Economics 1800: The Economics of Cities

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Abstract

These are notes[1] for Harvard's *Econ 1800*, an undergraduate class on the economics of cities, as taught by Professor Edward Glaeser and Dr. Denise DiPasquale in Spring 2023.

Course description: Addresses the central questions of why cities exist, what roles will cities continue to play in the economy, and what determines the rise and fall of cities. Special attention is paid to cities and information, and social problems in cities.

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1 January 24th, 2023

1.1 Logistics

This course is taught by Professor Edward Glaeser and Dr. Denise DiPasquale. The teaching fellows are Ziqi Lu and Peleg Samuels.

Office hours for Professor Glaeser are by appointment on Mondays and Wednesdays. Dr. DiPasquale will have office hours on Tuesdays 2:30-4:30 PM in Littauer 225 or by appointment.

The course has three empirical problem sets (with data sets), three theoretical problem sets (graded check/check plus/check minus), one in class midterm in March, one final exam during the final exam period, and one 5-7 paged essay on an urban question due in April.

Getting lunch with the professors is required.

1.1.1 Grading

Grading is as follows:

- Empirical problem sets: 21%
- Theoretical problem sets: 9%
- 5-7 paged memo: 16%
- Midterm: 18%
- Final: 36%

There are several required books for the course: DiPasquale and Wheaton's textbook, and Professor Glaeser's *Triumph of the City* and *Survival of the City*.

1.2 The arc of U.S. cities

The rise of the consumer city means that people go to the city to get better opportunities and growth. There has been recent growth of cities in the United States:

- Population change from 2000-2010 is higher with population density, and per-capita income in 2000 is higher with population density.
- The trend at the start of the 2000s is due to people clustering in towards cities. Note the relation is driven basically entirely by people moving into cities rather than birth rates, birth rates, in fact, tend to be lower.

Incomes are higher in cities, which promotes opportunity, but this is also a failure (affordability issues).

Urbanization looks different in poorer countries:

- In 1960, being poor meant rural, no countries with low GDP per-capita were over one-third urbanized. This changed by 2010, where a substantial fraction are. Megacities occur in countries that are poor *and* urbanized.
- Cities help function as connection between rich and poor, and to international economy.

Per-capita GDP growth strongly correlated with urbanization; no causality claims but cities are probably good. Higher GDP per-capita is correlated with smaller urban-rural differences in happiness.

1.2.1 Sickness in cities

The earliest record of sickness in cities is the plague of Athens. At the time, 5th century Athens is thriving economically, politically, culturally. During Peloponnesian War, closed themselves off for defense when the

plague hit. There were two vulnerabilities:

- Nodes for commerce and movement of people.
- Population density.

Black Death throughout Europe plunges the West into darkness.

In the last few centuries, cities become much more robust.

- In early years, very few public health protections.
- Many people recorded moving from poor places to richj places, largely because it is more well-documented when it happens in rich places.
- Yellow fever and cholera major illnesses across 19th century, but despite this, New York City continues to grow, even with 2.5% of population dying each year. Why?
  - Migration. People are poor. If you have choice between rural poverty and risking dying of cholera, maybe worth the risk.
  - Public health protections begin to emerge.
- 1866 New York Board of Health imposes some tax.

  Note (Takeaway)**.** Infrastructure is never enough, cannot just build more highways for congestion, have to tax road usage.

Covid changes some things:

- In New York City, cases per-capita are lowest in downtown Manhattan and highest in outer boroughs. People an Manhattan can work from home, go outside and travel less.
- Inequality of the remote workplace. More educated and richer people had higher percentage of virtual work. City share of people with B.A. is *very* negatively correlated with that city's Covid death rate.
- Wage spike when Covid hits. Labor supply effect far exceeds labor demand effect; big shortage with people not wanting to go outside to work outweighing lessened demand for leisure/hospitality services.
- Normality. In biggest cities, still only like half of people back in office, big decline in mobility and public transit from Google mobility data.

1.2.2 Technology and the city

There is a gradual transition from centripetal (bringing us closer) and centrifugal (bringing us apart) forces in cities:

- 19th century characterized by development of centripetal technologies like skyscrapers.
- 20th century characterized by development centrifugal technologies like cars, radios, and televisions. Enabled dispersal of people from one-time centers.
  Over time, there is significant decline in costs of moving goods (via highways), no longer a need for cities to be built near a river, ocean, or railroad. In fact, New York City's main hubs used to be around ports and airports.
- People start dispersing, increase in highways and ease of mobility leads to centrifugal movement.
- Globalization killed off many domestic industries. Production moves to rural areas, suburbs, and other places in world.
- Industry moves from "where transport is" to "where it is nice to live."

Population growth in cities. Housing policies. In rich areas, weather; for poor areas, being in a city is itself a luxury.

Note. Cities have generally been shrinking from 1950-2000. New York City saw +1.5%, St. Louis saw -60%, and Boston saw -26% changes in population.

The main cause of this is deindustrialization coupled with few housing developments and shrinking family sizes. To revive cities, you have to invest in people (education, jobs), not investments like the Detroit people mover.

People are currently in cities because of the passage of knowledge; it is easier face-to-face. Consider the Wall Street stock floor, universities, and technology companies forcing people to go back to work.

Note (Effects of remote work)**.** Fewer promotions, harder for collaboration, remote jobs hold steady on employment but harder to train and onboarding people.

Some of the weaknesses of urban areas include:

- Cities bring productivity but not upward mobility. Cities are good for adults but bad for kids.
- Successful cities are becoming permanently unaffordable. Triumph of insiders over outsiders.
- Unhappiness over policing and incarceration. Incomplete triumph of urban safety.
- Understandable anger over urban inequities collides with enhanced mobility (thanks to Zoom) and ongoing fear of the disease.

We can measure urban winners and losers bu looking at percent home price growth, wage growth, employment growth, and change in housing permits.

2 January 26th, 2023

Once you build something it is difficult to change; we need to understand history of city to understand its structure.

2.1 Why cities look the way they do

Changing the public infrastructure shaping cities can be very costly.

Example 2.1 (Boston Big Dig)**.** Elevated highway removed, and turned into Kennedy Greenway. Cost 2.6b USD.

There was a big perspective difference in 1950s-60s. Cities were seen as places to flee from (Boston Harbor viewed as ugly). San Francisco Embarcadero Freeway comes down after 1989 earthquake.

2.1.1 Boston

There are two big ways to increase land area: annexation and landfill. Boston did a ton of landfill in the Back Bay (and elsewhere). Boston also annexed surrounding cities, incentivized to join Boston to be a part of its water system. Dates below are [settled]-[annexed].

- Brighton (including Allston). 1807, 1874.
- Charlestown. 1628, 1874.
- Dorchester (including Mattapan). 1630, 1870.
- Hyde Park (including Readville). 1868, 1912.
- Roxbury. 1639, 1868.
- West Roxbury (including Jamaica Plain and Roslindale). 1851, 1874.

Political jurisdictions also matter. Some cities grow in physical size through annexation of adjacent unincorporated areas. For example, Charlotte, North Carolina doubles land area from 1980 to 2017.

2.1.2 Characteristics of urban land markets

Land is more expensive at better lcoations. Price determines development intensity: more expensive means more structure capital per square feet of land, taller buildings.

2.2 Alonso-Muth-Mills Model

This is a model of a monocentric city with the following properties and assumptions:

- Employment is at a single center.
- Workers commute distance d to the center along a straight line from their homes.
- Commuting costs k dollars annually per mile.
- Households are identical, fixed number of commuters.
- Housing units are identical, provided on fixed quantity of land per unit. The rent $R(d)$ depends on distance from center.
- Housing occupied by households who offer the highest rent, land goes to the use yielding highest rent.
- Spatial equilibrium is the condition that is satisfied when there is no longer any reason for anyone to want to make a move.

Thus the rent is given by:

$$R(d) = y - kd - x \tag{1}$$

where x is expenditure on all other goods.

This implies a breakdown of housing rent as shown in Fig. 1.

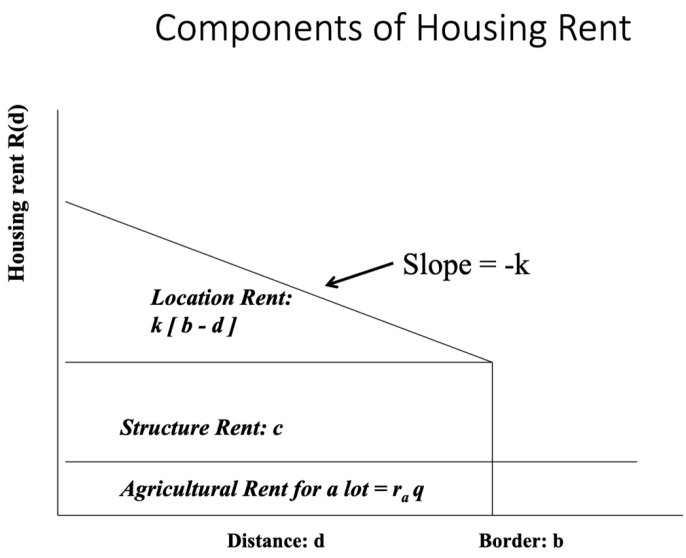


Figure 1: Components of housing rent.

The rent at the border b is given by

$$R(b) = r_a q + c \tag{2}$$

where r_a is the annual agriculture rent *per acre*, q is the lot size, c is the annual rent for constructing a house.

2.2.1 Implications

- With bigger cities (further border), there is more distance across which to potentially commute, so housing and land rent increase at all interior locations.
- If commuting costs per mile increase, it becomes more valuable to be closer to center, so housing and land rent increases at all interior locations.
- If rent per acre of agriculture land increases, housing and land rent increases at all interior locations.

Note. This model is over-simplifying. There are other places of interest besides the center. Consider Los Angeles: locations on the coast might be more expensive.

City size depends on number of households n, density of housing q, and topography of the area. For circular cities:

$$\pi b^2 = nq. \tag{3}$$

2.2.2 Competition and separation between land use

Consider households group 1 and 2, where group 1 really dislikes commuting and group 2 doesn't mind. Then $k_1 > k_2$. Equilibrium rents separate the two groups:

$$R_1(d) = R(b) + k_1(b - d), \qquad R_2(d) = R(b) + k_2(b - d) \tag{4}$$

Highest use implies this group is willing to pay more for all houses from 0 to m. Group 2 gets houses from m to b. This is shown in Fig. 2.

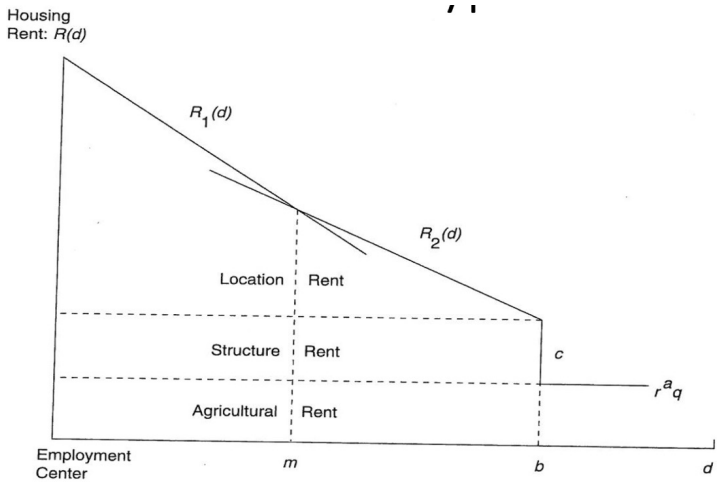


Figure 2: Rent separation between two groups with different commuting tolerances.

Note (Miscellaneous effects)**.** Population growth expands city borders. Technology improves transportation.

Proximity can have both positive and negative impacts; you want to be close to transportation but not too close (i.e. highway).

2.2.3 Changes in commuting costs

Transportation has transformed from walking to trolleys to modern subways to cars. With widespread adoption, electric vehicles (EV) cost per mile is much less than gas cars. Autonomous vehicles (AV) could make time spent in car less frustrating or nerve wracking, and even productive time.

Ride sharing could also reduce congestion and increase speed.

2.2.4 Relaxing assumption of fixed density

As land prices rise closer to the city center, we expect developers to substitute strucutre capital for land, and build taller buildings. This implies steeper rent gradient closer to the center as structure capital is substituted for land.

Moreover, there are lots of important locations clustered by highways. Offices are still highly centralized but industrial spaces are less so. Usually central business district, then residential areas, then industrial areas.

2.2.5 Covid impact

People are moving out of households in San Francisco (SF) and relocating elsewhere. Huge rise in vacant office spaces in SF; still going up now, since office leases are typically 5-10 years and many unrenewed leases from Covid are expiring now.

Kastle swipe data of how occupied offices in the top 10 cities are, top 10 average is 33.4% on lowest day and 58.1% on highest day. This past week, lowest day was Friday, highest days either Tuesday or Wednesday. There is a trend and shift towards hybrid working models.

Some final remarks from Professor Glaeser:

- We need these models that are general enough to make predictions when we do not or cannot observe what is going on. Helpful to think about questions like effect of improving transportation, effect of increasing work-from-home.

- Helpful for thinking about equilibrium: workplace density, housing density, employment, population as being *simultaneously determined*.
- Housing is a durable good. In short run, supply of office space is fixed. If demand drops, then prices drop quickly. This helps explain how Detroit's decline was slow but prices dropped quickly.
- Professor Glaeser is less confident in the speed of market adjusting because we've had decline in retail demand (Amazon) but there has been retail vacancies for forever in New York City.
- Other cities can also learn from Boston development (e.g. our process of retrofitting the city for the car).

3 January 31st, 2023

3.1 Real estate development

The following are featurs of real estate:

- **Fixed in space.** Location determines accessibility, public goods and services, neighborhoods.
- **Durability.** Older properties are good substitutes for new properties. Convertibility of existing units (upward or downward conversion).
- **Heterogeneity.** In structure, land lot, neighborhood.
- **Expensive.**
- **Substantial moving costs (especially business).**
- **Very regulated commodity.**

Redevelopment occurs under the following conditions:

- Lack of demand for existing structures can lead to disinvestment and abandonment. This is a big issue in cities that have lost population.
- Land use change will occur when value of land and new structure is greater than demolition and development costs. Demolition is expensive; permit process for new construction is expensive and time-intensive.
- Re-use of existing structures is viable if there is sufficient demand for the location or the existing structure can be modified to meet the requirements of the new use at a cost that makes the project viable.

3.1.1 Role of real estate in economy

Real estate stock is the value of existing structures (assets that are part of nation's wealth). **Real estate flow** is the value of additions to the stock in a given year (value of new construction put in place is counted as part of GDP).

Additions to the stock take time; on average, permit to completion is 7.5 months for single family home, 11.5 months for apartment building, and 3-5 years for office tower.

Land is not part of GDP because land is not produced.

3.2 DiPasquale-Wheaton 4-Quadrant model

Goal is to integrate different sections of real estate market in single framework and allow analysis of effects of changes on equilibrium. The sectors are:

- **Space (property) market.** Users of real estate.
- **Asset market.** Investors in real estate.
- **New construction.** Real estate development.
- **Stock adjustment.** How stock changes (time and durability).

The four quadrants are given in Fig. 3.

