Neighborhood Effects: Evidence from Wartime Destruction in London

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Motivation

- Within cities, we observe large differences in house prices and socioeconomic composition across neighborhoods
  - Prosperous areas such as Hampstead in London
  - Poorer areas such as Haringey in London

- What explains these observed differences in house prices and socioeconomic composition?
  - Fundamentals: Hampstead has attractive amenities
    - Bids up house prices, such that only the rich can afford to live there
  - Neighborhood effects: individual behavior influenced by surrounding socioeconomic composition
    - Rich people value living near other rich people
      - Either directly or indirectly through local public goods (e.g., schools)
    - Bids up house prices, such that only the rich can afford to live there

- Need an exogenous source of variation to distinguish location fundamentals from neighborhood effects
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• Need an exogenous source of variation to distinguish location fundamentals from neighborhood effects
This Paper

- We use German bombing of London during WWII as a natural experiment to distinguish between these explanations
  
  1. **Exogenous shock**: uncorrelated with pre-war location characteristics within geographical grid cells
  
  2. **Long-lasting effect on building quality**: reconstruction occurred during rationing, financial constraints, and expansion social housing

- Idea behind our approach
  
  - Higher-income residents care more about building quality
  - Bombing lowers building quality and reduces a location's attractiveness
  - This change in socioeconomic composition affects neighborhood effects and induces further spatial sorting

- We provide evidence on
  
  - Direct effect of war destruction on property values and spatial sorting
  
  - Spillover effects of war destruction on surrounding locations

- Examine the extent to which a theoretical model of spatial sorting with neighborhood effects can explain these empirical findings
  
  - Counterfactuals to evaluate the impact of neighborhood effects on the extent of spatial sorting across locations
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Related Literature

• Economic Geography and Urban Economics

• Neighborhood effects and spillovers

• Wartime bombing

• Natural experiments and economic activity
Outline

• Historical Background

• Data

• Reduced-form Evidence

• Theoretical Model

• Quantitative Analysis

• Conclusions
Historical Background

- Rich spatially-disaggregated data on socioeconomic status in London
  - Hubert Llewellyn-Smith, *New Survey of London Life and Labor*, 1928-31
  - Classify streets by socioeconomic status of residents (income)
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• London experienced heavy bombing during WWII
  – Initial German attacks on Royal Air Force (“Battle of Britain”)
  – Switch to strategic bombing of London (“Blitz” from Sept 1940-May 1941)
  – Heavy daylight losses led to largely night bombing from Oct 1940
  – Bombing sharply reduced after German invasion of USSR in June 1941
  – From June 1944-May 1945, London targeted by long-range missiles: V1 (cruise missile) and V2 (ballistic missile)

London County Council (LCC) recorded wartime damage to individual buildings using 1:2,500 OS maps
  – Monitor destruction and manage public services in response
  – Wartime redevelopment plans, but financial burden of war debt, shortages and urgent need for housing meant that most not implemented
  – Private repair of existing buildings (with compensation for war damage) and most new construction social housing
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Data

• New spatially-disaggregated dataset for pre and post-war periods
  – LCC administrative area, $300 \text{km}^2$, 4.4 million in 1931
  – Spatial units: 9,041 Output Areas, target size 125 households
  – Long-run impact: 1930s and 2001 (first post-war population census to report socioeconomic composition by Output Area)

• LCC Bomb Damage Maps
  – Building footprints and pre-war built-up area
  – Damage to buildings (from minor blast damage to total destruction)

• Property values
  – LCC valuation list 1936, 50,000 pages, >1 million properties, digitized, geolocated and matched to individual building footprints
  – Property transactions data 1995-2020

• Population from 1931, 2001 and 2011 Censuses

• Socioeconomic composition
  – NSOL 1930 socioeconomic status by street, matched to buildings
  – Socioeconomic composition 2001 and 2011

