Econ 8601:

Spillovers: "Economics of Density: Evidence from the Berlin Wall"

- Background about spillovers (literature)
  - lots of regressions...
  - IV/RD type approaches (say Greenstone, Hornbeck, Morreti
- Structural approach. This paper
- Background about structural models of cities (Monocentric model, Lucas and Rossi-Hansberg)

- Background about Berlin

Model

- City in a larger economy, individuals get reservation utility of $\bar{U}$.

- City consists of blocks, indexed by $i = 1, ..S$ and L_i is land area
  - θ_i share commercial
  - $1 - \theta_i$ share residential

- Single final good costless traded

- $\bar{H}$ exogenous stock of workers, perfectly mobile

Workers

- Risk neutral. Worker ω living at i and working at j gets

$$C_i(c_{ij\omega}, \ell_{ij\omega}) = B_i c_{ij\omega}^{\beta} \ell_{ij\omega}^{1-\beta},\ 0 < \beta < 1$$

  where

  – $B_i \geq 0$ is residential amenity (exogenous characteristic)

  – $c_{ij\omega}$ consumption of final good

  – $\ell_{ij\omega}$ consumption of land

- Workers pick a location, than pick a place to work, after drawing productivy $v_{ij\omega}$

$$v_{ij\omega} = \frac{z_{ij\omega} w_j}{d_{ij}}$$

where $d_{ij} = e^{\kappa \tau_{ij}}$ is iceberg factor

- Worker are drawn from the Frechet

$$F(z_{ij\omega}) = e^{-T z_{ij\omega}^{-\varepsilon}},\ T > 0,\ \varepsilon > 1$$

for scale parameter T and shape parameter ε. (Note WLOG can assume constant T across locations, because will have another force that allow exogenous productivity

- Income net of commuting costs for workers in block i working in block j is also Frechet

$$G_{ij}(v_{ij}) = e^{-T v_{ij}^{-\varepsilon} d_{ij}^{-\varepsilon} w_j^{\varepsilon}},\ T > 0,\ \varepsilon > 1$$

- Next look at maximum. This has Frechet too, given by

$$G_i(v_i) = e^{-\Phi_i v_i^{-\varepsilon}}$$

for

$$\Phi_i = \sum_{s=1}^{S} T \left(\frac{w_s}{d_{is}} \right)^{\varepsilon}$$

- Combining bilateral and multilateral distributions of income, the probably a worker commutes between blocks i and j (π_{ij}) exhibits the following gravity equation relationship

$$\pi_{ij} = \frac{\left(\frac{w_j}{d_{ij}} \right)^{\varepsilon}}{\sum_{s=1}^{S} T \left(\frac{w_s}{d_{is}} \right)^{\varepsilon}}, \; d_{ij} = e^{\kappa \tau_{ij}}$$

ratio of “Bilateral resistance” to “multilateral resistance”

- Measure of workers employed at location j is

$$H_{M_j} = \sum_{i=1}^{S} \frac{\left(\frac{w_j}{d_{ij}}\right)^{\varepsilon}}{\sum_{s=1}^{S} T\left(\frac{w_s}{d_{is}}\right)^{\varepsilon}} H_{R_i}$$

- Suppose have data on workplace employment H_{M_j}, residence employment H_{R_i} and bilateral traval times τ_{ij}. Can solve for the wages

- Ex ante decision making. Return to choosing location i is

$$E[U_i] = \beta^{\beta}(1-\beta)Q_i^{\beta-1}B_i\bar{v}_i = \bar{U}$$

where

  – Q_i is residential land price

– $\bar{v}_i$ is expected worker income net of commuting costs

$$\bar{v}_i = \Gamma\left(\frac{\varepsilon - 1}{\varepsilon}\right)\left[\sum_{s=1}^{S} T\left(\frac{w_s}{d_{is}}\right)^{\varepsilon}\right]^{\frac{1}{\varepsilon}}$$

where Γ() is the gamma funaction.

- Ammenities include location fundmental, and also population

$$B_i = b_i \Omega_i^{\eta},\ \Omega_i \equiv \sum_{s=1}^{S} e^{-\rho\tau_{js}}\left(\frac{H_{R_s}}{K_s}\right),\ \eta \geq 0,\ \rho \geq 0$$

where K_s is geographical land area.

Production

- Production is Cobb-Douglas

$$X_j = A_j \left(\widetilde{H_{M_j}}\right)^{\alpha} \left(\theta_j L_j\right)^{1-\alpha},$$

where A_j is final goods productivity: $\widetilde{H_{M_j}}$ denotes effective employment

- Equilibrium commercial land prices equal marginal product (plus zero profit condition)

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

- Market clearing condition

$$w_j \widetilde{H_{M_j}} = \sum_{i=1}^{S} \frac{\left(w_j/d_{ij}\right)^{\varepsilon}}{\left[\sum_{s=1}^{S} (w_s/d_{is})^{\varepsilon}\right]} \bar{v}_i H_{R_i}$$

where

$$A_j = \Upsilon_j^{\lambda} a_j \;\; \Upsilon_j \equiv \sum_{s=1}^{S} e^{-\rho\tau_{js}} \left(\frac{\widetilde{H_{M_j}}}{K_s}\right), \; \lambda \geq 0, \; \delta \geq 0$$

Land Market Clearing

- Total demand for residental land equals effect supply of land allocated to residentual use $(1-\lambda_i)\,L_i$, or

$$E[\ell_i]H_{R_i} = \bar{v}_i\,(1-\beta)\,\frac{H_{R_i}}{Q_i} = (1-\theta_i)\,L_i$$

- Commerical land market clearing

$$\widetilde{H_{M_j}}\left(\frac{w_j}{\alpha A_j}\right)^{\frac{1}{1-\alpha}} = \theta_j L_j$$

-

$$(1-\theta_i)\,L_i + \theta_i L_i = L_i = \varphi_i K_i$$

where φ_i is density of development

General Equilibrium

- Normalization $p_i = 1$ for all i, Let $\{w_i, Q_i, q_i\}$ be wages and land prices each location

- $\left\{H_{M_i}, H_{R_i}, \theta_i\right\}$ workers, residents, share commercial

- Consumers indifferent where to go

- Firms maximize profits, and they are zero

- If $\theta_i \in (0, 1)$, then $Q_i = q_i$.

