Online Appendix: Estimating the Economic Value of Zoning Reform

Santosh Anagol   Fernando Ferreira   Jonah Rexer

*Santosh Anagol: anagol@wharton.upenn.edu, Wharton School, University of Pennsylvania. Fernando Ferreira: fferreir@wharton.upenn.edu, Wharton School, University of Pennsylvania and NBER. Jonah Rexer: jrexer@princeton.edu, School of Public and International Affairs, Princeton University. We are grateful for support from the Wharton Dean's Research Fund, and the Research Sponsors Program of the Zell/Lurie Real Estate Center. We thank Tom Cui, Anna Gao, Lucas Fernandes, Gi Kim, Renan Muta, Sophia Winston, Alexandru Zanca, and Holly Zhang for excellent research assistance. We also thank Rohan Ganduri, Edward Glaeser, Joseph Gyourko, Raven Molloy, and seminar participants at Imperial College Business School, Wharton Urban Lunch, European Urban Economics Association meeting, American Urban Economics Association meeting, NBER Summer Institute Real Estate, FGV-SP, Brazilian Society of Econometrics, LACEA-LAMES, NBER Public Economics, NTA meeting, Biennial Atlanta-Dallas Fed Conference, and the SITE conference at Stanford for helpful comments and suggestions. Finally, we thank Danilo Igliori and the DataZap team for providing the real estate listing data used in this research.

A Supply side aggregation

Let q be the subprefeitura-quantile $\in [1, ..., Q]$. Then the predicted annual number of new building permits for q is:[1]

$$\hat{s}_q = \frac{1}{4}\exp(\hat{\alpha}^s p_q + \hat{\beta}^s X_q^s + \hat{\psi} M_q) \tag{11}$$

Each new permit is associated with a time-path of new housing units. To obtain this, we take a sample of permits which can be matched to our IPTU data and calculate the cumulative expected number of residential units $\hat{n}_t$ that will be constructed from the average permit, for each year t over a ten year horizon.[2] So each permit is associated with $\hat{s}_q \hat{n}_t$ units. The model-predicted number of new units for location q by year τ, then, is:

$$N_{q,\tau} = \sum_{t=0}^{\tau} \hat{n}_t \hat{s}_q \tag{12}$$

This formula accounts for the fact that, each year into our simulation, new permits are being filed at a constant rate implied by the predicted values of the supply equation. Finally, to obtain the market share of total units for q after 10 years, we add the new units to the existing stock, allowing for differential secular growth rates between the city, r_1, and the outside option, r_0.[3]

$$S_{q,\tau} = \frac{N_{q,\tau} + N_q^0(1+r_1)^\tau}{N_0^0(1+r_0)^\tau + \sum_{k=1}^{Q} N_{k,\tau} + N_k^0(1+r_1)^\tau} \tag{13}$$

S_q is defined at the subprefeitura-quantile-level but our equilibrium prices and quantities must be returned at the commuting zone-level. However, neighborhood-quantiles are not nested in commuting zones. As such, we construct the following mapping between the two. First, we overlay the maps of 1182 neighborhood-quantiles on to the 329 commuting zones and calculate the area of intersection between every q, j pair. Define weights $\omega_{qj} = \frac{km^2_{qj}}{km^2_q}$ as the share of the area in neighborhood-quantile q that falls into commuting zone j. Then, to translate a price vector p_j into p_q to be plugged into the supply equation, we calculate the weighted average of prices in all the zones that overlap with q:

[1] Note that we measure the outcome as the total number of permits for the four years from 2016-2019. So in order to annualize the predicted number of permits, we divide the fitted values by 4.

[2] In our matched sample, by year 10 the average new building permit will create 19 new residential units.

[3] We obtain these growth rates from census data on aggregate housing unit growth from 2000-2010, and estimate $r_1 = 0.01$ and $r_0 = 0.017$; over this period the suburbs have grown .7 percent per year faster in terms of housing units.

$$p_q = \sum_{j=1}^{J} \omega_{qj} p_j \tag{14}$$

Similarly, to translate a set of shares S_q into S_j for the equilibrium calculation, we apportion each neighborhood-quantile share to each of its constituent zones in proportion to their area share and then aggregate up to the commuting zone level:

$$S_j = \sum_{q=1}^{Q} \omega_{qj} S_q \tag{15}$$

B Zoning reform effect on productivity

Our estimates of the productivity effects of zoning reform are heavily based on the assumptions and estimates from Glaeser and Gyourko (2018).[4] Let L_i be the quantity of labor in location i, F_L^i be the marginal product of labor in location i and W the average national wage. Their work assumes that differences in payroll per worker can be considered the true differences in marginal product of labor. From that assumption they consider the thought experiment of moving populations from all areas with low initial wages to all areas with high wages until wages equalize to a similar level (W) across all locations. In this context, the gains from relocation can be written as:

$$Gains = \frac{1}{2\alpha} \sum_i L_i (F_L^i(L_i) - W) \tag{16}$$

α is the inverse elasticity of labor demand. In this set up equalizing wages will generate a reduction in the total wage bill and the output gain from reallocation will be proportionate to the total wage bill reduction.[5]

Glaeser and Gyourko (2018) use data across all MSAs in the U.S. and an estimate of α from the literature to calibrate a 2 percentage change in GDP resulting from a radical reallocation of labor that equalizes wages across all locations. If α=1, then a 33.3 percent increase in population will drop wages in the New York MSA to the national norm.

We use that information to estimate a simple back-of-the envelope calculation, only consider-

[4] See Appendix 3 of that paper for details on the calculation method and necessary assumptions.

[5] The reduction in the total wage bill comes intuitively from the fact that formerly high wage areas with stringent zoning restrictions now attract a lot of labor leading to large wage declines relative to low-wage unrestricted places. The key assumption is that that curvature of the marginal product curve is stronger in the restricted versus non restricted areas. The output gain is proportional to this because the higher the wages where in the restricted areas, the greater the productivity gains from labor re-allocation.

ing the effects of the Sao Paulo zoning reforming, and ignoring a potential equalization of wages across all cities in the country. Our counterfactual simulation estimates that the reform would increase population in Sao Paulo by an extra 2.2 percentage points in 10 years. Assuming that Sao Paulo plays a similar economic role in Brazil as that of of NYC in the US, the increase in population is 0.0661 of the effect required to equalize wages, assuming linearity of effects.

The Sao Paulo share of national GDP is 9.46%, which means that the reform would generate gains through reallocation of 2% GDP*9.46%*0.0661 = 0.0125% of the Brazilian GDP. That in turn corresponds to 0.132% of Sao Paulo GDP. A similar calculation was conducted for the double BAR simulations.

C Appendix Tables

Table A1: RD reduced form: Poisson model

Outcome	New multi-family building permits			
	(1)	(2)	(3)	(4)
Panel A: No sub-prefeitura FE				
Treat BAR	0.261*	0.683***	0.645***	0.403*
	(0.103)	(0.094)	(0.121)	(0.162)
Specification	Base	Linear	Quadratic	Cubic
Observations	43231	43231	43231	43231
Mean of Dep. Variable	0.007	0.007	0.007	0.007
Panel B: With sub-prefeitura FE				
Treat BAR	0.300***	0.373***	0.424***	0.345*
	(0.077)	(0.088)	(0.118)	(0.150)
Specification	Base	Linear	Quadratic	Cubic
Observations	43225	43225	43225	43225
Mean of Dep. Variable	0.006	0.006	0.006	0.006

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. All models are poisson regressions estimated with maximum likelihood. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2: RD type of development strategy 2016

Outcome	Type of block			
	(1) Residential	(2) Preservation	(3) Qualification	(4) Transformation
Cubic specification with sub-prefeitura FE				
Treat BAR	0.0128	-0.0609***	-0.152***	0.212***
	(0.00791)	(0.0137)	(0.0286)	(0.0272)
Observations	43225	43225	43225	43225
Mean of Dep. Variable	0.967	0.0949	0.793	0.112

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. Outcome is an indicator variable at block level for whether the specific block allows residential construction (1) or is under the preservation, qualification, or transformation development strategy (2, 3, 4) according to 2016 zoning law. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3: RD zoning parameters 2016

Outcome	Type of block			
	(1) Basic BAR	(2) Shadow ratio	(3) Max height	(4) Max lot area
Cubic specification with sub-prefeitura FE				
Treat BAR	0.0136***	0.0555***	3.179***	474.5**
	(0.00290)	(0.00647)	(0.755)	(148.7)
Observations	43225	43225	33175	42687
Mean of Dep. Variable	0.989	0.770	26.64	18885.6

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. Outcome is a 2016 zoning parameter at the block level: (1) basic built-area-ratio, (2) shadow ratio of building footprint to lot area for lots up to 500 square meters, (3) maximum height allowed in meters, and (4) maximum lot area allowed in square meters. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A4: RD first stage and reduced form with 2016 zoning controls

Outcome		
	(1) Max BAR change	(2) New build
Cubic specification with sub-prefeitura FE		
Treat BAR	1.042***	0.00199*
	(0.0283)	(0.000855)
Observations	43225	43225
Mean of Dep. Variable	-0.153	0.0056

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Models used are the same as in Table 1 column (4) and Table 2 column (4), with the addition of certain 2016 zoning parameters as controls: basic BAR, shadow ratio for lots under 500 square meters, maximum height in meters, and maximum lot area in square meters. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. Outcome is at block level: (1) maximum BAR change or (2) average annual new multi-family building permits filed after 2016. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A5: RD reduced form: approved permits

Outcome	New multi-family building permits			
	(1)	(2)	(3)	(4)
Panel A: No sub-prefeitura FE				
Treat BAR	0.00113*	0.00266***	0.00303***	0.00260***
	(0.00046)	(0.00047)	(0.00050)	(0.00058)
Specification	Base	Linear	Quadratic	Cubic
Observations	43231	43231	43231	43231
Mean of Dep. Variable	0.00307	0.00307	0.00307	0.00307
Panel B: With sub-prefeitura FE				
Treat BAR	0.00130***	0.00157***	0.00174***	0.00190***
	(0.00035)	(0.00040)	(0.00046)	(0.00057)
Specification	Base	Linear	Quadratic	Cubic
Observations	43225	43225	43225	43225
Mean of Dep. Variable	0.00307	0.00307	0.00307	0.00307

