

Lecture 6: Adding Commuting to Urban and Regional Models

Economics 552

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- Economic activity is highly unevenly distributed across space:
 - The existence of cities (e.g. 19 cities worldwide had a population greater than 10 million in 2007)
 - Concentrations of economic functions within cities (e.g. advertising agencies in mid-town Manhattan)
- A key research objective is determining the strength of agglomeration and dispersion forces
 - Agglomeration: increasing returns
 - Dispersion: land scarcity and commuting costs
- Determining the magnitude of these forces is central to a host of economic and policy issues:
 - Productivity advantages of cities
 - Cost-benefit analyzes of transport infrastructure
 - Effects of property taxation and regional policy

Empirical Challenges

- Economic activities often cluster together because of shared locational fundamentals
 - What are the roles of agglomeration/dispersion forces versus shared natural advantages?
 - Historical natural advantages can have long-lived effects through for example sunk costs or coordination effects
- One approach regresses productivity, wages or employment on the density of economic activity
 - Third variables can affect both productivity and wages and density
 - Difficult to find instruments that only affect productivity or wages through density (with a few exceptions)
- Little evidence on the spatial scale of agglomeration forces or separating them from congestion forces
- Difficult to find sources of exogenous variation in the surrounding concentration of economic activity

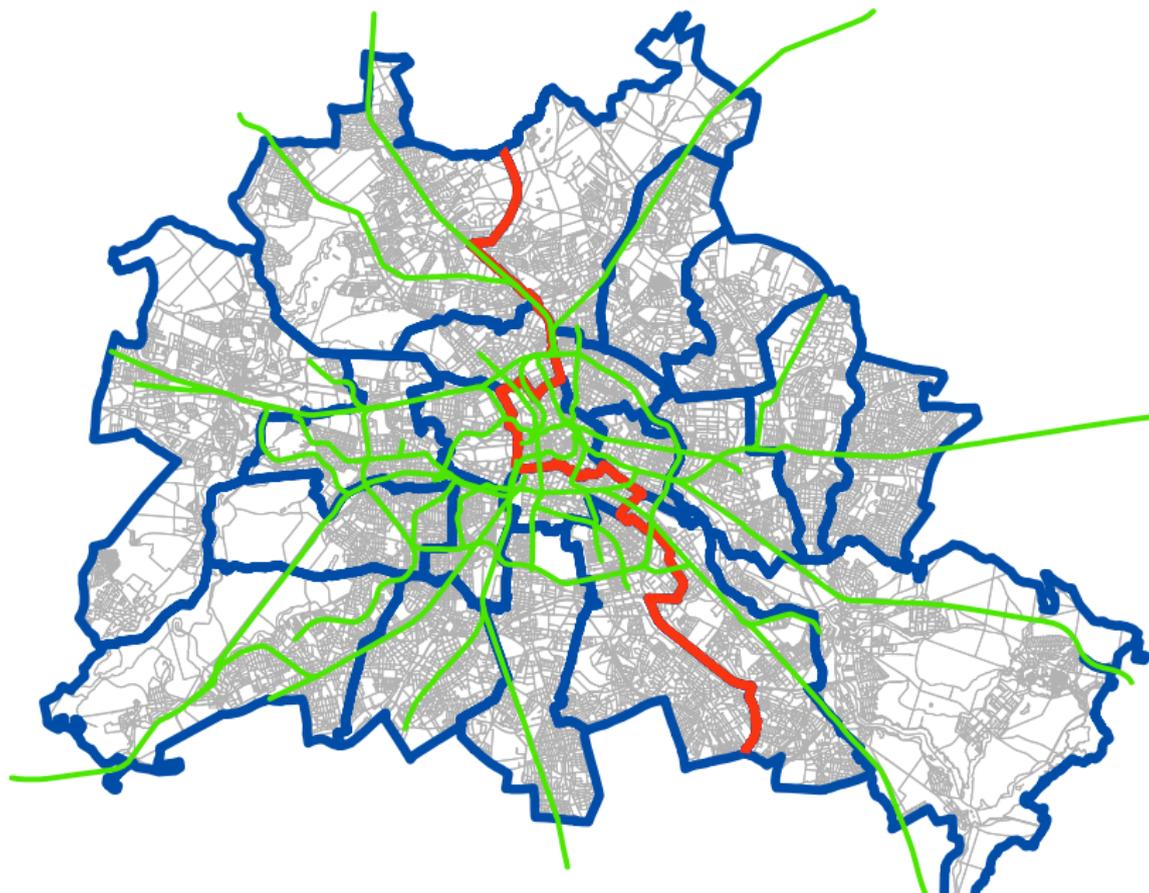
This Paper

- They develop a quantitative model of city structure to determine agglomeration and dispersion forces, while also allowing empirically-relevant variation in:
 - Production locational fundamentals
 - Residential locational fundamentals
 - Transportation infrastructure
- They combine the model with data for thousands of city blocks in Berlin in 1936, 1986 and 2006 on:
 - Land prices
 - Workplace employment
 - Residence employment
- They use the division of Berlin in the aftermath of the Second World War and its reunification in 1989 as a source of exogenous variation in the surrounding concentration of economic activity

Historical Background

- A protocol signed during the Second World War organized Germany into American, British, French and Soviet occupation **zones**
- Although 200km within the Soviet zone, Berlin was to be jointly occupied and organized into four occupation **sectors**:
 - Boundaries followed pre-war district boundaries, with the same East-West orientation as the occupation zones, and created sectors of roughly equal pre-war population (prior to French sector)
 - Protocol envisioned a joint city administration (“Kommandatura”)
- Following the onset of the Cold War
 - East and West Germany founded as separate states and separate city governments created in East and West Berlin in 1949
 - The adoption of Soviet-style policies of command and control in East Berlin limited economic interactions with West Berlin
 - To stop civilians leaving for West Germany, the East German authorities constructed the Berlin Wall in 1961

The Division of Berlin



Theoretical Framework

- We build on the urban model of Lucas and Rossi-Hansberg (2002), which has a number of attractive features
 - Models city structure in continuous two-dimensional space
 - Does not impose mono-centricity
 - But considers a symmetric circular city
- We develop an empirically-tractable version of this model
 - Model the city as a large number of discrete blocks
 - Allow for differences in production fundamentals, residential fundamentals and transport connections across blocks
 - As a result the model allows for a rich asymmetric distribution of economic activity within the city
- The model remains tractable because of heterogeneity in workers' commuting decisions, modeled following Eaton and Kortum (2002)
- The model provides a quantitative framework that can also be used for analyzing other interventions (e.g. transport network)

Model Setup

- We consider a city embedded within a larger economy, which provides a reservation level of utility (\bar{U})
- The city consists of a set of discrete blocks indexed by i , with supply of floor space depending on the density of development (φ_i)
- There is a single final good which is costlessly traded and is chosen as the numeraire
- Markets are perfectly competitive
- Workers choose a block of residence, a block of employment, and consumption of the final good and floor space to max utility
- Firms choose a block of production and inputs of labor and floor space to max profits
- Floor space within each block optimally allocated between residential and commercial use
- Productivity depends on fundamentals (a_i) & spillovers (Y_i)
- Amenities depend on fundamentals (b_i) & spillovers (Ω_i)
- Workers face commuting costs

Consumption

- Utility for worker ω residing in block i and working in block j :

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

- Consumption of the final good (c_{ij}), chosen as numeraire ($p_i = 1$)
 - Residential floor space (ℓ_{ij})
 - Residential amenity B_i
 - Commuting costs d_{ij}
 - Idiosyncratic shock $z_{ij\omega}$ that captures idiosyncratic reasons for a worker living in block i and working in block j
- Indirect utility

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

- The idiosyncratic shock to worker productivity is drawn from a Fréchet distribution:

$$F(z_{ij\omega}) = e^{-T_i E_j z_{ij\omega}^{-\epsilon}}, \quad T_i, E_j > 0, \quad \epsilon > 1,$$

Commuting Decisions

- Probability worker chooses to live in block i and work in block j is:

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

- Residential and workplace choice probabilities

$$\pi_{Ri} = \sum_{j=1}^S \pi_{ij} = \frac{\sum_{j=1}^S \Phi_{ij}}{\Phi}, \quad \pi_{Mj} = \sum_{i=1}^S \pi_{ij} = \frac{\sum_{i=1}^S \Phi_{ij}}{\Phi}.$$

- Conditional on living in block i , the probability that a worker commutes to block j follows a gravity equation:

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

Commuting Market Clearing

- In the model, workplace employment in block j equals the sum across all blocks i of residence employment times the probability of commuting from i to j :

$$H_{Mj} = \sum_{i=1}^S \frac{(w_j / d_{ij})^\epsilon}{\sum_{s=1}^S (w_s / d_{is})^\epsilon} H_{Ri}, \quad d_{ij} = e^{k\tau_{ij}}.$$

- In our data, they observe workplace employment (H_{Mj}), residence employment (H_{Ri}) and bilateral travel times (τ_{ij} and hence d_{ij})
- Given these observed data, they can solve for the wages for which the observed values of workplace and residence employment are an equilibrium of the model
- Commuting equilibrium above provides a system of S equations that determines unique values of the S unknown wages $\{w_j\}$

Consumer Equilibrium

- Expected utility

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

- Residential amenities (B_i) from residential choice probabilities:

$$\frac{B_i T_i^{1/\epsilon}}{\bar{U}/\gamma} = \left(\frac{H_{Ri}}{H} \right)^{\frac{1}{\epsilon}} \frac{Q_i^{1-\beta}}{W_i^{1/\epsilon}},$$

$$W_i = \sum_{s=1}^S E_s (w_s / d_{is})^\epsilon, \quad d_{is} = e^{k\tau_{is}}.$$

- Residential amenities are influenced by both fundamentals (b_i) and spillovers (Ω_i)

$$b_i = B_i \Omega_i^{-\eta}, \quad \Omega_i \equiv \left[\sum_{s=1}^S e^{-\rho\tau_{is}} \left(\frac{H_{Rs}}{K_s} \right) \right].$$

Production

- A single final good (numeraire) is produced under conditions of perfect competition, constant returns to scale and zero trade costs with a larger economy:

$$X_j = A_j (H_{Mj})^\alpha (\theta_j L_j)^{1-\alpha}, \quad 0 < \alpha < 1,$$

- H_{Mj} is workplace employment
- L_j is total floor space
- θ_j is the fraction of floor space allocated to commercial use
- Productivity (A_j) depends on fundamentals (a_j) and spillovers (Y_j):

$$A_j = a_j Y_j^\lambda, \quad Y_j \equiv \left[\sum_{s=1}^S e^{-\delta \tau_{is}} \left(\frac{H_{Ms}}{K_s} \right) \right],$$

- δ is the rate of decay of spillovers
- λ captures the relative importance of spillovers

Producer Equilibrium

- Firms choose a block of production, effective employment and commercial land use to maximize profits taking as given goods and factor prices, productivity and the locations of other firms/workers
- Productivity (A_j) from profit maximization and zero profits:

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

- Production fundamentals (a_j) and spillovers (Y_j) follow from the production technology:

$$a_j = A_j Y_j^{-\lambda}, \quad Y_j \equiv \left[\sum_{s=1}^S e^{-\delta \tau_{is}} \left(\frac{H_{Ms}}{K_s} \right) \right]^{-\lambda}.$$

Land Market Clearing

- Utility max and pop mobility imply demand residential floor space:

$$(1 - \theta_i)L_i = \frac{H_{Ri}\bar{U}^{\frac{1}{1-\beta}}}{\beta^{\frac{\beta}{1-\beta}} B_i^{\frac{1}{1-\beta}} \bar{v}_i^{\frac{\beta}{1-\beta}}}.$$

- Profit max and zero profits imply demand commercial floor space:

$$\theta_i L_i = H_{Mi} \left(\frac{w_i}{\alpha A_i} \right)^{\frac{1}{1-\alpha}}.$$

- Floor space L supplied by a competitive construction sector using geographic land K and capital M as inputs

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

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

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

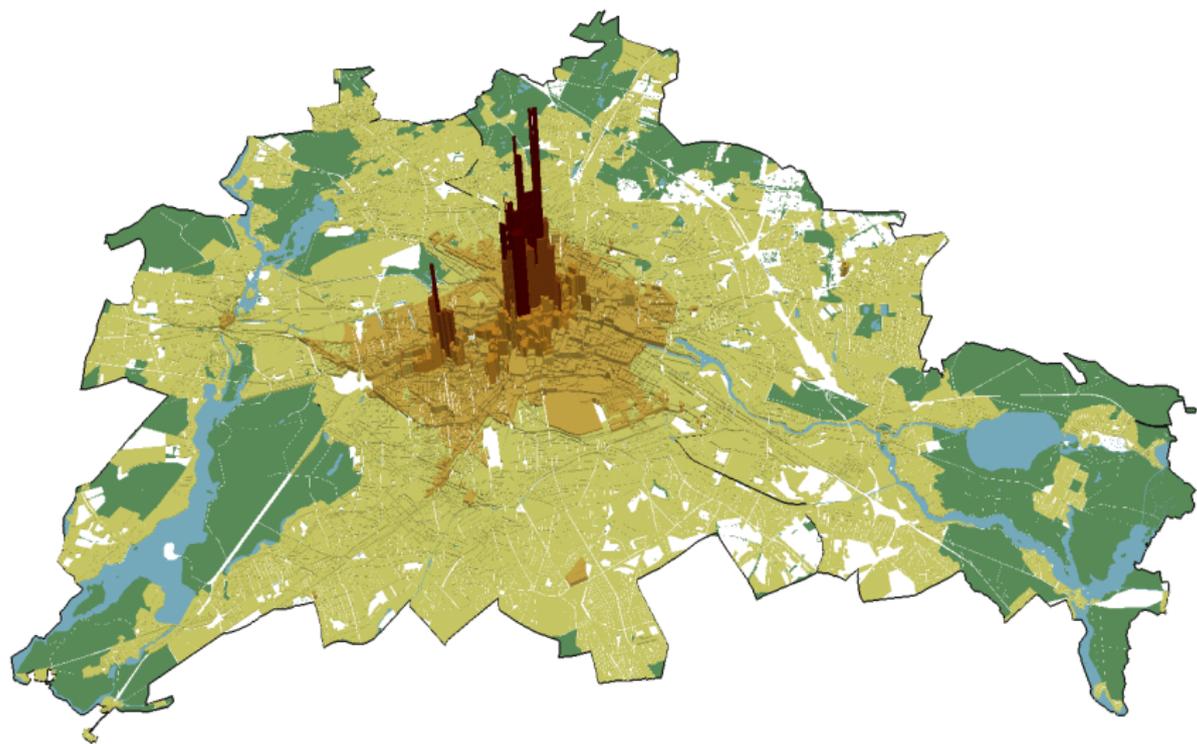
Qualitative Predictions for Division

- Firms in West Berlin cease to benefit from production externalities from employment centers in East Berlin
 - Reduces productivity, land prices and employment
- Firms in West Berlin lose access to flows of commuters from residential concentrations in East Berlin
 - Increases the wage required to achieve a given effective employment, reducing land prices and employment
- Residents in West Berlin lose access to employment opportunities and consumption externalities from East Berlin
 - Reduces expected worker income, land prices and residents
- The impact is greater for parts of West Berlin closer to employment and residential concentrations in East Berlin
- Employment and residents reallocate within West Berlin and the larger economy until wages and land prices adjust such that:
 - Firms make zero profits in each location with positive production
 - Workers are indifferent across all locations with positive residents
 - No-arbitrage between commercial and residential land use

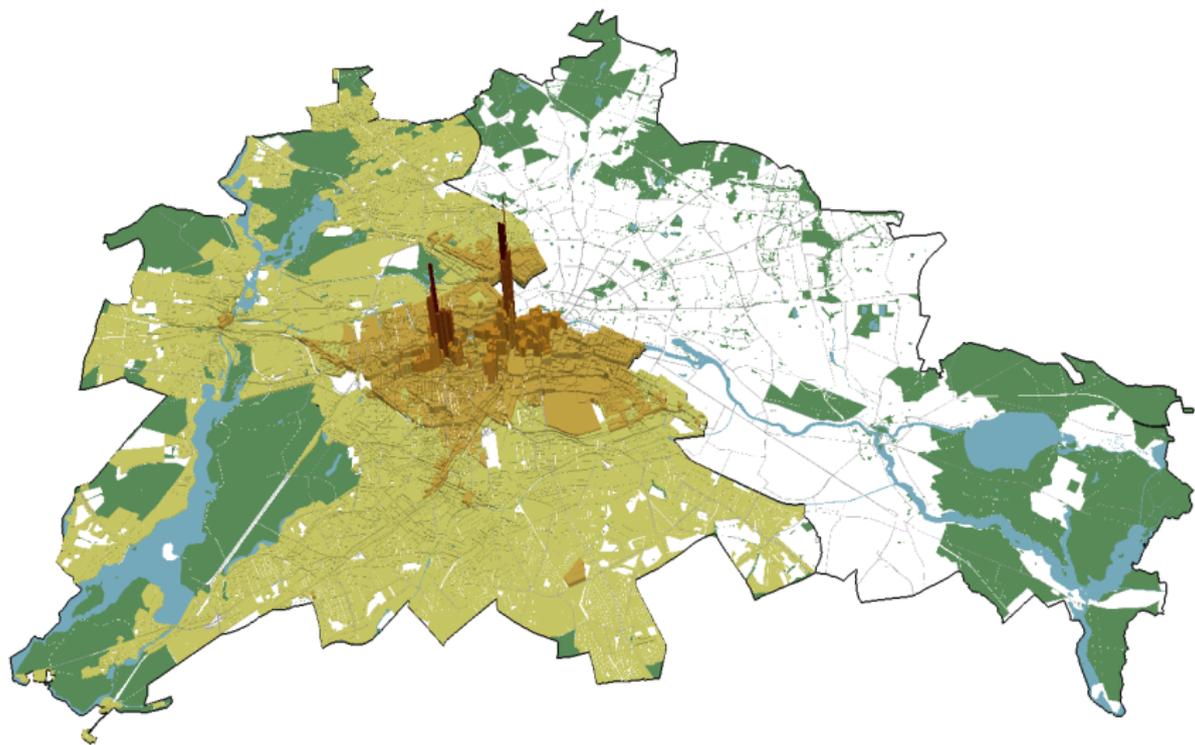
Data

- 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
- Data at the following levels of spatial aggregation:
 - Pre-war districts (“Bezirke”), 20 in Greater Berlin, 12 in West Berlin
 - Statistical areas (“Gebiete”), around 90 in West Berlin
 - Statistical blocks, around 9,000 in West Berlin
- 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:
 - land area, land use, 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

