Trade and Inequality:
From Theory to Estimation

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Motivation

- Neoclassical trade theory (H-O, SF, R)
  - — sector-level comparative advantage
  - — focus on "**between**" effects
- New trade theory
  - — Krugman: intra-industry trade
  - — Melitz: firm-level comparative advantage
  - — focus on "**within**" effects
- Trade and inequality
  - — Heavily influenced by H-O framework
  - — Empirically has limited explanatory power
- "New view" of trade and inequality
  - — link wages to firm performance
  - — **within**-industry, **between**-firm

This Paper

1. Uses matched employer-employee data from Brazil for 1986-1998
   - increase in inequality ▸ show
   - trade liberalization ▸ show

2. Documents, for both levels and changes, the importance of inequality:
   - within sector-occupations
   - for workers with similar observables (residual inequality)
   - between firms

3. Structurally estimates a heterogenous-firm model of firm employment, wages and export status
   - extension of HIR (2010)
   - a model of *within-sector*, *between-firm residual* inequality
   - reproduces empirical size and exporter wage premia:

$$w_{ij} = \alpha + \beta h_j + \delta_{xj} + \ldots + \varepsilon_{ij}$$

Related Literature

- Long and large tradition in labor literature
- "New view" empirics:
  - Bernard and Jensen (1995)...
  - Verhoogen (2008)
  - Amity and Davis (2011)
  - AKM (1999) estimation used in trade context
- "New view" theory:
  - Feenstra and Hanson (1999)...
  - Yeaple (2005)...
  - Egger and Kreickemeier (2009)
  - HIR (2010)...

DATA

Brazilian RAIS Data

- Matched employer-employee data from 1986–1998
  - All workers employed in the formal sector
  - Focus on the manufacturing sector
  - Observe firm, industry and occupation
  - Observe worker education (high school, college degree), demographics (age, sex) and experience (employment history)

- Over the period 1986-1998 as a whole, our sample includes more than 7 million workers and 100,000 firms in every year

- Trade transactions data from 1986-1998
  - Merged with the matched employer-employee data
  - Observe firm exports and export products and destinations

Sectors

- Twelve aggregate sectors (IBGE) 1986-1998

	Industry	Empl't share (%)	Rel. mean log wage	Fraction Exporters	Exporter Empl't %
2	Non-metallic mineral products	5.5	−0.12	2.3	32.3
3	Metallic products	9.8	0.27	6.1	49.9
4	Machinery, equipment & instr.	6.6	0.38	12.3	54.1
5	Electrical & telecomm. equip.	6.0	0.37	11.8	56.3
6	Transport equipment	6.3	0.61	11.2	70.6
7	Wood products & furniture	6.5	−0.48	3.2	23.5
8	Paper, publishing & printing	5.4	0.14	2.5	30.6
9	Rubber, tobacco, leather & fur	7.0	−0.04	8.6	50.8
10	Chemical & pharma. products	9.9	0.40	11.2	50.6
11	Apparel & textiles	15.7	−0.32	2.5	34.8
12	Footwear	4.4	−0.44	12.2	65.7
13	Food, beverages & alcohol	16.9	−0.30	3.9	38.0

- More than 250 disaggregated industries (CNAE) 1994-1998

Occupations

- Five aggregate occupations 1986-1998

	Occupation	Employment share (%)	Relative mean log wage
1	Professional and Managerial	7.8	1.08
2	Skilled White Collar	11.1	0.40
3	Unskilled White Collar	8.4	0.13
4	Skilled Blue Collar	57.4	−0.15
5	Unskilled Blue Collar	15.2	−0.35

- More than 300 disaggregated occupations (CBO) 1986-1998

STYLIZED FACTS

Within and Between Inequality

Sector-occupation bins

	Level (%)	Change (%)
A. Main Period	1994	1986–95
Within occupation	82	92
Within sector	83	73
Within sector-occupation	68	66
Within detailed-occupation	61	60
Within sector–detailed-occupation	56	54
B. Late Period	1994	1994–98
Within detailed-sector –detailed-occupation	47	141