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. Outcome is the average annual new building permits filed after 2016 and approved in 2017 or later. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A6: RD reduced form: listings difference 2022-2019

Outcome	New multi-family building permits			
	(1)	(2)	(3)	(4)
Panel A: No sub-prefeitura FE				
Treat BAR	1.289*	2.214***	2.586***	2.396**
	(0.500)	(0.599)	(0.655)	(0.778)
Specification	Base	Linear	Quadratic	Cubic
Observations	42504	42504	42504	42504
Mean of Dep. Variable	0.252	0.252	0.252	0.252
Panel B: With sub-prefeitura FE				
Treat BAR	2.597***	2.534***	2.502***	2.103**
	(0.626)	(0.667)	(0.693)	(0.789)
Specification	Base	Linear	Quadratic	Cubic
Observations	42498	42498	42498	42498
Mean of Dep. Variable	0.252	0.252	0.252	0.252

Standard errors clustered by commuting zones in parentheses. Specification refers to the order of the polynomial for the running variable, which is distance to the RD boundary. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. Outcome is the difference in number of real estate listings at block level between 2022 and 2019. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A7: RD balance of covariates

Panel A: Average Property Characteristics in 2015

	Block density (constructed area/m^2)	Average land value per m^2	Average constructed value per m^2	Number of buildings	Residential share of constructed area	Commercial share of constructed area
Treat BAR	-0.0273	26.66	23.03	-1.185	0.00296	-0.00547
	(0.0288)	(20.41)	(15.19)	(1.396)	(0.00931)	(0.00711)
Cubic	Y	Y	Y	Y	Y	Y
SP FE	Y	Y	Y	Y	Y	Y
Observations	41959	41959	41959	41959	41959	41959
Mean of Dep. Variable	0.930	621.8	822.8	54.97	0.771	0.154

Panel B: Average Labor Market Outcomes in RAIS Data in 2015

	Total employees in private firms	Log of mean private employee wages	Log of aggregate private employee wages	Number of private firms	Number of private firms with no employees	Number of private firms with employees
Treat BAR	4.125	0.0173	0.186**	-0.281	-0.385	0.104
	(12.05)	(0.0134)	(0.0635)	(1.084)	(0.691)	(0.445)
Cubic	Y	Y	Y	Y	Y	Y
SP FE	Y	Y	Y	Y	Y	Y
Observations	39582	31280	32251	39582	39582	39582
Mean of Dep. Variable	85.64	10.14	13.02	23.25	15.59	7.655

Standard errors clustered by commuting zones in parentheses. All specifications include a cubic polynomial of the running variable interacted with the treatment indicator. The polynomial is always interacted with the treatment indicator. Sample is all city blocks with zoning information. Mean of dependent variable calculated for control blocks within 0.1 km of the BAR boundary. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A8: Summary statistics for demand variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Price	Travel time	RCMA	Age	Units	Density	Paved	Income	College
Mean	6.24	33.36	2.03	39.89	5.40	5.17	0.98	4.65	0.33
SD	2.35	30.61	1.11	10.38	16.89	4.74	0.05	2.28	0.26

Table shows means and standard deviations for all commuting zone-level variables that enter demand equation (4). Price is measured in R$ ths, travel time in minutes, RCMA is an index of market access (see description in-text), average age of building is in years, units is units per building for the average building in the zone, density is constructed area per unit of zone area, paved is the share of paved roads, income is measured in monthly R$ ths, and college is the share of residents with a college degree.

Table A9: Second-stage demand estimation: IVs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Price	-0.793***	-2.274***	-1.383***	-1.521***	-2.690***	-2.491***	-1.222**	-3.884***	-1.975***
	(0.163)	(0.436)	(0.373)	(0.309)	(0.495)	(0.477)	(0.609)	(0.997)	(0.383)
RCMA	0.463***	0.822***	0.606***	0.640***	0.922***	0.874***	0.567***	1.211***	0.749***
	(0.145)	(0.198)	(0.165)	(0.167)	(0.220)	(0.206)	(0.212)	(0.337)	(0.183)
Age	-1.157***	-0.935***	-1.069***	-1.048***	-0.873***	-0.903***	-1.093***	-0.694***	-0.980***
	(0.099)	(0.111)	(0.109)	(0.100)	(0.120)	(0.118)	(0.122)	(0.197)	(0.105)
Units per building	-0.781***	-0.613***	-0.714***	-0.699***	-0.566***	-0.589***	-0.732***	-0.431***	-0.647***
	(0.049)	(0.072)	(0.066)	(0.059)	(0.079)	(0.077)	(0.081)	(0.132)	(0.067)
Density	0.708***	0.779***	0.736***	0.743***	0.799***	0.789***	0.729***	0.856***	0.765***
	(0.107)	(0.136)	(0.116)	(0.117)	(0.149)	(0.143)	(0.117)	(0.193)	(0.127)
Paved roads	0.083	0.092	0.087	0.087	0.094	0.093	0.086	0.101	0.090
	(0.064)	(0.074)	(0.067)	(0.068)	(0.078)	(0.076)	(0.065)	(0.090)	(0.071)
Average income	-0.600***	-0.375*	-0.510***	-0.489***	-0.312	-0.342	-0.535***	-0.130	-0.420**
	(0.174)	(0.220)	(0.185)	(0.187)	(0.240)	(0.229)	(0.205)	(0.322)	(0.206)
College share	0.104	0.691**	0.338	0.392*	0.855***	0.777***	0.274	1.329***	0.572**
	(0.196)	(0.278)	(0.248)	(0.232)	(0.302)	(0.297)	(0.295)	(0.495)	(0.260)
F-statistic		8.560	8.852	7.459	41.411	38.901	24.005	17.174	12.136
Observations	329	329	329	329	329	329	329	329	329
Instruments	None	X	Spatial	All	RCMA	Density	Pave	Favela	Strong

Robust standard errors in parentheses. Results are from the second step of a two-step demand estimation. The outcome variable is the mean location-specific utility term $\hat{\delta}_i$ estimated in the first step maximum likelihood procedure. All location characteristics including price are standardized relative to the zone-level sample mean and standard deviation. Instruments for housing prices are the average spatial and housing characteristics of all zones greater than 3 miles from a zone centroid. X instruments (2) are: paved road share, RCMA, housing stock age, average units per building, and density. Spatial instruments (3) are: favela share of zone area, flood-zone share of zone area, average slope, and metro station presence. Strong instruments (9) are the subset of jointly strongest instruments: favelas, slope, RCMA, and age.

Table A10: Summary statistics for supply variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Permits	MF Permits	SF Permits	Max BAR	Price	Density	Age	Units	Historic
Mean	4.55	3.22	0.35	2.11	5.35	0.58	34.62	5.93	0.04
SD	5.91	5.05	0.85	0.66	1.81	0.41	8.41	12.41	0.10

Table shows means and standard deviations for all subprefeitura-bin-level variables that enter supply equation. Permits is the total count of permits in the post-reform years 2016 to 2019 (total new building, multi-family, or single-family). Max BAR is the average Max BAR in 2016 in the subprefeitura-bin. Price is measured in R$ ths, average age of building is in years, units is units per building for the average building in the subprefeitura-bin, density is constructed area per unit of subprefeitura-bin area, and historic is the share of subprefeitura-bin area under historic preservation.

Table A11: Supply estimates: Poisson IV regressions, multiplicative error

Outcome	All new buildings			Single	Multi
	(1)	(2)	(3)	(4)	(5)
Max BAR	0.474***	0.896***	0.878***	0.727	0.978***
	(0.133)	(0.255)	(0.253)	(0.885)	(0.295)
Price	0.101*	0.104*	0.462	1.338*	0.091
	(0.047)	(0.047)	(0.246)	(0.662)	(0.270)
Density	0.130	0.031	-0.586	-0.799	-0.161
	(0.159)	(0.167)	(0.433)	(0.855)	(0.501)
Age	0.042***	0.040***	0.002	-0.112	0.033
	(0.011)	(0.011)	(0.028)	(0.079)	(0.034)
Units per building	0.008	0.007	-0.003	-0.099**	0.008
	(0.005)	(0.005)	(0.007)	(0.036)	(0.010)
Historical preservation	-1.132*	-1.206*	-1.396**	-1.331	-1.132
	(0.484)	(0.481)	(0.442)	(1.129)	(0.733)
Q	1.731e-27	9.673e-30	1.748e-30	7.511e-29	1.550e-29
Observations	1182	1182	1182	1182	1182
IVs	None	RD	RD, Bartik	RD, Bartik	RD, Bartik

Robust standard errors in parentheses. Results are from the estimation of fuzzy regression discontinuity (RD) exponential (Poisson) model, estimated with GMM, on the sample of subprefeitura-quantiles. The RD treatment indicator instruments for Max BAR, while the Bartik labor demand shock instruments for price. All models use a multiplicative error specification to form moment conditions. All specifications include controls for the running variable interacted with the treatment, and the following zoning parameters: maximum shadow ratio, minimum and basic BAR of 2004 and 2016, max BAR of 2004, maximum height, min and max. front setback and maximum area of 2016, (zoning variables averaged within subprefeitura-quantile). Q-statistic gives the value of the GMM criterion function at the optimal parameters. The outcome variable is the number of total new building, single-family, or multi-family permit applications between 2016-2019, as indicated. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A12: Supply estimates: Poisson IV regressions, approvals

