Worker Heterogeneity, Wage Inequality, and International Trade: Theory and Evidence from Brazil

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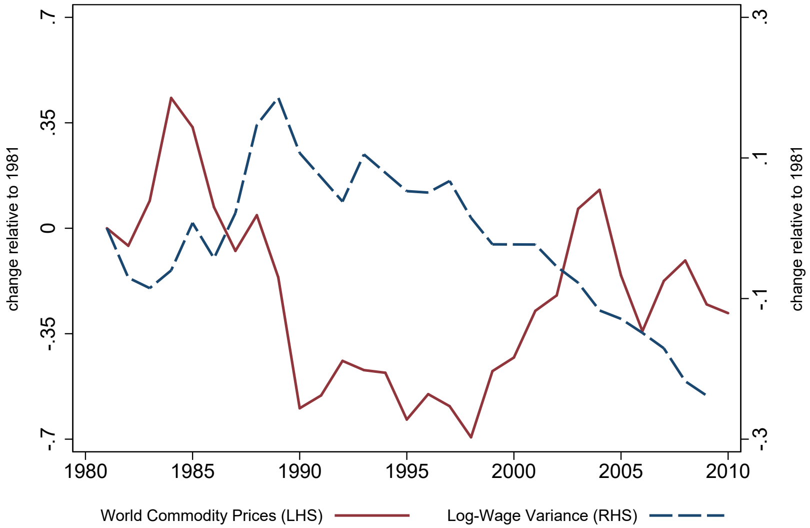
World commodity prices and Brazilian wage inequality



Log-Wage Variance Decomposition

Relative wage in the commodity sector

Relative employment in the commodity sector

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4. Counterfactual: 2000s commodity boom $\Rightarrow$ Brazilian wage inequality

Related Literature

1. Extensive Literature on Trade and Labor Markets

- **Neoclassical environments:** Lawrence & Slaughter, 1993; Berman et al., 1998; Leamer, 2000; Krugman, 2000; Wacziarg & Wallack, 2004; Goldberg & Pavcnik, 2007
- **Departures from Heckscher-Ohlin:** Verhoogen, 2008; Kambourov, 2009; Helpman et al., 2010, 2015; Artuc et al., 2010; Dix-Carneiro, 2014; Burstein & Vogel, 2015

2. Roy Model

- **Labor Economics:** Heckman & Sedlacek, 1985; Borjas, 1987; Heckman & Honoré, 1990; Dahl, 2004; handbook chapters of Acemoglu & Autor, 2011 and French & Taber, 2011
- **International Trade:** Mussa, 1982; Grossman, 1983; Matsuyama, 1992; Ohnsorge & Trefler, 2007; Costinot & Vogel, 2010
- **Recent quantitative applications:** Lagakos & Waugh, 2013; Hsieh et al., 2013; Young, 2014; Burstein et al., 2015; Galle et al., 2015; Caliendo et al., 2015

3. Local labor markets: Effects of import competition

- Topalova, 2010; Kovak, 2013; Autor et al., 2013; Dix-Carneiro & Kovak, 2015a,b

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- Two sectors: Commodity ($k = C$) and Non-commodity ($k = N$)

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$$q^j = Q^j \left(L_1^j, ..., L_G^j, X^j \right) \quad \text{where} \quad L_g^j \equiv \begin{cases} \int_{\mathcal{S}_g^j} L_g^C(i)\ di & \text{if } j \in \mathcal{J}^C \\ \int_{\mathcal{S}_g^j} L_g^N(i)\ di & \text{if } j \in \mathcal{J}^N \end{cases}$$

  and X^j is an industry-specific input.

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- Firms maximize profits:

$$w_g^k = p^k \frac{\partial Q^k}{\partial L_g^k}$$

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$$y_g^N(i) \equiv \omega_g^N + a_g(i) \quad \text{and} \quad y_g^C(i) \equiv \omega_g^C + s_g(i) + a_g(i)$$

Average log-wage by comparative advantage quantile

For each $q \in [0, 1]$, set of individuals with comparative advantage $\sigma_g(q) \equiv F_g^{-1}(q)$, and average absolute advantage $\alpha_g(q) \equiv E[a_g(i)|s_g(i) = \sigma_g(q)]$.

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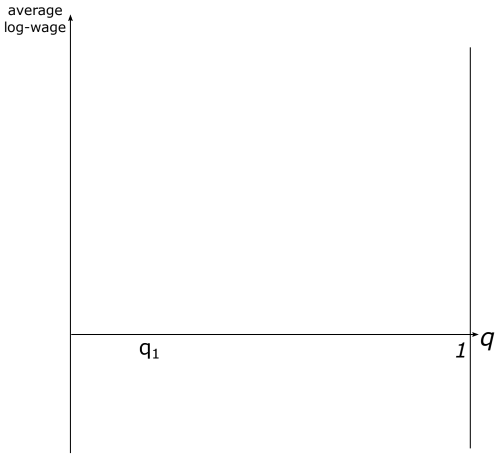

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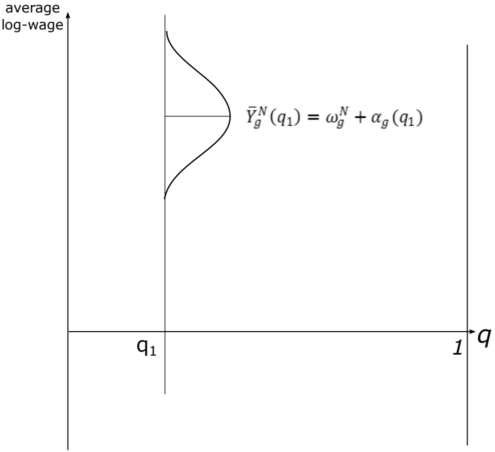

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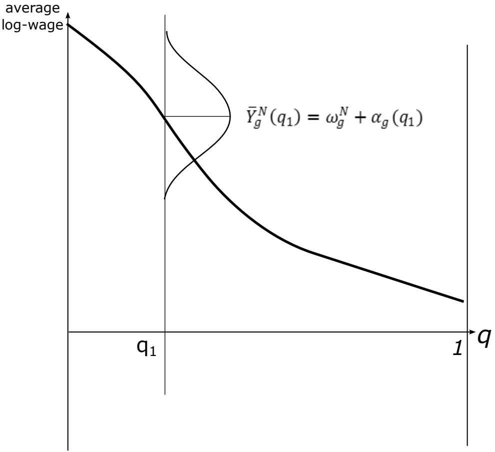

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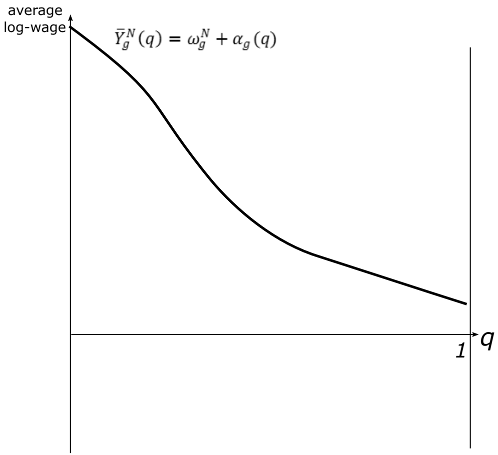

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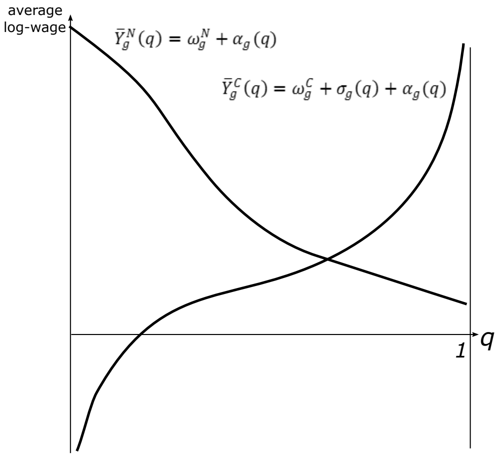
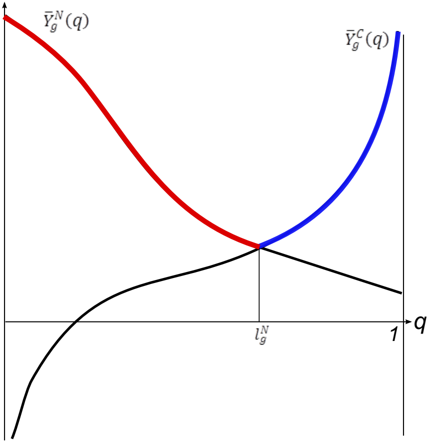