- Proposition: given $\left\{\alpha, \beta, \lambda, \delta, \kappa, \varepsilon, \eta, \rho, T, \bar{U}\right\}$ and observed data $\left\{Q_i, H_{M_i}, H_{R_i}, K_i, \tau_{ij}\right\}$, there exists unique values of the location fundamental and endogenous variables $\left\{a_i, b_i , \varphi_i, w_i\theta_i, Q_i, q_i\right\}$ for which the observed data are consistent with equilibrium of the model

Solution

- Given parameter vector $\left\{\alpha, \beta, \lambda, \delta, \kappa, \varepsilon, \eta, \rho, T, \bar{U}\right\}$, take data on $\left\{Q_i, H_{M_i}, H_{R_i,} K_i, \tau_{ij}\right\}$ and solve for

$$\{a_i, b_i\ , \varphi_i\}$$

- See identification problem

- But possibility of multiple equilibria is not a problem.

Four Key Channels from Berlin Wall

- Firms in West Berlin cease to benefit from production externalities in East Berlin
  - productivity down, driving down land prices and employment

- Firms in West Berlin loses access to commuters from residential locations in East Berlin
  - reduces land prices and employment

- Residents in West Berlin lose access to employment centers in East Berlin

  - Lowers expected worker income, lowering land prices and residential population

- Residents in West Berlin lose access to residential externalities
  - Lowers expected utlity, lowering land prices and residential population

- All of the above is stronger for locations closer to the wall.

- Mechanisms that restore equilibrium in the model are changes in wages, land prices

- In particular, key qualitative implication is that division leads to a decline in land prices, workplace employment, and residence employment in areas of West Berlin close to the pre-war CBD.

- What happens when wall comes down. Go back to before?
  - What if multiple equilibria?
  - What if shocks are different
  - Still expect qualatively to be good for pre-war CBD

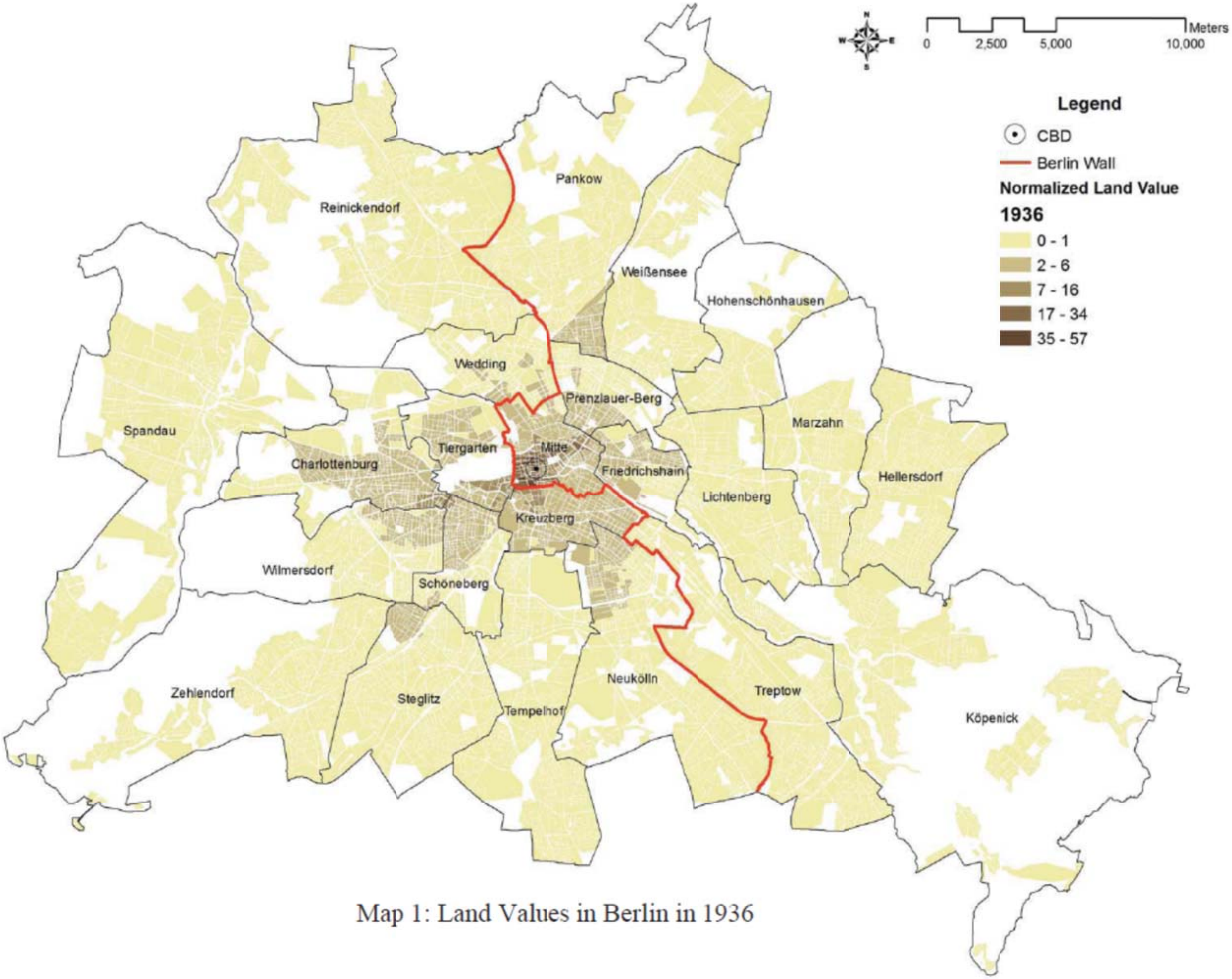
Data

- 15,937 city blocks

- Land price data for 1936, 1986, 2006 (assessed land value of representative undeveloped property) (used to determine property taxes.

- location of residents, location of works

- commuting costs. Calculate travel times (did a lot of work here, take minimum travel time over subway, bus,...)