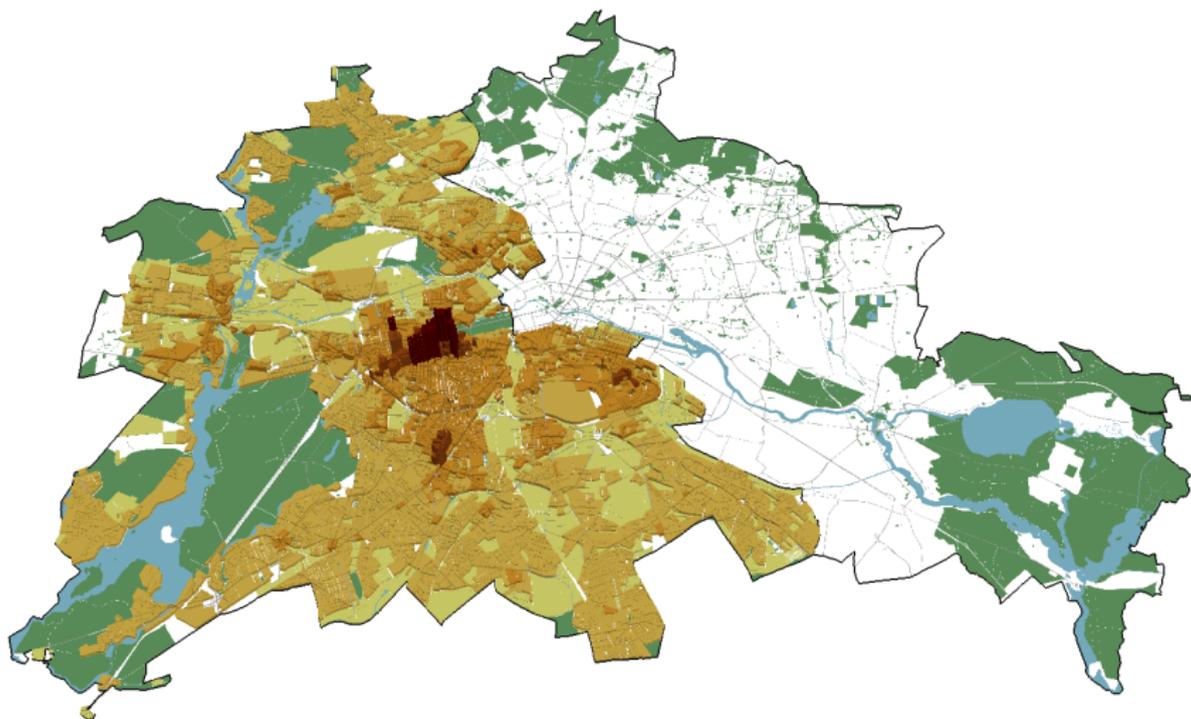
Berlin 1936



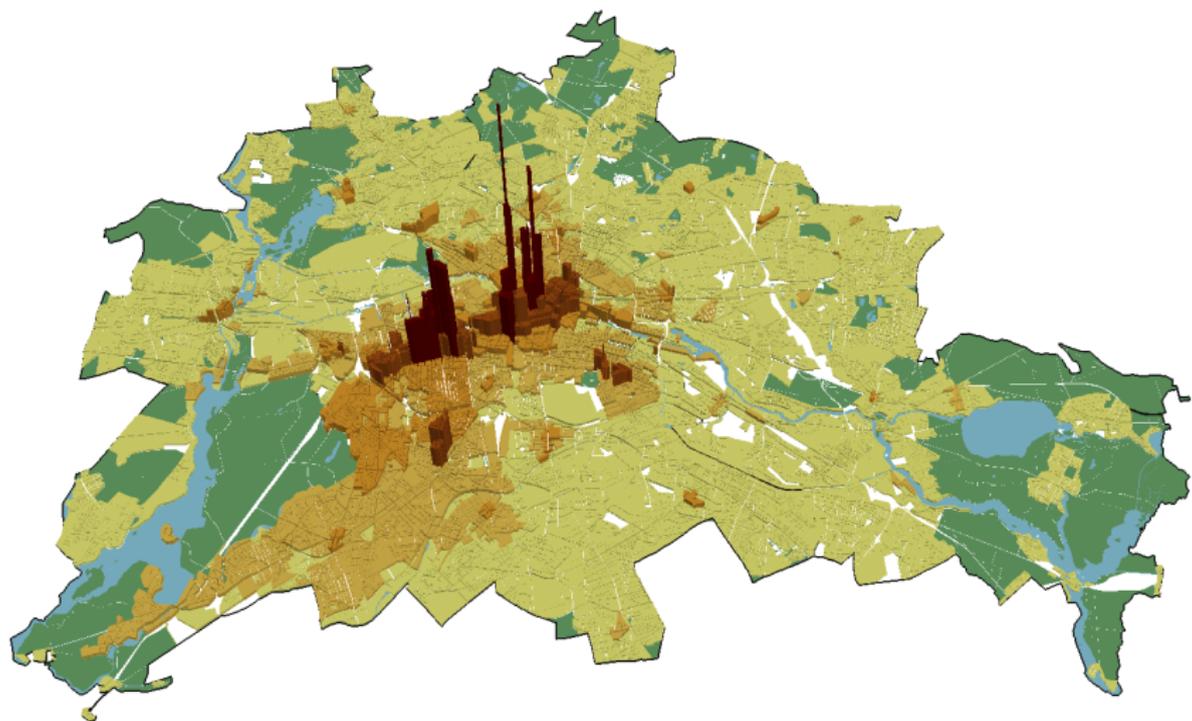
West Berlin 1936



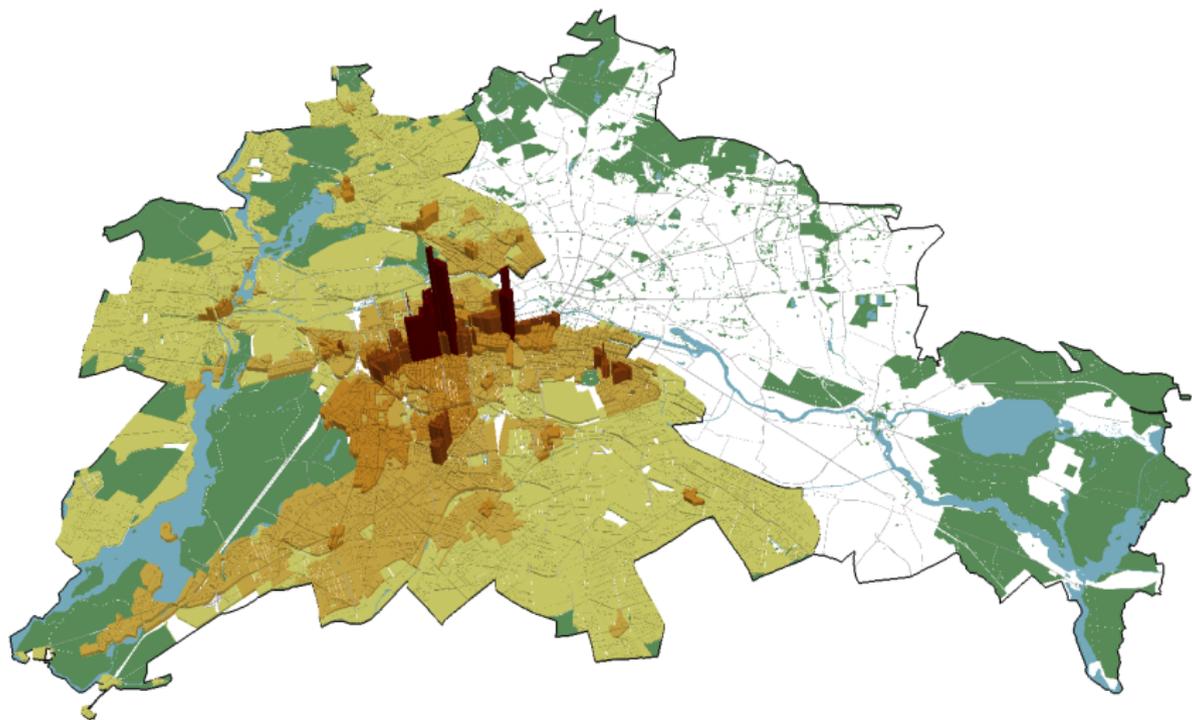
West Berlin 1986



Berlin 2006



West Berlin 2006



Difference-in-Differences Specification

- Long-differences specification using the change in log floor prices
- First-difference: before and after division
- Second-difference: areas of West Berlin close to and far from the pre-war CBD

$$\Delta \ln Q_i = \psi + \sum_{j=1}^J d_{ij} \zeta_j + \ln X_i \zeta + \chi_i, \quad (1)$$

- d_{ij} is a $(0, 1)$ dummy which equals one if block i lies within distance grid cell j and zero otherwise
- Allows for a fixed effect in the level of block land prices, which is differenced out when they take long differences
- 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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\Delta \ln Q$	$\Delta \ln \text{EmpR}$	$\Delta \ln \text{EmpR}$	$\Delta \ln \text{EmpW}$	$\Delta \ln \text{EmpW}$				
CBD 1	-0.800*** (0.071)	-0.567*** (0.071)	-0.524*** (0.071)	-0.503*** (0.071)	-0.565*** (0.077)	-1.332*** (0.383)	-0.975*** (0.311)	-0.691* (0.408)	-0.639* (0.338)
CBD 2	-0.655*** (0.042)	-0.422*** (0.047)	-0.392*** (0.046)	-0.360*** (0.043)	-0.400*** (0.050)	-0.715** (0.299)	-0.361 (0.280)	-1.253*** (0.293)	-1.367*** (0.243)
CBD 3	-0.543*** (0.034)	-0.306*** (0.039)	-0.294*** (0.037)	-0.258*** (0.032)	-0.247*** (0.034)	-0.911*** (0.239)	-0.460** (0.206)	-0.341 (0.241)	-0.471** (0.190)
CBD 4	-0.436*** (0.022)	-0.207*** (0.033)	-0.193*** (0.033)	-0.166*** (0.030)	-0.176*** (0.026)	-0.356** (0.145)	-0.259 (0.159)	-0.512*** (0.199)	-0.521*** (0.169)
CBD 5	-0.353*** (0.016)	-0.139*** (0.024)	-0.123*** (0.024)	-0.098*** (0.023)	-0.100*** (0.020)	-0.301*** (0.110)	-0.143 (0.113)	-0.436*** (0.151)	-0.340*** (0.124)
CBD 6	-0.291*** (0.018)	-0.125*** (0.019)	-0.094*** (0.017)	-0.077*** (0.016)	-0.090*** (0.016)	-0.360*** (0.100)	-0.135 (0.089)	-0.280** (0.130)	-0.142 (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

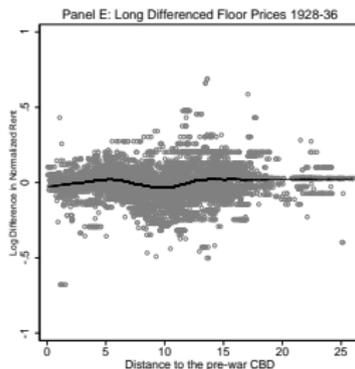
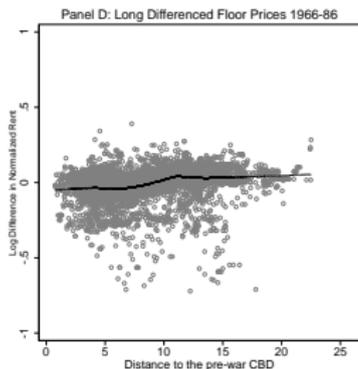
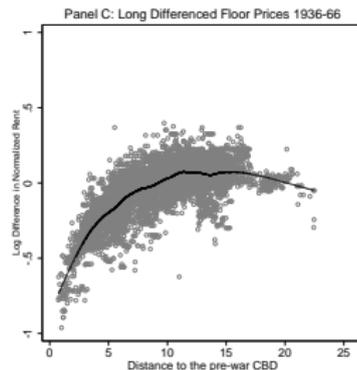
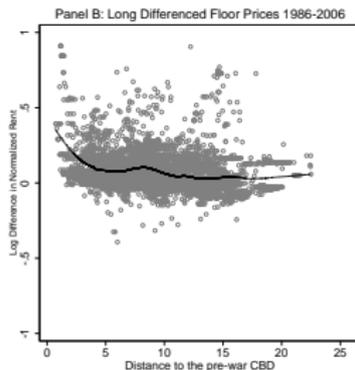
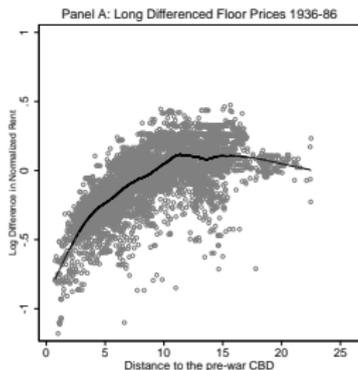
Note: Q denotes the price of floor space. EmpR denotes employment by residence. EmpW denotes employment by workplace. CBD1-CBD6 are six 500m distance grid cells for distance from the pre-war CBD. Inner Boundary 1-6 are six 500m grid cells for distance to the Inner Boundary between East and West Berlin. 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 Kurfirstendamm. 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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\Delta \ln Q$	$\Delta \ln \text{EmpR}$	$\Delta \ln \text{EmpR}$	$\Delta \ln \text{EmpW}$	$\Delta \ln \text{EmpW}$				
CBD 1	0.398*** (0.105)	0.408*** (0.090)	0.368*** (0.083)	0.369*** (0.081)	0.281*** (0.088)	1.079*** (0.307)	1.025*** (0.297)	1.574*** (0.479)	1.249** (0.517)
CBD 2	0.290*** (0.111)	0.289*** (0.096)	0.257*** (0.090)	0.258*** (0.088)	0.191** (0.087)	0.589* (0.315)	0.538* (0.299)	0.684** (0.326)	0.457 (0.334)
CBD 3	0.122*** (0.037)	0.120*** (0.033)	0.110*** (0.032)	0.115*** (0.032)	0.063** (0.028)	0.340* (0.180)	0.305* (0.158)	0.326 (0.216)	0.158 (0.239)
CBD 4	0.033*** (0.013)	0.031 (0.023)	0.030 (0.022)	0.034 (0.021)	0.017 (0.020)	0.110 (0.068)	0.034 (0.066)	0.336** (0.161)	0.261 (0.185)
CBD 5	0.025*** (0.010)	0.018 (0.015)	0.020 (0.014)	0.020 (0.014)	0.015 (0.013)	-0.012 (0.056)	-0.056 (0.057)	0.114 (0.118)	0.066 (0.131)
CBD 6	0.019** (0.009)	-0.000 (0.009)	-0.000 (0.012)	-0.003 (0.012)	0.005 (0.011)	0.060 (0.039)	0.053 (0.041)	0.049 (0.095)	0.110 (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		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%.

Treatments and Placebos



Note: Log floor prices are normalized to have a mean of zero in each year before taking the long difference. Solid lines are fitted values from locally-weighted linear least squares regressions.

Gravity

- Gravity equation for commuting from residence i to workplace j :

$$\ln \pi_{ij} = -\nu \tau_{ij} + \vartheta_i + \zeta_j + e_{ij}, \quad (2)$$

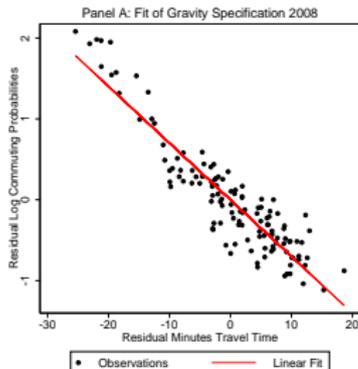
- where τ_{ij} is travel time in minutes and $\nu = \epsilon\kappa$ is semi-elasticity
- ϑ_i are residence fixed effects
- ζ_j are workplace fixed effects
- Using estimated ν , can solve for transformed wages $\omega_j = w_j^\epsilon$ and recover overall productivity A_j and amenities B_j
- (Without making assumptions about the relative importance of production and residential externalities versus fundamentals)

Gravity Equation Estimation

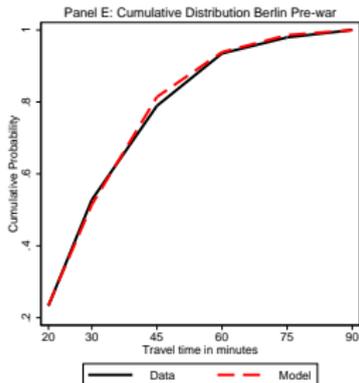
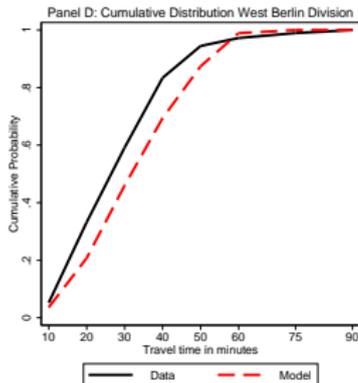
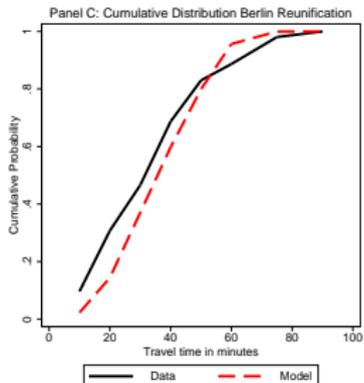
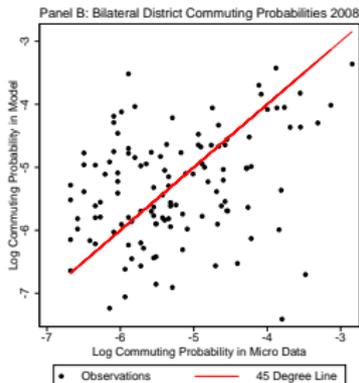
	(1)	(2)	(3)	(4)
	In Bilateral Commuting Probability 2008	In Bilateral Commuting Probability 2008	In Bilateral Commuting Probability 2008	In Bilateral Commuting Probability 2008
Travel Time ($-\kappa\epsilon$)	-0.0697*** (0.0056)	-0.0702*** (0.0034)	-0.0771*** (0.0025)	-0.0706*** (0.0026)
Estimation	OLS	OLS	Poisson PML	Gamma PML
More than 10 Commuters		Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes
Observations	144	122	122	122
R-squared	0.8261	0.9059	-	-

Note: Gravity equation estimates based on representative micro survey data on commuting for Greater Berlin for 2008. Observations are bilateral pairs of 12 workplace and residence districts (post 2001 Bezirke boundaries). Travel time is measured in minutes. Fixed effects are workplace district fixed effects and residence district fixed effects. The specifications labelled more than 10 commuters restrict attention to bilateral pairs with 10 or more commuters. Poisson PML is Poisson Pseudo Maximum Likelihood estimator. Gamma PML is Gamma Pseudo Maximum Likelihood Estimator. Standard errors in parentheses are heteroscedasticity robust. * significant at 10%; ** significant at 5%; *** significant at 1%.

Commuting Data and Model Predictions



Note: Residuals from conditioning on workplace and residence fixed effects.



Changes in Amenities and Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln A$	$\Delta \ln B$	$\Delta \ln A$	$\Delta \ln B$	$\Delta \ln QC$	$\Delta \ln QC$
	1936-86	1936-86	1986-2006	1986-2006	1936-1986	1986-2006
CBD 1	-0.207*** (0.049)	-0.347*** (0.070)	0.261*** (0.073)	0.203*** (0.054)	-0.229*** (0.020)	0.065*** (0.014)
CBD 2	-0.260*** (0.032)	-0.242*** (0.053)	0.144** (0.056)	0.109** (0.058)	-0.184*** (0.008)	0.065*** (0.009)
CBD 3	-0.138*** (0.021)	-0.262*** (0.037)	0.077*** (0.024)	0.059** (0.026)	-0.177*** (0.012)	0.043*** (0.009)
CBD 4	-0.131*** (0.016)	-0.154*** (0.023)	0.057*** (0.015)	0.010 (0.008)	-0.189*** (0.010)	0.048*** (0.009)
CBD 5	-0.095*** (0.014)	-0.126*** (0.013)	0.028** (0.013)	-0.014* (0.007)	-0.188*** (0.012)	0.055*** (0.012)
CBD 6	-0.061*** (0.015)	-0.117*** (0.015)	0.023** (0.010)	0.001 (0.005)	-0.170*** (0.009)	0.035*** (0.009)
Counterfactuals					Yes	Yes
Agglomeration Effects					No	No
Observations	2844	5978	5602	6718	6260	7050
R-squared	0.09	0.06	0.02	0.03	0.10	0.07

Note: Columns (1)-(4) based on calibrating the model for $\nu = \epsilon\kappa = 0.07$ and $\epsilon = 6.83$ from the gravity equation estimation. Columns (5)-(6) report counterfactuals for these parameter values. A denotes adjusted overall productivity. B denotes adjusted overall amenities. QC denotes counterfactual floor prices (simulating the effect of division on West Berlin). Column (5) simulates division holding A and B constant at their 1936 values. Column (6) simulates reunification holding A and B for West Berlin constant at their 1986 values and using 1936 values of A and B for East Berlin. CBD1-CBD6 are six 500m distance grid cells for distance from the pre-war CBD. Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors in parentheses (Conley 1999). * significant at 10%; ** significant at 5%; *** significant at 1%.