Outcome	All new buildings			Single	Multi
	(1)	(2)	(3)	(4)	(5)
Max BAR	0.458***	0.806***	0.764***	-0.051	0.981***
	(0.103)	(0.171)	(0.167)	(0.339)	(0.208)
Price	0.183***	0.191***	0.479***	0.417	0.466**
	(0.036)	(0.037)	(0.109)	(0.214)	(0.169)
Density	0.241	0.148	-0.300	-0.106	-0.297
	(0.124)	(0.129)	(0.208)	(0.433)	(0.302)
Age	0.010	0.009	-0.029	-0.044	-0.039
	(0.008)	(0.008)	(0.016)	(0.035)	(0.024)
Units per building	-0.003	-0.004	-0.011	-0.026	-0.019
	(0.004)	(0.005)	(0.007)	(0.014)	(0.013)
Historical preservation	-0.540	-0.500	-0.250	0.020	-0.791
	(0.354)	(0.362)	(0.398)	(0.790)	(0.517)
Q	2.674e-29	6.592e-27	3.851e-29	4.810e-29	4.397e-30
Observations	1182	1182	1182	1182	1182
IVs	None	RD	RD, Bartik	RD, Bartik	RD, Bartik

Robust standard errors in parentheses. Results are from the estimation of fuzzy regression discontinuity (RD) exponential (Poisson) model, estimated with GMM, on the sample of subprefeitura-quantiles. The RD treatment indicator instruments for Max BAR, while the Bartik labor demand shock instruments for price. All models use an additive error specification to form moment conditions. All specifications include controls for the running variable interacted with the treatment, and the following zoning parameters: maximum shadow ratio, minimum and basic BAR of 2004 and 2016, max BAR of 2004, maximum height, min and max. front setback and maximum area of 2016, (zoning variables averaged within subprefeitura-quantile). Q-statistic gives the value of the GMM criterion function at the optimal parameters. The outcome variable is the number of total new building, single-family, or multi-family permit approvals between 2016-2019, as indicated. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A13: Supply estimates: 2SLS IV regressions

Outcome	All new buildings			Single	Multi
	(1)	(2)	(3)	(4)	(5)
Max BAR	1.969***	3.386***	3.334***	-0.226*	2.775***
	(0.521)	(0.818)	(0.835)	(0.098)	(0.700)
Price	0.694***	0.711***	2.308**	0.197*	1.159*
	(0.183)	(0.186)	(0.704)	(0.095)	(0.564)
Density	1.275*	0.897	-1.970	-0.059	-0.969
	(0.618)	(0.639)	(1.342)	(0.184)	(1.054)
Age	0.067*	0.064*	-0.108	-0.021	-0.036
	(0.030)	(0.030)	(0.081)	(0.011)	(0.065)
Units per building	-0.015	-0.017	-0.045**	-0.007***	-0.034*
	(0.010)	(0.011)	(0.017)	(0.002)	(0.015)
Historical preservation	-2.824	-2.895*	-3.316*	0.033	-3.657**
	(1.462)	(1.470)	(1.571)	(0.220)	(1.155)
F-statistic		369.680	34.289	34.289	34.289
Observations	1182	1182	1182	1182	1182
IVs	None	RD	RD, Bartik	RD, Bartik	RD, Bartik

Robust standard errors in parentheses. Results are from the estimation of a 2SLS fuzzy regression discontinuity (RD) model, on the sample of subprefeitura-quantiles. The RD treatment indicator instruments for Max BAR, while the Bartik labor demand shock instruments for price. All specifications include controls for the running variable interacted with the treatment, and the following zoning parameters: maximum shadow ratio, minimum and basic BAR of 2004 and 2016, max BAR of 2004, maximum height, min and max. front setback and maximum area of 2016, (zoning variables averaged within subprefeitura-quantile). F-statistic refers to the first-stage regression. The outcome variable is the number of total new building, single-family, or multi-family permit approvals between 2016-2019, as indicated. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A14: Simulation results: individual-level consumer surplus, levels

Scenario	2016 zoning			Double BAR		
Update	P	X	τ	P	X	τ
	(1)	(2)	(3)	(4)	(5)	(6)
By demographic group						
Owner	59.74	140.23	139.05	803.21	2324.77	2280.55
Renter	61.11	113.55	112.20	857.98	1963.05	1921.31
Non-college	56.21	119.93	118.93	762.06	2006.24	1966.67
College	74.23	183.42	181.37	1017.39	3068.31	3009.99
By income quintile						
1	54.48	112.42	111.55	741.38	1903.61	1866.18
2	55.95	120.49	119.45	755.24	1981.58	1942.74
3	57.98	127.47	126.35	787.08	2137.35	2095.47
4	61.82	142.28	140.94	842.44	2390.08	2343.10
5	70.79	167.45	165.65	966.93	2796.81	2743.19
Totals						
Full sample	60.08	133.56	132.34	816.90	2234.36	2190.76
Aggregate consumer surplus (mm reales)	322.15	716.14	709.57	4380.04	11980.14	11746.37

Table shows per-household expected change in consumer surplus from equilibrium simulation of the 2016 zoning reform and Double BAR reform for different subgroups, measured in Brazilian reais. Bottom row shows the total consumer surplus aggregating across all households in millions of reais. Columns (1) and (3) update only equilibrium prices from the 2016 reform scenario, while columns (2) and (4) update both prices and the housing and neighborhood attributes included in X_j. Columns (3) and (6) update all variables, including travel time τ. All changes are evaluated relative to 2004 (status quo) zoning.

Table A15: Decomposition of welfare effects

Scenario	2016 zoning (1)	Double BAR (2)
Price only	25.45	344.52
Price and age	90.78	1475.26
Price and units	25.33	333.84
Price and density	40.68	726.38
Price and all X	108.46	2188.10

Table shows average individual-level welfare changes, measured in Brazilian reais from equilibrium simulation of the 2016 zoning reform and Double BAR reform. Each row represents the welfare change, relative to the 2004, from updating the variable indicated in the first row label.

D Appendix Figures

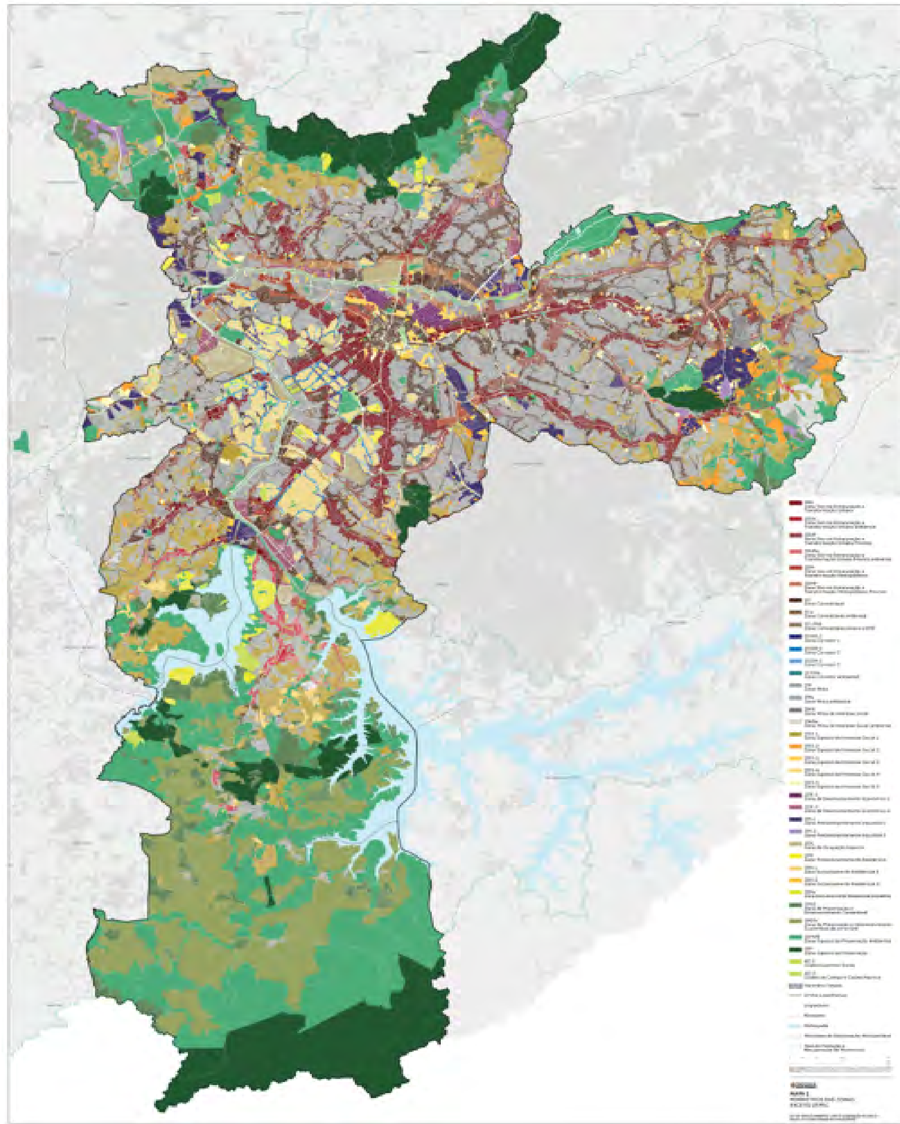


Figure A1: 2016 Zoning Reform Land Use

Map of Sao Paulo municipality shading blocks according to their associated zone type. Dark red areas correspond to transportation corridors.