Map 1: Land Values in Berlin in 1936

Figure 1: Greater Berlin Land Rents 1936

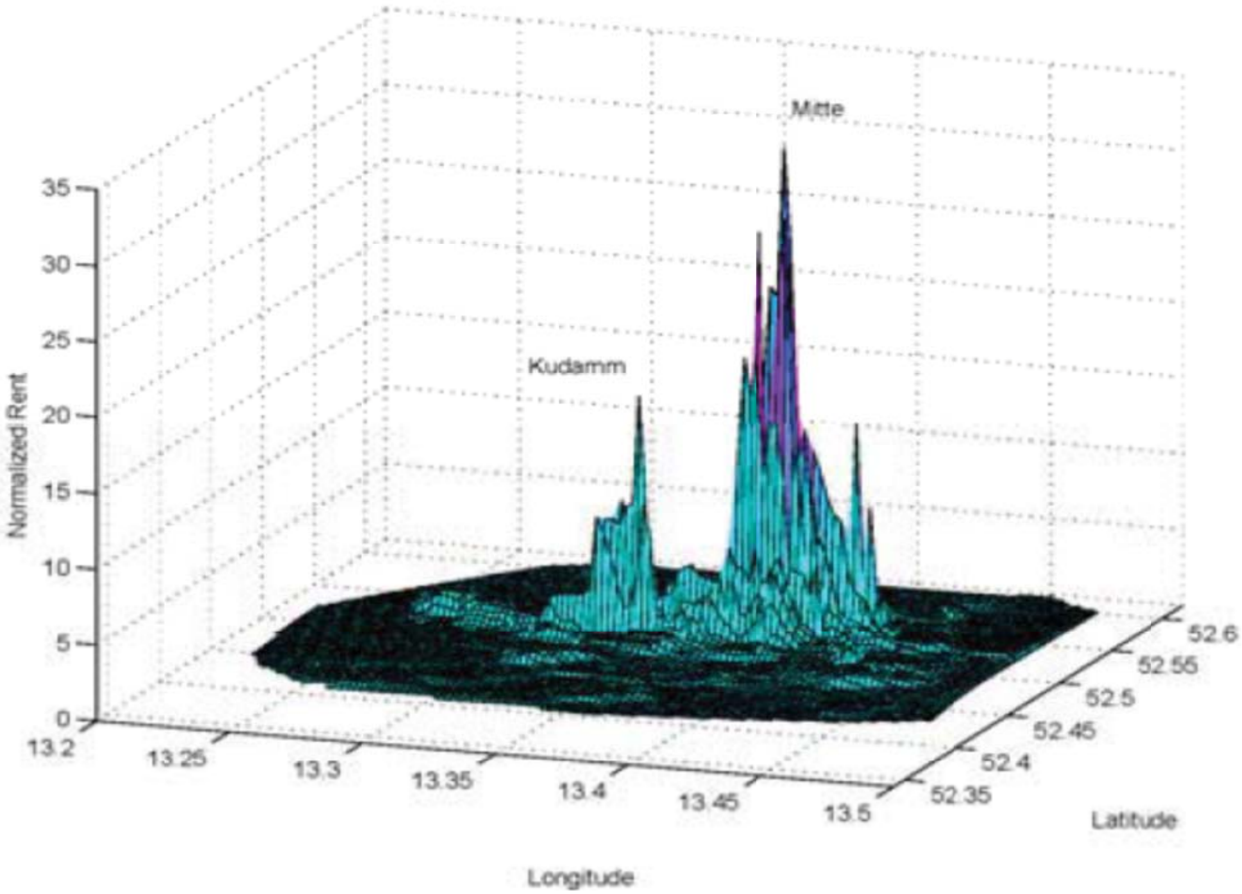