Structural Residuals

- One-to-one mapping from known model parameters $\{\alpha, \beta, \mu, \nu, \epsilon, \lambda, \delta, \eta, \rho\}$ and observed data $\{Q_{it}, H_{Mit}, H_{Rit}, K_i, \tau_{ijt}\}$ to adjusted production and residential fundamentals $\{\tilde{a}_i, \tilde{b}_i\}$
- Adjusted production and residential fundamentals $\{\tilde{a}_i, \tilde{b}_i\}$ capture other variables that enter the model isomorphically
- Adjusted production fundamentals relative to the geometric mean:

$$\Delta \ln \left(\frac{\tilde{a}_{it}}{\tilde{a}_t} \right) = (1 - \alpha) \Delta \ln \left(\frac{Q_{it}}{Q_t} \right) + \frac{\alpha}{\epsilon} \Delta \ln \left(\frac{\omega_{it}}{\omega_t} \right) - \lambda \Delta \ln \left(\frac{Y_{it}}{Y_t} \right),$$

- Adjusted residential fundamentals relative to the geometric mean:

$$\Delta \ln \left(\frac{\tilde{b}_{it}}{\tilde{b}_t} \right) = \frac{1}{\epsilon} \Delta \ln \left(\frac{H_{Rit}}{H_{Rt}} \right) + (1 - \beta) \Delta \ln \left(\frac{Q_{it}}{Q_t} \right) - \frac{1}{\epsilon} \Delta \ln \left(\frac{W_{it}}{W_t} \right) - \eta \Delta \ln \left(\frac{\Omega_{it}}{\Omega_t} \right),$$

- Adjusted fundamentals are **structural residuals**

Parameters

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

Moment Conditions

- Changes in adjusted fundamentals uncorrelated with exogenous change in surrounding economic activity from division/reunification

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

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

- where \mathbb{I}_k are indicators for distance grid cells
- Other moments are fraction of workers that commute less than 30 minutes and wage dispersion

$$\mathbb{E} \left[\vartheta H_{Mj} - \sum_{i \in \mathbb{N}_j} \frac{\omega_j / e^{v\tau_{ij}}}{\sum_{s=1}^S \omega_s / e^{v\tau_{is}}} H_{Ri} \right] = 0,$$

$$\mathbb{E} \left[(1/\epsilon)^2 \ln(\omega_j)^2 - \sigma_{\ln w_j}^2 \right] = 0,$$

Estimated Parameters

	(1) Division Efficient GMM	(2) Reunification Efficient GMM	(3) Division and Reunification Efficient GMM
Commuting Travel Time Elasticity ($\kappa\epsilon$)	0.0951*** (0.0016)	0.1011*** (0.0016)	0.0987*** (0.0016)
Commuting Heterogeneity (ϵ)	7.6278*** (0.1085)	7.7926*** (0.1152)	7.7143*** (0.1049)
Productivity Elasticity (λ)	0.0738*** (0.0056)	0.0449*** (0.0071)	0.0657*** (0.0048)
Productivity Decay (δ)	0.3576*** (0.0945)	0.8896*** (0.3339)	0.3594*** (0.0724)
Residential Elasticity (η)	0.1441*** (0.0080)	0.0740*** (0.0287)	0.1444*** (0.0073)
Residential Decay (ρ)	0.8872*** (0.2774)	0.5532 (0.3699)	0.7376*** (0.1622)

Note: 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%.

Localized Externalities

	(1) Production Externalities ($1 \times e^{-\delta t}$)	(2) Residential Externalities ($1 \times e^{-\rho t}$)	(3) Utility after Commuting ($1 \times e^{-\kappa t}$)
0 minutes	1.000	1.000	1.000
1 minute	0.698	0.478	0.987
2 minutes	0.487	0.229	0.975
3 minutes	0.340	0.109	0.962
5 minutes	0.166	0.025	0.938
7 minutes	0.081	0.006	0.914
10 minutes	0.027	0.001	0.880
15 minutes	0.005	0.000	0.825
20 minutes	0.001	0.000	0.774
30 minutes	0.000	0.000	0.681

Note: 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: $\delta=0.3594$, $\rho=0.7376$, $\kappa=0.0128$.

Counterfactuals

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln \text{QC}$					
	1936-86	1936-86	1936-86	1936-1986	1986-2006	1936-1986
CBD 1	-0.839*** (0.074)	-0.667*** (0.034)	-0.666*** (0.050)	-0.752*** (0.032)	0.472*** (0.045)	0.923*** (0.045)
CBD 2	-0.627*** (0.048)	-0.456*** (0.025)	-0.635*** (0.045)	-0.585*** (0.030)	0.251*** (0.055)	0.689*** (0.071)
CBD 3	-0.518*** (0.058)	-0.348*** (0.026)	-0.592*** (0.066)	-0.476*** (0.038)	0.086* (0.052)	0.416*** (0.048)
CBD 4	-0.521*** (0.060)	-0.329*** (0.019)	-0.642*** (0.071)	-0.470*** (0.035)	-0.060 (0.040)	0.311*** (0.044)
CBD 5	-0.544*** (0.042)	-0.306*** (0.022)	-0.733*** (0.044)	-0.482*** (0.036)	-0.076** (0.034)	0.253*** (0.042)
CBD 6	-0.489*** (0.043)	-0.265*** (0.015)	-0.709*** (0.059)	-0.417*** (0.027)	-0.133*** (0.038)	0.163*** (0.042)
Counterfactuals	Yes	Yes	Yes	Yes	Yes	Yes
Agglomeration Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6260	6260	6260	6260	7050	6260
R-squared	0.12	0.15	0.09	0.11	0.01	0.06

Note: This table is based on the parameter estimates pooling division and reunification from Table 5. QC denotes counterfactual floor prices. Column (1) simulates division using our estimates of production and residential externalities and 1936 fundamentals. Column (2) simulates division using our estimates of production externalities and 1936 fundamentals but setting residential externalities to zero. Column (3) simulates division using our estimates of residential externalities and 1936 fundamentals but setting production externalities to zero. Column (4) simulates division using our estimates of production and residential externalities and 1936 fundamentals but halving their rates of spatial decay with travel time. Column (5) simulates reunification using our estimates of production and residential externalities, 1986 fundamentals for West Berlin, and 2006 fundamentals for East Berlin. Column (6) simulates reunification using our estimates of production and residential externalities, 1986 fundamentals for West Berlin and 1936 fundamentals for East Berlin. CBD1-CBD6 are six 500m distance grid cells for distance from the pre-war CBD. Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors in parentheses (Conley 1999). * significant at 10%; ** significant at 5%; *** significant at 1%.

Conclusion

- This paper develops a quantitative theoretical model to provide evidence on agglomeration and dispersion forces
- Our framework allows for variation in production fundamentals, residential fundamentals and transport infrastructure
- We combine the quantitative model with exogenous variation provided by Berlin's division and reunification
- Division led to a re-orientation of West Berlin's land price gradient away from the pre-war city center
- Reunification led to a re-emergence of West Berlin's land price gradient towards the pre-war city center
- We provide evidence that this re-orientation of the land price gradient is in part shaped by the changing access to the surrounding concentration of economic activity emphasized in the model

Division and Pre-War CBD



Monte, Redding and Rossi-Hansberg

- Many changes in the economic environment are local
 - ▶ Climate, infrastructure, innovations, institutions, regulations
- The effect of these changes depends crucially on the ability of labor to move in response: *The elasticity of local employment*
- Two main sources for employment changes: Commuting and migration
 - ▶ Workers spend 8% of their work-day commuting
 - ★ Seek balance between residential amenities, cost of living and wage
- We propose a quantitative spatial GE theory with goods trade that incorporates these two channels
 - ▶ study the response of local outcomes to local shocks

Introduction

- We discipline our quantitative model to match
 - ▶ Gravity in goods trade
 - ▶ Gravity in commuting flows
 - ▶ Distribution of employment, residents and wages across counties
- The quantitative importance of these two channels varies across counties depending on their local characteristics
 - ▶ Leads to significant heterogeneity in the employment elasticity
 - ▶ Locations are not independent spatial units as often assumed in cross-section regressions
 - ▶ Underscores general equilibrium effects
- Affects the estimated effects of most local policies and shocks and their external validity
 - ▶ Heterogeneity is well accounted for by commuting links

Key Mechanisms

- Productivity differences and home market effects
 - ▶ Forces for the concentration of economic activity
- Inelastic housing supply and heterogeneous preferences
 - ▶ Forces for the dispersion of economic activity
- Commuting allows workers to access high productivity locations without having to live there
 - ▶ Effectively reduces the congestion effect in high productivity areas
- Elasticity of employment with respect to local shocks (e.g. productivity, amenities, infrastructure) depends on
 - ▶ Ability to attract migrants
 - ▶ Ability to attract commuters from surrounding locations

Commuting Across Counties and Commuting Zones

	p10	p25	p50	p75	p90	Max	Mean
Commuters from Residence	0.06	0.14	0.27	0.42	0.53	0.82	0.29
Commuters to Workplace	0.07	0.14	0.20	0.28	0.37	0.81	0.22
Outside CZ Total (Res)	0.04	0.14	0.33	0.58	0.79	1.00	0.37
Outside CZ Total (Work)	0.08	0.19	0.37	0.55	0.73	1.00	0.39

Tabulations on 3,111 counties and 709 CZ after eliminating business trips (trips longer than 120km); min is 0 for all.

- For the median county

- ▶ Around 1/4 of its residents work outside the county
- ▶ Around 1/3 of them work outside the county's commuting zone

Related Literature

- Quantitative international trade literature on costly trade in goods
 - ▶ Eaton and Kortum (2002) and extensions
- Economic geography literature on goods trade and factor mobility
 - ▶ Krugman (1991), Fujita et al. (1999), Rossi-Hansberg (2005), Allen and Arkolakis (2014), Allen et al. (2015), Caliendo et al. (2014), Desmet and Rossi-Hansberg (2014), Redding (2014)
- Urban literature on costly trade in people (commuting)
 - ▶ Alonso (1964), Mills (1967), Muth (1969), Lucas and Rossi-Hansberg (2002), Desmet and Rossi-Hansberg (2013), Ahlfeldt et al. (2014), Behrens et al. (2014), Monte (2016)
- Local labor markets literature
 - ▶ Greenstone et al. (2010), Moretti (2011), Busso et al. (2013), Autor et al. (2013), Diamond (2013), Notowidigdo (2013), Yagan (2014)

Preferences and Amenities

- Utility of an agent ω that lives in n and works in i is

$$U_{ni\omega} = \frac{b_{ni\omega}}{\kappa_{ni}} \left(\frac{C_{n\omega}}{\alpha} \right)^\alpha \left(\frac{H_{n\omega}}{1-\alpha} \right)^{1-\alpha}$$

where $C_{n\omega}$ is the CES consumption basket with elasticity of substitution σ , and $H_{n\omega}$ housing consumption

- Utility cost of commuting are given κ_{ni}
- Amenities, $b_{ni\omega}$, drawn i.i.d. from Fréchet distribution

$$G_{ni}(b) = e^{-B_{ni}b^{-\epsilon}}, \quad B_{ni} > 0, \epsilon > 1$$

Production

- Horizontally differentiated varieties produced under monopolistic competition
- Labor required to produce $x_i(j)$ units of output in i is

$$l_i(j) = F + \frac{x_i(j)}{A_i}$$

- Prices at n are given by

$$p_{ni}(j) = \left(\frac{\sigma}{\sigma - 1} \right) \frac{d_{ni} w_i}{A_i},$$

where $d_{ni} \geq 1$ denotes iceberg transport costs between i and n

- Constant equilibrium output $x_i(j) = A_i F (\sigma - 1)$ implies

$$M_i = \frac{L M_i}{\sigma F}$$

Land Market

- There is an inelastic supply of land at H_n
- Price of land Q_n determined from land market clearing

$$H_n Q_n = (1 - \alpha) v_n L_{Rn},$$

where v_n is expected income of residents at n and L_{Rn} is the total number of residents

- ▶ Resulting price of land correlates well with house prices in the data
- Land owned by landlords, who receive income from residents' expenditure on land, and consume goods where they live
 - ▶ Total expenditure on goods is the sum of expenditures by residents and landlords

$$P_n C_n = \alpha v_n L_{Rn} + (1 - \alpha) v_n L_{Rn} = v_n L_{Rn}$$

Trade in Goods

- Denote by L_{Mi} the number of workers at i
- Then, as in many trade frameworks, expenditure shares are given by

$$\pi_{ni} = \frac{L_{Mi} (d_{ni} w_i / A_i)^{1-\sigma}}{\sum_{k \in N} L_{Mk} (d_{nk} w_k / A_k)^{1-\sigma}}$$

- And so the price of the consumption basket at n is given by

$$P_n = \frac{\sigma}{\sigma - 1} \left(\frac{L_{Mn}}{\sigma F \pi_{nn}} \right)^{\frac{1}{1-\sigma}} \frac{w_n}{A_n}$$

Work-Residence Decision

- The indirect utility of an agent ω that lives in n and works in i is

$$U_{ni\omega} = \frac{b_{ni\omega} w_i}{\kappa_{ni} P_n^\alpha Q_n^{1-\alpha}}$$

which is drawn from

$$G_{ni}(u) = e^{-\Psi_{ni} u^{-\epsilon}}, \text{ with } \Psi_{ni} = B_{ni} \left(\kappa_{ni} P_n^\alpha Q_n^{1-\alpha} \right)^{-\epsilon} w_i^\epsilon$$

- So the unconditional probability that a worker chooses to live in region n and work in location i is

$$\lambda_{ni} = \frac{B_{ni} \left(\kappa_{ni} P_n^\alpha Q_n^{1-\alpha} \right)^{-\epsilon} w_i^\epsilon}{\sum_{r \in N} \sum_{s \in N} B_{rs} \left(\kappa_{rs} P_r^\alpha Q_r^{1-\alpha} \right)^{-\epsilon} w_s^\epsilon}$$

- Free mobility implies that $\bar{U} = E[U_{ni\omega}]$ for all ni

Commuting

- Conditional probability that worker commutes to location i conditional on living in location n is

$$\lambda_{ni|n} = \frac{B_{ni} (w_i / \kappa_{ni})^\epsilon}{\sum_{s \in N} B_{ns} (w_s / \kappa_{ns})^\epsilon}$$

- So labor market clearing implies that

$$L_{Mi} = \sum_{n \in N} \lambda_{ni|n} L_{Rn}$$

- Expected residential income is then

$$v_n = \sum_{i \in N} \lambda_{ni|n} w_i$$

General Equilibrium

- The general equilibrium is a vector of prices $\{w_n, v_n, Q_n, P_n\}$ and allocations $\{\pi_{ni}, \lambda_{ni}\}$ such that
 - ▶ Earnings equals expenditures (trade balance), $w_i L_{Mi} = \sum_{n \in N} \pi_{ni} v_n L_{Rn}$
 - ▶ Land markets clear
 - ▶ Agents move freely and labor markets clear, $\bar{L} = \sum_{i \in N} L_{Mi} = \sum_{n \in N} L_{Rn}$
- We formulate an isomorphic model using Armington or EK with external economies of scale, migration and commuting
- **Proposition (Existence and Uniqueness)** *If*

$$\frac{1 + \varepsilon}{1 + (1 - \alpha) \varepsilon} < \sigma$$

there exists a unique general equilibrium of this economy.

▶ More

Data

- Commodity Flow Survey (CFS)
 - ▶ Bilateral trade between 123 CFS regions
 - ▶ Bilateral distance shipped
- American Community Survey (ACS)
 - ▶ Commuting probabilities between counties
- Bureau of Economic Analysis
 - ▶ Employment by workplace county
 - ▶ Wages by workplace county
- GIS data
 - ▶ County maps
- Parameters
 - ▶ Share of expenditure on consumption goods, $\alpha = 0.6$ (Davis and Ortalo-Magne, 2011)
 - ▶ Elasticity of substitution, $\sigma = 4$ (Bernard et al., 2003)

County Bilateral Trade and Productivities

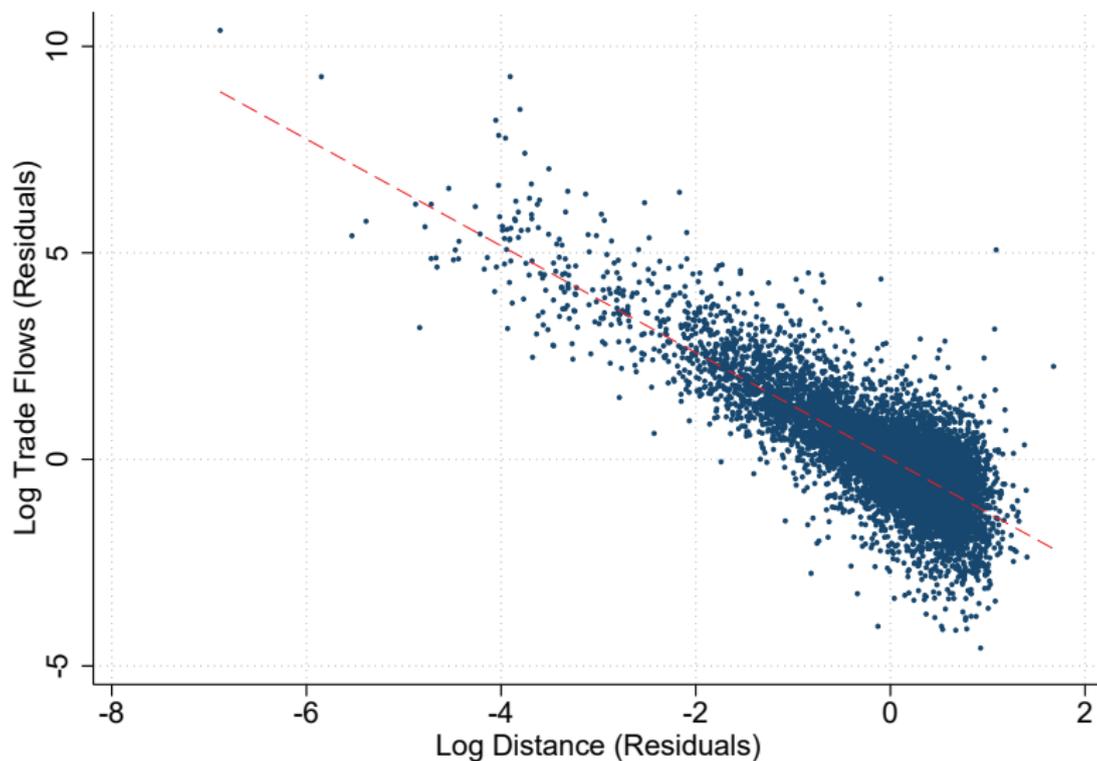
- Model is quantified for counties, but trade observed for CFS regions
- County trade balance implies

$$w_i L_{Mi} = \sum_{n \in N} \pi_{ni} v_n L_{Rn} = \sum_{n \in N} \frac{L_{Mi} (d_{ni} w_i)^{1-\sigma} A_i^{\sigma-1}}{\sum_{k \in N} L_{Mk} (d_{nk} w_k)^{1-\sigma} A_k^{\sigma-1}} v_n L_{Rn}.$$

- We observe (or can compute) $\{w_i, L_{Mi}, L_{Ri}, v_i\}$
- Let $d_{ni}^{1-\sigma} = (\text{distance}_{ni})^{-1.29}$, then we can solve uniquely for productivities, A_i
- Obtain predicted county bilateral trade flows, π_{ni}
- Aggregate to CFS level and compare with actual trade shares