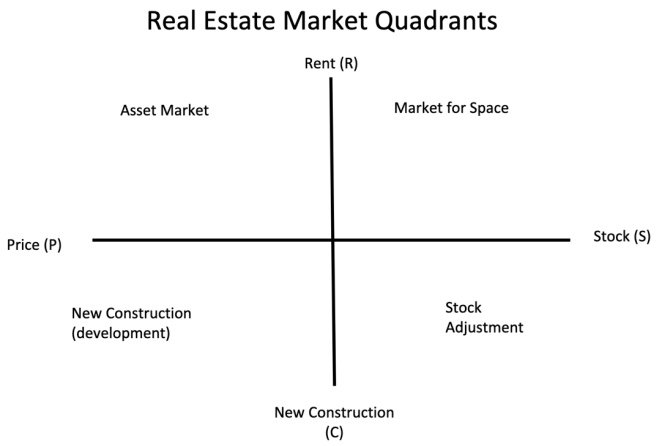


Figure 3: DiPasquale-Wheaton four-quadrants of real estate markets.

3.2.1 Northeast quadrant: Market for space

The northeast quadrant is the market for space. Demand curve describes space occupied at given rent, more space occupied as rent declines (downward sloping). Supply is fixed at existing stock S^*, which induces rent R^*. Demand shifts outward under the following conditions:

- **Retail.** Increases in population, income, tourism.
- **Housing.** Increases in population, income, changes in tastes/preferences.
- **Office or industrial.** Increases demand for sector's output.
- In short run, supply is fixed at S^*, so rents go up.
- In long run, supply increases.

3.2.2 Northwest quadrant: Asset market

The northwest quadrant is the asset market. This is where investors buy and sell real estate. Price P paid by an investor depends on rental income stream and capitalization rate i:

$$P = R/i. \tag{5}$$

Components of cap rate are (1) long term interest rate, (2) expected growth in rental income stream,)(3) risks associated with rental income stream (location, type of building), and (4) tax treatment of real estate.

Factors that matter:

- **Quality of buildings.** Higher quality office buildings have lower cap rates (higher price).

  Note (Class grades)**.** Class grades define relevant submarket of space which are close substitutes. **Class A** is characterized by premium, above average rent, high quality finishes, state-of-the-art systems, curb appeal; **Class B** is characterized by average rent, wide range of tenants, fair-to-good finishes, adequate systems.

- **Location of buildings.** Suburban office buildings have higher cap rates than central business district (CBD) buildings (lower price).
- **Property type.** Multifamily is much lower than office building.

More favorable treatment of real estate (faster depreciation, increase in deductions, decrease in tax rate) decrease cap rate i and increases asset price P. On the northwest quadrant, this causes a counter-clockwise rotation.

3.2.3 Southwest quadrant: Development

Compare asset values P with replacement cost $P = f(C)$. Replacement costs are land, labor, materials, development process. Shift and/or rotation in C determined by input prices, development timeline and regulatory process, technology. We need P to be greater than replacement cost to build new buildings, that determines the P-intercept.

P^* determines C^* with inverse.

3.2.4 Southeast quadrant: Stock adjustment

Buildings depreciate; it is costly to maintain quality; residential depreciation rate is 3% per year, rate for 30 year-old buildings is twice the rate of 10 year-old buildings. Stock adjusts through new construction (C^*) and depreciation of existing stock $\delta, 0 < \delta < 1$. In equilibrium, we have

$$S^* = S^* - \delta S^* + C^* \implies C_{\text{eq}} = S^* \delta. \tag{6}$$

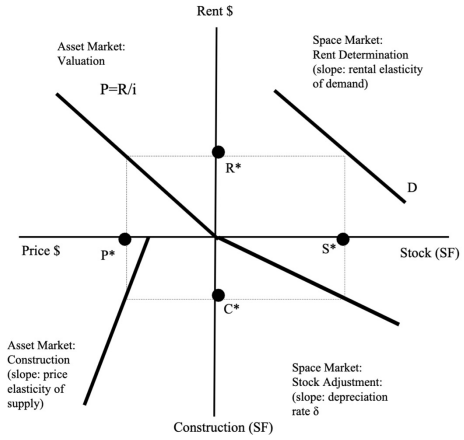
A figure of these transformations is given in Fig. 4.

3.2.5 Strengths and limitations

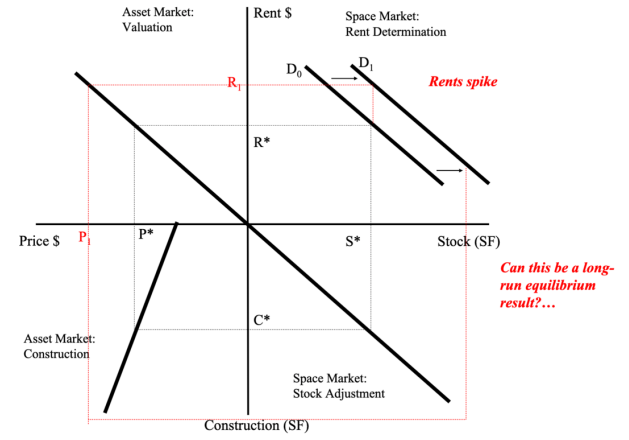
Conceptual framework shows relationship between space market, asset market, development, and stocks. In equilibrium, solution to endogenous variables R, P, C, S given exogenous values and parameters.

Can look at comparative statics — how changes in exogenous variables change equilibrium.

Note. This model **does not** provide exact path or timing, nor estimates of size of changes.



(a)



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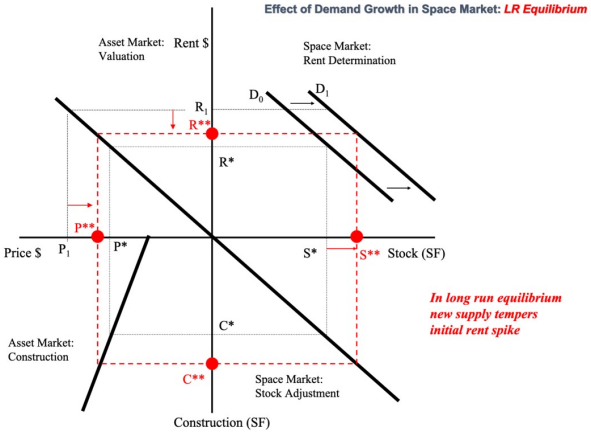

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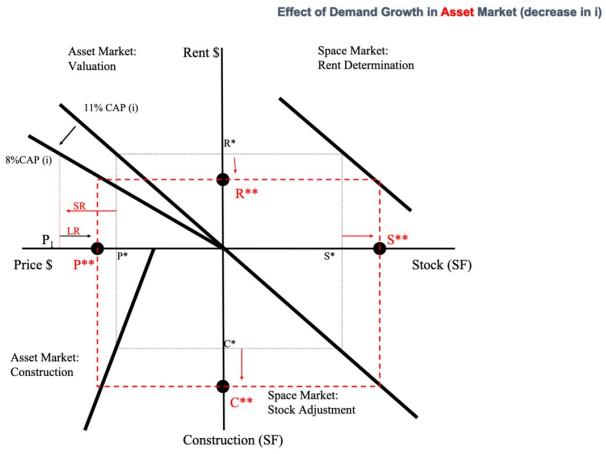

(d)

Figure 4: 4a. DiPasquale-Wheaton model with plots. 4b. Demand growth in space market, short-term effects. 4c. Demand growth in space market, long-term effects. Rents, asset prices, constuction, and stock all go up. 4d. Demand growth in asset market. Asset prices, construction, stocks go up, but rents go down.

4 February 2nd, 2023

4.1 Transport, density, and prices

4.1.1 Plots

We look at Manhattan density diagrams (see slides) and observe that rent, housing value, and commute time roughly reflect the AMM model. Commutes are lower and rents are higher closer to the business district. Some exceptions are public and affordable housing units and 5th Avenue.

In Boston, we see that commute times are lower around cities where people tend to work (Boston, Lowell, Worcester), or along Route 128. Housing prices are a little odd and not consistent; not always more expensive closer to the city center in Boston (perhaps they are paying for K-12 school systems).

We use models like AMM to do comparative statics — predictions about what happens when something changes. Useful for both testing model and for predictions: new technology may cause demand for being at city center to go up or down (intercept to go up or down, slope is the same); new transportation technologies can make commuting costs go down (cause slopes to flatten); changes in construction technology (skyscrapers) create zones for density; Covid could cause reduction in demand for being in city center or increase in demand for land; Zoom may reduce commute costs. Data shows this to be true, as Covid hits, rent gradient becomes zero.

4.1.2 Boston history

Boston was founded in 1630 with 150 settlers, Winthrop arrives for consumption, the freedom to be intolerant. Location determined by Charles River (clean water). Population grows to 7000 in 1690, 17000 in 1740 (and is the largest city until 1740 when overtaken by Philadelphia).

Early Boston is a colonial-era Ponzi scheme. Each new round of settlers come with British gold, pay it to previous generation of settlers to get settled, then they can use that to buy guns and Bibles.

Barbados famine brings triangle trade, bringing English manufacturers to Boston, food to the South, and sugar to England.

New England exported to other colonies; goods are basic commodities. Mid 18th century, New York has a better port, Pennsylvania has better farmland, both have better rivers and better access to hinterland. Both ports pass Boston and city stagnates from 1740-90. In 19th century, Boston grows to 90000 in 1840 (port ownership increases, Boston has better human capital).

In 1840-1920, Boston enters steam age. Boston's sail-specific human capital loses maritime advantage; switches to manufacturing, improvements in engine technology divorce manufacturing and river power; leads to creation of rail networks.

Transporatation adoption occurs in three phases.

- **Transportation revolution.** Watt separate condenser steam engine and Murdoch sun and planet gear in 1784; Siemens electrification of trains and elevators 1879-81; Otto, Daimler, Benz, internal combustion engine 1864-79.
- **Transportation infrastructure investment.** Rails for horse-drawn omnibuses (and then trains and electric trams); tunnels for electric trains; limited access highways for cars.
- **Built environment revolution.** Expansion of city outward, upward, and around highways in suburbs.

Boston has two notable suburbs. Brookline is a streetcar suburb that grows in mid-19th century, refused integration into Boston in 1873. Wellesley is train-accessible after the 1830s, town separates from Needham in 1881 (where land is cheaper, homes are surrounded by more areage).

4.2 America's first subway

London develops subways in 1860s before electrification. Electrification starts in 1890. U.S. pattern was for rails to go above city streats (cheaper but less pleasant). Tremont Street Subway (green line) opens in 1898, third oldest operating subway in the world. For the first 50 years, the are private companies, then they start losing money, so MBTA takes over in 1947.

Note (Spatial models)**.** Some algebra yields a rich spatial model (based on residence-workplace pair in Greater London)

$$\lambda_i^R = \frac{\sum_{i\in\mathbb{N}}(B_{ni}w_i^\epsilon)\left(\kappa_{ni}P_n^\alpha Q_n^{1-\alpha}\right)^{-\epsilon}}{\sum_{k\in\mathbb{N}}\sum_{\ell\in\mathbb{N}}(B_{k\ell}w_\ell)^\epsilon\left(\kappa_{k\ell}P_k^\alpha Q_k^{1-\alpha}\right)^{-\epsilon}}, \qquad \lambda_i^L = \frac{\sum_{n\in\mathbb{N}}(B_{ni}w_i^\epsilon)\left(\kappa_{ni}P_n^\alpha Q_n^{1-\alpha}\right)^{-\epsilon}}{\sum_{k\in\mathbb{N}}\sum_{\ell\in\mathbb{N}}(B_{k\ell}w_\ell)^\epsilon\left(\kappa_{k\ell}P_k^\alpha Q_k^{1-\alpha}\right)^{-\epsilon}}. \tag{7}$$

where R_n is employment by residence in location n, L_i denotes employment by workplace in location i. λ_i^L is the probability that a worker is employed in workplace $i \in \mathbb{N}$, conditional on choosing a residence-workplace pair in Greater London.

4.2.1 Skyscrapers

Marginal cost (MC) and average cost (AC). If it costs 100 USD/ft^2 for up to four stories, then MC = AC. If it costs 200 USD/ft^2 for five or more and 10000 USD ft^2/lot, then four stories cost 4m USD but five stories cost 10m USD. Marginal cost of 5th floor is 6m USD.

Fixed cost and variable cost. Building is fixed cost independent of use, but traveling upward in building generates costs on a daily basis in terms of pain and stairs (elevators alleviate that).

Height costs more because load-bearing walls must be thicker as building gets taller. Skyscrapers use metal skeletons to carry the weight of the building with much less weight on structure below. Elevator solves stairs.

Note (Economics of adding density)**.** In high value places (near city center), density increases.

There are math examples on the slides.

Note. Cities can vary continuously and discretely. Discrete technologies like subways, skyscrapers naturally create discrete land use zones. Natural breakpoints are joined by breakpoints associated with land use controls. Zones have capacity to shape social environment.

4.3 Solving problems

Some notes for solving AMM problems.

Recall there are two versions: open and closed cities. In both cases, the critical element is that **urban costs are the sum of housing and transportation costs, and these are the same everywhere**.

4.3.1 Closed cities

A **closed city** means population is fixed. And if land-per-capita is fixed, you can solve for the border of the city b. Recall, on the border, rent is

$$R(b) = r_a q + c \tag{8}$$

and rent everywhere else is

$$R(d) = R(b) + k(b - d). \tag{9}$$

This is easy to remember if we just remember point-slope form and that rent is a linear function with one point $(b, R(b)) = (b, r_a q + c)$ known to us and a slope $-k$.

4.3.2 Open cities

An **open city** means we fix net earnings (utility $\widetilde{U}$). We will usually be given the wage in the city that we care about. Let w be the wage and c be costs. Then

$$w - c = \widetilde{U}. \tag{10}$$

Housing costs everywhere are given by

$$R(d) = R(0) - kd \tag{11}$$

and the border costs are still

$$R(b) = r_a q + c. \tag{12}$$

4.3.3 Skyscraper zones (open city)

Calculate distance where we switch from low-rise to skyscrapers. In an open city, we are pretty much done, $R(d)$ is independent of population. Calculate s that is the outer limit of the skyscraper zone. Let b be the border prior to skyscrapers. We can then calculate total population implied by the low-rises and add the *additional* population implied by the skyscrapers.

4.3.4 Skyscraper zones (closed city)

In a closed city, we need to figure out how many number of homes add up to fixed population size. Let P^* be the price where we switch to skyscrapers, b be the edge of the city, and s be the distance where skyscrapers will be built. Then let

$$\underline{\mathrm{P}} \equiv R(b) = r_a q + c \tag{13}$$

be the price at the border for single family homes. Price at any other point is

$$R(d) = \underline{\mathrm{P}} + k(b - d). \tag{14}$$

The skyscraper zone solves

$$\underline{\mathrm{P}} + k(b - s) = P^* \tag{15}$$

and we can then calculate the number of people who live in the city as a function of the city edge b and the skyscraper start point s.

5 February 7th, 2023

Subsequent lectures will be about why cities are efficient and pleasant.

Some administrative reminders: there is a STATA review session today from 3-4 PM at Sever 110, and an R review session on Thursday 4:30-5:30 PM in Sever 213.

Professor Glaeser is also looking for research assistants to compile a literature review on climate change adaptation in developing world cities.

5.1 The imperial city and the consumer city

These are reasons why people will come to cities, but are inefficient.

Note. New York City did extremely well in hotel market, evidence that cities are desirable for people.

One of the main visions that came out of Paris is the "15 minute city." Glaeser et al. looked at cell phone data and observed that for the poor, 15 minute cities mean segregation.

