Residential Segregation in a Dual Labor Market: Evidence from Bogotá

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Motivation

Spatial differences in job opportunities and housing costs shape where people live in cities worldwide.

→ Alongside housing and transport frictions, widespread informality complicates how job access shapes residential choices in many developing cities.

→ About 76% of urban residents live in LMICs (WB, 2025), yet how residential segregation arises there remains less understood.

Understanding this link helps assess how transport and job-location policies affect segregation.

Bogotá, with concentrated formal jobs and substantial informality, provides a setting to study how job geography shapes residential segregation.

Research Question and Mechanism

Does the spatial concentration of formal jobs amplify residential segregation?

Mechanisms



Job access: Formal-job concentration $\Rightarrow$ nearby job access $\uparrow$ for both groups $\Rightarrow$ housing demand $\uparrow$ $\Rightarrow$ rents $\uparrow$.

Differentiated response: Higher college earnings $\Rightarrow$ higher rent bids $\Rightarrow$ college share near jobs $\uparrow$ $\Rightarrow$ segregation $\uparrow$.

(Amenities will play a key role.)

Literature Review

- QSMs applied to developing country cities. Zárate (2026); Tsivanidis (2026); Khanna et al. (2023); Warnes (2024).
- Segregation. Becker (1973); Benabou (1993); Diamond (2016); Couture & Handbury (2020).
- The geography of formal and informal work. Moreno-Monroy & Posada (2018); Mukim (2015); Tanaka & Hashiguchi (2020).
- Job concentration. Wheeler (2001); Ahlfeldt et al. (2015); Garcia-López & Moreno-Monroy (2018); Deffebach et al. (2025).

My contribution: I study how formal–informal labor-market duality, through job geography and earnings, shapes residential segregation by education.

Outline

~~1. Introduction~~

2. Data and Descriptive Evidence

3. Model

4. Counterfactuals

5. Summary

Bogotá in Context





Bogotá (8M+ residents) concentrates formal activity in the Central–Eastern area.

Data:

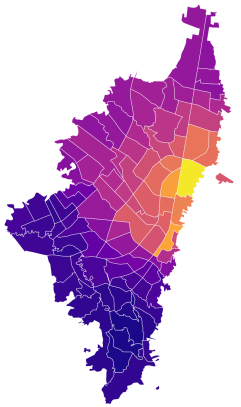
- Encuesta Multipropósito (2021): employment, income, education, residence, and (confidential) work locations.
- Sample: employed women ages 18–56 and men ages 18–61 living in Bogotá UPZs.
- Extensions: new wave should be available at any moment.

- Next, four stylized facts describe the geography of work, earnings, and residential segregation by education.

SF1: Formal Employment is Concentrated

$$E_{rF} = \sum_j L_{Fj} \frac{d_{rj}^{-1}}{\sum_k d_{rk}^{-1}}$$

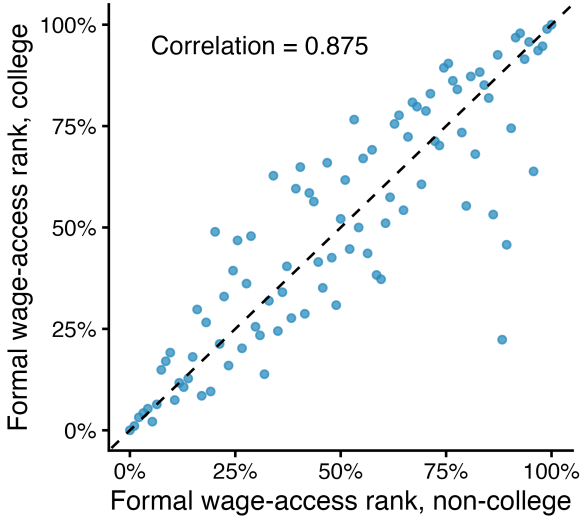
- Formal jobs are concentrated, while informal jobs are more dispersed. A1
- A pairwise-distance test corroborates the stronger concentration of formal employment. A2



Formal labor exposure

SF2: A Common Formal Access Gradient

- Formal wage-based CMA ranks UPZs similarly for college and non-college workers ($r = 0.875$). A3