Employment and log-wages in equilibrium



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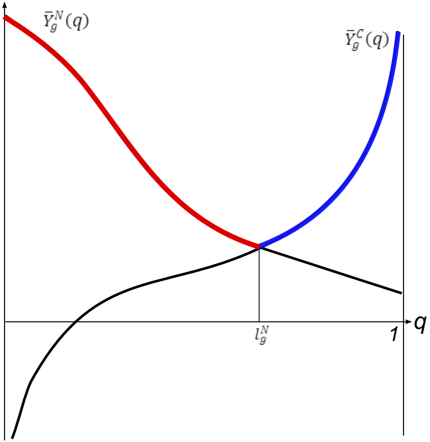
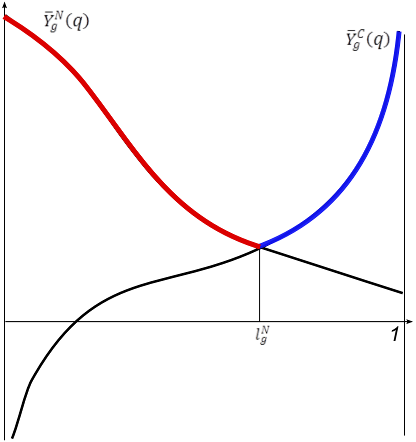


Sector employment composition, l_g^N: indifference of marginal workers.

$$\boxed{\omega_g^N - \omega_g^C = \sigma_g \left(l_g^N \right)}$$

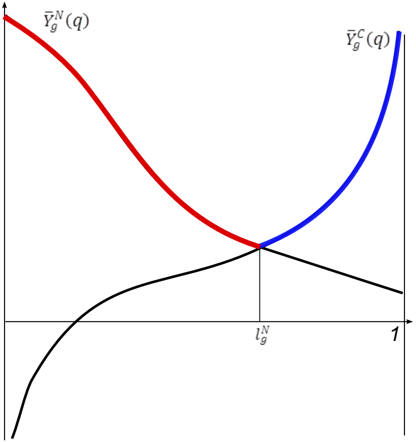
Employment and log-wages in equilibrium



Average log-wage in non-commodity sector:

$$\boxed{\bar{Y}_g^N = \omega_g^N + \frac{1}{l_g^N} \int_0^{l_g^N} \alpha_g(q)\ dq}$$

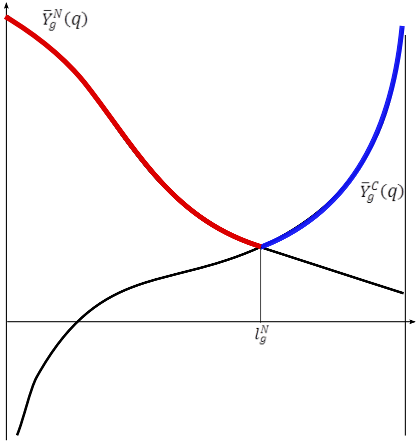
Employment and log-wages in equilibrium



Average log-wage in commodity sector:

$$\boxed{\bar{Y}_g^C = \omega_g^C + \frac{1}{l_g^C} \int_{l_g^N}^{1} \sigma_g(q) + \alpha_g(q)\ dq}$$

Effect of a change in sectoral wage per efficiency unit



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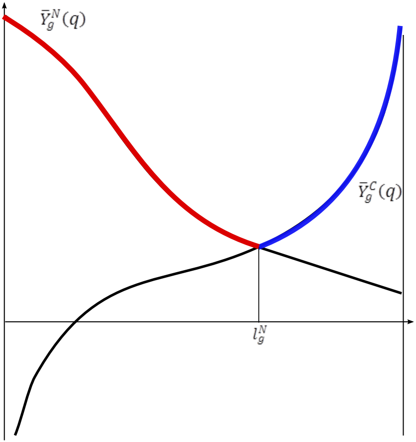

- ω_g^C increases
- ω_g^N constant

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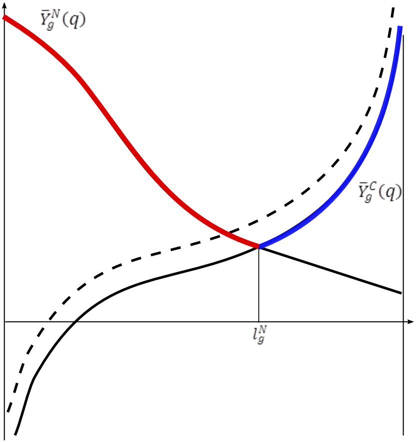

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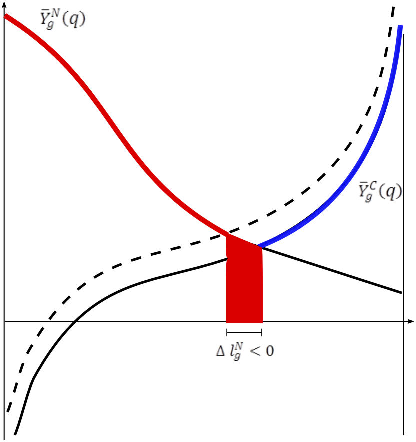
Response of sectoral employment



- Workers switch from non-commodity sector to commodity sector: $\Delta l_g^N < 0$

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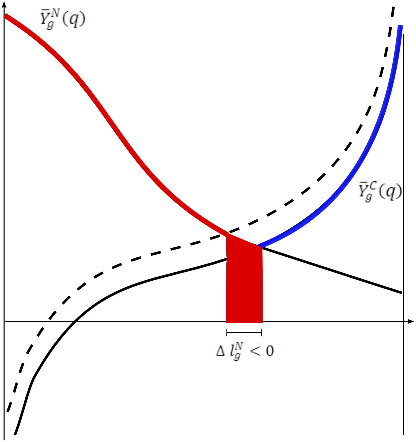
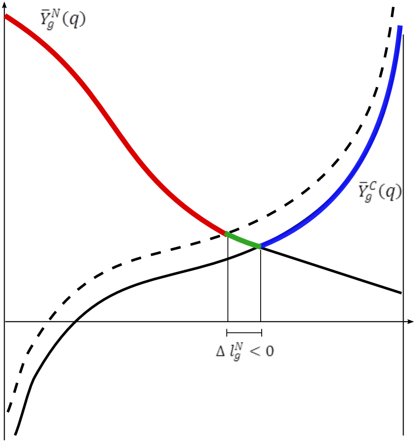


- Workers switch from non-commodity sector to commodity sector: $\Delta l_g^N < 0$

$$\Delta\omega_g^N - \Delta\omega_g^C \approx \frac{\partial\sigma_g(l_g^N)}{\partial q} \cdot \Delta l_g^N$$

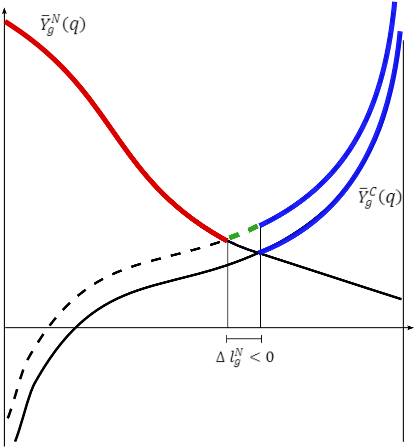
Response of average log-wage in non-commodity sector



- Change in employment composition $\Rightarrow$ Change in the average sector efficiency

$$\Delta \bar{Y}_g^N - \Delta\omega_g^N \approx \left[\alpha_g(l_g^N) - \frac{1}{l_g^N}\int_0^{l_g^N} \alpha_g(q)\ dq\right]\cdot \Delta \ln\left(l_g^N\right)$$

Response of average log-wage in commodity sector

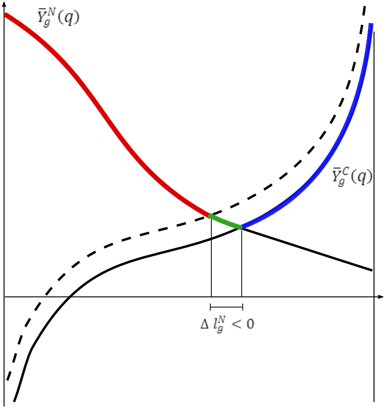


- Changes in ω_g^C and employment composition

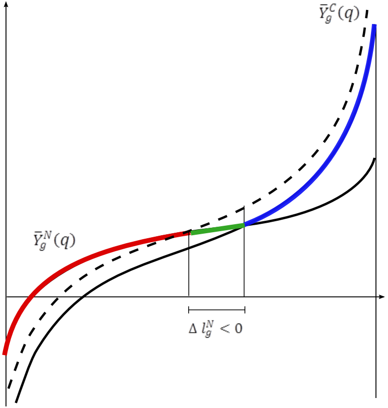
$$\Delta \bar{Y}_g^C - \Delta\omega_g^C \approx \left[\sigma_g(l_g^N) + \alpha_g(l_g^N) - \frac{1}{l_g^C} \int_{l_g^N}^{1} \sigma_g(q) + \alpha_g(q)\ dq \right] \cdot \Delta \ln\left(l_g^C\right)$$

Different patterns of selection into non-commodity sector

Case (a): Positive Selection



Case (b): Negative Selection



Response of wage inequality

Response of wage inequality

1. Average of log-wages in group g:

$$\Delta \bar{Y}_g = \Delta\omega_g^C \cdot l_g^C + \Delta\omega_g^N \cdot l_g^N + \left[\sigma_g\left(l_g^N + \Delta l_g^N\right) \cdot \Delta l_g^N - \int_{l_g^N}^{l_g^N + \Delta l_g^N} \sigma_g(q)\ dq\right]$$

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Direct effect

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2. Variance of log-wages in group g:

$$\Delta V_g = \Delta\left[l_g^N l_g^C \cdot (\bar{Y}_g^C - \bar{Y}_g^N)^2\right] + \Delta\left[l_g^N V\left[\alpha_g(q) \middle| q < l_g^N\right] + l_g^C V\left[\sigma_g(q) + \alpha_g(q) \middle| q \geq l_g^N\right]\right]$$

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Variance of sector average wage

Response of wage inequality

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Average of sector wage variance

Response of wage inequality

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Outline

Set of segmented labor markets, m

- Assume that wage per efficiency unit is observable: $(\omega^{C}_{g,m}, \omega^{N}_{g,m})$

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Assumption A1.