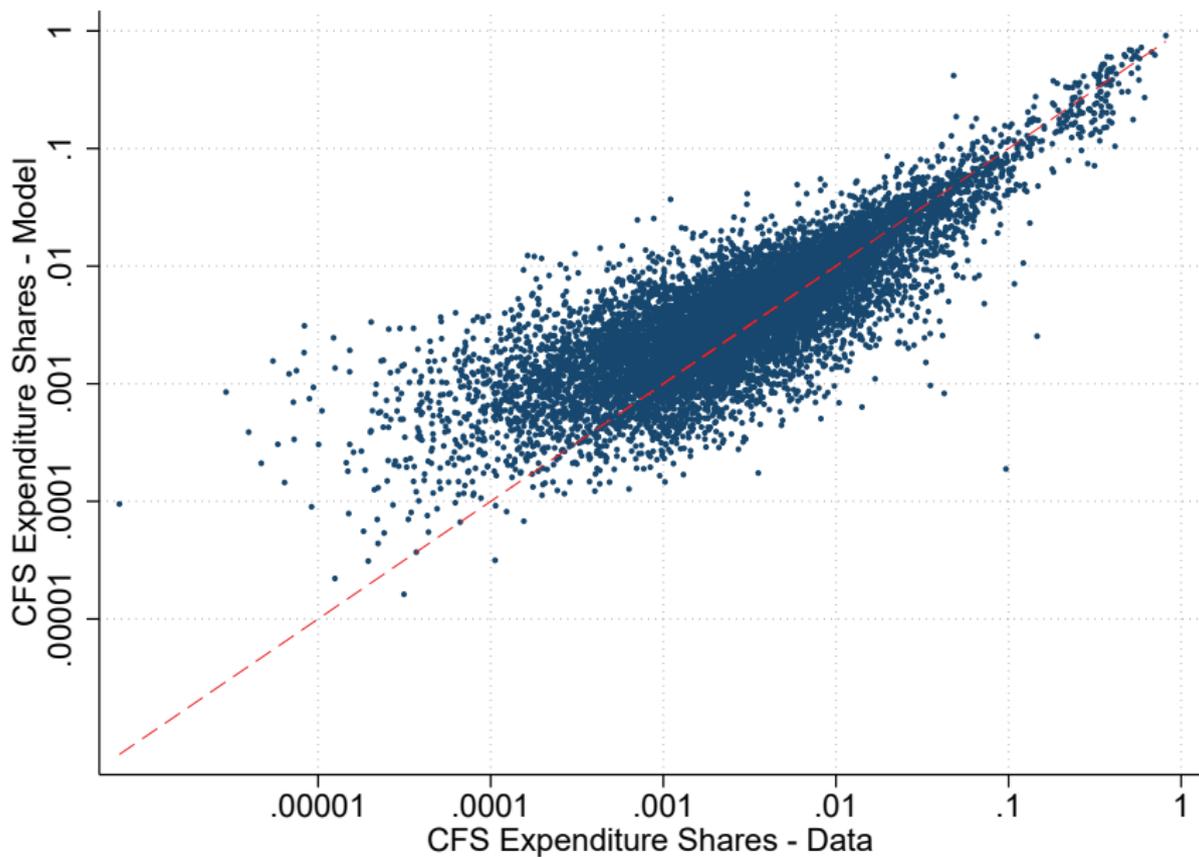
Gravity in Goods Trade Across CFS Regions

- Slope: -1.29 (after removing origin and destination fixed-effects)



Dashed line: linear fit; slope: -1.29

Data vs. Model CFS Expenditure Shares



County Commuting Probabilities and Amenities

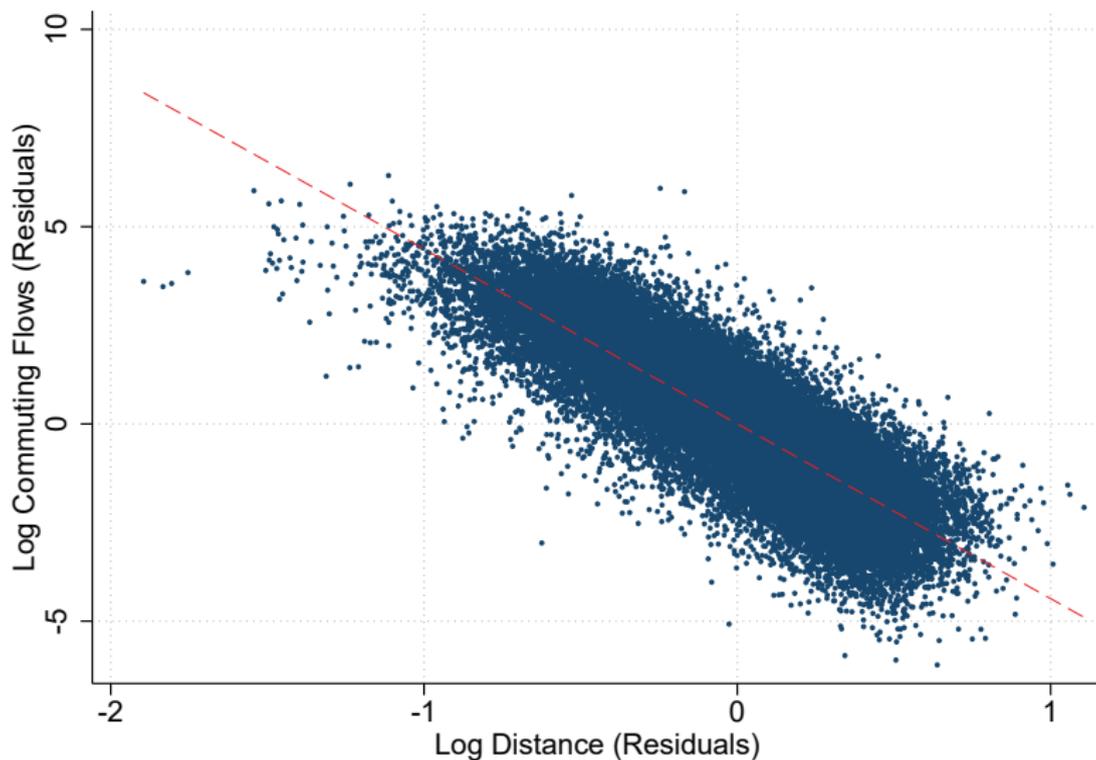
- Bilateral commuting probabilities are:

$$\lambda_{ni} = \frac{B_{ni} (\kappa_{ni} P_n^\alpha Q_n^{1-\alpha})^{-\epsilon} w_i^\epsilon}{\sum_{r \in N} \sum_{s \in N} B_{rs} (\kappa_{rs} P_r^\alpha Q_r^{1-\alpha})^{-\epsilon} w_s^\epsilon},$$

- We observe (or have solved for) $\{w_i, L_{Mi}, L_{Ri}, v_i, \pi_{ii}, A_i\}$ and so can calculate Q_n and P_n
- Use $\kappa_{ni} = \text{distance}_{ni}^\phi$ and $\phi\epsilon = 4.43$, we can solve for the unique matrix of amenities B_{ni}

Gravity in Commuting Flows

- Slope: -4.43 (after removing origin and destination fixed-effects)



Dashed line: linear fit; slope: -4.43

Separating ϕ and ϵ

- Can rewrite the bilateral commuting probability in logs as

$$\log \lambda_{ni} = \underbrace{-\log \sum_{r \in N} \sum_{s \in N} B_{rs} \left(\kappa_{rs} P_r^\alpha Q_r^{1-\alpha} \right)^{-\epsilon} w_s^\epsilon}_{\text{constant}} - \underbrace{\epsilon \log P_n^\alpha Q_n^{1-\alpha}}_{\text{residence f.e.}}$$
$$- \epsilon \phi \log \text{dist}_{ni} + \epsilon \log w_i + \log B_{ni}$$

- To estimate ϵ
 - ▶ Impose $\epsilon\phi = 4.43$
 - ▶ Instrument $\log w_i$ with $\log A_i$
 - ★ F-stat from first stage: 822.1
- We find $\epsilon = 3.30$ and $\phi = 1.34$

Three Quantitative Exercises

- ① Shock to productivity of individual counties
 - ▶ We find substantial heterogeneity of local employment elasticity
 - ▶ Due in large part to commuting
- ② Shutting down commuting
 - ▶ Large effects on the spatial distribution of economic activity
- ③ Reductions in trade costs with and without commuting
 - ▶ Trade and commuting are weak complements in aggregate

Local Labor Demand Shocks

- Large empirical literature on local labor demand shocks ▶ Literature
- “Differences-in-differences” specification across locations i and time t

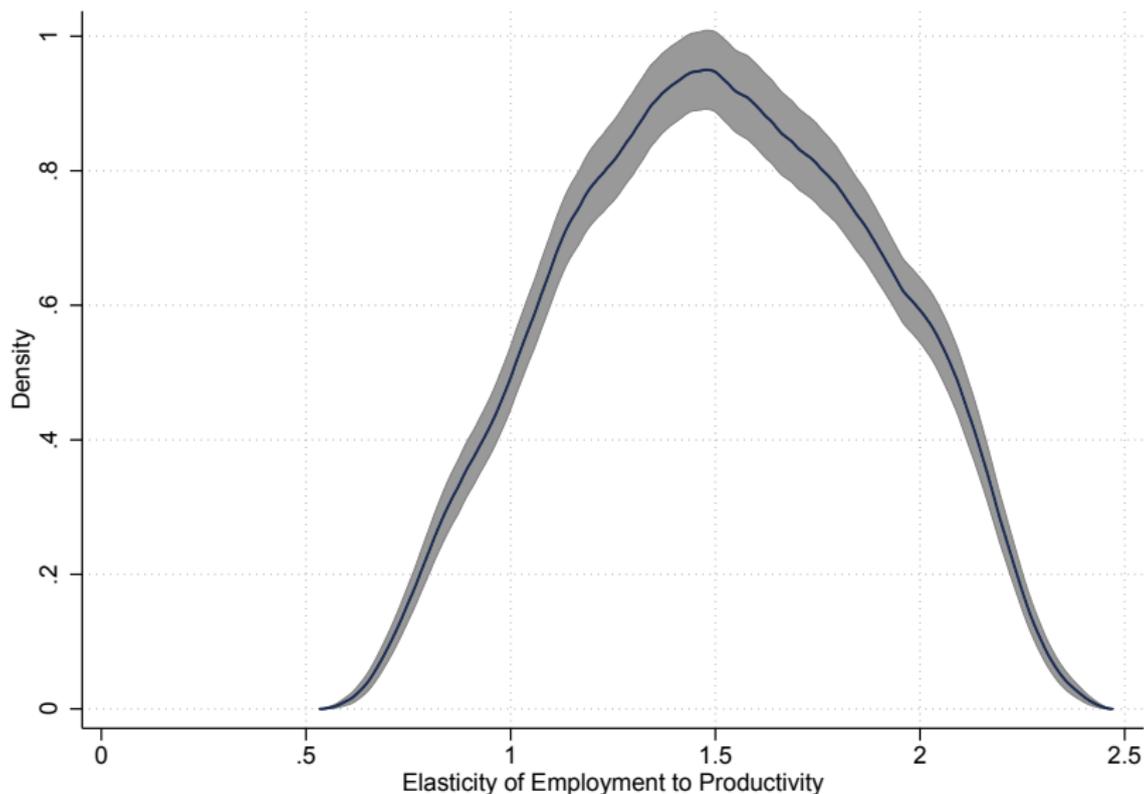
$$\Delta \ln Y_{it} = a_0 + a_1 \mathbb{I}_{it} + a_2 X_{it} + u_{it}$$

Y_{it} is outcome of interest and \mathbb{I}_{it} is demand shock (treatment), X_{it} are controls and u_{it} is a stochastic error

- Potential econometric concerns
 - ▶ Finding exogenous shocks to labor demand
 - ▶ Measuring the shock to local labor demand (interpreting a_1)
 - ▶ Heterogeneous treatment effects
 - ▶ Spatial linkages between counties and general equilibrium effects
- To what extent are heterogeneous treatment effects, spatial linkages and general equilibrium effects a concern?
- What if anything can be done to address these concerns?

Elasticity of Local Employment to Productivity

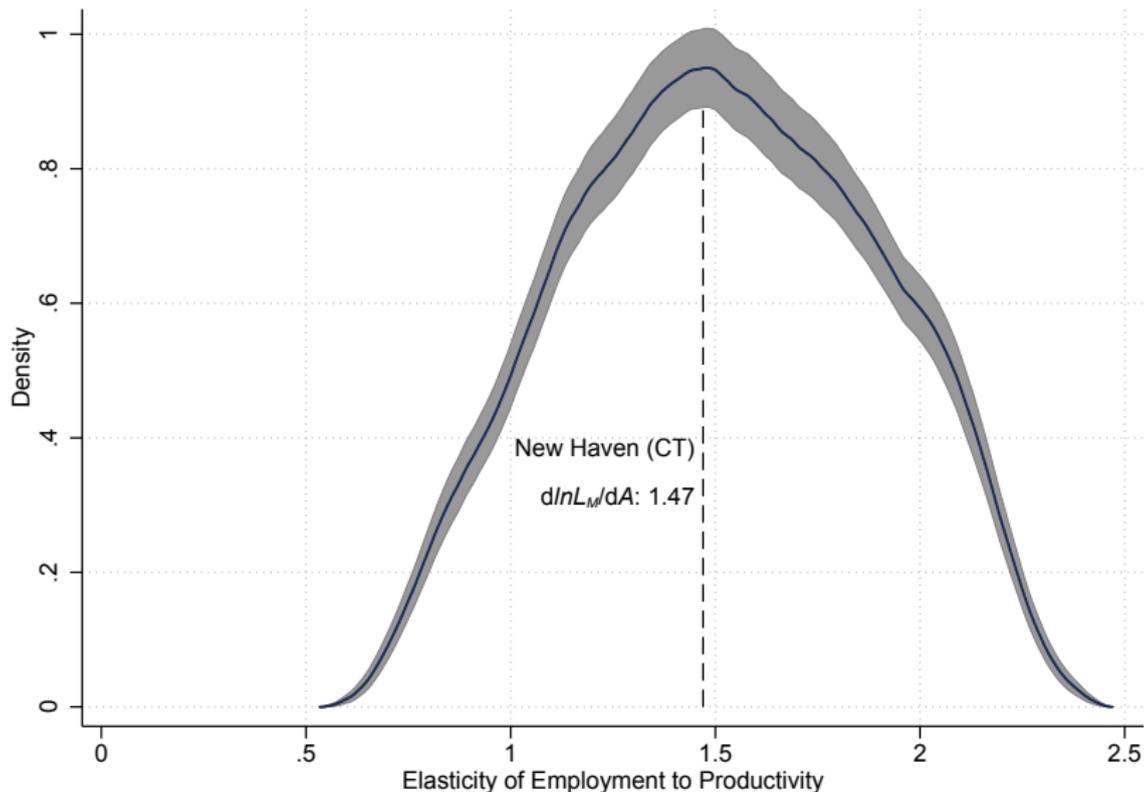
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Elasticity of Local Employment to Productivity

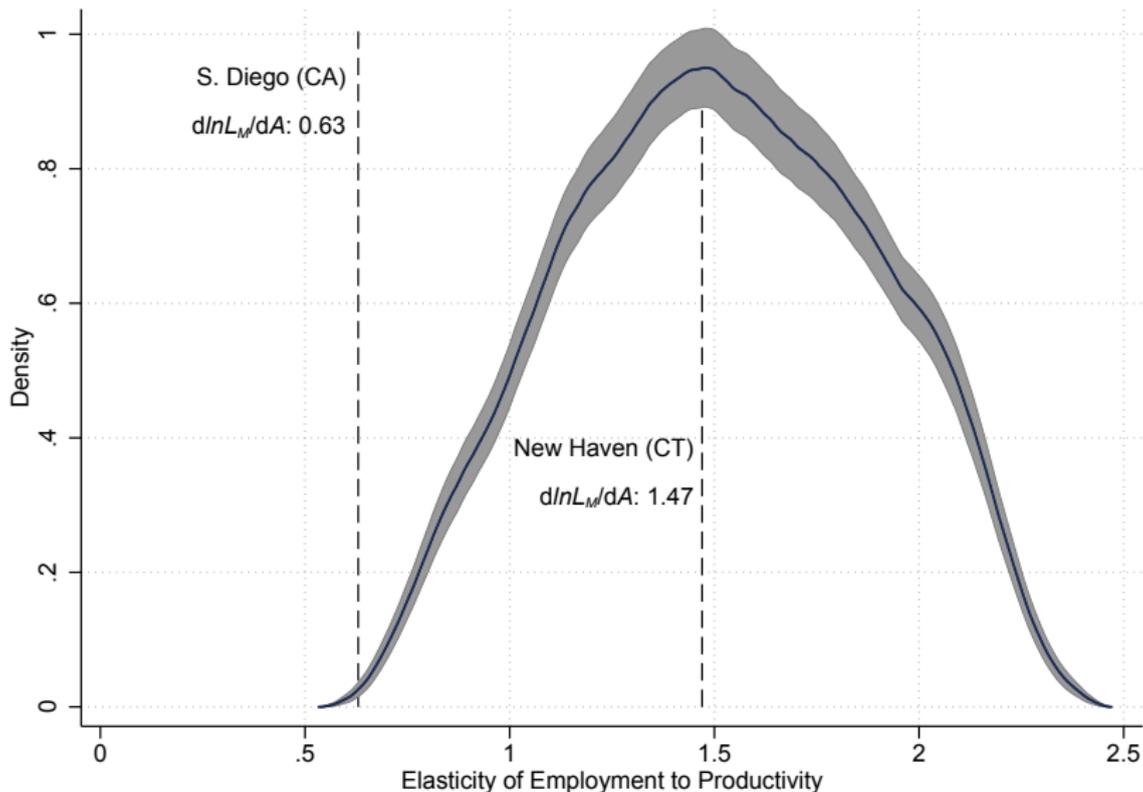
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Elasticity of Local Employment to Productivity

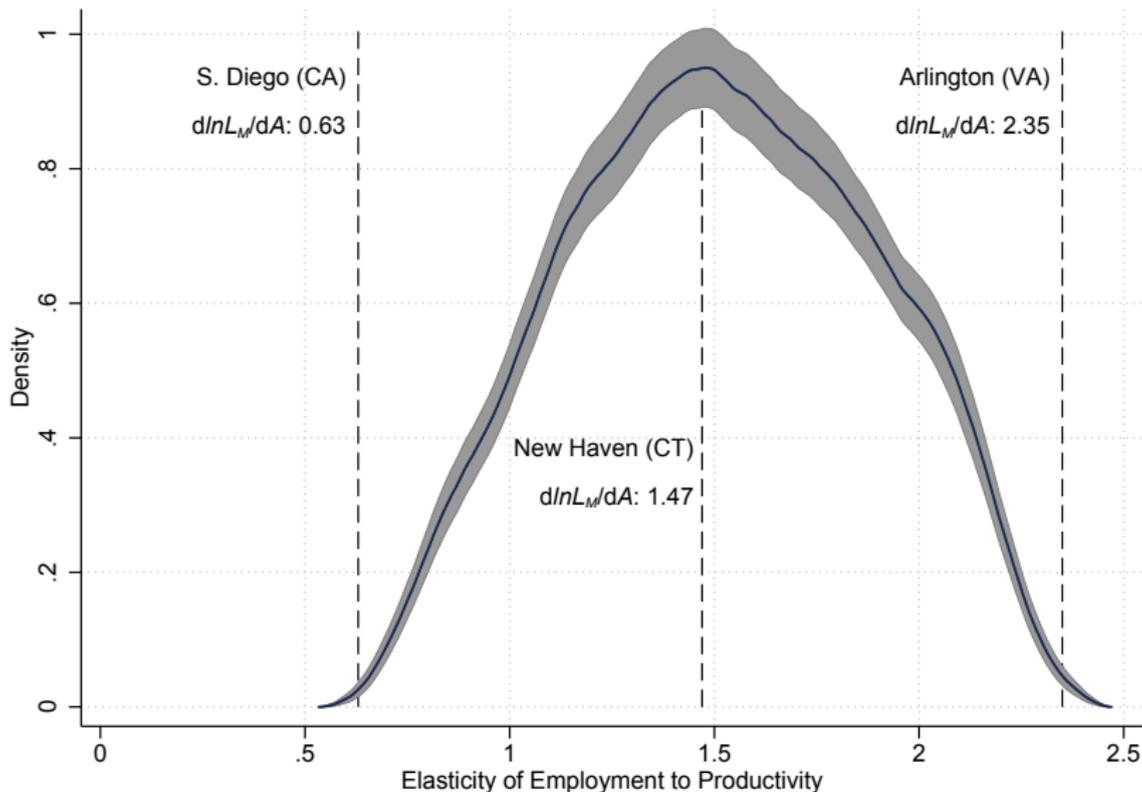
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Elasticity of Local Employment to Productivity