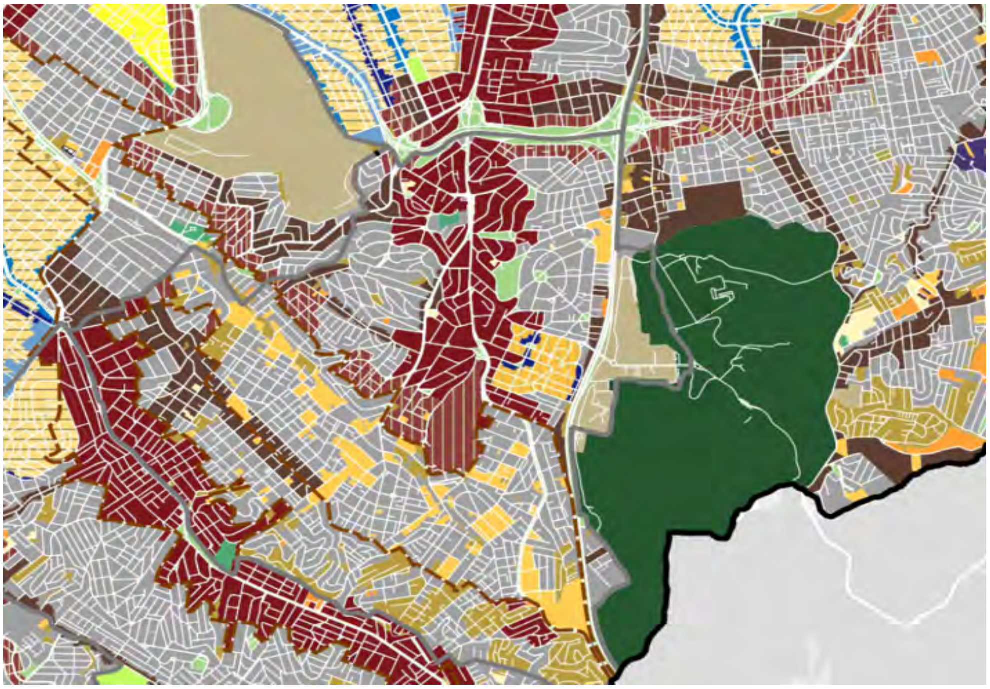


Figure A2: Block-by-block Land Use in Jabaquara Neighborhood

Map of Jabaquara neighbhorhood with blocks shaded according to their associate zone type.

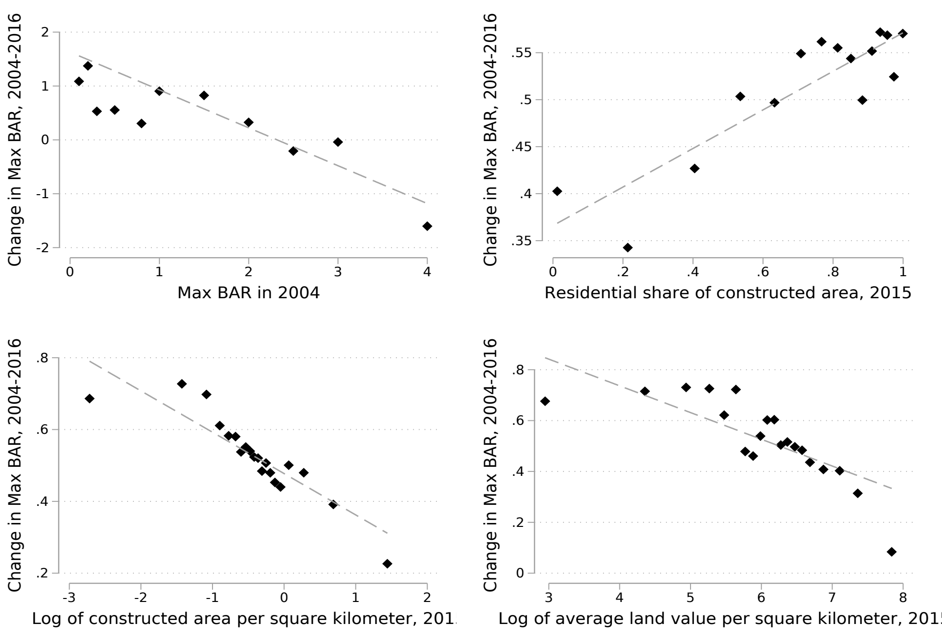


Figure A3: Correlates of Built Area Ratio Changes, Pre-to-Post 2016 Reform

This figure presents bin-scatters of neighborhood features on the x-axis and the change in max BAR that a block experienced from the 2004 to the 2016 zoning regime. The underlying data is at the block-level.

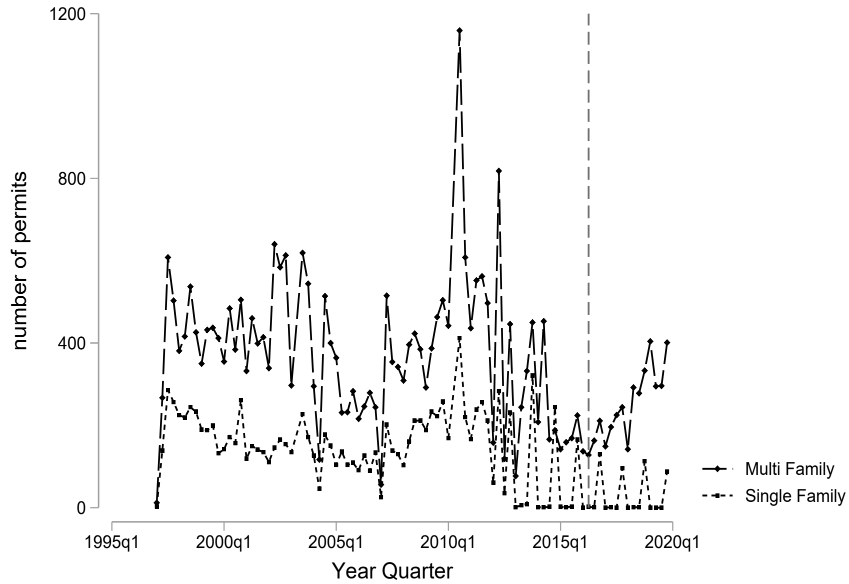


Figure A4: New Single and Multifamily Residential Building Permit Filings by Quarter

This figure shows the aggregate quarterly number of multi-family and single-family new building permit filings by developers in Sao Paulo municipality.

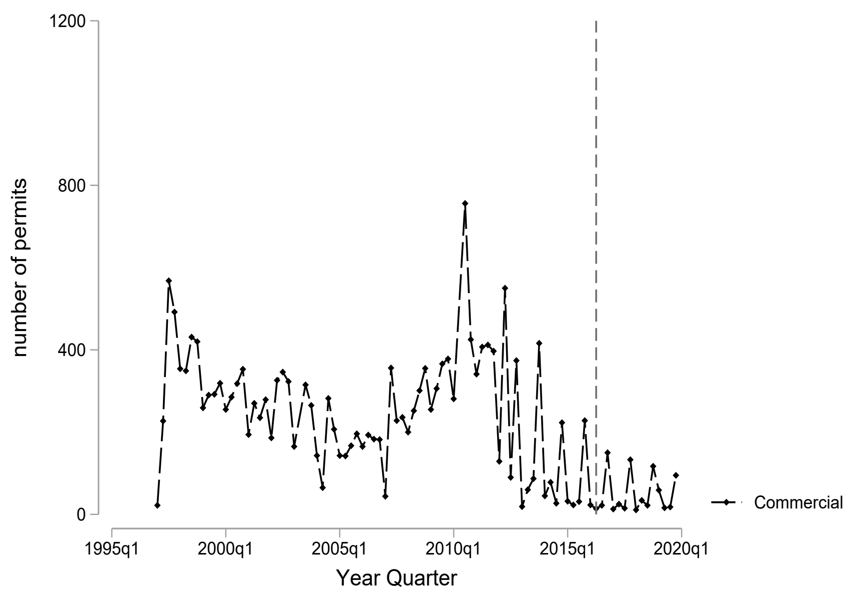


Figure A5: New Commercial Building Permit Filings by Quarter

This figure shows the aggregate quarterly number of commercial new building permit filings for developers in Sao Paulo municipality.

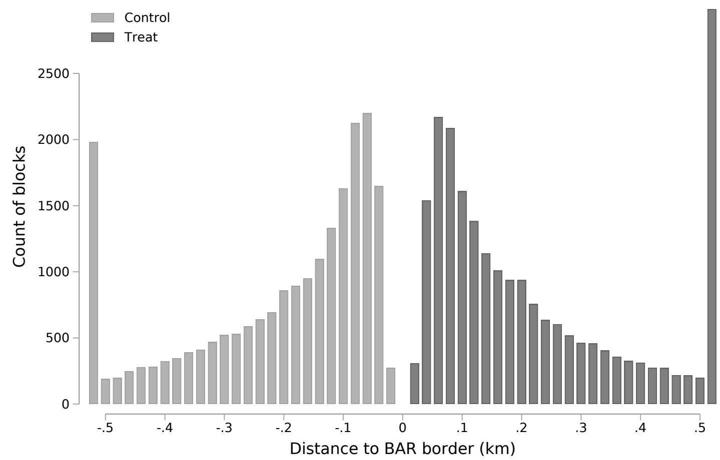


Figure A6: Histogram of blocks by running variable

This figure plots the number of blocks within a .02 kilometer bin of our running variable. Control blocks are to the left; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform.

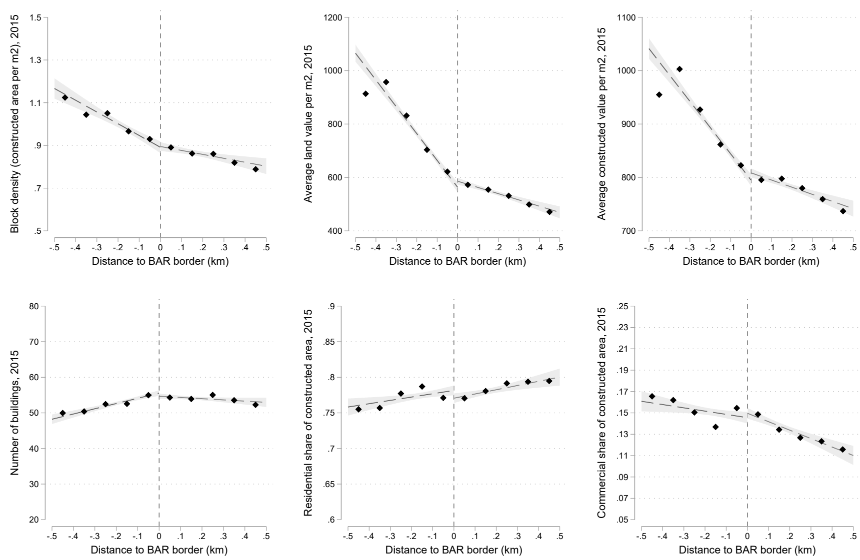


Figure A7: Average Property Characteristics in 2015 (Year Prior to 2016 Zoning Reform)

This figure plots average 2015 (i.e. just before the reform) block characteristics within a .1 km bin of our running variable. Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform. For the Number of Buildings outcome block level data is normalized by the area of the block before averaging into bins.

