f_{ni} + \ln\left(\frac{S_{ij}}{\Xi_{ij}}\right) + \frac{\xi_j}{\sigma_j - 1} \ln\left(\frac{Y_n}{P_n^{1-\sigma_j}}\right)$$

Test of Prediction 1: $\beta_1 < 0,\ \beta_2 > 0$

$$\ln S_{nij} = \beta_1 fixedcosts_{ni} + \beta_2 fixedcosts_{ni} * \ln ladder_j + x_{nij} + \rho_{ij} + \mu_{nj} + \varepsilon_{nij}$$

- $fixedcosts_{ni}$ = e.g. language, bilateral distance (controlling for variable trade costs)
- $ladder_j$ = degree of quality differentiation in industry j
- x_{nij} = gravity covariates, tariffs
- ρ_{ij} and μ_{nj}= exporter-industry and importer-industry fixed effects

Results: distance and aggregate trade flows

Table: Fixed costs and aggregate trade flows

Dependent variable $\ln S_{nij}$	(1)	(2)	(3)	(4)	(5)	(6)
$\ln Dist_{ni}$	-0.938***		-0.956***		-0.956***	
	(0.0221)		(0.0284)		(0.0284)	
$\ln Dist_{ni} * ladder_j$	**0.0431*** **	**0.0496*** **	**0.100*** **	**0.105*** **	**0.100*** **	**0.105*** **
	(0.00447)	**(0.00425)**	**(0.0122)**	**(0.0122)**	**(0.0122)**	**(0.0122)**
τ_{nij}			-0.564**	-0.679***	-0.830**	-0.710**
			(0.220)	(0.206)	(0.337)	(0.339)
$\tau_{nij} * ladder_j$					0.515	0.0603
					(0.518)	(0.554)
Constant	yes	yes	yes	yes	yes	yes
Industry-importer fixed effects	yes	yes	yes	yes	yes	yes
Industry-exporter fixed effects	yes	yes	yes	yes	yes	yes
Importer-exporter fixed effects	no	yes	no	yes	no	yes
Observations	420,849	420,849	159,486	159,039	159,486	159,039
R-squared	0.626	0.707	0.656	0.720	0.656	0.720

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

▸ Estimation results ▸ Further proxies for fixed costs

Empirical strategy

Log-linearized version for share of exporters:

$$\ln \gamma_{nij} = -\xi_j \ln \tau_{ni} - \xi_j \left(\frac{1}{\sigma_j - 1} - \frac{1-\theta_j}{\alpha_j} \right) \ln \left(\frac{f_{ni}}{f_{nn}} \right)$$

Test of Prediction 2: $\beta_1 < 0,\ \beta_2 > 0$

$$\ln \gamma_{nj} = \beta_1 fixedcosts_n + \beta_2 fixedcosts_n * \ln ladder_j + \nu_j + \varepsilon_{nj}$$

- $fixedcosts_n$ = e.g. bilateral distance between Brazil and destination n (controlling for tariffs and additive trade costs)
- $ladder_j$ = degree of quality differentiation in industry j
- v_j = industry fixed effects

Results: distance and share of exporters

Table: Fixed costs and the share of exporters

Dependent variable: γ_{nj}	(1)	(2)	(3)	(4)	(5)	(6)
$\ln Dist_n$	-0.0676***		-0.0579***		-0.0574***	
	(0.00398)		(0.00418)		(0.00420)	
$\ln Dist_n * ladder_j$	**0.00988*** **	**0.0105*** **	**0.00539** **	**0.00669*** **	**0.00509** **	**0.00648*** **
	(0.00209)	**(0.00215)**	**(0.00222)**	**(0.00216)**	**(0.00232)**	**(0.00224)**
τ_{nj}			-0.0235	-0.0243	0.0154	-0.0143
			(0.0277)	(0.0277)	(0.0202)	(0.0420)
$\tau_{nj} * ladder_j$					-0.00435	-0.00602
					(0.0348)	(0.0221)
Constant	yes	yes	yes	yes	yes	yes
Importer fixed effects	no	yes	no	yes	no	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Observations	60,032	60,032	30,646	30,646	30,646	30,646
R-squared	0.472	0.490	0.553	0.566	0.553	0.566

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by 4-digit industry.

▸ Further proxies for fixed costs

Robustness checks

- **R&D intensity and the GM index for horizontal differentiation**:
  - Alternative measure of vertical differentiation: R&D intensity from Kugler & Verhoogen (2012)
  - Controlling for horizontal differentiation: GM index
    $\Rightarrow$ *Interaction term is + for R&D intensity and - for GM*

▸ Estimation results ▸ Comparison to Chaney

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- **Variable trade costs using panel data**
  - From theory: $\frac{d \ln S_{nij}}{d \ln \tau_{ni}} = -\xi_j$ (no effect of quality differentiation!)
  - Estimation:

$$\ln S_{nijt} = \beta_1 \ln \tau_{nijt} + \beta_2 \ln \tau_{nijt} * \ln ladder_j + \upsilon_{nij} + \nu_t + \varepsilon_{nijt}$$

with $\beta_1 < 0$ and β_2 not significant.

