Quantitative Spatial Economics and Agglomeration Economies

Urban Economics

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The economics of density: evidence from the Berlin wall

- Ahlfeldt et al. (2015) tackle the question of how strong are agglomeration and dispersion forces in a city.
- We already know that this is a difficult question, and they point out two reasons why this is the case.
  1. Endogeneity: it is hard to disentangle the strength of agglomeration forces from simple differences in location fundamentals. For this you would need exogenous variation in agglomeration.
  2. It is hard to bring the traditional urban models to data on cities.
- Ahlfeldt et al. (2015) leverage a great source of exogenous variation to identify the effects of agglomeration: the Berlin Wall.

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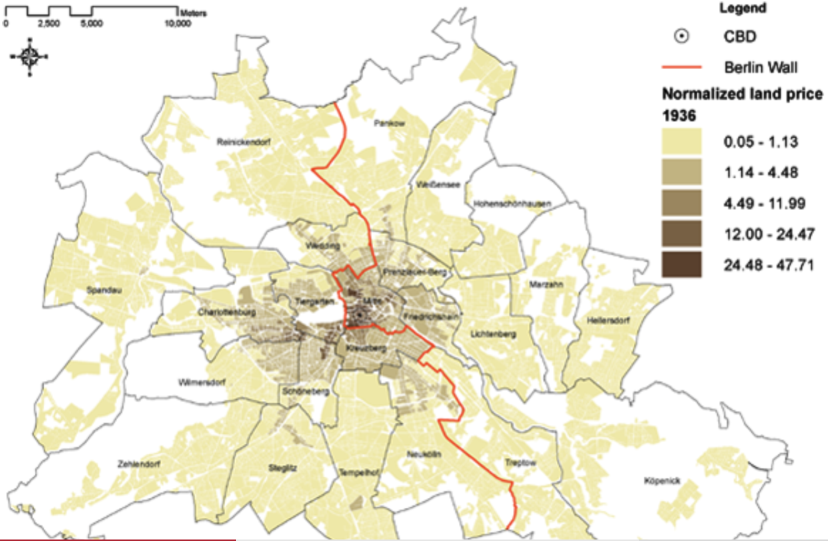
Historical Background



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Data

- Data on land prices, workplace employment, residence employment and bilateral travel times
  - Data for Greater Berlin in 1936 and 2006
  - Data for West Berlin in 1986
  - Land prices: official assessed land value of a representative undeveloped property or the fair market value of a developed property if it were not developed
  - Geographical Information Systems (GIS) data on:
    - landarea,landuse,building density, proximity to U-Bahn(underground) and S-Bahn (suburban) stations, schools, parks, lakes, canals and rivers, Second World War destruction, location of government buildings and urban regeneration programs

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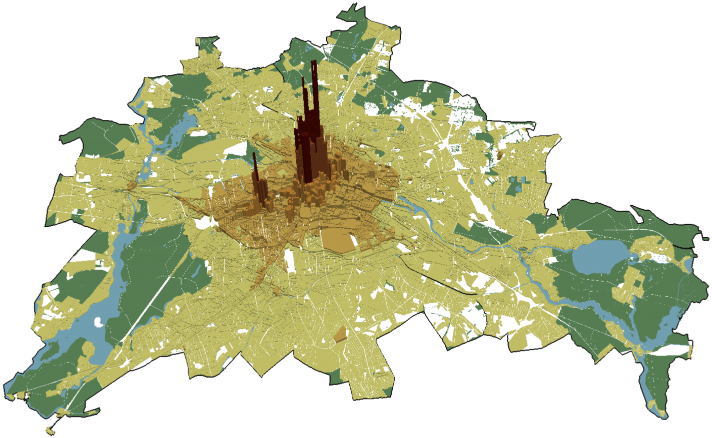
Reduced form evidence