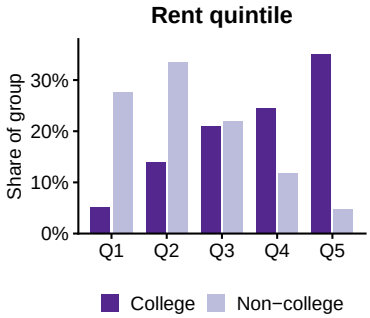
SF3: Earnings and Formal Employment by Education

Category	Mean wage (millions of COP per month)	Median wage	Share within education
College, formal	4.054	3.225	79.9%
College, informal	2.618	1.800	20.1%
Non-college, formal	1.512	1.220	47.8%
Non-college, informal	0.957	0.900	52.2%

- A decomposition attributes 87.4% of the college–non-college mean wage gap to wage differences within sectors and 12.6% to differences in formal employment shares. A4

SF4: Segregation Along Rent and Formal Labor Access

- College workers live in higher-rent UPZs.
- They also live in high-formal-CMA UPZs. A5
- The dissimilarity index is $D = 0.452$, comparable to the upper end of U.S. metros (Friedman & Tom, 2023).
- The college rent-rank gap remains 13.5 points after earnings and controls (dual-earner couples). A6



$$D = \frac{1}{2} \sum_{r} \left| \frac{N_{rc}}{N_c} - \frac{N_{rn}}{N_n} \right|$$

Descriptive Evidence: Four Stylized Facts

SF1: Formal jobs are more concentrated than informal jobs.

SF2: Formal access ranks locations similarly for both education groups.

SF3: College workers earn more within both sectors and are more likely to work formally.

SF4: College workers live in higher-rent, higher-access UPZs.

- **What remains:** The descriptives cannot quantify how much formal-job concentration adds to segregation beyond the earnings gap.

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Model: Overview

- **Locations:** The city is open and consists of a discrete set of R neighborhoods, indexed by r for residence and j for workplace/production.
- **Worker types:** Workers belong to one of two education groups, $e \in \{h, l\}$, where h denotes college and l denotes non-college workers.
- **Firms:** At each workplace, a continuum of potential firms draws productivity, chooses formal or informal operation ($s \in \{F, I\}$), and hires both worker types.
- **Worker choices:** Workers choose residence r, then sector s, then workplace j.
- **Housing supply:** Developers choose floor space in response to neighborhood rents.

Model: Households

- Households: Stone–Geary housing and nested Fréchet shocks govern residence and job choices. A7, A8

- Wages net of minimum housing, job access, and commuting determine the payoff:

$$\widetilde{v}_{rsje} = \lambda_{sje} \frac{(w_{sje} - p_r^H \bar{H})_+}{P_r^{\alpha}(p_r^H)^{1-\alpha}} d_{rj}^{-1}.$$

- Residential appeal combines a common neighborhood amenity with the local college share.

- Each education group's population responds to citywide expected utility.

Model: Firms and Housing Supply

- Firms: After a Pareto productivity draw, firms choose formal or informal production; formal productivity rises with local college employment. A9

- Formal firms pay a fixed operating cost and a non-wage labor wedge; a minimum wage applies to non-college workers.

$$\max_{s\in\{F,I\}} \Pi_j^s(\varphi), \qquad \Pi_j^s(\varphi) = p_j^s(\varphi)q_j^s(\varphi) - (1+\tau_s)\sum_{e\in\{h,l\}} w_{sje}L_{sje}(\varphi) - \mathbf{1}\{s=F\}FC_F.$$

- Housing supply: Developers supply more floor space where rents rise; building costs are convex. A10

Calibration

- Calibrated parameters: $\bar{H} = 0.305$ (COP 412,000), $\mu_1 = 1.537$, $\mu_2 = 1.218$, $\lambda_{Fh} = 0.292$, $\chi_F = 0.770$, $\xi = 0.282$, $FC_F = 3.098$.