1. **Comparative Advantage:**

$$\tilde{s}_g(i) \sim F_g\left(s\right)$$

2. **Absolute Advantage:**

$$\{a_g(i) | \tilde{s}_g(i) = s\} \sim \quad H_g^a\left(a|s\right)$$

Set of segmented labor markets, m

- Assume that wage per efficiency unit is observable: $(\omega^C_{g,m}, \omega^N_{g,m})$

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1. **Comparative Advantage:**

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2. **Absolute Advantage:**

$$\{a_g(i) | \tilde{s}_g(i) = s\} \sim \mu H^a_g(a|s) + (1-\mu) H^e_{g,m}(a)$$

Set of segmented labor markets, m

- Assume that wage per efficiency unit is observable: $(\omega_{g,m}^{C}, \omega_{g,m}^{N})$

Assumption A1.

1. **Comparative Advantage:**

$$\tilde{s}_g(i) \sim F_g(s) \quad \text{and} \quad s_g(i) = \tilde{s}_g(i) + \tilde{u}_{g,m}$$

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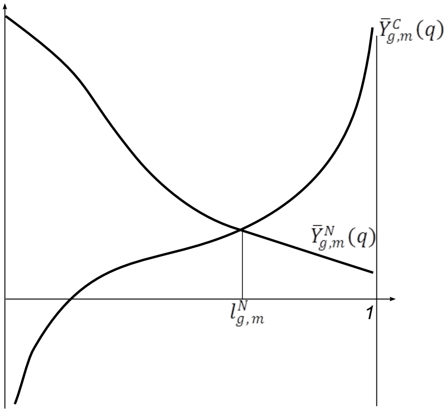
Shocks to comparative and absolute advantage

$$\omega^N_{g,m} - \omega^C_{g,m} = \sigma_g \left(l^N_{g,m} \right) + \tilde{u}_{g,m}$$

$$\bar{Y}^k_{g,m} - \omega^k_{g,m} = \bar{\alpha}^k_g \left(l^N_{g,m} \right) + \tilde{v}^k_{g,m}$$



Shocks to comparative and absolute advantage

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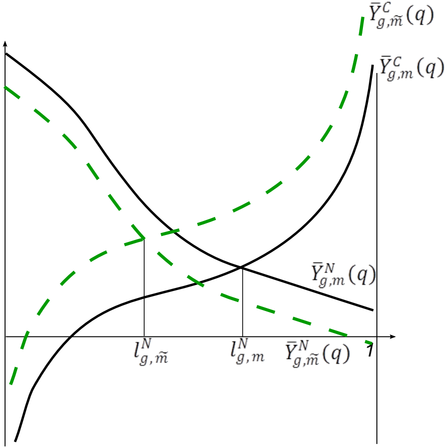

Identification of Comparative and Absolute Advantage

NPIV: Newey and Powell (2003)

$$\omega_{g,m}^{N} - \omega_{g,m}^{C} = \sigma_g\left(l_{g,m}^{N}\right) + \tilde{u}_{g,m}$$

$$\bar{Y}_{g,m}^{k} - \omega_{g,m}^{k} = \bar{\alpha}_g^{k}\left(l_{g,m}^{N}\right) + \tilde{v}_{g,m}^{k}$$

Identification of Comparative and Absolute Advantage
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$$\omega^N_{g,m} - \omega^C_{g,m} = \sigma_g\left(l^N_{g,m}\right) + \tilde{u}_{g,m}$$

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A2 $E\left[\tilde{u}_{g,m}|\mathbf{Z}_{g,m}\right] = E\left[\tilde{v}_{g,m}|\mathbf{Z}_{g,m}\right] = 0$

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A3 For $f(.)$ with finite expectation, $E\left[f(l^N_{g,m})\middle|\mathbf{Z}_{g,m}\right] = 0 \ \Rightarrow \ f(l^N_{g,m}) = 0$

Identification of Comparative and Absolute Advantage
NPIV: Newey and Powell (2003)

$$\omega^N_{g,m} - \omega^C_{g,m} = \sigma_g\left(I^N_{g,m}\right) + \tilde{u}_{g,m}$$

$$\bar{Y}^k_{g,m} - \omega^k_{g,m} = \bar{\alpha}^k_g\left(I^N_{g,m}\right) + \tilde{v}^k_{g,m}$$

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Theorem

Suppose that A1-A3 hold. Then, the schedules of comparative advantage, $\sigma_g(.)$, and absolute advantage, $\alpha_g(.)$, are nonparametrically identified.

Extensions

1. Multiple Sectors: ▸ Multiple Sectors

2. Non-Monetary Employment Benefit: ▸ Non-Monetary

Outline

Empirical Application: sample of Brazilian regions

Employment and wages

- Brazilian Census (1991, 2000, 2010): male, white, full-time, 21-60 years
- Two groups: High School Graduates (HSG) and High School Dropouts (HSD)
- Two sectors: commodity (agriculture and mining) and non-commodity (manufacturing and service)
- Regional labor markets: 518 microregions

World price of agriculture and mining commodities

- Six groups in CRB index: Grains, Soft, Livestock, Precious Metals, Metals, Oil
- Prices in U.S. exchange markets converted to Brazilian currency

▸ Worker Sample ▸ Commodity Prices

Exposure to commodity price shocks: groups and regions

$$\Delta \mathbf{Z}_{g,r,t} = \left\{ \phi^{j}_{g,r} \cdot \Delta \ln p^{j}_{t} \right\}_{j \in \mathcal{J}^C}$$

- $\phi^j_{g,r}$: Share of product j in earning of group g in region r at 1991
  [within commodity sector]
- $\Delta \ln p^j_t$: Log-change in the world price of product j, 1991-2000 and 2000-2010

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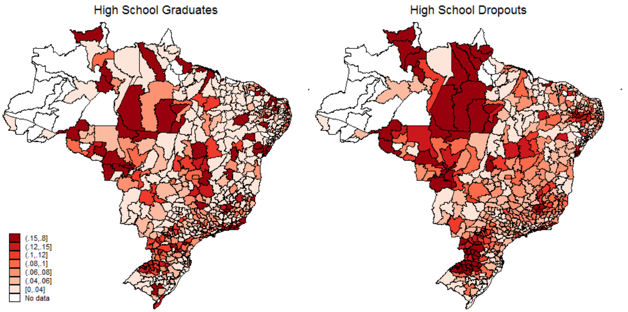
- $\phi^{j}_{g,r}$: Share of product j in earning of group g in region r at 1991
  [within commodity sector] ▸ Sector Composition
- $\Delta \ln p^{j}_{t}$: Log-change in the world price of product j, 1991-2000 and 2000-2010



Effect of shock exposure on sectoral labor outcomes

$$\Delta l^{C}_{g,r,t} = \beta_g \cdot \left[\sum_{j \in \mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t \right] + X_{g,r,t}\gamma_g + v_{g,r,t}$$

Dependent Variable: Change in	Commodity Sector Employment Share	Commodity Sector Average Log Wage Premium	Average of Log Wage	Variance of Log Wage
	(1)	(2)	(3)	(4)
A. High School Graduates				
Commodity price shock	0.031***			
	(0.010)			
R^2	0.402			
B. High School Dropouts				
Commodity price shock	0.072**			
	(0.028)			
R^2	0.556			
Baseline Controls (interacted with period dummies)				
Initial sector composition controls	Yes			
Initial labor market conditions	Yes			

▸ Pre-trends ▸ Other groups ▸ Labor Supply ▸ Industry-level responses

Effect of shock exposure on sectoral labor outcomes

$$\Delta\left(\bar{Y}^{C}_{g,r,t}-\bar{Y}^{N}_{g,r,t}\right)=\beta_g\cdot\left[\sum_{j\in\mathcal{J}^C}\phi^j_{g,r}\cdot\Delta\ln p^j_t\right]+X_{g,r,t}\gamma_g+v_{g,r,t}$$

Dependent Variable: Change in	Commodity Sector Employment Share	Commodity Sector Average Log Wage Premium	Average of Log Wage	Variance of Log Wage
	(1)	(2)	(3)	(4)
A. High School Graduates				
Commodity price shock	0.031***	0.407***		
	(0.010)	(0.111)		
R^2	0.402	0.199		
B. High School Dropouts				
Commodity price shock	0.072**	-0.145		
	(0.028)	(0.177)		
R^2	0.556	0.232		
Baseline Controls (interacted with period dummies)				
Initial sector composition controls	Yes	Yes		
Initial labor market conditions	Yes	Yes		

