Topic 8
ARSW (2015): Counterfactuals

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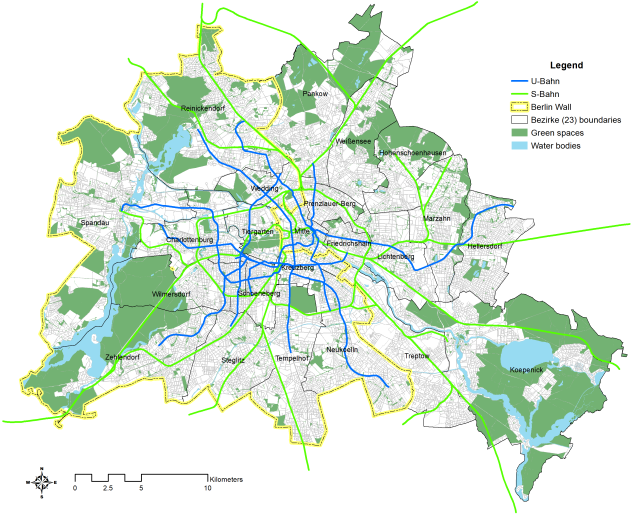
Introduction

Counterfactuals

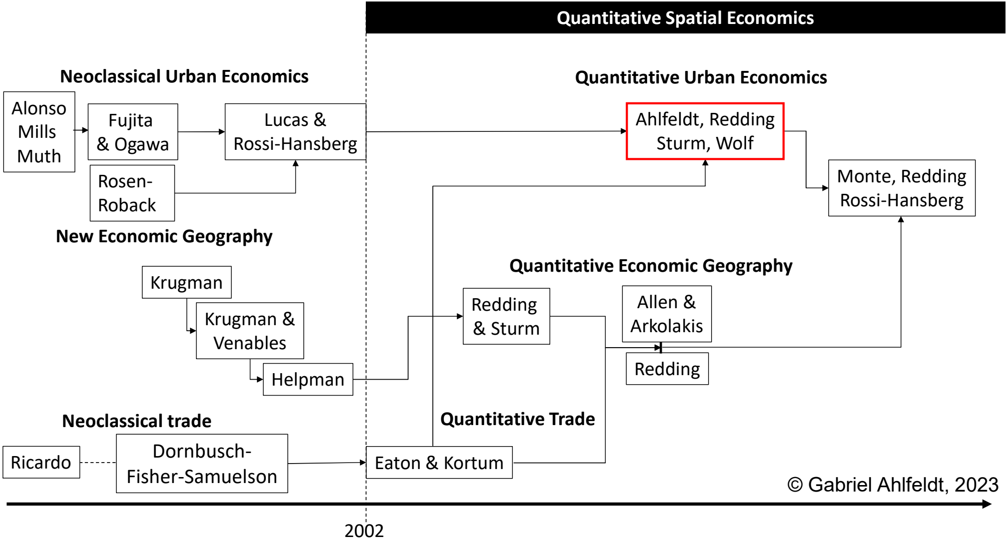
- **Reduced-form** models provide transparent evidence, but there are **limitations**
  - If a spatial policy attracts workers, these must come from somewhere
  - Hard to establish where they come from and what happens at those locations
  - Are there aggregate welfare effects?
- Key **strength of QSMs** is the ability to perform counterfactuals
  - in **general equilibrium**
  - accounting for **relocation** effects
    - Identify spatial winners and losers
  - Establishing **welfare** effects

Counterfactual

What will happen to the spatial structure if we ban cars?



History of thought



Roadmap

- **Topic 6**
  - Building blocks of the model
  - Reduced-form evidence
- **Topic 7**
  - Estimation
  - Inversion
- **Topic 8** (today)
  - Counterfactuals with exogenous fundamentals
  - Counterfactuals with agglomeration forces

Variants of the model

- **Exogenous fundamentals**
  - Unique equilibrium
- **Endogenous agglomeration forces**
  - $\{A_i, B_i\}$ depend on fundamentals and surrounding (endogenous) density
  - Multiple equilibria are theoretically possible
    - More likely if agglomeration forces are stronger
- **Closed city**
  - Total employment H is exogenous, utility $\bar{U}$ is endogenous
- **Open city**
  - Total employment H is endogenous, utility $\bar{U}$ is exogenous
- This lecture is closely connected to the ARSW **toolkit**, use it! ARSW2015-toolkit

Exogenous fundamentals

General equilibrium

- Given
  - Given the model's exogenous parameters $\{\alpha, \beta, \mu, \varepsilon, \kappa\}$
  - the exogenous reservation utility level $\bar{U}$ (or exogenous total employment H)
  - exogenous location characteristics $\{T_i, E_i, A_i, B_i, \varphi_i, K_i, \xi_i, \tau_{ij}\}$
- the **unique general equilibrium** of the model is referenced by
  - the endogenous objects $\{\pi_{Mi}, \pi_{Ri}, Q_i, q_i, w_i, \theta_i, H\}$ (or H instead of $\bar{U}$)
    - If we have them, we can compute all other objects