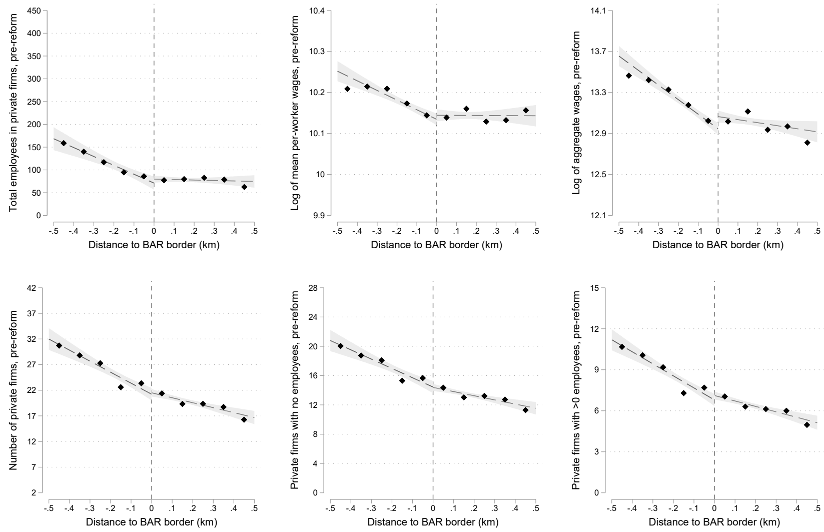


Figure A8: Average Labor Market Outcomes in RAIS Data in 2015 (Year Prior to 2016 Zoning Reform)

This figure plots average 2015 (i.e. just before the reform) formal sector labor market outcomes from the RAIS data within a .1 km bin of our running variable. Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform. All outcome variables except "Log of mean per-worker wages" and "Log of aggregate wages" are normalized by the area of the block before averaging into bins.

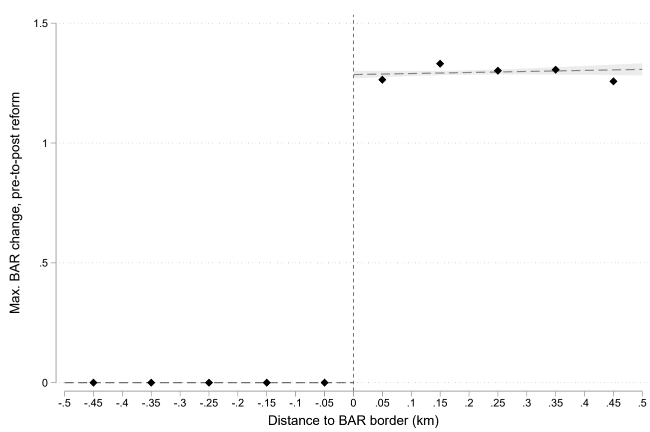


Figure A9: Control Blocks Defined as those With No Change in BAR: Built Area Ratio Change, Pre-to-Post 2016 Reform

This figure plots the change in the maximum BAR allowed for blocks within a .1 kilometer bin of our running variable. Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR stayed the same.

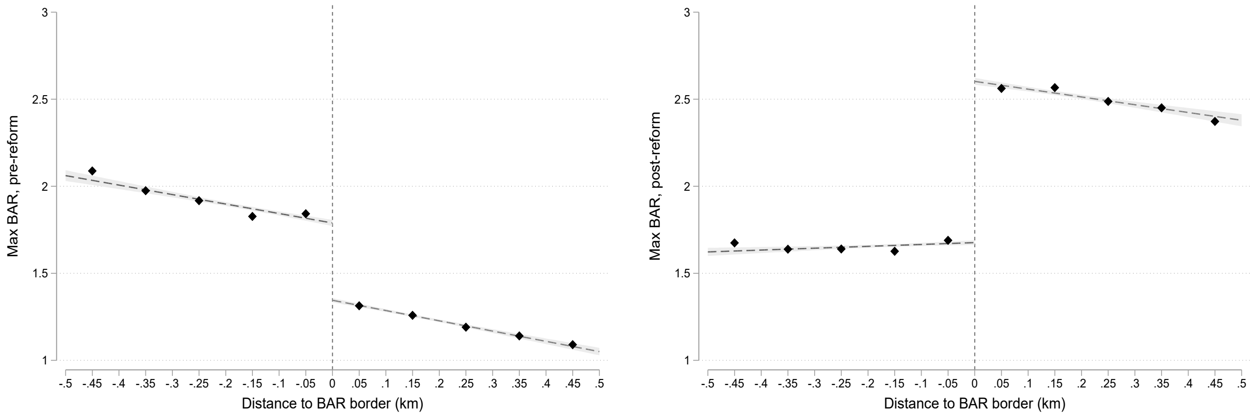


Figure A10: Built Area Ratios, Before and After 2016 Reform

The left figure plots average 2004 zoning regime max BAR for blocks within a .1 km bin of our running variable. The right figures does the same for the 2016 reform. Control blocks are to the left of the dashed vertical line; treatment blocks are to the left. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform.

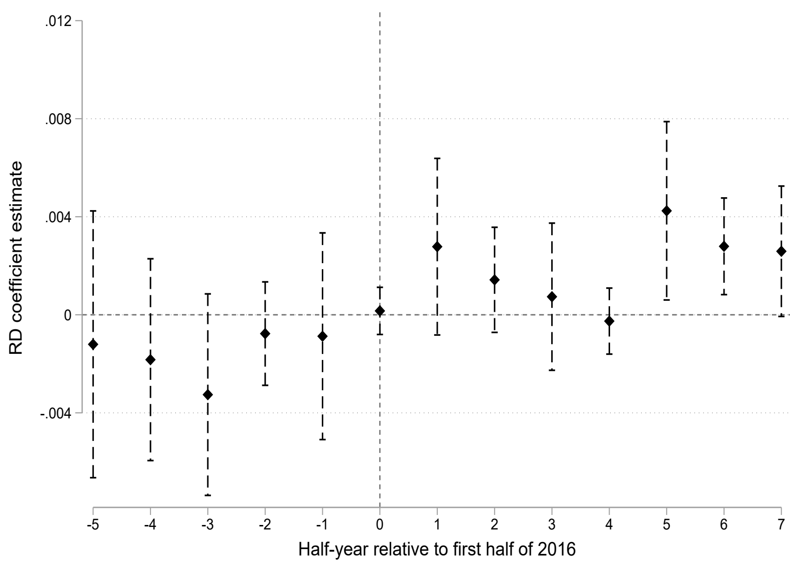
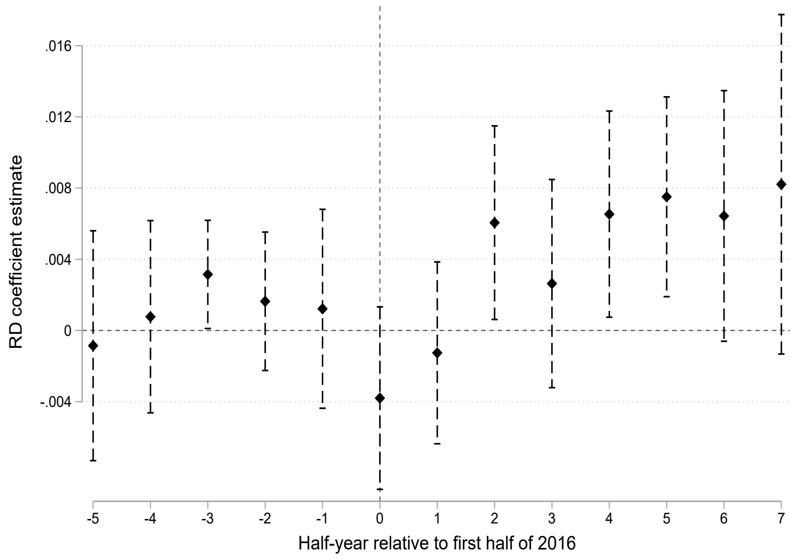
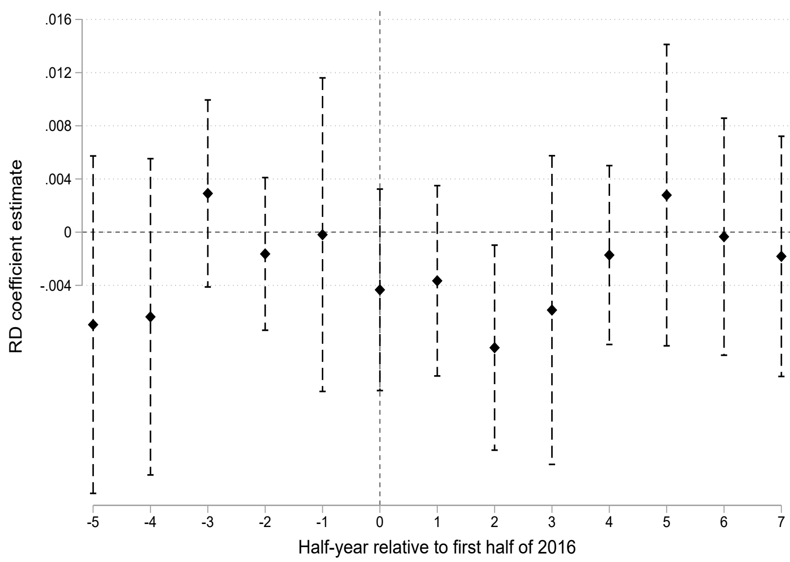


Figure A11: Dynamic RD coefficients for commercial permit filings

This figure plots the regression-discontinuity coefficients separately estimated for quarters around the reform. The outcome variable is mean quarterly commercial permits filed within a block. The estimates come from a linear specification as in Column (2) of Table 2 with sub-prefeitura fixed effects.