▸ Pre-trends ▸ Other groups ▸ Labor Supply ▸ Industry-level responses

Effect of shock exposure on sectoral labor outcomes

$$\color{red}{\Delta \bar{Y}_{g,r,t}} = \beta_g \cdot \left[\sum_{j \in \mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t \right] + X_{g,r,t}\gamma_g + v_{g,r,t}$$

Dependent Variable: Change in	Commodity Sector Employment Share	Commodity Sector Average Log Wage Premium	Average of Log Wage	Variance of Log Wage
	(1)	(2)	(3)	(4)
A. High School Graduates				
Commodity price shock	0.031***	0.407***	0.141***	
	(0.010)	(0.111)	(0.051)	
R^2	0.402	0.199	0.467	
B. High School Dropouts				
Commodity price shock	0.072**	-0.145	0.144**	
	(0.028)	(0.177)	(0.073)	
R^2	0.556	0.232	0.653	
Baseline Controls (interacted with period dummies)				
Initial sector composition controls	Yes	Yes	Yes	
Initial labor market conditions	Yes	Yes	Yes	

▸ Pre-trends ▸ Other groups ▸ Labor Supply ▸ Industry-level responses

Effect of shock exposure on sectoral labor outcomes

$$\Delta V_{g,r,t} = \beta_g \cdot \left[\sum_{j \in \mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t \right] + X_{g,r,t}\gamma_g + v_{g,r,t}$$

Dependent Variable: Change in	Commodity Sector Employment Share	Commodity Sector Average Log Wage Premium	Average of Log Wage	Variance of Log Wage
	(1)	(2)	(3)	(4)
A. High School Graduates				
Commodity price shock	0.031***	0.407***	0.141***	-0.129**
	(0.010)	(0.111)	(0.051)	(0.057)
R^2	0.402	0.199	0.467	0.361
B. High School Dropouts				
Commodity price shock	0.072**	-0.145	0.144**	-0.135
	(0.028)	(0.177)	(0.073)	(0.086)
R^2	0.556	0.232	0.653	0.388
Baseline Controls (interacted with period dummies)				
Initial sector composition controls	Yes	Yes	Yes	Yes
Initial labor market conditions	Yes	Yes	Yes	Yes

▸ Pre-trends ▸ Other groups ▸ Labor Supply ▸ Industry-level responses

Measuring changes in wage per efficiency unit

Measuring changes in wage per efficiency unit

Exposure to changes in wage per efficiency unit of own sector of employment

$$\Downarrow$$

$$\boxed{\text{Variation in } \textbf{pre-shock} \text{ sector allocation} \Rightarrow \text{Variation in wage } \textbf{growth}}$$

Measuring changes in wage per efficiency unit

Exposure to changes in wage per efficiency unit of own sector of employment

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$$\boxed{\text{Variation in } \textbf{pre-shock} \text{ sector allocation} \Rightarrow \text{Variation in wage } \textbf{growth}}$$

Let $\Delta Y_g(\pi)$ be the wage growth in quantile π of the log-wage distribution.

Measuring changes in wage per efficiency unit

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$$\Delta Y_g(\pi) = \Delta\omega_g^C +$$

Measuring changes in wage per efficiency unit

Exposure to changes in wage per efficiency unit of own sector of employment

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Let $\Delta Y_g(\pi)$ be the wage growth in quantile π of the log-wage distribution.

$$\Delta Y_g(\pi) = \Delta\omega_g^C + \left[\Delta\omega_g^N - \Delta\omega_g^C\right] \cdot l_g^N(\pi)$$

where, at quantile π of the log-wage distribution,

- $l_g^N(\pi)$ is the initial employment share in non-commodity sector

Measuring changes in wage per efficiency unit

Exposure to changes in wage per efficiency unit of own sector of employment

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$$\Delta Y_g(\pi) = \Delta\omega_g^C + \left[\Delta\omega_g^N - \Delta\omega_g^C\right] \cdot l_g^N(\pi) + \Delta v_g(\pi)$$

where, at quantile π of the log-wage distribution,

- $l_g^N(\pi)$ is the initial employment share in non-commodity sector
- $\Delta v_g(\pi)$ is an idiosyncratic efficiency shock

Measuring changes in wage per efficiency unit

Exposure to changes in wage per efficiency unit of own sector of employment

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where, at quantile π of the log-wage distribution,

- $l_g^N(\pi)$ is the initial employment share in non-commodity sector
- $\Delta v_g(\pi)$ is an idiosyncratic efficiency shock

For each of the 2,072 group-region-period, estimate this equation by OLS.

Details

Effect of shock exposure on wage per efficiency unit

$$\Delta\omega^k_{g,r,t} = \beta_g \cdot \left[\sum_{j\in\mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t\right] + \Delta\mathbf{X}_{g,r,t}\gamma_g + e_{g,r,t}$$

Dependent Variable: change in wage per efficiency unit	**Commodity sector**	**Non-commodity sector**
	(1)	(2)
A. High School Graduates		
Commodity price shock	0.974***	0.276***
	(0.372)	(0.066)
R^2	0.598	0.596
B. High School Dropouts		
Commodity price shock	1.436**	-0.003
	(0.638)	(0.088)
R^2	0.672	0.575
Baseline Controls (interacted with period dummies)		
Initial sector composition controls	Yes	Yes
Initial labor market conditions	Yes	Yes

Parametric Restrictions: Log-Linear System

For $\sigma_g > 0$ and $\alpha_g \in \mathbb{R}$,

$$\boxed{\sigma_g(q) = \sigma_g \cdot [\ln(q) - \ln(1-q)] \quad \text{and} \quad \alpha_g(q) = \alpha_g \cdot \ln(q)}$$

Fréchet, $\sigma_g = -\alpha_g$: sector wage premium and log-wage variance are constant

Parametric Restrictions: Log-Linear System

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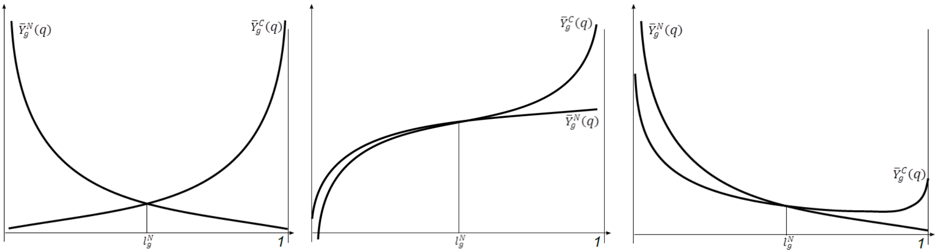


Case (a): **Fréchet** $\alpha_g = -\sigma_g$ and $\sigma_g \in (0,1)$

Case (b): $\alpha_g > 0$ and $\alpha_g + \sigma_g > 0$

Case (c): $\alpha_g < 0$ and $\alpha_g + \sigma_g < 0$

GMM Estimator of structural parameters

Under Assumption A5, estimate $\Theta_g \equiv (\sigma_g, \alpha_g)$ using

$$\begin{aligned}
\Delta\omega^N_{g,r,t} - \Delta\omega^C_{g,r,t} &= \Delta\sigma_g \left(I^N_{g,r,t}\right) && +\Delta\mathbf{X}_{g,r,t}\gamma^u_g + \Delta u_{g,r,t} \\
\Delta\bar{Y}^k_{g,r,t} - \Delta\omega^k_{g,r,t} &= \Delta\bar{\alpha}^k_g \left(I^N_{g,r,t}\right) && +\Delta\mathbf{X}_{g,r,t}\gamma^k_g + \Delta v^k_{g,r,t}
\end{aligned}$$

With $\mathbf{W}_g \equiv \left[\Delta\mathbf{Z}^C_{g,r,t}, \Delta\mathbf{X}_{g,r,t}\right]$,

$$\hat{\Theta}_g = \arg\min_{\Theta_g} \ \mathbf{e}_g(\Theta_g)'\mathbf{W}_g\mathbf{\Phi}\mathbf{W}'_g\mathbf{e}_g(\Theta_g)$$

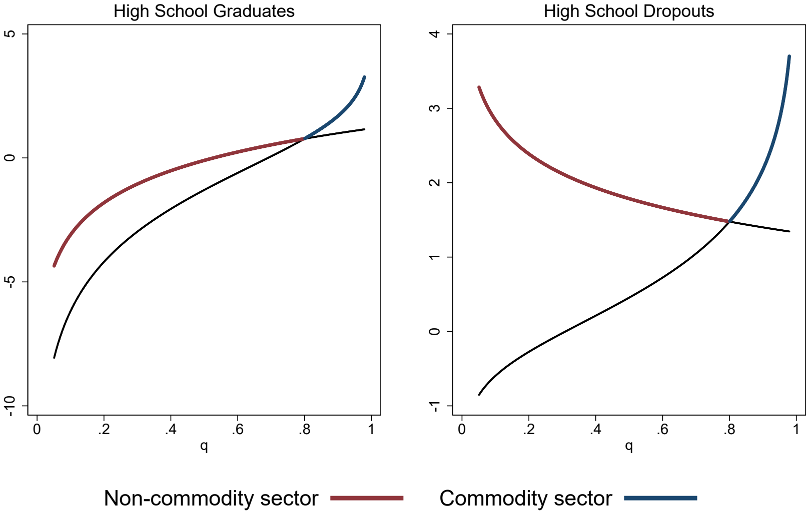
where $\mathbf{\Phi}$ is the optimal weight matrix.