Fact 1

Within sector-occupation component of wage inequality accounts for over 2/3 of both level and growth of wage inequality

show within regions

Residual Inequality

Conditional on worker observables

	Level (%) 1994	Change (%) 1986–95
Residual wage inequality	59	49
— within sector-occupation	89	91

Fact 2

(i) *Residual inequality is at least as important as worker observables for both level and growth of wage inequality*
(ii) *Almost all residual inequality is within sector-occupations*

Between-firm Inequality

- Mincer log-wage regression with firm fixed effect:

$$w_{it} = z_{it}'\vartheta_{\ell t} + \psi_{j\ell t} + \nu_{it}$$

  - i worker
  - j firm
  - ℓ sector-occupation bin

- $\psi_{j\ell t}$ firm fixed effect includes:
  - Returns to unobserved skill (workforce composition)
  - Worker rents (differences in wage for same workers)
  - Match effects

- Decomposition of within inequality:
  - Observables: $\mathrm{var}\left(z_{it}'\hat{\vartheta}_{\ell t}\right)$
  - Between-firm component: $\mathrm{var}\left(\hat{\psi}_{j\ell t}\right)$
  - Covariance: $\mathrm{cov}\left(z_{it}'\hat{\vartheta}_{\ell t}, \hat{\psi}_{j\ell t}\right)$
  - Within-firm component: $\mathrm{var}\left(\hat{\nu}_{it}\right)$

Between-firm Inequality

Within sector-occupation bins

	Unconditional firm wage component, $\psi^U_{j\ell t}$		Conditional firm wage component, $\psi^C_{j\ell t}$	
	Level (%) 1994	Change (%) 1986–1995	Level (%) 1994	Change (%) 1986–1995
Between-firm wage inequality	55	115	39	86
Within-firm wage inequality	45	−15	37	−11
Worker observables			13	2
Covar observables–firm effects			11	24

Fact 3

Between-firm component account for about half of level and the majority of growth of within sector-occupation wage inequality

Between-firm Inequality

Size and exporter wage premia

	UNCONDITIONAL FIRM WAGE COMPONENT, $\hat{\psi}^{U}_{jt}$	CONDITIONAL FIRM WAGE COMPONENT, $\hat{\psi}^{C}_{jt}$
Firm Employment Size	0.122^{***}	0.104^{***}
	(0.010)	(0.009)
Firm Export Status	0.262^{***}	0.168^{***}
	(0.042)	(0.024)
Sector Fixed Effects	yes	yes
Within R-squared	0.17	0.13
Observations	91,410	91,410

Fact 4

Larger firms on average pay higher wages; exporters on average pay higher wages even after controlling for size. The remaining variation in wages is substantial.

STRUCTURAL MODEL

Model: Extension of HIR

1. Melitz (2003) product market:

$$R = \Upsilon A y^{\beta}, \qquad \Upsilon \in \{1, \Upsilon_x > 1\}$$

2. Heterogeneity in fixed cost of exports: $e^{\varepsilon} F_x$

3. Complementarity between productivity and worker ability:

$$y = e^{\theta} H^{\gamma} \bar{a}, \qquad \gamma < 1$$

4. Unobserved heterogeneity and costly screening:

$$e^{-\eta} C \frac{(a_c)^{\delta}}{\delta} \qquad \Rightarrow \qquad \bar{a} = \frac{k}{k-1} a_c$$

5. DMP frictional labor market and wage bargaining:

$$W = \frac{\beta\gamma}{1+\beta\gamma} \frac{R}{H} = b \cdot (a_c)^{k/\delta}$$

Model Predictions

- A firm with idiosyncratic shock $\{\theta, \eta, \varepsilon\}$:

$$R(\theta,\eta,\varepsilon) = \kappa_r \Upsilon^{\frac{1-\beta}{\Gamma}} \left(e^{\theta}\right)^{\frac{\beta}{\Gamma}} \left(e^{\eta}\right)^{\frac{\beta(1-\gamma k)}{\delta\Gamma}}$$