(a) Positive BAR change treatment group, no BAR change control group



(b) Negative BAR change treatment group, no BAR change control group

Figure A12: Dynamic RD

These figures plot the regression-discontinuity coefficients separately estimated for quarters around the reform. The outcome variable is mean quarterly multifamily permits filed within a block. The estimates come from a linear specification as in Column (2) of Table 2 with sub-prefeitura fixed effects.

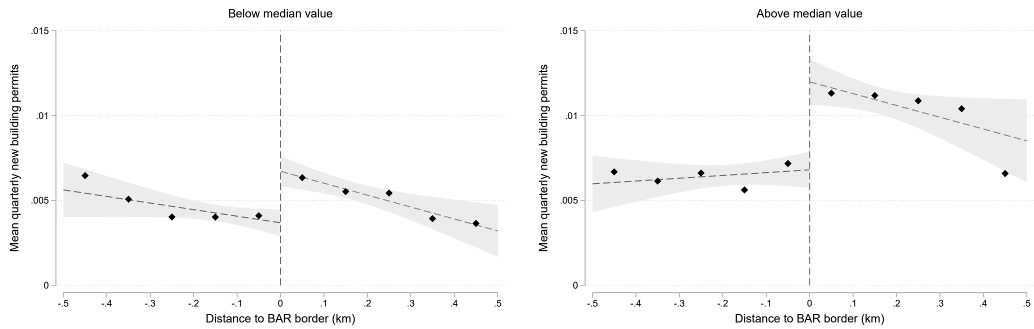


Figure A13: Heterogeneity: land values

This figure splits the sample by whether a block's average land value per square meter falls below (left) or above (right) the median block land value, and then reports the mean quarterly new building permits issued in the post-reform period (2016Q2-2019Q1). Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform.

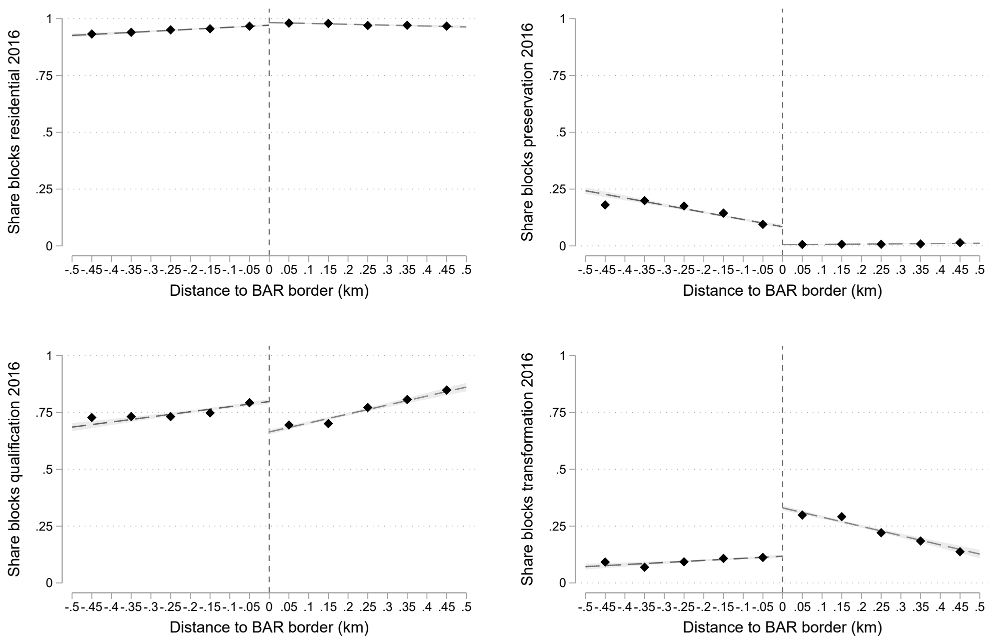


Figure A14: Share of Blocks by Development Strategy 2016

This figure plots share of blocks that allow residential construction or belong to a certain development strategy (preservation, qualification, or transformation) starting with the 2016 reform within a .1 km bin of our running variable. Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform.

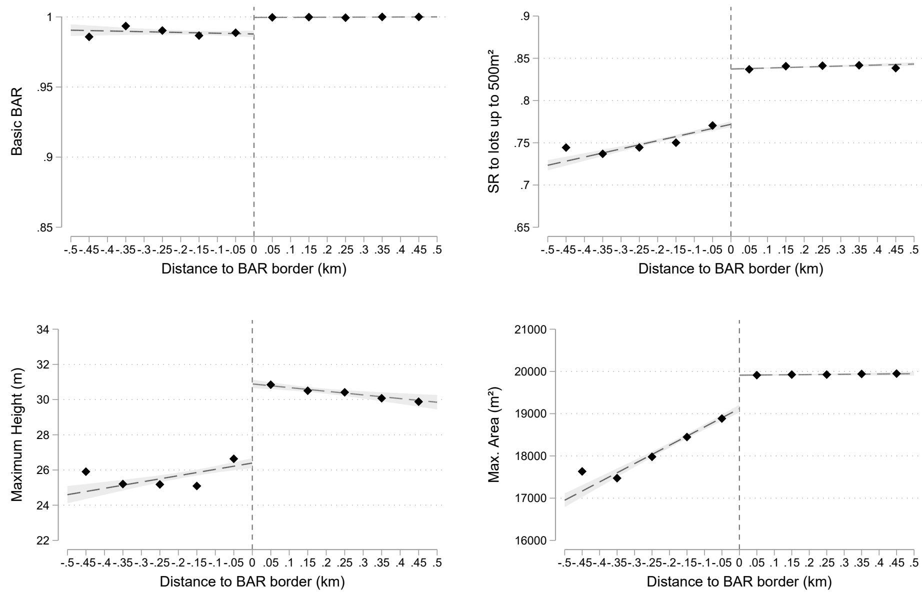


Figure A15: Average Zoning Parameters 2016

This figure plots the average of 2016 reform zoning parameters for blocks within a .1 km bin of our running variable. The zoning parameters are: basic built-area-ratio (BAR), shadow ratio (SR) of building footprint to lot area for lots under 500 square meters, maximum allowed height in meters, and maximum allowed lot area in square meters. Control blocks are to the left of the dashed vertical line; treatment blocks are to the right. For control (treatment) blocks the running variable is the distance to the nearest treatment (control) block. A treatment block is defined as a block whose max BAR increased in the 2016 reform. Control blocks are those whose max BAR declined or stayed the same in the 2016 reform.

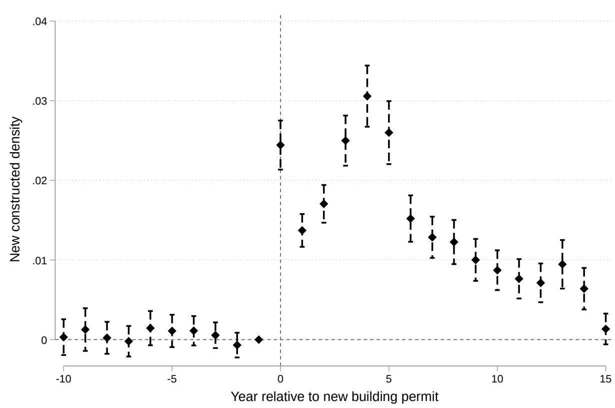


Figure A16: Event-Study Evidence on Relationship Between Block-Level Permit Issuance and Future New Construction Density

This figure presents coefficients from a block-level annual event-study model of the impact of a permit being issued/approved on the density of new construction, measured as new constructed area divided by total land area in all blocks in the IPTU data, in the period 2000-2019. The model includes block and year fixed effects. Coefficients reported are on estimates on leads and lags of the permitting treatment.

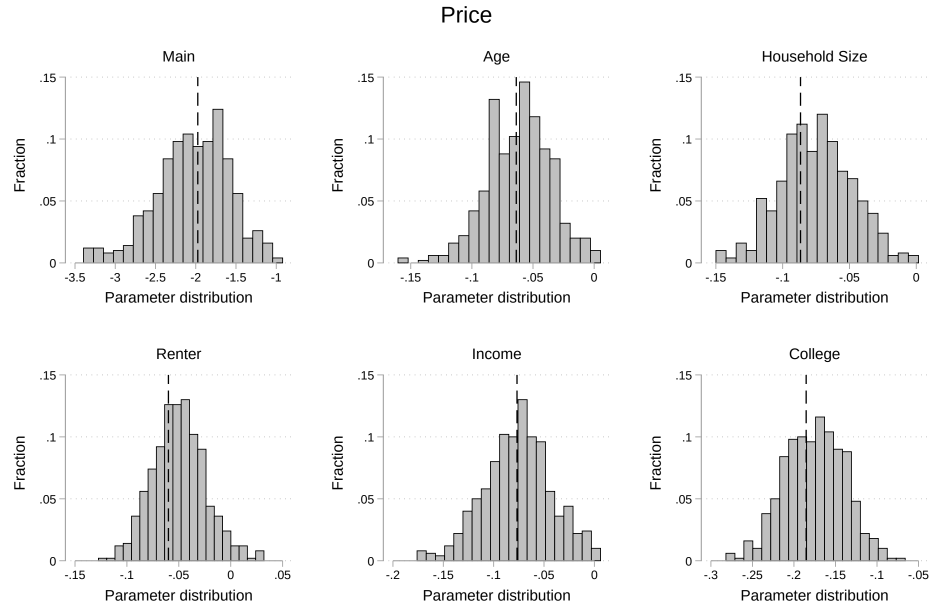


Figure A17: Bootstrap results: price

This figure plots bootstrap distributions of price elasticity parameter estimates across 500 replications of the demand model. Top-left histogram shows the distribution of the price elasticity at the average demographics, α^d. Each additional histogram provides distributions for the $\pi_{\alpha,1}...\pi_{\alpha,D}$ parameters on the interacted price terms, with demographics indicated in subfigure headers. Dotted line shows full-sample estimate.