▸ Tariff data ▸ Estimation results

Robustness checks

- **Estimation strategy**: Poisson Maximum Likelihood
- **Product weights and income per capita:** Alchian-Allen effect and home market effect
- **Alternative proxies for fixed costs:**
  - Common language from CEP II
  - Administrative barriers from the World Bank *Trading Across Borders*: Time (importer and exporter) spent for documentary compliance t_doc_{ni} and border compliance t_border_{ni}
- **"The Tip of the Iceberg"**: Additive trade costs as in Irarrazabal, Moxnes and Opromolla (2015)

▸ Poisson ▸ Income, weights ▸ Proxies for fixed costs

Parameter estimation: 3-step procedure

- Effects of trade liberalization with and without quality?
- **3 Unknowns**: Pareto shape parameter ξ_j,

  Elasticity of substitution σ_j, R&D intensity $\frac{1-\theta_j}{\alpha_j}$

Parameter estimation: 3-step procedure

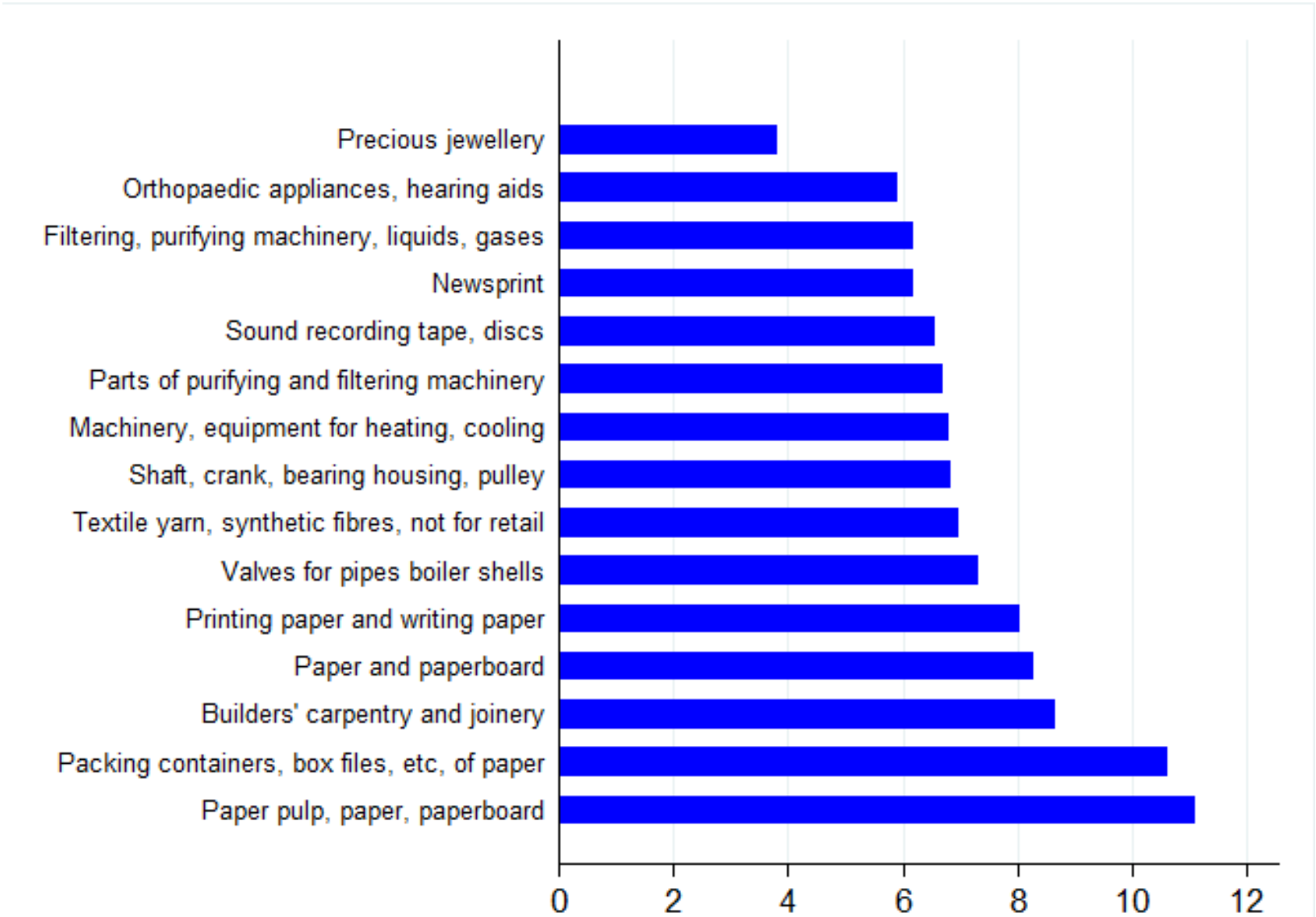
- Effects of trade liberalization with and without quality?
- **3 Unknowns**: Pareto shape parameter ξ_j,
  Elasticity of substitution σ_j, R&D intensity $\frac{1-\theta_j}{\alpha_j}$
- **3 Steps of estimation:**
  1. Trade elasticity of exports: $\frac{d\ln S_{nij}}{d\ln \tau_{ni}} = -\xi_j \Rightarrow$ Crozet & Koenig (2010)
  2. Distance elasticity of exports: $\beta_1 = \frac{d\ln S_{nij}}{d\ln f_{ni}} = 1 - \frac{\xi_j}{\sigma_j - 1} + \frac{\xi_j(1-\theta_j)}{\alpha_j}$
  3. R&D intensity (Kugler & Verhoogen, 2012): $\beta_2 = \frac{\sigma_j - 1}{\sigma_j}\frac{1-\theta_j}{\alpha_j}$