For high-income people, 15 minute cities seem to cause them to interact with people from all background; low-income people experienced segregation. For income above first quartile, no association between 15-minute usage and experienced income segregation.

5.1.1 City pre-history

Cities require some means of feeding themselves — this means they need to make goods and services. Cities were also able to feed themselves by stealing from hinterland (extraction as tribute).

One of most important uses of cities was military, people could crowd behind city or town walls. Cost of wall goes down depending on city arrangement (linear in the area if circular).

All pre-modern mega cities were imperial cities. See slides for a list.

5.1.2 Babylon as imperial city

Bablyon was an early city-state along the Euphrates River. Hammurabi conquered neighbors and created a small empire, Babylon was capital and probably largest city in the world in 1700 B.C.

Hammurabi's code was the first known law code and represents the need of bringing order to urban world (there is even a building code).

Assyrian conquest leads to Babylon decline, rises again with independence in 600 B.C. Cyrus the Great of Persia conquers the city, diverting river and entering through underground waterways.

5.1.3 Alexandria: the Ptolemaic capital

Alexander the Great founded city in 331. Locational value was on the Mediterranean and Nile Delta. Ptolemy of Lagus starts Hellenistic dynasty which rules until death of Cleopatra and Roman domination; great grain wealth of Egypt supplies its citizens.

Famous as a repository of wisdom (Library of Alexandria), its notable lighthouse, and had largest Jewish population in the ancient world.

5.1.4 Rome

Rome had seven kings from 753 to 509 B.C. The Romans were the great engineers of cities: Etruscan engineering responsible for Cloaca Maxima (Rome's great sewers).

Lucius Junius Brutus (and urban mob) overthrows the last Tarquin; followed by 3.5 centuries of oligarchic rule and military success. System begins to break down in 144 B.C.; Tiberius Gracchus pushes for land for the urban poor and gets clubbed to death by Senators.

Roman empire and city characterized by weakness at home and strength abroad. In first century B.C., Rome achieves military success abroad, but faces increasing challenges; Rome wins wars and extends citizenship to all Italians. As a result, city expands enormously (350000 people on grain rolls).

Other aspects of Rome:

- Abundant monuments celebrating emperors.
- Large infrastructure for pacifying the population. Infrastructure also kept the city healthier — aqueducts and sewers. Also famous road system and legal system.
- Incentives also matter; consider Caesar's traffic ban.

5.2 An imperial model

There is an emperor with resources who fears an uprising. If urbanites can travel to emperor's palace (in infinitely tall building at the capital's center), the emperor will buy them off with bread dole. Emperor fears uprising, and people will riot if bread dole goes below 20 gold ducats (in a better model, probability of revolution would be continuous). The city is otherwise completely unproductive.

Cost of getting to imperial palace 1 ducat per 1000 feet per year.

This is an AMM model with a wage of 20, transportation costs of 1 per 1000 feat. Assume that value of land is 1 on the city's edge and the cost of a structure is 4 units per year. Home on city's edge is 5. Prices elsewhere will be $5 +$ (distance to edge $-$ distance to home).

Note. We are ensuring that total urban costs (transportation and housing) are equal everywhere in the city.

5.2.1 Predictions

If farm productivity falls, price to live in city center increases and city expands spatially.

Central way in which differs from AMM is that fears of the king, rather than market wage, determines core appeal of the city.

Emperors in fact do not want to tax citizens, they want to avoid this situation (exogenous shifts to city size). Some solutions:

- Constrain city growth or move city away from population centers (St. Petersburg).
- Rebuild city to make it safer (Haussman).
- Impose internal passport.
- Buy a bigger army. Though this can cause problems if army is not willing to open fire on people.

5.2.2 Facts from Ades and Glaeser (1994)

Overwhelming majority of primate cities (largest city in the country) are capitals (79/85 in sample). Exceptions are former English colonies where political wrangling recognized tendency of rents to flow to the capital, and Turkey.

Capital primates are about 42% larger than non-capital primates. Capital cities of dictatorships 40% larger than capital cities of democracies, also true for *new* democracies. Unstable democracies have larger primate cities. More protectionism (and worse roads) mean larger capitals as well.

5.2.3 Changan

Han dynasty capital as early as 200 B.C. Population reaches 240000 around 0 B.C. Decline during chaotic six dynasties period. Rebirth in Sui dynasty caused population to soar towards 1m. Location tied to center of road network like Milan (Mediolanum) has advantage of facing northern invaders directly.

Chinese cities were notably walled — strict regulations linking political importance of city to size and shape. Many important Chinese innovations in urban quality of life, including night soil farming, effective urban fire fighting.

More urbanized and advanced society than Europe after 500 A.D.

5.2.4 Paris and Baron Haussman

France was La Grande Nation and capital was consequently grand. Epicenter of city was old Gaulish island, roads running through isle are based on Roman roads; French invested in universities.

Broad boulevards create appearance and military mobility; political and population centralization of France makes it sensitive to urban uprisings (1789, 1830, 1848, 1871).

5.3 Rise of consumer cities: Los Angeles and Miami

Los Angeles is initially incredibly far away from the core of the United States. Region ships hides and tallows around the Horn to the east and supplies beef to the miners of the 1849 gold rush.

Railroad and Panama Canal connect L.A. to the east; still no natural industry. Retiring midwestern farmers come in droves. Frank L. Baum moved to Hollywood in 1910. Howard Hughes also relocates for fun.

Movie industry also produced a product with very low transport costs, benefits from good weather and rich people (presence of that industry builds further amenities).

5.3.1 Amenities

Amenities have become more important over time. One hypothesis is rising incomes. Basic idea is that weather is a luxury good; as we get richer, we are willing to pay more for it.

For higher incomes, linear structure does not allow amenities to be a luxury good. We will introduce the log function as a way to model diminishing returns.

See slides for algebra.

5.3.2 Consumer cities and the urban core

Location within metropolitan areas owes great deal to heterogeneity within metropolitan areas in terms of amenities. There are two ideas:

- Imperial cities (Paris) invest disproportionarly in the urban core (near the king); consequently, there will be higher amenities in city center, higher prices in the city center, and more rich people.
- America's climate amenities are complements with leisuer and access to open space (California). They are more valuable in places with more land and this will lead to a flatter price-distance profile and rich people living in the suburbs.

20th century leveled the entertainment playing field; rising education increases demand for high-end entertainment (live theater, museums, fancy restaurants); increasing value of time causes increased demand for experiences relative to goods; cities specialize in connecting people (may be strongest urban asset as "marriage market").

5.3.3 Concluding thoughts

Rising incomes mean that quality of life is an important determinant of urban success; cities can't do anything about the weather, but they can do something about other amenities (crime, cleanliness, and fun).

The types of amenities that cities should target depends on who you want to attract (urban hipsters want different things than a mother who is a research scientist).

6 February 9th, 2023

6.1 Density, hedonics, and housing

Density is largely determined by commuting patterns. We see examples of Dallas/Fort Worth, Chicago, Boston, and Los Angeles.

There are many competing land uses in cities like Boston.

6.1.1 Density gradients

The standard specification for density gradient is negative exponential

$$D(d) = D_0 e^{-\alpha d} \tag{16}$$

where D is density, d is distance from the center, D_0 is density at the center, and α is the estimated coefficient on d (order parameter).

To estimate statistically, transform negative exponential into linear expression:

$$\ln D(d) = \ln D_0 - \alpha d. \tag{17}$$

Bertaub and Malpezzi (2014) estimate density gradients for 50 world cities.

The following are distinctive features of real estate:

- **Fixed in space.** Location determines accessibility, public goods and services, and neighborhood.
- **Durability.** Older properties are good substitutes for new properties.
- **Properties are heterogeneous.** Structure, land lot, neighborhood.
- Real estate is expensive.
- Substantial moving costs.
- Real estate is very regulated commodity.

6.1.2 Hedonic regression analysis

We take a linear regression of the price of a home:

$$P = \alpha + \sum_i \beta_{i x_i} \tag{18}$$

where x_is are structural, location attributes. The regression can be in many forms:

- **Linear.** Effect of one unit increase in independent variable is linear in P.
- **Log linear.** Percentage change in the dependent variable P from a unit increase in independent variable. Has the form:

$$P = \exp \alpha + \sum_i \beta_i x_i, \qquad \ln P = \alpha + \sum_i \beta_i x_i. \tag{19}$$

- **Log log.** Percentage change in dependent variable from one percentage point increase in independent variable. It has the form

$$P = \alpha \prod_i x_i^{\beta_i}, \qquad \ln P = \ln \alpha + \sum_i \beta_i \ln x_i. \tag{20}$$

Hedonic models are widely used. Examples include governments using models to estimate property assessments to levy property taxes; real estate firms use hedonic models to estimate market values; builders and architects use estimates to decide which attribute will provide greatest return on projects; researchers estimate value of structure and locational attributes such as schools.

6.1.3 Optimizing house configuration

Builders and developers compare incremental *value* of additional house features against incremental *cost*. Optimizing capital inputs. A profit maximizing house is one where the cost of an additional square foot, bath, fireplace falls to the marginal cost of construction.

Builders and developers seek optimal density or floor area ratio (FAR).

There is an optimal FAR value. We can use hedonic regression:

$$P = \alpha + \beta F \tag{21}$$

where α is price per unit of floor area for all housing, β is marginal impact of FAR on price per square foot, F is the FAR and

$$C = \mu + \tau F \tag{22}$$

where μ is the cost of construction, τ is the marginal impact of FAR on cost per square foot. We can find the optimal FAR F^* and optimal land price p^* by the following:

$$p = F(P - C) = F(\alpha - \mu) - F^2(\beta - \tau) \implies \frac{\partial p}{\partial F} = 0 \implies F^* = \frac{\alpha - \mu}{2(\beta + \tau)}, \quad p^* = \frac{(\alpha + \mu)^2}{4(\beta + \tau)}. \tag{23}$$

Note. There is a point where there is too much structure capital on a piece of land.

6.1.4 Concluding thoughts

Hedonics can be useful when buying your own home. Glaeser finds that lower density of town levels does not correlate with changing land value.

Hedonic models permit valuation of structure attributes, amenities of location, and even the cost of regulation. Getting the specification right requires careful consideration of what can be measured with the data available and what cannot be observed that could influence the results.

Redevelopment occurs when the value of land developed optimally exceeds the value of existing use plus demolition costs.

7 Section 2

Today, we will discuss three models recently covered in class. These include the stock-flow model, Rosen-Roback model, and the imperial city model.

7.1 Stock-flow model

This is a mode lf real estate development. Note that in the AMM model, everything is determined simultaneously: rents are determined by consumer demand, demand determined by commuting costs, everything is static. There is power in simplicity, it is useful for intuition, quantifying, testing, and comparative statics.

Developers are assumed to have constructed houses instantly. The reality is more dynamic and interdependent. Housing prices determine construction, which determines houses (slowly).

The stock-flow model is a stylistic model of adjustment, endogenizing investor and developer behavior and allows for dynamic adjustments where all variables affect one another.

It will be helpful for understanding current trends in the housing market.

7.1.1 Prices and rents (and asset pricing)

Rents are paid for the right to use a house for a period of time. There is an end date with other stipulations.

Prices are paid for ownership. Ownership is different than rent for a few reasons: it is indefinite, and owners have the right to live there and collect rent.

There is a relationship between rents and prices. Assuming only the things specified above, you can either own or rent indefinitely.

Note (Equilibrium)**.** In equilibrium, you should be indifferent. There is a caveat: when you buy a home today, you are also buying ability to collect rent in the future.

Rent in the future is discounted by a discount rate i with discount factors

$$P = r_0 + \sum_t \beta_t r_t = \sum_{t=0}^{\infty} \frac{r_t}{1+i^t}, \qquad \beta_t \equiv \frac{1}{i^t}. \tag{24}$$

If rents are constant, then $P = r/i$. If rents grow at a constant rate, then $P = \frac{ri}{i-g}$ where g is the growth rate of rents. We call i the **capitalization rate**. Rearranging, we have

$$\frac{r}{P} = i \tag{25}$$

Prices are linked to rents. The link is the capitalization rate i. In the asset market, prices reflect future streams of rent. Assets are discounted by capitalization rate. Higher rents thus correspond to higher prices; higher capitalization rates mean lower prices (future rents aren't as valuable).

7.1.2 Four markets

In the stock-flow model, there are four markets that adjust together.

- **(Living) Space.** Rents are determined by demand. Model nests both an open and closed city, primary case is half-open half-closed.
- **Asset market.** Investors buy houses. In this case, investors are paying themselves the rent collected.
- **Construction market.** Developers observe prices and decide how much to build.
- **Nature market.** Nature takes its toll, and given new construction decides total housing stock.

In the model, curves are set in time, but position on the curves can change. We can visually trace these effects over time.

- The first quadrant is the market for space. This is a demand curve. Total space and demand determine rent. An *open* city is one where people have alternatives and there is a fixed rent cost (because of alternative options); a *closed* city is one where the number of houses are fixed, which corresponds to a vertical line.
- The second quadrant is the asset market. The slope corresponds with the capitalization rate i.
- The third quadrant is the construction sector. Prices determine constructions.
- The fourth quadrant is total stock adjustments due to nature. Stock depreciates like δ: stock = construction/δ.

Using the model, we can start with some rent and stock of houses R^*, S^* determined by the market for space. we can follow the lines to determine the number of constructions given the total stock house C^*. C^* and R^* then determine prices P^* that investors *and* developers are willing to pay to invest and construct new houses. When these lines match up, then we have reached a **steady-state equilibrium**.

See slides for visual representation of shifting stock and rents given transformations to one of the four markets.

Note. It is assumed that adjustments in asset market, construction market, and stock adjustments begin from the market for space.

Note (Changes to markets)**.** We can observe the effects of increasing rent on the four quadrants; the model can describe booms and busts in the housing market (although not quantifiable).

We can also observe the effect of investors willing to accept lower rents for higher prices.

Note (AMM model)**.** Changes in the stock-flow model correspond to translations (vertical) on the AMM model; changing $R(0)$ and the border length/city size.

7.2 Rosen-Roback model

Recall the open-city model of AMM

$$w - (R(d) + kd) = \widetilde{U} \tag{26}$$

where $\widetilde{U}$ is the utility. Living in cities also has amenities (climate, entertainment, etc.) and disadvantages (crime, pollution, etc.). We can add a linear term to the open-city model

$$w + A - (R(d) + kd) = \widetilde{U} \tag{27}$$

where A is the net effect of amenities of living in cities (including disadvantages).

In the Rosen-Roback model, we note that net income and amenities may not add linearly. **In this model, we have fixed welfare** across cities.

$$\text{welfare} = \ln(\text{net income}) + \text{amenities} = \text{constant}. \tag{28}$$

We can suppose living costs increase population. We can assume that costs are $a \times N$ where N is the population. We can then write the welfare in terms of net income (wage − cost) as

$$\boxed{\text{welfare} = \ln(w - aN) + A} \tag{29}$$

where w the wage, $c = aN$ the cost, and A the amenities.

Note. To find equilibria (population, for example), we assume population across cities (e.g. Metropolis and Gotham) is the same, and welfare in both cities is the same (fixed welfare assumption).

7.2.1 Problems with Rosen-Roback model

Results depend heavily on functional form of welfare. Welfare may not be logarithmic in net income. This implicitly means that amenities are more important when incomes are high; $\ln x$ increase in slope like $1/x$.