Berlin 1936



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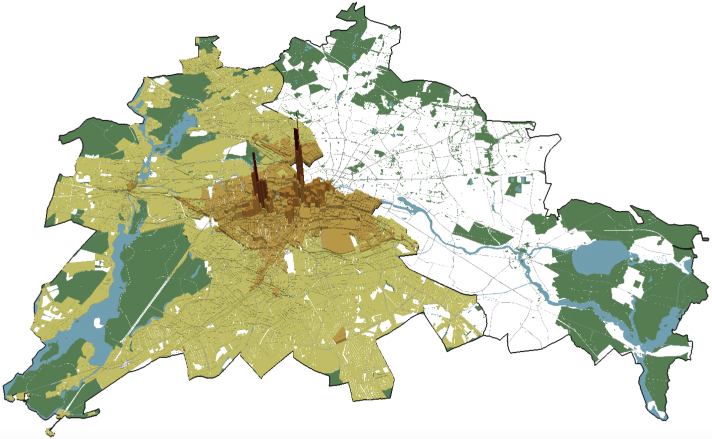
Reduced form evidence

West Berlin 1936



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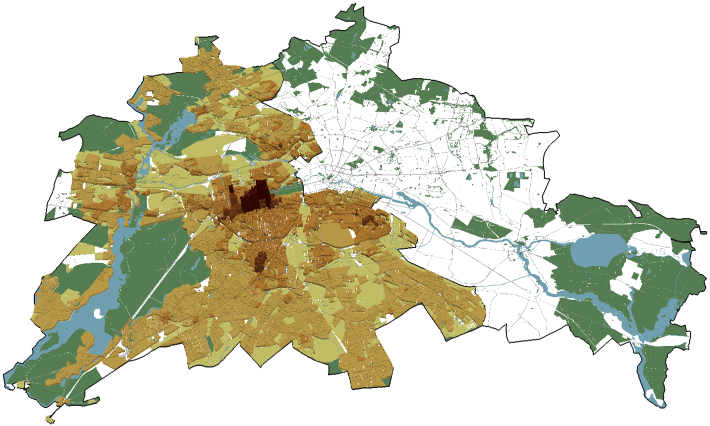
Reduced form evidence

West Berlin 1986



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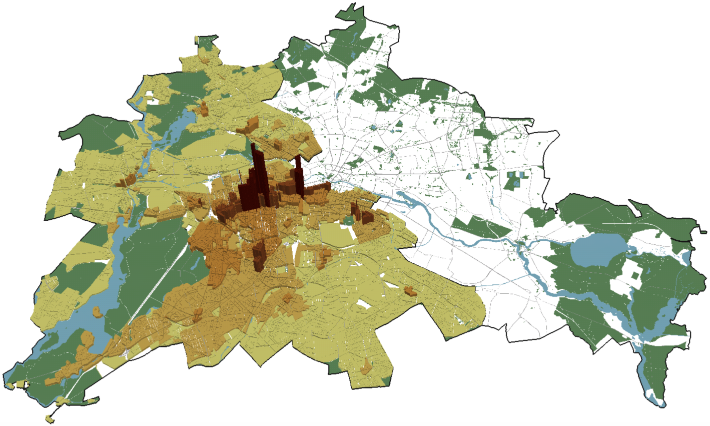
Reduced form evidence

West Berlin 2006



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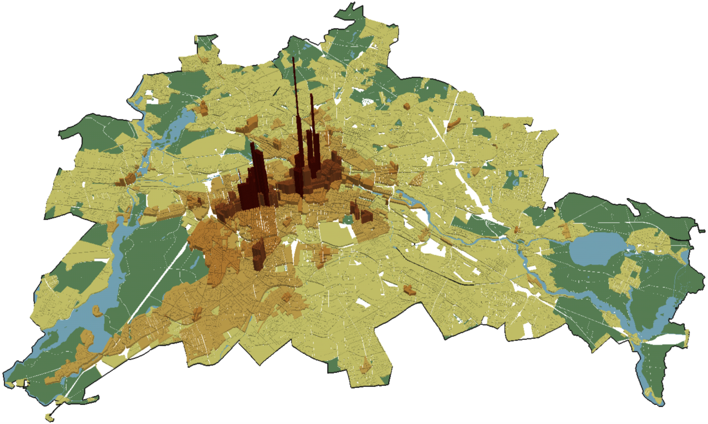
Reduced form evidence

Berlin 2006



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Reduced form evidence

TABLE I

BASELINE DIVISION DIFFERENCE-IN-DIFFERENCE RESULTS (1936–1986)[a]