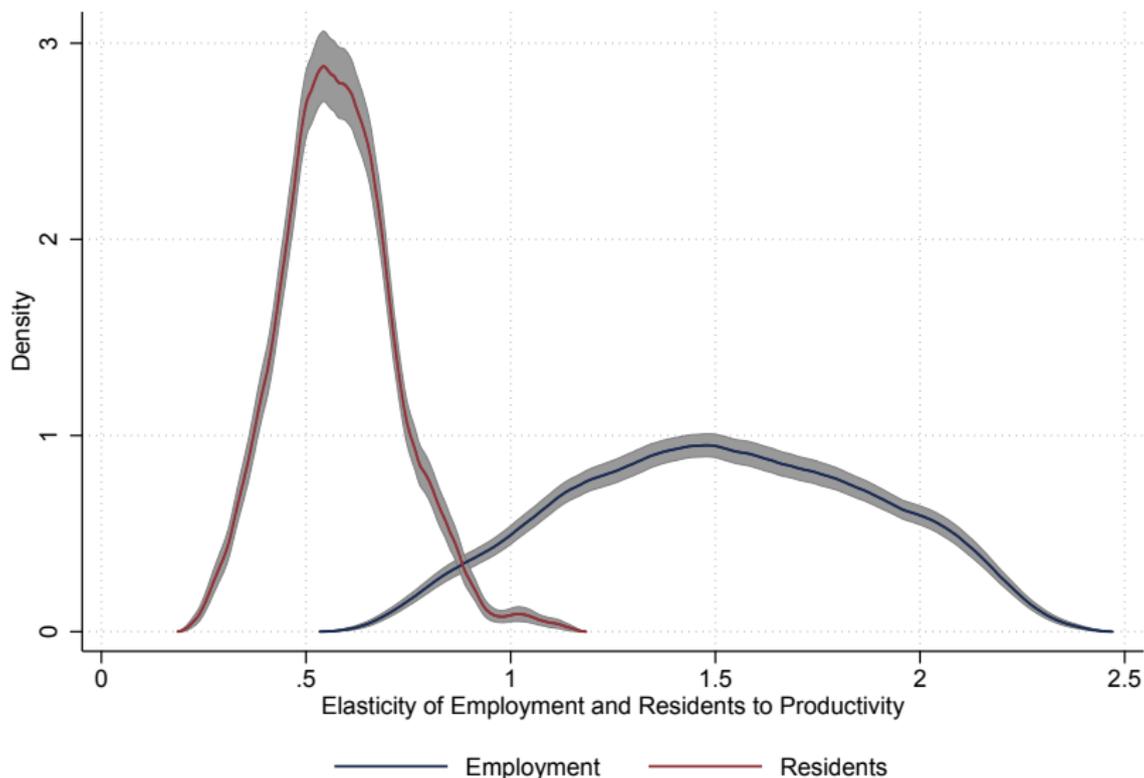
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

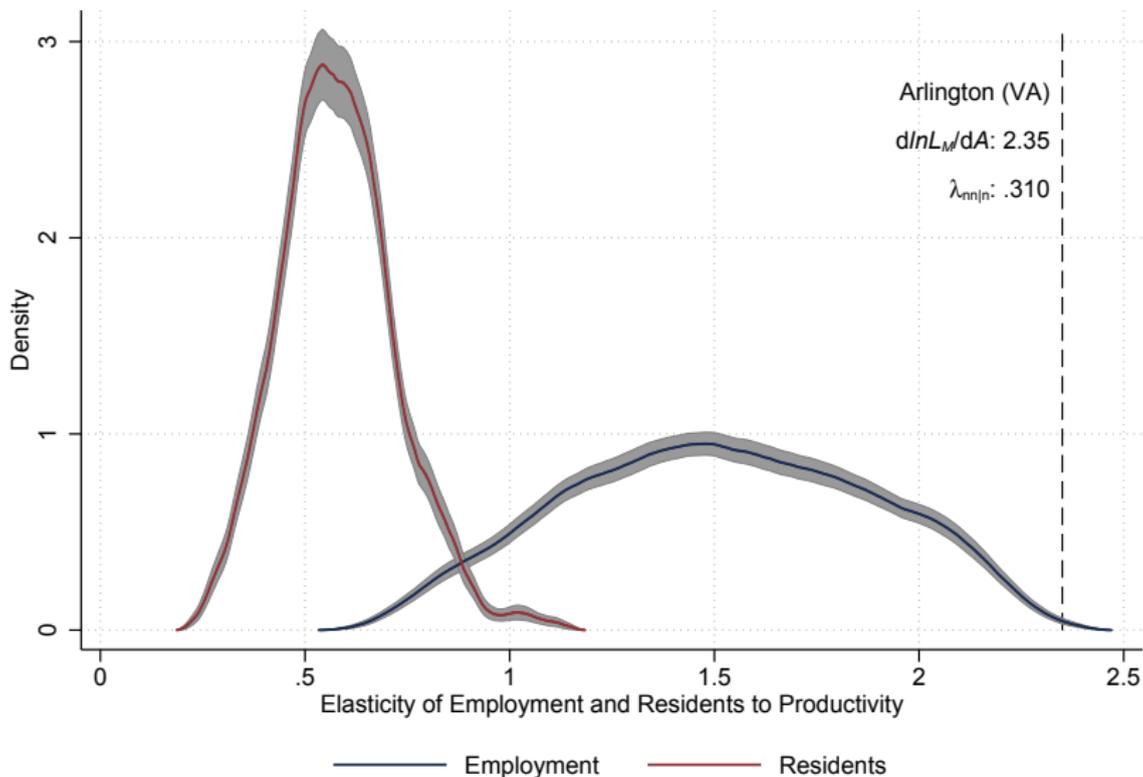
Local Employment vs. Resident Elasticity to Productivity

5% productivity shocks



Local Employment vs. Resident Elasticity to Productivity

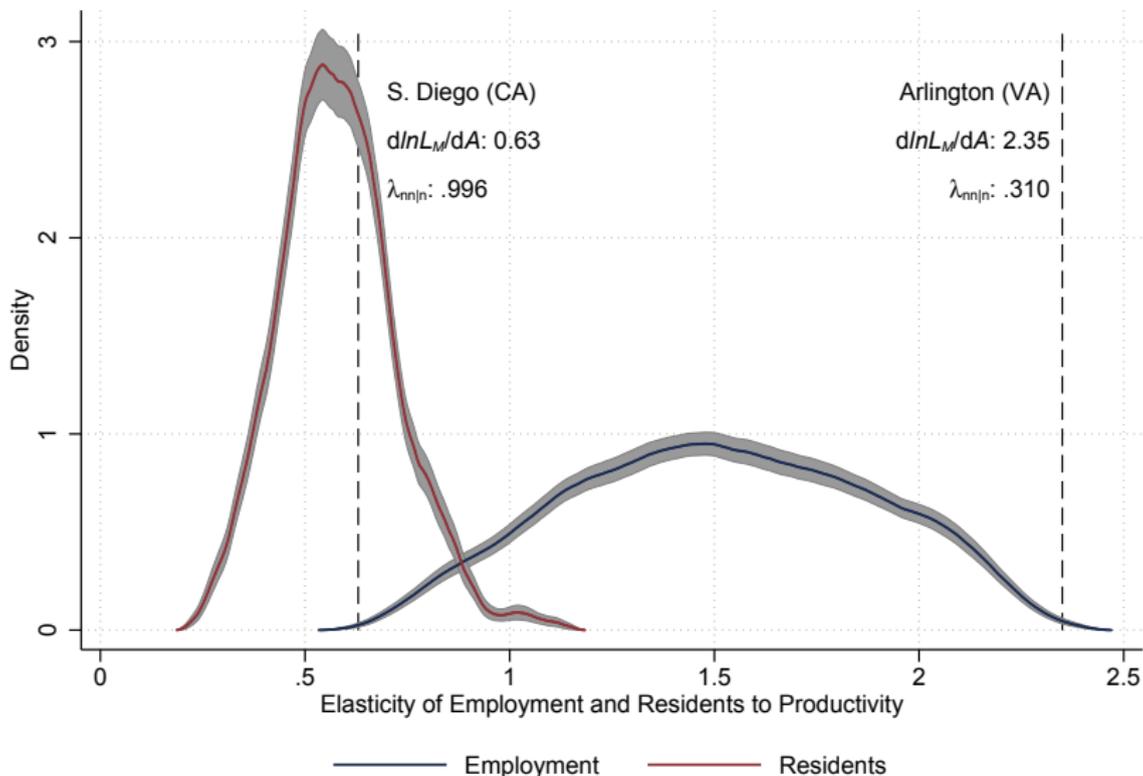
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Local Employment vs. Resident Elasticity to Productivity

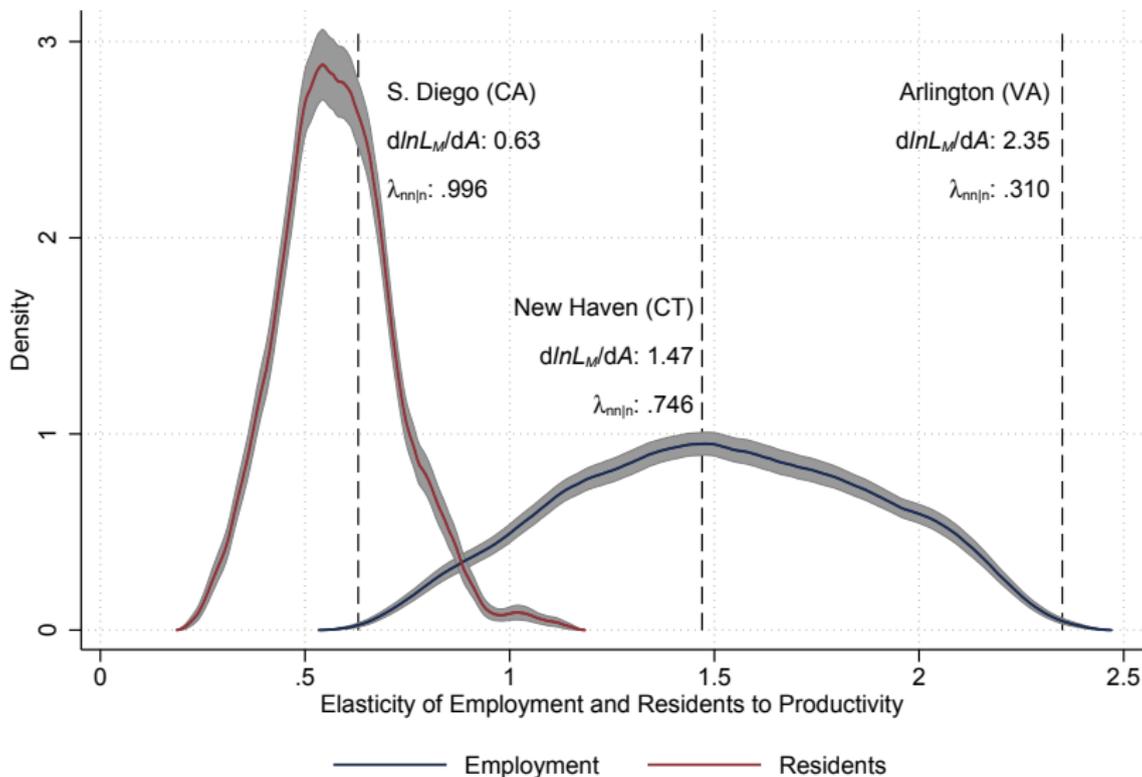
5% productivity shocks



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Local Employment vs. Resident Elasticity to Productivity

5% productivity shocks



Eliminating bottom and top 0.5%, gray area: 95% bootstrapped CI

Explaining The Elasticity of Employment

Dependent Variable:	1	2	3	4	5	6	7	8	9
	Elasticity of Employment								
$\log L_{Mn}$		-0.003 (0.005)	0.009* (0.004)	-0.054** (0.005)				0.037** (0.002)	0.033** (0.002)
$\log w_n$			-0.201** (0.028)	-0.158** (0.027)				-0.257** (0.009)	-0.263** (0.009)
$\log H_n$			-0.288** (0.006)	-0.172** (0.009)				0.003 (0.003)	0.009** (0.003)
$\log L_{M,-n}$				0.118** (0.007)				-0.027** (0.003)	-0.027** (0.003)
$\log \bar{w}_{-n}$				0.204** (0.047)				0.163** (0.015)	0.207** (0.015)
$\lambda_{nn n}$					-2.047** (0.013)				
$\sum_{r \in N} (1 - \lambda_{rn r}) \vartheta_{rn}$						2.784** (0.092)		2.559** (0.098)	
$\vartheta_{nn} \left(\frac{\lambda_{nn}}{\lambda_{Rn}} - \lambda_{Mn} \right)$						0.915** (0.090)		0.605** (0.096)	
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n}$						-1.009** (0.046)		-0.825** (0.053)	
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n} \cdot \sum_{r \in N} (1 - \lambda_{rn r}) \vartheta_{rn}$							1.038** (0.036)		1.100** (0.048)
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n} \cdot \vartheta_{nn} \left(\frac{\lambda_{nn}}{\lambda_{Rn}} - \lambda_{Mn} \right)$							-0.818** (0.036)		-0.849** (0.047)
constant	1.515** (0.007)	1.545** (0.044)	5.683** (0.275)	1.245** (0.437)	2.976** (0.009)	0.840** (0.084)	1.553** (0.035)	1.861** (0.171)	2.064** (0.152)
R^2	0.00	0.00	0.40	0.51	0.89	0.93	0.93	0.95	0.95
N	3,111	3,111	3,111	3,081	3,111	3,111	3,111	3,081	3,081

* $p < 0.05$; ** $p < 0.01$.

► Standardized

► Spatially Correlated Shocks

► More

Deviation in Diff-in-Diff Estimates

- We estimate

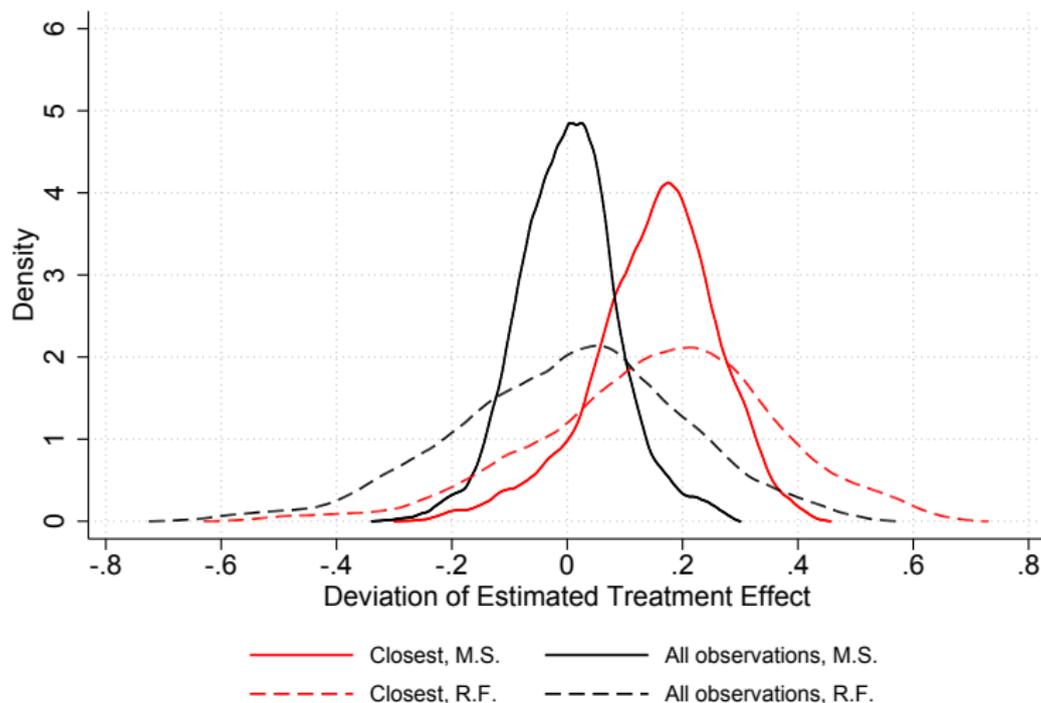
$$\Delta \ln L_{Mi} = a_0 + a_1 \mathbb{I}_i + a_2 X_i + a_3 (\mathbb{I}_i \times X_i) + u_i$$

- Using different comparison sets of “control counties”
 - ▶ Closest county, random county, neighbors, non neighbors, all counties
- Using two sets of controls
 - ▶ *Reduced-form controls*: land, employment, residents, workplace wages, employment and wages in neighboring areas
 - ▶ *Model-suggested controls*: partial equilibrium elasticities for commuting, migration, and goods market linkages
- Compute the deviation as

$$\beta_i = \frac{(a_1 + a_3 X_i)}{dA_i} - \frac{dL_{Mi}}{dA_i} \frac{A_i}{L_{Mi}}$$

Distribution of Deviations in Diff-in-Diff Estimates

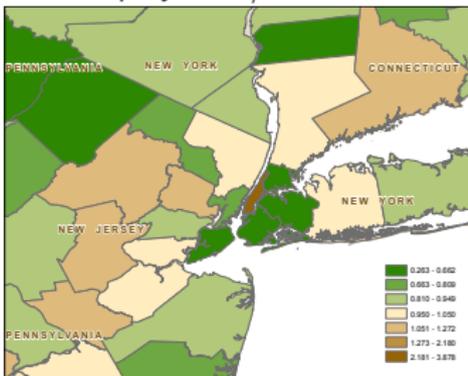
Using “closest county” and “all observations” control groups



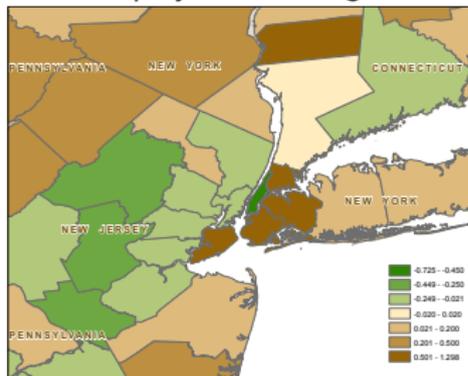
Eliminating bottom and top 0.5%; M.S.: model-suggested controls; R.F.: reduced-form controls

Shutting Down Commuting: the NY Area

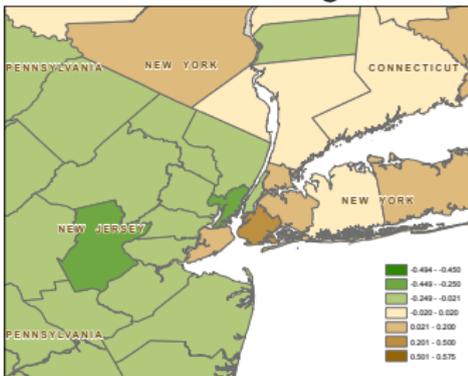
employment/residents



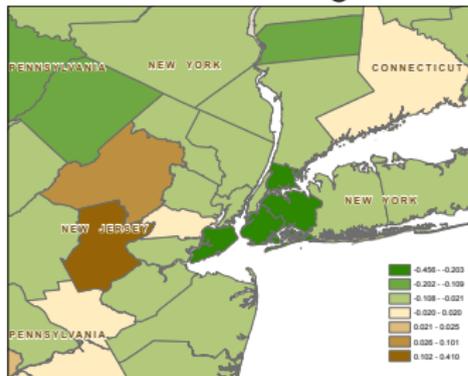
employment change



residents change



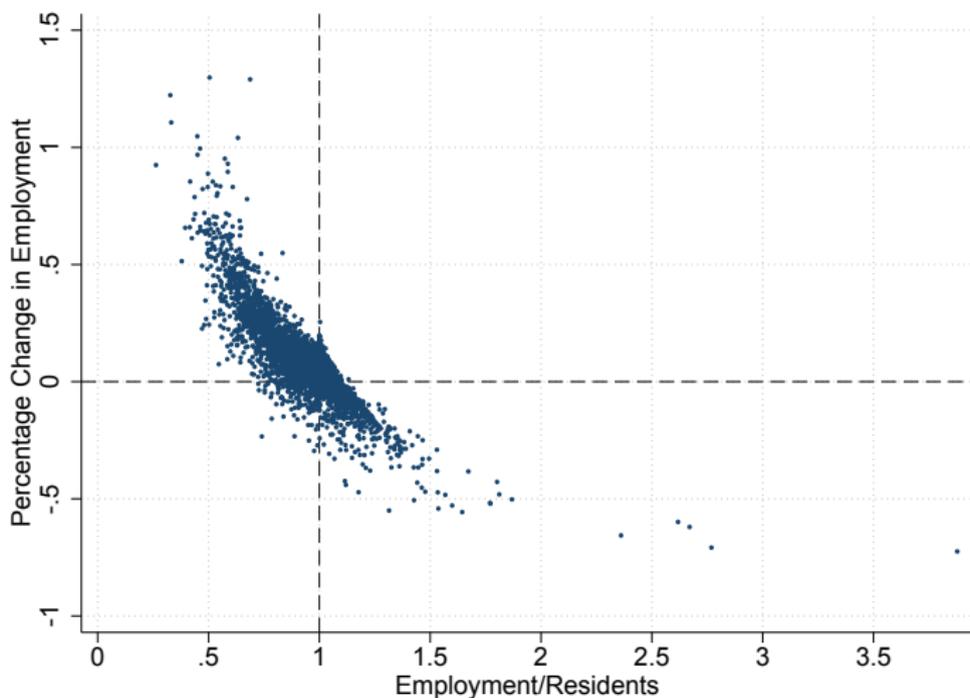
real income change



Change in Employment and Importance of Commuting

Shutting down commuting

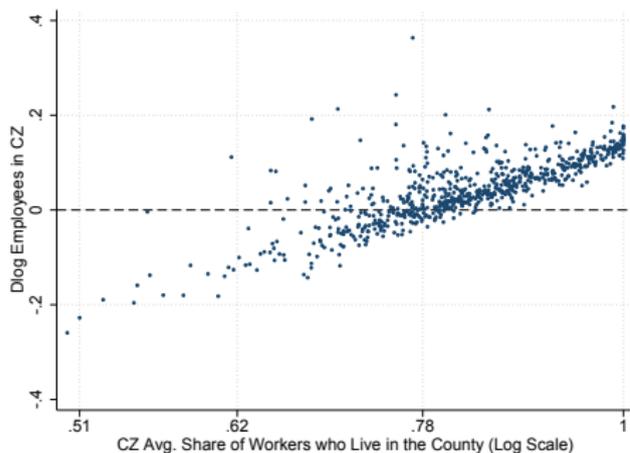
- The welfare cost of shutting down commuting is 7.2%