7.3 Imperial city model

This model is based on observation in pre-modern times, nation's population is heavily concentrated in one city. Ades and Glaeser (1995) gives one potential explanation in an AMM-type model.

Their model has the following assumptions: emperors live in the capital and are easily overthrown by nearby residents; they extract resources from rural hinterland and feed urbanites. This motivates people to move into the central city.

In this case, we can think of this model as an AMM with higher wages.

The main conjecture is that if rulers have weaker legitimacy and higher risks of revolution, they would try harder to redistribute wealth to capital urbanites.

Some effects:

- If there is a weaker centralized army, there will be more redistribution and a bigger imperial city.
- If rural hinterlands are less stable, with fewer redistribution and corresponds to a smaller imperial city.

8 February 14th, 2023

Some notes on problem set grades. Check plus is 10 points and you should feel really good. Check is 10 points and you should feel good. Check minus is 5 points. Zero is zero.

8.1 Agglomeration economies and the industrial city

Centripetal technologies steepen productivity gradient and flatten the congestion gradient.

8.1.1 Bigger, denser places are more productive

Note. Data shows that this is true across the United States, Brazil, China, and India.

There are some theories for this:

- **Reverse causality.** Areas have intrinsic productivity advantages that lure people (ports, coal mines). Better government can also be seen as a productivity advantage. Variants: there were historical agglomeration advantages which have disappeared but capital remains

  Note. Economists don't believe that this is as important today as it used to be.
- **Agglomeration of people in space.** This makes people more productive. This is a **causal** explanation via reduced transport costs for goods, people, and ideas.
- **Selection.** More able people sort into cities, perhaps for consumption advantages.

Note. Glaeser thinks agglomeration and selection are the most important factors.

8.1.2 Cities before industrialization

Villages housed farmers and maybe few craftsmen who served the farmers (e.g. blacksmith). Towns provided rarer services, trade fairs also helped. Cities housed the Bisop (traditional definition) and higher Nobility.

Walter Christaller (seminal economic geographer) and August Losch developed central place theory trying to fit the structure of Germany. Losch was anti-Nazi; Christaller helped the SS design Generalplan Ost.

When transportation costs are high, you need lots of little towns strewn throughout countryside. When transportation costs low, and there are scale economies, you need a few big cities.

8.1.3 Cities in Europe and South America

Europe's population is 50% higher than South America (740m v 422m).

Largest cities in Western Europe (excluding Russia and Istanbul) include London (8.8m city/14.8m metro), Berlin (3.7m city/5.2m metro), Madrid (3.2m city/6.5m metro), Rome (2.8m city/4.5m metro), and Paris (2.1m city/12.2 metro).

Largest cities in South America include San Paulo (12m city/21m metro), Lima (8.9m city/9.9m metro), Bogota (7.8m city/9.2m metro), Rio de Janeiro (6.5m city/ 12.3m metro), and Santiago (5.5m city/ 6.7m metro).

Cities in South America developed largely starting in the 1950s, during the age of the automobile. Historically, people assumed that things like soil quality were important in determining density but density lingers today (though does not determine productivity).

When you include fixed effects, the density premium drops significantly, suggesting that there's a lot of selection that's driving these higher wages in city. However, consider the notion that place effects develop overtime (i.e. living in cities is not necessarily associated with higher wages right away but higher wages overtime).

8.2 Urban wage growth hypothesis

These data seem to show that migrants do really receive an urban wage premium suggesting that it is not all selection. But that wage premium accrues over time.

A very nice paper by Diego Puga uses much better Spanish data and confirms that hypothesis (rich income tax data basically is what you need). Cities seem to be approximately like universities. These facts are compatible with the learning in cities view (we will address this in the lecture on learning and entrepreneurship in cities). This can also be called cities reducing transport costs for ideas.

8.2.1 Agglomeration

In the Christaller/Losch view, the cities are primarily about providing stuff for the nearby farmers. But urban providers also make stuff for other urbanites. This is obvious in city services: restaurants, barber shops but also accountants and lawyers. Also in manufacturers: Fisher Body made car bodies for General Motors.

The core idea is that there is a virtuous circle where an initial bunch of people then attract more firms and it snowballs, growing on itself. This becomes more important when there are scale economies. This helps link industrialization and urbanization and now a detour.

8.2.2 Understanding industrialization

Two separate strands come together: textiles and power. Textiles story is torturous. Full of examples of ideas being stolen from people around them, but not all that urban. Power story is deeply urban and feels more modern. Together, they made mankind wealthy for the first time in history. They also helped make cities such as Birmingham, Manchester, Lowell (MA), and Chicago. Agglomeration ended up being the partner of industrialization.

We consider the textiles story. There are a lot of steps in going from cotton or wool to cloth, but we can focus on spinning (making thread out of fluffy stuff) and weaving (taking the thread and turning into cloth). Roller spinning is an attempt to use a machine to replace the person.

- Lewis Paul tries to produce a viable machine between 1729 and 1750. He and John Wyatt patent in 1738, but they fail.
- Thomas Highs follows at this. He seeks help from John Kay, a neighboring watchmaker, and they are pretty successful.
- Kay goes traveling in 1766 and runs into a wig-maker, Richard Arkwright. Arkwright buys him an ale (allegedly), takes the idea and hires Kay. Lawsuits and the Cromford Mill (1771) follow.

The story of power is one that comes after textiles.

- Newcomen Steam Engine exists after 1700.
- James Watt is a Scottish shipwright's son – who goes to London at the age of 18 to learn instrument-making (cities as schools) and then goes to Glasgow then a center of the Scottish Enlightenment.
- He becomes friends with professors Joseph Black (expert on thermodynamics) and Adam Smith (much less relevant but fun).
- He is sent a Newcomen engine to fix and comes up with improvement (a separate condenser) that doubles efficiency. He tries to make it in Scotland but no one can make good enough iron.

After James Watt met Matthew Boulton:

- Watt originally partnered with a Scottish collier (John Roebuck). Coal mining is a big user of pumps and hence engines.

- Roebuck goes bust, and gives his share of the engine to Matthew Boulton of Birmingham to cover a debt.
- Matthew Boulton is a pioneer of mass production (primary of baubles), a great entrepreneur and politically connected enough to get Watt's patent extended.
- He also brings connections to Birmingham's historic iron-making expertise, as epitomized by John "Iron Mad" Wilkinson. Their partnership produces engines but then the engines empower a chain of related inventions, including steam boats and steam trains.
- Later factories could rely on coal-power engines rather than rivers.

Note (Manchester)**.** Waterways (Irwell and Mersey) are navigable by 1736 which brings access to Liverpool and the sea, Bridgewater canal connects to coal. Cotton joins wool and linen as early as 1600, pure cotton in 1750. Large commodities exchange (also important in Chicago).

Arkwright opens a mill in 1780. Perhaps the largest industrial city in the world in 1830. First intercity steam train (Manchester and Liverpool) 1830. Lots of small mills (over 100) not a big three.

Industrialization meant the replacement of human craft with large machines, eventually machines would leave the city. In 19th century, the larger issue was to ensure enough workers and customers for machines. Massive infrastructure could not be spread all around the countryside in small villages (needed to be concentrated in one place). Cities also benefit from having lots of activity around them (benefits of agglomeration).

8.3 Agglomeration economies

Three benefits of agglomeration: reducing costs of moving goods, people, and ideas. There are five core ideas.

- You choose location to reduce transportation costs. When people are fixed in space (farmers), this acts against agglomeration. When people can move, then this acts for agglomeration.
- Increasing returns (or fixed costs) at the firm level can be saved by locating in a single location instead of spreading out.
- With enough scale, shocks to employers or customers average out, making the world more predictable and productive.
- With enough customers, producers can specialize, meaning that they have to learn less about multiple products and can learn more about their primary product.
- In dense areas, ideas spread between people. Consequently, we become more productive when we are around people we can learn from.

8.3.1 Models: Old-style hand production

Consider the following: if there are two merchants selling to each other, it is more convenient for them to live closer to each other. Two towns each have 2500 farmers, each person requires one "industrial good" and we can ship coats from one town to another for 10 dollars. Each craftsman can produce industrial goods for 51 people. There are 51 craftsmen in each town, 50 for the farmers and 1 for themselves. There is no reason why you would put all the craftsmen in one town; they should be spread out to save on transport costs.

Now consider that at a fixed cost, we can build a factor (50000 USD). This factory means 1 craftsman can supply 501 coats. There are two options:

- Two factories in each town and 5 craftsmen in each place. This costs 100000 USD.
- One factor in one town and 10 craftsmen there, none in the other town. 25000 coats are shipped to the other town. The total cost is 75000 USD.

Agglomeration (second option) looks better! So we agglomerate if $c_{\text{factory}} > FT$. There is a trade-off between shipping costs and multiple factories. Dispersal more likely if fixed costs are lower, or if transport costs are higher, or if there are more farmers in the other town.

Example 8.1 (Cyrus McCormick)**.** Think about how Cyrus McCormick relocates his reaper factory to Chicago from VA to be closer to farmers.

8.3.2 Models: Agglomeration and manufacturing

Assume there are 100 factories, each of which employ 100 workers. Each factory makes a distinct good and evry person will buy one of these goods. People can live in an AMM world and there are two cities. Cost of living on edge is 10000 USD.

Each person takes 1 unit of space (city is long narrow ray). Commuting costs 2 USD per unit of space up to 5263 units of distance. After that, it costs 10000 units + 0.1 per unit of space.

Hence if 10000 people live in the town, the commuting costs for the person on the edge is 101000 and the total costs of living are 20100. Costs of shipping industrial goods within cities is 0; cost of shipping goods across cities is 150 USD.

We can instead assume there are 50 factories in each of the two towns and that factories need to pay shipping and housing and commute costs. Total shipping costs for each factory is 750000 USD, total living cost is 20000 USD per worker or 2000000 USD. Living costs go up to 20200 USD per worker (other city is 100 people bigger). Shipping costs would be 735000 USD.

If we are all in one town, there are no transportation costs. Commute and housing costs sum to 20100 USD per person. If factory breaks out and forms a new town, commuting and housing costs drop to 10200 USD per person. Increase in shipping cost is more than enough to keep factory in place.

Note. Typically economists focus on the trade-off between agglomeration (good for cities) and congestion (bad for cities). In our model, the congesting force came from commute costs. The agglomerating force came from transport costs for the final good. Other congestion forces include pollution, costs of maintaining public goods. Agglomeration forces include learning, labor market pooling and so forth. These can sometimes be measured. They will generally mean that a market equilibrium is not a social optimum.

8.4 Agglomeration and place-based policies

Agglomeration means that areas benefit from more development. The case for benefiting from skilled people is even stronger. Yet does that mean we should be trying to stop brain drain from Kentucky to Palo Alto or encouraging it.

Palo Alto benefits, Kentucky loses. Maybe there is an equity-based reason for stemming the tide (but who usually benefits from attractive places in our models); but the efficiency argument means we have to weight the losers against the winners, and deal with non-linear effects that we cannot measure well.

8.4.1 New York City

Some New York history:

- The city's industries are born of its harbor and the Hudson.
- Sugar refining, apparel, printing and publishing, finance.
- Transportation-related infrastructure was surely important, but no one thing (e.g. the Erie Canal) made the city (unlike Buffalo, NY).
- Sugar refining was a product of the initial triangle trade.
- This is an example of fixed costs and transport costs driving manufacturing
- Early 19th century growth reflects larger ship sizes leading towards hub-and-spoke, instead of point-to-point, shipping.
- Both packet ships and ready-to-wear apparel are examples of statistical returns to scale.
- 1817. Jeremiah Thompson (Yorkshire Wool Man) and Isaiah Wright (New York Cotton Merchant) found the Black Ball Line.

- This is the first regular packet service that sailed on a fixed schedule.
- This is only possible because NYC scale has become large enough so that it is unlikely that you will travel with an empty hull.
- Ready-to-wear clothing, starting with the War of 1812. Brooks Brothers is frequently cited as a pioneer.
- This garment industry becomes the largest sector in NYC.
- Also benefits from vast home market and ability to test ideas on customers.

8.4.2 Shocks average out

Agglomeration of factories in one location averages out shocks in the economy. This is a variant on the law of large numbers.

8.4.3 Little model

There is a training cost to learn how to teach physics and how to teach economics. In a small town, only ten people want to learn physics and ten want to learn economics.

That's not enough for me to specialize. I have to teach both, so I either pay the learning costs twice or teach badly. However, in a big city, 100 people want to learn each subject. Consequently, teachers just specialize in one. Similar to the old idea of a one room schoolhouse.

9 February 16th, 2023

Today, we discuss the neighborhood, amenities, and ethnic agglomeration.

9.1 Neighborhoods, amenities, and ethnic agglomeration

Many cities are defined by their neighborhoods; neighborhoods evolve over time and serve changing populations.

Example 9.1 (North End)**.** The North End dates back to 17th century and initially housed wealthy Bostonians in the 18th century. 19th century was characterized by crowded conditions and a deteriorating housing stock. Wealthy residents move to newer Boston neighborhoods as waves of immigrants settle in the North End.

9.1.1 Redevelopment

Durability of existing structures generates a barrier to a smooth adjustment of FAR. We do not see incremental FAR increases; old uses are destroyed and replaced with new.

Recall the following. Let v_0 be the value of the pre-existing capital that exists on a square foot of land:

$$v0 = F_0(\alpha_0 - \beta F_0) \tag{30}$$

where α_0 is the price per unit of floor area for all housing and location factors besides FAR, F_0 is the existing FAR, δ is the demolition cost per square foot of floor area. We get redevelopment when

$$p^* - v_0 > \delta F_0, \tag{31}$$

when value of land developed optimally exceeds the value of existing use and demolition costs, p^* is the price when redevelopment occurs.

9.1.2 Hedonics and location characteristics

Location of house determines schools, public parks, municipal services, neighbors, aesthetics (nature, architecture, etc.) available to household. Value of these locational amenities are capitalized into price of house (households pay more to live in good school districts).

Note. Accurately measuring locational amenities remain a challenge.

Black (1999) explores value parents place on good elementary schools by estimating house price hedonic models in attempt to isolate contribution of school quality. She estimates

$$\ln p_{iaj} = \alpha + X'_{iaj}\beta + Z'_j\delta + \gamma \text{test}_{aj} + \epsilon_{iaj} \tag{32}$$

where p is the price, X are structure characteristics of house i, Z are neighborhood characteristics of school district j, and test is fourth grade average test score for elementary school in attendance district a in school district j. She also estimates

$$\ln p_{iab} = \alpha + X'_{iab}\beta + K'_b\phi + \gamma \text{test}_a + \epsilon_{iab}, \tag{33}$$

replacing neighborhood characteristics Z with attendance district boundary dummies K.

Note. Black's results suggest that unobserved neighborhood characteristics lead to an overestimate of the value placed on school quality (5% increase in test score increased house prices by 4.9%)

9.1.3 Ethnic enclaves

Edin, Fredriksson, Åslund (2003) observe the impact of living in immigrant communities (ethnic enclaves) on the economic success of immigrants. Their results suggest that the effects are ambiguous.

Definition 9.2 (Ethnic enclave)**.** An ethnic enclave as neighborhood where the share of the ethnic group residing in the neighborhood is at least twice as large as the share of the ethnic group in the population.

Living in an ethnic enclave may have the following impacts:

- May result in slower acquisition of host country skills like language.
- Provides a valuable network with information on available jobs, services like language classes.
- A spatial mismatch. Enclaves may be far from job opportunities.
- Human capital externalities. Recent immigrants benefit from high skill enclaves.

