Lecture 3: Land Use, Zoning and Slums

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Introduction

Urban Land Use: Key Questions

- How is land used within cities? What determines these patters of land use?
- What determines the differences in land and property prices across locations?
- What determines the location choices of different types and subgroups of residents?
- How can we understand the patterns of land conversion (residential-commercial, informal-formal, high density-low density, etc.)?

Land Use in Paris - Duranton and Puga (2015)

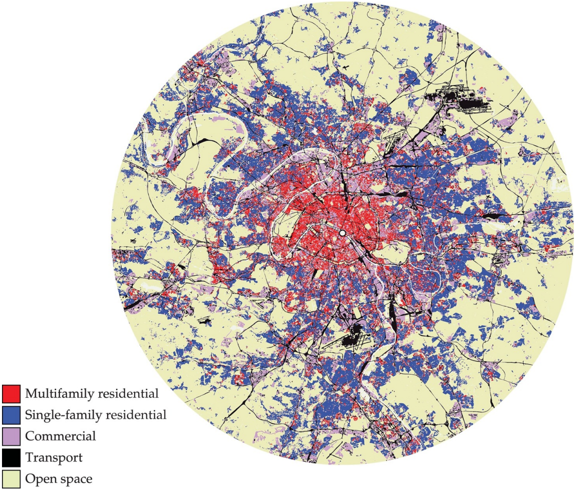


Figure 1: Duranton and Puga (2015). Land use distribution in Paris (disk with radius of 30km centered on Notre Dame).

Land Use in Paris - Duranton and Puga (2015)

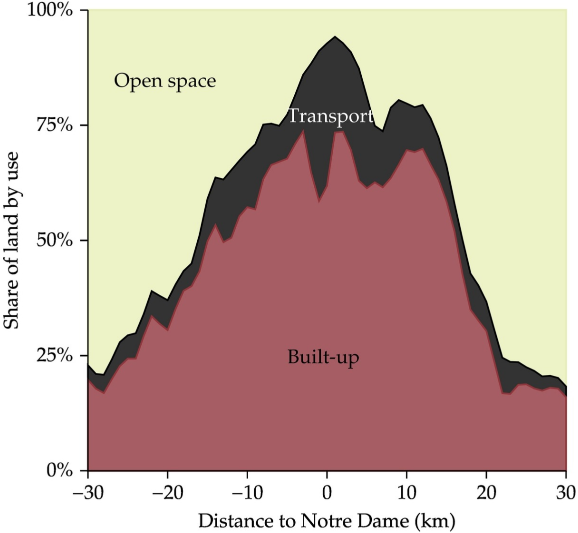


Figure 2: Duranton and Puga (2015). Land use distribution in Paris between Built-up land, Open Space and Transportation.

Land Use in Paris - Duranton and Puga (2015)

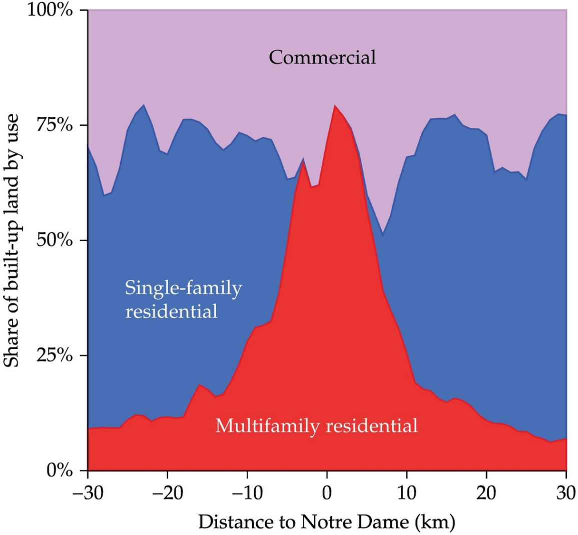


Figure 3: Duranton and Puga (2015). Share of built-up land by use between Commercial, Single-family residential and Multifamily residential.