  $\Rightarrow \sigma_j = \frac{1+\beta_1+\xi_j}{1+\beta_1+\xi_j\beta_2}$

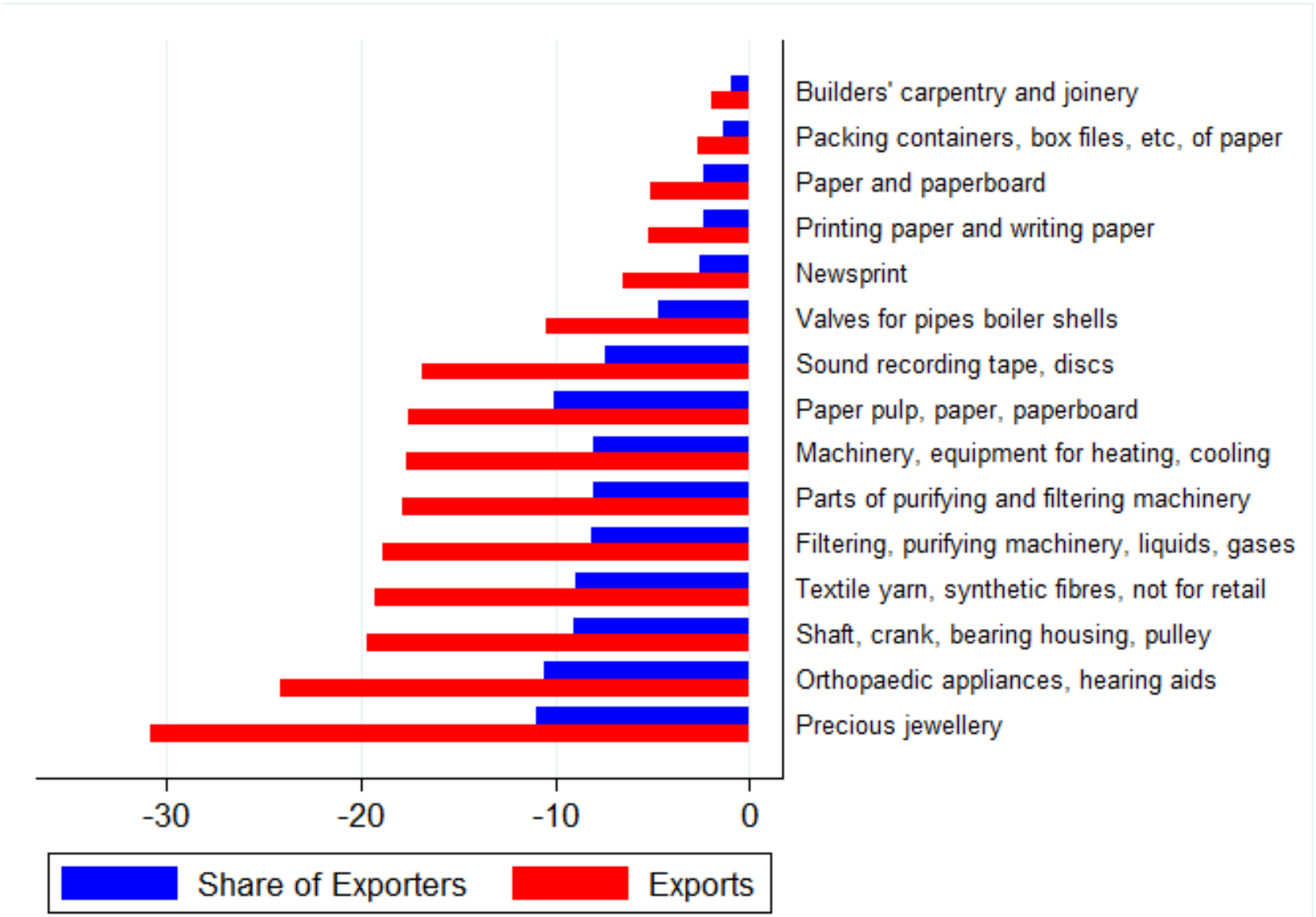
Parameter estimates

Industry	ξ_j	σ_j	$\frac{1-\theta_j}{\alpha_j}$
Builder's carpentry and joinery	1.65	1.88	0.011
Newsprint	3.71	3.23	0.012
Printing paper and writing paper	3.71	3.01	0.012
Paper and paperboard	3.71	2.98	0.012
Packing containers, box files of paper	3.71	2.77	0.008
Paper pulp, paper, paperboard	3.71	2.58	0.064
Textile yarn, synthetic fibres, not for retail	1.84	1.99	0.091
Machinery, equipment for heating and cooling	3.21	2.76	0.045
Filtering, purifying machinery, for liquids, gases	3.21	2.82	0.045
Parts of purifying and filtering machinery	3.21	2.77	0.045
Valves for pipes boiler shells	3.21	2.77	0.027
Shaft, crank, bearing housing, pulley	3.21	2.74	0.052
Precious jewellery	1.92	2.24	0.089
Sound recording tape, discs	1.92	2.07	0.070
Orthophaedic appliances, hearing aids	1.92	2.08	0.098