Moment	Data	Model
Calibration targets		
College formal/informal wage ratio	1.548	1.596
Non-college formal/informal wage ratio	1.581	1.672
Formal college/non-college wage ratio	2.680	2.599
Formal employment share: college	**0.798**	**0.953**
Formal employment share: non-college	0.471	0.516
Central-east formal-firm share	0.120	0.143
Formal-wage/college-density gradient	0.095	0.075
Aggregate formal-firm share	0.303	0.306
Residential dissimilarity index	0.442	0.445
Validation moments		
College share by UPZ: data–model correlation	0.959	
Formal CMA slope	-0.198	-0.184
Informal CMA slope	-0.121	-0.118
Mean formal commute (km)	**5.020**	**9.596**
Mean informal commute (km)	**3.280**	**8.775**

Common amenities $\bar{B}_r$ are calibrated to match total residential shares by UPZ (maximum absolute gap: 0.00016).

Fixed inputs: A11, A12; endogenous variables: A13.

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Dispersing Formal Jobs

→ We give formal jobs the same spatial distribution as informal jobs, holding formal employment by education fixed.

→ We let amenities respond to the new job distribution and re-solve the model (log cor between amenity residuals and the local formal-job concentration index: 0.480).

→ Relative to U.S. metros, D moves from near the upper end to just above the mean (0.363; Friedman & Tom, 2023).

Scenario	D	College/non-college earnings ratio
→ Baseline	0.445	3.170
→ Dispersed formal jobs	0.442	3.155
→ Amenities respond	**0.397**	3.149

Housing Subsidies for Non-College Workers

→ A monthly housing voucher may be more feasible.

→ We hold calibrated productivity and common amenities fixed; jobs, rents, residential choices, and endogenous amenities adjust.

Scenario	Monthly voucher (COP)	D	Total cost (COP bn/mo)
→ Baseline	—	0.445	—
→ Citywide	66,500	0.397	144.3
→ Top formal-exposure quartile (24 UPZs)	82,200	0.397	34.5

- Same D at about one-quarter of citywide cost.
- Other counterfactuals: A14.

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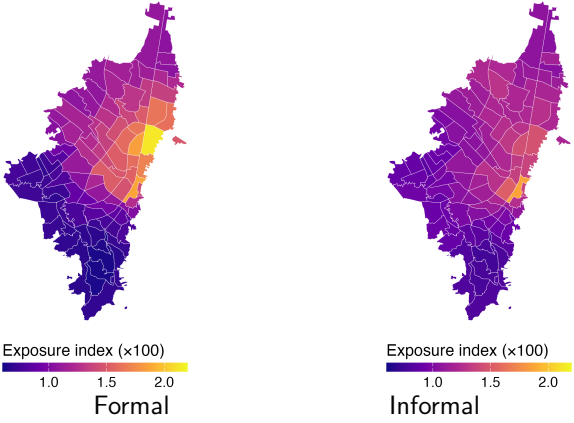
Summary and Next Steps

- **Stylized facts:**
  - Formal jobs are geographically concentrated.
  - College workers sort into high-rent, high-access neighborhoods.
  - Segregation is substantial ($D \approx 0.45$).
- **Model:**
  - Dispersing formal jobs alone barely moves segregation.
  - Letting amenities adapt lowers it substantially (D: $0.445 \rightarrow 0.397$).
  - A housing voucher for non-college workers also lowers D to 0.397.
- **Next steps:** Incorporate the new EM 2025 survey wave to analyze how amenities and formal opportunities evolve.

Thank you!

A1: Labor Exposure by Sector

$$E_{rs} = \sum_{j=1}^{R} L_{sj} \frac{d_{rj}^{-1}}{\sum_k d_{rk}^{-1}}, \qquad s \in \{F, I\}.$$

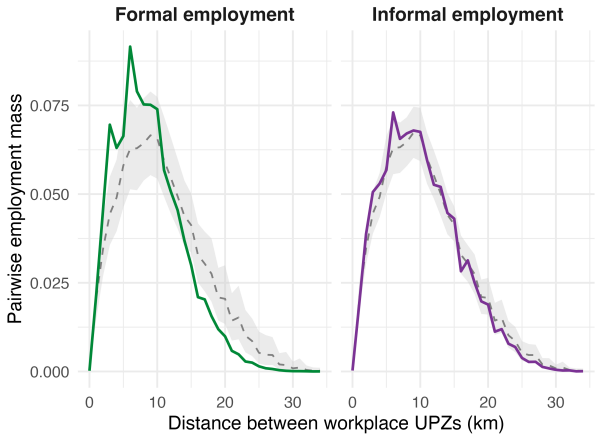


Both maps use the same color scale; brighter areas have higher labor exposure.