Road Map for Today

- Monocentric city model with homogeneous residents (review)
- Monocentric city model with two modes of transport and two income levels
- Highways and suburbanization
- ~~Land use regulation (briefly)~~
- Informality, slums and slum-upgrading

Basic Monocentric City Model

Setup

- We will start with basic AMM model as in lecture 2.
- Linear monocentric city.
- Production and consumption of numeraire good happen in the CBD, at distance $r = 0$.
- Land covered by city is endogenously determined.
- Residents consume:
  - Numeraire consumption good ("c")
  - Housing ("h")
- Preferences are represented by utility function over housing and consumption good: $u(h, c)$.
- budget constraint: $\mathrm{y} = \mathrm{T(r)} + \mathrm{P(r)\ h} + \mathrm{c}$
- In spatial equilibrium, all utility must be equalized across space in the city.
- Assume open city, so utility is determined by outside option.

The Bid-rent Approach

- Bid-rent function for housing: maximum price a resident is willing to pay for housing at distance r from the CBD while enjoying utility $\underline{u}$ and satisfying the budget constraint:

  $$\Phi(r, \underline{u}) := \max_{h(r), c(r)} \{P(r) | u(h, c) = \underline{u}, y = T(r) + P(r)h(r) + c(r)\}.$$

The Bid-rent Approach: Deriving housing prices graphically

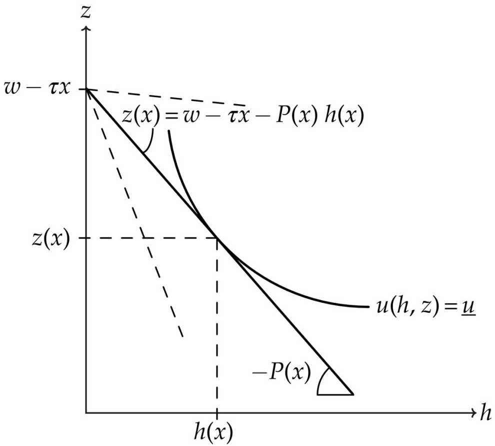


Figure 4: Duranton and Puga (2015)

The Bid-rent Approach: Comparative Statics

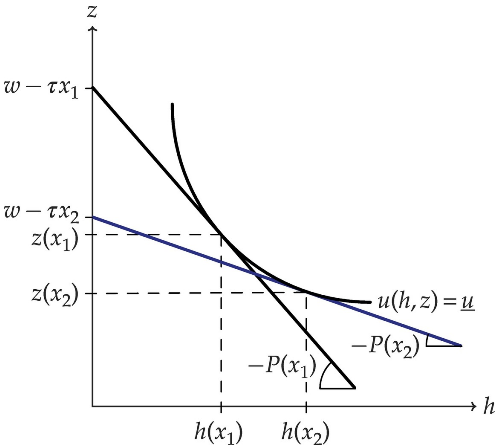


Figure 5: Duranton and Puga (2015)

Some Key Findings from the Model

- **Housing prices decrease with distance to city center (r).** Intuition: compensating diff. from increase in commute costs.
- **Housing consumption (h) increases with distance to CBD.** Intuition: substitution effect.

Housing Supply

- Perfectly competitive construction industry.
- Uses land and capital under CRS production function to build $f(r)$ units of housing floorspace per unit of land at distance r.
- Rental price of land ($l(r)$) at distance r: R(r).
- Rental price of capital is exogenous and constant.
- Zero profits imply costs unit costs ($C(R(r))$) must be equal to price ($P(r)$):

$$P(r) = C(R(r)).$$

Housing Supply

- Totally diff. the zero profit condition ($P(r) = C(R(r))$):

$$\frac{dP(r)}{dr} = \frac{dC(R(r))}{dR(r)} \frac{dR(r)}{dr}.$$

- Which implies

$$\frac{dR(r)}{dr} = \frac{dP(r)}{dr} \frac{1}{\frac{dC(R(r))}{dR(r)}} = \frac{dP(r)}{dr} \frac{1}{l(r)} < 0$$

- As one moves away from the CBD, land prices decrease. Intuition: As the price of housing declines, so must costs (from zero profit condition).
- Construction industry then reacts to lower land cost by substituting capital (which is relatively more expensive now) for land when r increases.