Effects of trade liberalization



Relative effects of trade liberalization



Effects of trade liberalization

With quality differentiation:

- Smaller effects of trade liberalization (10% decrease fixed trade costs)
- Export flows by industry: on average by 14% lower
- Share of exporters: on average by 6% lower

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- Heterogeneous effects across industries:
  - Exports: between -2% and -31%
  - Extensive margin: between -0.9% and -11%
- Correlation between R&D intensity and relative trade effect: -0.95

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  - Exports: between -2% and -31%
  - Extensive margin: between -0.9% and -11%
- Correlation between R&D intensity and relative trade effect: -0.95

Result: Gravity models without quality differentiation overestimate the effects of trade liberalization, especially in industries with high scope for vertical differentiation and large firm heterogeneity.

Summary

- Effect of distance on trade lower in industries with high scope for quality differentiation
- Theory: Derivation of gravity equations
  - Endogenous quality
  - Firm heterogeneity
- Empirics: Estimation of gravity equations
  - Aggregate trade flows: COMTRADE
  - Extensive margin: Brazilian firm-level data
- Estimation: Effects of trade liberalization
  - With vertical differentiation: effects on exports by 14% lower
  - Heterogeneous effects across industries: reduction between 2% and 31%

Optimal firm behavior

- Optimal price: $p_{nij}(\varphi) = \frac{\sigma_j}{\sigma_j - 1} \frac{\tau_{ni} q_{nij}^{\theta_j}}{\varphi}$
- Quality level: $q_{nij} = \left[(1-\theta_j) A_{nj} \left(\frac{\sigma_j}{\sigma_j - 1} \right)^{-\sigma_j} \left(\frac{\tau_{ni}}{\varphi} \right)^{1-\sigma_j} \right]^{\frac{1}{\alpha_j - (\sigma_j - 1)(1-\theta_j)}}$
- Zero-profit condition:

$$\pi_{nij}(\varphi^*_{nij}) = 0 \;\Leftrightarrow\; s_{nij}(\varphi^*_{nij}) = \frac{\alpha_j \sigma_j f_{ni}}{\alpha_j - (1-\theta_j)(\sigma_j - 1)} \tag{10}$$

- Free entry condition:

$$\sum_{n=1}^{N} \int_{\varphi^*_{nij}}^{\infty} \pi_{nij}(\varphi) g_{ij}(\varphi) = f_{\mathrm{Ei}} \tag{11}$$

▸ Role of quality

Scope for vertical product differentiation:

- Firm sales:

$$s_{nij}(\varphi) = \left[(1-\theta_j)^{1-\theta_j} A_{nj}^{\frac{\alpha_j}{\sigma_j-1}} \left(\frac{\sigma_j}{\sigma_j-1} \right)^{\theta_j-1-\alpha_j} \left(\frac{\tau_{nij}}{\varphi} \right)^{-\alpha_j} \right]^{\frac{\sigma_j-1}{\alpha_j-\left(\sigma_j-1\right)\left(1-\theta_j\right)}}$$

- Investment costs:

$$\frac{1}{\alpha_j} q_{nij}^{\alpha_j}(\varphi) = \frac{1}{\alpha_j} \left[(1-\theta_j) A_{nj} \left(\frac{\sigma_j}{\sigma_j-1} \right)^{-\sigma_j} \left(\frac{\tau_{nij}}{\varphi} \right)^{1-\sigma_j} \right]^{\frac{\alpha_j}{\alpha_j-\left(\sigma_j-1\right)\left(1-\theta_j\right)}}$$

- Scope for vertical product differentiation:

$$\frac{\frac{1}{\alpha_j} q_{nij}^{\alpha_j}}{s_{nij}(\varphi)} = \frac{1-\theta_j}{\alpha_j} \frac{\sigma_j-1}{\sigma_j}$$

Back to Model

Gravity equation with Pareto distribution

$$S_{nij} = \frac{S_{ij}}{\Xi_{ij}} \left(\frac{\Upsilon_n}{P_n^{1-\sigma_j}} \right)^{\frac{\xi_j}{\sigma_j - 1}} \tau_{ni}^{-\xi_j} f_{ni}^{\frac{\alpha_j(\sigma_j - 1) - \xi_j[\alpha_j - (\sigma_j - 1)(1-\theta_j)]}{\alpha_j(\sigma_j - 1)}}$$

