Earnings Inequality and the Minimum Wage: Evidence from Brazil

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This project

Shed light on drivers of earnings inequality by studying Brazil

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Question: To what extent can the rise in minimum wage explain Brazil's inequality decline?

What we do

1. Decompose evolution of earnings inequality in Brazil
2. Build a search model with heterogeneous firms and workers
3. Quantify effects of increase in minimum wage

Data

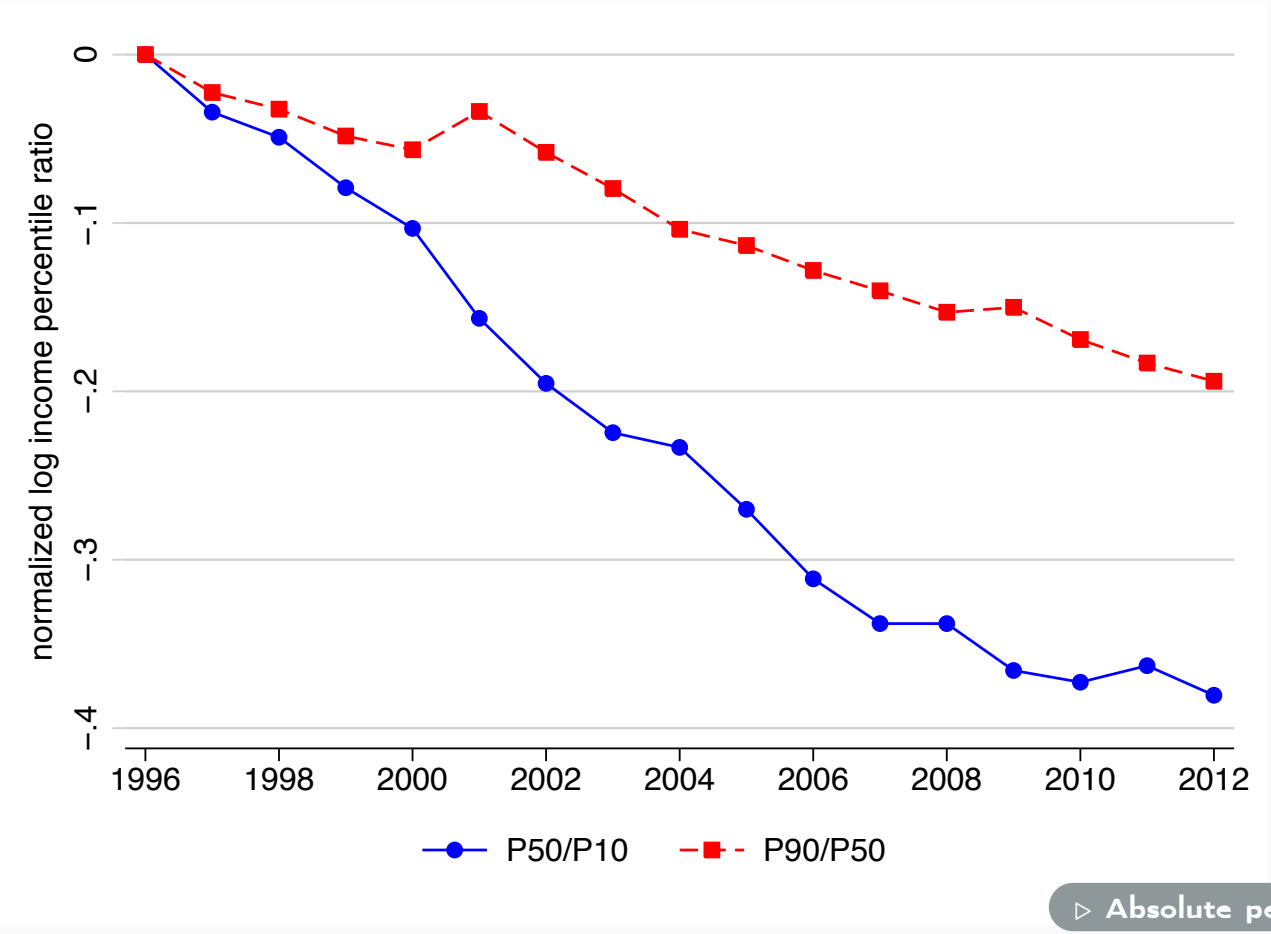
Data overview

1. Administrative linked employer-employee data (RAIS)
    - Universe of formal sector workers from 1988–2012
    - Restriction to male workers age 18–64
    - Earnings = average monthly labor income in employment
2. Administrative firm characteristics data (PIA)
    - All Manufacturing & Mining (M&M) firms with $\geq$ 30 employees or $\geq$ \$300,000 revenues from 1996–2012
    - Value added p.w. = (revenues - operating costs) / effective hours
3. Publicly available household survey data (PNAD)
    - Geography and informal sector

Facts

Fact 1: Compression throughout earnings distribution

- Compression up to 90th percentile, more pronounced at bottom



▷ Absolute percentiles

Decomposition into firm and worker components

- Most initial inequality and the decline are between firms ▷ Graph

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- How to tell apart changes among firms vs. workers?

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- Most initial inequality and the decline are between firms ▷ Graph
- How to tell apart changes among firms vs. workers?
- Two-way fixed effects model (AKM 1999):

$$\log(y_{it}) = \alpha_i + \alpha_{J(i,t)} + \gamma_t + \varepsilon_{it}$$

where α_i are worker effects, $\alpha_{J(i,t)}$ are firm effects, γ_t are year dummies, and ε_{it} is an error term

  - Estimate this by OLS in overlapping 5-year periods
  - Restriction to largest connected set

Decomposition into firm and worker components

Table 1: Variance decomposition into components from AKM estimation

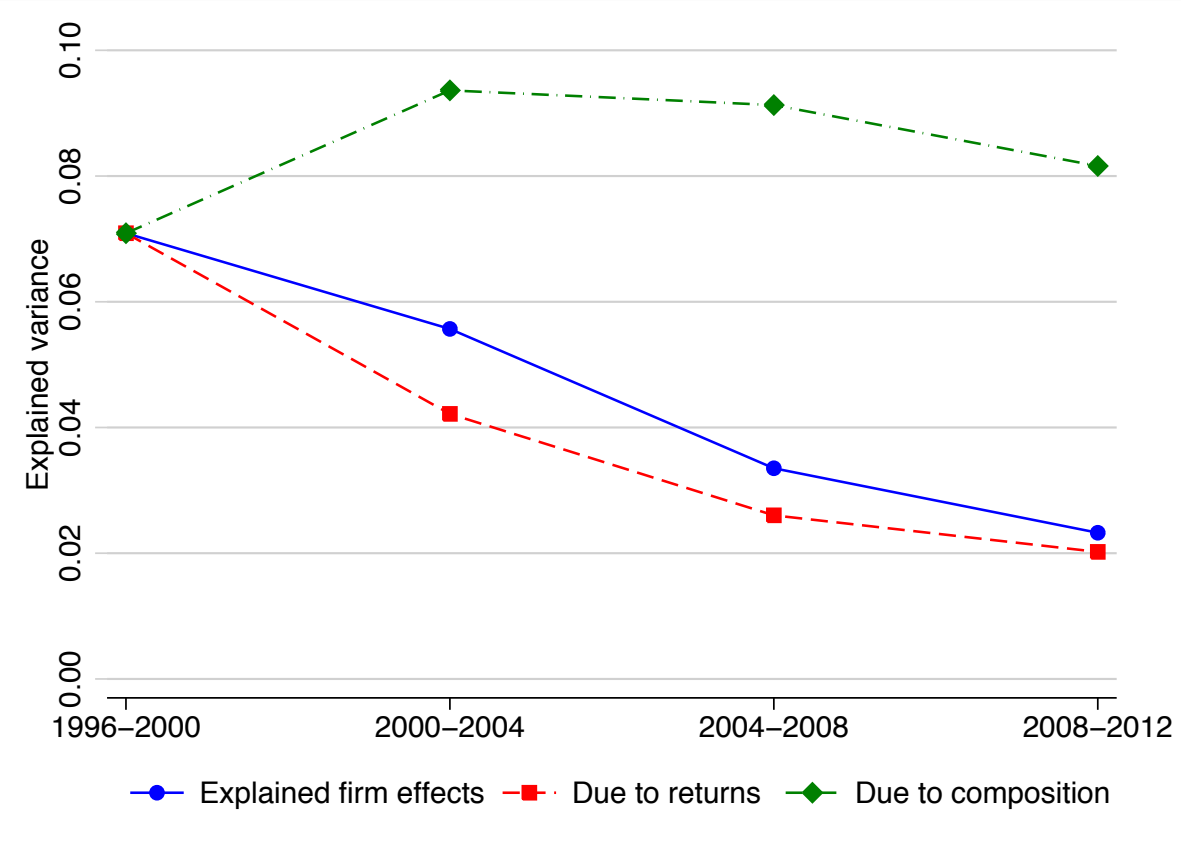
	(1) 1996–2000	(2) 2008–2012	(3) Change
Total variance of log earnings	0.72 (100%)	0.52 (100%)	-0.20 (100%)
Variance of firm effects	0.17 (24%)	0.08 (15%)	-0.09 (45%)
Variance of individual effects	0.35 (49%)	0.29 (57%)	-0.06 (28%)
Covariance	0.14 (19%)	0.11 (21%)	-0.03 (16%)
Variance of residual	0.06 (7%)	0.04 (7%)	-0.02 (10%)
# worker years	90.2	123.7	
R^2	0.92	0.93	

Note: Cells contain variance level (share) explained by each component.