Estimates of structural parameters

	Fréchet model	Log-linear model
	$\sigma_g = -\alpha_g$	
	(1)	(2)
A. High School Graduates		
σ_{HSG}	0.711***	0.860***
	(0.261)	(0.263)
α_{HSG}	-0.711***	1.864*
	(0.261)	(0.995)
Test of Fréchet restriction (p-value)	-	0.011
J-test of overidentification (p-value)	0.058	0.314
B. High School Dropouts		
σ_{HSD}	0.967***	0.960*
	(0.167)	(0.529)
α_{HSD}	-0.967***	-0.656***
	(0.167)	(0.196)
Test of Fréchet restriction (p-value)	-	0.618
J-test of overidentification (p-value)	0.138	0.447

2SLS Specification Other groups

Average log-wage by comparative advantage quantile
Main estimates



Model fit

$$\Delta \bar{Y}_{g,r,t} = \beta_g \cdot \left[\sum_{j \in \mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t \right] + \Delta \mathbf{X}_{g,r,t} \gamma_g + e_{g,r,t}$$

	Regression Analysis	Predicted change with Log-linear model	Predicted change with Fréchet model
	(1)	(2)	(3)
A. High School Graduates			
Change in log-wage average	0.141***	0.335	0.334
	[0.06, 0.22]	[0.22, 0.45]	[0.22, 0.46]
Change in log-wage variance			
B. High School Dropouts			
Change in log-wage average	0.144**	0.166	0.166
	[0.02, 0.26]	[-0.01, 0.52]	[-0.02, 0.38]
Change in log-wage variance			

Model fit

$$\Delta V_{g,r,t} = \beta_g \cdot \left[\sum_{j \in \mathcal{J}^C} \phi^j_{g,r} \cdot \Delta \ln p^j_t \right] + \Delta \mathbf{X}_{g,r,t} \gamma_g + e_{g,r,t}$$

	Regression Analysis	Predicted change with Log-linear model	Predicted change with Fréchet model
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A. High School Graduates			
Change in log-wage average	0.141***	0.335	0.334
	[0.06, 0.22]	[0.22, 0.45]	[0.22, 0.46]
Change in log-wage variance	-0.129**	-0.099	-
	[-0.22, -0.03]	[-0.71, 0.07]	-
B. High School Dropouts			
Change in log-wage average	0.144**	0.166	0.166
	[0.02, 0.26]	[-0.01, 0.52]	[-0.02, 0.38]
Change in log-wage variance	-0.135	0.104	-
	[-0.28, 0.01]	[-0.44, 0.33]	-

Outline

In 1991, how would wage inequality change if commodity prices were equal to those of 2010?

In 1991, how would wage inequality change if commodity prices were equal to those of 2010?

Sectoral shock: change in world price of basic commodities

$\Downarrow$ (1^{st} step)

Change in wage per efficiency unit: $\Delta\omega^{C}_{g,r,t}$ and $\Delta\omega^{N}_{g,r,t}$

$\Downarrow$ (2^{nd} step)

Change in wage inequality using estimates of comparative and absolute advantage parameters

In 1991, how would wage inequality change if commodity prices were equal to those of 2010?

Sectoral shock: change in world price of basic commodities

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Change in wage per efficiency unit: $\Delta\omega^{C}_{g,r,t}$ and $\Delta\omega^{N}_{g,r,t}$

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Change in wage inequality using estimates of comparative and absolute advantage parameters

Two alternative procedures for 1^{st} step:

1. Reduced-form pass-through: Use estimates from regression of wage per efficiency unit on shock exposure across Brazilian regions

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Sectoral shock: change in world price of basic commodities

$\Downarrow$ (1^{st} step)

Change in wage per efficiency unit: $\Delta\omega^C_{g,r,t}$ and $\Delta\omega^N_{g,r,t}$

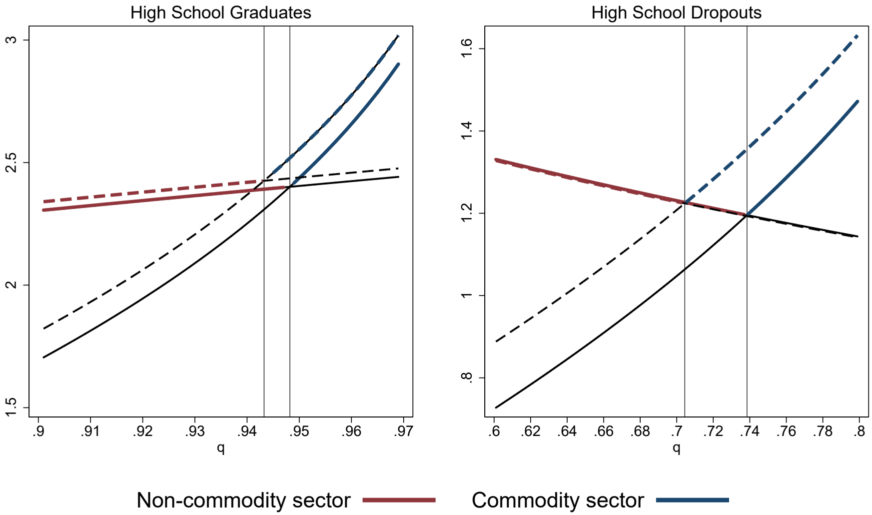
$\Downarrow$ (2^{nd} step)

Change in wage inequality using estimates of comparative and absolute advantage parameters

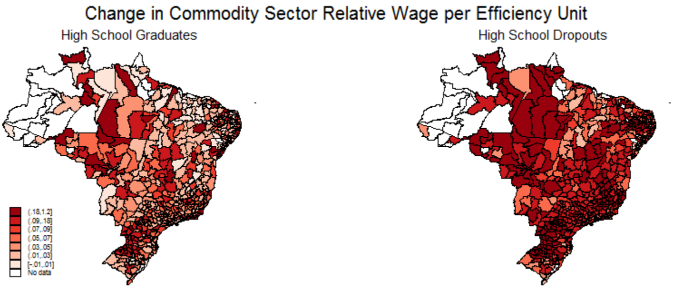
Two alternative procedures for 1^{st} step:

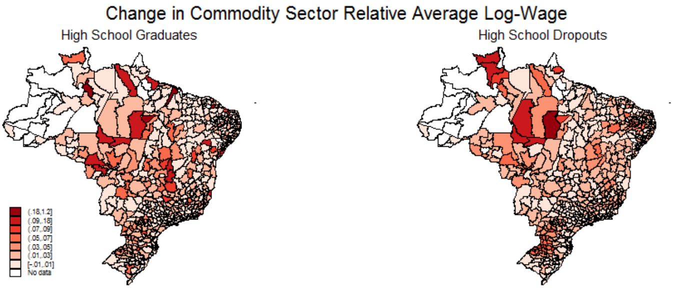
1. Reduced-form pass-through: Use estimates from regression of wage per efficiency unit on shock exposure across Brazilian regions
2. General equilibrium model: Calibrate labor demand structure and compute counterfactual changes in wage per efficiency unit (Dekle-Eaton-Kortum, 2007)

1991–2010 commodity price rise

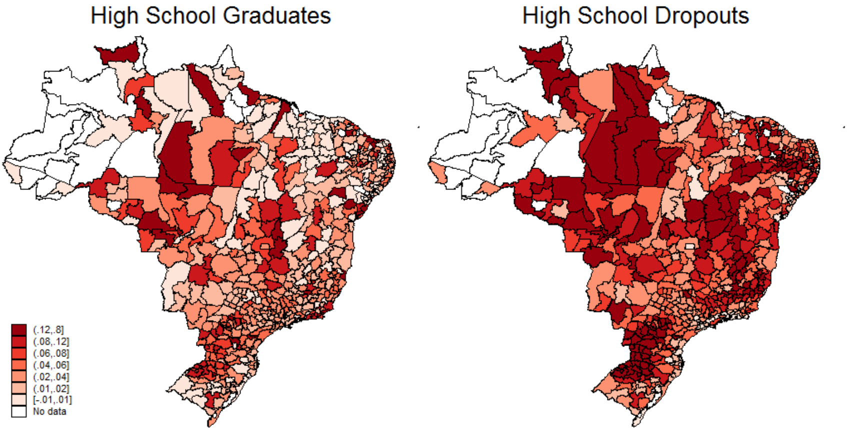


1991–2010 commodity price rise: Effect on sectoral wage





1991–2010 commodity price rise: Effect on average wage



1991–2010 commodity price rise: Effect on Brazilian log-wage variance

	Log-linear model	Fréchet model
	(1)	(2)
Panel A. High School Graduates		
	-0.012	
	8.13%	
Panel B. High School Dropouts		
	-0.008	
	2.46%	
Panel C. All Workers		
	-0.016	
	5.12%	

Note. Counterfactual change in Brazilian log-wage variance, along with the percentage of the actual change in log-wage vairance between 1991 and 2010.