Figure 2: West Berlin Land Rents 1936

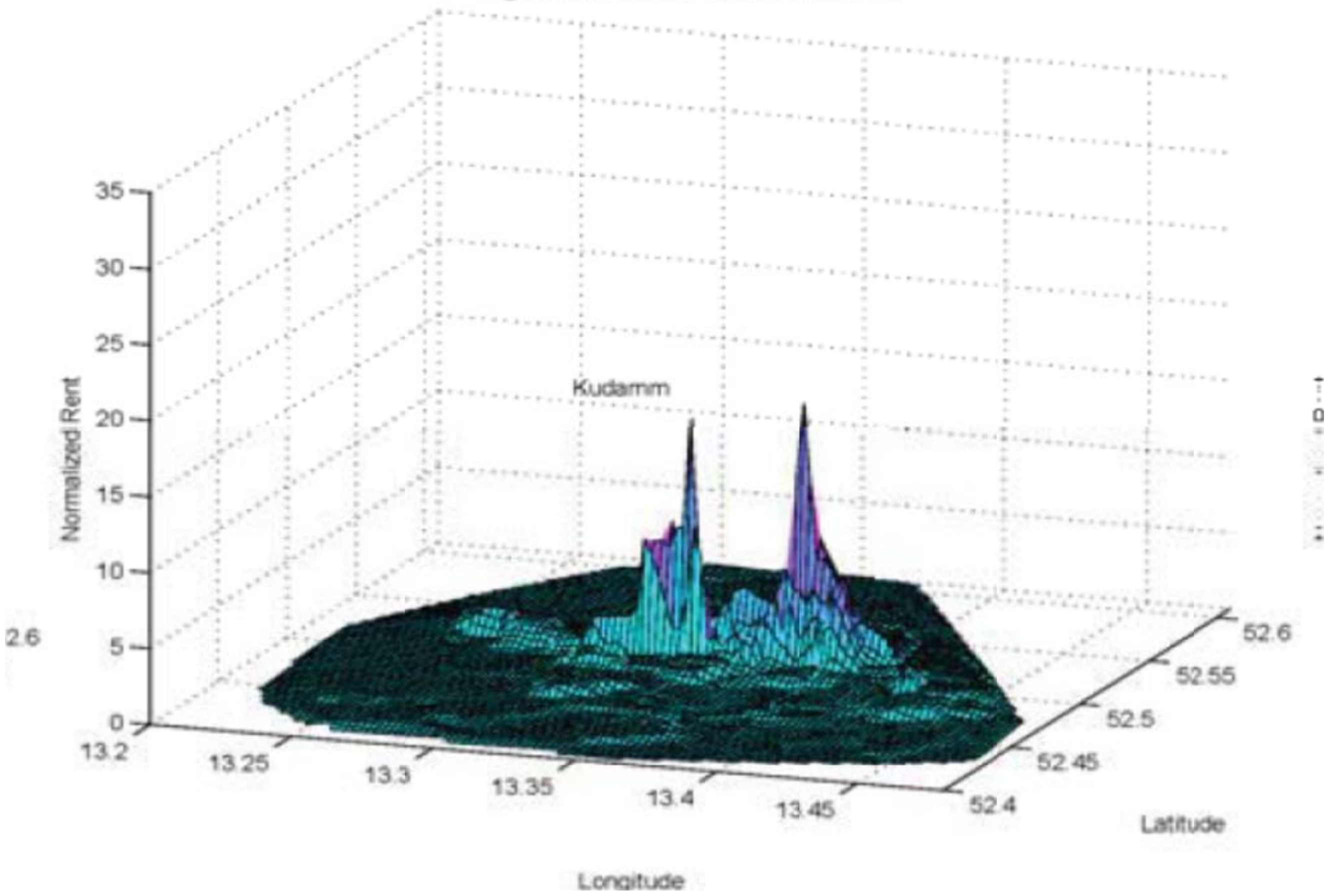
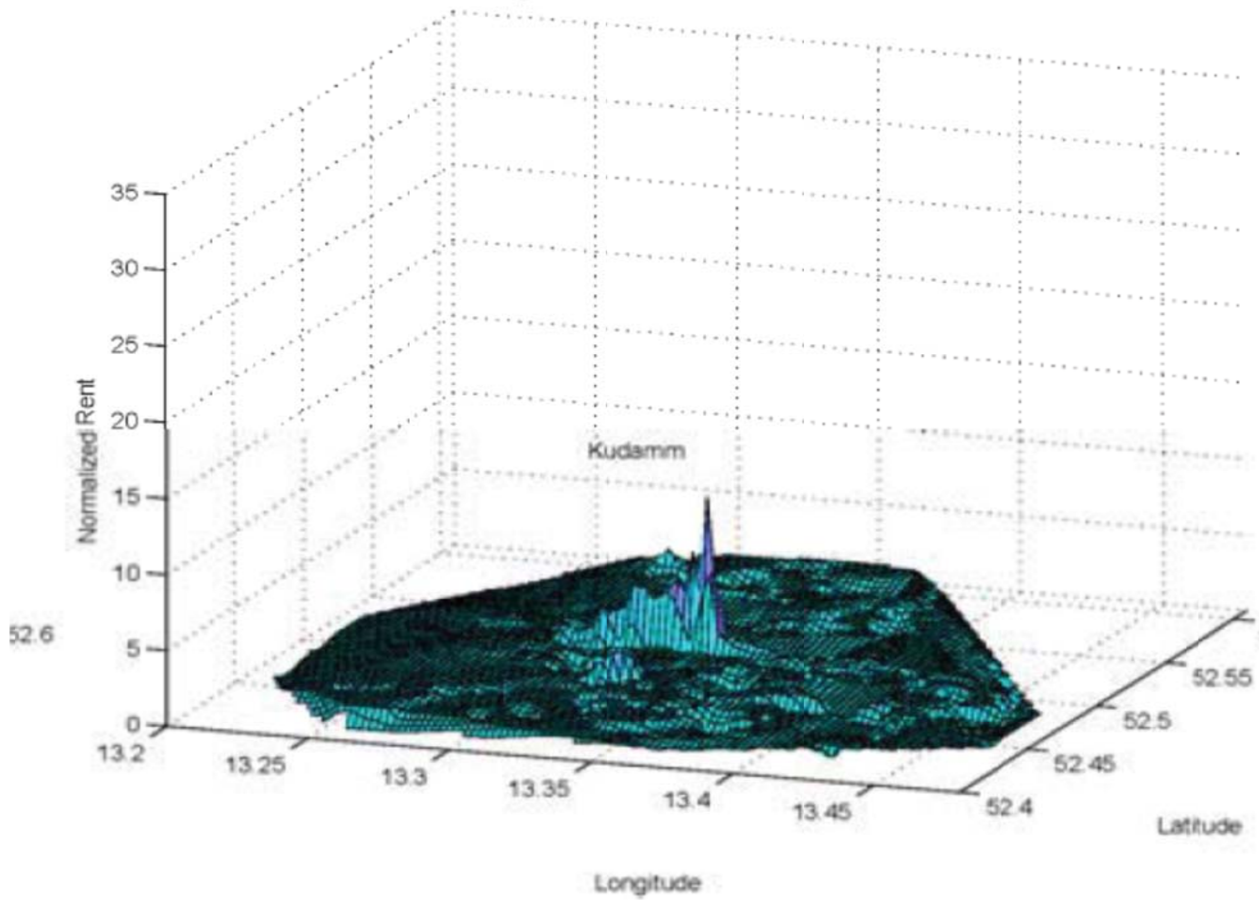