• Transport network: Over- and under-ground rail, buses, and trams
**Notes:** minor blast damage (yellow); general blast damage (orange); seriously damaged but repairable at cost (light red); seriously damaged and doubtful if repairable (dark red); damaged beyond repair (purple); and total destruction (black); large black circle in Regent’s Park shows a V-1 missile impact; 40 percent pre-war built-up area some damage (yellow above); 20 percent serious damage (red above)
Wartime Destruction in LCC Area

Notes: minor blast damage (yellow); general blast damage (orange); seriously damaged but repairable at cost (light red); seriously damaged and doubtful if repairable (dark red); damaged beyond repair (purple); total destruction (black); 40 percent some damage (yellow above); 20 percent serious damage (red above)
### NSOL 1928-31

<table>
<thead>
<tr>
<th>Color</th>
<th>Group</th>
<th>Category</th>
<th>Weekly Family Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Low</td>
<td>Extreme Poverty</td>
<td>Under £2 &amp; Criminality</td>
</tr>
<tr>
<td>Blue</td>
<td></td>
<td>Below Poverty Line</td>
<td>Under £2</td>
</tr>
<tr>
<td>Purple</td>
<td></td>
<td>Unskilled Workers</td>
<td>£2-3</td>
</tr>
<tr>
<td>Pink</td>
<td>Middle</td>
<td>Skilled Workers</td>
<td>£3-5</td>
</tr>
<tr>
<td>Red</td>
<td>High</td>
<td>Middle-Class and Wealthy</td>
<td>£5 or above</td>
</tr>
</tbody>
</table>
Notes: Socioeconomic status by building in the LCC area based on the New Survey of London Life and Labor 1928-31. The colour of each building corresponds to the socioeconomic index of the residents of the building with red denoting high and blue low socioeconomic status. Non-residential buildings such as factories or churches are shown in gray.
Pre-War Property Values by Output Area

Notes: Property values in 1936 based on the market rental value for tax purposes. The property values are the Output Area fixed effects from a hedonic regression of the logarithm of rateable values on observed property characteristics. Red denotes high values; blue denotes low values.
Outline

- Historical Background
- Data
- Reduced-form Evidence
- Theoretical Model
- Quantitative Analysis
- Conclusions
Bombing Regressions

- Randomization Check

\[ Y_{i, \text{Pre-War}} = \beta D_{i, \text{War}} + \varrho_k + u_i \]

- Causal Impact of Bombing

\[ Y_{i, \text{Post-War}} = \beta D_{i, \text{War}} + \varrho_k + u_i \]

- Spillover Impact of Bombing

\[ Y_{i, \text{Post-War}} = \beta D_{i, \text{War}} + \sum_{g=1}^{G} \gamma_g D_{ig, \text{War}} + \varrho_k + u_i \]

- \( i \) are Output Areas and \( \varrho_k \) are fixed effects for hexagonal grid cells
- \( g \) are grid cells for 100 meter buffers and \( u_i \) is stochastic error
- Standard errors clustered by hexagonal grid cells
- Robustness using Conley (HAC) standard errors
## Pre-war Randomization Check