Fact 2: Lower pass-through from firm productivity to pay

- Firm productivity explains 50% of variation in firm pay premia
- And >50% of compression in firm pay premia

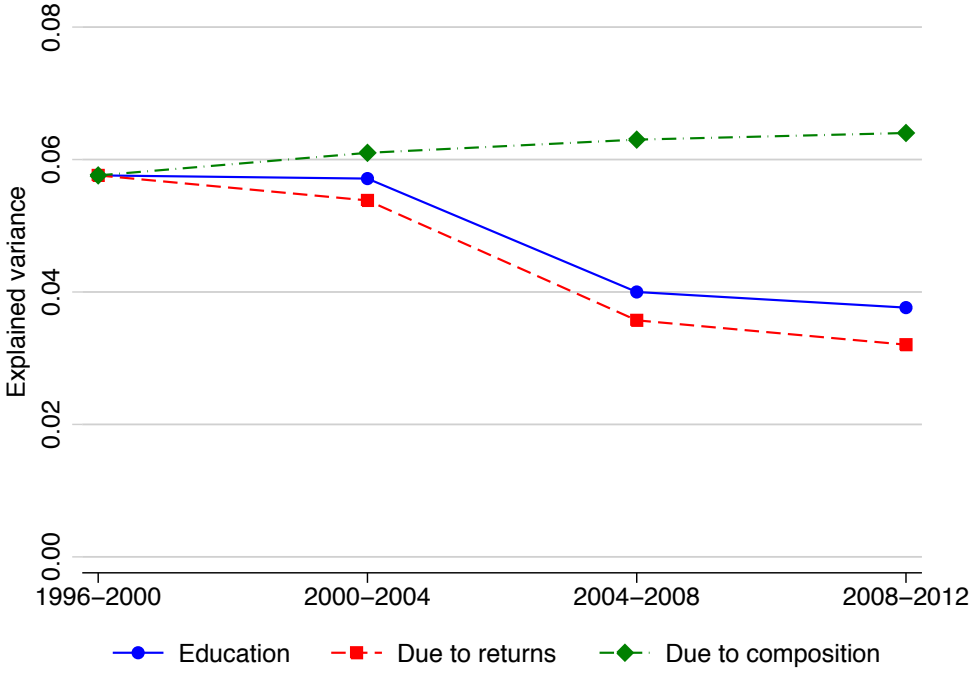
$\Longrightarrow$ All due to rapid fall in pass-through from productivity to pay

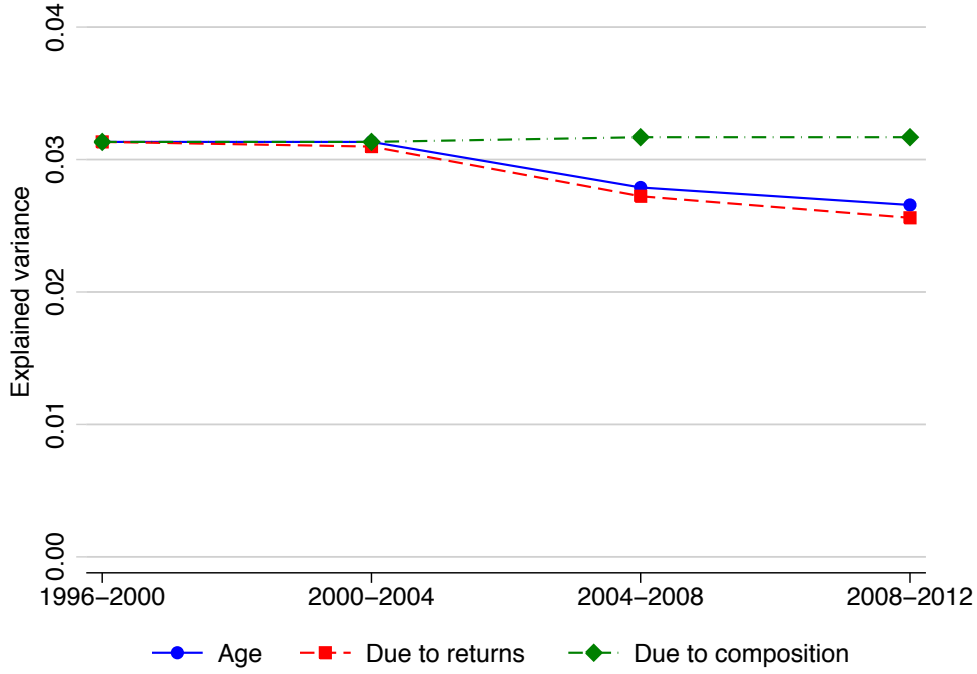


Fact 3: Lower returns to worker ability

- Worker observables explain 35-45% of variation in worker component
- And close to 50% of the declining dispersion

$\Longrightarrow$ All due to rapid fall in return to education and age





What do we learn about Brazil's inequality decline?

- Key insight:
  - In spite of greater underlying inequality...
  - ...changes in "wage policies" drove the decline

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- Key insight:
  - In spite of greater underlying inequality...
  - ...changes in "wage policies" drove the decline
- **Salient change in "wage policy": rise of minimum wage**
  - 119% real growth
  - Minimum-to-median earnings from 34% to 60%

Model Summary

Model fundamentals

- Extension of Burdett-Mortensen (1998) equilibrium search model
- Heterogeneous worker abilities and firm productivities
- Workers search in frictional labor markets:
  - Search for jobs from unemployment
  - Search for better jobs while employed
- Firms post wages to maximize profits:
  - Profit per workers vs. number of employees
- Key feature: optimal wage depends on wages offered by other firms
  $\Rightarrow$ spill-over effects of minimum wage

Model results

Theoretical results:

1. More productive firms pay more for any worker
2. More able workers are paid more within any firm
3. Minimum wage reduces pass-through from productivity to pay as well as return to worker ability

Estimation

Quantitative experiment

- Estimate the model to fit data moments in 1996–2000 period
- Productivity-adjusted real minimum wage growth of 44.7 log points
- Holding all else constant, evaluate impact on earnings distribution

Estimation part 1

- One key parameter: $\kappa^e = \lambda^e/\delta =$ speed of climbing firm ladder
- Similar estimates and time trends for κ^e across methods ▷ Details
- Calibrate or fix other parameters

Table 2: Monthly model parameters

Description	Parameter	Value
Discount rate	ρ	0.009
Exogenous separation rate	δ	0.030
Job finding rate from unemployment	λ^u	0.200
Labor market friction parameter	κ^e	1.101

Estimation part 2

Method of simulated moments / indirect inference (Smith 1993):

- Solve and simulate the model for a range of parameter values
- Apply AKM framework as auxiliary model on simulated data ▷ Details
- Find model parameters that minimize distance between AKM components in model versus data

Effects of the Minimum Wage

Inequality decomposition in model vs. data

Table 3: AKM decomposition of variance of log earnings

	1996–2000		2008–2012		Change		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Data	Model	Data	Model	Data	Model	% Explained
Variance of earnings	0.72	0.46	0.52	0.32	-0.20	-0.14	70%
Firm effects	0.17	0.17	0.08	0.13	-0.09	-0.04	48%
Worker effects	0.35	0.35	0.29	0.29	-0.06	-0.06	110%
Covariance	0.14	-0.06	0.11	-0.10	-0.03	-0.04	118%
Residual	0.06	0.00	0.04	0.00	-0.02	0.00	0%

Explaining Facts 1–3

Model predicts:

1. Largest effect at the bottom, yet significant compression far up the distribution ✓ Fact 1

Table 4: Percentile ratios of earnings in data vs. model

	1996–2000		2008–2012		Change		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Data	Model	Data	Model	Data	Model	% Explained
P50-P05	1.06	0.90	0.62	0.62	-0.44	-0.28	64%
P50-P10	0.86	0.77	0.55	0.55	-0.31	-0.22	71%
P50-P25	0.48	0.46	0.33	0.35	-0.15	-0.11	73%
P75-P50	0.60	0.52	0.50	0.44	-0.10	-0.08	80%
P90-P50	1.30	1.01	1.17	0.89	-0.13	-0.12	92%
P95-P50	1.76	1.30	1.65	1.17	-0.11	-0.13	118%

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Model predicts:

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2. All compression in firm effects due to lower pass-through from productivity ✓ Fact 2

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1. Largest effect at the bottom, yet significant compression far up the distribution ✓ Fact 1
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3. All compression in worker effects driven by fall in returns to worker ability ✓ Fact 3

Empirical Evidence

Further support for the model

- We find empirical evidence in support of:
  1. The minimum wage story: different exposure by region and sector
     ▷ Details
  2. The model key ingredient: job ladder view of the labor market
     ▷ Details
  3. The model mechanism: minimum wage effect on worker composition
     ▷ Details