	(1) $\Delta \ln Q$	(2) $\Delta \ln Q$	(3) $\Delta \ln Q$	(4) $\Delta \ln Q$	(5) $\Delta \ln Q$	(6) $\Delta \ln \text{EmpR}$	(7) $\Delta \ln \text{EmpR}$	(8) $\Delta \ln \text{EmpW}$	(9) $\Delta \ln \text{EmpW}$
CBD 1	−0.800***	−0.567***	−0.524***	−0.503***	−0.565***	−1.332***	−0.975***	−0.691*	−0.639*
	(0.071)	(0.071)	(0.071)	(0.071)	(0.077)	(0.383)	(0.311)	(0.408)	(0.338)
CBD 2	−0.655***	−0.422***	−0.392***	−0.360***	−0.400***	−0.715**	−0.361	−1.253***	−1.367***
	(0.042)	(0.047)	(0.046)	(0.043)	(0.050)	(0.299)	(0.280)	(0.293)	(0.243)
CBD 3	−0.543***	−0.306***	−0.294***	−0.258***	−0.247***	−0.911***	−0.460**	−0.341	−0.471**
	(0.034)	(0.039)	(0.037)	(0.032)	(0.034)	(0.239)	(0.206)	(0.241)	(0.190)
CBD 4	−0.436***	−0.207***	−0.193***	−0.166***	−0.176***	−0.356**	−0.259	−0.512***	−0.521***
	(0.022)	(0.033)	(0.033)	(0.030)	(0.026)	(0.145)	(0.159)	(0.199)	(0.169)
CBD 5	−0.353***	−0.139***	−0.123***	−0.098***	−0.100***	−0.301***	−0.143	−0.436***	−0.340***
	(0.016)	(0.024)	(0.024)	(0.023)	(0.020)	(0.110)	(0.113)	(0.151)	(0.124)
CBD 6	−0.291***	−0.125***	−0.094***	−0.077***	−0.090***	−0.360***	−0.135	−0.280**	−0.142
	(0.018)	(0.019)	(0.017)	(0.016)	(0.016)	(0.100)	(0.089)	(0.130)	(0.116)
Inner Boundary 1–6			Yes	Yes	Yes		Yes		Yes
Outer Boundary 1–6			Yes	Yes	Yes		Yes		Yes
Kudamm 1–6				Yes	Yes		Yes		Yes
Block Characteristics					Yes		Yes		Yes
District Fixed Effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,260	6,260	6,260	6,260	6,260	5,978	5,978	2,844	2,844
R^2	0.26	0.51	0.63	0.65	0.71	0.19	0.43	0.12	0.33

[a] Q denotes the price of floor space. EmpR denotes employment by residence. EmpW denotes employment by workplace. CBD1–CBD6 are six 500 m distance grid cells for distance from the pre-war CBD. Inner Boundary 1–6 are six 500 m grid cells for distance to the Inner Boundary between East and West Berlin. Outer Boundary 1–6 are six 500 m grid cells for distance to the outer boundary between West Berlin and East Germany. Kudamm 1–6 are six 500 m grid cells for distance to Breitscheid Platz on the Kurfürstendamm. The coefficients on the other distance grid cells are reported in Table A.2 of the Technical Data Appendix. Block characteristics include the log distance to schools, parks and water, the land area of the block, the share of the block's built-up area destroyed during the Second World War, indicators for residential, commercial and industrial land use, and indicators for whether a block includes a government building and urban regeneration policies post-reunification. Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors in parentheses (Conley (1999)). * significant at 10%; ** significant at 5%; *** significant at 1%.

