International Trade and Macro:
Economic geography ARSW: (2015)

Question

- Can we identify agglomeration forces from exogenous characteristics?
- Big idea: Use exogenous change in geography (the Berlin Wall) to measure agglomeration.

Model overview

- Agents choose to live in Berlin or somewhere else
- Berlin is a set of “blocks” indexed by i
- Blocks have heterogenous productivity and residential amenities
- Each block can be used for residential and commercial space (endogenous)
- Workers choose which block to live and which to work (w/commuing costs)
- Firms choose which block to produce

- One homogenous good. Focus is on endogenous distribution of work AND residence

Households

- Utility of household o living in i and working in j

$$U_{ijo} = \frac{B_i z_{ijo}}{d_{ij}} \left(\frac{c_{ij}}{\beta}\right)^{\beta} \left(\frac{\ell_{ij}}{1-\beta}\right)^{1-\beta}, \qquad 0 < \beta < 1$$

  - Consumption (c_{ij}), with $p_i = 1$
  - Residential floor space (ℓ_{ij}), price Q_i
  - Residential amenity B_i
  - Commuting costs d_{ij}
  - Idiosyncratic shock z_{ijo}
  - Wage w_j
- The idiosyncratic shock is Frechet:

$$F(z_{ijo}) = e^{-T_i E_j z_{ijo}^{-\epsilon}}, \qquad T_i, E_j > 0, \ \epsilon > 1$$

Indirect utility and commuting time

- Indirect utility

$$U_{ijo} = \frac{z_{ijo} B_i w_j Q_i^{\beta-1}}{d_{ij}}$$

- Commuting cost

$$d_{ij} = \exp(\kappa \tau_{ij})$$

  - τ_{ij} commuting time

- Because *d* enters multiplicative, it is as if commuting reduces labor supply

Masses of workers and firms

- Probability who live in i and work in j (Frechet tricks, see Eaton and Kortum (2002))

$$\pi_{ij} = \frac{T_i E_j \left(d_{ij} Q_i^{1-\beta}\right)^{-\epsilon} \left(B_i w_j\right)^{\epsilon}}{\sum_{r=1}^{S} \sum_{s=1}^{S} T_r E_s \left(d_{rs} Q_r^{1-\beta}\right)^{-\epsilon} \left(B_r w_s\right)^{\epsilon}} \equiv \frac{\Phi_{ij}}{\Phi} \tag{1}$$

- Probability who live in i

$$\pi_{Ri} = \sum_{j=1}^{S} \pi_{ij} = \frac{\sum_{j=1}^{S} \Phi_{ij}}{\Phi} \tag{2}$$

- Probability who work in j

$$\pi_{Mj} = \sum_{i=1}^{S} \pi_{ij} = \frac{\sum_{i=1}^{S} \Phi_{ij}}{\Phi} \tag{3}$$

Commuting gravity equation

- Conditional on living in block i, probability you work in j

$$\pi_{ij|i} = \frac{\pi_{ij}}{\pi_{Ri}} = \frac{\Phi_{ij}}{\sum_{s=1}^{S} \Phi_{is}} = \frac{E_j \left(w_j/d_{ij}\right)^{\epsilon}}{\sum_{s=1}^{S} E_s \left(w_s/d_{is}\right)^{\epsilon}},$$

- Depends on wages in location j, commuting cost to j and wages and commuting costs to all other blocks
- ϵ controls the sensitivity to wages/commuting

Total workers in a block

- H_{mj} is mass of workers in j, H_{Ri} is mass of households in i
- $H_{mj} = \sum_i$[pr(i works in j) $\times$ mass of people in i]

$$H_{Mj} = \sum_{i=1}^{S} \frac{E_j \left(w_j/d_{ij}\right)^{\epsilon}}{\sum_{s=1}^{S} E_s \left(w_s/d_{is}\right)^{\epsilon}} H_{Ri}$$

Free entry and spillovers

- Household does not see $z_{ij\omega}$ before choosing to live in city (free entry)
- Expected indirect utility equals the outside option

$$\mathbb{E}[U] = \gamma \left[\sum_{r=1}^{S} \sum_{s=1}^{S} T_r E_s \left(d_{rs} Q_r^{1-\beta} \right)^{-\epsilon} (B_r w_s)^{\epsilon} \right]^{1/\epsilon} = \bar{U}, \tag{4}$$