$$H(\theta,\eta,\varepsilon) = \kappa_h \Upsilon^{\frac{(1-\beta)(1-k/\delta)}{\Gamma}} \left(e^{\theta}\right)^{\frac{\beta(1-k/\delta)}{\Gamma}} \left(e^{\eta}\right)^{\frac{\beta(1-\gamma k)(1-k/\delta)}{\delta\Gamma}-\frac{k}{\delta}}$$

$$W(\theta,\eta,\varepsilon) = \kappa_w \Upsilon^{\frac{k(1-\beta)}{\delta\Gamma}} \left(e^{\theta}\right)^{\frac{\beta k}{\delta\Gamma}} \left(e^{\eta}\right)^{\frac{k}{\delta}\left(1+\frac{\beta(1-\gamma k)}{\delta\Gamma}\right)}$$

- Market access variable

$$\Upsilon = 1 + \iota \cdot \left(\Upsilon_x - 1\right), \qquad \Upsilon_x = 1 + \tau^{-\frac{\beta}{1-\beta}} \frac{A_x}{A_d}$$

- Selection into exporting

$$\iota = \iota(\theta,\eta,\varepsilon) = \mathbb{I}\left\{\kappa_\pi \left(\Upsilon_x^{\frac{1-\beta}{\Gamma}} - 1\right) \left(e^{\theta}\right)^{\frac{\beta}{\Gamma}} \left(e^{\eta}\right)^{\frac{\beta(1-\gamma k)}{\delta\Gamma}} \geq F_x e^{\varepsilon}\right\}$$

Econometric Model

- Empirical model of $X_j = \{h_j, w_j, \iota_j\}_j$:

$$\begin{cases} h_j = \alpha_h + \mu_h \cdot \iota_j + u_j, \\ w_j = \alpha_w + \mu_w \cdot \iota_j + \zeta u_j + v_j, \\ \iota_j = \mathbb{I}\{z_j \geq f\} \end{cases}$$

- Distributional assumption:

$$(u_j, v_j, z_j)' \sim \mathcal{N}(\mathbf{0}, \Sigma), \qquad \Sigma = \begin{pmatrix} \sigma_u^2 & & \\ 0 & \sigma_v^2 & \\ \rho_u \cdot \sigma_u & \rho_v \cdot \sigma_v & 1 \end{pmatrix}$$

- **Selection** (ρ_u, ρ_v) versus **Market access** (μ_h, μ_w)

- Theoretical restriction: $\mu_h, \mu_w > 0$

Identification

1. Maximum Likelihood

   — under additional orthogonality assumption between structural productivity shocks θ and η:

$$\zeta \leq \frac{\mu_w}{\mu_h} \leq \zeta + \frac{\sigma_v^2}{(1+\zeta)\sigma_u^2}$$