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Reduced form evidence

TABLE II

BASELINE REUNIFICATION DIFFERENCE-IN-DIFFERENCE RESULTS (1986–2006)[a]

	(1) $\Delta \ln Q$	(2) $\Delta \ln Q$	(3) $\Delta \ln Q$	(4) $\Delta \ln Q$	(5) $\Delta \ln Q$	(6) $\Delta \ln$ EmpR	(7) $\Delta \ln$ EmpR	(8) $\Delta \ln$ EmpW	(9) $\Delta \ln$ EmpW
CBD 1	0.398***	0.408***	0.368***	0.369***	0.281***	1.079***	1.025***	1.574***	1.249**
	(0.105)	(0.090)	(0.083)	(0.081)	(0.088)	(0.307)	(0.297)	(0.479)	(0.517)
CBD 2	0.290***	0.289***	0.257***	0.258***	0.191**	0.589*	0.538*	0.684**	0.457
	(0.111)	(0.096)	(0.090)	(0.088)	(0.087)	(0.315)	(0.299)	(0.326)	(0.334)
CBD 3	0.122***	0.120***	0.110***	0.115***	0.063**	0.340*	0.305*	0.326	0.158
	(0.037)	(0.033)	(0.032)	(0.032)	(0.028)	(0.180)	(0.158)	(0.216)	(0.239)
CBD 4	0.033***	0.031	0.030	0.034	0.017	0.110	0.034	0.336**	0.261
	(0.013)	(0.023)	(0.022)	(0.021)	(0.020)	(0.068)	(0.066)	(0.161)	(0.185)
CBD 5	0.025***	0.018	0.020	0.020	0.015	−0.012	−0.056	0.114	0.066
	(0.010)	(0.015)	(0.014)	(0.014)	(0.013)	(0.056)	(0.057)	(0.118)	(0.131)
CBD 6	0.019**	−0.000	−0.000	−0.003	0.005	0.060	0.053	0.049	0.110
	(0.009)	(0.012)	(0.012)	(0.012)	(0.011)	(0.039)	(0.041)	(0.095)	(0.098)
Inner Boundary 1–6			Yes	Yes	Yes		Yes		Yes
Outer Boundary 1–6			Yes	Yes	Yes		Yes		Yes
Kudamm 1–6				Yes	Yes		Yes		Yes
Block Characteristics					Yes		Yes		Yes
District Fixed Effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,050	7,050	7,050	7,050	7,050	6,718	6,718	5,602	5,602
R^2	0.08	0.32	0.34	0.35	0.43	0.04	0.07	0.03	0.06

[a] Q denotes the price of floor space. EmpR denotes employment by residence. EmpW denotes employment by workplace. CBD1–CBD6 are six 500 m distance grid cells for distance from the pre-war CBD. Inner Boundary 1–6 are six 500 m grid cells for distance to the Inner Boundary between East and West Berlin. Outer Boundary 1–6 are six 500 m grid cells for distance to the outer boundary between West Berlin and East Germany. Kudamm 1–6 are six 500 m grid cells for distance to Breitscheid Platz on the Kurfürstendamm. The coefficients on the other distance grid cells are reported in Table A.4 of the Technical Data Appendix. Block characteristics include the log distance to schools, parks and water, the land area of the block, the share of the block's built-up area destroyed during the Second World War, indicators for residential, commercial and industrial land use, and indicators for whether a block includes a government building and urban regeneration policies post-reunification. Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors in parentheses (Conley (1999)). * significant at 10%; ** significant at 5%; *** significant at 1%.

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Model

Assumptions:

- Open city.
- In the agricultural area utility is $\bar{U}$.
- The city is in discrete space, and there are S blocks indexed by $i = 1, \ldots, S$
- There is L_i floor space in every block, and these blocks can be assigned to residential or commercial usage.
- θ_i is the endogenous fraction of every block that is dedicated to commercial use.
- The city produces a single numeraire good that is costlessly traded.
- The blocks are connected, and there are H (endogenous) workers that can freely move within the city.

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Model: Workers

$$U_{ijo} = \frac{B_i}{d_{ij}} \left(\frac{c_{ijo}}{\beta} \right)^{\beta} \left(\frac{l_{ijo}}{1-\beta} \right)^{(1-\beta)} z_{ijo} \tag{1}$$

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Model: Workers

$$z_{ijo} \sim Frechet \tag{2}$$

$$F(z_{ijo}) = exp(-T_i E_j z_{ijo}^{-\epsilon}) \tag{3}$$

with

- $T_i > 0$ scale parameter determines the average utility derived from living in block i
- $E_j > 0$ scale parameter determines the average utility derived from working in block j
- the shape parameter $\epsilon > 1$ controls the dispersion of idiosyncratic utility.