Figure 3: West Berlin Land Rents 1986



Longitude

Figure 5: West Berlin Land Rents 2006

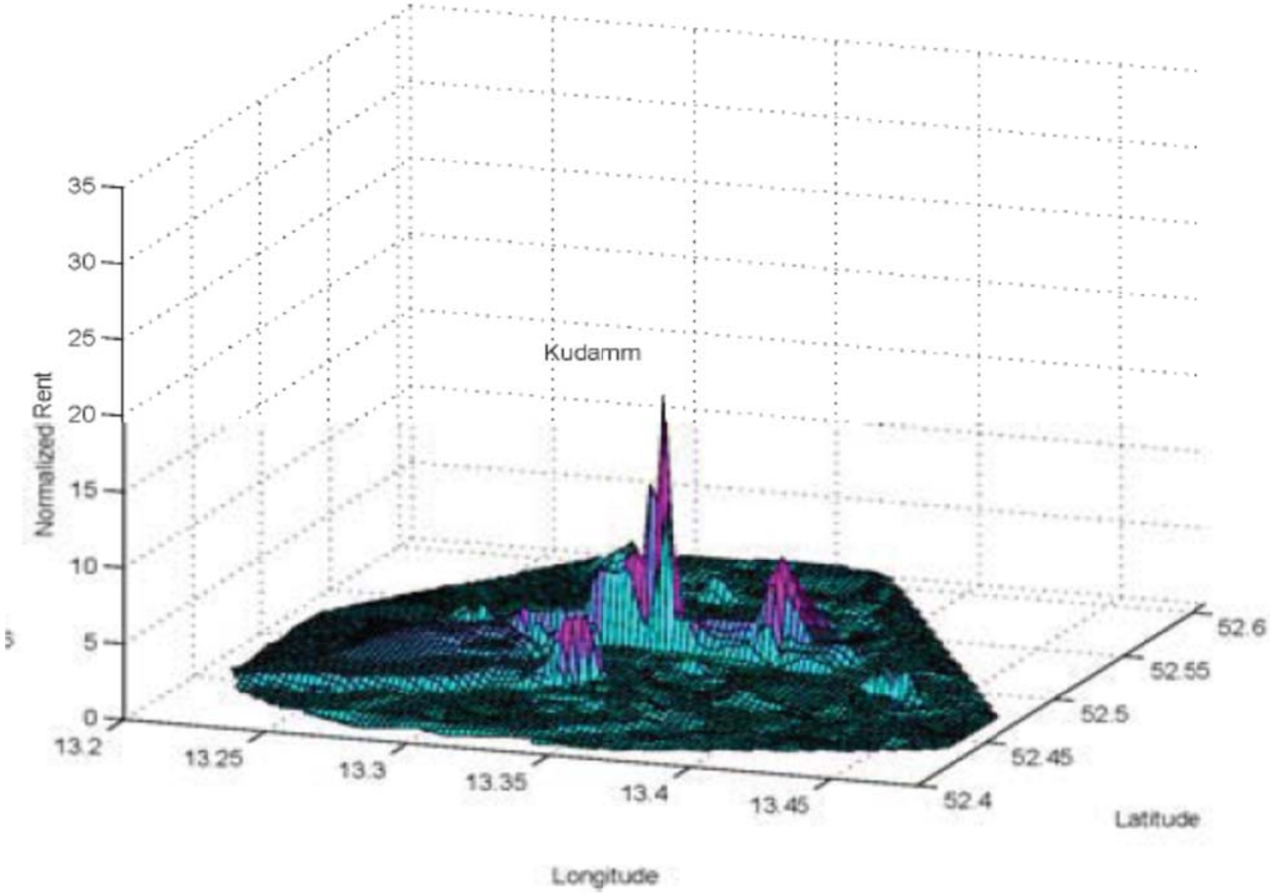
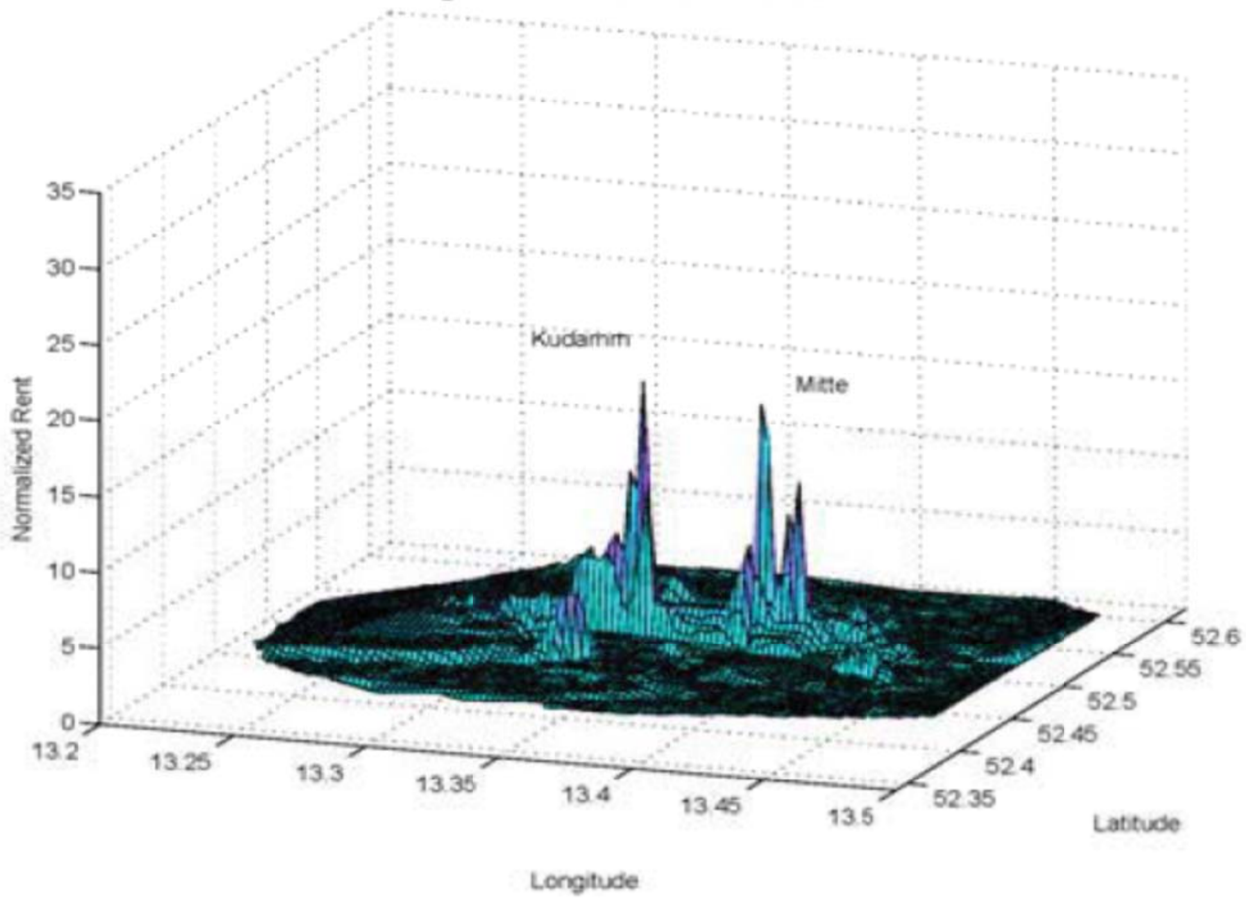


Figure 4: Greater Berlin Land Rents 2006



Difference-in-Difference Estimates

- Reduced form specification

$$\ln O_{it} = \psi_i + f(D_{it}) + \ln M_i \mu_t + \nu_t + u_{it},$$

where i denotes block and t corresponds to time and $O_{it} \in \left\{Q_{it}, H_{M_{it}}, H_{R_{it}}\right\}$

- Taking (long) differences

$$\Delta \ln O_{it} = \tilde{\nu} + \tilde{f}(D_{it}, D_{it-T}) + \ln M_i \tilde{\mu} + \tilde{u}_i,$$

for

$$\begin{aligned}
\tilde{\nu} &= \nu_t - \nu_{t-T} \\
\tilde{f}(D_{it}, D_{it-T}) &= f(D_{it}) - f(D_{it-T}) \\
\tilde{\mu} &= \mu_t - \mu_{t-T} \\
\tilde{u}_i &= u_{it} - u_{it-T}
\end{aligned}$$

- Note estimating this, rather something different

$$\Delta \ln O_{it} = \tilde{\nu} + \sum_{k=1}^{K} d_{ik}\xi_k + \ln M_i\tilde{\mu} + \tilde{u}_i,$$

  where d_{ik} is dummy variable whether lies within a disctance grid cell k from pre-war CBD and ξ_k is coefficient.