Conclusion

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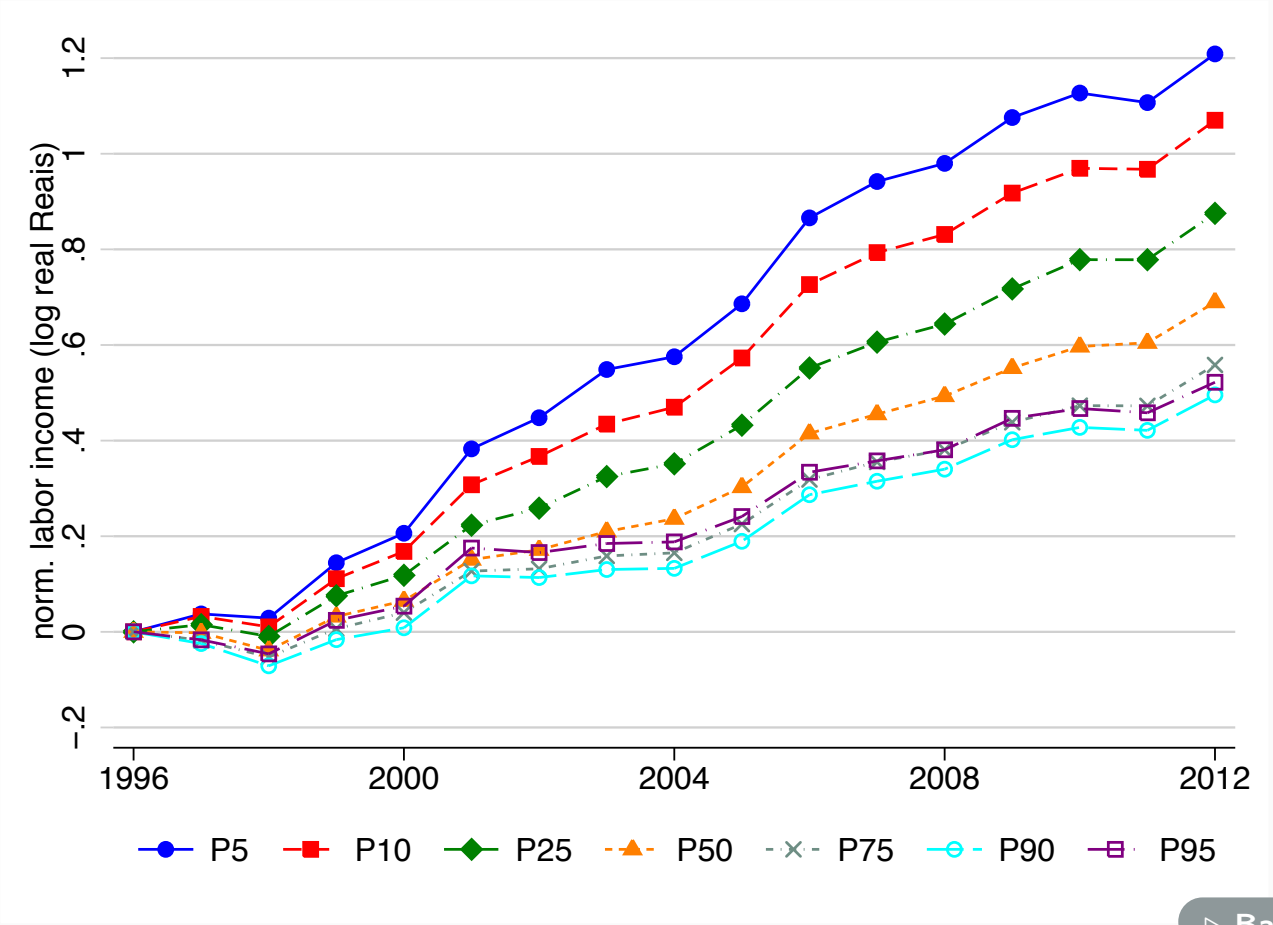
- Substantial fall in earnings inequality in Brazil 1996–2012
- We study the importance of the minimum wage for this decline
- We build an equilibrium search model, and show that in line with the data the model predicts:
    1. Fall in inequality throughout the distribution
    2. Compression in firm component due to lower pass-through from productivity to pay
    3. Compression in worker component due to lower return to worker ability
- Minimum wage was a significant contributor to the decline in earnings inequality (up to 70%)

Backup

Absolute earnings growth across percentiles

- All percentiles experienced real earnings growth from 1996–2012
- Fastest growth among bottom 75 percentiles



▷ Back to Fact 1

▷ Back to minimum wage

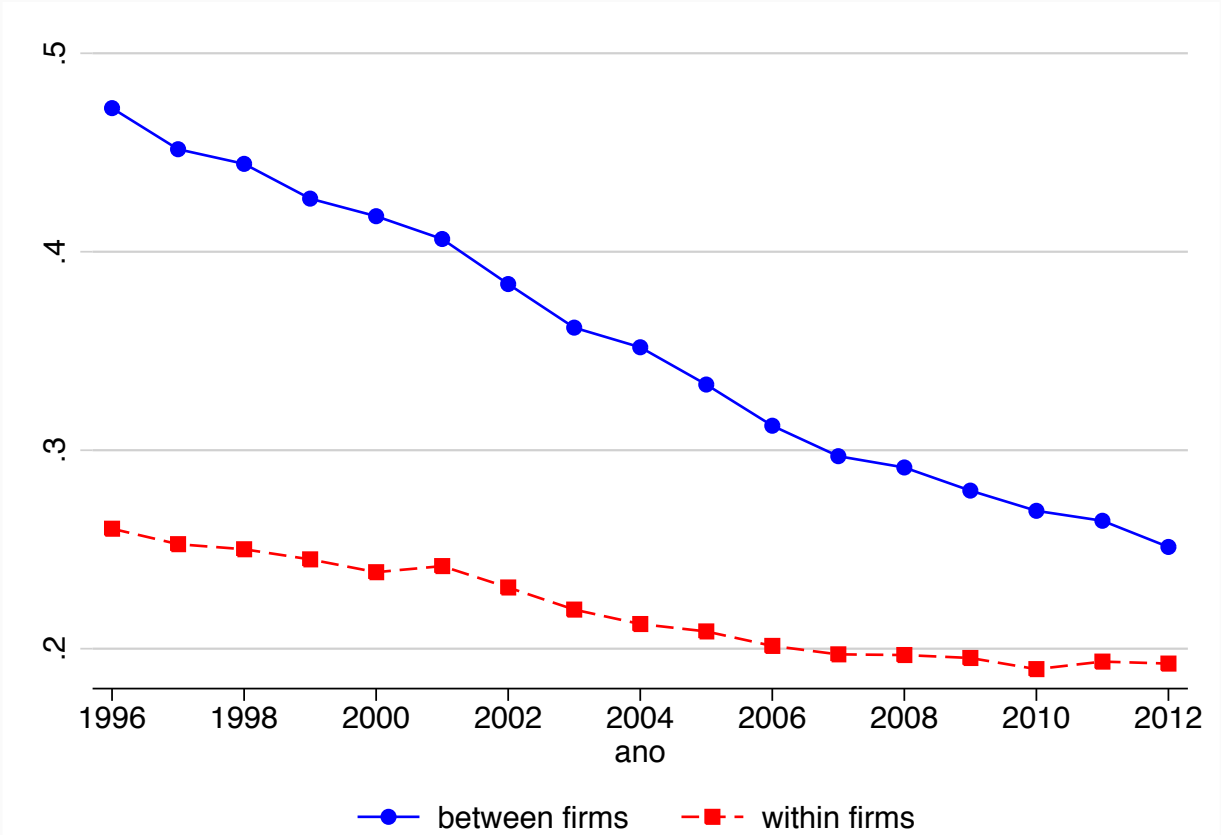
Much initial inequality and decline was between firms

- Recent work stresses firms as drivers of inequality dynamics
- Let y_{ijt} denote log earnings of worker i at firm j in year t, then:

▷ Derivation

$$Var\left(y_{ijt}\right) = \underbrace{Var\left(\overline{y}_t^j\right)}_{\text{between firms}} + \underbrace{\overline{Var\left(y_{ijt} \middle| i \in j\right)}}_{\text{within firms}}$$

▷ Percentiles



▷ Back

Between and within firms: derivation

- Let y_{ijt} denote earnings of worker i employed by firm j in year t, then:

$$y_{ijt} = \underbrace{\overline{y}_t}_{\text{economy average}} + \underbrace{\left(\overline{y}_t^j - \overline{y}_t\right)}_{\text{employer deviaion}} + \underbrace{\left(y_{ijt} - \overline{y}_t^j\right)}_{\text{worker deviation}}$$

- Re-arranging and taking variances on both sides we get

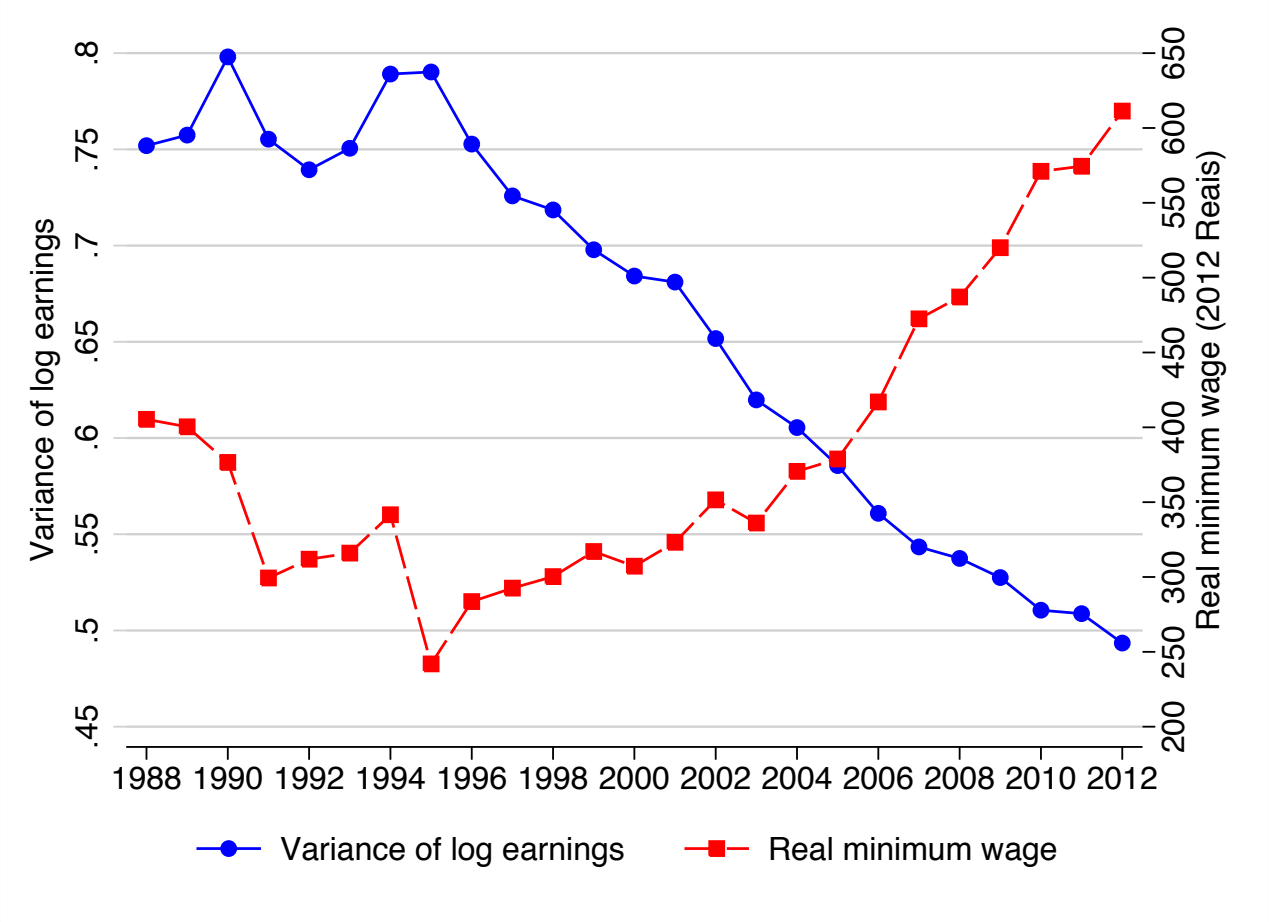
$$Var\left(y_{ijt} - \overline{y}_t\right) = Var\left(\overline{y}_t^j - \overline{y}_t\right) + Var\left(y_{ijt} - \overline{y}_t^j\right) + \underbrace{2Cov\left(\overline{y}_t^j - \overline{y}_t, y_{ijt} - \overline{y}_t^j\right)}_{=0}$$