2. GMM Bounds

   — based on a subset of moments

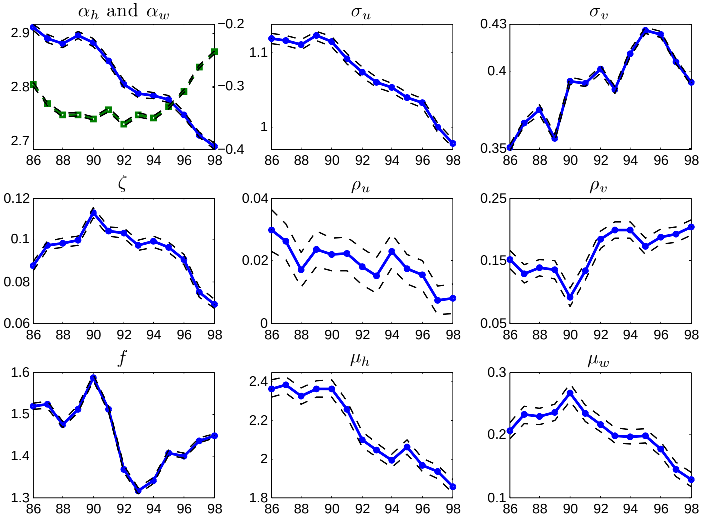
3. Semi-parametric estimation

   — using alternative instruments for export participation

RESULTS

Estimation Results

Parameters

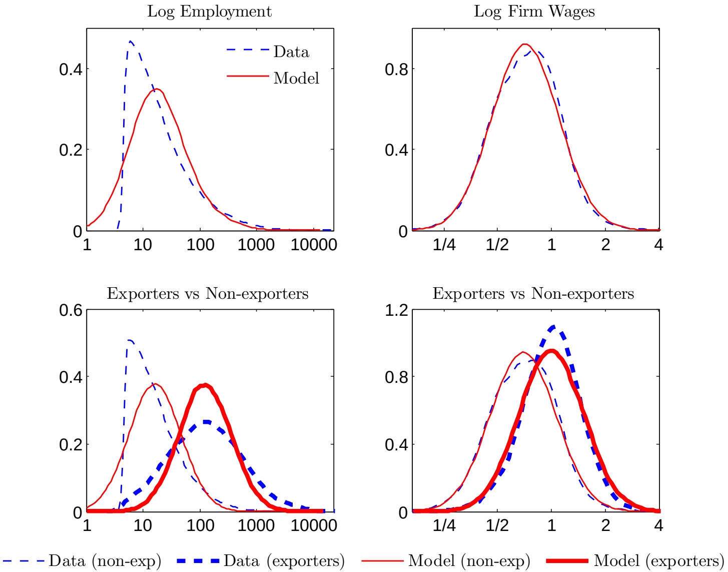


Model Fit

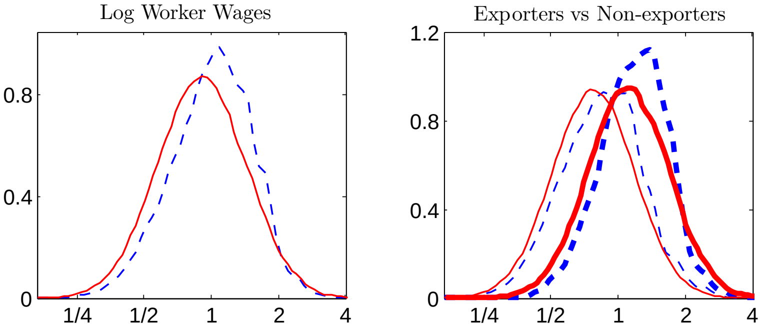
Firm-level moments

	All firms	Non-exp.	Exporters
		DATA	
Mean h	2.96	2.78	4.82
Mean w	-0.33	-0.37	-0.01
Std deviation h	1.20	1.00	1.46
Std deviation w	0.43	0.43	0.38
Correlation h & w	0.33	0.24	0.32
Fraction of exporters	9.0%		
		MODEL	
Mean h	2.96	2.78	4.83
Mean w	-0.33	-0.37	0.00
Std deviation h	1.20	1.05	1.05
Std deviation w	0.43	0.42	0.42
Correlation h & w	0.32	0.25	0.24
Fraction of exporters	9.0%		

Employment and Wage Distributions



Worker Wage Distribution



Model Fit

Worker wage dispersion

	Data	Model
Std deviation	0.42	0.46
— non-exporters	0.42	0.42
— exporters	0.35	0.42
Gini coefficient	0.23	0.25
90/10-ratio	2.95	3.23
— 90/50	1.63	1.80
— 50/10	1.81	1.80

Model Fit

Worker wage dispersion

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Size and exporter wage premia

	Data	Model
Employment premium	0.10	0.10
Exporter premium	0.16	0.16
R-squared	0.11	0.11

Counterfactuals

- Estimated model:

$$\begin{cases} h_j = \alpha_h + \mu_h \cdot \iota_j + u_j, \\ w_j = \alpha_w + \mu_w \cdot \iota_j + \zeta u_j + v_j, \\ \iota_j = \mathbb{I}\{z_j \geq f\} \end{cases} \qquad (u_j, v_j, z_j)' \sim \mathcal{N}(\mathbf{0}, \Sigma)$$