Need seven equations to bin down seven endogenous objects

Referencing the equilibrium

- The general equilibrium is referenced by the following seven equations
  1. Population mobility (9): $\mathbb{E}[u] = \gamma \left[\sum_{r=1}^{S} \sum_{s=1}^{S} T_{r,s} E_s \left(d_{rs} Q_r^{-\beta}\right)^{-\varepsilon} (B_r, w_s)^{\varepsilon}\right]^{1/\varepsilon} = \bar{U}$
  2. Residential choice probability (5): $\pi_{R_i} = \sum_{j=1}^{S} \pi_{ij} = \frac{\sum_{j=1}^{S} \Phi_{ij}}{\Phi}$
  3. Workplace choice probability (5): $\pi_{M_j} = \sum_{i=1}^{S} \pi_{ij} = \frac{\sum_{i=1}^{S} \Phi_{ij}}{\Phi}$
  4. Commercial land market clearing (18): $\left(\frac{(1-\alpha)A_j}{q_j}\right)^{1/\alpha} H_{M_j} = \theta_j L_j$
  5. Residential land market clearing (19): $\left(\frac{(1-\alpha)A_j}{q_j}\right)^{1/\alpha} H_{R_j} = \theta_j L_j$
  6. Profit maximization and zero profits (12): $q_j = (1-\alpha)\left(\frac{\alpha}{w_j}\right)^{\alpha/(1-\alpha)} A_j^{1/(1-\alpha)}$.
  7. No-Arbitrage between alternative uses of land (13): $\theta_i = \begin{cases} 1 & \text{if } q_i > \xi_i Q_i, \\ [0,1] & \text{if } q_i = \xi_i Q_i, \\ 0 & \text{if } q_i < \xi_i Q_i. \end{cases}$

Target variables

- System of equations that reference equilibrium solve for:
  - $\{\pi_{Mi}, \pi_{Ri}, Q_i, q_i, w_i, \theta_i, H\}$ (or H instead of $\bar{U}$)
- Need to solve the following target variables numerically
  - $\{q_i, Q_i, w_i.\theta_i\}$
- Use **recursive structure** to solve for the remaining non-target objects
  - Get H (or $\bar{U}$) from 1.
    - Notice that $H = \Phi$ corresponds to the term in brackets, see p. 18 in the supplement
  - Get π_{Ri} from 2.
    - Notice that $\Phi_{ij} = T_i E_j (d_{ij} Q_i^{1-\beta})^{-\varepsilon} (B_i w_j)^{\varepsilon}$, hence, we have all we need
  - Get π_{Mi} from 3.
    - Again, we have all we need since $\Phi_{ij} = T_i E_j (d_{ij} Q_i^{1-\beta})^{-\varepsilon} (B_i w_j)^{\varepsilon}$

Fixed-point solver (closed-city case)

- Treat the solution for $\{\pi_{Mi}, \pi_{Ri}, Q_i, q_i, \tilde{w}_i, \theta_i, \bar{U}\}$ as a **fixed-point problem**
  - Notice that we solve for adjusted (for workplace amenities) wages $\tilde{w}_i$
- Basic idea is as follows:
  - Start with **guessed values of the target objects** $\{Q_i^0, q_i^0, \tilde{w}_i^0, \theta_i^0\}$
  - **Solve for non-target objects** that reference the equilibrium $\{\pi_{Mi}, \pi_{Hi}, \bar{U}\}$
  - Use non-target objects to **predict target objects** $\{Q_i^1, q_i^1, \tilde{w}_i^1, \theta_i^1\}$
  - **Update guesses** to weighted combinations of old guesses '^{0}' and predicted values '^{1}'
  - Iterate until guesses no longer change

Cookbook for fixed-point solver

Algorithm 1: Solving for the equilibrium for given primitives: `smodexog.m`

Data: Given values of structural parameters $\{\alpha, \beta, \kappa, \varepsilon\}$, bilateral travel times τ_{ij}, inverted adjusted productivity, adjusted amenity, and floor space stock $\{\tilde{A}_j, \tilde{B}_i, L_i\}$; guesses of the target variables adjusted wages, commercial and residential floor space prices, commercial floor space shares $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$; total employment H.

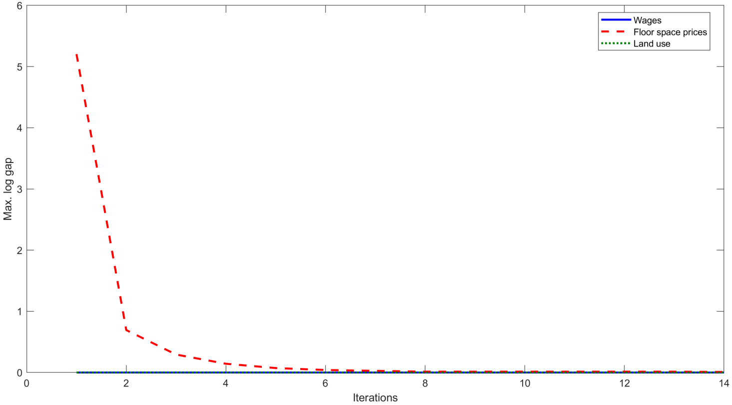
while *guesses of target variables* $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ *change* **do**