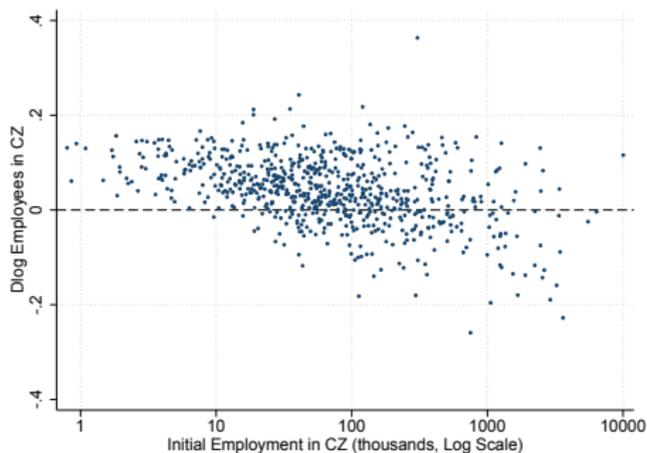
Change in CZ Employment

Shutting down commuting

importance of commuting



size



► Importance of Commuting

► Change in CZ Residents

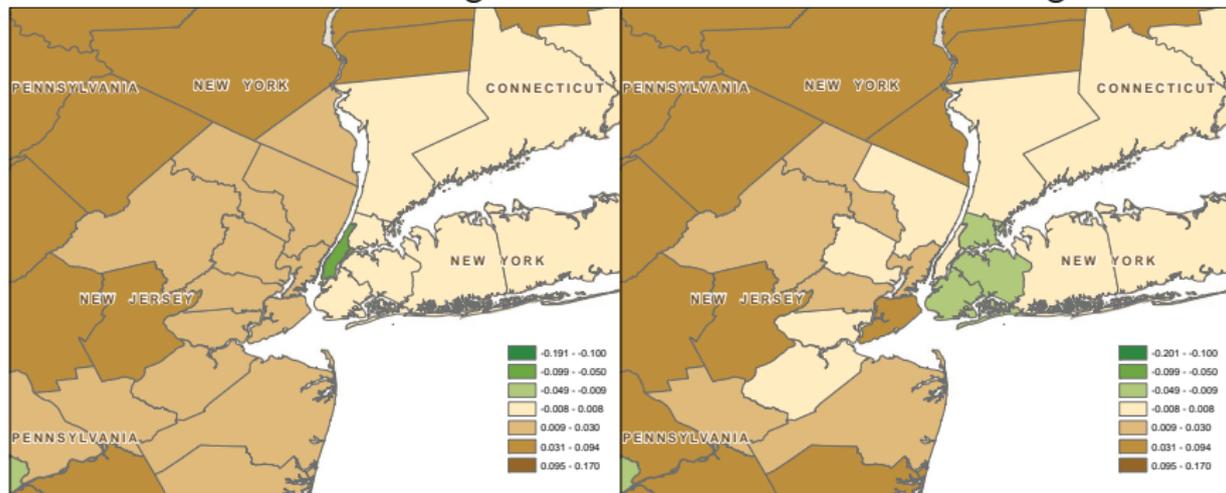
► Commuting and Size

The Interaction Between Trade and Commuting Costs

20% reduction in trade costs: effects on employment in the NY area

without commuting

with commuting



► Residents

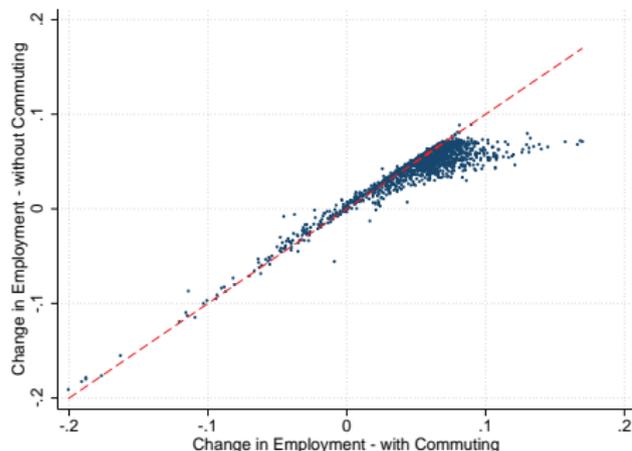
► Land Prices

► Real Income

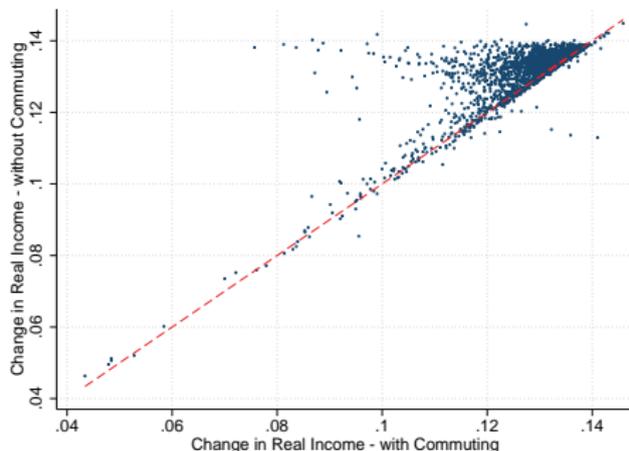
The Interaction Between Trade and Commuting Costs

20% reduction in trade costs: effects on employment and real income across counties

employment



real income



- As a result of 20% reduction in trade costs welfare gains are
 - ▶ 11.56% without commuting
 - ▶ 11.66% with commuting

Conclusions

- Study changes in local employment in response to local shocks
 - ▶ To do so we introduced migration and commuting into a spatial GE model
- Found that local employment elasticities are very heterogenous
 - ▶ Puts into question the external validity of empirical estimates of any single local employment elasticity
- Heterogeneity in commuting patterns important in generating the heterogeneity in employment elasticities
 - ▶ The model suggests simple controls to recover such heterogeneity
 - ▶ Underscores the importance of GE effects
- Emphasize the role of commuting to determine
 - ▶ the spatial distribution of economic activity
 - ▶ the consequences of reduction in trade costs

Existence and Uniqueness

Systems of $2N$ equations for $2N$ unknown values of $\{\mathbf{w}, \mathbf{L}_R\}$.

$$w_n^\sigma A_n^{1-\sigma} = \bar{W} \frac{1-\sigma}{\sigma F} \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} \left[\sum_{k \in N} \bar{w}_k \frac{\sigma-1}{\alpha} L_{Rk}^{1-(\sigma-1)\left(\frac{1}{\alpha\bar{\epsilon}} + \frac{1-\alpha}{\alpha}\right)} \bar{v}_k^{1-(\sigma-1)\left(\frac{1-\alpha}{\alpha}\right)} H_k^{(\sigma-1)\left(\frac{1-\alpha}{\alpha}\right)} d_{kn}^{1-\sigma} \right].$$

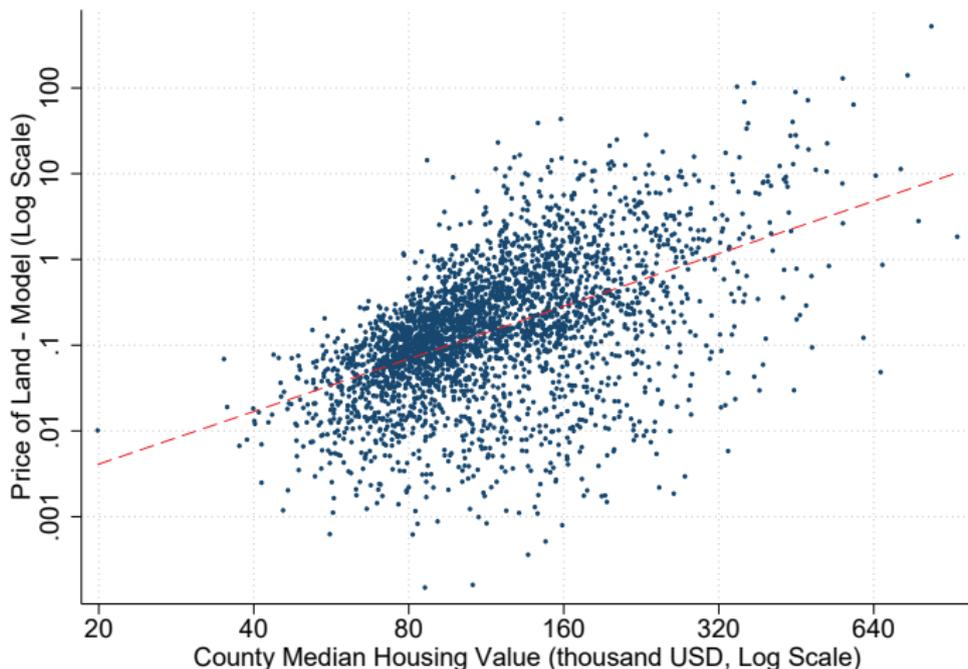
$$\begin{aligned} \bar{w}_n \frac{1-\sigma}{\alpha} \bar{v}_n^{-(1-\sigma)\left(\frac{1-\alpha}{\alpha}\right)} H_n^{(1-\sigma)\left(\frac{1-\alpha}{\alpha}\right)} L_{Rn}^{-(1-\sigma)\left(\frac{1}{\alpha\bar{\epsilon}} + \frac{1-\alpha}{\alpha}\right)} \\ = \bar{W} \frac{1-\sigma}{\alpha} \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} \left\{ \sum_{k \in N} \left[\sum_{r \in N} \frac{B_{rn}(w_n/\kappa_{rn})^\epsilon}{\sum_{s \in N} B_{rs}(w_s/\kappa_{rs})^\epsilon} L_{Rr} \right] \left(\frac{d_{nk} w_k}{A_k} \right)^{1-\sigma} \right\}. \end{aligned}$$

Can show that this system has a unique fixed point.

► Back

Land Prices in Model vs. House Prices in Data

- Correlation: 0.51



Dashed line: linear fit; slope: 2.04

Explaining The Elasticity of Employment

Standardized

	1	2	3	4	5	6	7	8	9
Dependent Variable:	Elasticity of Employment								
$\log L_{Mn}$		-0.012 (0.018)	0.036* (0.018)	-0.217** (0.019)				0.147** (0.008)	0.132** (0.008)
$\log w_n$			-0.126** (0.018)	-0.100** (0.017)				-0.162** (0.006)	-0.166** (0.006)
$\log H_n$			-0.621** (0.014)	-0.372** (0.019)				0.007 (0.007)	0.020** (0.007)
$\log L_{M,-n}$				0.429** (0.027)				-0.097** (0.009)	-0.097** (0.010)
$\log \bar{w}_{-n}$				0.090** (0.021)				0.072** (0.007)	0.091** (0.007)
$\lambda_{nn n}$					-0.945** (0.006)				
$\sum_{r \in N} (1 - \lambda_{rn r}) \vartheta_{rn}$						1.462** (0.048)		1.343** (0.051)	
$\vartheta_{nn} \left(\frac{\lambda_{nn}}{\lambda_{Rn}} - \lambda_{Mn} \right)$						0.487** (0.048)		0.322** (0.051)	
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n}$						-0.110** (0.005)		-0.090** (0.006)	
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n} \cdot \sum_{r \in N} (1 - \lambda_{rn r}) \vartheta_{rn}$							0.544** (0.019)		0.576** (0.025)
$\frac{\partial w_n}{\partial A_n} \frac{A_n}{w_n} \cdot \vartheta_{nn} \left(\frac{\lambda_{nn}}{\lambda_{Rn}} - \lambda_{Mn} \right)$							-0.428** (0.019)		-0.444** (0.025)
constant	-0.000 (0.018)	-0.000 (0.018)	0.000 (0.014)	0.000 (0.013)	-0.000 (0.006)	0.000 (0.005)	-0.000 (0.005)	-0.006 (0.004)	-0.006 (0.004)
R^2	0.00	0.00	0.40	0.51	0.89	0.93	0.93	0.95	0.95
N	3,111	3,111	3,111	3,081	3,111	3,111	3,111	3,081	3,081

Dependent variables and all regressors are standardized. * $p < 0.05$; ** $p < 0.01$.

Local Employment Elasticities and Productivity Shocks

5% productivity shocks

- Goods and labor market clearing imply that

$$w_i L_{Mi} = \sum_{n \in N} \pi_{ni} v_n L_{Rn} \quad \text{and} \quad L_{Mi} = \sum_{n \in N} \lambda_{ni|n} L_{Rn}$$

- Partial equilibrium elasticities:

$$\frac{\partial L_{Mi}}{\partial A_i} \frac{A_i}{L_{Mi}} = \frac{\partial L_{Mi}}{\partial w_i} \frac{w_i}{L_{Mi}} \cdot \frac{\partial w_i}{\partial A_i} \frac{A_i}{w_i}$$

- ▶ Not GE, since holding w_{-i} , P , v constant
- ▶ $\frac{\partial L_{Mi}}{\partial w_i} \frac{w_i}{L_{Mi}} = \epsilon \sum_{n \in N} \left(1 - \lambda_{ni|n}\right) \frac{\lambda_{ni|n} L_{Rn}}{L_{Mi}} + \left(\frac{\partial L_{Ri}}{\partial w_i} \frac{w_i}{L_{Ri}}\right) \frac{\lambda_{ii|i} L_{Ri}}{L_{Mi}}$
- ▶ $\frac{\partial w_i}{\partial A_i} \frac{A_i}{w_i} = \frac{(\sigma-1) \sum_{n \in N} (1 - \pi_{ni}) \alpha_{ni}}{[1 + (\sigma-1) \sum_{n \in N} (1 - \pi_{ni}) \alpha_{ni}] + [1 - \sum_{n \in N} (1 - \pi_{ni}) \alpha_{ni}] \frac{\partial L_{Mi}}{\partial w_i} \frac{w_i}{L_{Mi}} - \alpha_{ii} \frac{\partial L_{Ri}}{\partial w_i} \frac{w_i}{L_{Ri}}}$
- ▶ $\frac{\partial L_{Ri}}{\partial w_i} \frac{w_i}{L_{Ri}} = \frac{\epsilon \left(\frac{\lambda_{ii}}{\lambda_{Ri}} - \lambda_{Mi}\right)}{1 + \epsilon(1 - \alpha)(1 - \lambda_{Ri})}$

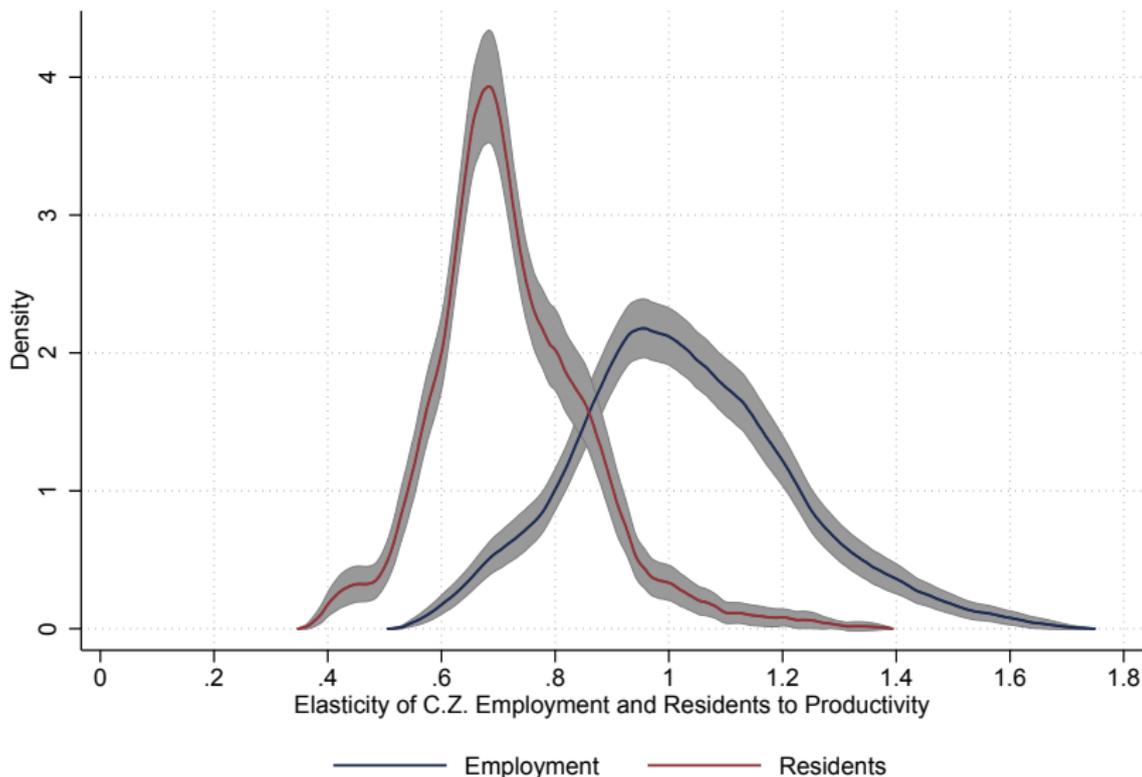
▶ Back

Literature on Local Labor Demand Shocks

- Large empirical literature on local labor demand shocks
 - ▶ Blanchard and Katz (1992): measure labor demand shocks using innovations in employment
 - ▶ Bound and Holzer (2000): measure labor demand shocks using total local hours and industry composition as in Bartik (1991)
 - ▶ Greenstone, Hornbeck and Moretti (2010): million-dollar plants
 - ▶ Michaels (2011): oil abundance in Southern USA
 - ▶ Yagan (2014): great recession
 - ▶ Notowidigdo (2013): industry composition as in Bartik (1991)

Local Employment vs. Resident Elasticity to Productivity

5% productivity shocks to Commuting Zones

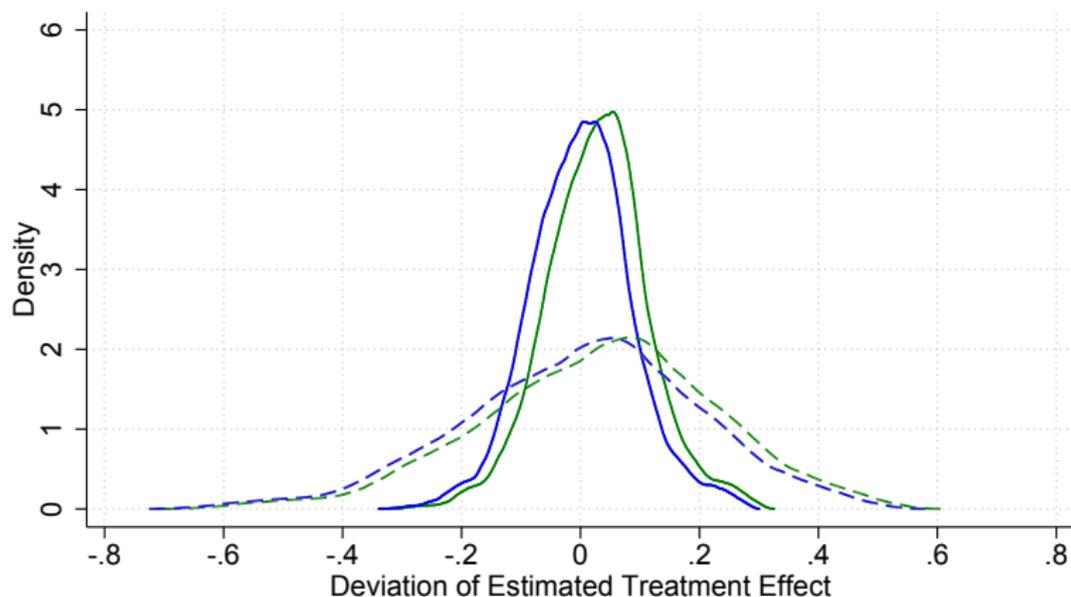


▶ Back

Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Distribution of Deviations in Diff-in-Diff Estimates

Using “neighbors”, “non-neighbors” and “random county” control groups



— Neighbors, M.S. — Non-Neighbors, M.S. — Random, M.S.
- - - Neighbors, R.F. - - - Non-Neighbors, R.F. - - - Random, R.F.