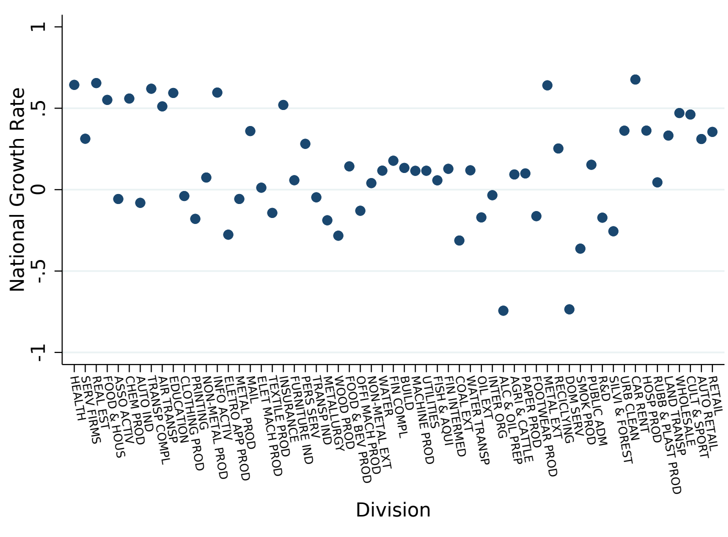


Figure A18: National Formal Sector Labor Growth Rate from 2007 - 2017

This figure shows the national level growth rate of formal sector employment in our 59 sectors. The growth rates exclude Sao Paulo municipality.

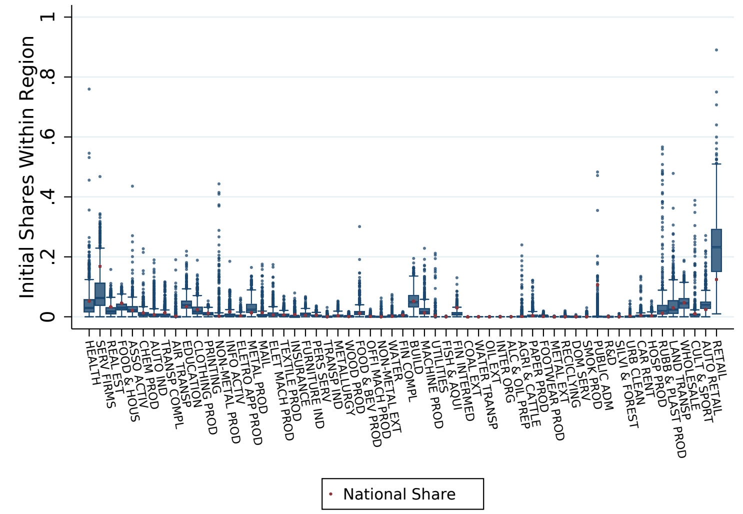


Figure A19: National and Commuting Zone Average †Employment Shares from RAIS Data

This figure shows a box plot summarizing variation in the 2007 formal sector employment shares in each of our 59 sectors.

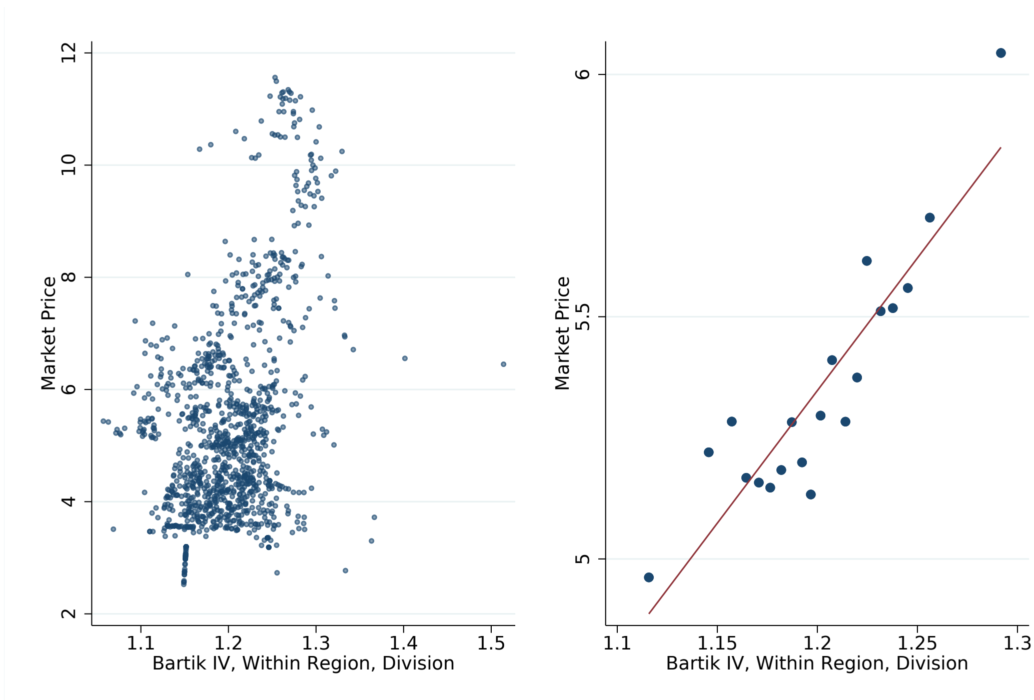


Figure A20: First Stage Relationship Between Price and Bartik Instrument

The left panel shows a scatterplot of average price (measured in our multiple listing service data) against our Bartik instrument variable using the raw data. See text for IV variable construction. The right figure is a binned scatterplot version of the left figure, where both x and y variables are residualized by the control variables we use in a our IV supply model.

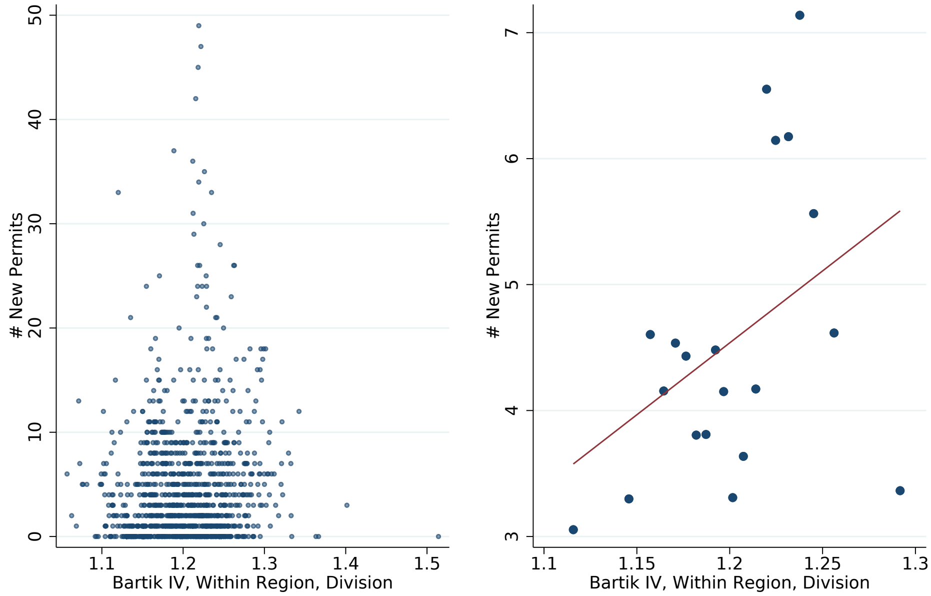


Figure A21: Reduced Form Relationship Between New Permits and Bartik Instrument

The left panel shows a scatterplot of number of new permits issued against our Bartik instrument variable. See text for IV variable construction. The right figure is a binned scatterplot version of the left figure, where both x and y variables are residualized by the control variables we use in a our IV supply model.

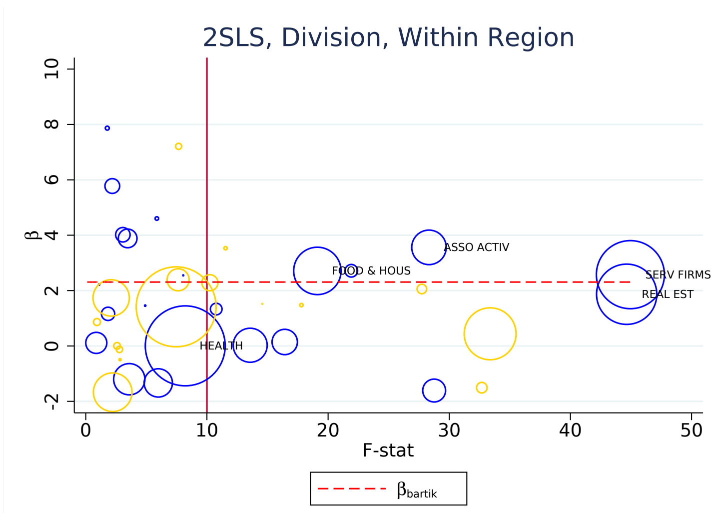


Figure A22: Heterogeneity of β_k: Bartik National Employment Growth Price Instrument

This figure plots the estimate of industry k's coefficient as the sole instrument for price against the instrument's F-statistic. The size of the circle for each point is proportional to the estimate's "Rotemberg weight" (i.e. this instrument's weight in our overall instrument's coefficient Goldsmith-Pinkham, Sorkin and Swift (2020)). The circles indicate positive Rotemberg weights and the diamonds indicate negative Rotemberg weights. The horizontal dashed line shows the two-stated least squares coefficient with our Bartik instrument (Table 3, Column (3)).