SF1

A2: Pairwise-Distance Concentration Test

$$K_s(b) = \sum_{j \neq k} p_{sj} p_{sk} \, \mathbf{1}\{d_{jk} \in b\}.$$

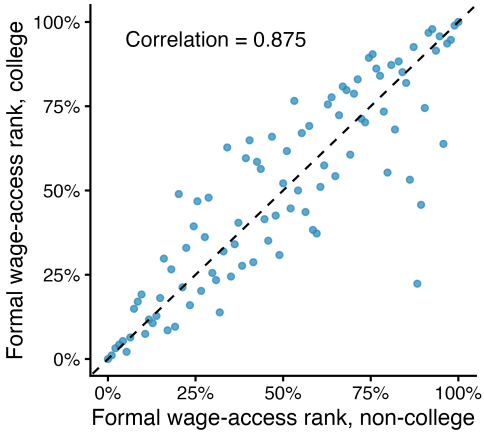


Gray bands: 95% envelope from 1,000 permutations of employment shares. Inspired by Duranton and Overman (2005).

SF1

A3: Formal Wage-Access Rankings

$$\Phi_{rFe} = \sum_j w_{Fje}^{\theta_F} d_{rj}^{-\theta_F}.$$



SF2

A4: Decomposing the Education Wage Gap

For education group $e \in \{c, n\}$, mean wages combine sectoral wages and the formal employment share:

$$\bar{w}_e = \pi_e w_{Fe} + (1 - \pi_e) w_{Ie}.$$

The symmetric Kitagawa (two-factor Shapley) decomposition averages the two possible orders of changing wages and formal shares:

$$\begin{aligned} \Delta_w = \bar{w}_c - \bar{w}_n = \; & [\bar{\pi}(w_{Fc} - w_{Fn}) + (1 - \bar{\pi})(w_{Ic} - w_{In})] \\ & + [(\pi_c - \pi_n)(\bar{w}_F - \bar{w}_I)] \,, \end{aligned}$$

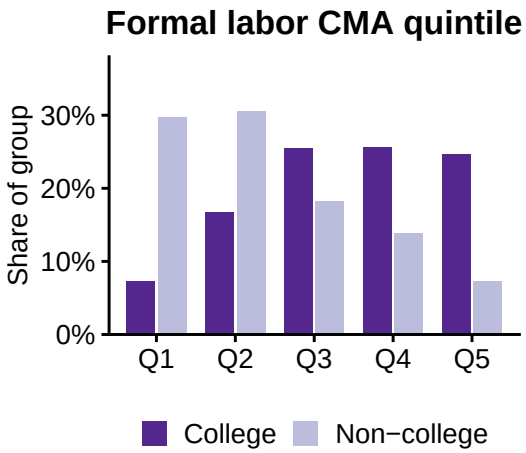
where $\bar{\pi} = (\pi_c + \pi_n)/2$ and $\bar{w}_s = (w_{sc} + w_{sn})/2$. The first bracket is the within-sector education wage gap; the second is the formal–informal composition effect.

$2.542 = 2.223\ (87.4\%) + 0.319\ (12.6\%)$ million COP per month.

SF3

A5: Formal Labor CMA by Education

Formal labor CMA sums education-specific formal employment across workplace UPZs, giving nearby jobs more weight: $\Phi^{L}_{rFe} = \sum_j L^{\theta_F}_{Fje} d^{-\theta_F}_{rj}$.



A6: Education and Residential Rent Ranks

- Outcome: percentile rank (0–100) of average rent in the worker's residential UPZ.