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Panel A - All Damage</th>
<th>Panel B - Residential Damage</th>
<th>Panel C - Commercial Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Fraction High Status</td>
<td>(2) Fraction Middle Status</td>
<td>(3) Fraction Low Status</td>
</tr>
<tr>
<td>None</td>
<td>−0.235*** (0.031)</td>
<td>0.039* (0.023)</td>
<td>0.196*** (0.025)</td>
</tr>
<tr>
<td>4 km Hexagons</td>
<td>−0.061*** (0.020)</td>
<td>0.020 (0.018)</td>
<td>0.042** (0.017)</td>
</tr>
<tr>
<td>1 km Hexagons</td>
<td>−0.007 (0.014)</td>
<td>−0.004 (0.013)</td>
<td>0.011 (0.012)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Panel B - Residential Damage</th>
<th>Panel C - Commercial Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Fraction High Status</td>
<td>(2) Fraction Middle Status</td>
</tr>
<tr>
<td>None</td>
<td>−0.207*** (0.028)</td>
<td>0.023 (0.021)</td>
</tr>
<tr>
<td>4 km Hexagons</td>
<td>−0.051*** (0.018)</td>
<td>0.005 (0.016)</td>
</tr>
<tr>
<td>1 km Hexagons</td>
<td>−0.003 (0.013)</td>
<td>−0.015 (0.012)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Panel C - Commercial Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Fraction High Status</td>
</tr>
<tr>
<td>None</td>
<td>−0.170*** (0.023)</td>
</tr>
<tr>
<td>4 km Hexagons</td>
<td>−0.046*** (0.015)</td>
</tr>
<tr>
<td>1 km Hexagons</td>
<td>−0.016 (0.011)</td>
</tr>
</tbody>
</table>
### Post-war Direct Effect of Bombing

<table>
<thead>
<tr>
<th></th>
<th>(1) Fraction High Status</th>
<th>(2) Fraction Middle Status</th>
<th>(3) Fraction Low Status</th>
<th>(4) Socio-Economic Index</th>
<th>(5) Log of Property Value</th>
<th>(6) Log of Property Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A - All Damage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Damage</td>
<td>–0.039***</td>
<td>–0.023***</td>
<td>0.062***</td>
<td>–0.051***</td>
<td>–0.180***</td>
<td>–0.112***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.009)</td>
<td>(0.007)</td>
<td>(0.022)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>Hexagon Fixed Effects</td>
<td>1 km</td>
<td>1 km</td>
<td>1 km</td>
<td>1 km</td>
<td>1 km</td>
<td>1 km</td>
</tr>
<tr>
<td>Observations</td>
<td>8912</td>
<td>8912</td>
<td>8912</td>
<td>8912</td>
<td>8797</td>
<td>8797</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.505</td>
<td>0.280</td>
<td>0.439</td>
<td>0.483</td>
<td>0.637</td>
<td>0.782</td>
</tr>
</tbody>
</table>

| **Panel B - Residential and Commercial Damage** |                          |                           |                         |                          |                           |                           |
| Residential Damage  | –0.038***                | –0.024***                 | 0.062***                | –0.050***                | –0.193***                 | –0.111***                 |
|                     | (0.006)                  | (0.004)                   | (0.008)                 | (0.007)                  | (0.025)                   | (0.020)                   |
| Commercial Damage   | –0.003                   | 0.001                     | 0.003                   | –0.003                   | 0.003                     | –0.007                    |
|                     | (0.005)                  | (0.004)                   | (0.006)                 | (0.005)                  | (0.019)                   | (0.016)                   |
| Hexagon Fixed Effects | 1 km                     | 1 km                      | 1 km                    | 1 km                     | 1 km                      | 1 km                      |
| Observations        | 8511                     | 8511                      | 8511                    | 8511                     | 8423                      | 8423                      |
| R-squared           | 0.518                    | 0.290                     | 0.455                   | 0.498                    | 0.645                     | 0.786                     |

- Wartime destruction negative causal impact on post-war economic outcomes within 1km hexagons.
### Post-war Spillover Effects of Bombing