- Simplifying, we have

$$Var\left(y_{ijt}\right) = \underbrace{Var\left(\overline{y}_t^j\right)}_{\text{between firms}} + \underbrace{Var\left(y_{ijt} \middle| i \in j\right)}_{\text{within firms}}$$

▷ Back

Minimum wage evolution mirrors earnings inequality



▷ Back to minimum wage

Can the minimum wage explain Brazil's inequality decline?

- Rapid rise in federal real minimum wage from 1996–2012:
  - 119% growth, reaching BRL622 (USD-PPP410) per month
  - Minimum-to-median earnings from 34% to 60%
- Suggestive evidence on link b/w minimum wage and inequality:
  1. Minimum wage mirrors earnings inequality from 1988–2012
     ▷ Mirror image
  2. Faster wage growth at the bottom ▷ Absolute percentiles
- But <5% of workers earning exactly minimum wage throughout
  - Qualitative challenge: compression throughout distribution
  - Quantitative challenge: magnitude of decline & worker/firm channels
- Potential solution: indirect "spill-over" effects of minimum wage

▷ Back

Model: workers' problem

- Value of unemployment:

$$\rho W_\theta = b_\theta + \lambda_\theta^u \int \max\{V_\theta(w) - W_\theta, 0\}\, dF_\theta(w)$$

- Value of employment of type θ at current wage w:

$$\rho V_\theta(w) = w + \lambda_\theta^e \int_w [V_\theta(w') - V_\theta(w)]\, dF_\theta(w') + \delta_\theta [W_\theta - V_\theta(w)]$$

- Worker types' reservation wage:

$$w_\theta^R = b_\theta + (\lambda_\theta^u - \lambda_\theta^e) \int_{w_\theta^R} \frac{1 - F_\theta(w)}{\phi + \delta_\theta + \lambda_\theta^e(1 - F_\theta(w))} dw$$

▷ Back

Model: firms' problem

- In each active market θ, a firm with productivity p solves:

$$\max_{w_\theta \geq w^{min}} (p\theta - w_\theta)\, l_\theta\,(w_\theta)$$

- Equilibrium firm size:

$$\begin{aligned} l_\theta(w) &= (1-u_\theta)\, m_\theta \frac{dG_\theta(w)}{dF_\theta(w)} = (1-u_\theta)\, m_\theta \frac{1+\kappa^e}{\left[1+\kappa^e\,(1-F_\theta\,(w))\right]^2} \\ l(w) &= \int l_\theta(w) d\theta \end{aligned}$$

▷ Back

Equilibrium with segmented labor markets

A search equilibrium with segmented labor markets is a set

$$\left\{w^{min}, \phi_\theta, u_\theta, l_\theta(w), F_\theta(w), G_\theta(w)\right\}$$

for each $\theta \in \Theta = \{\theta_1, \ldots, \theta_N\}$ such that:

1. Productivity $\Gamma_\theta(p)$ is truncated at $\underline{p}\left(\theta; w^{min}\right) = \max\left\{\frac{\phi_\theta}{\theta}, \frac{w^{min}}{\theta}, p_0\right\}$.
2. Ability distribution $H(\theta)$ is truncated at $\underline{\theta}\left(w^{min}\right) = \frac{w^{min}}{\overline{p}}$.
3. Workers accept any higher-paid job while employed and any job whose wage exceeds their reservation value ϕ_θ while unemployed.
4. Firms choose which markets θ to recruit from and offer wage schedule $\{w_\theta(p)\}_\theta$ to maximize profits.
5. The unemployment rate $u = \int u_\theta dH(\theta)$ and firm sizes $l(\cdot) = \int l(\cdot;\theta)\, dH(\theta)$ are consistent with $F_\theta(\cdot)$, $G_\theta(\cdot)$, and$(\delta, \lambda^u, \lambda^e)$.

▷ Back

Characterizing equilibrium firm decisions

Lemma 1

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$$w\left(p, \theta; w^{min}\right) = \theta p - \theta \int_{\underline{p}(\theta; w^{min})}^{p} \left[\frac{1 + \frac{\lambda^e}{\delta}\left(1 - \Gamma_\theta\left(p; w^{min}\right)\right)}{1 + \frac{\lambda^e}{\delta}\left(1 - \Gamma_\theta\left(x; w^{min}\right)\right)} \right]^2 dx$$

where

$$\Gamma_\theta(p; w^{min}) = \frac{\Gamma(p) - \Gamma\left(\underline{p}\left(\theta; w^{min}\right)\right)}{1 - \Gamma\left(\underline{p}\left(\theta; w^{min}\right)\right)}$$

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3. *More productive firms post higher wages:*

$$\partial w\left(p, \theta; w^{min}\right) / \partial p > 0$$

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3. *More productive firms post higher wages:*

$$\partial w\left(p, \theta; w^{min}\right)/\partial p > 0$$

4. *Higher ability workers are offered higher wages:*

$$\partial w\left(p, \theta; w^{min}\right)/\partial \theta > 0$$

Estimation part 1

- Key labor parameter κ^e over-identified in data relative to model:

▷ Back to estimation part 1

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  1. Duration: Mean job duration along the firm ladder

$$\overline{d}_\theta(w) = \underbrace{\frac{1}{\delta(1+\kappa^e)}}_{\equiv \beta_0} + \underbrace{\frac{\kappa^e}{\delta(1+\kappa^e)}}_{\beta_1} G_\theta(w) \quad \Longleftrightarrow \quad \hat{\kappa}^e_{duration} = \frac{\hat{\beta}_1^{OLS}}{\hat{\beta}_0^{OLS}}$$

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  2. Nonparametric: Relation between job offer distribution F_θ and realized wage distribution $G_\theta(w)$

$$F_\theta(w) = \frac{(1+\kappa^e) G_\theta(w)}{1+\kappa^e G_\theta(w)} \quad \Longleftrightarrow \quad \hat{\kappa}^e_{nonparametric} = \frac{\hat{F}_\theta(w) - \hat{G}_\theta(w)}{\left(1-\hat{F}_\theta(w)\right)\hat{G}_\theta(w)}$$

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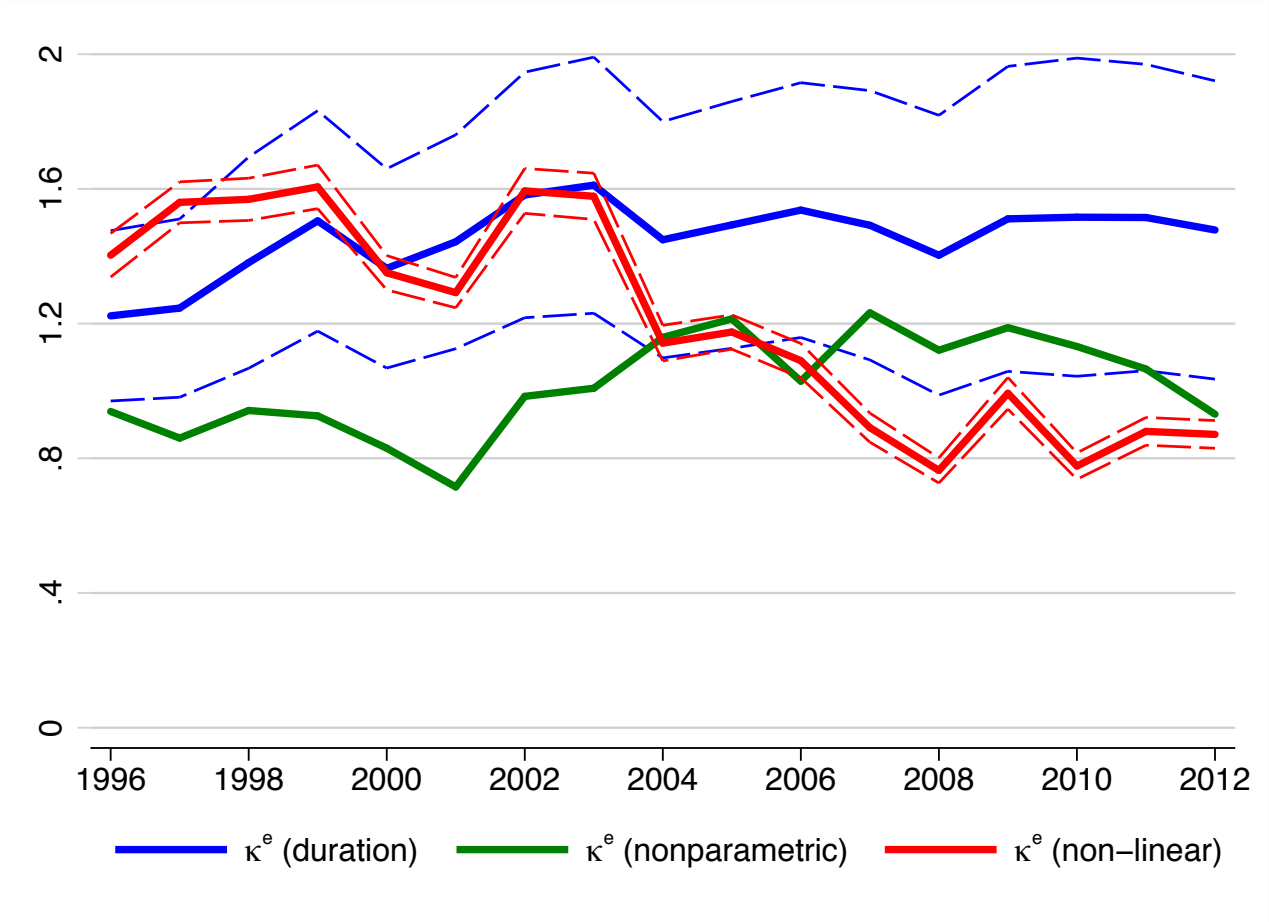
  3. Nonlinear: From distribution of wages of recently hired workers $G_{m,\theta}(w)$