1991–2010 commodity price rise: Effect on Brazilian log-wage variance

	Log-linear model	Fréchet model
	(1)	(2)
Panel A. High School Graduates		
	-0.012	-0.002
	8.13%	1.33%
Panel B. High School Dropouts		
	-0.008	-0.025
	2.46%	8.09%
Panel C. All Workers		
	-0.016	-0.026
	5.12%	8.38%

Note. Counterfactual change in Brazilian log-wage variance, along with the percentage of the actual change in log-wage vairance between 1991 and 2010.

General equilibrium model

General equilibrium model

Additional parametric assumptions

- Industry j of in the aggregate sector k: Nested-CES production function

$$q^j = B^j \cdot (L^j)^{\eta^j}(X^j)^{1-\eta^j} \quad \text{where} \quad L^j \equiv \left[\beta^j_{HSG}(L^j_{HSG})^{\frac{\rho-1}{\rho}} + \beta^j_{HSD}(L^j_{HSD})^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

- Sectoral supply of effective labor units are given by

$$\bar{L}^N_g = \kappa_g \int_0^{l^N_g} e^{\alpha_g(q)}\, dq \quad \text{and} \quad \bar{L}^C_g = \kappa_g \int_{l^N_g}^1 e^{\sigma_g(q)+\alpha_g(q)}\, dq$$

General equilibrium model

Additional parametric assumptions

- Industry j of in the aggregate sector k: Nested-CES production function

$$q^j = B^j \cdot (L^j)^{\eta^j} (X^j)^{1-\eta^j} \quad \text{where} \quad L^j \equiv \left[\beta^j_{HSG} (L^j_{HSG})^{\frac{\rho-1}{\rho}} + \beta^j_{HSD} (L^j_{HSD})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

- Sectoral supply of effective labor units are given by

$$\bar{L}^N_g = \kappa_g \int_0^{I^N_g} e^{\alpha_g(q)} \, dq \quad \text{and} \quad \bar{L}^C_g = \kappa_g \int_{I^N_g}^1 e^{\sigma_g(q)+\alpha_g(q)} \, dq$$

Computation: $\{\hat{\omega}^C_{HSD}, \hat{\omega}^N_{HSD}, \hat{\omega}^C_{HSG}, \hat{\omega}^N_{HSG}\}$ from labor market clearing with

- η^j: Labor share in production of industry j
- $\rho = 1.63$: Match aggregate elasticity between skilled and unskilled workers of 1.8

1991–2010 commodity price rise: effect on Brazilian log-wage variance

	Calibrated General Equilibrium Model	Reduced-Form Pass-Through
	(1)	(2)
Panel A. High School Graduates		
	-0.020	-0.012
	13.26%	8.13%
Panel B. High School Dropouts		
	-0.009	-0.008
	2.75%	2.46%
Panel C. All Workers		
	-0.024	-0.016
	7.72%	5.12%

Note. Counterfactual change in Brazilian log-wage variance, along with the percentage of the actual change in log-wage vairance between 1991 and 2010.

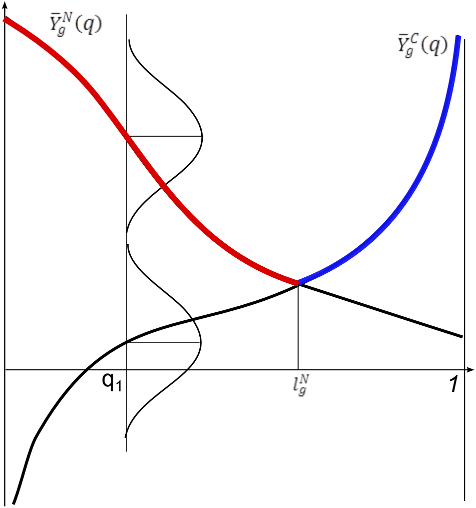
Outline

Concluding Remarks

- Neoclassical economy with worker heterogeneity in sectoral productivity
- Sector demand shifter triggers sectoral responses in employment and wages that uncovers comparative and absolute advantage schedules
- Structural estimation in a sample of regional labor markets in Brazil

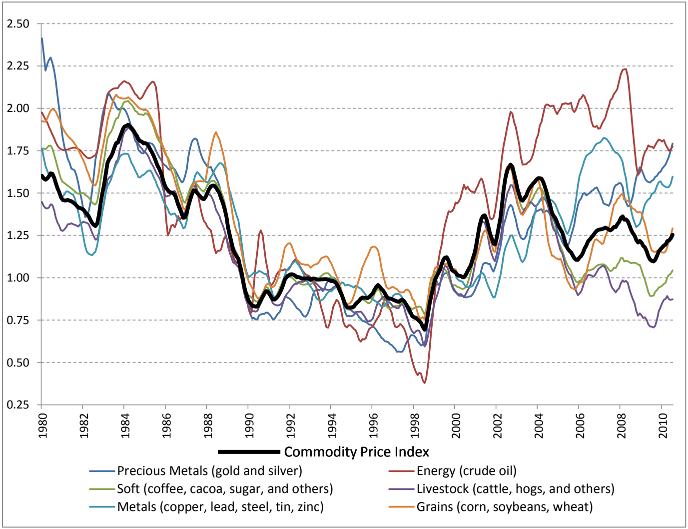
1. Model matches cross-regional responses in wage inequality
2. Importance of allowing for comparative and absolute advantage
3. World commodity prices $\Rightarrow$ Wage inequality in producer countries

Graphical representation: Change in wage inequality



Change in Wage Inequality

Trends in World Commodity Prices



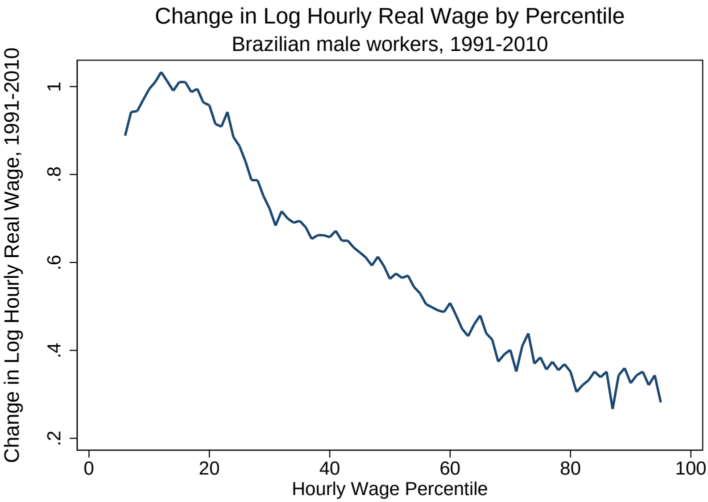
◂ Data

Summary Statistics: Benchmark Sample

	Commodity sector		Non-commodity sector	
	1991	2010	1991	2010
Average Age	33.5	36.3	32.8	35.5
Share of high school dropouts	93.8%	76.8%	70.2%	44.7%
Share in urban areas	30.4%	46.4%	94.2%	95.5%
Share in formal sector	33.8%	65.2%	80.0%	84.0%
Share earning below minimum wage	59.1%	41.2%	19.5%	14.2%

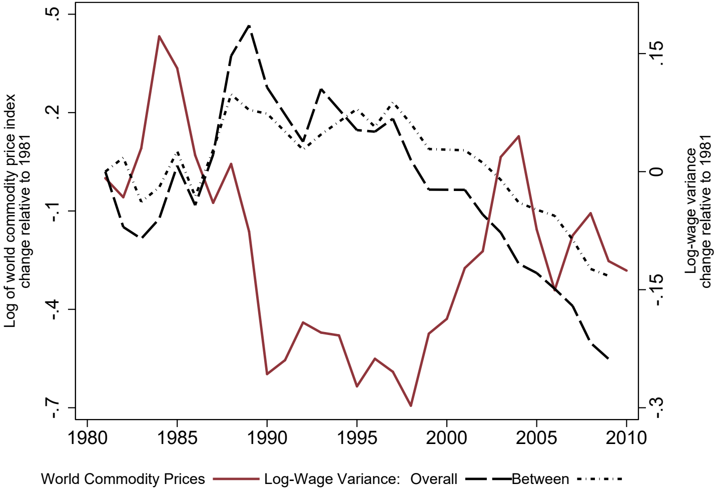
Data

Trends in Brazilian Wage Inequality



◂ Data ◂ Introduction

Trends in Brazilian Wage Inequality



Between component: predicted values of the regression of log wage on a full set of dummies for years of experience (0–39 years), years of education (0–16 years), state of residence (27 states), race (white dummy), and sector of employment (commodity sector). Data Introduction