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Socio-Economic Index</th>
<th></th>
<th>Log of Property Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Destruction in own area</td>
<td>-0.042***</td>
<td>-0.045***</td>
<td>-0.095***</td>
<td>-0.096***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.007)</td>
<td>(0.017)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Destruction in 100m buffer</td>
<td>-0.030**</td>
<td>-0.024*</td>
<td>-0.072*</td>
<td>-0.086**</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.038)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>Destruction in 200m buffer</td>
<td>-0.026</td>
<td>-0.022</td>
<td>-0.110**</td>
<td>-0.119**</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.019)</td>
<td>(0.045)</td>
<td>(0.051)</td>
</tr>
<tr>
<td>Destruction in 300m buffer</td>
<td>-0.026</td>
<td>-0.027</td>
<td>-0.092*</td>
<td>-0.075</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.052)</td>
<td>(0.054)</td>
</tr>
<tr>
<td>Destruction in 400m buffer</td>
<td>0.004</td>
<td>-0.024</td>
<td>0.027*</td>
<td>-0.110**</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.020)</td>
<td>(0.069)</td>
<td>(0.055)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Total</th>
<th>Res</th>
<th>Com</th>
<th>Total</th>
<th>Res</th>
<th>Com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexagon Fixed Effects</td>
<td>1 km</td>
<td>1 km</td>
<td></td>
<td>1 km</td>
<td>1 km</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>8910</td>
<td>8500</td>
<td></td>
<td>8795</td>
<td>8412</td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.485</td>
<td>0.500</td>
<td></td>
<td>0.782</td>
<td>0.787</td>
<td></td>
</tr>
</tbody>
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- Negative and localized impacts of neighbors’ wartime destruction on post-war outcomes within 1km hexagons.
Outline

• Historical Background
• Data
• Reduced-form Evidence
• Theoretical Model
• Quantitative Analysis
• Conclusions
Model Setup

- We consider a city (London) in a wider economy (Britain)
- City consists of a discrete set of locations $n, i \in \mathbb{N}$
- Two types of agents: workers and landlords
- Workers belong to one of three types (occupations) that are imperfect substitutes in production: $o \in \{Low, Mid, High\}$
- Utility depends on amenities, consumption of the final good and floor space, commuting costs and idiosyncratic preference shocks
- Amenities depend on wartime destruction, neighborhood effects and location fundamentals (e.g., scenic views)
- Firms use labor and floor space to produce a freely-traded final good
- Productivity depends on wartime destruction, agglomeration effects and location fundamentals (e.g., access to water)
- Markets are perfectly competitive
- Consider steady-states before and after wartime destruction
- Consider both closed and open-city specifications
Spatial Sorting

• Probabilistic sorting across residence-workplace pairs

\[
\lambda_{nit}^o = \frac{E_{nit}^o}{E_t^o} = \frac{(B_{nt}^o w_{it}^o)^{\epsilon^o} \left( \kappa_{nit}^o P_{nt}^o Q_{nt}^{1-\alpha^o} \right)^{-\epsilon^o}}{\sum_{k \in N} \sum_{\ell \in N} \left( B_{kt}^o w_{\ell t}^o \right)^{\epsilon^o} \left( \kappa_{k\ell t}^o P_{kt}^o Q_{kt}^{1-\alpha^o} \right)^{-\epsilon^o}}
\]

• Amenities \((B_{nt}^o)\) depend on neighborhood effects \((B_{nt})\)

\[
B_{nt}^o = e^{\eta_{Dnt}^o B_{nt}^0} b_{nt}^o, \quad B_{nt} \equiv \left[ \sum_{i \in N} \mathbb{I}_{B_{nit}} \times s_{it} \right]
\]

• Residents \((R_{nt}^o)\) and employment \((E_{it}^o)\)

\[
\lambda_{nt}^{Ro} = \frac{R_{nt}^o}{E_t^o} = \sum_{i \in N} \lambda_{nit}^o, \quad \lambda_{it}^{Eo} = \frac{E_{it}^o}{E_t^o} = \sum_{n \in N} \lambda_{nit}^o
\]

• Occupation utility equalized across residence-workplace pairs

\[
U_t^o = \vartheta^0 \left[ \sum_{k \in N} \sum_{\ell \in N} \left( B_{kt}^o w_{\ell t}^o \right)^{\epsilon^o} \left( \kappa_{k\ell t}^o P_{kt}^o Q_{kt}^{1-\alpha^o} \right)^{-\epsilon^o} \right]^{\frac{1}{\epsilon^o}}, \quad \vartheta^0 \equiv \Gamma \left( \frac{\epsilon^o - 1}{\epsilon^o} \right)
\]
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Preferences and Production