Eliminating bottom and top 0.5%; M.S.: model-suggested controls; R.F.: reduced-form controls
Densities using Non-Neighbors and Random controls are visually indistinguishable

Greenstone-Hornbeck-Moretti

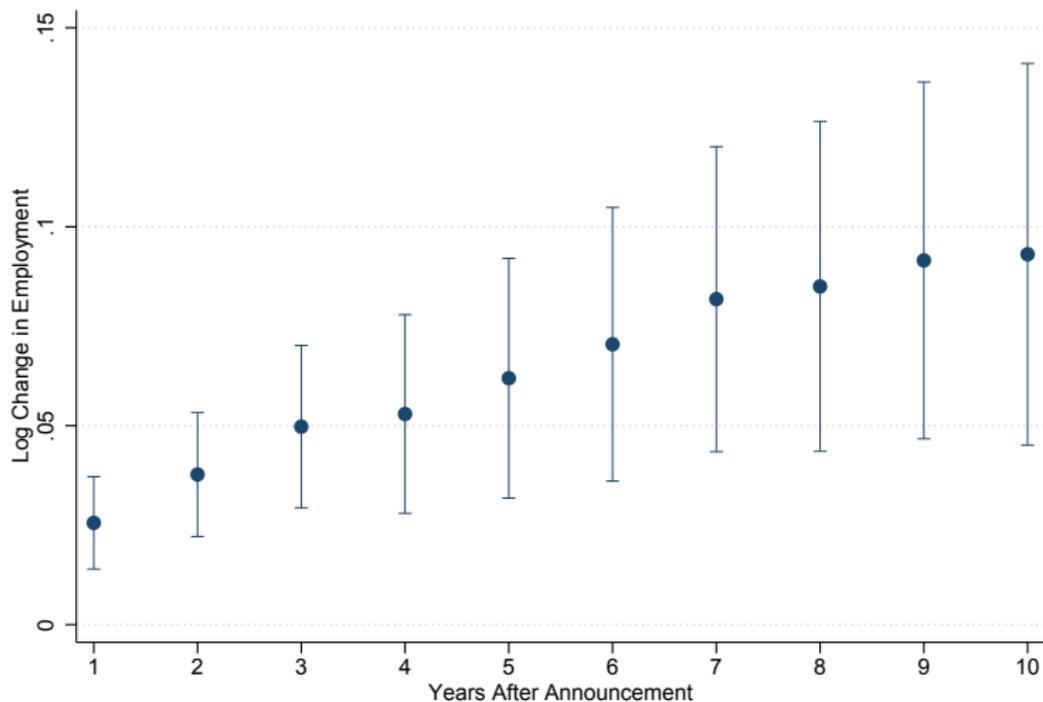
- Announcements of Million Dollar Plants (MDP)
 - ▶ Winning county where new firm locates
 - ▶ Runner-up counties (losing counties)
- 82 MDP announcements from Greenstone and Moretti (2004)
 - ▶ Greenstone, Hornbeck and Moretti (2010) use subset of 47 MDP openings that could be located in (confidential) Census data
 - ▶ We use (publicly available) 82 announcements
- Difference-in-Difference specification
 - ▶ Before and after plant opening (at different time intervals)
 - ▶ Between winning and losing counties
- We run

$$\Delta \ln Y_{nkt} = \alpha \mathbb{I}_{nk} + \beta \lambda_{nn|n} + \gamma (\lambda_{nn|n} \times \mathbb{I}_{nk}) + \mu_k + \varepsilon_{nkt}$$

- ▶ $\Delta \ln Y_{nkt}$: change in log employment t years after announcement
- ▶ \mathbb{I}_{nk} : dummy for winning county in case k
- ▶ $\lambda_{nn|n}$: share of residents working in county n in 1990
- ▶ μ_k : case fixed-effect

Greenstone-Hornbeck-Moretti

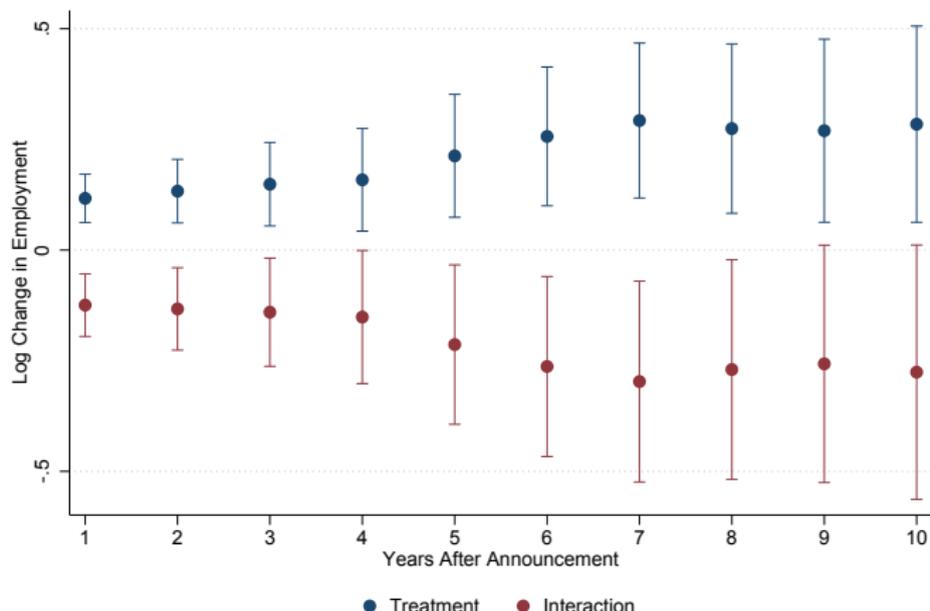
Only treatment



Range is 95% confidence interval
The average increase in adjusted r-squared over an case-dummies model is 9.3%

Greenstone-Hornbeck-Moretti

Treatment and interaction

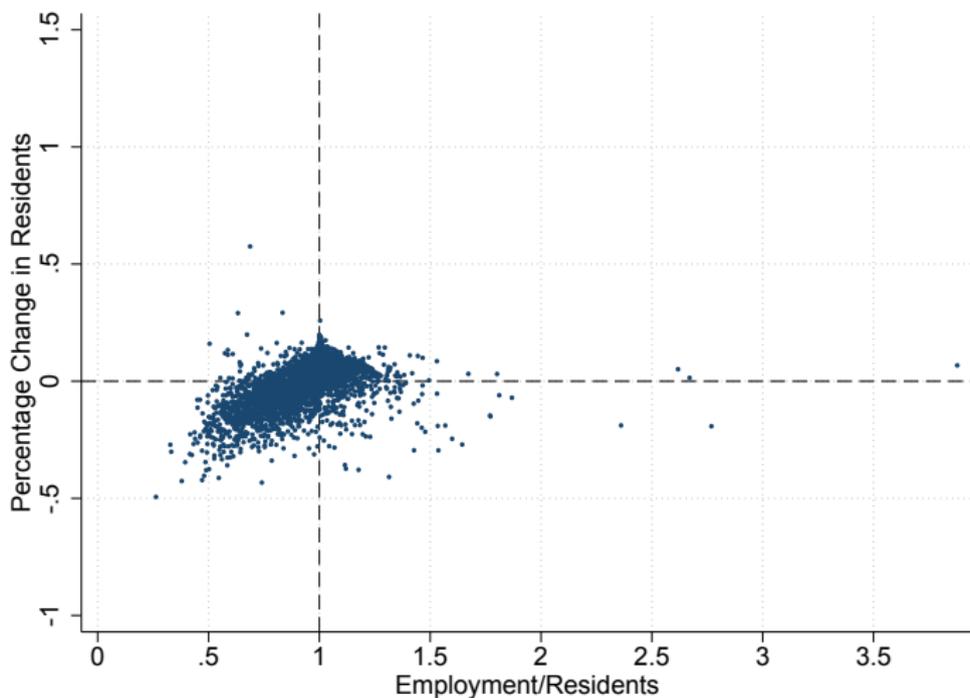


Range is 95% confidence interval
The average increase in adjusted r-squared over a dummies+treatment model is 10.2%

- Ratio treatment/interaction: 0.99 (on average) in GHM, 0.67 in our simulation

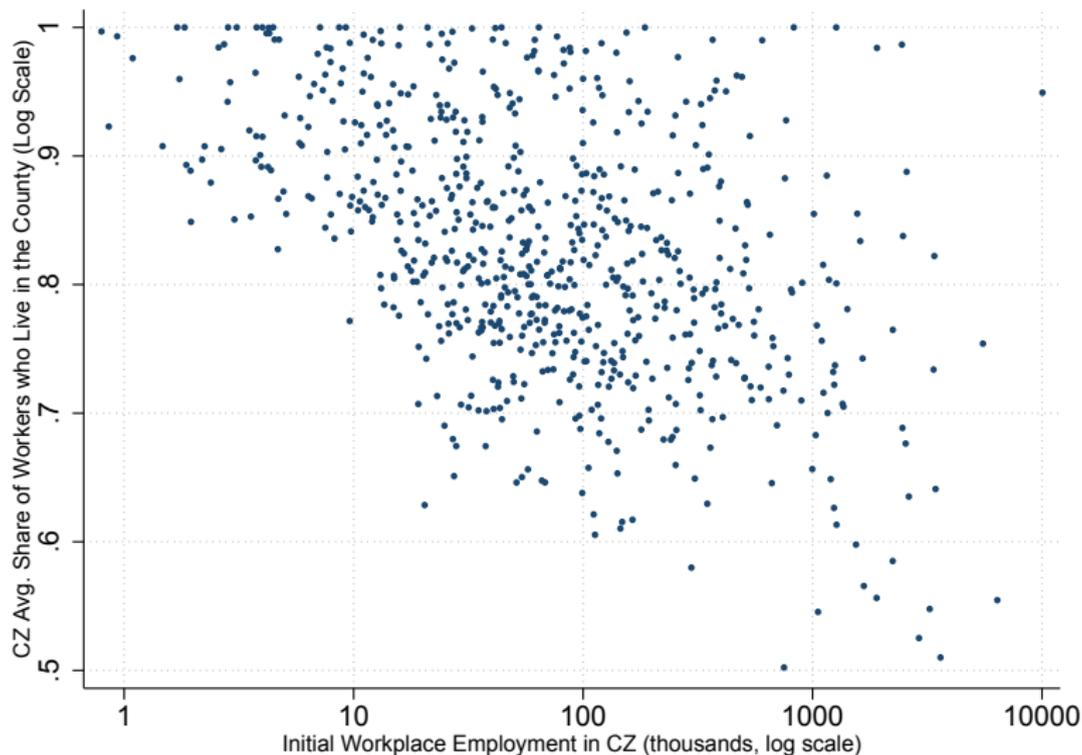
Change in Residence Empl. and Importance of Commuting

Shutting down commuting



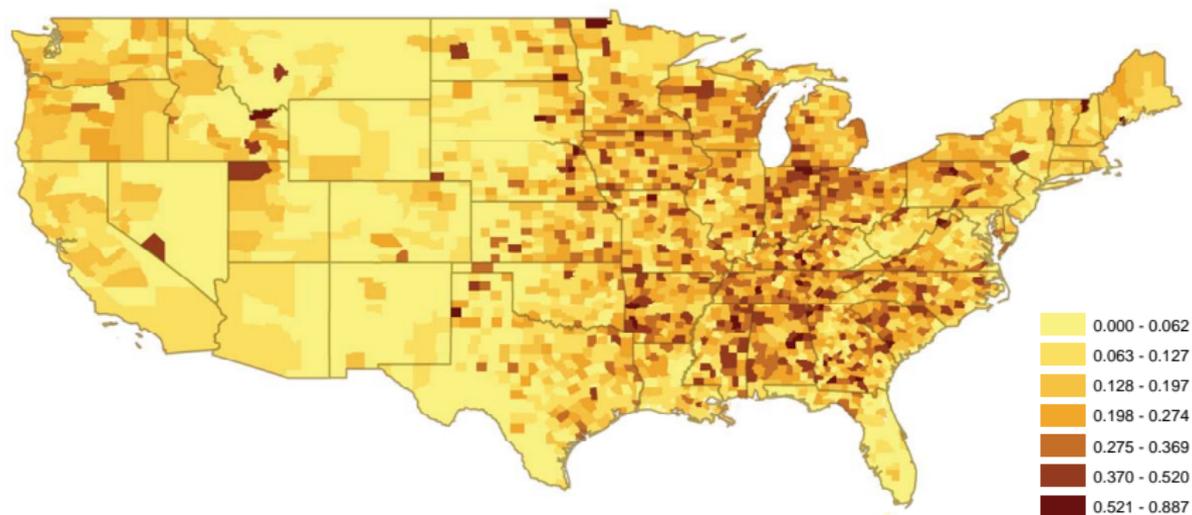
▶ Back

CZ Own-commuting vs initial workplace employment



Spatially Correlated Shocks

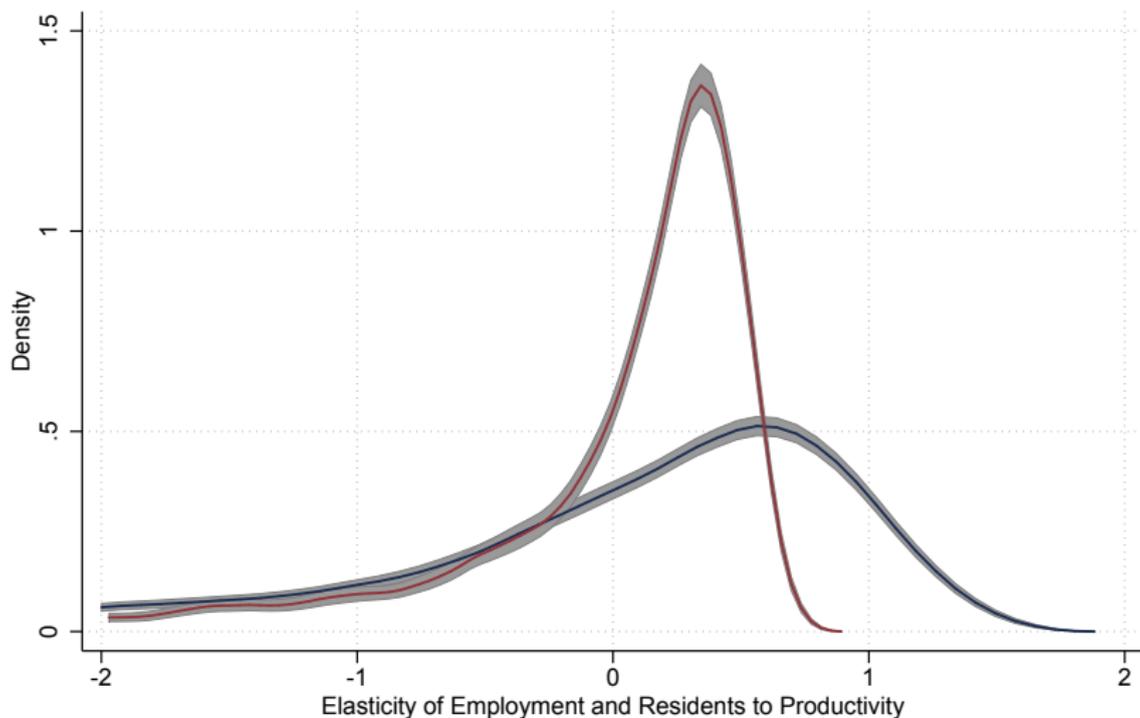
Shares of manufacturing employment across counties (2007)



▶ [Back to Main](#)

Spatially Correlated Shocks: Manufacturing

Elasticity to 6.2% manufacturing shock



► Non-mfg

► Back to Main

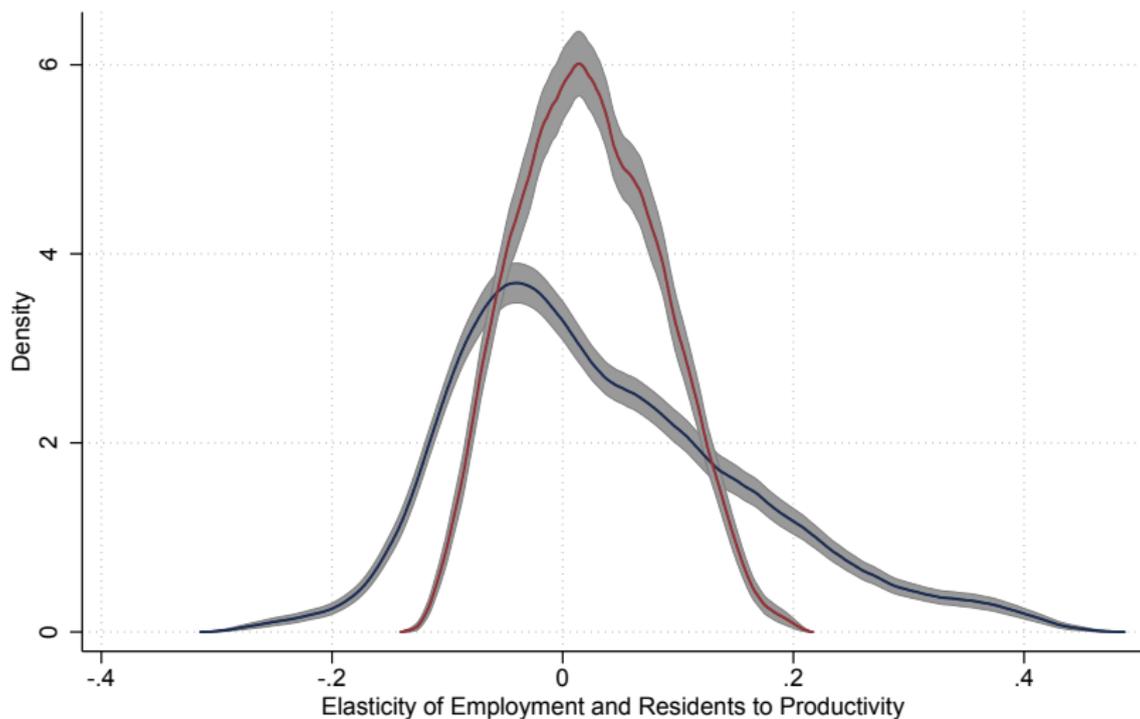
— Employment

— Residents

Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Spatially Correlated Shocks: All Sectors