- Amenities have an exogenous and endogenous part

$$B_i = b_i \Omega_i^{\eta}, \qquad \Omega_i = \sum_{r=1}^{S} e^{-\rho \tau_{ir}} \left(\frac{H_{Rr}}{K_r} \right)$$

- K_r is land in r; H_R/K is residential density

Production

- Perfect competition, constant returns to scale

$$y_j = A_j \left(H_{Mj}\right)^{\alpha} \left(L_{Mj}\right)^{1-\alpha}, \qquad 0 < \alpha < 1$$

- H_{Mj} = employment
- L_{Mj} = floor space used in prodcution
- Productivity as an exogenous and endogenous part

$$A_j = a_j \Upsilon_j^{\lambda}, \qquad \Upsilon_j = \sum_{s=1}^{S} e^{-\delta \tau_{is}} \left(\frac{H_{Ms}}{K_s}\right)$$

Land prices

- θ is share of land used in production; *q* is price of land

$$\begin{aligned} \theta_i = 1 \quad \text{if} \qquad q_i > \xi_i Q_i, \\ \theta_i \in [0,1] \quad \text{if} \qquad q_i = \xi_i Q_i, \\ \theta_i = 0 \quad \text{if} \qquad q_i < \xi_i Q_i. \end{aligned} \tag{5}$$

- $\xi_i \geq 1$ taxes on land use
- Observed land prices are max of production vs. residential $\mathbb{Q}_i = \max\{q_i, Q_i\}$

Land supply

- Floor space L uses geographic land K and capital M as inputs

$$L_i = \varphi_i K_i^{1-\mu}, \qquad \varphi_i = M_i^{\mu},$$

- Density of development (φ_i) from land market clearing:

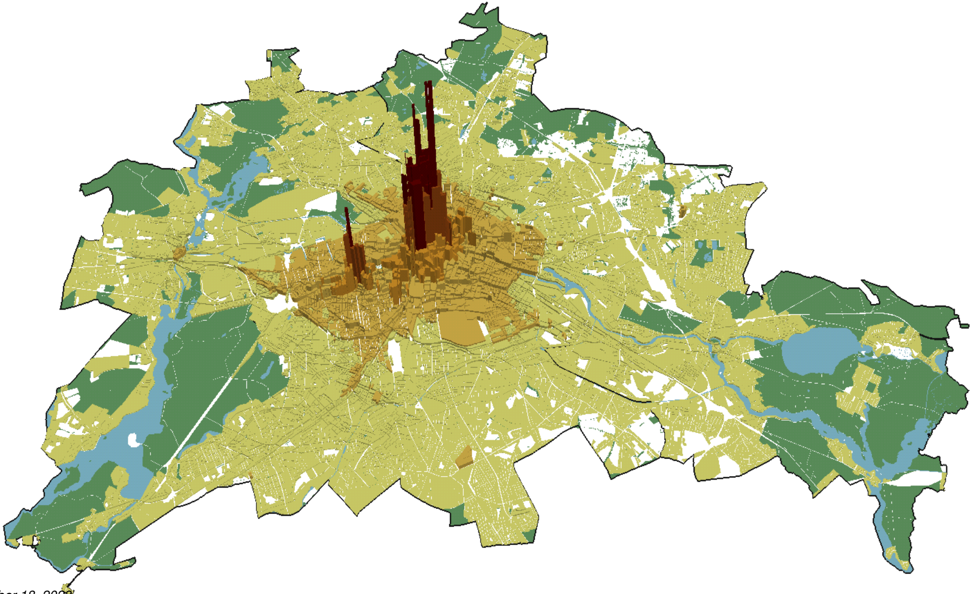
$$\varphi_i = \frac{L_i}{K_i^{1-\mu}} = \frac{(1-\theta_i)L_i + \theta_i L_i}{K_i^{1-\mu}}$$