Decomposition of the Variance of Log-Wages, 1980-2010

	1981	1986	1990	1995	1999	2005	2009
Overall	0.938	0.895	1.045	0.990	0.915	0.809	0.700
Residual	0.480	0.469	0.514	0.462	0.434	0.403	0.378
Between	0.457	0.426	0.531	0.529	0.481	0.405	0.322
Sector	0.026	0.014	0.034	0.036	0.029	0.013	0.011
Education	0.310	0.321	0.322	0.294	0.274	0.255	0.206
State	0.056	0.045	0.051	0.053	0.043	0.045	0.033
Race	-	-	0.006	0.005	0.006	0.004	0.004
Experience	0.055	0.064	0.062	0.046	0.044	0.047	0.039
Covariance	0.011	-0.019	0.055	0.095	0.085	0.041	0.028

Data

Labor Income Share by Industry in Brazil, 1991

Industry	High School Graduates		High School Dropouts	
	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
1. Commodity Sector	9.0	9.6	21.4	19.6
Grains (corn, soybeans, wheat)	4.7	11.7	10.1	16.3
Soft (coffee, cocoa, sugar and other)	12.9	16.1	19.2	17.9
Livestock (cattle, hogs, and others)	35.5	21.2	27.0	15.8
Metals (copper, lead, steel, tin, and zinc)	3.0	7.2	1.7	4.4
Precious Metals (gold and silver)	1.0	4.0	1.8	4.7
Energy (crude oil)	8.5	17.2	2.4	6.4
Other agriculture and mining	34.3	20.8	37.8	19.9
2. Manufacturing	16.0	10.7	17.8	11.3
3. Non-Tradable Goods and Services	75.0	10.8	60.8	14.7

Note. Sample of male white full-time workers extracted from the Brazilian Census of 1991. Statistics are weighted by the microregion share in national population on 1991.

◂ Shock Exposure

Estimation of wage per efficiency unit
Implementation details

- Discretization of log-wage distribution: 1 p.p. bins, 6^{th}–94^{th} percentiles (N = 88)
- $X_{g,r,t}(\pi)$: dummies for distribution range (bottom, middle, top) and minimum wage proximity (pre and post periods)

	Log change in commodity sector wage per efficiency unit		Log change in non-commodity sector relative wage per efficiency unit		R^2
	Mean	SD	Mean	SD	Mean
	(1)	(2)	(3)	(4)	(5)
A. High School Graduates					
1991 - 2000	0.320	0.370	-0.151	0.347	55.5%
2000 - 2010	0.150	0.645	-0.306	0.609	75.8%
B. High School Dropouts					
1991 - 2000	0.524	0.579	-0.364	0.619	71.5%
2000 - 2010	0.440	0.579	-0.360	0.634	83.0%

Main Results

Estimation of wage per efficiency unit
Alternative specification

Change in wage per efficiency unit	Commodity sector			Non-commodity sector		
	(1)	(2)	(3)	(4)	(5)	(6)
A. High School Graduates						
Correlation with baseline estimates	0.855	0.973	0.926	0.874	0.969	0.916
B. High School Dropouts						
Correlation with baseline estimates	0.914	0.960	0.886	0.912	0.960	0.893
Baseline Controls						
Percentile below federal minimum wage	Yes	No	Yes	Yes	No	Yes
Percentile in bottom, middle or top of wage distribution	No	Yes	Yes	No	Yes	Yes
Discretization of wage distribution						
Bins of 1 p.p. (N = 88)	Yes	Yes	No	Yes	Yes	No
Bins of 2 p.p. (N = 44)	No	No	Yes	No	No	Yes

Main Results

Commodity Price Shocks and Commodity Sector Employment Share

Dependent Variable:	**Change in Commodity Sector Employment Share**							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. High School Graduates								
Commodity price shock	0.031***	0.042***	0.039***	0.039***	0.039***	0.049***	0.019**	0.014*
	(0.010)	(0.010)	(0.012)	(0.011)	(0.012)	(0.017)	(0.009)	(0.007)
R^2	0.402	0.210	0.291	0.420	0.329	0.427	0.411	0.444
B. High School Dropouts								
Commodity price shock	0.072**	0.177***	0.086***	0.062**	0.063***	0.058**	0.092***	0.100***
	(0.028)	(0.066)	(0.029)	(0.029)	(0.020)	(0.027)	(0.029)	(0.032)
R^2	0.556	0.232	0.521	0.567	0.498	0.612	0.618	0.652
Baseline Controls								
Initial sector composition controls	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Initial labor market conditions	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls x period dummies	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1980-1991 dependent variable x period dummies	No	No	No	Yes	No	No	No	No
Extended Sample								
Including 1980-1991	No	No	No	No	Yes	Yes	No	No
with microregion-specific linear time trend	No	No	No	No	No	Yes	No	No
Additional worker groups								
Including nonwhite	No	No	No	No	No	No	Yes	Yes
Including female	No	No	No	No	No	No	No	Yes

◂ Reduced-Form Evidence

Commodity Price Shocks and Commodity Sector Wage Premium

Dependent Variable:	Commodity Sector Average Log Wage Premium							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. High School Graduates								
Commodity price shock	0.407***	0.347***	0.426***	0.492***	0.192*	0.194	0.310***	0.387***
	(0.111)	(0.095)	(0.114)	(0.119)	(0.109)	(0.144)	(0.099)	(0.100)
R^2	0.199	0.101	0.138	0.250	0.196	0.311	0.216	0.309
B. High School Dropouts								
Commodity price shock	-0.145	-0.255	-0.215	-0.183	0.266***	0.352***	0.032	0.023
	(0.177)	(0.163)	(0.189)	(0.200)	(0.090)	(0.122)	(0.112)	(0.100)
R^2	0.232	0.158	0.199	0.266	0.261	0.420	0.290	0.306
Baseline Controls								
Initial sector composition controls	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Initial labor market conditions	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls x period dummies	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1980-1991 dependent variable x period dummies	No	No	No	Yes	No	No	No	No
Extended Sample								
Including 1980-1991	No	No	No	No	Yes	Yes	No	No
with microregion-specific linear time trend	No	No	No	No	No	Yes	No	No
Additional worker groups								
Including nonwhite	No	No	No	No	No	No	Yes	Yes
Including female	No	No	No	No	No	No	No	Yes

◂ Reduced-Form Evidence

Commodity Price Shocks and Group Wage Average

Dependent Variable:	Average of Log Wage							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. High School Graduates								
Commodity price shock	0.141***	0.322***	0.139***	0.111***	0.096**	0.102*	0.164***	0.151***
	(0.051)	(0.120)	(0.052)	(0.043)	(0.041)	(0.054)	(0.042)	(0.050)
R^2	0.467	0.336	0.434	0.536	0.482	0.582	0.590	0.643
B. High School Dropouts								
Commodity price shock	0.144**	0.379**	0.201**	0.095	0.112**	0.148**	0.149*	0.163**
	(0.073)	(0.158)	(0.087)	(0.074)	(0.044)	(0.061)	(0.080)	(0.077)
R^2	0.653	0.302	0.598	0.695	0.619	0.708	0.679	0.692
Baseline Controls								
Initial sector composition controls	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Initial labor market conditions	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls x period dummies	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1980-1991 dependent variable x period dummies	No	No	No	Yes	No	No	No	No
Extended Sample								
Including 1980-1991	No	No	No	No	Yes	Yes	No	No
with microregion-specific linear time trend	No	No	No	No	No	Yes	No	No
Additional worker groups								
Including nonwhite	No	No	No	No	No	No	Yes	Yes
Including female	No	No	No	No	No	No	No	Yes

◂ Reduced-Form Evidence

Commodity Price Shocks and Group Wage Variance

Dependent Variable:	**Variance of Log Wage**							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. High School Graduates								
Commodity price shock	-0.129**	-0.246***	-0.119*	-0.144**	-0.112***	-0.136**	-0.093*	-0.081*
	(0.057)	(0.092)	(0.062)	(0.058)	(0.041)	(0.055)	(0.050)	(0.044)
R^2	0.361	0.264	0.301	0.428	0.451	0.516	0.477	0.524
B. High School Dropouts								
Commodity price shock	-0.135	-0.185**	-0.201*	-0.109	-0.017	-0.009	-0.330***	-0.310***
	(0.086)	(0.089)	(0.104)	(0.085)	(0.032)	(0.041)	(0.076)	(0.068)
R^2	0.388	0.208	0.290	0.400	0.595	0.684	0.494	0.508
Baseline Controls								
Initial sector composition controls	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Initial labor market conditions	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls x period dummies	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1980-1991 dependent variable x period dummies	No	No	No	Yes	No	No	No	No
Extended Sample								
Including 1980-1991	No	No	No	No	Yes	Yes	No	No
with microregion-specific linear time trend	No	No	No	No	No	Yes	No	No
Additional worker groups								
Including nonwhite	No	No	No	No	No	No	Yes	Yes
Including female	No	No	No	No	No	No	No	Yes