Elasticity to 6.2% manufacturing and 3.1% non-manufacturing shock

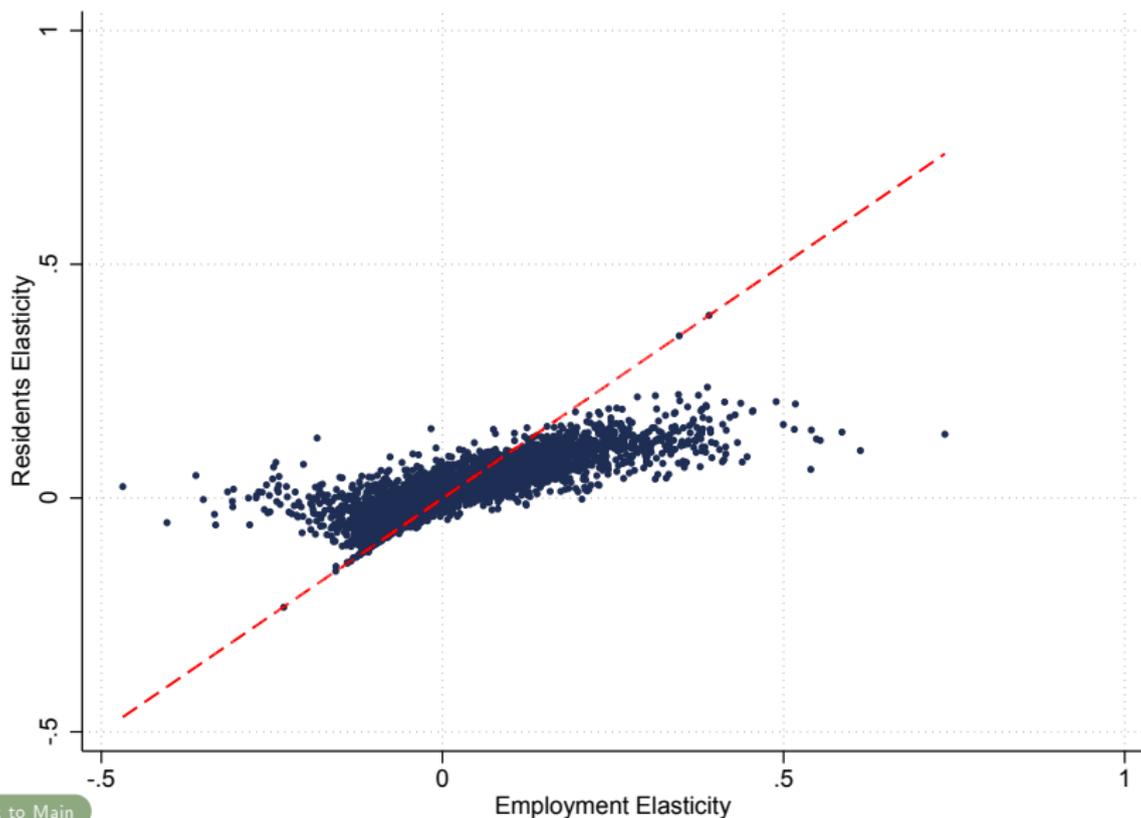


▶ Back to Main

— Employment — Residents

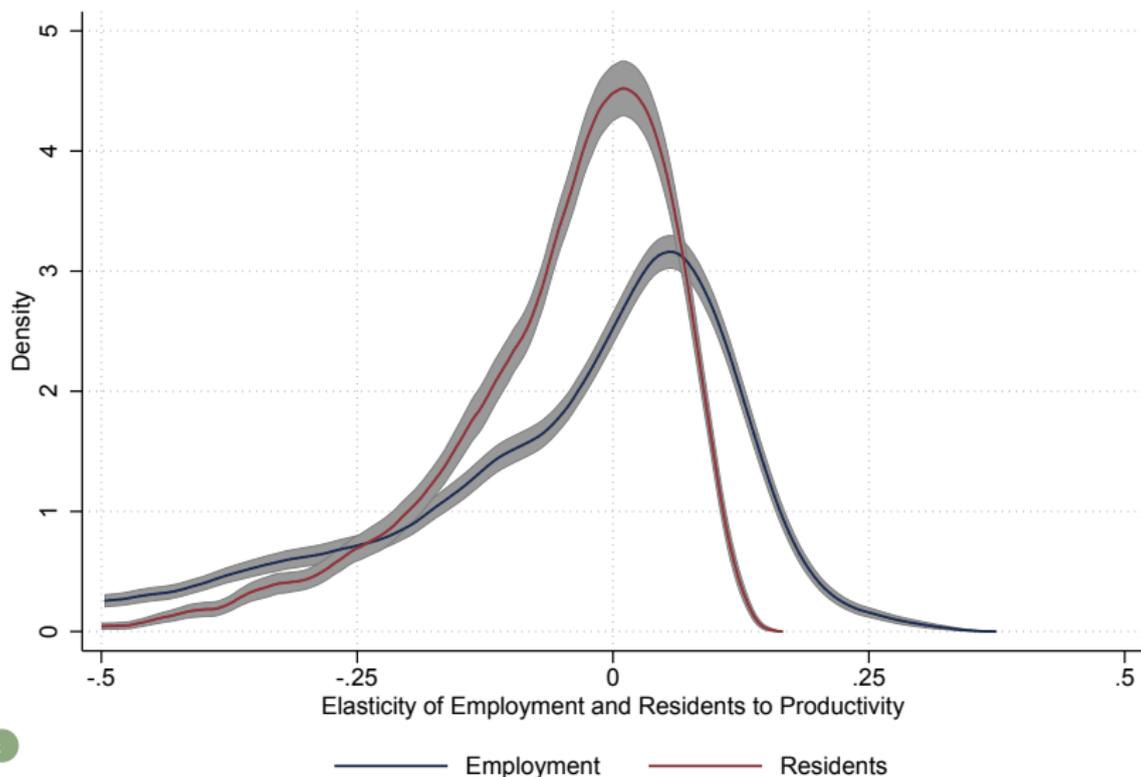
Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

Spatially Correlated Shocks: All Sectors



Spatially Correlated Shocks: Non-Manufacturing

Elasticity to 3.1% non-manufacturing shock



Eliminating bottom and top 0.5%; gray area: 95% bootstrapped CI

▶ Back

Explaining the Importance of Commuting

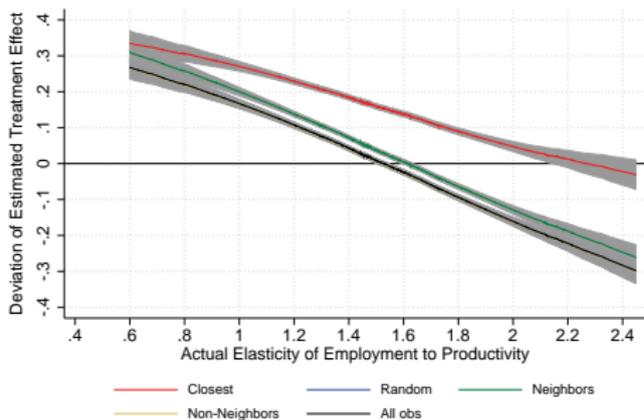
Dependent Variable:	1	2	3	4	5	6	7	8
	$\log L_{Mn}$	$\log L_{Rn}$	$\log L_{Mn}$	$\log L_{Rn}$	L_{Mn}/L_{Rn}	L_{Mn}/L_{Rn}	L_{Mn}/L_{Rn}	L_{Mn}/L_{Rn}
$\log L_{Rn}$	0.974** (0.003)		1.001** (0.004)		-0.000 (0.003)		0.020** (0.004)	
$\log w_n$	0.460** (0.018)		0.480** (0.018)			0.341** (0.018)		0.331** (0.018)
$\log L_{Mn}$		0.957** (0.003)		0.922** (0.004)		-0.001 (0.003)		0.028** (0.003)
$\log \bar{v}_n$		0.066** (0.025)		0.019 (0.026)	0.171** (0.023)		0.239** (0.025)	
$\log H_n$			0.015* (0.006)	0.037** (0.006)			-0.011 (0.006)	-0.022** (0.006)
$\log L_{R,-n}$			-0.020** (0.005)				0.609** (0.123)	0.389** (0.112)
$\log \bar{w}_{-n}$			-0.330** (0.032)				0.247 (0.240)	0.070 (0.218)
$\log L_{M,-n}$				0.084** (0.005)			-0.654** (0.122)	-0.435** (0.111)
$\log \bar{v}_{-n}$				0.044 (0.039)			-0.347 (0.242)	-0.238 (0.220)
Constant	-4.667** (0.174)	-0.165 (0.238)	-1.485** (0.301)	-1.199** (0.336)	-0.881** (0.223)	-2.647** (0.169)	-0.057 (0.338)	-0.262 (0.306)
R^2	0.98	0.98	0.99	0.98	0.03	0.16	0.15	0.30
N	3,111	3,111	3,081	3,081	3,111	3,111	3,081	3,081

In this table, $L_{M,-n} \equiv \sum_{r:d_{rn} \leq 120, r \neq n} L_{Mr}$ is the total employment in n neighbors whose centroid is no more than 120km away; $\bar{w}_{-n} \equiv \sum_{r:d_{rn} \leq 120, r \neq n} \frac{L_{Mr}}{L_{M,-n}} w_r$ is the weighed average of their workplace wage. Analogous definitions apply to $L_{R,-n}$ and \bar{v}_{-n} . * $p < 0.05$; ** $p < 0.01$.

Deviations vs. General Equilibrium Elasticities

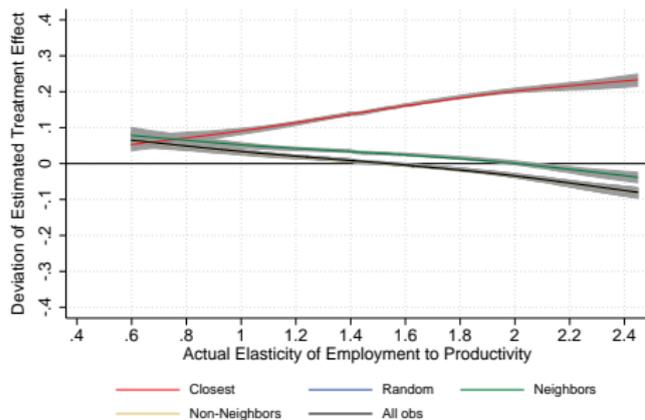
Comparing reduced-form and model-suggested controls

reduced-form controls



Lines of Non-Neighbors, Random and All Observations overlap
Gray area: 95% CI

model-suggested controls



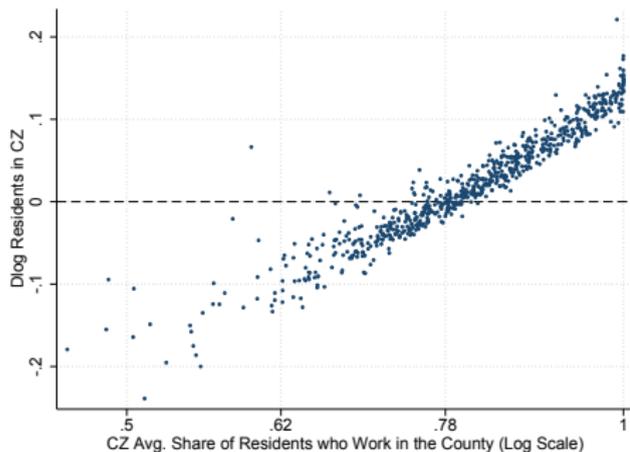
Lines of Non-Neighbors, Random and All Observations overlap
Gray area: 95% CI

▶ Back

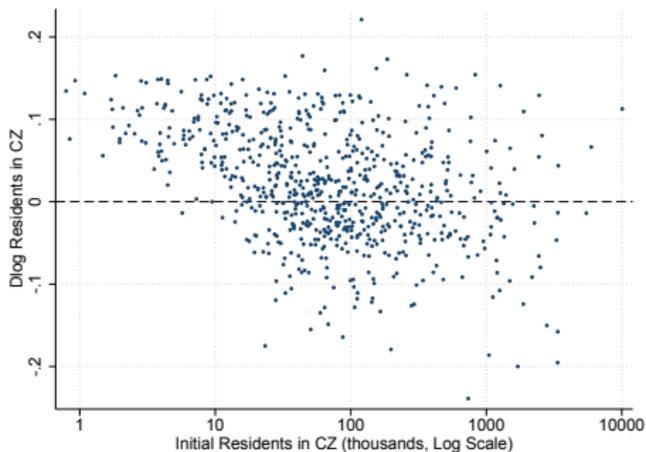
Change in CZ Residents

Shutting down commuting

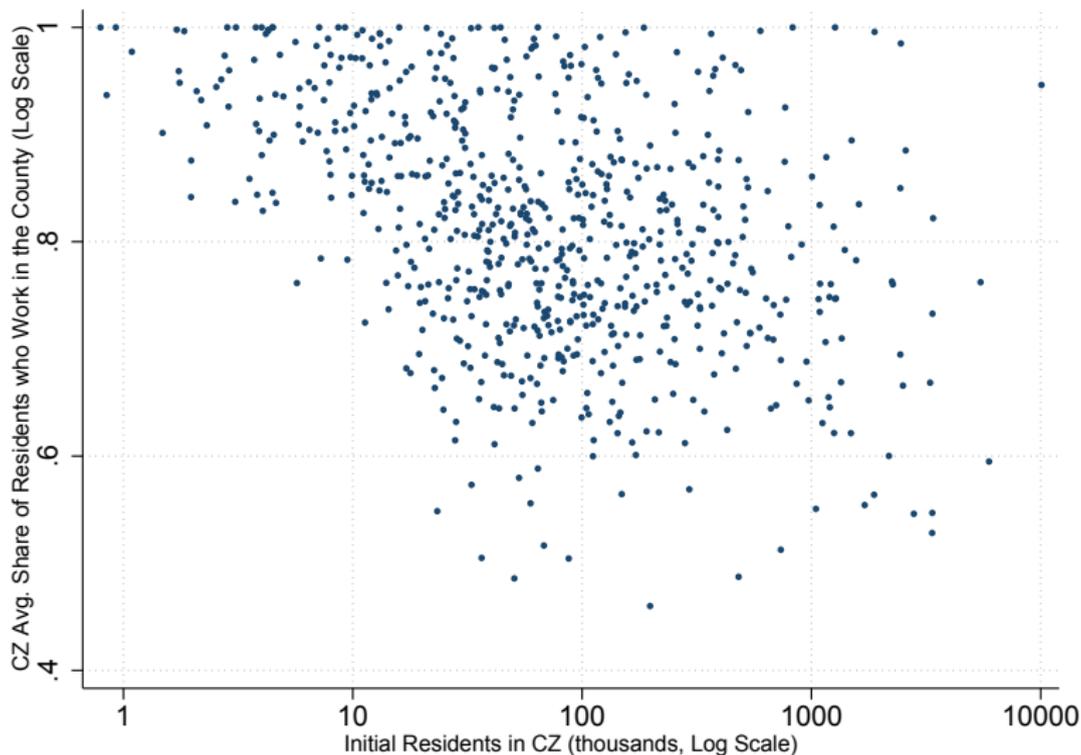
importance of commuting



size



CZ Own-commuting vs initial residence employment



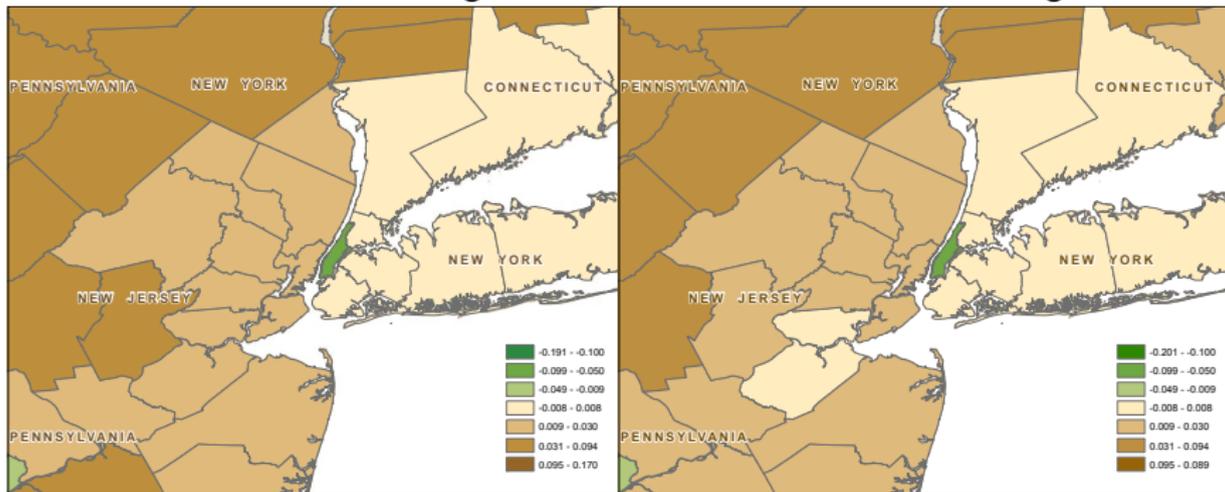
▶ Back

The Interaction Between Trade and Commuting Costs

20% reduction in trade costs: effects on residents in the NY area

without commuting

with commuting



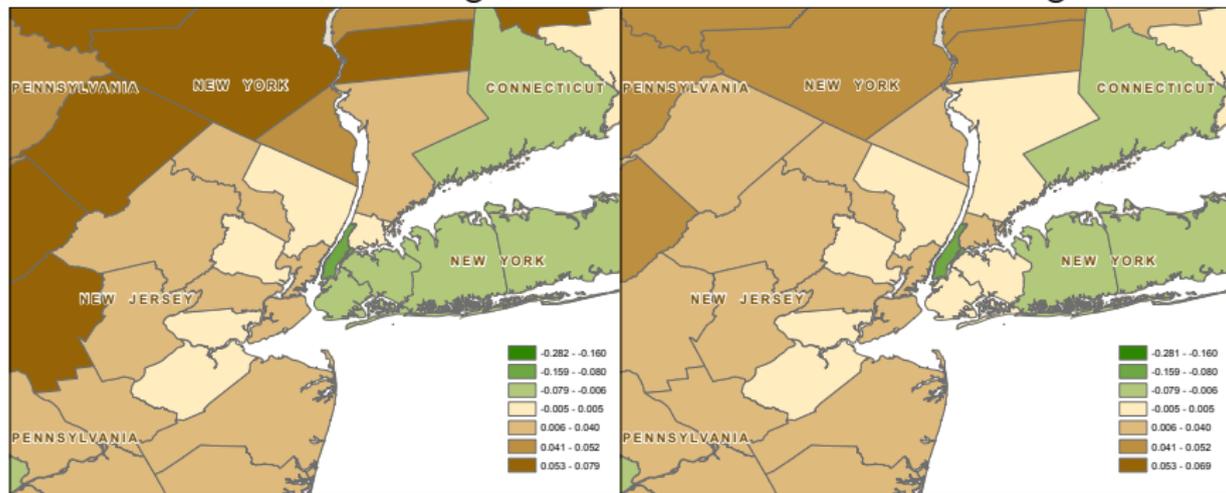
▶ Back

The Interaction Between Trade and Commuting Costs

20% reduction in trade costs: effects on land prices in the NY area

without commuting

with commuting



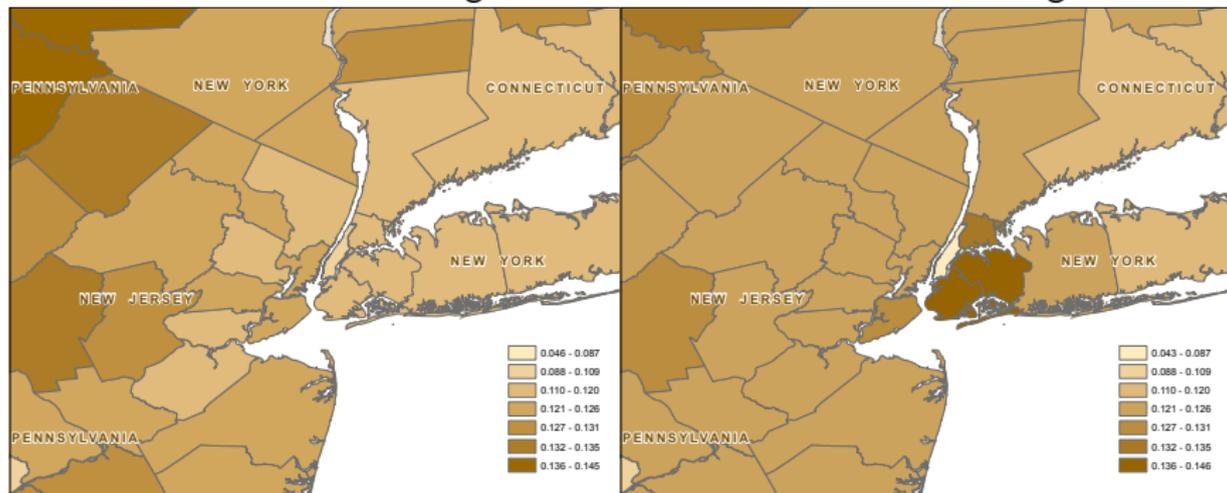
▶ Back

The Interaction Between Trade and Commuting Costs

20% reduction in trade costs: effects on real income in the NY area

without commuting

with commuting



▶ Back