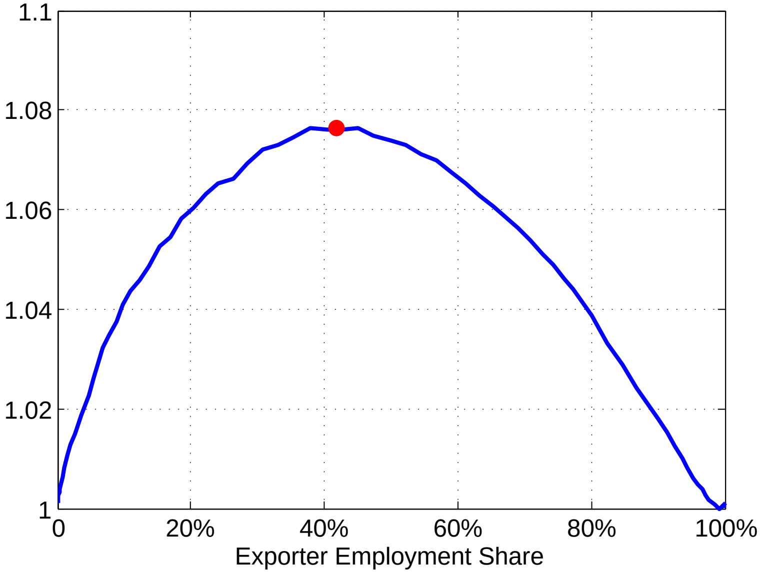
- Parameters (μ_h, μ_w, f) form a **sufficient statistic**:

$$f = \frac{1}{\sigma}\left[\alpha_f + \log F_x - \log\left(\Upsilon_x^{\frac{1-\beta}{\Gamma}} - 1\right)\right]$$

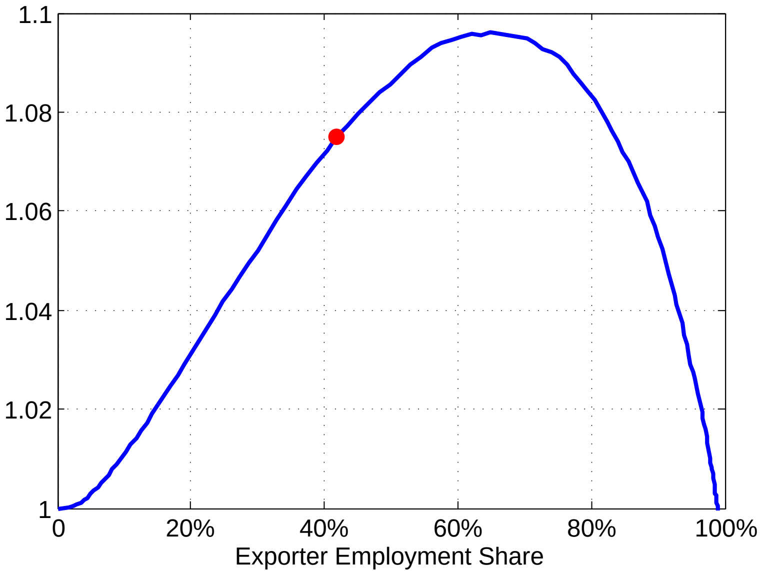
$$\mu_h + \mu_w = \Upsilon_x^{\frac{1-\beta}{\Gamma}}, \qquad \Upsilon_x = 1 + \tau^{-\frac{\beta}{1-\beta}} \frac{A_x}{A_d}$$