- Compute location choice probabilities π_{ij} using guesses of $\{\tilde{w}_i^0, q_i^0, Q_i^0\}$ and $\{\tilde{A}_j, \tilde{B}_i\}$ in in Eq. (4)
- Compute residence and workplace employment $\{\hat{H}_{Mi}, \hat{H}_{Ri}\}$ using π_{ij}, H and residence and Eq. (5).
- Compute output $\hat{Y}_i$ using the production function in Eq. (10), workplace employment $\hat{H}_{Mi}$, inverted total floor space L_i, and guesses of θ_i^0.
- Compute predicted adjusted wage $\tilde{w}_i^1 = \alpha \frac{\hat{Y}_i}{\hat{H}_{Mi}}$ using the input demand function derived from F.O.C. of Eq. (10) and $\{\hat{Y}_i$, and $\hat{H}_{Mi}\}$
- Compute total income $\mathbb{E}(\hat{w}_i \times \hat{H}_{Mi}\}$ using Eq. (S.20), predicted $\tilde{w}_i^1$, $\hat{H}_{Mi}$, and conditional commuting probabilities $\pi_{ij|i} = \pi_{ij} / \sum_j \pi_{ij}$
- Compute predicted commercial and residential floor space prices $\{q_i^1, Q_i^1\}$ using $\hat{Y}$, guesses of θ_i^0, and Marshallian demand and input demand based on Eqs. (1) and (10)
- Compute predicted values of θ_i^0 using commercial floor space input $L_{Mi} = (1-\alpha)\hat{Y}_i / q_i^1$ recovered from input demand function based on Eq. (10) and L_i in Eq. (S.53)
- Update guesses of target variables $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ to weighted average of old guesses $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and predicted values $\{w_i^1, q_i^1, Q_i^1, \theta_i^1\}$

Result: Predicted values of adjusted wage, total income, commercial floor space shares, output, commercial and residential floor space prices, workplace employment and residence, total employment, unconditional commuting probabilities $\{\tilde{w}_i, \mathbb{E}(\hat{w}_i \times \hat{H}_{Mi}), \theta_i, Y_i, q_i, Q_i, H_{Mi}, H_{Ri}, \pi_{ij}\}$

Matlab code

Covergence path



Track the value of the objective function and check for bouncing... Matlab code

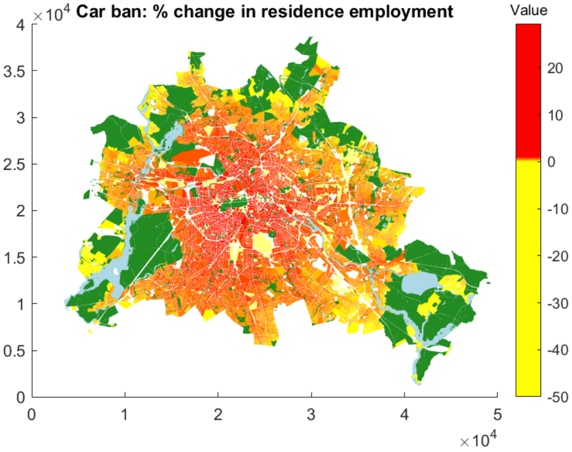
Counterfactuals

- QSM recovers observed values of endogenous variables by construction
  - **Fundamentals** have been inverted to **rationalize data as an equilibrium of the model**
- Solve for **counterfactual equilibria**
  - **Update** any of the model's **primitives**
  - Run the equilibrium solver
- Compare counterfactual equilibrium values to initial equilibrium
  - Initial equilibrium corresponds data where observed
  - Usually use relative differences, e.g. percentage changes or log differences

Ban cars by changing τ_{ij} to public transit travel times

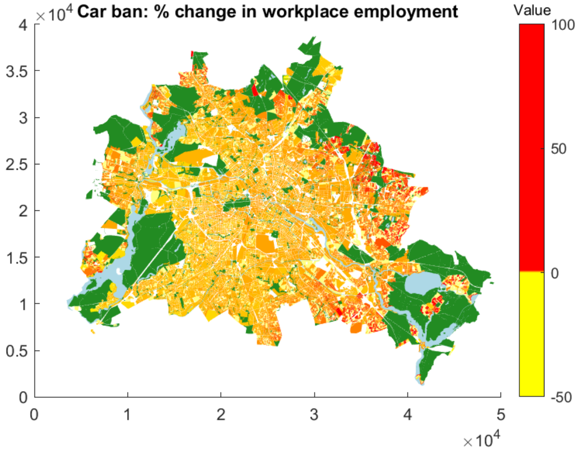
Car ban: Impact on residence employment

- **More costly to reach jobs from suburbs**
- **Workers relocate to central areas**



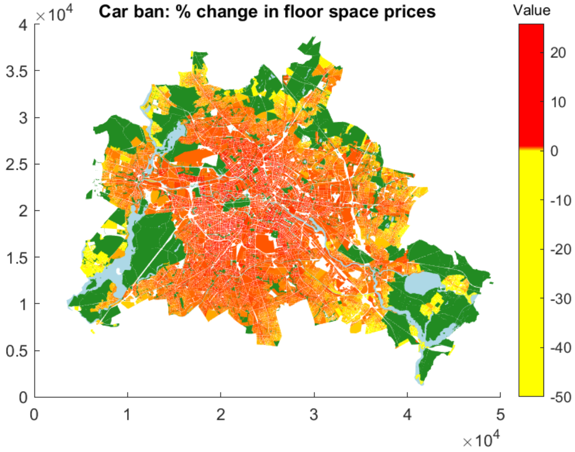
Car ban: Impact on workplace employment

- **Commuting cost higher ⇒ Mixed use more widespread**
  - **Residents leaving suburbs free up space for firms**
  - **Workplace employment increases in suburbs**