Population Density

- Recall from lecture 2, population density:

$$n(r) = \frac{f(r)}{h(r)}.$$

- Since capital intensity decreases with r, the amount of housing per unit of land also must decrease, so $\frac{df(r)}{dr} < 0$.
- Since housing consumption per resident increases with r, $\frac{dh(r)}{dr} > 0$.
- Therefore, density must decrease with r: $\frac{dn(r)}{dr} < 0$.

Five Important Gradients

- As one moves away from the CBD:
  - housing prices decrease
  - housing consumption increases
  - land prices decrease
  - the density of construction declines
  - population density declines

Monocentric City Model with multiple modes of transport and heterogenous residents

Motivation: Income distribution within cities - NYC

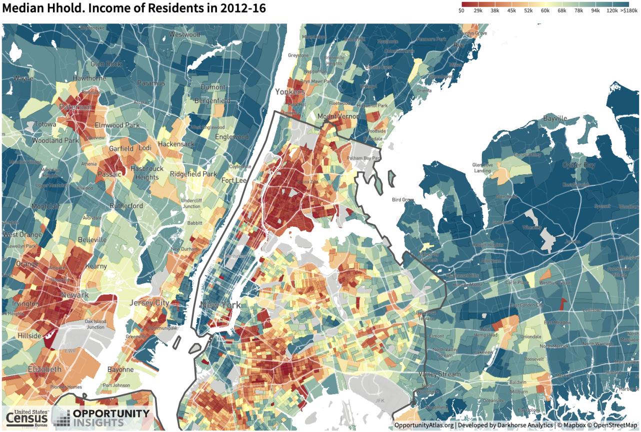


Figure 6: Median household by census tract in NYC. From Atlas of Opportunity (https://www.opportunityatlas.org/).

Motivation: Income distribution within cities - Chicago

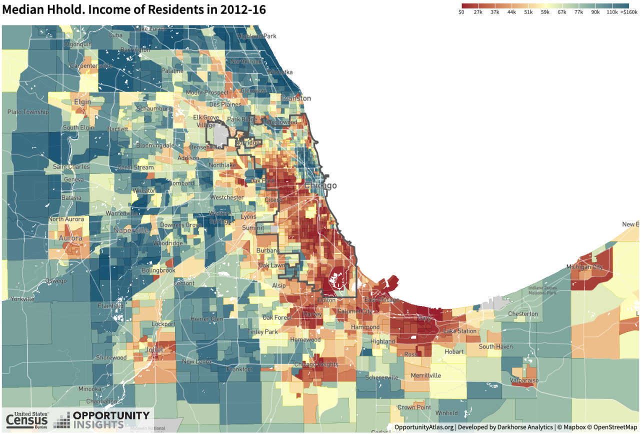


Figure 7: Median household by census tract in Chicago. From Atlas of Opportunity (https://www.opportunityatlas.org/).

Setup

- Linear city as in the previous case.
- Two types of residents: high income (H) and low income (L).
- Same utility function:

$$u(c, h) = 2h^{\frac{1}{2}} c^{\frac{1}{2}}.$$

- Budget constraint:

$$Y_i = T_i(r) + P(r)h + c$$

- High income residents earn wages w_H and low income residents earn wages w_L.
- Assumptions: $Y_H > Y_L$, $\frac{Y_H}{Y_L} > \frac{\underline{u}_H}{\underline{u}_L}$, $w_H > w_L$, $\frac{w_H}{w_L} > \frac{\underline{u}_H}{\underline{u}_L}$.