- Two counterfactuals: variation in F_x and τ

Variation in Fixed Export Cost



Variation in Variable Trade Cost



GMM BOUNDS

GMM Bounds

- We drop the orthogonality assumption and use the following set of moments:
  (a) conditional first moments: $\mathbb{E}\iota$, $\mathbb{E}\{h|\iota\}$ and $\mathbb{E}\{w|\iota\}$
  (b) unconditional second moments: $\mathrm{var}(h)$, $\mathrm{var}(w)$ and $\mathrm{cov}(h, w)$
  (c) size and exporter wage premia λ_s and λ_x, and R^2 from:

$$\mathbb{E}\{w|h,\iota\} = \lambda_0 + \lambda_s h + \lambda_x \iota$$

  — In addition, we impose $|\rho_u|, |\rho_v| < 1$ and $\sigma_u, \sigma_v > 0$
  — and $\mathrm{corr}\big((1+\zeta)u + v, z\big) = (1+\zeta)\rho_u\sigma_u + \rho_v\sigma_v > 0$
  — We check that $\mu_h, \mu_w > 0$

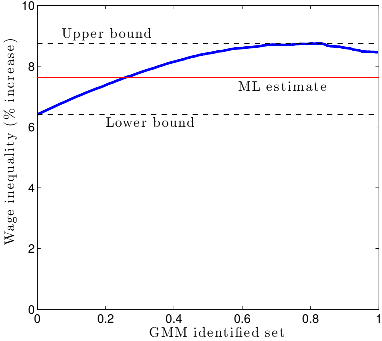
- This identifies a uni-dimensional interval in the 10-dimensional parameter space, the GMM identified set ▸ Show the iSet

- For each element of this set we conduct: (a) autarky and (b) variable trade cost counterfactual:
  — $\tau \uparrow$ to generate a 10p.p.$\downarrow$ in exporter employment share

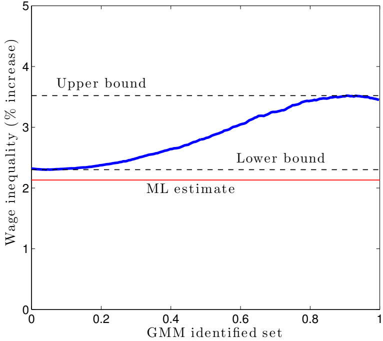
GMM Bounds

Results

(a) Autarky counterfactual



(b) τ counterfactual



- Autarky bounds: $[6.6\%, 9.0\%]$ vs ML estimate 7.6%
- τ bounds: $[2.3\%, 3.5\%]$ vs ML estimate 2.2%

Semi-parametric

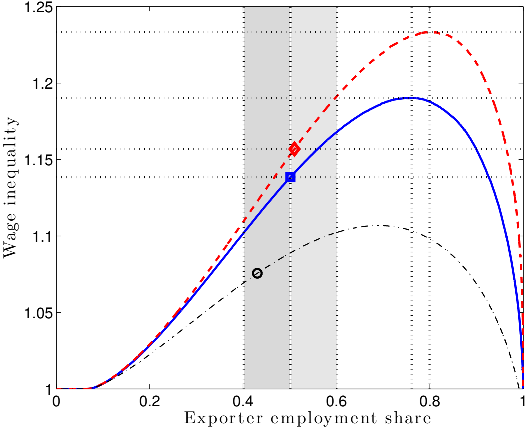
Two-stage estimation

	(1) Ease Business	(2) Foreign Worker	(3) Meso Foreign Worker	(4) Layoff Meso Foreign Worker	(5) Ease Business and Layoff Meso Foreign Worker
Panel A: Selection Equation					
Ease of Business	-0.0044	-	-	-	-0.0045
	(0.0009)				(0.0009)
Foreign Worker	-	5.237	-	-	-
		(0.4239)			
Meso Foreign Worker	-	-	244.9714		
			(10.5173)		
Layoff Meso Foreign Worker	-	-		168.2080	169.0699
				(10.6992)	
First-stage F-statistic	23.88	152.59	542.53	247.17	271.67
Panel B: Employment Equation					
Employment market access (μ_h)	2.0227	1.9968	2.0321	2.0324	2.0341
	(0.0166)	(0.0168)	(0.0165)	(0.0165)	(0.0165)
Second-stage F-statistic	52.10	103.65	23.80	30.26	14.93
Panel C: Wage Equation					
Wage market access (μ_w)	0.3519	0.3432	0.3121	0.3209	0.3231
	(0.0045)	(0.0045)	(0.0042)	(0.0043)	(0.0044)
Second-stage F-statistic	341.27	167.39	6757.53	4997.21	3964.15