Berlin

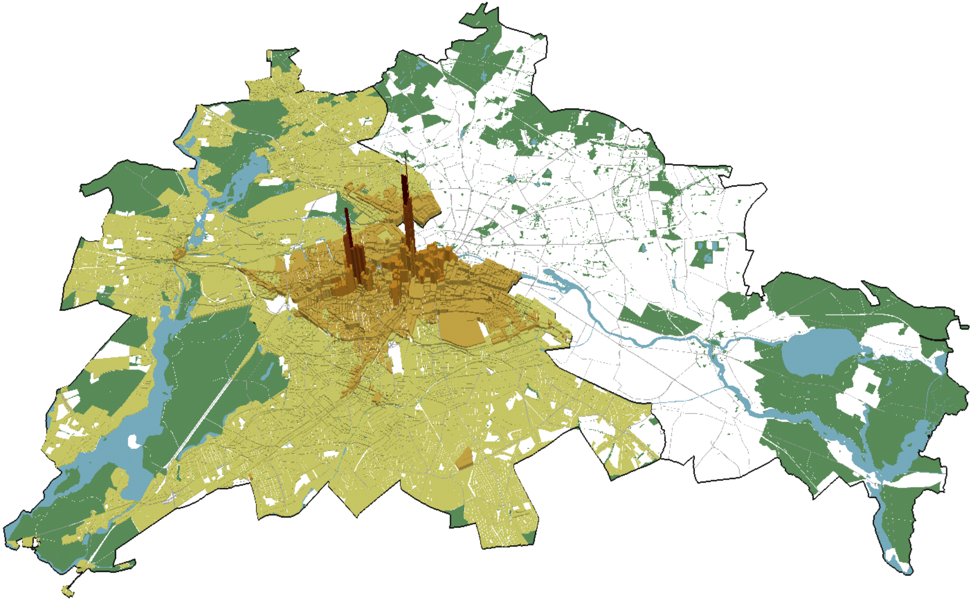
- Focus on West Berlin since it was always market-based
- The Berlin wall is: no trade in final good + κ, δ, $\rho \to \infty$
- Division affects
  - Loss of employment opportunities in E Berlin
  - Loss of commuters from E Berlin
  - Loss of production externalities from E Berlin
  - Loss of residential amenities externalities from E Berlin
- Expect these to matter more for places close to the original CBD
- Utility falls, people move out; wages and floor prices change to get to new equilibrium
- Reunification does not reverse this; spillovers may lead to multiple equilibria

Land prices Berlin 1936

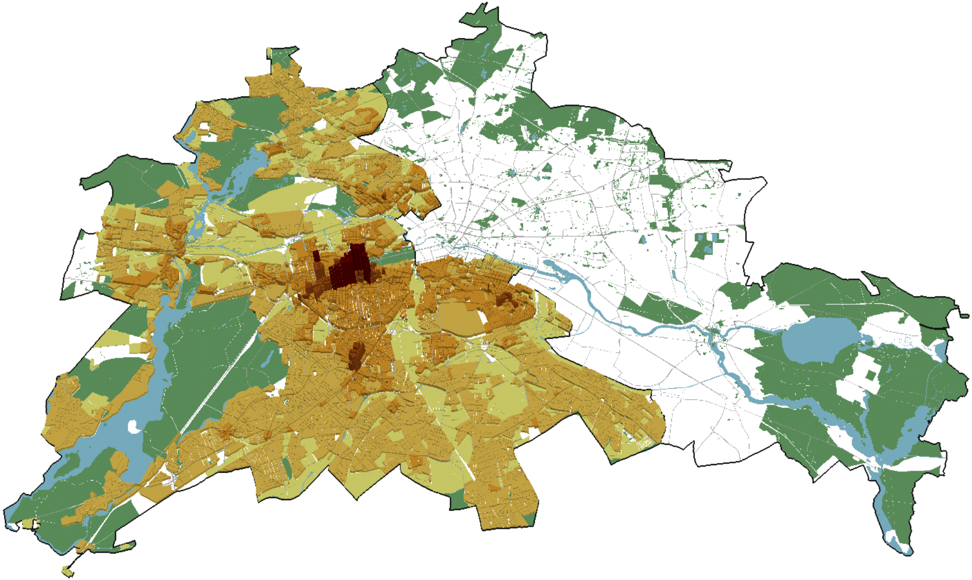
Land prices are normalized to have a mean of 1 in each year.