- differences in differences

- Look at results (note controls for U-Bahn station, parks, schools, etc, in M_i)

- Point about government policies to promote employment (and government buildings)

- Look at flip side after wall comes back down.
- Placebo exercises to see if this is about trends
- Transport access results.

Table 1: Baseline Division Results (1936-1986)

	(1) Δ ln Land Value	(2) Δ ln Land Value	(3) Δ ln Land Value	(4) Δ ln Land Value	(5) Δ ln Land Value	(6) Δ ln Emp Residence	(7) Δ ln Emp Residence	(8) Δ ln Emp Workplace	(9) Δ ln Emp Workplace
CBD 1	-3.016***	-2.159***	-1.980***	-1.944***	-1.732***	-0.835***	-0.693***	-0.619	-0.381
	(0.529)	(0.449)	(0.441)	(0.447)	(0.368)	(0.164)	(0.215)	(0.471)	(0.452)
CBD 2	-2.411***	-1.559***	-1.441***	-1.377***	-1.158***	-0.423*	-0.338	-1.197***	-1.196***
	(0.388)	(0.345)	(0.332)	(0.327)	(0.281)	(0.217)	(0.246)	(0.339)	(0.292)
CBD 3	-1.619***	-0.791***	-0.708***	-0.644***	-0.476***	-0.812***	-0.634**	-0.341	-0.352
	(0.177)	(0.206)	(0.211)	(0.194)	(0.151)	(0.230)	(0.275)	(0.304)	(0.291)
CBD 4	-1.395***	-0.598***	-0.515***	-0.459***	-0.415***	-0.267*	-0.109	-0.506***	-0.525***
	(0.160)	(0.154)	(0.170)	(0.162)	(0.138)	(0.152)	(0.157)	(0.171)	(0.177)
CBD 5	-1.189***	-0.479***	-0.393**	-0.341**	-0.256**	-0.272*	-0.157	-0.431***	-0.475***
	(0.139)	(0.148)	(0.156)	(0.151)	(0.109)	(0.151)	(0.169)	(0.163)	(0.157)
CBD 6	-0.950***	-0.394***	-0.266**	-0.212*	-0.140	-0.338**	-0.196	-0.259*	-0.345**
	(0.179)	(0.136)	(0.132)	(0.125)	(0.090)	(0.141)	(0.137)	(0.138)	(0.157)
Inner Boundary 1			-0.169	-0.153	0.039		0.028		-0.255
			(0.195)	(0.197)	(0.159)		(0.259)		(0.263)
Inner Boundary 2			-0.044	-0.024	0.123		0.189		0.113
			(0.186)	(0.187)	(0.150)		(0.218)		(0.257)
Outer Boundary 1			0.800***	0.804***	-0.006		1.035***		-1.358***
			(0.139)	(0.138)	(0.130)		(0.203)		(0.380)
Outer Boundary 2			0.855***	0.861***	0.112		1.113***		-0.471**
			(0.129)	(0.129)	(0.123)		(0.147)		(0.234)
Inner Boundry 3-6			Yes	Yes	Yes		Yes		Yes
Outer Boundary 3-6			Yes	Yes	Yes		Yes		Yes
Kudamm 1-6				Yes	Yes		Yes		Yes
Hedonic Controls					Yes				
Further Controls					Yes				
District Fixed Effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7617	7617	7617	7617	7617	5832	5832	2844	2844
R-squared	0.21	0.51	0.66	0.67	0.79	0.18	0.28	0.11	0.14

Table 2: Baseline Reunification Results (1986-2006)

	(1) Δ ln Land Value	(2) Δ ln Land Value	(3) Δ ln Land Value	(4) Δ ln Land Value	(5) Δ ln Land Value	(6) Δ ln Emp Residence	(7) Δ ln Emp Residence	(8) Δ ln Emp Workplace	(9) Δ ln Emp Workplace
CBD 1	1.514**	1.502***	1.425***	1.475***	0.997**	0.758***	0.792***	1.498**	1.482**
	(0.645)	(0.446)	(0.428)	(0.449)	(0.463)	(0.071)	(0.077)	(0.710)	(0.701)
CBD 2	1.110**	1.112***	1.082***	1.167***	0.820***	0.187**	0.187**	0.436	0.397
	(0.480)	(0.338)	(0.319)	(0.338)	(0.276)	(0.072)	(0.075)	(0.290)	(0.298)
CBD 3	0.298	0.331*	0.333*	0.384**	0.300**	0.283	0.271	0.305	0.305
	(0.188)	(0.185)	(0.185)	(0.192)	(0.118)	(0.207)	(0.206)	(0.184)	(0.199)
CBD 4	0.118	0.174	0.212*	0.248**	0.225***	0.070	0.037	0.316*	0.337*
	(0.114)	(0.116)	(0.119)	(0.115)	(0.073)	(0.064)	(0.068)	(0.178)	(0.191)
CBD 5	0.109	0.177*	0.201**	0.214**	0.214***	-0.041	-0.049	0.100	0.105
	(0.104)	(0.096)	(0.097)	(0.092)	(0.057)	(0.061)	(0.060)	(0.130)	(0.144)
CBD 6	0.077	0.072	0.068	0.050	0.088**	0.056*	0.075**	0.049	0.045
	(0.103)	(0.073)	(0.075)	(0.061)	(0.042)	(0.032)	(0.035)	(0.087)	(0.089)
Inner Boundary 1			0.040	0.036	-0.021		-0.061		-0.008
			(0.069)	(0.070)	(0.065)		(0.047)		(0.130)
Inner Boundary 2			-0.058	-0.058	-0.096*		-0.009		0.049
			(0.061)	(0.061)	(0.050)		(0.038)		(0.135)
Outer Boundary 1			-0.181***	-0.181***	-0.144**		0.019		0.106
			(0.044)	(0.044)	(0.066)		(0.034)		(0.086)
Outer Boundary 2			-0.187***	-0.188***	-0.151**		0.001		0.047
			(0.046)	(0.046)	(0.062)		(0.033)		(0.082)
Inner Boundary 3-6			Yes	Yes	Yes		Yes		Yes
Outer Boundary 3-6			Yes	Yes	Yes		Yes		Yes
Kudamm 1-6				Yes	Yes		Yes		Yes
Hedonic Controls					Yes				
Further Controls					Yes				
District Fixed Effects		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8022	8022	8022	8022	8022	6763	6763	5624	5624
R-squared	0.09	0.49	0.51	0.53	0.71	0.02	0.03	0.03	0.03