Commuting Costs and Modes of Transport

- Two modes of transport: car and subway (or public transport, could be bus).
- Travelling by subway costs w_i times the commute distance:

$$T_{i,\text{subway}} = w_i r.$$

- Travelling by car requires a fixed investment F, but lowers the marginal cost by $alpha < \frac{1}{2}$:

$$T_{i,\text{car}} = F + w_i \alpha r.$$

- Each resident then chooses travel mode to minimize travel costs:

$$T_i(r) = min\{T_{i,\text{subway}}(r), T_{i,\text{car}}(r)\}.$$

Indirect Utility Function

- From the residents utility max. problem:

$$h(P(r), Y_i - T_i(r)) = \frac{1}{2}\frac{Y_i - T_i(r)}{P(r)},$$

$$c(P(r), Y_i - T_i(r)) = \frac{1}{2}(Y_i - T_i(r)).$$

- Plugging this into the utility function we get the indirect utility function:

$$v_i(P(r), Y_i - T_i(r)) = \frac{Y_i - T_i(r)}{(P(r))^{\frac{1}{2}}}.$$

Bid-rent Functions

- Let $\underline{u}_i$ be the utility level for a resident of type $i \in \{H, L\}$.
- Spatial eq. implies that $v_i = \underline{u}_i$, which implies

$$P_i(r)^{\frac{1}{2}} = \frac{Y_i - T_i(r)}{\underline{u}_i},$$

- So we get a bid-rent function:

$$P_i(r) = \left[\frac{Y_i - T_i(r)}{\underline{u}_i}\right]^2.$$

Bid-rent Functions

- Evaluating this for different modes of transport and income levels we get:

$$P_{H,\text{subway}}(r) = \left[\frac{Y_H - w_H r}{\underline{u}_H}\right]^2,$$

$$P_{L,\text{subway}}(r) = \left[\frac{Y_L - w_L r}{\underline{u}_L}\right]^2,$$

$$P_{H,\text{car}}(r) = \left[\frac{Y_H - F - w_H \alpha r}{\underline{u}_H}\right]^2,$$

$$P_{L,\text{car}}(r) = \left[\frac{Y_L - F - w_L \alpha r}{\underline{u}_L}\right]^2.$$

Bid-rent functions: Equilibrium result graph

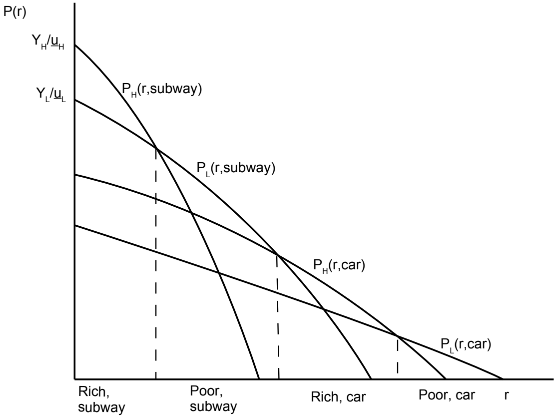


Figure 8: Sorting of high and low income residents according to bid-rent functions.

Key Results

- There is a tension between two forces:
  - Commute costs push people towards city center. Since commute costs are higher for rich than poor, they are willing to pay more for living near CBD.
  - Housing consumption push people further away from CBD (where prices are lower). Since rich people have higher income, they will want to consume more housing (normal good).
- Rich out-bid poor near city center and they take the subway.
- Eventually the commute costs are high enough for rich (with subway) and the poor out-bid the rich.
- When rich switch to cars, their bid-rent function becomes steeper and eventually they outbid the poor in the suburbs.
- Poor residents might eventually live in the furthest suburbs and pay high commute costs.

Key Results

- This patter of sorting is not the only possibility.
- What determines who lives near CBD is the relationship between the *income elasticity of commuting costs* and the *income elasticity of demand of housing* for each mode of transport.
- Glaeser, Kahn and Rappaport (2008) develop a very similar model but where poor live in the city center.
- This might reflect better certain cities in the US.