• Calibrate housing expenditure shares \((1 - \alpha^o)\)
  
  – Ministry of Labor Survey of household expenditure from 1937-8
  
  – Separate households into 3 groups based on the £3 and £5 thresholds between low-middle and high-middle NSOL income categories

<table>
<thead>
<tr>
<th>Mean Expenditure Share</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>((1 - \alpha^o))</td>
<td>0.26</td>
<td>0.22</td>
<td>0.16</td>
</tr>
</tbody>
</table>

• Calibrate labor share \((\beta = 0.55)\)
  
  – Center of range of estimates from 0.43-0.63 in Antràs and Voth (2003)

• Calibrate shares of workers types in labor costs using share of the three groups in pre-war residential rateable values \(\left(\psi_i^o\right)\)

<table>
<thead>
<tr>
<th>Cost Share</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\gamma^o)</td>
<td>0.17</td>
<td>0.38</td>
<td>0.46</td>
</tr>
</tbody>
</table>

\[\gamma^o = \frac{\sum_{i=1}^{N} \frac{\psi_i^o}{1-\alpha^o}}{\sum_{h\in\{L,M,H\}} \sum_{i=1}^{N} \frac{\psi_i^h}{1-\alpha^h}}.\]

• Drop time subscript from now onwards
Commuting Parameters

- Estimate commuting gravity for each type by PPML for 2011
  \[
  \ln \lambda_{ni}^o = \vartheta_{no}^R + \vartheta_i^E \phi^o \ln \tau_{ni} + u_{ni}^o, \quad \phi^o \equiv \epsilon^o \kappa, \quad (\kappa_{ni}^o)^{-\epsilon^o} = \tau_{ni}^{-\phi^o}
  \]

- Instrument for travel time ($\tau_{ni}$) using straightline distance and a control function approach (Wooldridge 2014)

<table>
<thead>
<tr>
<th>Occupation</th>
<th>PPML</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control Function</td>
</tr>
<tr>
<td>Low-income ($\phi^L$)</td>
<td>$-2.923$</td>
</tr>
<tr>
<td>Mid-income ($\phi^M$)</td>
<td>$-2.411$</td>
</tr>
<tr>
<td>High-income ($\phi^H$)</td>
<td>$-1.873$</td>
</tr>
</tbody>
</table>

- Assume $\epsilon^M = 5.25$ based on Heblich et al. (2020) estimates for London
- Recover $\epsilon^L$ and $\epsilon^H$ assuming common commuting cost elasticity $\kappa$

  \[
  \epsilon^L = \frac{\phi^L}{\phi^M} \epsilon^M = 6.36, \quad \epsilon^H = \frac{\phi^H}{\phi^M} \epsilon^M = 4.07
  \]
Pre-war Wages and Commuting

- Recover unobserved endogenous variables in initial equilibrium

- **Wages** \((w_i^o)\) by worker type from commuter market clearing

\[
\frac{\beta \gamma^o}{1 - \beta} V_i^E = w_i^o E_i^o = \sum_{n \in N} \lambda_{ni|n}^o w_n^o R_n^o = \sum_{n \in N} \left( \frac{(w_i^o)^{\epsilon^o}}{\tau_{ni}} \right) - \phi^o \sum_{\ell \in N} (w_\ell^o)^{\epsilon^o} - \phi^o w_i^o R_n^o
\]

- **Expected income** \((v_n)\) from conditional commuting probabilities

\[
v_n^o = \sum_{i \in N} \lambda_{ni|n}^o w_i^o = \sum_{i \in N} \left( \frac{(w_i^o)^{\epsilon^o}}{\tau_{ni}} \right) - \phi^o \sum_{\ell \in N} (w_\ell^o)^{\epsilon^o} - \phi^o w_i^o
\]