$$G_{m,\theta}(w) = \frac{\log(1+\kappa^e G_\theta(w))}{\log(1+\kappa^e)} \quad \Longleftrightarrow \quad \hat{\kappa}^e_{nonlinear} \text{ using NLLS}$$

▷ Back to estimation part 1

Estimation part 1

Figure 1: Different estimates of labor mobility parameter κ^e



▷ Back to estimation part 1

Mapping from model into AKM decomposition

Proposition 1

Without binding minimum wage, workers' earnings are given by

$$\log w(p,\theta) = \underbrace{\log \theta}_{\text{"worker effect"}} + \underbrace{\log \tilde{w}(p)}_{\text{"firm effect"}}$$

where

$$\tilde{w}(p) = p - \int_{p_0}^{p} \left[\frac{1+\kappa^e(1-F(p))}{1+\kappa^e(1-F(x))}\right]^2 dx$$

▷ Back to estimation part 2

Mapping from model into AKM decomposition

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Key insight:

- Exact mapping of model into AKM framework
- Minimum wage distorts mapping $w(p,\theta)$, but retains monotonicity

▷ Back to estimation part 2

Estimation part 2

- Sparse parameterization of worker and firm heterogeneity:

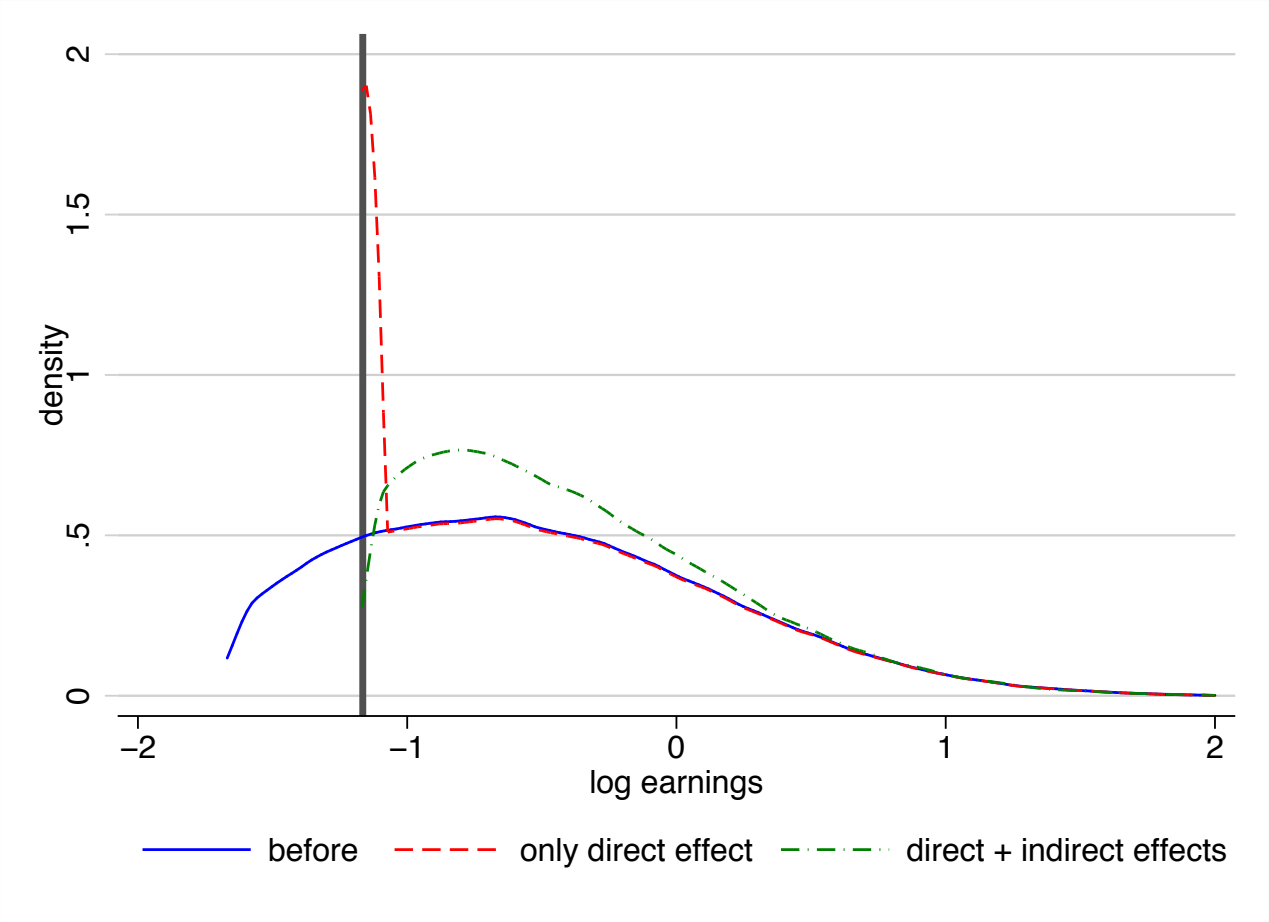
$$\log(\theta) \sim \mathcal{N}\left(0, \sigma_\theta^2\right), \qquad \log(p) \sim \mathcal{N}\left(0, \sigma_p^2\right)$$

- Three model parameters: σ_θ, σ_p, and minimum wage (numeraire)
- Three data targets:
  1. Variance of AKM worker effects
  2. Variance of AKM firm effects
  3. Minimum-to-median wage ratio

▷ Back to estimation part 2

Direct vs. indirect effects

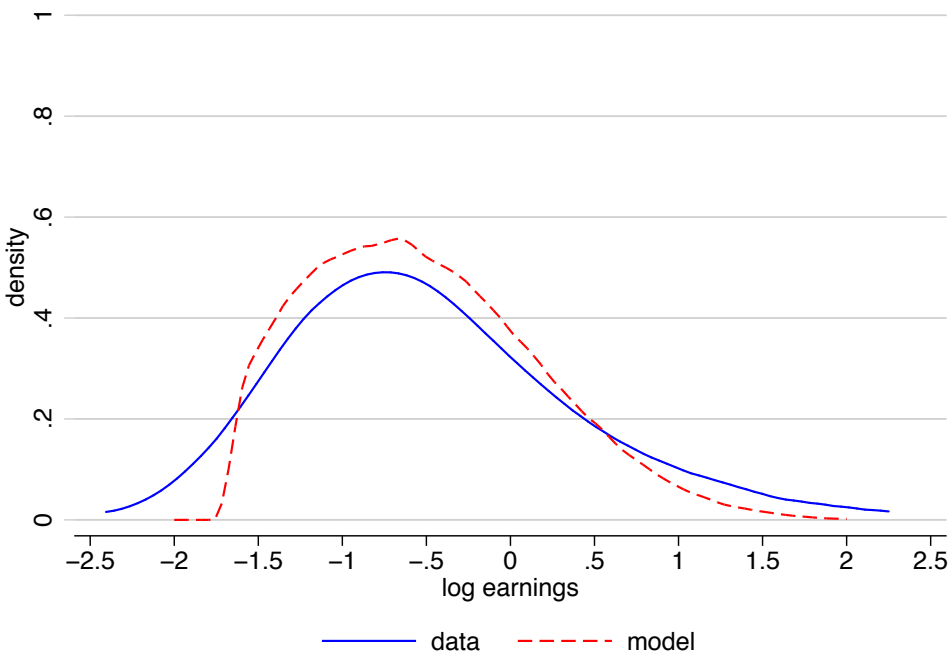
Figure 2: Illustration of direct and indirect effects of minimum wage