They find the following:

$$\ln \text{earnings}_{ijk(t+8)} = \alpha' \boldsymbol{X}_{ik(t+8)} + \beta \ln e_{jk(t+8)} + \delta_{j^*} + \delta_k + \delta_t + \boldsymbol{\epsilon}_{ijk(t+8)} \tag{34}$$

where indices i are individuals, j municipalities, k countries of origin, t years of immigration. $\boldsymbol{X}$ are individual characteristics (gender, age, marital status, etc.) and $e_{jk(t+8)}$ is the size of ethnic group in municipality j.

Estimate that living in enclaves improves labor markets outcomes for less skilled immigrants by 13%. Those living in high quality ethnic enclaves gain more than those living in a low quality enclave.

Note (Impact of neighborhoods on behavior and opportunities)**.** Quality of local services, role models, peer groups, social networks, safety, isolation.

9.2 Moving to opportunity (MTO)

The U.S. Department of Housing and Urban Development (HUD) ran MTO from 1994 to 1998 in Baltimore, Boston, Chicago, New York, and LA. 4604 families living in public housing were randomly assigned (RA) to three groups:

- Experimental voucher group offered a subsidized housing voucher but was require to move to a census tract with poverty rate below 10%.
- Section 8 voucher group offered a standard subsidized housing voucher with no additional requirements.
- Control group that was not offered voucher (but retained access to public housing).

Participants were tracked over time to measure impact of vouchers on various outcome measures. They found the following:

- Early studies found significant improvements for participants who moved to better neighborhoods in terms of physical and mental health, subjective feelings of well being, and safety.
- No evidence of an impact on economic outcomes (employment and earnings) were found for adults and older children.

Chetty, Hendren, and Katz (2016) revisited MTO data to examine impact on children who were young (<13 years old) at time of RA. They tested

- Does moving to better neighborhoods (lower poverty) when young result in better economic outcomes as adults?
- Do gains from moving to a better neighborhood decline as age at time of move increases?

Note. This could not be done by previous authors because young children did not yet reach adulthood.

They confirmed results for results and older children. They did find that children under the age of 13 in the experimental group had:

- Earnings as adults that were 31% higher.
- More likely to attend college (and better colleges).
- More likely to live in lower poverty neighborhoods as adults.
- Less likely to be single parents.

Note (Housing vouchers)**.** Housing vouchers are scarce resources; it is not clear how to best allocate these scarce resources to produce the most welfare.

9.2.1 Challenges in measuring neighborhood effects

Neighborhood choice is a complicated decision influenced by neighborhood and family characteristics. Measuring those characteristics and the causal relationships is challenging. Isolating the impact of a specific neighborhood attribute can be difficult due to unobserved neighborhood characteristics.

9.2.2 Housing in California

Los Angeles SB9 model is to add accessory dwelling units. Only 58 units permitted in thirteen largest areas in California.be

10 Section 3

Recall problem set 2 is live. This is an empirical problem set with many provided resources.

10.0.1 Problem set 1 review: Welfare of highway (closed city)

Welfare benefits of highways is one of Peleg's dissertation chapters. We will discuss welfare analysis in a **closed city**. In AMM, welfare is defined as net income. Recall

$$w - (c + k(b - d)) \tag{35}$$

and we care about spatial equilibrium; there is the same welfare for everyone **within** the city.

The direct highway then, means that there will be lower transportation costs everywhere (especially on the edge). Imposing spatial equilibrium, residents across the entire city should be indifferent everywhere in the city; thus, housing costs adjust to maintain the same net welfare.

10.0.2 Problem set 1 review: Welfare of highway (open city)

In an **open city**, there is spatial equilibrium **within** and **between** cities. Total welfare is fixed to outside welfare (reservation utility). The direct effect of a highway is lower transportation costs, especially on edge. Spatial equilibrium **within** city means incumbents receive higher utility. Spatial equilibrium **between** cities means in-migration and expansion (border expands to meet new demand, commute costs at border increases, increasing costs for everyone, until utility is the same as reservation utility).

The city will have more people, shorter commutes at the center, longer commutes at the new border, and prices will go up.

10.1 Data and models

We need two things to describe cities: data and models. All empirical exercises have some implicit model.

Examples are provided in section slides. Some models may assume different functional forms, and these different functional forms can be tested for accuracy and descriptive power.

10.1.1 Basics

For example, we consider a model of rent

$$R(d_i) = R_0 - \alpha d_i \tag{36}$$

or

$$R(d_i) = \beta_0 + \beta_1 d_i + \epsilon_i \tag{37}$$

where ϵ is the error, β_0 is price at city center, and we expect β_1 to be negative. We will want to estimate β_0, β_1 that best fits current data set, usually with least squares regression.

10.1.2 Adding another variable

We can add another variable

$$R(d_i) = \beta_0 + \beta_1 d_i + \beta_2 \ln \rho + \epsilon_i \tag{38}$$

where we added β_2 and ρ is the density. β_1 is how rent changes (linearly) with respect to distance, holding density constant (we added new free variables with new parameters).

10.1.3 Indicator variable

We can also add an indicator variable in our model.

$$R(d_i) = \beta_0 + \beta_1 d_i + \beta_2 \mathbb{I}(\rho > 10^4) + \epsilon_i \tag{39}$$

where the indicator is 1 when condition is true and 0 otherwise. β_0 is the rent at the city center if the population density is less than 10^4 per-mi^2; β_2 fixes the rent if the population density is greater than the threshold.

10.1.4 Interaction variable

Suppose we think that rent decreases linearly on distance to city center, but something is different between pre and post-Covid. We can try

$$R(d_i) = \beta_0 + \beta_1 d_i + \beta_2 \mathbb{I}(\text{post}) + \beta_3 d_i \times \mathbb{I}(\text{post}) + \epsilon_i \tag{40}$$

where the third term is the "interaction term." Rent changes at β_1 on distance when pre-Covid, and changes at $\beta_1 + \beta_3$ when post-Covid.

10.1.5 Indicators for pre and post-Covid

We can run two regressions

$$R(d_{i,\text{pre}}) = \beta_{0,\text{pre}} + \beta_{1,\text{pre}} d_i + \epsilon_i, \qquad R(d_{i,\text{post}}) = \beta_{0,\text{post}} + \beta_{1,\text{post}} d_i + \epsilon_i. \tag{41}$$

We can also run one regression that measures the changes

$$R(d_i, t) = \beta_{0.\text{pre}} + (\beta_{0,\text{post}} - \beta_{0,\text{pre}})\mathbb{I}(t \geq 2020) + \beta_{1,\text{pre}} d_i + (\beta_{1,\text{post}} - \beta_{1,\text{pre}})\mathbb{I}(t \geq 2020) d_i + \epsilon_i \tag{42}$$

where this gives the rent at time t.

10.1.6 Log-level regression

Suppose rent depends only on distance, but model is not linear. We can assume rent decays exponentially in distance

$$R(d_i) = R_0 e^{-\alpha d_i} \implies \log R(d_i) = \log R_0 - \alpha d_i \implies \log R(d_i) = \beta_0 + \beta_1 d_i + \epsilon_i. \tag{43}$$

For each mile, rent drops at a fixed percentage. This also posits that rent decreases at rate β_1 continuously (as α) as distance increases gradually. We can see this by taking ∂_{d_i} on both sides and obtain

$$\frac{1}{R}\frac{\partial R}{\partial d} = \beta_1 \implies \frac{\partial R}{R} = \beta_1 \partial d. \tag{44}$$

10.1.7 Log-log regression

Suppose we think correct model is different, something like $R(d) \propto d^{-1}$. We can take logs to transform this into linear form

$$\log R(d_i) = \log A - \gamma \log d_i \implies \log R(d_i) = \beta_0 + \beta_1 \log d_i + \epsilon_i. \tag{45}$$

We can inerpret β_1 with the following

$$\partial_d \log R = \frac{1}{R}\frac{\partial R}{\partial d} = \beta_1 \frac{1}{d} \implies \frac{\partial R}{R} = \beta_1 \frac{\partial d}{d}, \tag{46}$$

so when distance increases by a certain percentage, β_1 changes by the same percentage.

10.2 Judging estimates

We give some (loose) introduction to estimation. We want to discern whether or not estimation is meaningful, and if estimation explains variations in rents.

We can do estimation testing by collecting data, estimating best fit parameters, calculating errors around the parameters β_0, β_1, and calculating R^2 values, which is a quantity that captures the variation in the model.

Note (Standard errors)**.** It is also useful to find the standard error on the parameters. A good heuristic is that the estimation is twice as large as the standard error; if this is true, there is a less than 5% chance that actual relationship is zero and we found correlations due to noise.

We note that R^2 is calculated via

$$R^2 = 1 - \frac{\sum_i (y_i - f_i)^2}{\sum_i (y_i - \bar{y})^2} \tag{47}$$

where y_i are data, f_i are estimates, and $\bar{y}$ is the average value of the data.

Note. R^2 values are automatically calculated by Stat or R.

Economists use regression tables, which can be viewed in R using `stargazer`.

11 February 21st, 2023

11.1 Urban innovation and entrepreneurship

A history of Renaissance innovations as extensions of linear perspective:

- **Brunelleschi.** Brunelleschi figured out out to make two-dimensional spaces three-dimensional (linear perspective).
- **Donatello.** Donatello figured out how to create depth in sculpture. For example, his base on Orsanmichele (1415-17).
- **Masaccio.** The Brancacci Chapel (1425) is the chapel of the Carmine church in Florence (starts the artistic revolution).
- **Fra Filippo Lippi.** Lippi's Annunciation (1440) extends this notion of distance, and introduces donors. Paintings until this time are still religious-based.
- **Sandro Botticelli.** In his Primavera (1482), he shifted away from religious subjects and painted natural scenes.

We can also consider the creation of modern finance:

- **Savage and Friedman.** Begun thinking about the trade-off between risk and return (
- **Markowitz and Sharpe.** Extended these ideas of risk and return to asset management
- **Treynor and Black.** Black carries the Black-Scholes options formula to Goldman Sachs; begin applying theory to Wall Street.
- **Milken, Kravis.** Milken is associated with high-yield high-risk debt (junk bonds). He had to convince investors that they carried enough returns to offset the risk.
- **Ranieri, Bloomberg.** Worked at Salomon Brothers in the time period. Bloomberg is focused on supplying the traders at Salomon Brothers what they need, terminals. He knows what they want because of what he learned on the trading floor, because of New York City. Knowledge is more valuable than space.

11.2 Innovation in cities

We will now consider data about what we know about cities.

- **Creation of large-scale breakthroughs.** Audretsch and Feldman (1996). Patent creation by Jaffe, Trajtenberg, Henderson (1993).
  Jaffe, Trajtenberg, Henderson (1993) found that a huge amount of patent citations came from New York City.
- **Learning in cities.** Alfred Marshall once said that "the mysteries of the trade becomes no mystery but are, as it were, in the air." Glaeser (1999) and De La Roca and Puga (2015).
- **Entrepreneurship as urban human capital and longer impacts of industrial history.** Chinitz (1960); Glaeser, Kallal, Scheinkman and Shleifer (1992); Glaeser, Kerr and Kerr (2015).

Example 11.1 (Ford and Detroit)**.** Henry Ford starts working on engines in the farms and moves to Detroit (build on the rivers). He becomes Edison's employee and learns how entrepreneurship works. He then learns how to mass produce the automobile, using the assembly line model.

Example 11.2 (Madam C. J. Walker)**.** Walker was born in 1867 in the Mississippi Delta Region as a child of freed slaves; she was married at 14 and remarried in 1894 (working as a sales agent in 1903 for Annie Turnbo). She moves from St. Louis to Denver and starts competing with her old boss.

11.3 Learning in cities model

This is the only model we will get in this class. We assume the following:

- People are born at skill level 1.
- They have an interaction every period with a random person.
- If they meet someone who is more skilled than them, they move up a skill level with probability 0.1.
- With probability 0.05, they die or leave the city each period. New people come in at skill level 1 to fill their apartment.
- Top skill level is indeterminate; if not one is higher than skill level 1, no one will ever get more skilled.
- We assume there are people up to skill level 2.

11.3.1 Steady states

We want to look for a steady state s^* where

$$s^* = \frac{95}{100}\left[s^* + \frac{1}{10}(1-s^*)s^*\right] \implies s^* = \frac{47}{100}. \tag{48}$$

We can plot the function with varying parameters of death rate and imitation rate.

With algebra, we can rewrite the model. Let δ be the probability of exit (and death rate), q the probability of learning, $s(n)$ be the share of the population at skill n, and $S(n)$ be the share of the population with skill n or greater. The steady state, then is given by

$$\boxed{S(n) = (1-\delta)\left[S(n) + s(n-1)S(n)q\right] \implies s(n-1) = \frac{\delta}{q(1-\delta)}.} \tag{49}$$

The highest skill level is still indeterminate and its share is

$$1 - \frac{N\delta}{q(1-\delta)}, \tag{50}$$

which is the remainder.

11.3.2 Urban model.

We can change the bump rate to reflect urban density and make assumptions that we meet someone every half-period. Moreover, if we have m meetings, then the equation $\delta(1/m)$ becomes

$$s(n-1) = \frac{\delta(1-m)}{q(1-\delta(1/m))} \tag{51}$$

where δ is now a function of m.

11.3.3 Implications

This model predicts that density leads to innovation, but also that skilled cities will be more successful. Skills and density are complements; more to learn means a desire for faster learning. This also predicts that economic segregation may be important for cities. Explains the location choice of idea-intensive industries (New York, Silicon Valley). This also explains why skilled cities have come back and unskilled cities have not.

Note (Interesting data)**.** We can find interesting plots in the slides, reinforcing the idea that skills are tied to mobility and economic outcomes.

11.4 Chinitz: Contrast in agglomeration

There is a difference between New York and Pittsburgh.

"My feeling is that you do not breed as many entrepreneurs per capita in families allied with steel as you do in families allied with apparel, using these two industries for illustrative purposes only. The son of a salaried executive is less likely to be sensitive to opportunities wholly unrelated to his father's field than the son of an independent entrepreneur."

Example 11.3. We see that this difference is reflected in A.E. Lefcourt (of New York) going from clothes to banking and building; and Samuel Goldwyn (of Pittsburgh) starting MGM.

We can turn to natural resources to explain this variation in outcome. Where you are able to accomplish and go depends on where you come from.

12 February 23rd, 2023

Today, we discuss transportation and urban form.

12.1 Transportation and urban form

We first go over a brief history of transportation.

Roads have been essential to urban development. Large cities in Roman empire sustained by wheeled transport delivering food via road grids; roads built with deep roadbeds of crushed stone and sometimes topped with pavers.

- **1860s.** Boulevards of Paris paved with asphalt
- **New York City.** Poor quality roads motivate first public transit, 12-person omnibus.
- **1880s.** Good Roads Movement leads to creation of U.S. Office of Road Inquiry; want federal role in road construction.
- **1916.** Wilson signs Federal Aid Road Act, beginning federal aid for road construction.
- **1956.** Federal Aid Highway Act mandates construction of 41000 miles of Interstate Highway System, with USFG paying 90% of costs.

Roads have also changed commuting speeds and costs (flattening out rent and density gradients).

- **1840.** Walking means average commute speeds 3 mph.
- 1870: Trolley cars increase to 7 mph.
- **1910.** More modern subways lead to 15 mph speeds.
- **1950-today.** Cars average 25 mph.
- **Future tech.** Electric cars, autonomous driving, ride sharing, other technologies.