Reduced-Form Evidence

Commodity Price Shocks and Regional Labor Supply

Dependent Variable:	Change in Log of Total Labor Supply	Change in Log of Immigrants' Labor Supply	Change in formal sector size
	(1)	(2)	(3)
A. High School Graduates			
Commodity price shock	0.085	0.054	0.007
	(0.139)	-0.159	(0.036)
R^2	0.812	0.750	0.818
B. High School Dropouts			
Commodity price shock	0.188	0.146	0.081*
	(0.150)	(0.185)	(0.041)
R^2	0.873	0.860	0.800
Baseline Controls			
Controls in Table 1	Yes	Yes	Yes

Reduced-Form Evidence

Commodity Price Shocks and Industry Relative Average Log Wage

Dependent Variable: Change in	Relative Industry Log Employment	Relative Industry Average Log Wage
	(1)	(2)
A. High School Graduates		
Commodity price shock	3.241***	0.383
	(1.089)	(0.351)
R^2	0.331	0.111
B. High School Dropouts		
Commodity price shock	2.438	0.654
	(3.338)	(0.483)
R^2	0.300	0.148
Baseline Controls (interacted with period dummies)		
Initial sector composition controls	Yes	Yes
Initial labor market conditions	Yes	Yes

◂ Reduced-Form Evidence

Estimates of structural parameters
Alternative sample

	(1)	(2)	(3)
A. High School Graduates			
σ_{HSG}	0.860***	0.818***	0.639***
	(0.263)	(0.243)	(0.184)
α_{HSG}	1.864*	3.633*	4.923**
	(0.995)	(1.914)	(2.032)
B. High School Dropouts			
σ_{HSD}	0.960*	1.175***	1.163***
	(0.529)	(0.417)	(0.363)
α_{HSD}	-0.656***	-0.621***	-0.542***
	(0.196)	(0.203)	(0.165)
Additional worker groups			
Baseline sample: male / white	Yes	Yes	Yes
Including non-white	No	Yes	Yes
Including female	No	No	Yes

Structural Estimation

Estimates of structural parameters
Alternative estimator

Estimator	Baseline: GMM	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
A. High School Graduates				
σ_{HSG}	0.860***	0.118	0.835***	1.336***
	(0.263)	(0.081)	(0.274)	(0.456)
CLR Confidence Interval	-	-	[0.503, 2.007]	[0.036, 3.303]
F of excluded instruments	-	-	2.70	10.48
α_{HSG}	1.864*	-0.031	1.927**	1.651*
	(0.995)	(0.142)	(0.950)	(0.916)
CLR Confidence Interval	-	-	[0.480, 5.861]	[-0.355, 5.602]
F of excluded instruments	-	-	4.02	9.81
B. High School Dropouts				
σ_{HSD}	0.960*	-0.174***	0.657	3.884
	(0.529)	(0.061)	(0.653)	(3.164)
CLR Confidence Interval	-	-	[0.455, 5.255]	[0.097, 7.081]
F of excluded instruments	-	-	3.61	1.53
α_{HSD}	-0.656***	-0.477***	-0.910***	-0.903***
	(0.196)	(0.032)	(0.163)	(0.214)
CLR Confidence Interval	-	-	[-1.401,-0.560]	[-1.778,-0.433]
F of excluded instruments	-	-	10.69	17.78
Vector of Excluded Instruments				
Disaggregated exposure to price shocks	Yes	No	Yes	No
Aggregate exposure to price shocks	No	No	No	Yes

◂ Structural Estimation

Estimates of structural parameters
Alternative estimates of wage per efficiency unit

	Baseline	Alternative measure of wage per efficiency unit		
	(1)	(2)	(3)	(4)
A. High School Graduates				
σ_{HSG}	0.860***	0.976*	0.644**	0.523
	(0.263)	(0.557)	(0.255)	(0.958)
α_{HSG}	1.864*	1.352	1.928*	0.764
	(0.995)	(0.877)	(1.020)	(0.570)
B. High School Dropouts				
σ_{HSD}	0.960*	0.654	1.464**	0.494
	(0.529)	(0.630)	(0.667)	(0.647)
α_{HSD}	-0.656***	-0.626***	-0.496*	-0.374*
	(0.196)	(0.200)	(0.261)	(0.223)
Baseline controls				
Percentile below federal minimum wage	Yes	Yes	No	Yes
Percentile in bottom, middle or top of wage distribution	Yes	Yes	Yes	No
Discretization of wage distribution				
Bins of 1 p.p. (N = 88)	Yes	No	Yes	Yes
Bins of 2 p.p. (N = 44)	No	Yes	No	No

◂ Structural Estimation

Extensions: Multiple Sectors, $k = 0, \ldots, K$

1. Comparative advantage: $s_g^k(i) + \tilde{u}_{g,m}^k \equiv \ln\left[L_g^k(i)/L_g^0(i)\right]$ with $\boldsymbol{s}_g(i) \sim F_g(\boldsymbol{s})$
2. Absolute advantage: $a_g(i) \equiv \ln\left[L_g^0(i)\right] \sim \mu H_g\left(a|\boldsymbol{s}\right) + (1-\mu)H_{g,m}^e(a)$

- Identify comparative advantage schedule: $F_g(\boldsymbol{s})$
- Identify absolute advantage schedule: $\alpha_g(\boldsymbol{s}) \equiv \mu \int a \; dH_g\left(a|\boldsymbol{s}\right)$
- Sufficient to compute changes in the average and the variance of log-wage distribution

Extensions: Multiple Sectors, $k = 0, ..., K$
Identification of $F_g(.)$

Employment share in sector k:

$$l^k_{g,m} = \chi^k_g\left(\tilde{\boldsymbol{\omega}}_{g,m}\right) \equiv \int_{\tilde{s}\in\mathcal{S}^k(\tilde{\boldsymbol{\omega}}_{g,m})} dF_g(\boldsymbol{s}),$$

I show that $\boldsymbol{\chi}_g(.)$ is invertible:

$$\omega^0_{g,m} - \omega^k_{g,m} = \sigma^k_g(l^1_{g,m}, ..., l^K_{g,m}) + \tilde{u}^k_{g,m}$$

where $l^k = \chi^k_g(\boldsymbol{\sigma}_g(l^1, ..., l^K))$ for all k.

Thus,

$$F_g(\boldsymbol{s}) = 1 - \sum_{k=1}^{K} \chi^k_g(-\boldsymbol{s}).$$

Extensions: Multiple Sectors, $k = 0, \ldots, K$
Identification of $\alpha_g(.)$

Average wage in sector $k = 0$:

$$\bar{Y}^0_{g,m} = \omega^0_{g,m} + \bar{\alpha}^0_g(l^1_{g,m}, \ldots, l^K_{g,m}) + \tilde{v}_{g,m}$$

where

$$\bar{\alpha}^0_g(l) \equiv \frac{1}{l^0} \int_{-\infty}^{\sigma^1_g(l)} \cdots \int_{-\infty}^{\sigma^K_g(l)} \alpha_g(\boldsymbol{s})\ f_g(\boldsymbol{s})\ d\boldsymbol{s}$$

Thus,

$$\alpha_g(\boldsymbol{s}) = \frac{1}{f_g(\boldsymbol{s})} \frac{\partial^K \left[l^0 \cdot \bar{\alpha}^0_g(\chi_g(\tilde{\boldsymbol{\omega}})) \right]}{\partial \tilde{\omega}^1 \ldots \partial \tilde{\omega}^K} \bigg|_{\tilde{\omega} = s}.$$

Extensions

Extensions: Non-Monetary Benefit

$$U_g^k(i) = \tau_g^k(i) \cdot w_{g,m}^k L_g^k(i)$$

1. Comparative advantage: $s_g(i) + \tilde{u}_{g,m} \equiv \ln[\tau_g^C(i) L_g^C(i) / \tau_g^N(i) L_g^N(i)] \sim F_g(.)$
2. Absolute advantage in sector k: $a_g^k(i) + \tilde{v}_{g,m}^k \equiv \ln\left[L_g^k(i)\right] \sim H_g\left(a|s\right)$

Extensions: Non-Monetary Benefit

$$U_g^k(i) = \tau_g^k(i) \cdot w_{g,m}^k L_g^k(i)$$

1. Comparative advantage: $s_g(i) + \tilde{u}_{g,m} \equiv \ln[\tau_g^C(i) L_g^C(i) / \tau_g^N(i) L_g^N(i)] \sim F_g(.)$
2. Absolute advantage in sector k: $a_g^k(i) + \tilde{v}_{g,m}^k \equiv \ln\left[L_g^k(i)\right] \sim H_g\left(a|s\right)$

$$\omega_{g,m}^N - \omega_{g,m}^C = \sigma_g\left(l_{g,m}^N\right) + \tilde{u}_{g,m}$$

$$\bar{Y}_{g,m}^k = \omega_{g,m}^k + \bar{\alpha}_g^k(l_{g,m}^N) + \tilde{v}_{g,m}^k \quad \text{where} \quad \bar{\alpha}_g^k(l) \equiv \begin{cases} \frac{1}{l}\int_0^l \alpha_g^N(q)\ dq \\ \\ \frac{1}{1-l}\int_l^1 \alpha_g^C(q) dq \end{cases}$$

Extensions