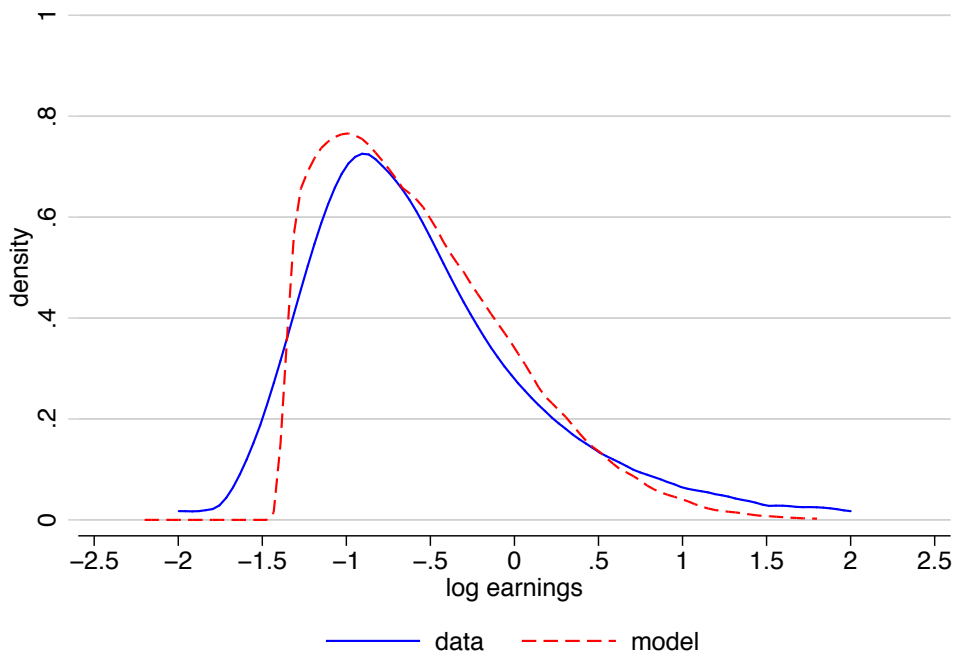


▷ Back

Explaining Fact 1: Bottom-driven inequality decline

Figure 3: Earnings distributions in 1996–2000 (left) and 2008–2012 (right)

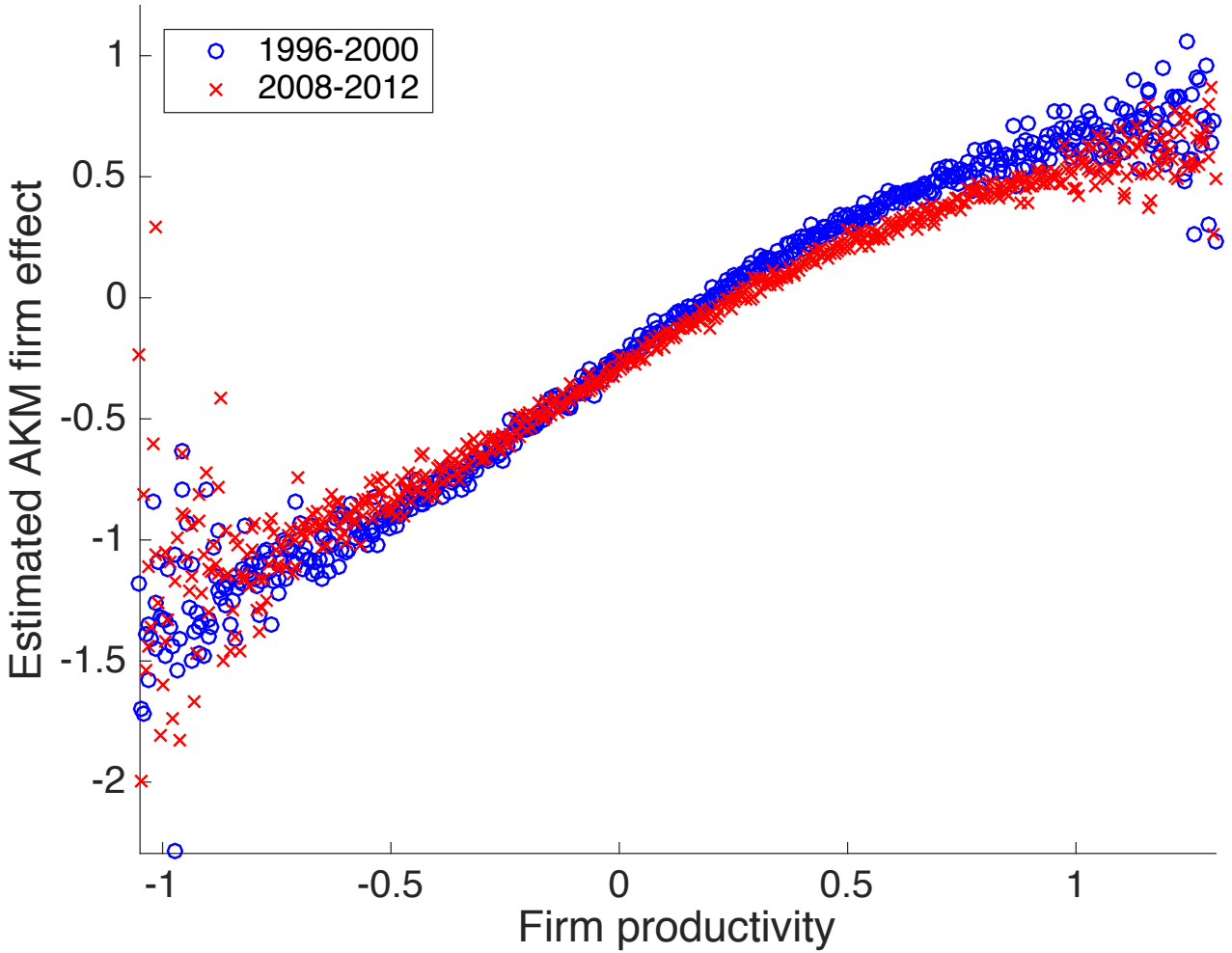




▷ Back

Fact 2: Illustration

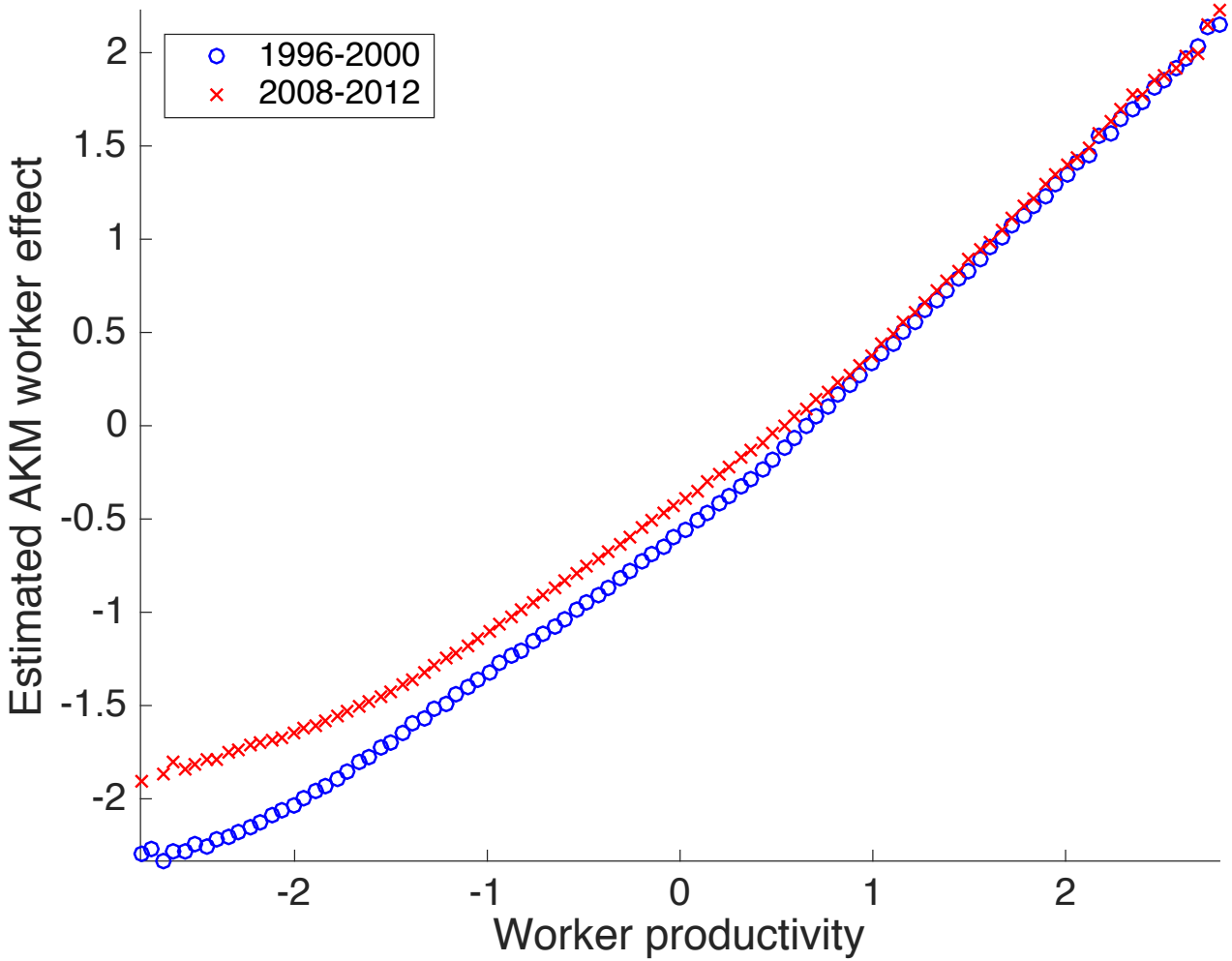
Figure 4: Firm productivity-pay gradient