MULTIDESTINATION

Multidestination Model

Counterfactuals

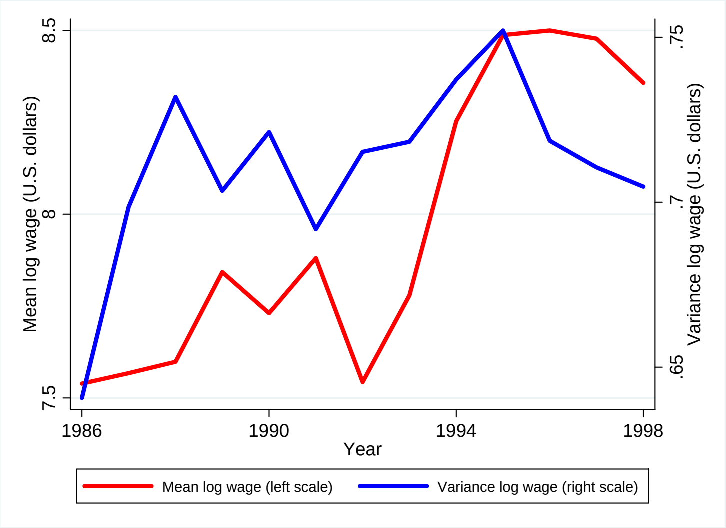


▸ Show the model

Conclusions

- Neoclassical trade theory emphasizes wage inequality between occupations and industries
- In contrast, new theories of firm heterogeneity and trade point to wage dispersion within occupations and industries
- Using matched employer-employee data for Brazil, we show:
  - Much of the increase in wage inequality since the mid-1980s has occurred within sector-occupations
  - Increased within-group wage inequality
  - Increased wage dispersion between firms
  - Between-firm wage dispersion related to trade participation
- Develop a framework for the structural estimation of a model with firm heterogeneity and wage dispersion across firms
- Use this framework to quantify the effect of trade on wage dispersion

Wage Inequality



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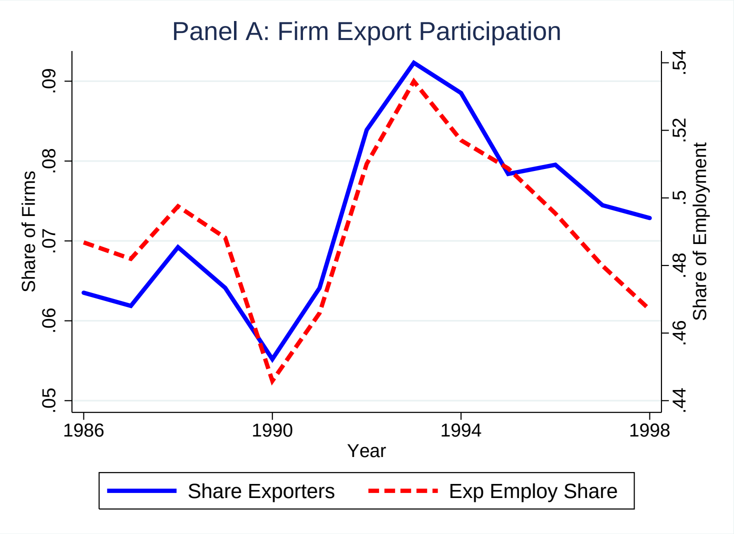
Trade Openness



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Regional Robustness

	Overall inequality		Residual inequality	
	Level 1994	Change 1986–95	Level 1994	Change 1986–95
Within sector-occupation	68	66	89	91
Within sector-occupation, São Paulo	64	49	89	71
Within sector-occupation-state	58	38	76	56
Within sector-occupation-meso	54	30	72	49