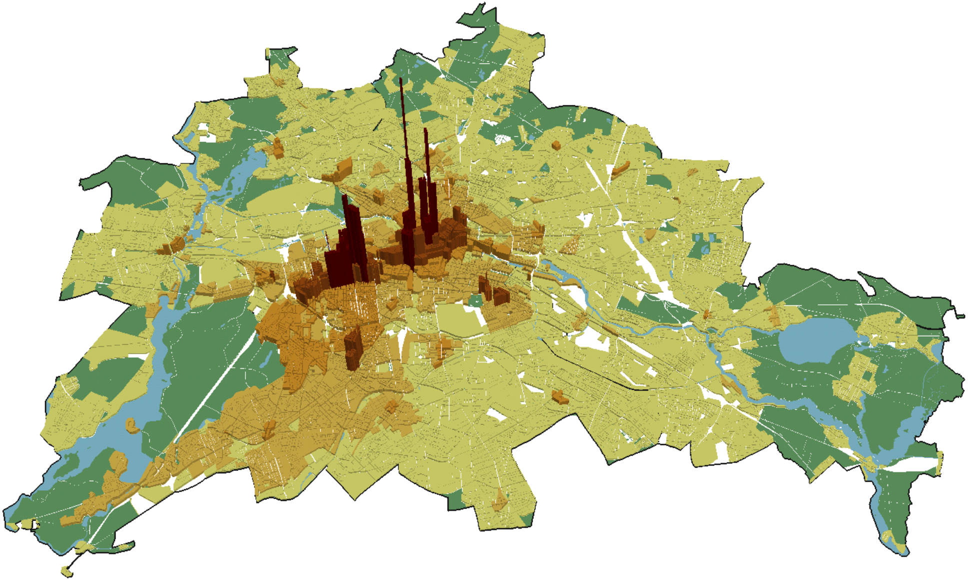
Land prices West Berlin 1936



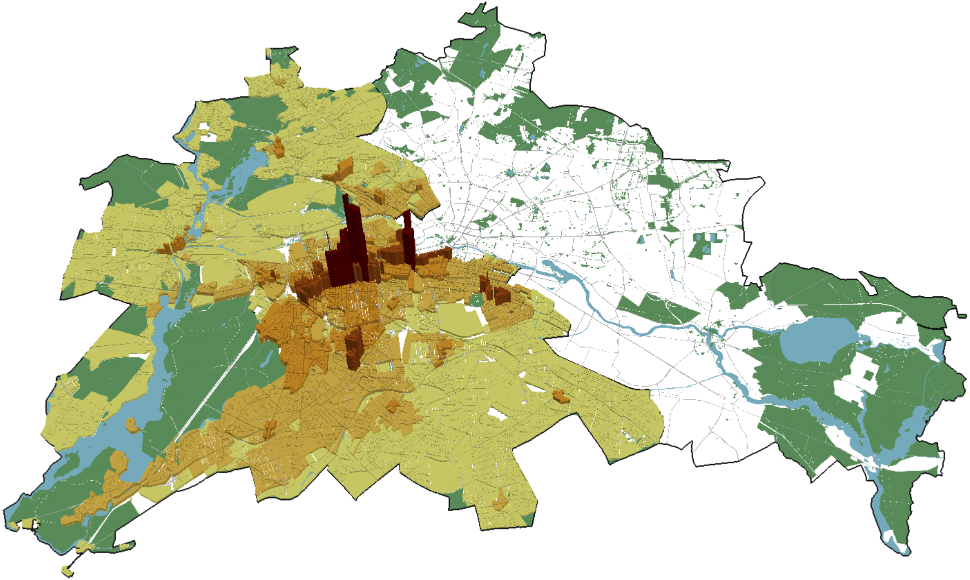
Land prices West Berlin 1986



Land prices Berlin 2006



Land prices West Berlin 2006



Reduced form evidence

$$\triangle \ln Q_i = \psi + \sum_{k=1}^{K} I_{ik}\beta_k + \ln X_i\zeta + \chi_i$$

- I_{ik} dummy equal one if block i lies within distance grid cell k from the pre-war CBD
- Observable block characteristics (X_i): Land area, land use, distance to nearest U-Bahn station, S-Bahn station, school, lake, river or canal, and park, war destruction, government buildings and urban regeneration programs