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Model: Workers choice

- After observing her realizations for idiosyncratic utility for each pair of residence and employment blocks,
- each worker chooses where to live and work to maximize her utility, taking as given residential amenities, goods prices, factor prices, and the location decisions of other workers and firms.
- The indirect utility

$$V_{ijo} = \frac{B_i}{d_{ij}} \left(\frac{w_j}{Q_i^{(1-\beta)}} \right) z_{ijo} \tag{4}$$

- Therefore, workers sort across pairs of residence and employment blocks depending on their idiosyncratic preferences and the characteristics of these locations

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Model: Workers choice

- Since z_{ijo} is Frechet, then V_{ijo} is also Frechet

$$\Phi_{ij} = T_i E_j \left(d_{ij} Q_i^{(1-\beta)} \right)^{-\epsilon} \left(B_i w_j \right)^{\epsilon} \tag{5}$$

- The individuals will choose to live in i and work in j with some probability, which is the probability of $V_{ijo} = max_{r,s} V_{rso}$

$$\pi_{ij} = \frac{\Phi_{ij}}{\sum_{r=1}^{S} \sum_{s=1}^{S} \Phi_{ij}} = \frac{\Phi_{ij}}{\Phi} \tag{6}$$

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Model: Workers choice

- This completely characterizes the solution of the household's problem and the spatial distribution of households.
- We can now find the fraction of people who reside in i,

$$\pi_{Rj} = \sum_j \pi_{ij} \tag{7}$$

- The fraction of people who work in j,

$$\pi_{Mj} = \sum_i \pi_{ij} \tag{8}$$

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Model: Workers choice

- The probability of working on a particular place j conditional on living in i is

$$\pi_{ij|i} = \frac{\pi_{ij}}{\sum_s \pi_{is}} \tag{9}$$

- Adding up then requires that the workers in each place j, H_{Mj} , equal the sum of the residents in each place, H_{Ri}, times the probability that they work in j:

$$H_{Mj} = \sum_i \pi_{ij|i} H_{Ri} \tag{10}$$

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Model: Firm choice

- Firms are assumed to have CRS Cobb-Douglas production functions over workers H_{Mj} and commercially-used land L_{Mj} , for which they pay wages w_j and rents q_j :

$$y_j = A_j H_{Mj}^{\alpha} L_{Mj} 1 - \alpha \tag{11}$$

From the first-order conditions of the firm's problem:

$$H_{Mj} = \left(\frac{\alpha A_j}{w_j} \right)^{\frac{1}{1-\alpha}} \tag{12}$$

$$q_j = (1-\alpha) \left(\frac{\alpha}{w_j} \right)^{\frac{\alpha}{1-\alpha}} A_j^{\frac{1}{1-\alpha}} \tag{13}$$

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Model:Land Markets

- Floor space is supplied proportionally to land K at each location

$$L_i = \phi_i K_i^{1-\mu} \tag{14}$$

- The expected demand of land from each individual (l_i):

$$E[l_i]H_{Ri} = (1-\beta)\frac{E(w_s|i)H_{Ri}}{Q_i} = (1-\theta)L_i \tag{15}$$

- Residential land market clearing implies that the demand for residential floor space equals the supply of floor space allocated to residential use in each location

An equilibrium here requires:

- Firms maximize profits and choose optimal locations
- Households maximize utility and choose optimal locations
- Land markets clear
- Labor markets clear

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Model: Equilibrium and agglomeration

- To model agglomeration, Ahlfeldt et al. (2015) make residential and workplace amenities depend on the density of employment and residency:

$$B_i = b_i \left(\sum_s e^{-\rho \tau_{js}} \left(\frac{H_{Ms}}{K_s} \right) \right)^{\eta} \tag{16}$$

$$A_i = a_j \left(\sum_s e^{-\delta \tau_{js}} \left(\frac{H_{Ms}}{K_s} \right) \right)^{\lambda} \tag{17}$$