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Likelihood Function

$$\mathcal{L}(\Theta|X_j) = \prod_j \mathbb{P}\{(h_j, w_j, \iota_j)|\Theta\}$$

$$\mathbb{P}\{(h_j, w_j, \iota_j)|\Theta\} =$$

$$\frac{1}{\sigma_u}\phi\big(\hat{u}_j\big)\frac{1}{\sigma_v}\phi\big(\hat{v}_j\big)\left[\Phi\left(\frac{f-\rho_u\hat{u}_j-\rho_v\hat{v}_j}{\sqrt{1-\rho_u^2-\rho_v^2}}\right)\right]^{1-\iota_j}\left[1-\Phi\left(\frac{f-\rho_u\hat{u}_j-\rho_v\hat{v}_j}{\sqrt{1-\rho_u^2-\rho_v^2}}\right)\right]^{\iota_j}$$

$$\hat{u}_j = \frac{h_j-\alpha_h-\mu_h\iota_j}{\sigma_u},$$

$$\hat{v}_j = \frac{(w_j-\alpha_w-\mu_w\iota_j)-\zeta(h_j-\alpha_h-\mu_h\iota_j)}{\sigma_v}$$

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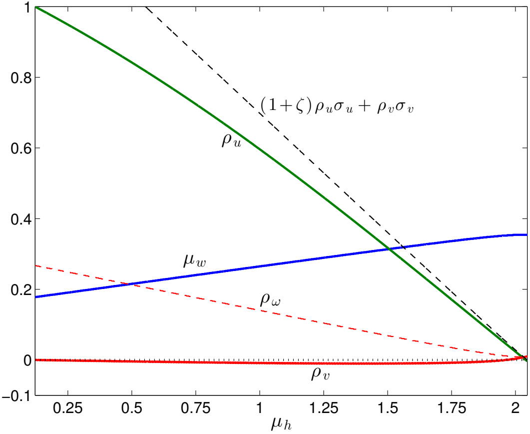
GMM Identified Set

- Main idea: $\bar{h}_1 - \bar{h}_0 = \mu_h + \rho_u \sigma_u (\lambda_1 - \lambda_0)$



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Multidestination Model

$$\begin{cases} h &= \alpha_h + \mu_{h,1}\iota_1 + (\mu_{h,2} - \mu_{h,1})\iota_2 + (\mu_{h,3} - \mu_{h,2})\iota_3 + u, \\ w &= \alpha_w + \mu_{w,1}\iota_1 + (\mu_{w,2} - \mu_{w,1})\iota_2 + (\mu_{w,3} - \mu_{w,2})\iota_3 + \zeta u + v, \\ \iota_\ell &= \mathbb{I}\left\{f_{\ell-1} \leq z \leq f_\ell\right\}, \qquad \ell = 1, 2, 3, \end{cases}$$

$$\mu_{h,\ell} = \frac{\delta - k}{\delta} \log \Upsilon_{x,\ell}^{\frac{1-\beta}{\Gamma}}, \qquad \mu_{w,\ell} = \frac{k}{\delta - k}\mu_{h,\ell},$$

$$f_\ell = \frac{1}{\sigma}\left[-\alpha_\pi + \log F_{x,\ell} - \log\left(\Upsilon_{x,\ell}^{\frac{1-\beta}{\Gamma}} - \Upsilon_{x,\ell-1}^{\frac{1-\beta}{\Gamma}}\right)\right],$$

$$\Upsilon_x = 1 + \tau^{-\frac{\beta}{1-\beta}} \sum_{\ell=1,2,3} \iota_\ell \left(\frac{A_{x,\ell}}{A_d}\right)^{\frac{1}{1-\beta}}$$

$$\iota_\ell = \mathbb{I}\left\{\kappa_\pi \left[\Upsilon_{x,\ell}^{\frac{1-\beta}{\Gamma}} - \Upsilon_{x,\ell-1}^{\frac{1-\beta}{\Gamma}}\right] \left(e^\theta\right)^{\frac{\beta}{\Gamma}} \left(e^\eta\right)^{\frac{\beta(1-\gamma k)}{\delta\Gamma}} \geq e^\varepsilon F_{x,\ell}\right\}, \qquad \ell = 1, 2, 3$$

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