West Berlin 1936-86 division

	(1) Δ ln Q	(2) Δ ln Q	(3) Δ ln Q	(4) Δ ln Q	(5) Δ ln Q	(6) Δ ln EmpR	(7) Δ ln EmpR	(8) Δ ln EmpW	(9) Δ ln 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	6260	6260	6260	6260	6260	5978	5978	2844	2844
R-squared	0.26	0.51	0.63	0.65	0.71	0.19	0.43	0.12	0.33

Note: Q denotes the price of floor space. EmpR denotes employment by residence. EmpW denotes employment by workplace. CBD1-CBD6 are six 500m distance grid cells for distance from the pre-war CBD. Inner Boundary 1-6 are six 500m grid cells for distance to the Inner Boundary between East and West Berlin. Outer Boundary 1-6 are six 500m grid cells for distance to the outer boundary between West Berlin and East Germany. Kudamm 1-6 are six 500m grid cells for distance to Breitscheid Platz on the Kurfürstendamm. The coefficients on the other distance grid cells are reported in Table A2 of the web appendix. Block characteristics include the logarithm of 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%.

West Berlin 1986-2006 unification

	(1) Δ ln Q	(2) Δ ln Q	(3) Δ ln Q	(4) Δ ln Q	(5) Δ ln Q	(6) Δ ln EmpR	(7) Δ ln EmpR	(8) Δ ln EmpW	(9) Δ 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)	(0.009)	(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	7050	7050	7050	7050	7050	6718	6718	5602	5602
R-squared	0.08	0.32	0.34	0.35	0.43	0.04	0.07	0.03	0.06

Note: Q denotes the price of floor space. EmpR denotes employment by residence. EmpW denotes employment by workplace. CBD1-CBD6 are six 500m distance grid cells for distance from the pre-war CBD. Inner Boundary 1-6 are six 500m grid cells for distance to the Inner Boundary between East and West Berlin. Outer Boundary 1-6 are six 500m grid cells for distance to the outer boundary between West Berlin and East Germany. Kudamm 1-6 are six 500m grid cells for distance to Breitscheid Platz on the Kurfürstendamm. The coefficients on the other distance grid cells are reported in Table A4 of the web appendix. Block characteristics include the logarithm of 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%.

Model without spillovers

- Turn off spillovers; unique equilibrium
- Can back out exogenous amenities, productivities
- Simulate division and unification
  - Solve the model before division, after division, unification
  - Run the DiD regressions from before
- Does not fit data very well

No spillovers

TABLE IV

PRODUCTIVITY, AMENITIES, AND COUNTERFACTUAL FLOOR PRICES[a]

	(1) $\Delta \ln A$ 1936–1986	(2) $\Delta \ln B$ 1936–1986	(3) $\Delta \ln A$ 1986–2006	(4) $\Delta \ln B$ 1986–2006	(5) $\Delta \ln QC$ 1936–1986	(6) $\Delta \ln QC$ 1986–2006
CBD 1	−0.207***	−0.347***	0.261***	0.203***	−0.408***	−0.010
	(0.049)	(0.070)	(0.073)	(0.054)	(0.038)	(0.020)
CBD 2	−0.260***	−0.242***	0.144**	0.109*	−0.348***	0.079**
	(0.032)	(0.053)	(0.056)	(0.058)	(0.017)	(0.036)
CBD 3	−0.138***	−0.262***	0.077***	0.059**	−0.353***	0.036
	(0.021)	(0.037)	(0.024)	(0.026)	(0.022)	(0.031)
CBD 4	−0.131***	−0.154***	0.057***	0.010	−0.378***	0.093***
	(0.016)	(0.023)	(0.015)	(0.008)	(0.021)	(0.026)
CBD 5	−0.095***	−0.126***	0.028**	−0.014*	−0.380***	0.115***
	(0.014)	(0.013)	(0.013)	(0.007)	(0.022)	(0.033)
CBD 6	−0.061***	−0.117***	0.023**	0.001	−0.354***	0.066***
	(0.015)	(0.015)	(0.010)	(0.005)	(0.018)	(0.023)
Counterfactuals					Yes	Yes
Agglomeration Effects					No	No
Observations	2,844	5,978	5,602	6,718	6,260	7,050
R^2	0.09	0.06	0.02	0.03	0.07	0.03

Structural estimation with spillovers

- Estimate the agglomeration effects (unlike in AA 2014)