- Total sales of industry j in country i: $S_{ij} = \sum_n S_{nij}$
- $\Xi_{ij} = \sum_n \left(\frac{\Upsilon_{nj}}{P_{nj}^{1-\sigma_j}} \right)^{\frac{\xi_j}{\sigma_j - 1}} \tau_{ni}^{-\xi_j} f_{ni}^{\frac{\alpha_j(\sigma_j - 1) - \xi_j[\alpha_j - (\sigma_j - 1)(1-\theta_j)]}{\alpha_j(\sigma_j - 1)}}$
- Log-linearized version of gravity equation:

$$\begin{aligned} \ln S_{nij} = & \ln \left(\frac{S_{ij}}{\Xi_{ij}} \right) + \frac{\xi_j}{\sigma_j - 1} \ln \left(\frac{\Upsilon_n}{P_n^{1-\sigma_j}} \right) - \xi_j \ln \tau_{ni} \\ & + \frac{\alpha_j (\sigma_j - 1) - \xi_j [\alpha_j - (\sigma_j - 1)(1 - \theta_j)]}{\alpha_j (\sigma_j - 1)} \ln f_{ni} \end{aligned}$$

▸ Gravity

Comparison to Chaney (2008)

- Effect of fixed trade costs on share of exporters:

$$\frac{d \ln \gamma_{nij}}{d \ln f_{ni}} = \underbrace{-\frac{\xi_j}{\sigma_j - 1}}_{\text{Chaney (2008)}} + \underbrace{\frac{\xi_j \left(1 - \theta_j\right)}{\alpha_j}}_{\text{Quality effect}}$$

- Comparison vertical vs. horizontal differentiation:

	Vertical (low α)	**Horizontal** (low σ)
Degree competition	high	low
New entrants	relatively small	relatively large
Effect of trade	weak on EM	strong on EM

▸ Robustness checks

Welfare

- Price index: $P_j = \left[\sum_{i=1}^{N} M_{nij} \int_{\varphi^*_{nij}}^{\infty} \left(\frac{p_{nij}(\varphi)}{q_{nij}(\varphi)}\right)^{1-\sigma_j} \mu_{nij}(\varphi) d\varphi\right]^{\frac{1}{1-\sigma_j}}$
- Welfare:

$$W_j = P^{-1} = \Omega_{nnj} \left(\beta_j L_i\right)^{\frac{1}{\sigma_j - 1}} \varphi^*_{nnj} \tag{12}$$

- $\Omega_{iij} = (1-\theta_j)^{\frac{1-\theta_j}{\alpha_j}} \left(\frac{\sigma_j - 1}{\sigma_j}\right)^{\frac{1+\alpha_j-\theta_j}{\alpha_j}} \left(\frac{\alpha_j - \left(1-\theta_j\right)\left(\sigma_j - 1\right)}{\alpha_j \sigma_j f_{nn}}\right)^{\frac{\alpha_j - \left(\sigma_j - 1\right)\left(1-\theta_j\right)}{\alpha_j \left(\sigma_j - 1\right)}}$
- Domestic cutoff productivity:

$$\varphi^{*\xi_j}_{iij} = \chi_j \sum_n \frac{f_{ni}}{f_{\mathrm{Ei}}} \tau_{ni}^{-\xi_j} \left(\frac{f_{ni}}{f_{nn}}\right)^{-\frac{\xi_j\left[\alpha_j - \left(\sigma_j - 1\right)\left(1-\theta_j\right)\right]}{\alpha_j \left(\sigma_j - 1\right)}} \tag{13}$$

- with $\chi_j = \frac{\alpha_j \left(\sigma_j - 1\right)}{\xi_j\left[\alpha_j - \left(\sigma_j - 1\right)\left(1-\theta_j\right)\right] - \alpha_j \left(\sigma_j - 1\right)}$ ▸ Welfare effect

Gollop-Monahan measure of horizontal differentiation

- Gollop-Monahan (1991) measure:

$$GM_k = \sum_{j,k,t} \omega_{jt} \left(\sum_i \frac{\left| s_{ijkt} - \bar{s}_{ikt} \right|}{2} \right)^{\frac{1}{2}}$$

- i = inputs, j = plants, k = 5-digit industries, t = years
- s_{ijkt} = expenditure share on input i of plant j in industry k and year t
- $\bar{s}_{ikt}$ = average expenditure share
- measure of dissimilarity of input mixes
- ω_{jt} = share of revenues

▸ Back to data

Khandelwal measure and quality differentiation

- Khandelwal-type expression of sales:

$$\ln s_{nij}(\varphi) = \ln A_{nj} + (\sigma_j - 1)\left(\ln q_{nij} - \ln p_{nij}\right)$$

- Log quality-price:

$$\ln q_{nij} - \ln p_{nij} = \frac{(1-\theta_j)\left[\ln(1-\theta_j) + \ln A_{nj}\right] + (\theta_j - 1 - \alpha_j)\ln\left(\frac{\sigma_j}{\sigma_j - 1}\right) + \alpha_j\left(\ln\varphi - \ln\tau_{nij}\right)}{\alpha_j - (\sigma_j - 1)(1-\theta_j)}$$