	All workers		Dual-earner couples		
	(1)	(2)	(5)	(6)	(7)
	Education	+ Formal	+ Own earnings	+ Partner earnings	+ Covariates
College	27.76***	27.17***	17.76***	13.92***	13.50***
	(3.02)	(2.95)	(2.08)	(1.74)	(1.67)
Formal		1.85***	-5.87***	-5.91***	-5.61***
		(0.59)	(0.76)	(0.73)	(0.71)
Log labor earnings			11.25***	7.97***	7.64***
			(0.79)	(0.52)	(0.49)
Partner's log labor earnings				7.77***	7.69***
				(0.55)	(0.53)
Covariates					✓
Observations	80,217	80,217	25,148	25,148	25,148
R^2	0.227	0.228	0.338	0.384	0.395

Survey-weighted estimates; standard errors clustered by residential UPZ. Columns (5)–(7) use the dual-earner-couple sample. Associations are descriptive.

SF4

A7: Household Consumption and Payoff

- Stone–Geary preferences require minimum housing $\bar{H}$. Workers use wages to buy housing H_{rsje} and a composite good C_{rsje}: $P_r C_{rsje} + p_r^H H_{rsje} = w_{sje}$.
- C_{rsje} combines formal and informal goods through CES aggregation:

$$C_{rsje} = \left[\omega C_{F,rsje}^{\frac{\sigma-1}{\sigma}} + (1-\omega) C_{I,rsje}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

- Formal goods have price 1; informal goods have local price P_r^I. The composite price is

$$P_r = \left[\omega^\sigma + (1-\omega)^\sigma (P_r^I)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}.$$

- Net wages, job access λ_{sje}, and commuting cost d_{rj} give the choice score:

$$\widetilde{v}_{rsje} = \lambda_{sje} \frac{\max\{w_{sje} - p_r^H \bar{H}, 10^{-8}\}}{P_r^\alpha (p_r^H)^{1-\alpha}} d_{rj}^{-1}.$$

Model

A8: Household Choice Shocks

- Independent Fréchet shocks enter workplace, sector, and residence choices. For shape ρ and weight b, their centered distribution is

$$\Pr(\epsilon \le z) = \exp\left[-be^{-\gamma_E} z^{-\rho}\right], \quad z > 0, \qquad (\rho, b) \in \{(\theta_s, 1), (\kappa, B_s), (\eta, B_{re})\}.$$

- In logs, these are centered Type-I extreme-value shocks; γ_E is the Euler–Mascheroni constant. $B_F = B_I = 1$. Residential amenities respond to the local college share: $B_{re} = \bar{B}_r (L_r^h / L_r)^{\psi_e}$ (Tsivanidis, 2026).

- With $d_{rj} = e^{\delta t_{rj}}$, workplace choice assigns weight

$$\pi_{j|rse} \propto \left[\lambda_{sje} \max\{w_{sje} - p_r^H \bar{H}, 10^{-8}\}\right]^{\theta_s} d_{rj}^{-\theta_s}.$$

Model

A9: Formal and Informal Firms

- Potential firms draw Pareto productivity φ, then choose a sector. Each combines college and non-college labor with CES weight χ_s:

$$q_j^s(\varphi) = A_j^s \varphi N_j^s(\varphi),$$
$$N_j^s(\varphi) = [\chi_s L_{sjh}(\varphi)^\nu + (1-\chi_s) L_{sjl}(\varphi)^\nu]^{1/\nu}.$$

- Formal firms pay a labor wedge and fixed cost; informal firms do not. A minimum wage also constrains formal non-college employment.

$$\Pi_j^s(\varphi) = p_j^s(\varphi) q_j^s(\varphi) - (1+\tau_s) \sum_{e \in \{h,l\}} w_{sje} L_{sje}(\varphi) - \mathbf{1}\{s = F\} FC_F.$$

- Formal goods trade citywide; informal goods sell locally. Only formal productivity responds to college-employment density: $\mathcal{A}_j = (L_j^h/E_j)/\min_k(L_k^h/E_k)$ and $A_j^F = \bar{A}_j^F \mathcal{A}_j^\xi$ (inspired by Ahlfeldt et al., 2015).