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

Amenities and productivities with spillovers

- Adjusted productivity: $\tilde{a}_i = a_i E_i^{\alpha/\epsilon}$
- Adjusted productivity: $\tilde{b}_i = b_i T_i^{1/\epsilon} \xi_{Ri}^{1-\beta}$
- The model implies

$$\Delta \ln\left(\frac{\tilde{a}_{it}}{\bar{a}_t}\right) = (1-\alpha)\Delta \ln\left(\frac{\mathbb{Q}_{it}}{\bar{\mathbb{Q}}_t}\right) + \frac{\alpha}{\epsilon}\Delta \ln\left(\frac{\omega_{it}}{\bar{\omega}_t}\right) - \lambda \Delta \ln\left(\frac{\Upsilon_{it}}{\bar{\Upsilon}_t}\right)$$

$$\Delta \ln\left(\frac{\tilde{b}_{it}}{\bar{b}_t}\right) = \frac{1}{\epsilon}\Delta \ln\left(\frac{H_{Rit}}{\bar{H}_{Rt}}\right) + (1-\beta)\Delta \ln\left(\frac{\mathbb{Q}_{it}}{\bar{\mathbb{Q}}_t}\right) + \frac{1}{\epsilon}\Delta \ln\left(\frac{W_{it}}{\bar{W}_t}\right) - \eta \Delta \ln\left(\frac{\Omega_{it}}{\bar{\Omega}_t}\right)$$

- Where Δ is before/after unification or division
- The RHS stuff is all functions of observables and model parameters
- The “bar” variables are geometric averages

Identification

- The division or unification is the exogenous variation
- Changes in adjusted fundamentals uncorrelated with exogenous change in surrounding economic activity from division/reunification

$$\mathbb{E}\left[\mathbb{I}_k \times \triangle \ln\left(\tilde{a}_{it}/\bar{a}_t\right)\right] = 0, \qquad k \in \{1, \ldots, K_{\mathbb{I}}\},$$

$$\mathbb{E}\left[\mathbb{I}_k \times \triangle \ln\left(\tilde{b}_{it}/\bar{b}_t\right)\right] = 0, \qquad k \in \{1, \ldots, K_{\mathbb{I}}\}.$$

  where $\mathbb{I}_k$ are indicators for distance grid cells from pre-war CBD

- "Requires that systematic changes in the gradient of activity relative to pre-war is explained by the model mechanisms rather than systematic changes in the pattern of structural residuals"

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)

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

Counterfactuals

TABLE VII

COUNTERFACTUALS[a]

	(1) Δ ln QC 1936–1986	(2) Δ ln QC 1936–1986	(3) Δ ln QC 1936–1986	(4) Δ ln QC 1936–1986	(5) Δ ln QC 1986–2006	(6) Δ ln QC 1986–2006	(7) Δ ln QC 1986–2006
CBD 1	−0.836***	−0.613***	−0.467***	−0.821***	0.363***	1.160***	0.392***
	(0.052)	(0.032)	(0.060)	(0.051)	(0.041)	(0.052)	(0.043)
CBD 2	−0.560***	−0.397***	−0.364***	−0.624***	0.239***	0.779***	0.244***
	(0.034)	(0.025)	(0.019)	(0.029)	(0.028)	(0.044)	(0.027)
CBD 3	−0.455***	−0.312***	−0.336***	−0.530***	0.163***	0.594***	0.179***
	(0.036)	(0.030)	(0.030)	(0.036)	(0.031)	(0.045)	(0.031)
CBD 4	−0.423***	−0.284***	−0.340***	−0.517***	0.140***	0.445***	0.143***
	(0.026)	(0.019)	(0.022)	(0.031)	(0.021)	(0.042)	(0.021)
CBD 5	−0.418***	−0.265***	−0.351***	−0.512***	0.177***	0.403***	0.180***
	(0.032)	(0.022)	(0.027)	(0.039)	(0.032)	(0.038)	(0.032)
CBD 6	−0.349***	−0.222***	−0.304***	−0.430***	0.100***	0.334***	0.103***
	(0.025)	(0.016)	(0.022)	(0.029)	(0.024)	(0.034)	(0.023)
Counterfactuals	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agglomeration Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,260	6,260	6,260	6,260	7,050	6,260	7,050
R^2	0.11	0.13	0.07	0.13	0.12	0.24	0.13