- Quality ladder depends on:

$$Ladder_j(\alpha_j) = \frac{\alpha_j(\sigma_j - 1)}{\alpha_j - (\sigma_j - 1)(1-\theta_j)}$$

- with $\frac{\partial Ladder_j(\alpha_j)}{\partial \alpha_j} < 0$ ▸ Back to data

Results: Fixed costs and aggregate trade flows

Table: Aggregate trade flows, R&D intensity and horizontal differentiation

Dependent variable $\ln S_{nij}$	(1)	(2)	(3)	(4)	(5)	(6)
$\ln Dist_{ni}$	-0.451***	-0.643***		-0.321***	-0.512***	
	(0.0319)	(0.0365)		(0.0355)	(0.0406)	
$\ln Dist_{ni}$* R&D Intensity	0.0462***	0.0619***	0.0705***	0.0476***	0.0625***	0.0716***
	(0.00693)	(0.00826)	(0.00796)	(0.00690)	(0.00824)	(0.00789)
$\ln Dist_{ni}$* GM Index				-0.253***	-0.262***	-0.312***
				(0.0316)	(0.0473)	(0.0466)
Constant	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	no	no	yes	no	no
Importer fixed effects	yes	no	no	yes	no	no
Exporter fixed effects	yes	no	no	yes	no	no
Industry-importer fixed effects	no	yes	yes	no	yes	yes
Industry-exporter fixed effects	no	yes	yes	no	yes	yes
Importer-exporter fixed effects	no	no	yes	no	no	yes
Observations	88,789	88,789	88,789	88,789	88,789	88,789
R-squared	0.351	0.621	0.723	0.352	0.621	0.723

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

▸ Back to estimation ▸ Robustness checks

Results: Fixed costs and share of exporters

Table: Share of exporters, R&D intensity and horizontal differentiation

Dependent variable: γ_{nj}	(1)	(2)	(3)	(4)
$\ln Dist_n$	-0.00387	0.0324**		
	(0.0119)	(0.0130)		
$\ln Dist_n *$ R&D Intensity	0.0118***	0.0109***	0.0131***	0.0122***
	(0.00330)	(0.00314)	(0.00325)	(0.00309)
$\ln Dist_n$ * GM Index		-0.0779***		-0.0724***
		(0.0133)		(0.0134)
Constant	yes	yes	yes	yes
Destination country fixed effects	no	no	yes	yes
Product fixed effects	yes	yes	yes	yes
Observations	13,990	13,990	13,990	13,990
R-squared	0.472	0.473	0.510	0.510

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by 4-digit industry.

▸ Robustness checks

Results: Alternative fixed costs and aggregate trade flows

Table: Aggregate trade flows, alternative proxies for fixed costs

Dependent variable $\ln S_{nij}$	(1)	(2)	(3)	(4)	(5)	(6)
$\ln t\_border_{ni}$	-0.111***					
	(0.0269)					
$\ln t\_border_{ni} * ladder_j$	0.00612**	0.0114***				
	(0.00257)	(0.00272)				
$\ln t\_doc_{ni}$			-0.399***			
			(0.0284)			
$\ln t\_doc_{ni} * ladder_j$			0.00966***	0.0161***		
			(0.00202)	(0.00208)		
$language_{ni}$					1.072***	
					(0.0768)	
$language_{ni} * ladder_j$					-0.0685***	-0.0745***
					(0.0112)	(0.0104)
Constant	yes	yes	yes	yes	yes	yes
Industry-importer fixed effects	yes	yes	yes	yes	yes	yes
Industry-exporter fixed effects	yes	yes	yes	yes	yes	yes
Importer-exporter fixed effects	no	yes	no	yes	no	yes
Observations	374,349	373,032	425,407	424,089	422,843	421,120
R-squared	0.530	0.710	0.526	0.709	0.534	0.707

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

Results: Alternative fixed costs and share of exporters

Table: Share of firms, alternative proxies for fixed costs

Dependent variable γ_{nj}	(1)	(2)	(3)	(4)
$\ln t\_border_n$	-0.0139***			
	(0.00171)			
$\ln t\_border_n * ladder_j$	0.00647**	0.00477*		
	(0.00282)	(0.00274)		
$\ln t\_doc_n$			-0.0296***	
			(0.00497)	
$\ln t\_doc_n * ladder_j$			0.00967***	0.00781***
			(0.00266)	(0.00277)
Constant	yes	yes	yes	yes
Destination country fixed effects	no	yes	no	yes
Industry fixed effects	yes	yes	yes	yes
Observations	43,802	43,802	42,647	42,647
R-squared	0.321	0.407	0.502	0.540

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

Results: Income and weights for aggregate trade flows

Table: Aggregate trade flows, alternative proxies for fixed costs

Dependent variable $\ln S_{nij}$	(1)	(2)	(3)	(4)
$\ln Dist_{ni} * ladder_j$	0.0494***		0.0489***	
	(0.00492)		(0.00426)	
$\ln Dist_{ni} *$ R&D		0.0590***		0.0508***
		(0.00894)		(0.00701)
$\ln Dist * \ln kg\_value_{nij}$	0.00788***	0.00292***		
	(0.000569)	(0.00107)		
$\ln CGDP_{ni} * ladder_j$			-1,993	
			(1,711)	
$\ln CGDP_{ni} *$ R&D				0.0214***
				(0.00554)
Constant	yes	yes	yes	yes
Industry-importer fixed effects	yes	yes	yes	yes
Industry-exporter fixed effects	yes	yes	yes	yes
Importer-exporter fixed effects	yes	yes	yes	yes
Importer fixed effects	no	no	no	no
Industry fixed effects	no	no	no	no
Observations	317,771	67,557	418,107	91,872
R-squared	0.719	0.732	0.708	0.723