Model

A10: Housing Supply Elasticity

- Following Harari & Wong (2025), a developer chooses floor space g_r per unit of developable land E_r. Resulting land rents accrue to absentee owners, not resident workers:

$$\max_{g_r \geq 0} \left\{ p_r^H g_r - C_r^H g_r^{\nu_H} \right\}, \qquad \nu_H > 1.$$

- The first-order condition gives $p_r^H = \nu_H C_r^H g_r^{\nu_H - 1}$, so

$$\bar{H}_r^S = E_r \left(\frac{p_r^H}{\nu_H C_r^H} \right)^{1/(\nu_H - 1)}, \qquad \varepsilon_H = \frac{1}{\nu_H - 1}.$$

Model

A11: Fixed Inputs — Households and Commuting

Parameter	Code value	Source / interpretation
α	0.6804	EM housing expenditure relation at calibrated $\bar{H}$
ω	0.5	Autor & Dorn (2009)
σ	2	Benchmark assumption
η	2.142	Tsivanidis, earlier benchmark used in Julia calibration
κ	2.8	Zárate, earlier benchmark used in Julia calibration
θ_F	1.64	EM commuting PPML estimate
θ_I	4.09	EM commuting PPML estimate
δ	0.027	EM mode-choice logit estimate
ψ_l	0.730	Tsivanidis, earlier benchmark used in Julia calibration
ψ_h	1.002	Tsivanidis, earlier benchmark used in Julia calibration
ι	2	Sturm et al. (2023) benchmark

These are the values used by the current Julia calibration; the newer paper draft reports revised literature benchmarks.

Calibration

A12: Fixed Inputs — Firms and Housing

Parameter	Code value	Source / interpretation
σ_φ	3	Variety substitution benchmark
$\underline{\varphi}$	1	Normalization of minimum firm productivity
ζ	3.08	Ulyssea (2018)
χ_I	0.25	Benchmark assumption
ν	0.2	Benchmark assumption
τ_F	0.45	Colombian non-wage labor costs
τ_I	0	Normalization of informal labor wedge
$\underline{w}$	0.673	2021 minimum wage / EM median wage
ν_H	1.69	Harari & Wong (2025)
E_r	UPZ-specific	Cadastral plot area per normalized worker; scales housing supply
B_F, B_I	$1, 1$	Normalization of sector choice weights
λ_{Ije}	1	Normalization of informal job access
P^F	1	Formal-good numeraire

Other UPZ-specific inputs: M_j from EM firm-size reports; travel times from Bogotá maps; $\mathcal{C}_r^H$ recovered by housing-supply inversion.

Calibration

A13: Endogenous Equilibrium Variables

Variable	Determined by
$(w_{sje})_{s,j,e}$	Labor-market clearing by sector, workplace, and education
$(\lambda_{Fjl})_j$	Low-educated formal labor clearing under the minimum-wage constraint
$(\widetilde{\varphi}_j)_j$	Formal–informal firm-profit cutoff
$(A_j^F)_j$	Local college-employment density and formal productivity spillovers
$(B_{re})_{r,e}$	College share by residence and education-specific amenity response
$(Q_r^I)_r,\ Q^F$	Informal and formal goods-market clearing
$(p_r^H)_r$	Housing-market clearing
(L_I, L_h)	Open-city migration response

Baseline: the minimum wage binds in all 95 UPZs; $\lambda_{Fjl} \in [0.018, 0.171]$, $p_r^H \in [0.308, 3.496]$, and $(L_I, L_h) = (0.615, 0.457)$. Ranges are across UPZs; values are in model units.

Calibration

A14: Other Counterfactuals

- We test policies to raise non-college formal employment.

Scenario	Non-college formal share	Non-college mean earnings	D
$\rightarrow$ Baseline (model)	51.59%	0.542	0.445
Panel A: Spatial counterfactuals			
$\rightarrow$ Formal commute cost -25%	51.58%	0.542	0.447
$\rightarrow$ Targeted entry -25%	52.72%	0.549	0.446
Panel B: Labor counterfactuals			
$\rightarrow$ Minimum wage -25%	82.79%	0.566	0.460
$\rightarrow$ Citywide entry cost -25%	55.15%	0.560	0.444

- Formal commuting costs fall only for non-college workers; Entry costs fall in 24 reachable UPZs with relatively few formal jobs.

Housing subsidy