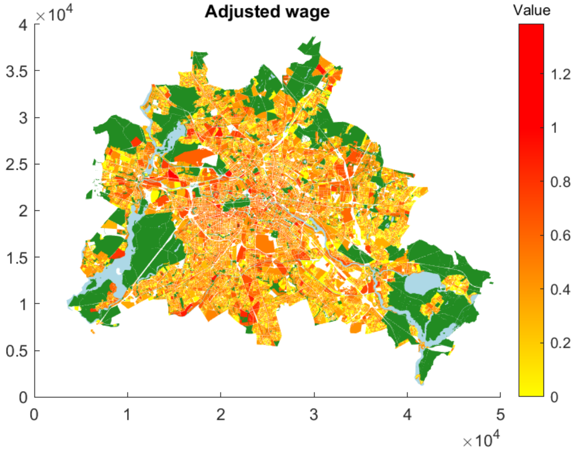
Car ban: Impact on floor space prices

- **Accessibility comes at a premium ⇒ cost savings increasingly capitalize in floor space prices**
  - **Floor space prices increase in places well-connected by public transit**
  - **Floor space prices in remote areas fall due to worse accessibility**



Car ban: Impact on wages

- **Firms need to compensate for higher commuting costs $\Rightarrow$ Wages generally increase**
- **Commuting cost increase domitates**
- **Utility falls by 5.8%**



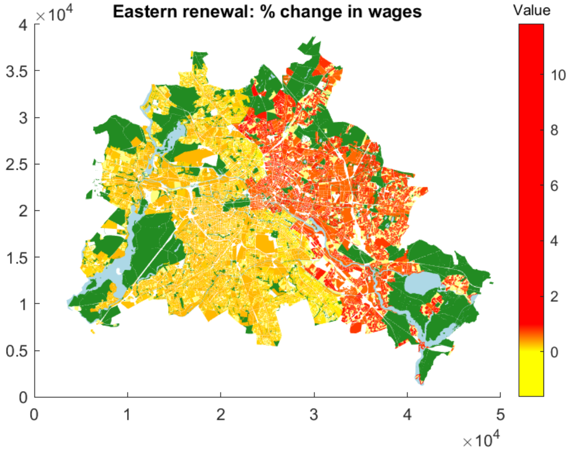
Counterfactuals (again)

- Transport policies are just one of many applications for counterfactuals
  - Albeit a particularly popular one (see list of studies in Topic 6)
- But we can think of many others
  - New parks, better urban design affect **amenity** $\Rightarrow$ change B_i
  - Change effective land supply, more **floor space** $\Rightarrow$ change φ_i
  - Improvements that affect **productivity** $\Rightarrow$ change A_i

What happens if productivity in former East Berlin increases by 10% (e.g. due to an upgrade of capital stock)?

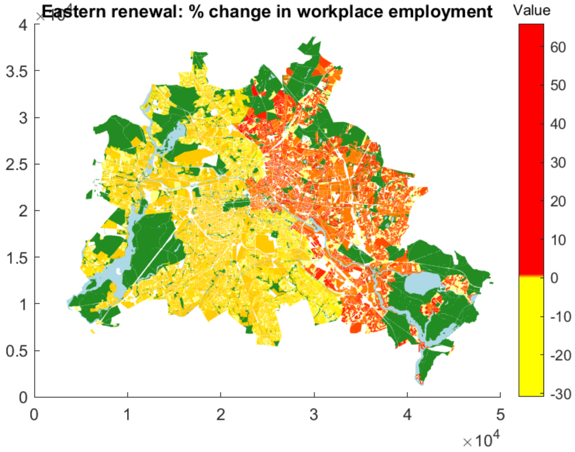
East Berlin productivity increase: Impact on wages

- **Greater productivity ⇒ greater labour demand ⇒ higher wages**



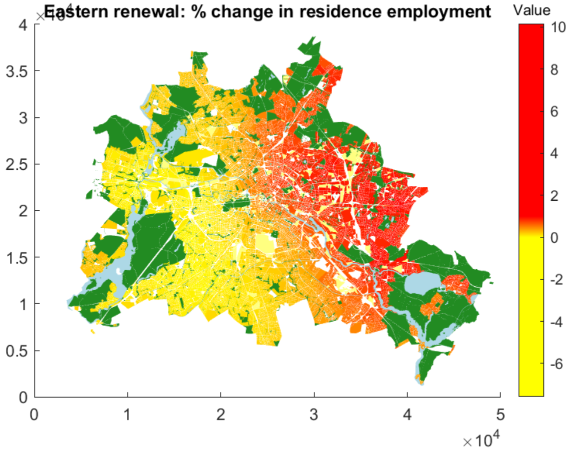
East Berlin productivity increase: Impact on workplace employment

- **Greater productivity ⇒ greater labour demand ⇒ more workplace employment**



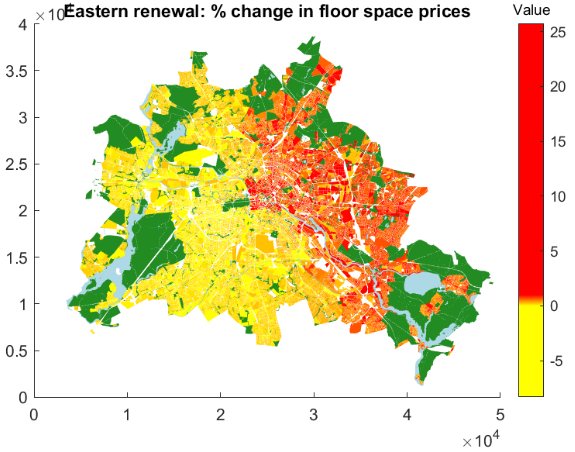
East Berlin productivity increase: Impact on residence employment

- **Labour supply adjusts, subject to commuting friction**
- **East-West gradient in residence employment**



East Berlin productivity increase: Impact on floor space prices

- **Demand for floor space by firms and residents increases ⇒ higher floor space prices**
- **Impact on wages dominates floor space price effect ⇒ $\bar{U}$ increases by 3.8%**



Endogenous agglomeration forces

Endogenous agglomeration forces

Q: How do the effects of a productivity upgrade in East Berlin **differ under endogenous agglomeration forces**?