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

Results: Income and weights for share of firms

Table: Share of firms, alternative proxies for fixed costs

Dependent variable γ_{nj}	(1)	(2)	(3)	(4)
$\ln Dist_{ni} * ladder_j$	0.0125***		0.0133***	
	(0.00228)		(0.00238)	
$\ln Dist_{ni} *$ R&D		0.0124***		0.0101***
		(0.00356)		(0.00336)
$\ln Dist * \ln kg\_value_{nij}$	7.95e-05	4.67e-05		
	(5.63e-05)	(0.000121)		
$\ln CGDP_{ni} * ladder_j$			-0.00150	
			(0.00139)	
$\ln CGDP_{ni} *$ R&D				0.00343
				(0.00271)
Constant	yes	yes	yes	yes
Industry-importer fixed effects	no	no	no	no
Industry-exporter fixed effects	no	no	no	no
Importer-exporter fixed effects	no	no	no	no
Importer fixed effects	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes
Observations	55,845	13,095	59,681	13,889
R-squared	0.484	0.477	0.489	0.483

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter pair.

Summary statistics tariff data 1996-2000

Table: Summary statistics

Sample for the analysis of variable trade costs using panel data			
Variable	Obs	Mean	Std. Dev.
$\ln S_{nijt}$	798,412	6.908	1.744
$ladder_j$	798,412	1.906	0.700
τ_{nijt}	798,412	1.081	0.089

▸ Robustness checks

Results: Variable trade costs and aggregate trade flows

Dependent variable: $\ln S_{nijt}$	(1)	(2)	(3)	(4)
$\ln \tau_{nijt}$	-0.627***	-0.272***	-0.359**	-0.399***
	(0.0555)	(0.0537)	(0.170)	(0.0992)
$\ln \tau_{nijt} * ladder_j$			0.0454	
			(0.0833)	
$\ln \tau_{nijt} * \ln ladder_j$				0.216
				(0.139)
Observations	798,412	798,412	798,412	798,131
R-squared	0.919	0.920	0.920	0.920
Number of nij groups	310,092	310,092	310,092	309,971
Constant	yes	yes	yes	yes
Importer-Exporter-Industry FE	yes	yes	yes	yes
Year FE	no	yes	yes	yes

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.
The errors clustered by importer-exporter and 4-digit industry.

▸ Robustness checks

Results using Poisson PML: Fixed costs and aggregate trade flows

Table: Zeros and trade: Esimations with PPML

Dependent variable S_{nij}	(1)	(2)	(3)	(4)
$\ln Dist_{ni}$	-0.501***	-0.365***	-0.841***	-0.874***
	(0.109)	(0.117)	(0.0427)	(0.0500)
$\ln Dist_{ni} * R\&D_j$ Intensity	0.0724**	0.0711**		
	(0.0297)	(0.0292)		
$\ln Dist_{ni}$*GM Index		-0.280		
		(0.193)		
$\ln Dist_{ni} * \ln ladder_j$			0.0639*	
			(0.0341)	
$\ln Dist_{ni} * ladder_j$				0.0383**
				(0.0163)
Constant	yes	yes	yes	yes
Industry SITC 3-digit fixed effects	yes	yes	no	no
Industry SITC 2-digit fixed effects	no	no	yes	yes
Importer fixed effects	yes	yes	yes	yes
Exporter fixed effects	yes	yes	yes	yes
Observations	243,575	243,575	231,827	231,829

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%.

▸ Robustness checks

Welfare effects of trade liberalization

- Effect of fixed trade costs on welfare:

$$\frac{d \ln W}{d \ln f_{ni}} = \left(\frac{1}{\xi_j} - \frac{1}{\sigma_j - 1} + \frac{1 - \theta_j}{\alpha_j} \right) \lambda_{nij} \tag{14}$$

- Trade share of goods from industry j and country i to country n:

$$\lambda_{nij} = \frac{S_{nij}}{S_{ij}} = \frac{\left(\frac{f_{ni}}{f_{nn}} \right)^{-\xi_j \frac{\alpha_j - \left(\sigma_j - 1\right)\left(1 - \theta_j\right)}{\alpha_j \left(\sigma_j - 1\right)}} f_{ni} \tau_{ni}^{-\xi_j}}{\sum_n \left(\frac{f_{ni}}{f_{nn}} \right)^{-\xi_j \frac{\alpha_j - \left(\sigma_j - 1\right)\left(1 - \theta_j\right)}{\alpha_j \left(\sigma_j - 1\right)}} f_{ni} \tau_{ni}^{-\xi_j}} \tag{15}$$