Figure 6: Long Differenced Rents and Transport Access 1936-86

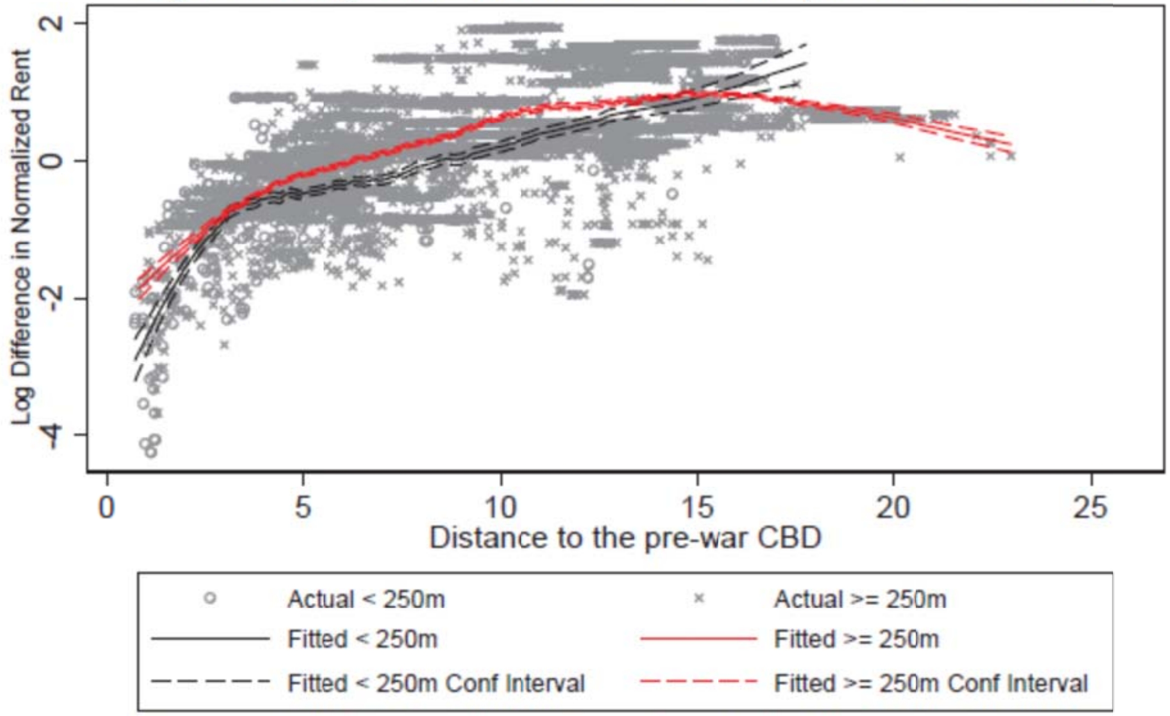
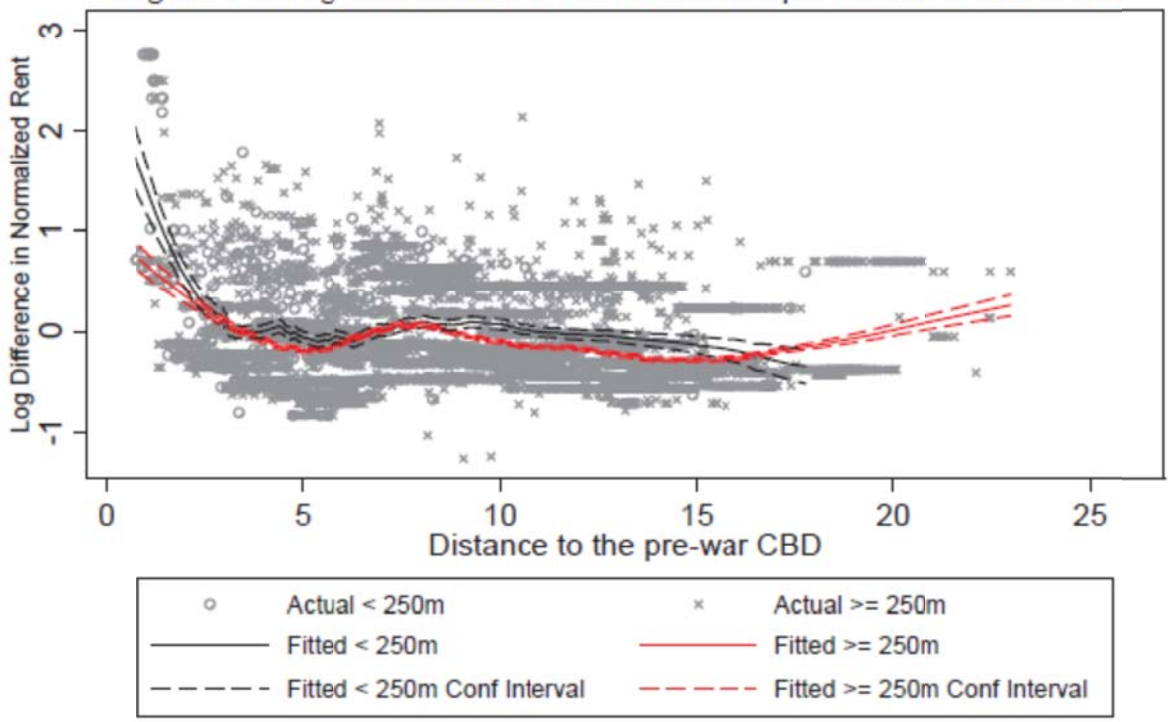


Figure 7: Long Differenced Rents and Transport Access 1986-2006



Note: Rents are normalized to have a mean of one in each year before taking the long difference.
Solid lines are fitted values based on locally-weighted linear least squares. Separate fitted values estimated for blocks within and beyond 250 metres of U-Bahn or S-Bahn station in 1936. Dashed lines are pointwise confidence intervals.