We can use hedonics to model how important accessibility is to households.

- **Baum-Snow and Kahn (2001).** Moving from three miles to one mile from transit station increases rent 19 USD/mo, prices 4972 USD.
- **Benjamin and Sirmans (1996).** Decrease of 2.4%-2.6% in price for every tenth of a mile from DC metro station.
- **Garrett (2004).** Increase of 140 USD in price per 10 ft closer to Metrolink station in St. Louis.
- **Cervero (2003).** Multifamily residential parcels in San Diego located > 1 miles from freeway sell at 67k USD premium; parcels located more than 1 mile away from on ramp have 43k USD decrease in value.

Note (Data)**.** Office locations, industrial locations maps all show everything is along major roads. Amazon HQ ideal site requirements lists proximity to population center, airport, highways, mass transit.

12.2 Automobile externalities: Congestion costs

The private trip cost of an individual making a trip is given by

$$\text{private trip cost} = m + d \times T(V) \tag{52}$$

where m is out-of-pocket monetary costs, d is the value of time, T is the trip time which is a function o traffic volume V.

This model includes the impact of other drivers on that individual but ignores the impact of that she places on other drivers. **Private trip cost is the same as average trip cost.**

External trip cost is the cost that each driver imposes on the other drivers on the road (if a road is congested, the next driver imposes a cost on all the other drivers already on the road by increasing their travel time).

$$\text{social trip cost} = \text{private trip cost} + \text{external trip cost} = \text{marginal trip cost} \tag{53}$$

Graphically, social trip cost gets higher than private trip cost as volume increases, demand is downward sloping. Deadweight loss from not being at social optimum, which motivates congestion tax to reach social optimum.

12.2.1 Congestion tax

Parry and Small (2009) estimate efficient congestion tax. They see significant variation between locations, because different locations have different costs per mile based on infrastructure and structure. Technology makes it feasible (Singapore, Milan, Stockholm, London all use Electronic Road Pricing (ERP)).

Note (Driving in the United States)**.** Graphs to the effect of "people drive a lot for a variety of purposes." There are some areas where driving isn't as key, e.g. college towns, and in New York metro area only 56% of people commute to work in private vehicle.

12.2.2 Trip cost and mode choice

We can model trip cost as

$$\text{trip cost} = m + d_a T_a + d_V T_V \tag{54}$$

where m are monetary costs, d_a is the marginal disutility of access time, T_a is access time, d_V is the marginal disutility of in-vehicle time and T_V is in-vehicle time.

For car trips, access time is functionally 0 (maybe finding parking, but often employers provide location). Studies show transit riders are willing to pay 80% of wage to decrease access time and only 50% of wage to decrease vehicle time (people really hate waiting time in public transit).

Note. U.S. public transit use is fairly consistent around 5% of workers. Plummeted during Q1 2020 and has been slowly climbing back up, but still only around 60% of 2019 levels.

12.3 Paying for roads and transits

Federal government provides 25% of annual funding, state governments 40% and local governments 35%. Very little federal government funding is actually building.

Use fees (fuel taxes, vehicle fees, tolls) account for approximately 48% of expenditures. Fuel taxes are 66% of federal government funding. Gas tax revenue has fallen over the past decade.

General fund revenues and bond proceed provide the rest. Federal Highway Trust Fund is facing growing shortfalls.

Note. It is extremely expensive to build infrastructure in the United States. Pricing on building highway roads is completely detached from construction materials and construction worker wages. But also has many advantages, 1.8 mi. subway extension in Manhattan costs 4.5b USD, study estimates increase in real estate values of 5.5b USD.

Infrastructure is expensive in the United States. It does not have to be expensive, however.

- **Altshuler and Luberoff (2003).** Community activism. In late 1960s, 1970s, neighborhood activists and environmental groups began to succeed in blocking large infrastructure project, leading many to think that mega projects were dead. "Do No Harm" planning succeeded in completing mega projects by minimizing disruptive side effects and aggressively mitigating any harm. This approach has been effective but costly.

- **Brooks and Liscow (2020).** Increase in highway construction starting in 70s does not reflect increases in real prices for labor and materials which move very little over time. Demand for more expensive highways increases with income. Increase in "citizen voice" - the increase in mechanisms by which citizens can voice their concerns about large scale projects and their impacts.

12.3.1 Underpricing cars and transit

Fare subsidies are good, decreasing price for transit ridership increases ridership and lowers cost per trip. This discourages car use which reduces external costs from congestion, pollution, accidents.

12.3.2 Transit options and residential density

Mass transit requires sufficient population density to produce enough riders. Buses require lower densities because of lower capital costs. As cities grow and change, bus service offers greater flexibility to meet those future need. Routes and service frequencies can be changed more easily than with fixed rail.

Urban economist mantra: Bus good, train bad!

12.3.3 Concluding thoughts

Subsidizing any form of transit besides buses is dumb. Subsidizing cars are bad because of pollution and climate change; subsidizing commuter rail is bad (rich people in suburbs do not need subsidies); subsidizing air travel is more dumb (more rich). United States is dumb and regulates procurement on public transit super intensely.

13 Section 4

Some administrative announcements: the midterm is Thursday March 9th during class. Practice materials will be uploaded shortly (about 3-4 practice midterms). The midterm will have 5-6 questions, two of which will be mathematical, and others will be true/false/uncertain.

Note that the grading policy is not particularly strict but the due date and time are strictly binding.

13.0.1 Problem set 2 review

Goal was to get comfortable summarizing data. Note that rents and house prices have lots of variation on top of gradients. Gradients are very different for different cities.

13.1 Course roadmap

We started the course with a historical overview of cities. We then talked about how space shapes cities. This led us to a discussion of what occurs **within cities**. We reviewed the AMM model; discussed what gets built (and where); we then discussed transportation and commuting costs in cities. We then embarked on a chapter **across cities**: what drives cities, where we have the Rosen-Roback model; industries as drivers of old cities (Pittsburg, Detroit, Manchester); innovation, amenities as drivers of new cities.

Looking forward, we will discuss challenges to cities, including climate change, pandemics, big data, and housing as a market and an asset.

13.1.1 Sections

In lectures, we are focused on bringing data to models. Sections function to provide tools for thinking. Following lectures, we provided tools for the AMM model (in conjunction with data). The following problem set will use data for housing.

13.2 Causality

Recall we estimated a negative relationship between house price and distance to city center

$$p_i = \beta_0 + \beta_1 d_i + \epsilon_i \tag{55}$$

where p_i the price, d_i the distance, and ϵ_i the noise. There are many variables outside the model that tend to be correlated with distance and also affect prices. Note for Seattle, $\beta 1 < 0$.

Regressions uncover correlation, not causation. This distinction is critical for interpreting results. Recall we wrote a model based on AMM where distance matters because of distance:

$$\widetilde{U} = w - (R + kd) \tag{56}$$

where $\widetilde{U}$ the utility, w the wage, R the rent, k the annual commuting cost, d the distance. We then estimated a price gradient, but it is unclear what is *causing* the relationship; AMM claims that it is commuting costs k.

We will discuss direction of bias, model interpretation, and causal inference as tools to understand causality.

13.2.1 Direction of bias

Assume that school quality is correlated with house price. Thus prices will be higher further away from a school (commute costs notwithstanding). This relationship will shift the gradient.

This may lead to underestimation the negative relationship between commute costs and distance (model cannot decouple commutes and school quality). Result is a combination of commute effect and better schools are better further out of central business district (CBD).

If we make a compelling case for how an omitted variable is correlated with variables, we can **sign the bias**. This allows us to claim our effect is a "lower bound" or "upper bound."

Note. If there are two or more omitted variables, and they are correlated, signing bias becomes *much* more difficult.

13.2.2 Interpreting the model

In most basic economics model, price and quantity are both determined at the same time. Recall we estimated price gradients and rent per-square-foot gradients. We estimated

$$p_i = \beta_0 + \beta_1 d_i + \epsilon_i, \qquad r_i = \gamma_0 + \gamma_1 d_i + \epsilon_i. \tag{57}$$

We found that $\gamma_1 < \beta_1$ because housing units tend to be smaller in the center. But square footage is not an omitted variable. The true cause is that land is more expensive at the city center. Rents and square footage are both outcomes of land prices. We need a better model.

13.2.3 Causal inference

Most regressions measure a statistical relationship between two variables. Density and the city center, house price and the city center, etc.

Causal inference is difficult because of omitted variable bias, selection/sorting bias, and reverse causality. Some solutions are controlling for confounding variables, "natural experiments," and randomized control trials.

13.2.4 Controlling for confounding variables (Black 1999)

Black studies the causal effect of school quality on house prices. The naive regression is

$$\log p_{iaj} = \alpha + \beta X_{iaj} + \delta Z_j + \gamma \text{test}_{aj} + \epsilon_{iaj}. \tag{58}$$

This regression may be biased due to **omitted variables** (e.g. income) and other neighborhood characteristics. Black solves this by only using houses close to attendance borders, allowing her to **control for very local characteristics using boundary fixed effects**:

$$\log p_{iab} = \tag{59}$$

Black finds that the effect of school quality is half of what it was previously thought to be.

13.2.5 Natural experiments (Edin, Fredriksson, Aslund 2003)

Edin, Fredriksson, Aslund sought to understand the causal effect of living in an ethnic enclave on immigrant economic outcomes. The naive regression regresses outcomes on whether an immigrant lives in ethnic enclave. This regression is biased because of **selection;** different people choose to live in an ethnic enclave.

Their solution is to use a **natural experiment from Swedish refugee placement policies**, and OLS finds that negative effects of enclaves, but this paper finds large positive effects for low-education immigrants.

13.2.6 Moving to Opportunity (Chetty, Hendren, Katz, and others)

Chetty et al. seek to understand the causal effect of living in a "better" (low-poverty) neighborhood on child/adult outcomes. The naive regression regresses outcomes on neighborhood poverty levels. This regression is biased because of **selection**. Different people choose to live in different neighborhoods.

Their solution was to design the **Moving to Opportunity Experiment (MTO)**. Naive regression likely finds large effects due to sorting. Initial evaluations of MTO did not find any economic effects (they only had data for adults). Chetty, Hendren, Katz show that long-run outcomes of young children improve (larger effect for young kids).

13.3 Hedonic models

Hedonic models are built on a similar intuition as AMM: the price of each housing unit should compensate for various attributes. In AMM, attributes were location advantage. In hedonic model, these attributes can be almost anything (number of bedrooms, bathrooms, whether the unit has cockroaches, quality of local school, etc.). We can break down prices into components and estimate their values.

Hedonic models are easy to implement and are very flexible. Run a regression of price on whatever attributes of housing we want to include.

Note (Challenges)**.** There are three challenges. It is sometimes difficult to account for variables that have diminishing returns (or hard to quantify). We can interpret $beta_i$ as the valuation (marginal value) of X_i, but interpretation depends on use. Finally, heterogeneity breaks the clean interpretation (of β_i as the value of the marginal X_i for the marginal buyer).

13.3.1 Ordinal and categorical variables

We have to decide how to treat observations (as either ordinal or categorical). Treating something as an ordinal variable (linearly) does not capture marginal increases or returns. If we include it as a fixed effect, where we do not impose any order on the bins.

13.4 Agglomeration effects

Agglomeration forces are positive effects of people locating in the same place; disagglomeration effects are negative effects.

There is some agglomeration force because of the existence of cities and the urban wage premium. The data suggest *strong* agglomeration forces. There is also another causal inference problem: what is the causal relationship between density and urban wage?

- **Migrants (Glaeser and Maré, 2001; Roca and Puga, 2015).** Rules out selection. Same person earns higher wage when move to city; lower wage when move out. Wage premium accrues over time, suggests that learning is likely a component.
- **Soil quality (Combes et al. 2010), Mining deposit (Glaeser, Kerr, and Kerr 2015).** Creates as-if random density distribution in France, allows us to rule out reverse causality. Opposite effect of mining-related activity.

Sources of agglomeration forces include:

- **Increasing returns to scale at the firm level (fixed costs).** Industrialization created fixed costs. If fixed cost to build factory exceeds transportation costs to ship goods, you will only build one factory.

- **Statistical returns to scale (labor market pooling 1).** If two industries get bad shocks 1/2 the time, if they locate in same city, workers can move to industry with good shock 3/4 of the time.
- **Specialization (labor market pooling 2).** In a small city, you have to pay two learning costs to teach both physics and economics. In big city, you can tech economics and someone else can teach physics.
- **Learning, spread of ideas.** Easier to learn from each other in close proximity.

14 February 28th, 2023

We discuss how government tools can be used to combat the negative density-related externalities of the city.

14.1 The demons of density in the developing world

We see poor-world urbanization (without growth and industrialization) first in Latin America and then in Africa.

14.1.1 The Matsuyama Twist (1992)

In a closed economy, like the U.S. historically, agricultural productivity increases urbanization and industrialization. This works through a price effect: more agricultural productivity lowers the return to agriculture.

In an open economy, low agricultural productivity leads to more (not less) urbanization. Price effect is turned off, Port au Prince can be fed out of New Orleans; many poorer cities specialize in services.

We can create a model. The following ideas and assumptions are the following:

- People must eat, and in a closed economy (no food imports), there need to be farmers.
- In a simple world, in which everyone eats their minimum caloric need (2000 calories), there are only enough farmers to feed people.
  This gives a constraint on the number of farmers in society.
- Without trade, when agricultural output is low, there are more farmers.

14.1.2 Open economy

With trade, assume there is one non-agricultural food and there is a global price of this good in terms of calories. Critical value is the traded good output per worker multiplied by the price. Critical condition is if this quantity is greater than the caloric output per farmer,

If this condition is met, everyone will come to the city and make the traded good. If not, everyone will farm. If farms are less productive, there will be fewer farmers.

Note. In Brazil, this was related to U.S. policy on closing Peron's market to U.S. economy.

Note (Glaeser's urban triad)**.** Cities have a tripod on which they run. Glaeser uses the city of Jerusalem as an example. The first is the magic of human interaction (exchange of ideas, goods, etc.). The second is the government battling the "demons of density." The third is the physical city.

Note. The tolerance of a city size is highly dependent on the quality of the state that governs it. For example, Singapore is managed extremely well.

14.2 Negative density-related externalities

Some negative externalities include contagious diseases (water or airborne), polluted air (smoke), congestion of city streets, crime (a bit of an externality).

Definition 14.1 (Externalities)**.** One person's action impacts another person's welfare in a way that is not mediated by the market mechanism.

There are ways that cities can reduce these externalities:

- **Reduce effective density.** For example, Roman importation of water from low-density places. Reduce effect of density on roads by building more roads.
- **Change behavior through fines (Pigouvian taxes).** Subsidies, lawsuits (Coase Theorem), and regulations (Euclidean zoning, Clean Water Act).

Note. In Johannesburg, South Africa, and Mexico City, Mexico, we see a tale o two cities. Different technologies and amenities in different areas of the city.

14.2.1 Major points for dealing with demons of density

- Fining misbehavior is often more efficient than subsidizing "good" behavior.
  - Paying for free sewers artificially induces urbanization.
  - Cheap subways encourages more travel, as well as some substitution out of driving.
- The ability to impose efficient fines depends on legal institutions. If inspectors extort the innocent, then efficiency declines.
- Infrastructure often encourages more externality-creating behavior. More roads mean more driving (Duranton and Turner, the Fundamental Law).
- Maintaining infrastructure can be as difficult and important as building. Institutions, such as Public Private Partnerships, impact maintenance incentives.
- Procurement is important and a source of both waste and corruption.