Suburbanization and Highways

Did Highways Cause Suburbanization? (Baum-Snow, 2007)

TABLE I
AGGREGATE TRENDS IN SUBURBANIZATION, 1950–1990

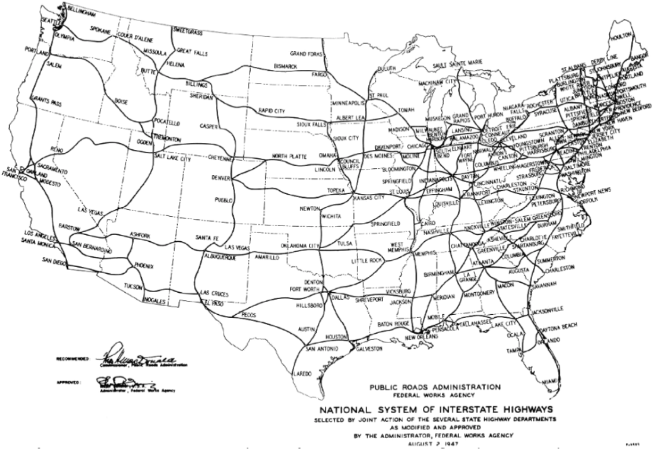
	1950	1960	1970	1980	1990	Percent change 1950–1990
Panel A: Large MSAs						
MSA population	92.9	115.8	134.0	144.8	159.8	72
Total CC population	44.7	48.5	51.3	49.2	51.0	14
Constant geography CC population	44.7	44.2	42.6	37.9	37.1	−17
N for constant geog. CC population	139	132	139	139	139	
Panel B: Large Inland MSAs						
MSA population	39.2	48.9	57.0	65.0	73.5	88
Total CC population	16.8	19.7	22.1	22.1	23.2	38
Constant geography CC population	16.8	16.5	15.4	13.3	12.5	−26
N for constant geog. CC population	100	94	100	100	100	
Total U. S. population	150.7	178.5	202.1	225.2	247.1	64

Notes: All populations are in millions. CC stands for central city. The sample includes all metropolitan areas (MSAs) of at least 100,000 people with central cities of at least 50,000 people in 1950. The sample in Panel B excludes MSAs with central cities located within 20 miles of a coast, major lake shore, or international border. MSA populations are for geography as of year 2000. Constant geography central city population uses 1950 central city geography. Census tract data are not available to build constant geography central city populations for some small cities in 1960. These cities are assigned a population of 0 for constructing the aggregates. Reported total U. S. population excludes Alaska and Hawaii.

Baum-Snow (2007)

- **Motivation:** Population of central cities in the US has declined by 17% between 1950 and 1990, while overall population in MSAs grew by 72%.
- **Main question:** Did the expansion of highways passing through central cities contribute to this decline? I.e. did highways cause suburbanization?
- **Endogeneity problem:** State and local governments adjusted metropolitan area highway infrastructure at least partly in response to local commuting demand.
- **Identification strategy:** Uses planned route instrumental variable based on the 1947 plan for the interstate highway network that measures the number of planned radial highways (rays) in each city's center.

Baum-Snow (2007) - 1947 National Highway System Plan



Baum-Snow (2007) - Identification

Exclusion Restriction:

- Requires that the planned number of interstate highway rays passing through each MSA's center is not correlated with factors affecting suburbanization between 1950 and 1990, except for MSA population.
- Relies on the fact that the the plan "was designed to facilitate **trade** and **national defense**, not to facilitate metropolitan area development".
- The paper shows that Δ planned rays is not related to MSA population growth in the decade preceding the highway expansion (unlike realized rays).
- Also rules out that plan was affected by central city decline between 1910 and 1950.
- Claims that Highway Act and related reports that "do not mention" local commuting explicitly.

Baum-Snow (2007) - Results

TABLE IV
LONG-DIFFERENCE REGRESSIONS OF THE DETERMINANTS OF CONSTANT GEOGRAPHY CENTRAL CITY POPULATION GROWTH, 1950–1990

Large MSAs in 1950						
		Change in log population in constant geography central cities				
	OLS3	IV1	IV2	IV3	IV4	IV5
Change in number of rays	−.059 (.014)**	−.030 (.022)	−.106 (.032)**	−.123 (.029)**	−.114 (.026)**	−.101 (.046)*
1950 central city radius	.080 (.014)**		.111 (.023)**	.113 (.023)**	.106 (.023)**	.125 (.021)**
Change in simulated log income	.084 (.378)			.048 (.417)	−6.247 (6.174)	−.137 (.480)
Change in log of MSA population	.363 (.082)**			.424 (.094)**	.374 (.079)**	.405 (.108)**
Change in Gini coeff of simulated income					−23.416 (23.266)	
Log 1950 MSA population						−.062 (.062)
Constant	−.640 (.260)*	−.203 (.078)*	−.359 (.076)**	−.588 (.281)*	4.580 (5.091)	−.611 (.265)*
Observations	139	139	139	139	139	139
R-squared	.39	.00	.01	.30	.33	.37

Figure 9: Baum-Snow (2007): One new highway passing through a central city reduces its population by about 12 percent.