▷ Back

Fact 3: Illustration

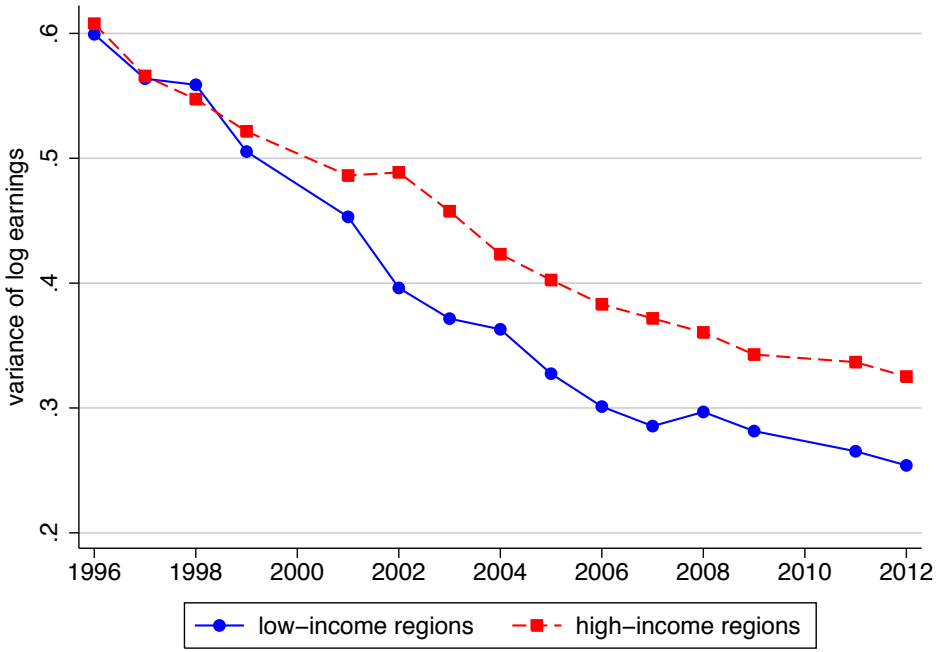
Figure 5: Worker ability-pay gradient

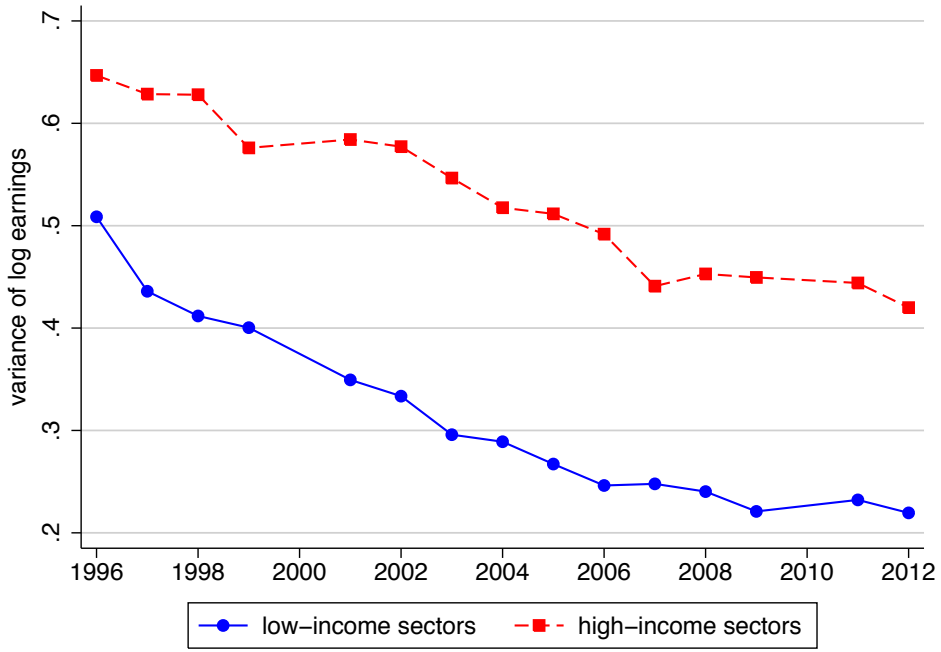


▷ Back

Evidence in support of minimum wage #1

- More pronounced decline of earnings inequality in:
  - initially low-income regions
  - initially low-income sectors

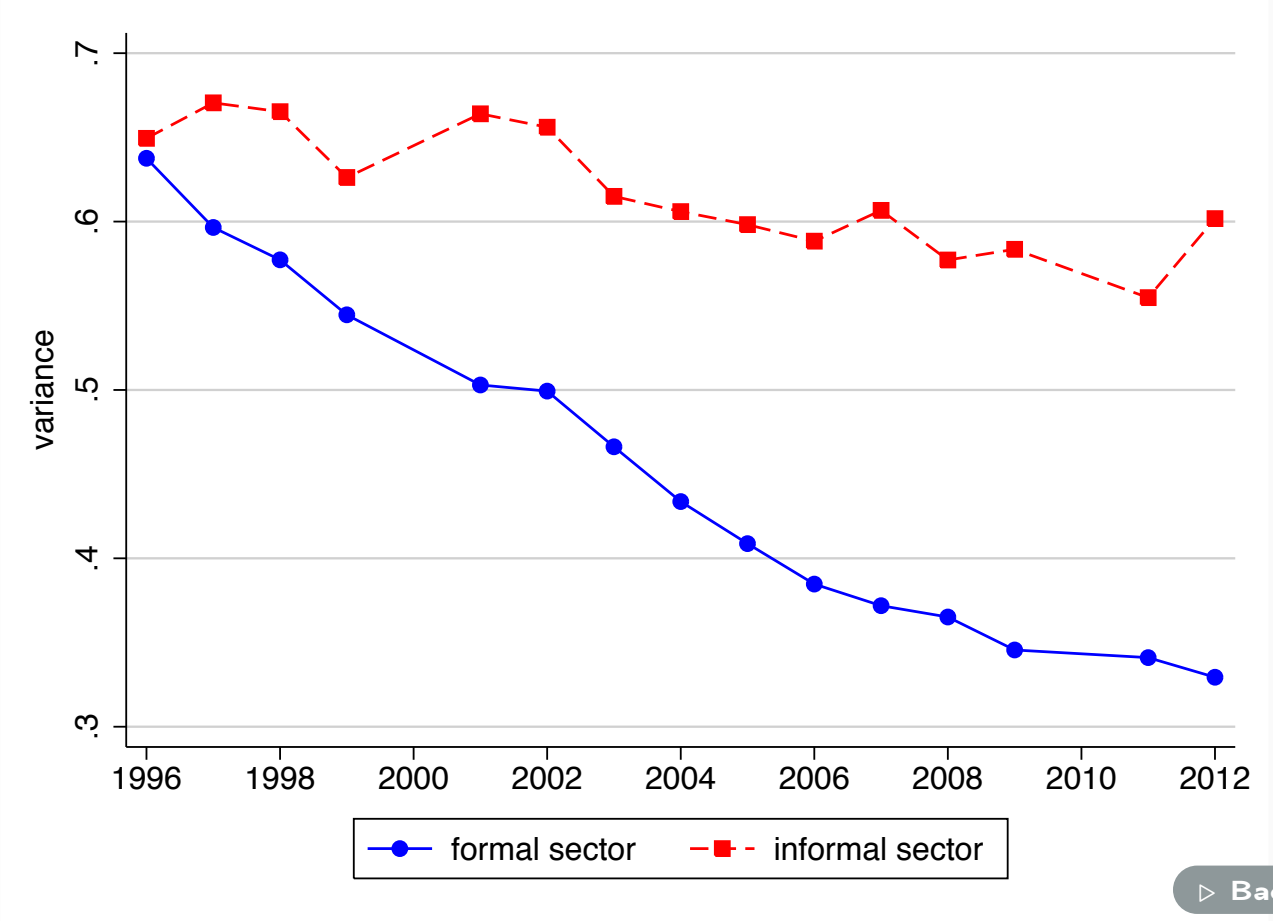




▷ Back

Evidence in support of minimum wage #2

- More pronounced decline of earnings inequality in formal sector
- Consistent w/ enforcement of labor regulation in formal sector



▷ Back to decline
▷ Back to evidence

Evidence in support of job ladder #1

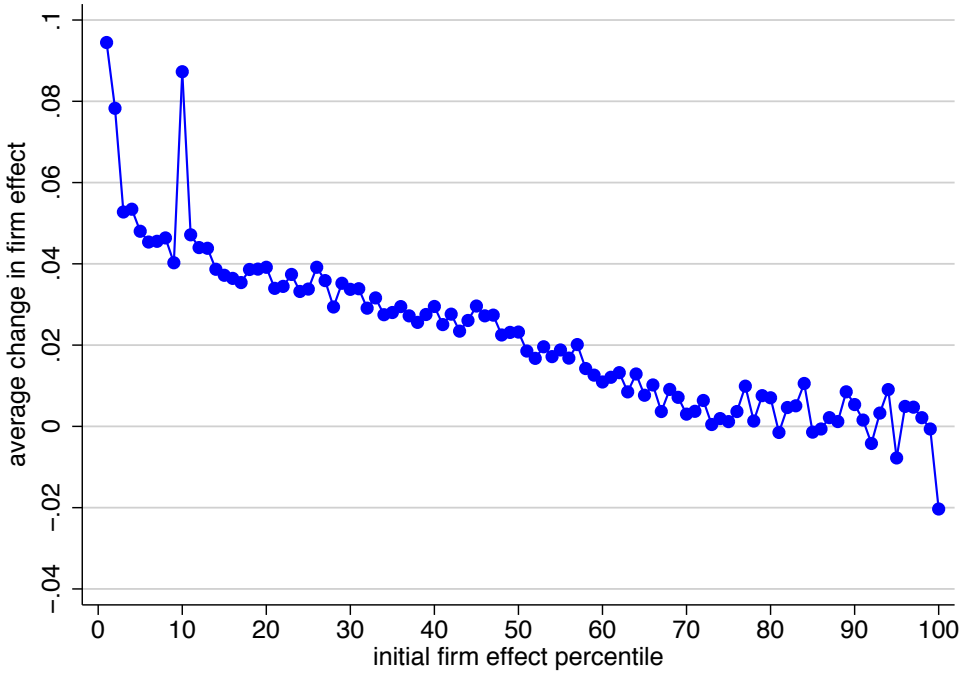
- Workers climb up firm ranks
  - Realized wage distribution FOSDs wage offer distribution
  - Employer transitions associated with positive change in firm effect