- Given wages \((w_i^o)\), commuting costs \((\tau_{ni}^{-\phi^o})\), and residents \((R_n^o)\), recover commuting and employment \((\lambda_{ni|n}^{R_n}, \lambda_{ni}^o, E_n^o)\)
Neighborhood Effects Estimation

• Recover amenities from residential choice probabilities

\[
\ln B_n^o = \ln \left( \frac{\bar{U}^o}{\delta^o} \right) + \frac{1}{e^o} \ln (\lambda_n^{R^o}) + (1 - \alpha^o) \ln Q_n - \ln RMA_n^o
\]

\[
RMA_n^o = \left[ \sum_{\ell \in N} (w^o_{\ell})^\epsilon^o \tau_{n\ell}^{-\phi^o} \right]^\frac{1}{e^o}
\]

• Estimate direct effects of bombing and socioeconomic composition on post-war amenities

\[
\ln B_{nt}^o = \eta_{Dt}^o D_{nt} + \eta_R^o \ln B_{nt} + \varrho_{kt}^o + d_{nt}^o
\]

• Instrument socioeconomic composition using neighbors’ bombing

\[
\ln B_{nt} = \varphi_D D_{nt} + \varphi_N D_{nt}^{Neigh} + \varpi_{kt} + u_{nt}
\]

• where \( B_{nt} \) is the unweighted average of the socioeconomic composition (\( S_{nt} \)) of the own location and its first three 100m buffers
# Neighborhood Effects

<table>
<thead>
<tr>
<th>(A) High-income</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ln B_n^H$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$D_{n,\text{war}}$</td>
<td>$-0.102^{***}$</td>
<td>$-0.036^{***}$</td>
<td>$-0.055^{***}$</td>
<td>$-0.067^{***}$</td>
<td>$-0.068^{***}$</td>
<td>$-0.090^{***}$</td>
</tr>
<tr>
<td></td>
<td>$(0.014)$</td>
<td>$(0.009)$</td>
<td>$(0.011)$</td>
<td>$(0.010)$</td>
<td>$(0.010)$</td>
<td>$(0.010)$</td>
</tr>
<tr>
<td>$ln B_{n,\text{post-war}}$</td>
<td>$1.514^{***}$</td>
<td>$1.081^{***}$</td>
<td>$0.963^{***}$</td>
<td>$0.919^{***}$</td>
<td>$0.900^{***}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(0.032)$</td>
<td>$(0.205)$</td>
<td>$(0.167)$</td>
<td>$(0.185)$</td>
<td>$(0.209)$</td>
<td></td>
</tr>
<tr>
<td>$ln B_{n,\text{pre-war}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0.0811^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$(0.030)$</td>
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<table>
<thead>
<tr>
<th>Estimation</th>
<th>OLS</th>
<th>OLS</th>
<th>IV</th>
<th>IV</th>
<th>IV</th>
<th>IV</th>
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<tbody>
<tr>
<td>Observations</td>
<td>8,780</td>
<td>8,778</td>
<td>8,776</td>
<td>8,594</td>
<td>8,594</td>
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<tr>
<td>R-squared</td>
<td>0.556</td>
<td>0.794</td>
<td>0.497</td>
<td>0.465</td>
<td>0.462</td>
<td>0.191</td>
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</table>