General equilibrium

- With endogenous agglomeration forces, we have
  - four more parameters, i.e. $\{\alpha, \beta, \mu, \varepsilon, \kappa, \lambda, \delta, \eta\rho\}$
  - two more endogenous objects, $\{\pi_{Mi}, \pi_{Ri}, Q_i, q_i, w_i, \theta_i, H, A_i, B_i\}$ (or H instead of $\bar{U}$)
    - $\{a_, b_i\}$ replace $\{A_i, B_i\}$ as exogenous characteristics $\{T_i, E_i, a_i, b_i, \varphi_i, K_i, \xi_i, \tau_{ij}\}$
  - two more equations that determine the equilibrium

    8. Productivity spillovers (20): $A_j = a_j \times \Upsilon_j^{\lambda}, \quad \Upsilon_j = \left[\sum_{s=1}^{S} e^{-\delta\tau_{is}} \left(\frac{H_{Ms}}{K_s}\right)\right]$
    9. Residential spillovers (21): $B_i = b_i \times \Omega_i^{\eta}, \quad \Omega_i = \left[\sum_{s=1}^{S} e^{-\rho\tau_{is}} \left(\frac{H_{Rs}}{K_s}\right)\right]$
- the same objects still reference the **general equilibrium**
  - the endogenous objects $\{\pi_{Mi}, \pi_{Ri}, Q_i, q_i, w_i, \theta_i, H\}$ (or H instead of $\bar{U}$)

Two more variables, two more equations, **can still solve for the equilibrium** ✓

Algorithm 2: Solving for the equilibrium with endogenous agglomeration forces and exogenous total employment H: `smodendog.m`

Data: Given values of structural parameters $\{\alpha, \beta, \kappa, \varepsilon, \mu\}$, bilateral travel times τ_{ij}, land area K_i; inverted fundamental productivity and amenity $\{a_i, b_i\}$, adjusted density of development $\tilde{\varphi}_i$; guesses of the target variables: adjusted wages, commercial and residential floor space prices, commercial floor space shares $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and initial values of workplace and residence employment $\{H_{Mi}, H_{Ri}\}$; total employment H

Compute floor space L_i using $\tilde{\varphi}_i$ and K_i in Eq. (S.52)
Compute adjusted productivity $\tilde{A}_i$ using τ_{ij} and initial values of H_{Mi} and Eq. (20)
Compute adjusted amenity $\tilde{B}_i$ using τ_{ij} and initial values of H_{Ri} and Eq. (21)
Compute total employment $H = \sum H_{Mi}$
while *guesses of target variables* $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ *change* **do**
- Compute choice probabilities π_{ij} using guesses of $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and $\{\tilde{A}_i, \tilde{B}_i\}$ in Eq. (4)
- Compute residence and workplace employment $\{\hat{H}_{Mi}, \hat{H}_{Ri}\}$ using $\hat{\pi}_{ij}$, H and Eq. (5)
- Compute utility $\hat{U}$ using guesses of $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and $\{\tilde{A}_i, \tilde{B}_i\}$ in Eq. (9)
- **Compute $\tilde{A}_i$ using τ_{ij} and $\hat{H}_{Mi}$ in Eq. (20)**
- **Compute $\tilde{B}_i$ using τ_{ij} and $\hat{H}_{Ri}$ in Eq. (21)**
- Compute output $\hat{Y}_i$ using the production function in Eq. (10), $\hat{H}_{Mi}$, total floor space L_i, and guesses of θ_i^0
- Compute predicted adjusted wage $\tilde{w}_i^1 = \alpha \hat{Y}_i / \hat{H}_{Mi}$ using the input demand function derived from F.O.C. of Eq. (10), and $\{\hat{Y}_i, \hat{H}_{Mi}\}$
- Compute total income $\mathbb{E}(\hat{w}_i \times \hat{H}_{Ri}\}$ using Eq. (S.20), $\{\tilde{w}_i^1, \hat{H}_{Mi}\}$, and conditional commuting probabilities $\pi_{ij|i} = \Phi_{ij} / \sum_j \Phi_{ij}$
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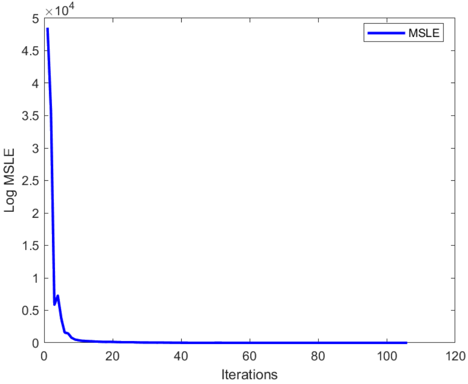
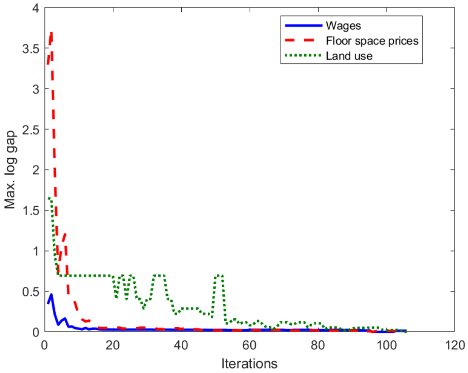
- Compute predicted values of commercial floor space θ_i^1 using commercial floor space input $L_{Mi} = (1-\alpha)\hat{Y}_i / q_i^1$ recovered from input demand function based on Eqs. (10) and (S.53)
- Update guesses of target variables $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ to weighted average of old guesses $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and predicted values $\{w_i^1, \hat{q}_i^1, \hat{Q}_i^1, \hat{\theta}_i^1\}$