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Structural Estimation

Assumed Parameter		Source	Value
Residential land	$1-\beta$	Morris-Davis (2008)	0.25
Commercial land	$1-\alpha$	Valentinyi-Herrendorf (2008)	0.20
Fréchet Scale	T	(normalization)	1
Expected Utility	$\bar{u}$	(normalization)	1000

Estimated Parameter	
Production externalities elasticity	λ
Production externalities decay	δ
Residential externalities elasticity	η
Residential externalities decay	ρ
Commuting semi-elasticity	$\nu = \epsilon\kappa$
Commuting heterogeneity	ϵ

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Structural Estimation

TABLE V

GENERALIZED METHOD OF MOMENTS (GMM) ESTIMATION RESULTS[a]

	(1) Division Efficient GMM	(2) Reunification Efficient GMM	(3) Division and Reunification Efficient GMM
Commuting Travel Time Elasticity ($\kappa\varepsilon$)	0.0951***	0.1011***	0.0987***
	(0.0016)	(0.0016)	(0.0016)
Commuting Heterogeneity (ε)	6.6190***	6.7620***	6.6941***
	(0.0939)	(0.1005)	(0.0934)
Productivity Elasticity (λ)	0.0793***	0.0496***	0.0710***
	(0.0064)	(0.0079)	(0.0054)
Productivity Decay (δ)	0.3585***	0.9246***	0.3617***
	(0.1030)	(0.3525)	(0.0782)
Residential Elasticity (η)	0.1548***	0.0757**	0.1553***
	(0.0092)	(0.0313)	(0.0083)
Residential Decay (ρ)	0.9094***	0.5531	0.7595***
	(0.2968)	(0.3979)	(0.1741)

[a]Generalized Method of Moments (GMM) estimates. Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors in parentheses (Conley (1999)). * significant at 10%; ** significant at 5%; *** significant at 1%.

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Structural Estimation

TABLE VI

EXTERNALITIES AND COMMUTING COSTS[a]

	(1) Production Externalities $(1 \times e^{-\delta\tau})$	(2) Residential Externalities $(1 \times e^{-\rho\tau})$	(3) Utility After Commuting $(1 \times e^{-\kappa\tau})$
0 minutes	1.000	1.000	1.000
1 minute	0.696	0.468	0.985
2 minutes	0.485	0.219	0.971
3 minutes	0.338	0.102	0.957
5 minutes	0.164	0.022	0.929
7 minutes	0.079	0.005	0.902
10 minutes	0.027	0.001	0.863
15 minutes	0.004	0.000	0.802
20 minutes	0.001	0.000	0.745
30 minutes	0.000	0.000	0.642

[a]Proportional reduction in production and residential externalities with travel time and proportional reduction in utility from commuting with travel time. Travel time is measured in minutes. Results are based on the pooled efficient GMM parameter estimates: $\delta = 0.3617$, $\rho = 0.7595$, $\kappa = 0.0148$.

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Counterfactuals

TABLE VII

COUNTERFACTUALS[a]

	(1) $\Delta \ln QC$ 1936–1986	(2) $\Delta \ln QC$ 1936–1986	(3) $\Delta \ln QC$ 1936–1986	(4) $\Delta \ln QC$ 1936–1986
CBD 1	−0.836***	−0.613***	−0.467***	−0.821***
	(0.052)	(0.032)	(0.060)	(0.051)
CBD 2	−0.560***	−0.397***	−0.364***	−0.624***
	(0.034)	(0.025)	(0.019)	(0.029)
CBD 3	−0.455***	−0.312***	−0.336***	−0.530***
	(0.036)	(0.030)	(0.030)	(0.036)
CBD 4	−0.423***	−0.284***	−0.340***	−0.517***
	(0.026)	(0.019)	(0.022)	(0.031)
CBD 5	−0.418***	−0.265***	−0.351***	−0.512***
	(0.032)	(0.022)	(0.027)	(0.039)
CBD 6	−0.349***	−0.222***	−0.304***	−0.430***
	(0.025)	(0.016)	(0.022)	(0.029)
Counterfactuals	Yes	Yes	Yes	Yes
Agglomeration Effects	Yes	Yes	Yes	Yes
Observations	6,260	6,260	6,260	6,260
R^2	0.11	0.13	0.07	0.13