<table>
<thead>
<tr>
<th>(B) Middle-income</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ln B_n^M$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$D_{n,\text{war}}$</td>
<td>$-0.046^{***}$</td>
<td>$-0.020^{***}$</td>
<td>$-0.021^{***}$</td>
<td>$-0.030^{***}$</td>
<td>$-0.030^{***}$</td>
<td>$-0.044^{***}$</td>
</tr>
<tr>
<td></td>
<td>$(0.007)$</td>
<td>$(0.006)$</td>
<td>$(0.007)$</td>
<td>$(0.006)$</td>
<td>$(0.006)$</td>
<td>$(0.006)$</td>
</tr>
<tr>
<td>$ln B_{n,\text{post-war}}$</td>
<td>$0.610^{***}$</td>
<td>$0.585^{***}$</td>
<td>$0.600^{***}$</td>
<td>$0.581^{***}$</td>
<td>$0.566^{***}$</td>
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</tr>
<tr>
<td></td>
<td>$(0.021)$</td>
<td>$(0.162)$</td>
<td>$(0.129)$</td>
<td>$(0.140)$</td>
<td>$(0.137)$</td>
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<tr>
<td>$ln B_{n,\text{pre-war}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0.035$</td>
</tr>
<tr>
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<td></td>
<td>$(0.023)$</td>
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</table>

<table>
<thead>
<tr>
<th>Estimation</th>
<th>OLS</th>
<th>OLS</th>
<th>IV</th>
<th>IV</th>
<th>IV</th>
<th>IV</th>
</tr>
</thead>
<tbody>
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<td>Observations</td>
<td>8,795</td>
<td>8,793</td>
<td>8,791</td>
<td>8,609</td>
<td>8,609</td>
<td>8,609</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.614</td>
<td>0.719</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>First-stage F</td>
<td>–</td>
<td>–</td>
<td>10.08</td>
<td>21.33</td>
<td>19.89</td>
<td>24.57</td>
</tr>
</tbody>
</table>
Counterfactuals

- Exact-hat algebra counterfactuals (PPML+model-predicted shares)
  - Counterfactual (prime) and relative changes (hat, $\hat{x} = x'/x$)
- Two sets of counterfactuals to quantify spatial sorting
  - Wartime destruction with and without ($\eta_R^o = 0$) neighborhood effects:
    \[
    \hat{B}_n^o = \frac{B_n^{o'}}{B_n^o} = \exp(\eta_D D_n) \hat{B}_n^{\eta_R^o},
    \]
  - Removing neighborhood effects
    \[
    \hat{B}_n^o = \frac{B_n^{o'}}{B_n^o} = \frac{b_n^o}{b_n^o (B_{n,\text{Pre-war}}) \eta_R^o} = \frac{1}{(B_{n,\text{Pre-war}}) \eta_R^o}
    \]
- Baseline specification
  - Closed-city, exogenous productivity and inelastic supplies of commercial and residential floor space (Town and Country Planning Act 1942)
- Robustness specifications
  - Open-city, agglomeration forces, and imperfectly elastic supplies of commercial and residential floor space
Bombing Counterfactual
Neighborhood Effects Counterfactual

A. Entire LCC Area

B. Five Boroughs with Lowest Pre-War Social Status

C. Five Boroughs with Highest Pre-War Social Status

D. Entire LCC Area

Socioeconomic Index (Black pre-war data, Gray CF)
Outline

• Historical Background

• Data

• Reduced-form Evidence

• Theoretical Model

• Quantitative Analysis

• Conclusions
Conclusion

• We use German bombing of London during WWII as a natural experiment to provide evidence on neighborhood effects
  – **Exogenous shock**: uncorrelated with pre-war location characteristics within geographical grid cells
  – **Long-lasting effect on building quality**: reconstruction occurred during rationing, financial constraints, and expansion social housing

• Provide reduced-form evidence on wartime bombing
  – Direct negative effects on post-war economic outcomes
  – Negative spillover effects on post-war economic outcomes

• Develop a quantitative urban model to rationalize these findings
  – Workers belonging to each occupation $o \in \{L, M, H\}$ endogenously sort across residences and workplaces
  – Higher-income workers value high-quality buildings and socioeconomic status more than lower-income workers

• Counterfactuals for wartime destruction and neighborhood effects
  – Neighborhood effects magnify the impact of wartime destruction on socioeconomic composition and income distribution
  – Neighborhood effects account for much of the observed differences in socioeconomic composition across locations
Thank You