Result: Predicted values of adjusted wage, total income, commercial floor space shares, output, commercial and residential floor space prices, workplace employment and residence, total employment, unconditional commuting probabilities $\{\tilde{w}_i, \mathbb{E}(\hat{w}_i \times \hat{H}_{Mi}, \theta_i, Y_i, q_i, Q_i, H_{Mi}, H_{Ri}, \tilde{A}i, \tilde{B}_i, \bar{U}, \pi_{ij}\}$

- Program similar to `smodexog.m`, except that we need to compute endogenous productivity and amenity $\{\tilde{A}_i, \tilde{B}_i\}$ using the model-based predictions of $\{H_{Mi}, H_{Ri}\}$ Matlab code

Convergence path





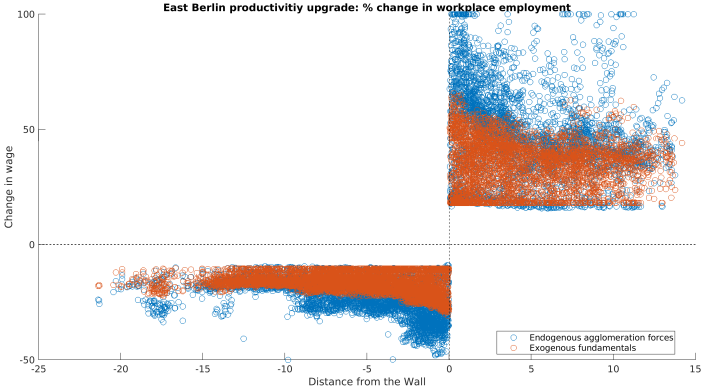
- Overall smooth path, except for θ which seems a bit bumpy
  - But there we expect changes at the extensive margin, so naturally less smooth

Uniqueness

- With agglomeration spillovers, the equilibrium is **not necessarily unique**
  - Typical feature of models with agglomeration forces
    - If you shift a sufficiently large mass of economic activity to a different location
    - Density at that location generates productivity or amenity
    - Firms or workers will have an incentive to remain at that location
  - **Temporary policies could have permanent effects**

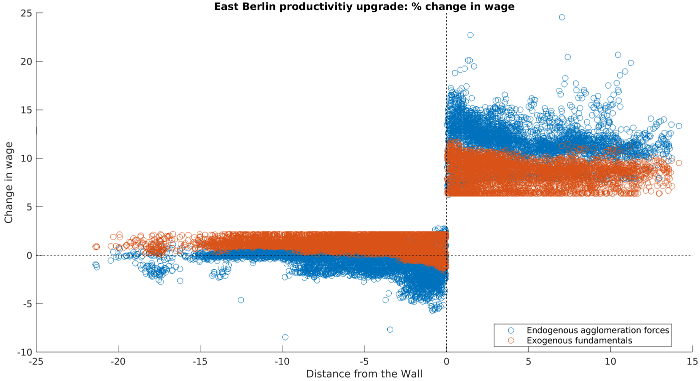
In practice, not particularly relevant as long as the **congestion force is strong enough** and there is **enough heterogeneity in location fundamentals**

East Berlin productivity increase: Workplace employment



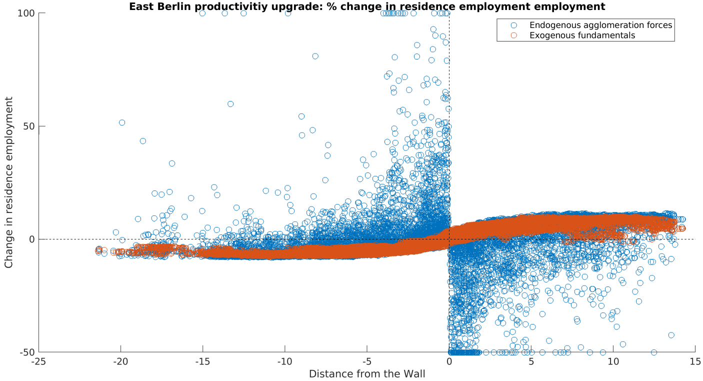
- Agglomeration spillovers amplify direct productivity effect
- More pronounced relocation of workplace employment to East Berlin

East Berlin productivity increase: Wages



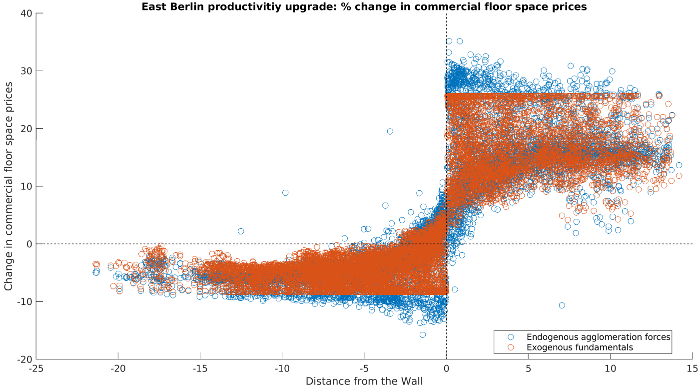
- Amplification of productivity increases in East ⇒ larger wage gains in East
- Relocation of workplace employment to East ⇒ Negative wage spillovers to West