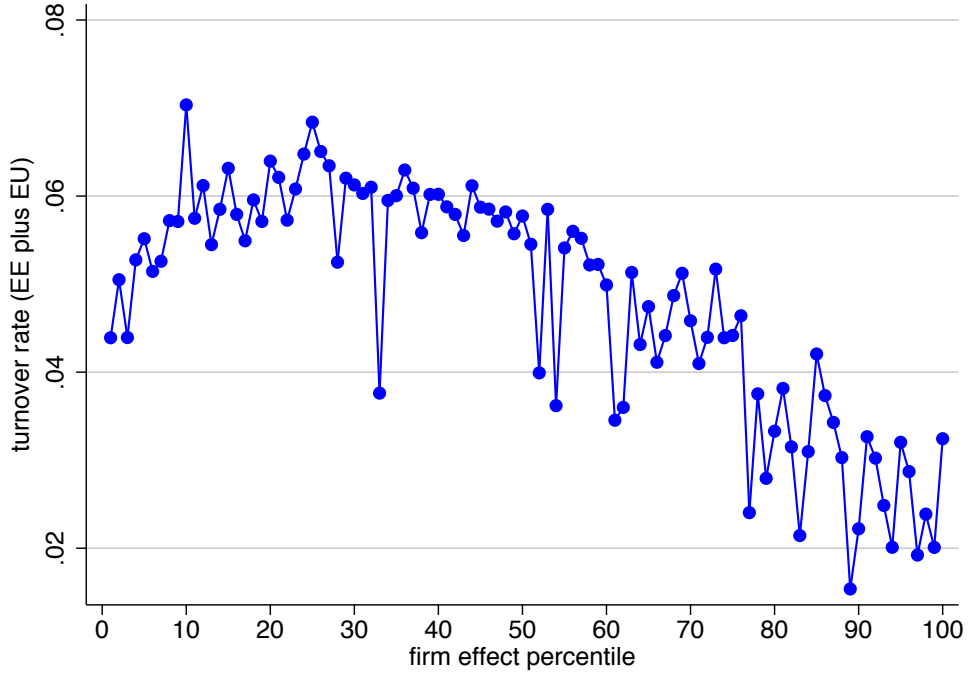
Change in firm effect from switching employer	Average value, 1996–2012
Absolute change	6.8
Percentile rank change	6.0

▷ Back

Evidence in support of job ladder #2

- Further evidence in support of job ladder:
  - Gains from switching decline in previous firm pay percentile
  - Turnover rate lower for higher-paying firms





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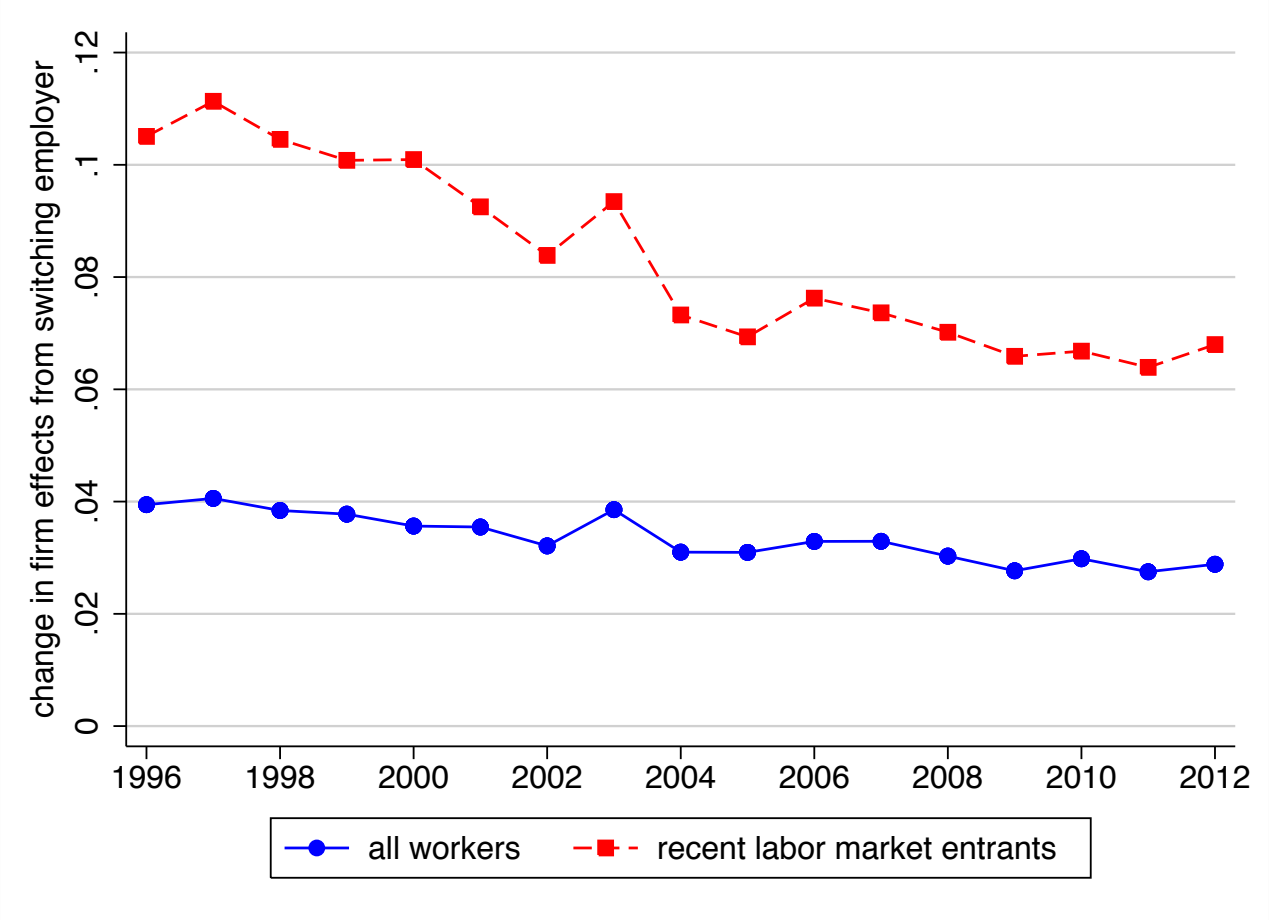
Evidence in support of job ladder #3

- Job ladder becomes flatter as minimum wage increases
  - Particularly pronounced for new labor market entrants



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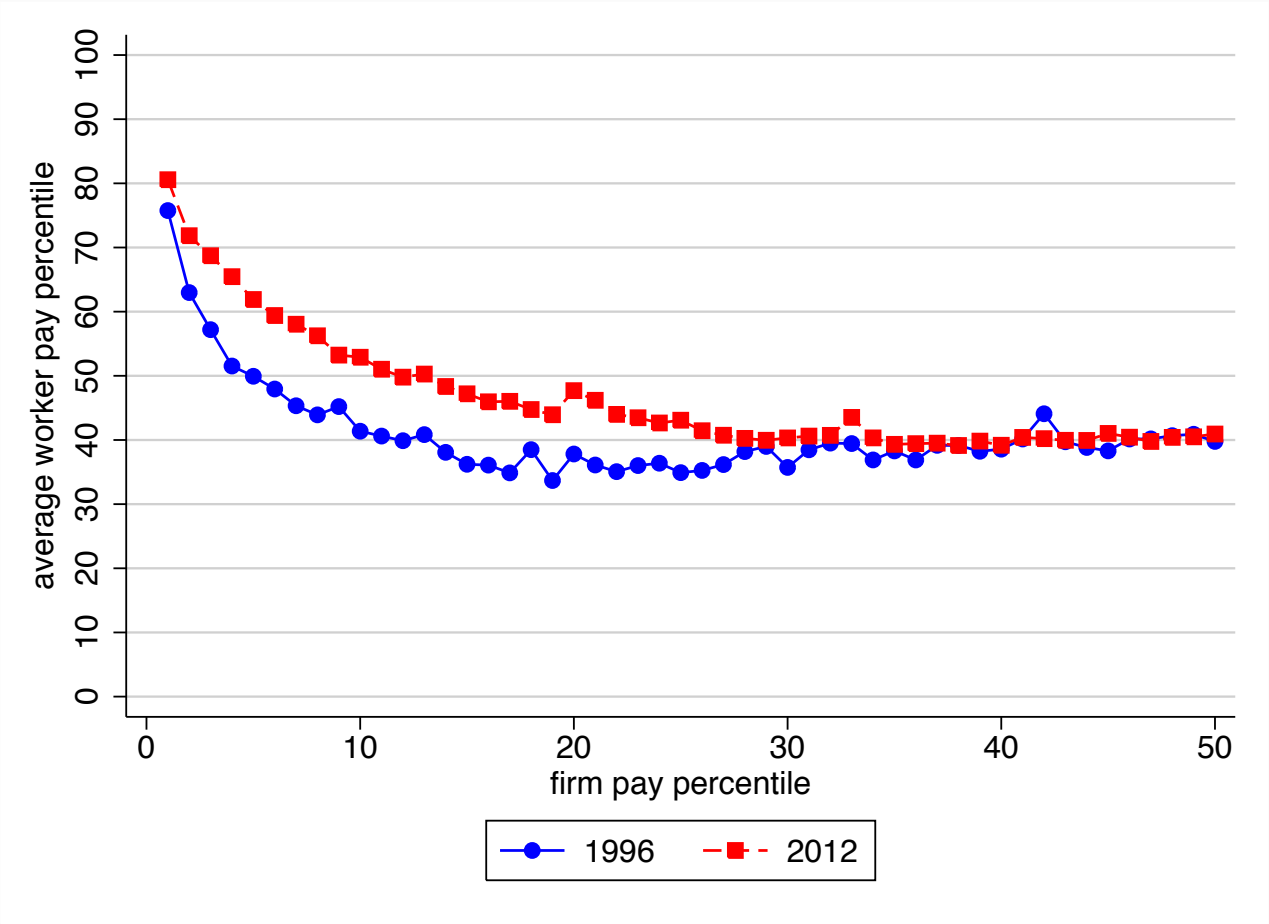
Evidence in support of model mechanism

- Confirm key model prediction:
  - Minimum wage cuts off lowest-paying firms from lowest-paid workers
  - Degree of negative sorting becomes stronger as minimum wage rises



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