14.2.2 Solving the Last Mile problem

Assume it costs 1000 USD to connect the water system. Poor households value a connection at 500 USD. There is an extra social benefit of 750 USD (reduction in disease-related externalities).

We can subsidize, but this creates (1) artificially induces people to come to city, and (2) subsidization creates great scope for waste. We can use fines, but assume inspectors may extract bribes. In weak legal environment, no fines paid (only bribes). We note this is efficient as long as the guilty pay bribes (this is equivalent to a fine). In a very weak legal environment, inspectors also impose bribes on the innocent.

Note. We can do some math and model the effect of legal system strength A on waste from subsidies δ. Some takeaways include:

- Low δ means subsidies do little to create waste (efficient executive branch and no distortion of migration). Line $\delta_{SN}/\delta_{FN}(A)$ is upper level on waste to have pure subsidies.
- High A means inspectors are honest, $A > A^*$ means you just use fines ($\delta > \delta_{FN}(A)$).
- $A > \underline{A}$ then for intermediate δ_S, you can use combination of modest fines and subsidies.
- Exists a range where δ is high and A is intermediate, that you have finds only knowing inspectors will also extort the innocent.
- Often the right answer in developing world is to use really small punishment.
- Sometimes, you have to give up.

14.2.3 The Maintenance problem

Water access is a maintenance problem. We see that incentives matter: metered households provide the incentive for water management companies to help restore access and connectivity to water.

14.3 Public and private ownership, procurement

We tend to focus on public v. private ownership as a distinction between Karl Marx and Adam Smith. Public ownership often associated with private provision, because road is often built by private company. Construction phase typically requires a highly specialized labor force which makes outsourcing appealing.

Across the world, public procurement may be the most important source of global corruption (rivalling regulatory relief and underpricing the transfer of public services).

Within the U.S., rules regarding public procurement add or subtract billions, or lead to lower or higher quality infrastructure.

Note. It is foolish to approach public or private provision with ideology. Depending on what method gets the job done in its environment, that is the most optimal solution.

Note. Glaeser provides a typology of infrastructure providers:

- **Public integrated.** Government organizations.
- **Public independent.** Public and associated with government, but has political independence.
- **For-profit independent.** Companies that manage public goods.
- **Non-profit independent.** Non-profits that help build infrastructure.

See slides.

14.3.1 Hart-Shleifer-Vishny (HSV) model of public v. private.

A company produces a service: prisons or airport security pre-September 11th. For an effort cost monetized at 100000 USD, the service cuts costs but also cuts quality at the same time.

Let's say it cuts costs by 200000 USD and cuts quality by a value worth 300000 USD (bad prison guards, airport scanners). The public entity has weak incentives– and does not exert effort. The private entity has strong incentives and it cuts costs.

Glaeser and Shleifer argue that non-profits are a bit like public entities, with weaker incentives to cut costs, which can avoid quality cutting (USAA, hospitals).

Note (Glaeser's variant on HSV)**.** For 100000 USD in bribes and effort, the company can extract 200000 USD in public value via the following: renegotiation of highway or service contracts (Manila Water story), underpriced use of public space, streetcleaning in New York City.

Public entity does not pay bribes, since they do not keep the money. Private entity will pay the bribes and extract rents from voters. Non-profit might not (weaker incentives).

14.3.2 The renegotiation problem

Initial auction can be arms length and produce what seem like good prices. Once work begins and conditions change, there is an opportunity for renegotiation (there is scope for hold-up, since we are no longer in a competitive setting; this is where procurement gets expensive). In Manila case, initial auction is about prices that can be charged, the bid is "return on investment."

Renegotiation substantially increased return on investment; even though customers did not want to have septic tanks cleaned, they built plans because of cost of those plants could be built into the water prices at a high return.

14.3.3 The independent public model

Allows flexibility of wages and incentives (Collier). It can attract a top person who wants the fame and recognition and who can really deliver services. Downside of the Moses model is that person is not democratically accountable. Problem with parastatals in Sub-Saharan Africa is that the benefits of serving the political master is much higher than impressing the general public.

14.3.4 Regulation of government

When regulating private actors, there is usually a tradeoff between limiting negative externalities (good) and reducing individual autonomy (bad). These are not the tradeoffs in the regulation of government. Tradeoff is between limiting socially harmful, but privately advantageous actions (corruption) and allowing leeway to follow more subtle strategies that benefit society. Optimal regulation of government will depend on how aligned the public actor's interests are with society as a whole.

14.3.5 World Bank procurement survey

A new component of the Doing Business survey, questionnaire completed by more than 1200 professionals across 187 countries involved in the procurement activity, including lawyers, construction and engineering firms, and procuring entities. Each country, only consulted with professionals who had been involved in procurement of works contracts with the relevant Procuring Entity (PE) over the previous 12 months. Lawyers answer law questions; engineers answer engineering questions. Two rounds in 2018 and 2019. Survey was structured around a hypothetical case.

We find that laws are stricter in poor countries; practices are better in rich countries. Stronger laws imply better practices, better practices lead to better integrity of process, which leads to higher quality of product. We see that laws do not improve quality of product. See slides for plots.

14.4 Procurement model

There is a procuring entity (PE), who is running an auction. There are two bidders, an insider (who knows how to pay bribes) and an outsider (who cannot bribe the PE). Two bidders have different quality levels that are observed by the PE.

There are two institutions:

1. **PE must accept low bid.** Rules out corruption, but sometimes get poor quality product.
2. **PE can exclude low quality bidder.** Allows for corruption, but in places with strong institutions, this enables efficient exclusion of low-quality producers.

Looking at plots of outsider's quality advantage as a function of accountability of procuring entity, we can consider two cases:

1. **Outsider is the lower-cost producer.** There are three regions created by two curves. In the top region, outsider has a large quality advantage, so PE never removes her, regulation is as good as discretion. In the middle region, corrupt PEs exclude high quality outsiders, causing prices to rise and quality to fall, regulation is better than discretion. In the bottom region, the outsider is much better than the insider and so discretion (which tosses out the outsider) is good.
2. **Insider is the lower-cost producer.** In the second case, we see three regions, with one curve that looks like an exponential decay and another that is a vertical line. In the top region, outsider has a large quality advantage (similar to case 1). In the bottom-left region, corrupt PEs toss out the outsider, this does not change quality relative to regulation, but increases the price. In the bottom-right region, discretion and regulation are equivalent and the PE does not exclude the outsider.

Some empirical implications of the model include:

- Regulatory laws that reduce PE discretion reduce bribery.
- Practices are better than laws when accountability is high and worse when accountability is low.
- Process and product improve — regardless of the laws — in more accountable countries.
- Regulation is good in low accountability countries and bad in high accountability countries.
  There are two measures of accountability: WGI Government Effectiveness and National Human Capital (many past papers on this).

15 March 2nd, 2023

Today, we discuss cities and climate change.

15.1 Water infrastructure in the United States

There are 3m miles of water and sewer pipes in the U.S., with an average age of 45 years. Cast iron pipes can be more than a century old. American Society of Civil Engineers gave nation's drinking water infrastructure a C- grade; wastewater infrastructure a D+. Estimated 240000 water main breaks per year in the U.S. result in an estimated loss of 6b gallons of water per day. 7b gallons of water leaking out of pipes every year. The worst leakage problems are in Atlanta, Cleveland, Philadelphia, Pittsburgh, Detroit, and New York City.

There are 6.1m lead services lines still in use across America. These are pipes that connect water to a main building's plumbing.

Significant investments are needed to upgrade water and sewage infrastructure. Aging water systems and wastewater treatment are a problem in many cities; they are aging and often processing more waste than they were designed to handle. Older combined sewer systems (New York City, Atlanta, San Francisco) where single pipe handles human waste, industrial waste and storm water runoff during storms can overflow into surface water. Until 1980s, 60-70% of funding for water infrastructure cam from federal government; since then, funds decreased to less than 10%. New Infrastructure and Jobs Act allocates 55b USD to water and wastewater infrastructure.

Poor water quality is an issue in many cities:

- Flint water crisis produced serious health concerns, particularly in children.
- Milwaukee mayor advised residents in homes built before 1950 to install water filters to deal with toxic levels of lead.
- Brady, Texas has water with nine times more radium than recommended.
- In 2016, Pittsburgh Water and Sewer Authority sent out letters indicating the lead in their water was 1.5 times greater than the federal limit.
- In August 2022, Jackson, Mississippi water system overwhelmed with flood waters, leaving 180000 people with no water and no flushing toilets. In February 2021 and December 2022, deep freeze results in bursting water pipes.

15.1.1 Miami-Dade county

With more intense storms, flooding pushes toxins from Superfund sites into the groundwater; limestone mining along border with Everglades also produced toxins that seep into groundwater. Rapid residential development resulted in dependence on septic tanks for sewage, avoiding the time and expense of hooking up homes to the sewer system. Rising groundwater resulted in untreated human waste seeping into groundwater. As oceans rise, saltwater pushed into the aquifer.

Note. Miami-Dade County includes 34 cities and towns including Miami and Miami Beach, governed by Mayor and Board of County Commissioners. Water and Sewer Department (WASD) serves 2.3m people and 27 cities and towns. WASD owns 6300 mi of pipe, 1000 pumping stations and 3 large sewage treatment plants. Largest of treatment plants is in Central Wastewater Treatment Plant located on the Virginia Key. WASD provides water services at a very low rate compared with other departments in Florida and nationally.

The county is in negotiations with state and federal governments.

- Miami-Dade violated the U.S. Clean Water Act by illegally discharging waste more than 260 times between 2006 and 2012 due to corroded and decayed pipes and pumps.
- The county also needed to meet Florida state requirement to reduce ocean outfalls for disposal of treated wastewater and end ocean outfalls by 2025.

- Faced stiff fines and court actions from both federal and state government.
- WASD agree to negotiate a consent decree with federal and state officials to invest in fixing the decaying infrastructure.
- Total costs of improvements over 10b USD. A breakdown of the costs are on the slides.

The Biscayne Bay Waterkeepers Alliance threatened to sue the county because negotiations neglected potential impact of climate change on water and sewage system. Wanted the deal to include "climate proofing" the planned investments, arguing that improved facilities that were vulnerable to flooding and storm surge is risky both economically and environmentally.

15.1.2 Risks posed by climate change

60% of county is less than 6 ft above sea level, leaving it vulnerable to storm surges following tropical storms and hurricanes. Sea level rise threatens coast and property (over 4b USD at risk). Sea level projected to rise by 9-24 inches by 2060.

15.1.3 Mayor Gimenez's decision

Mayor Gimenez can do the following:

- **Nothing.** No climate proofing investments to the consent decree.
- **Make "no regret investments" only.** Investments such as restoring mangrove swamps or other natural barriers.
- Make investments in options like raising and hardening treatment plant sites (cost between 20m and 115m USD).
- Relocate three treatment plants over 10-15 year period (estimates over 8b USD).

In 2013, Gimenez filed a consent decree with the Board of Commissioners with **no language** calling for climate adaptation. In April 2014, court accepted the consent decree.

Rationale was to fix existing system and meeting state outfall requirements, which would cost water ratepayers 6.6b USD. No state or federal guidelines for mitigating climate-related risks might lead to extended debate and delays in fixing existing problems.

The court dismissed the Waterkeeper's suit. U.S. Environmental Protection Agency and the Justice and the State of Florida did not support Waterkeeper's demand for climate adaptation. County passed a resolution requiring that planning, designing, and construction of infrastructure consider potential sea level rises; approved annual increases in sewer tariffs for 5 years resulting in 35% increase by 2019; build public acceptance for increase through campaign (timeforanupgrade.org).

Note. The case rases three key issues facing local governments concerning investments in climate adaptation: uncertainties surrounding potential impacts; how much to allocate to address impacts; responsibilities of each level of government for investments in climate adaptation.

Note (Boston Seaport)**.** Boston flooding in January and March 2018. Boston's Seaport is 1000 acres of landfill. These were once among some of the most prized real estate in the East Coast (Mayor Menini 1997), but Mayor Michelle Wu says that the Seaport is one of the starkest examples of what is wrong with development system.

Seaport is now home to billions of dollars of real estate assets. Seaport now floods, some parts of the area are 1 or 2 feet above sea level. City is planning seawalls to defend the area, with an estimated cost of 1b USD.

We then look at flooding maps in Boston and Shanghai and future projections given storm conditions and rising sea levels. See slides.

16 Section 5

Problem set 3 is due Monday, March 6th at 5 pm EST. Midterm is on March 9th. Previous years' midterms are posted. If you are a senior and thesising, you can opt to not take the midterm, but the final will be worth 54% of the grade.

The format of the exam is six true/false/uncertain questions, where we will be given a statement and evaluate the validity of the statement. Explanations and intuition are important, even if the answer is not expected. There will also be two short answer/calculation questions.

Peleg would recommend remembering the key themes that came up multiple times: New York garment v. Pittsburg steel; the plagues of New York plagues and the water system; Renaissance paintings as an example of the city as drivers of innovation.

Today, we review three topics: (1) entrepreneurship and innovation, (2) urban form, (3) congestion pricing, (4) urbanization in open and closed economies.

16.1 Entrepreneurship and innovation

Knowledge is more important than space. Recall Brunelleschi's influence and the rise of Wall Street; both are examples that highlight the potential for cascades of innovation aided by proximity.

The importance of proximity can be seen in Jaffe, Trajtenberg, and Henderson (1993) which shows the local concentration of patent citations (in New York City).

De La Roca and Puga (2015) uses Spanish administrative data to show that cities provide valuable experience which accumulates over time. This is in contrast to there being some fixed different in ability between people in more or less populated areas.

We are expected to be able to read the plots provided by De La Roca and Puga, which show that the **denser, larger city** of Madrid not only has higher wages but exhibits **higher wage growth**.

16.1.1 Learning in cities model

In order to understand why skills may concentrate and spread in cities, we develop a simple model of learning.

We have the following assumptions. Let S be the initial fraction of skilled people. Unskilled learn by interacting with skilled people. Let δ be the probability that any person exits. We have a birth rate of unskilled people (exactly offsets death). Unskilled become skilled at rate q.

We want to produce a steady state, or a fixed point. We want to find a level of S that does not change over time. This occurs when the number of exiting skilled is the same as the number of new skilled. Thus the condition is

$$S\delta = S(1-S)q(1-\delta) \implies \boxed{S = 1 - \frac{\delta}{q(1-\delta)}} \tag{60}$$

We note that we assume that all interactions occur in the year.

Note (Implications)**.** This model shows that cities increase the likelihood of bumping into people, especially if there are high skills present. Suggests that cities with higher skill levels may be more robust. This also suggests that if there are high returns to skills, dense areas will have higher wages and housing costs; if skilled workers are better able to learn from others, they are more likely to cluster in dense skill-intensive areas.

We find that cities with smaller firms tend to grow more quickly. Causality is hard because of confounding variables or reverse causality.

Glaeser et al.'s paper use an instrument for firm size by using the presence of coal deposits as well as iron and lignite; these deposits lead to mining which tends to create large integrated corporations that like interacting with other large integrated corporations. This allows us to quantify the effect of firm size on city development (regressions).

16.2 Urban form

Modes of transportation evolved significantly over last 200 years. Access to transportation has come at a premium.

One of the issues with infrastructure is that it has gotten really really expensive. We find that interstate spending per mile has increased exponentially while labor and materials have more or less remained the same.