East Berlin productivity increase: Residence employment



- Shift in workplace employment to East crowds out residence employment
- Increase in residence employment in West at border to East

East Berlin productivity increase: Floor space prices



- More pronounced floor space price response
- Net effect on $\bar{U}$ slightly lower at 3% (instead of 3.8%)
  - Fundamental productivity relatively less important

Open city

Population mobility

Q: How do the effects of a productivity upgrade in East Berlin **differ in an open-city model**?

Open-city model

- In a **closed-city model**, H is a fixed endowment
  - $\{H_{Ri}, H_{Mi}\}$ follow directly from location choice probabilities $\{\pi_{Ri}, \pi_{Mi}\}$ given fixed H
  - We know already from the MCM that utility is endogenous
- In an **open-city model**, $\bar{U}$ is fixed and H is endogenous
  - We need to find the H that equates $\mathbb{E}[u]$ to the reservation utility $\bar{U}$
  - This is actually straight forward since the population mobility implies $\mathbb{E}[u] = \gamma [H]^{\frac{1}{\varepsilon}}$
    - Expected utility falls in total employment at an elasticity $-\varepsilon$
  - If expected utility exceeds $\bar{U}$, we increase the population until we converge
    - Need to invert $\bar{U}$ to have the target value, which is done by Matlab code

H becomes a target object

Algorithm 3: Solving for the equilibrium with endogenous agglomeration forces and exogenous reservation utility: `ussmodendog.m`

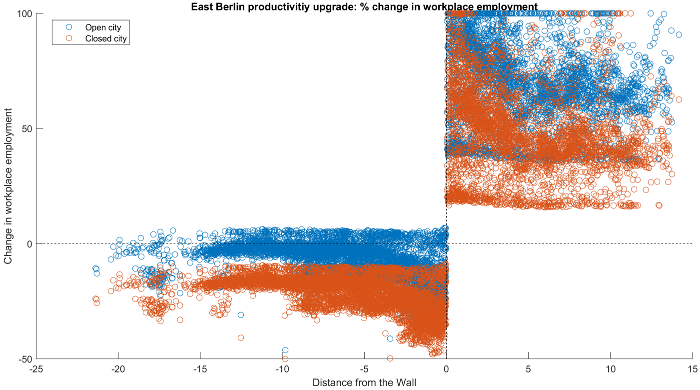
Data: Given values of structural parameters $\{\alpha, \beta, \kappa, \varepsilon, \mu\}$, bilateral travel times τ_{ij}, land area K_i; inverted fundamental productivity and amenity $\{a_i, b_i\}$, adjusted density of development $\tilde{\varphi}_i$; guesses of the target variables: adjusted wages, commercial and residential floor space prices, commercial floor space shares $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and initial values of workplace and residence employment $\{H_{Mi}, H_{Ri}\}$; calibrated value of exogenous reservation utility level $\bar{U}$

Compute floor space L_i using $\tilde{\varphi}_i$ and K_i in Eq. (S.52)
Compute adjusted productivity $\tilde{A}_i$ using τ_{ij} and initial values of H_{Mi} and Eq. (20)
Compute adjusted amenity $\tilde{B}_i$ using τ_{ij} and initial values of H_{Ri} and Eq. (21)
Compute total employment $H = \sum H_{Mi}$
while *guesses of target variables* $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ *change or* $\mathbb{E}(U) \neq \bar{U}$ **do**
    Compute choice probabilities π_{ij} using guesses of $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and $\{\tilde{A}_i, \tilde{B}_i\}$ in Eq. (4)
    Compute residence and workplace employment $\{\hat{H}_{Mi}, \hat{H}_{Ri}\}$ using $\hat{\pi}_{ij}$, H and Eq. (5)
    Compute utility $\hat{U}$ using guesses of $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and $\{\tilde{A}_i, \tilde{B}_i\}$ in Eq. (9)
    Compute $\tilde{A}_i$ using τ_{ij} and $\hat{H}_{Mi}$ in Eq. (20)
    Compute $\tilde{B}_i$ using τ_{ij} and $\hat{H}_{Ri}$ in Eq. (21)
    Compute output $\hat{Y}_i$ using the production function in Eq. (10), $\hat{H}_{Mi}$, total floor space L_i, and guesses of θ_i^0
    Compute predicted adjusted wage $\tilde{w}_i^1 = \alpha \frac{\hat{Y}_i}{\hat{H}_{Mi}}$ using the input demand function derived from F.O.C. of Eq. (10), and $\{\hat{Y}_i, \hat{H}_{Mi}\}$
    Compute total income $\mathbb{E}(\hat{w}_i \times \hat{H}_{Ri}\}$ using Eq. (S.20), $\{\tilde{w}_i^1, \hat{H}_{Mi}\}$, and conditional commuting probabilities $\pi_{ij|i} = \Phi_{ij} / \sum_j \Phi_{ij}$
    Compute predicted commercial and residential floor space prices $\{q_i^1, Q_i^1\}$ using $\hat{Y}$, guesses of θ_i^0, and Marshallian demand functions and input demand functions based on Eqs. (1) and (10)
    Compute predicted values of commercial floor space θ_i^1 using commercial floor space input $L_{Mi} = (1-\alpha)\hat{Y}_i / q_i^1$ recovered from input demand function based on Eqs. (10) and (S.53)
    Update guesses of target variables $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ to weighted average of old guesses $\{\tilde{w}_i^0, q_i^0, Q_i^0, \theta_i^0\}$ and predicted values $\{w_i^1, \hat{q}_i^1, \hat{Q}_i^1, \hat{\theta}_i^1\}$
    Update H using adjustment factor that depends on $\frac{\hat{U}}{\bar{U}}$ (we increase total employment if expected utility exceeds reservation utility)