Informality, slums and slum-upgrading

Henderson et al. (2021): Building the City

- Model the development of a city where there are institutional frictions in the conversion of land use.
- Use monocentric city model framework in a dynamic setting.
- Use unique satellite data from Nairobi to calibrate the model.
- Hopefully someone will present this paper...

Henderson et al. (2021): Building the City

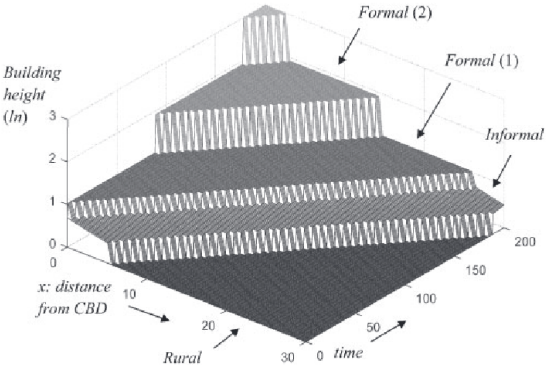


FIGURE 1
Urban development with perfect foresight

Figure 10: Henderson et al. (2021): Evolution of stylized benchmark city without frictions.

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

What is the Research Question?

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

What is the Research Question?

- What is the long term impact of slum upgrading projects?
- Why is this important?

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

What is the Research Question?

- What is the long term impact of slum upgrading projects?
- Why is this important?
- Dynamic inefficiencies associated with slum upgrading: may slow down formalization in the long run.

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

2. What is the empirical strategy for answering this research question?

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

2. What is the empirical strategy for answering this research question?

- Compare KIP treated sub-blocks to non-treated sub-blocks that were also part of slums and with similar characteristics.
- Boundary discontinuity design (BDD)comparing observations within 200 meters of KIP boundaries.

Harari and Wong (2021): Slum Upgrading and Long-run Urban Development: Evidence from Indonesia

What are the main conclusions of the authors?

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Table 2: Effect of KIP on land values and building heights

Dependent variable:	**Log land values**		**1(Height>3)**	
Sample:	Historical kampung (1)	BDD 200m (2)	Historical kampung (3)	BDD 200m (4)
KIP	-0.14***	-0.17***	-0.12***	-0.08**
	(0.05)	(0.06)	(0.02)	(0.03)
N	3144	1291	5277	1036
R-Squared	0.73	0.81	0.29	0.38
Distance	Y	Y	Y	Y
Topography	Y	Y	Y	Y
Landmarks	Y	Y	Y	Y
Distance to KIP boundary	N	Y	N	Y
Geography FE	Locality	KIP Boundary	Locality	KIP Boundary

* 0.10 ** 0.05 *** 0.01

Notes: This table reports the effect of KIP on land values and building heights. Columns 1 and 2 report the effect of KIP on log assessed land values in a sub-block, where the key regressor is an indicator that is 1 for sub-blocks in KIP. Column 1 includes the historical kampung sample with 196 locality fixed effects. Column 2 uses observations within 200 meters from a KIP boundary, controlling for distance to the KIP boundary (and its square), and 123 KIP boundary fixed effects. Columns 3 and 4 present the analysis for heights at the pixel level, where the dependent variable is a dummy equal to 1 if the tallest building in the pixel has more than 3 floors. We also control for strata fixed effects from our photographic survey and an indicator for pixels with no buildings. All other controls are listed in Table 1. Standard errors are clustered by locality (historical specification) and by KIP boundary (BDD specification).

Next class: Location sorting and preferences over amenities

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