Structural Estimation

- $\{a_i, b_i, \varphi_i\}$ uniquely determined from $\left\{Q_i, H_{M_i}, H_{R_i}, K_i, \tau_{ij}\right\}$ and given values of $\left\{\alpha, \beta, \lambda, \delta, \kappa, \varepsilon, \eta, \rho, T, \bar{U}\right\}$

- Normalize $\bar{U} = 1000$ and $T = 1$

- From literature

  - residential land share $(1 - \beta) = .25$

  - commerical land share $(1 - \alpha) = .20$

- $\{\lambda, \delta, \kappa, \varepsilon, \eta, \rho\}$ Leaves six parameters to estimate by GMM

Moment Conditions

- Solve out for $\{a_i, b_i, \varphi_i\}$

- From population mobility

$$E[U_i] = \beta^{\beta}(1-\beta)Q_i^{\beta-1}B_i\bar{v}_i = \bar{U}$$

and

$$B_i = b_i\Omega_i^{\eta},\ \Omega_i \equiv \sum_{s=1}^{S} e^{-\rho\tau_{js}}\left(\frac{H_{R_s}}{K_s}\right),\ \eta \geq 0,\ \rho \geq 0$$

get

$$\ln b_{it} = (1-\beta)\ln Q_{it} + \ln \bar{U} - \beta \ln \beta - (1-\beta)\ln \beta - \ln \bar{v}_{it} - \eta \ln \Omega_{it}$$

where

  - land prices Q_{it} observed

- expected worker income depends upon wages w_{it}
- Wages a function of H_{Mit}, H_{Rit}, and τ_{it}
- Ω_{it} a function of τ_{ij}

From Firm Side

- Zero profits

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

and

$$A_j = \Upsilon_j^{\lambda} a_j \;\; \Upsilon_j \equiv \sum_{s=1}^{S} e^{-\rho\tau_{js}} \left(\frac{\widetilde{H_{M_j}}}{K_s}\right), \; \lambda \geq 0, \; \delta \geq 0$$

Can write

$$\ln a_{it} = (1-\alpha)\ln Q_{it} - (1-\alpha)\ln(1-\alpha) - \alpha \ln\left(\frac{\alpha}{w_{it}}\right) - \lambda \ln \Upsilon_{it}$$

where

  - prices Q_{it} observed

- Wages a function of H_{Mit}, H_{Rit}, and τ_{it}
- Υ_{it} a function of τ_{ij} K_i,$\widetilde{H_{M_j}}$

Last Piece

- Pulls these together: Residential Demand

$$E[\ell_i]H_{R_i} = \bar{v}_i\,(1-\beta)\,\frac{H_{R_i}}{Q_i} = (1-\theta_i)\,L_i$$

- Commerical land market clearing

$$\widetilde{H_{M_j}}\left(\frac{w_j}{\alpha A_j}\right)^{\frac{1}{1-\alpha}} = \theta_j L_j$$

- Total and market

$$(1-\theta_i)\,L_i + \theta_i L_i = L_i = \varphi_i K_i$$

- To get

$$\ln \varphi_i = \ln \left[\left(\frac{w_j}{\alpha A_j} \right)^{\frac{1}{1-\alpha}} + \bar{v}_i \left(1 - \beta\right) \frac{H_{R_i}}{Q_i} \right] - \ln K_i$$

- Note need a fixed point in wages for 15,937 blocks. (involving 254 million bilateral commuting flows)

- Write time varying residential and location fundamentals as

$$\begin{aligned} \ln b_{it} &= \ln b_{F_i} + \ln b_{V_{it}} \\ \ln a_{it} &= \ln a_{F_i} + \ln a_{V_{it}} \end{aligned}$$

Using above get

$$\begin{aligned} \Delta \ln b_{Vit} &= (1-\beta)\, \Delta \ln Q_{it} - \Delta \ln \bar{v}_{it} - \eta \Delta \ln \Omega_{it} \\ \Delta \ln a_{Vit} &= (1-\alpha)\, \Delta \ln Q_{it} - \alpha \Delta \ln w_{it} - \lambda \Delta \ln \Upsilon_{it} \end{aligned}$$

- Changes in residential fundamentals $\Delta \ln b_{Vit}$ and production fundamentals $\Delta \ln a_{Vit}$ will not vary systematically within West Berlin

- Specifically

$$\Delta \ln b_{Vit} \text{ distributed } i.i.d.(\mu_b, \sigma_b^2)$$

$$\Delta \ln b_{Vit} \text{ distributed } i.i.d.(\mu_b, \sigma_b^2)$$

Form moments

- $$\begin{aligned}
\left[\omega' \Delta \ln b_{Vt}\right] - \left[\frac{1}{N} I' \Delta \ln b_{Vt}\right] &= 0 \\
\left[\omega' \Delta \ln a_{Vt}\right] - \left[\frac{1}{N} I' \Delta \ln a_{Vt}\right] &= 0 \\
\left[\omega' \left(\Delta \ln b_{Vt} - \frac{1}{N} I' \Delta \ln b_{Vt}\right)^2\right] - \left[\frac{1}{N} I' \left(\Delta \ln b_{Vt} - \frac{1}{N} I' \Delta \ln b_{Vt}\right)^2\right] &= 0 \\
\left[\omega' \left(\Delta \ln a_{Vt} - \frac{1}{N} I' \Delta \ln a_{Vt}\right)^2\right] - \left[\frac{1}{N} I' \left(\Delta \ln a_{Vt} - \frac{1}{N} I' \Delta \ln a_{Vt}\right)^2\right] &= 0
\end{aligned}$$

  where pick three sets of weights: (1) distance to pre-war CBD, (2) distance to inner boundary, (3) distance to outer boundary

Thinking about identification

- $\{\eta, \rho\}$ identified from spatial distribution of changes in land prices relative to changes in residence

$$\Delta \ln b_{Vit} = (1 - \beta)\, \Delta \ln Q_{it} - \Delta \ln \bar{v}_{it} - \eta \Delta \ln \Omega_{it}$$

- $\{\lambda, \delta\}$ identified from spatial distribution of changes in land prices relative to changes in workplace employment

$$\Delta \ln a_{Vit} = (1 - \alpha)\, \Delta \ln Q_{it} - \alpha \Delta \ln w_{it} - \lambda \Delta \ln \Upsilon_{it}$$

- More complicated argument for $\{\kappa, \varepsilon\}$ "identified from spatial distribution of changes in land prices relative to the joint spatial distribution of changes in workplace employment and residence.

Let's just look at the paper.