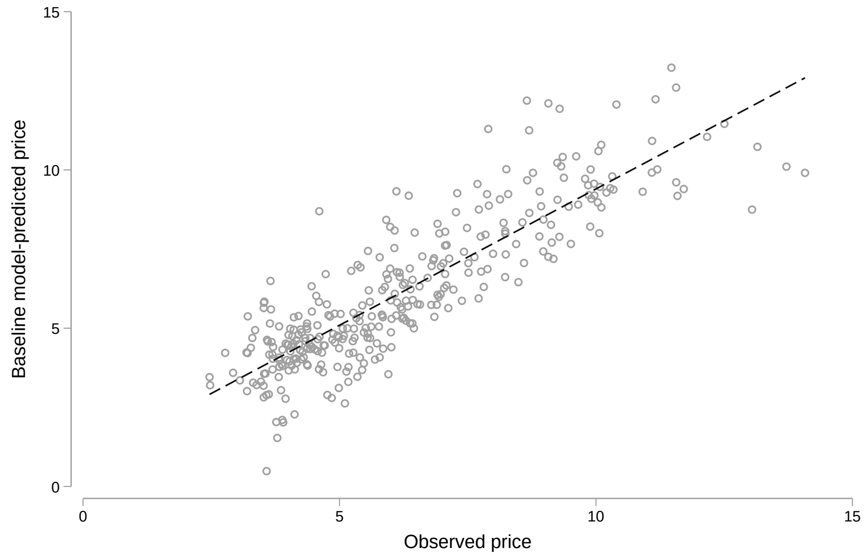


Figure A23: Model validation: prices

Figure plots the relationship between observed market prices and equilibrium model-predicted market prices from the baseline scenario using fixed supply for 329 commuting zones. Dashed line indicates linear fit.

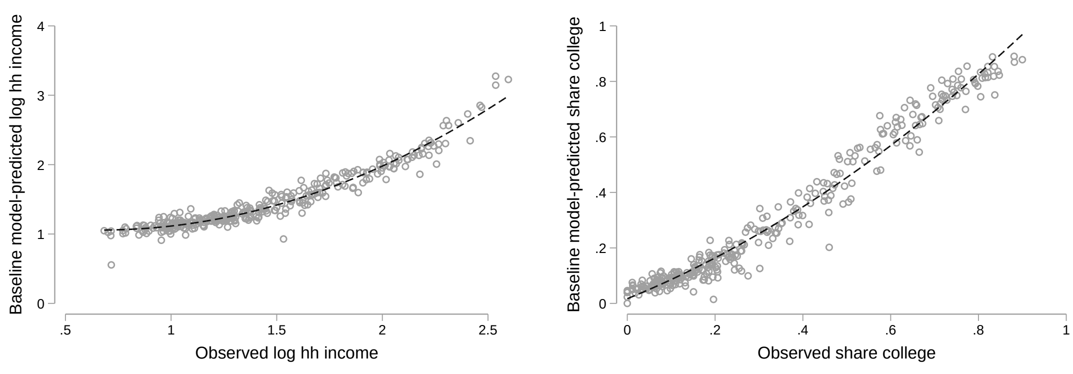


Figure A24: Model validation: demographics

Figure shows the relationship between observed and model-predicted demographics from the baseline scenario using fixed supply for 329 commuting zones. Left panel uses log of household income, while right panel plots the share of college-educated households. Dashed line indicates quadratic fit.

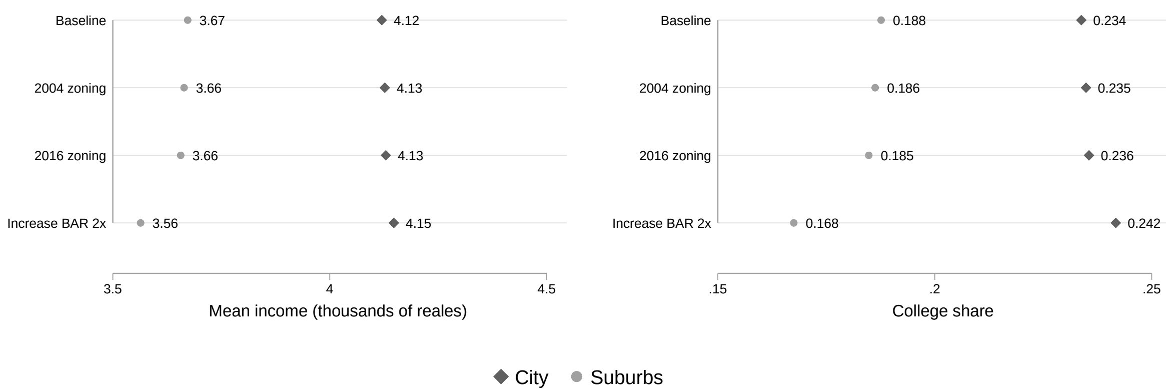


Figure A25: Demographic change in the suburbs and city under policy counterfactuals

Figure shows aggregate model-predicted demographics within the city (329 commuting zones) and the suburbs (outside option) under 4 different counterfactual scenarios, as indicated in categorical axis. Left panel shows mean household income in thousands of reais while right panel shows share of college-educated.

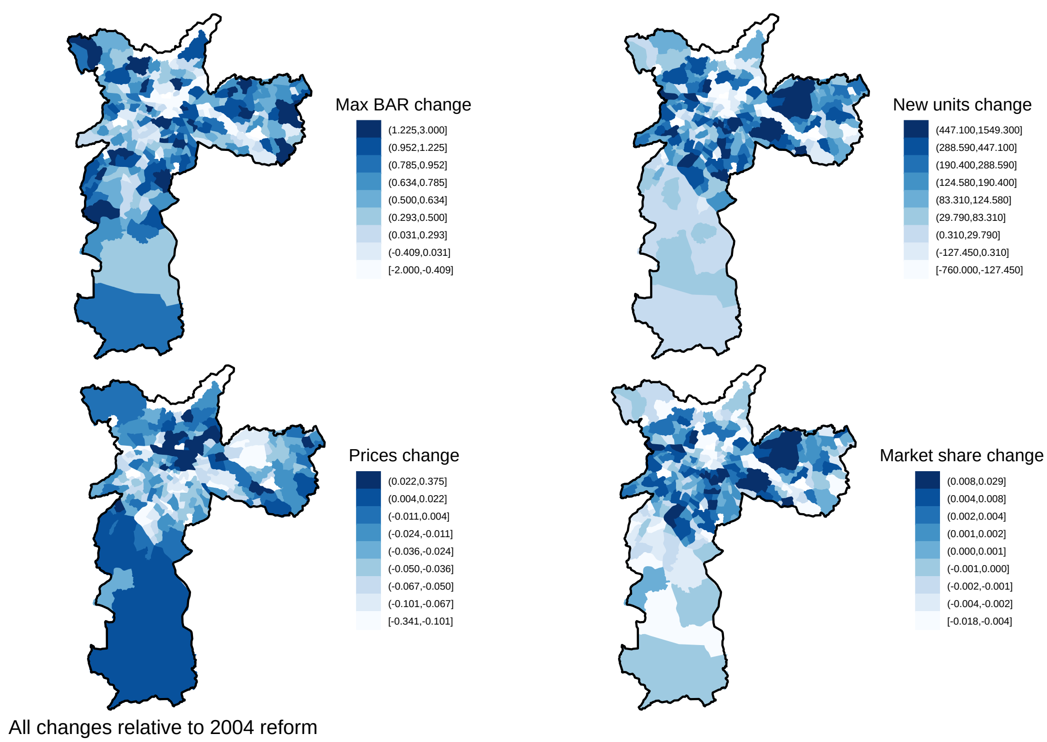


Figure A26: Equilibrium changes under the 2016 reform: map

The top-left figure shows the 2016 reform induced change max BAR by commuting zone. The other three figures show model simulated changes in new housing units (measured as number of units), prices (measured in thousands of reais per square meter) and market shares. Change means relative to the simulation where the 2004 zoning regime remained in place for 10 years after the 2016 reform.

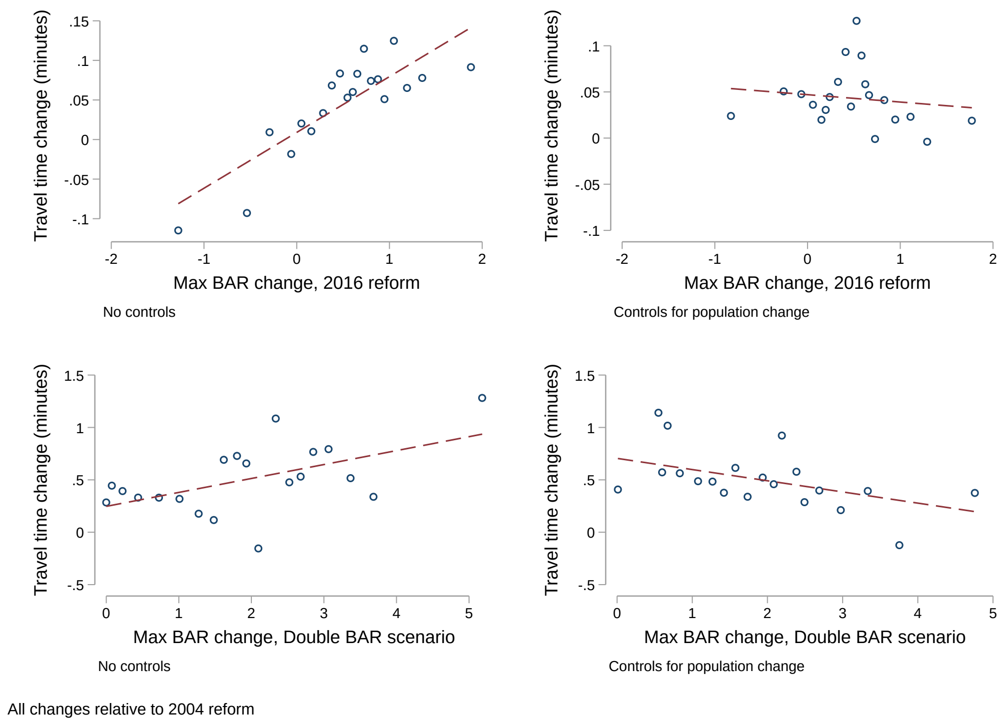


Figure A27: Travel time changes under policy counterfactuals

Figure shows the relationship between the change in average zone-level commuting time and BAR change under the 2016 (top panel) and Double BAR (bottom panel) 2026 counterfactual scenarios. Plots are presented with (right panel) and without (left panel) controls for predicted population change under the counterfactual. All changes are relative to the 2004 reform equilibrium.