Welfare effects of trade liberalization

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$$\frac{d \ln W}{d \ln f_{ni}} = \left(\frac{1}{\xi_j} - \frac{1}{\sigma_j - 1} + \frac{1 - \theta_j}{\alpha_j} \right) \lambda_{nij} \tag{14}$$

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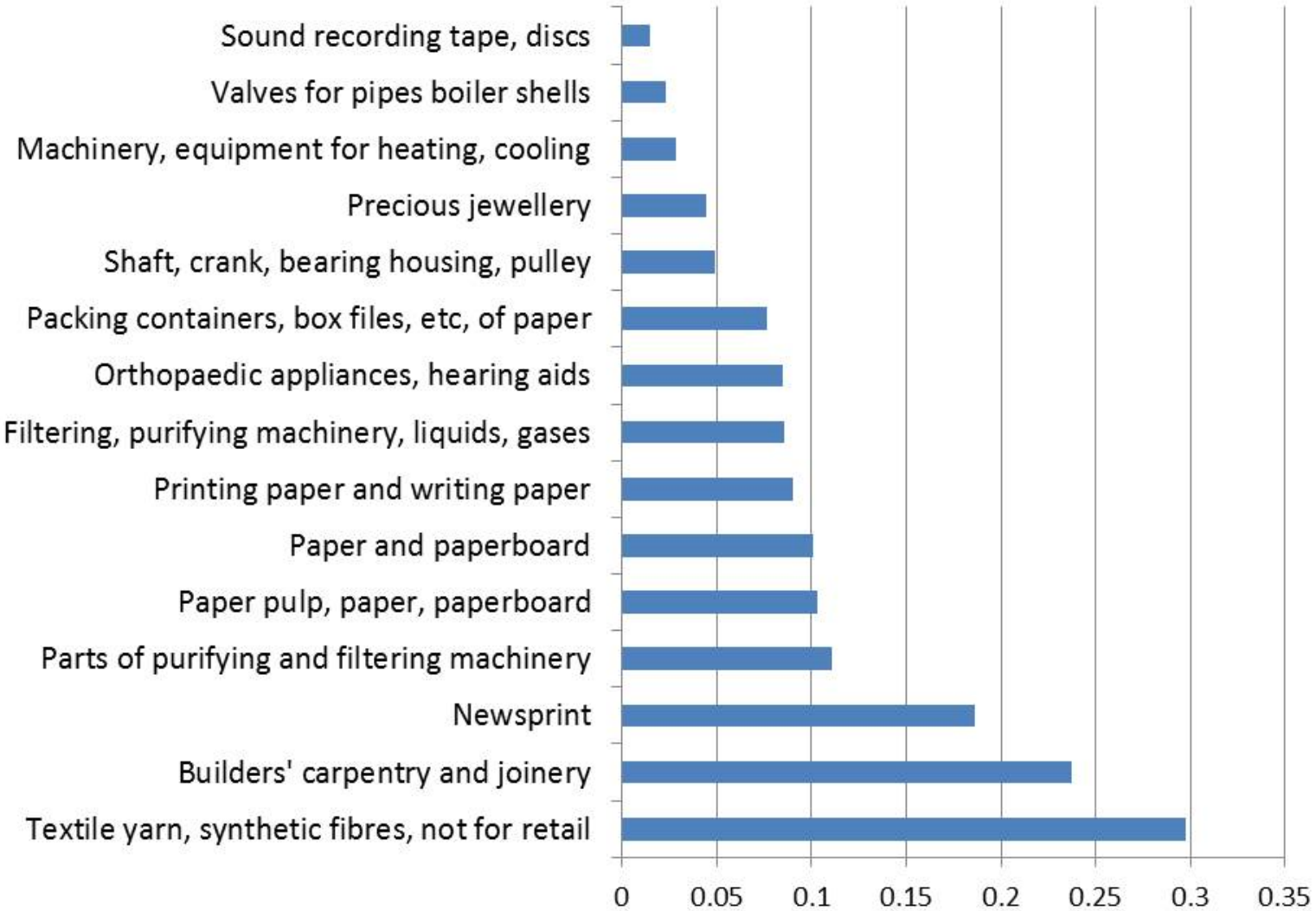
$$\lambda_{nij} = \frac{S_{nij}}{S_{ij}} = \frac{\left(\frac{f_{ni}}{f_{nn}} \right)^{-\xi_j \frac{\alpha_j - \left(\sigma_j - 1\right)\left(1 - \theta_j\right)}{\alpha_j \left(\sigma_j - 1\right)}} f_{ni} \tau_{ni}^{-\xi_j}}{\sum_n \left(\frac{f_{ni}}{f_{nn}} \right)^{-\xi_j \frac{\alpha_j - \left(\sigma_j - 1\right)\left(1 - \theta_j\right)}{\alpha_j \left(\sigma_j - 1\right)}} f_{ni} \tau_{ni}^{-\xi_j}} \tag{15}$$

Result: Welfare gains from trade liberalization are lower in industries with a high scope for vertical differentiation.

▸ Welfare

Welfare effects by industry



Relative welfare effects compared to benchmark