Result: Predicted values of adjusted wage, total income, commercial floor space shares, output, commercial and residential floor space prices, workplace employment and residence, total employment, unconditional commuting probabilities $\{\tilde{w}_i, \mathbb{E}(\hat{w}_i) \times \hat{H}_{Mi}, \theta_i, Y_i, q_i, Q_i, H_{Mi}, H_{Ri}, \tilde{A}i, \tilde{B}_i, H, \pi_{ij}\}$

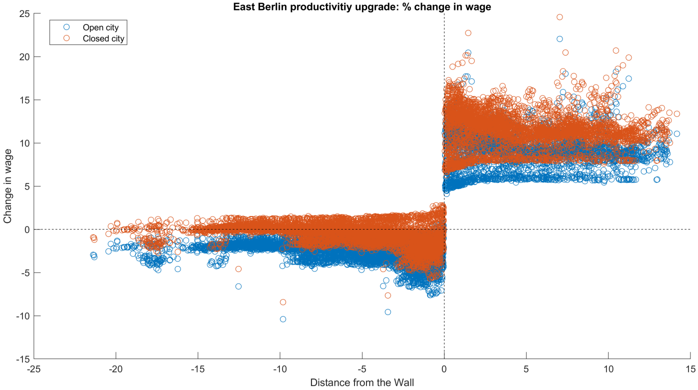
- Program similar to `smodendog.m`, except that we update H to that $\mathbf{E}(U)$ matches $\bar{U}$

East Berlin productivity increase: Workplace employment



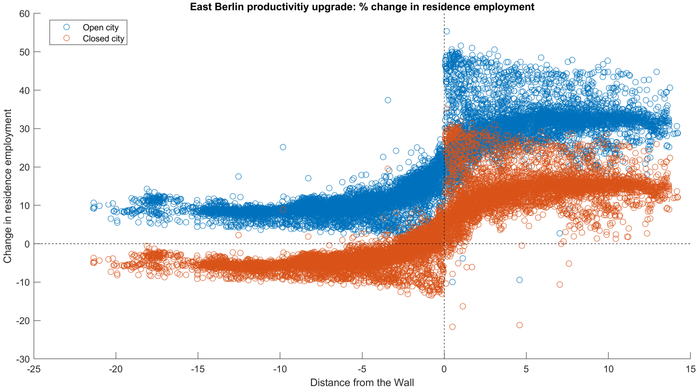
- Total employment increases by about 300k to restore reservation utility
- Some blocks in West turn from losers to winners!

East Berlin productivity increase: Wages



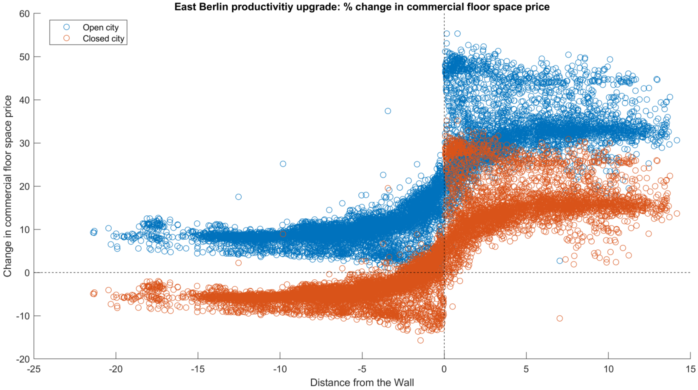
- Wages increase since city generates more agglomeration economies (more workers)
- Some blocks in West turn from losers to winners!

East Berlin productivity increase: Residence employment



- Residence employment increases throughout city
- Most blocks in West turn from losers into winners!

East Berlin productivity increase: Floor space prices



- Floro space prices increase throughout city (to restore the reservation utility)
- Most blocks in West turn from losers into winners!

Conclusion

Summary

- QSMs can perform counterfactuals in spatial general equilibrium
  - Re-solve the model under different primitives that reflect, e.g. a policy change
- With **endogenous agglomeration forces** spatial adjustments tend to be larger
  - Model with exogenous fundamentals doesn't fully account for Berlin Wall effects
- Local shocks tend to generate spatial winners and losers due to relocation effects
  - Positive shocks produce more losers in **closed city model**
  - In **open-city** model large inflow of workers mitigates local losses
- ARSW assumes perfect mobility across the city border
  - No idiosyncratic tastes for living in a specific city $\Rightarrow$ akin to RR
  - One could add idiosyncratic tastes for being in the city maybe more realistic

Next week: **Quantitative Economic Geography**

Literature I

Core readings

- **Ahlfedt, G., Redding, S., Sturm, D., Wolf, N. (2015): The economics of Density: Evidence From the Berlin Wall. Econometrica, 83(6), 2127–2189.**

Other readings

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