These projects are largely funded by local and state governments (75%) and through user fees (48%). The key change, recently, is that people have a lot more power to change and restrict construction and infrastructure projects. Another explanation is that surging price seems to be related to "citizen voice," where communities can be involved in permitting projects (Brooks and Liscow 2020).

16.3 Congesion pricing

In general private cost of trip is not equal to social cost of trip due to congestion externalities.

$$\text{Private trip cost} = m + d \times T(N), \qquad \text{Social trip cost} = \text{Private trip cost} + \text{Congestion externality} \quad (61)$$

where N is the total number of people on the road. Externalities can include traffic, noise, road erosion, accidents, pollution, carbon emissions, etc.

Optimal congestion tax sets private cost (inclusive of tax) equal to social cost; this leads individuals to internalize the externality that they impose on others. In general, optimal congestion tax varies across space and time (different from user fees).

In general the imposed tax is the difference between the cost at the intersection of the social trip cost and demand curve, and the private trip cost at the same point.

16.4 Urbanization

We present a model of urbanization. We need a population who can either farm of make industrial goods; productivity of farming and producing industrial goods; transport costs associated with industrial goods.

16.4.1 Closed economy

We first consider a closed economy, where the agriculture and industrial markets are closed. When agricultural productivity is high, fewer farmers are needed to feed population. This shifts workers towards the city. which leads to increase in industrialization. Price of the industrial good adjusts to incentivize working in the city.

16.4.2 Open economy

In an open economy, the price is determined in a global market. More productive agriculture will lead to more people wanting to enter the agriculture sector.

17 March 7th, 2023

Today, we discuss measuring new cities with new technologies. The midterm is in-class on Thursday.

17.1 Measuring cities with new technologies

Big data is helpful.

- **Yelp data** to track business change. Can be used to predict housing price growth, some demographic change (specifically college age students), but harder to predict gentrification.
- **Street level imagery** can be used as evidence in arguing theories about what makes different parts of cities grow more. We will discuss these theories later.
- **Uber data** to see if road roughness impacts speed (surprise: it does) and estimate the social costs of that. Increase of 1 standard deviation in predicted roughness generates welfare loss of 14 cents/mile.

There are lots of big data tools now:

- **Surveys.** Census, field surveys.
- **Human activity.** Cell phone records, mobility data, social networks.
- **Built environment.** Street-level imagery, aerial imagery, satellite imagery.

17.1.1 Local economies

We can nowcast local economies with Yelp.

- **Regression.** Adding Yelp data to (lagged) survey data improves R^2, with improvement bigger in highly dense, high income, highly educated places, because they have a larger digital footprint.
- **Predicting housing price growth.** Using Yelp Starbucks growth can predict housing prices going up (gentrification).
- **Predicting demographic changes.** Certain businesses correlate quite well with change in demographics.

17.1.2 Gentrification

We can also use Yelp to look at gentrification. We define the following

- Zip codes with below median poverty rate are rich.
- Zip codes with above median poverty rate and below median change in college share are poor, non-gentrifying.
- Zip codes with above median poverty rate and above median change in college share are gentrifying.

We see that the first order effect is redistribution. Gentrification associated with rising rents, which leads to wealth transfer from renters to landlords, which means that existing renters lose out. The impact of gentrification on rents depends on the supply of housing: more elastic housing supply means housing impacts will be reduced. Cultural impact is harder to investigate, one model is that you have local idiosyncratic retailers who generate more consumer surplus than coffee shops that are basically providing convenience.

There is not a ton of evidence for more business change in gentrifying areas (seen in regressions).

17.1.3 Street-level imagery

Salesses, Schechtner, and Hidalgo (2013) crowdsourced urban appearance survey (Place Pulse). 200,000 pairwise comparisons. Compute location ELO to get ranked scores. They then trained a model to extrapolate

many more block images scores from this data set. The find that street score does not correlate with neighborhood safety at all, lots of the low scores are just empty places.

Using this, we can measure change in physical landscape of cities. We go over theories that we'll cover in more depth later:

- **Human capital agglomeration theory.** Population and density are strongest predictors of future growth in neighborhoods. Glaeser wrote a paper here so this is probably the course's correct interpretation.
- **Tipping theory.** Neighborhoods with better initial appearances experience larger positive improvement.
- **Invasion theory.** Neighborhoods are more likely to improve when they are close to downtown and/or other neighborhoods perceived as safe.

17.2 Infrastructure inequality

American Society of Civil Engineers (ASCE) road grades have been downgraded for years but our highways are actually getting better. Local roads are the problem. We will attempt to model the costs of road roughness and measure relationship between driver speeds and road roughness. Slower speed means less impact of bumpiness, so it measures how much people are willing to pay to avoid bumpiness.

Use Uber data. Standard deviation of acceleration on road segment versus car median speed on road segment. Turns out this measure is good, see slides.

17.2.1 Social costs to road roughness

We give a simple model in which impact of roughness on speed is a sufficient statistic to measure private costs of road roughness on drivers. Intuition is that slower driver means less vertical acceleration, and the associated time loss is essentially the willingness to pay for less acceleration.

We will measure the impact of roughness on speeds. There are two empirical methods:

- Road repaving in Chicago.
- Border discontinuities nationwide.

We find the following:

- Decrease in roughness results in about 12% increase in speed.
- National experiment with 137 Uber cities (think MSAs), restrict within 1 km of border and include border-pair fixed effects, instrument for roughness level by roughness further within each town. We find that roughness impacts speed.
- More interestingly: Increase in 1 standard deviation in predicted roughness generates a welfare loss of 14 cents per mile. Worse roads in minority neighborhoods.
- **Policy.** Going back to Chicago, there is basically **no correlation between our measure for road roughness and which roads Chicago is choosing to repave.** There's no real targeting; they're just going for whatever is convenient to repave.

17.3 Steve Poftak, former head of the MBTA

The current annual operating budget 2.5b USD, with 2.5b USD for capital. There is not a ton of picking battles in this role, mostly putting out fires; not a ton of time to think big picture strategic.

In policy, the big issue is capacity rather than good ideas. It turns out that operating costs are not aligned with revenue. This is the new normal absent some big change in work-from-home (WFH) norms. This means

transit agencies have lost a lot of revenue. Pre-COVID, there were 2.5b USD in revenues, about 700m USD from fares. Now it is 350m USD. We got like 200m USD from Biden, but that will run out.

The new parking fare system cuts down on operating costs and gives MBTA much more big data to work with. MBTA has signed the deal to get new green line cars, which should come late 2025 or early 2026, from a company called CAF with factories in upstate New York.

The procurement for the red and orange line cars was signed by Deval Patrick, was probably 250k USD cheaper per car than the next closest bid, now tons of delays, media flames him as obvious in retrospect, but media would have had a field day if he had agreed to 250k USD more per car at the time.

With respect to climate adaptations, we cannot we do an all electric bus system here. It is cold, hilly, buses have limited range depending on temperature. The goal of full electrification by 2030 is completely not happening.

Green line extension: extra demands, cost inflation about the station; unconstrained public process did not work super well, also procurement was not well-managed. Performance is measured on ridership, time between service; there are big disagreements between data and operations people on what is most useful

18 March 9th, 2023

Today is the in-class midterm examination.

19 March 21st, 2023

Today, we discuss land use controls. Midterms have been graded and will be handed out in section. The mean was 77 with a standard deviation of 9.4. The rough grade ranges are something like A (86-95), A- (76-85), B+ (70-75), B (60-70). B- (50-59).

Final grades are determined by the weighted distribution of all points in the class. Paper topics are due **March 31st by 5pm**. Topics have to be approved by a member of the course staff.

Recall that every student is required to attend one pizza lunch.

19.1 Land use controls

There are some distinctive features of real estate.

- **Fixed in space.** Location determines accessibility, public goods and services, and neighborhood.
- **Durability.** Older properties are good substitutes for new properties.
- **Properties are heterogenous.** Structure, land lot, neighborhood.
- **Real estate is expensive.**
- **Substantial moving costs.**
- **Real estate is a very regulated commodity.**

We will discuss real estate regulation. There are two types of regulation:

- **Building codes.** Construction and maintenance requirements focused on insuring health, safety, energy efficiency.
  This is useful for ensuring safety, preservation.
- **Land use regulations (zoning).** Mandates how land can be developed (e.g. intensity of development (FAR), mandatory setbacks, open space requirements, zones of use for industry, retail, commercial, residential.)

19.1.1 Building codes

A brief history of building codes is given by

- **Building codes date back to the Code of Hammurabi in Babylon (1780 B.C.).** Builder put to death if they build a house for someone and does not construct it properly (and kills the recipient).
- **Building codes developed after disasters.** Examples include Rome fir in 64 A.D. leading to wider streets and height restrictions; Great Fire of London in 1666 led to wider streets and houses build with brick and stone; the Great Chicago Fire of 1871 led to stricter building and fire codes.
- **New York City tenement laws.** 1867 law required fire escapes and a window in every room; 1879 law required windows face fresh source of air and light; 1901 law dealt with garbage removal.
- **Water and sanitation requirements.** Used to deal with cholera epidemics and other diseases.

Modern building codes:

- **Rationale for government creation and enforcement of building codes.** Externalities include fire and disease (that can adversely impact neighbors); real estate is durable: potential buyers of existing buildings do not know what is inside the walls. Building codes attempt to ensure a minimum standard.
- **Building codes can increase costs and decrease stock of housing.** Requirements like fire resistant materials or energy-efficient appliances can increase costs. Housing stock serving the poor is often in poor condition. Costly code requirements can lead to abandonment.
  There is a tough **tradeoff.** Enforce code to provide safe and healthy environment v. keep poor quality units in the stock because those units are affordable to the very poor.

Note (Decline of substandard housing)**.** We see that the quality and standard for housing has increased. There is a rapid decline of substandard housing in the stock across the United States. The conversation of affordable housing is no longer about quality, it is now about affordability.

Part of the conversation is how to we regulate development.

Note. There is spatial separation in land use for commercial, residential, and industrial use.

19.1.2 Land use regulations

New York City adopted the first comprehensive zoning law in 1916. Equitable Building is often cited as the catalyst for the new law, blocking light and air from the streets. This caused unhealthy conditions (congestion) in street and transit traffic.

Zoning laws quickly spread and by 1936, over 1300 cities and towns had zoning laws.

There are two predominant theories about why land use regulations spread quickly:

- **Fischel (2015).** Changes in urban transportation led to rapid rise of zoning between 1910 and 1930.

  Prior to this time, commercial and industrial uses tended to be centrally located to be near transportation. Apartments for workers tended to be within walking distance of jobs or close to transportation. Homeowners were generally isolated from these uses. The motorized truck and jitney buses made industry and renters more footloose. Homeowners wanted to protect their communities from these uses.

- **Land usage shifting away from farming.** Zoning required because city growth taking land away from farming.

Municipalities use zoning laws to address externalities. For example, and industrial plant with smokestacks spewing pollution affects neighboring residents; high density housing developments generate externalities such as traffic congestion, parking issue, stress on existing infrastructure and public services like schools.

19.1.3 Zoning and the courts

There are two cases:

- **Euclid v. Ambler (1924).** Euclid zoned a parcel of land owned by Ambler Realty as residential. Amber indented to sell property or industrial use and sued the city because zoning devalued property. Federal court sided with Ambler. Appeal to Supreme Court (sided with City of Euclid) stated that zoning was legitimate exercise of police power as long as it promoted health, safety, morals, and general welfare.
- **Southern Burlington County NAACP v. Mt. Laurel (1975).** New Jersey Suprem Court found that Mt. Laurel's exclusionary zoning harmed low-income outsiders and mandated that local zoning provide fair share of affordable housing.

  Note. The impact of this case has been small. State legislature modified quotas and communities can buy and sell their quotas.

Fiscal zoning is zoning to attract firms and households that generate a net fiscal surplus. Poorer communities often willing to take firms with net fiscal surplus even if they bring environmental concerns. Minimum lot size zoning can help to generate enough property tax base per household to cover services consumed. Exclude poor households who consume more in public services than they contribute in taxes.

Cities provide open space by providing public land in parks and greenbelts and zoning to restrict use of private land.

19.1.4 Impact of land use regulations on house prices

Some studies:

- **Quigley and Rosenthal (2005).** Impact of land use regulation on house prices is difficult to assess because of the limited information on land use regulations.
- **Glaeser, Gyourko, and Saks (2005).** Cost of adding extra floor to Manhattan building is significantly lower than the potential benefit from the additional housing.
- **Gyourko, Mayer, and Sinai (2013).** Show high housing price appreciation with low growth in housing units.
- **Gyourko, Saiz, and Summers (2009).** Show that stronger regulation index increases the housing price premium. Some correlation between regulation index and housing price. One of the first papers that quantifies regulation (and produces data with regulation).
- **Gyourko and Krimmel (2021).** Look at land value and calculated zoning tax per quarter acre.
- **Ganong and Shoag (2017).** Assemble unique data on land use regulation by creating a panel by totaling the number of state supreme and appellate court cases that contain the phrase land use over time. They find the following:
  - Estimate that regulation negatively impact the number of permits wiping out the positive impact of higher income on permits.
  - Positive correlation between income and house prices; slope of income coefficient doubles in high regulation state years.
  - In past 30 years, migration to high-income areas and income convergence has slowed. Returns to low-skilled workers from moving to high-income states fall due to high housing prices.
- **Hsieh and Moretti (2018).** Stringent restrictions on housing supply in highly productive cities like New York and San Francisco limit the number of workers in those cities reducing productivity. Estimated impact of supply constraints across 220 metro areas between 1964 and 2009: lower aggregate US growth by 36%.

19.1.5 Concluding thoughts

We see that larger cities experience greater zoning and feel the impacts of housing market fluctuations. Larger macroeconomic costs of the closing of the metropolitan frontier.

20 March 23rd, 2023

Today, we discuss crime in the city.

20.1 Crime and the city

If you are the mayor of a city, it is hard to find a better metric of governance of a city than crime. In 2020, the murder of George Floyd catalyzed national debate about reforming police. Crime rates have risen dramatically in some big cities over the past three years.

Note (Homicides per 100000)**.** Crime rates have increased in Philadelphia and Chicago to almost 1990s levels, measured by homicides per 100k residents. Homicides are often reported and have been historically used to measure crime.

Note (New York City)**.** We also note that homicides per 100000 in New York City experience a dramatic spike in the 1970s and has since decreased in the late 1990s/early 2000s.

20.1.1 Homicide

In the last thirty years, there is a general decline in homicide, with a particularly large decline in large cities. Smaller cities and suburban areas declined more slowly (but had a lower starting point). Pre-1990s, the prime form of homicide is by argument and spousal homicides. For causes of homicide, felonies have declined, but gang homicide and unknown cases have increased.

20.1.2 Theft

To measure other forms of crime, we look at victimization surveys, which are survey responses collected from victims. The most common form of crime is theft.

We note that victimization rate per 100000 in white males, black males, white females, black females peaked in the 1990s, and we see that the rate is higher for people aged 18-24. We note that the peak values for these demographics are 20, 200, 6, 30 per 100000, respectively. Within gender, there is a 4-fold difference in the high-peak difference between white and black women. Between white and black men, black men experience a 10-fold increase in the high-peak difference in homicide rate.

When we look at alleged perpetration by gender, race, and age, we see that white women are less likely to perpetuate murders than to be victims of them.

Note. In all cultures, there tends to be a significant difference between male violence and female violence. The gulf between the races is less severe.

There is a difference between hot and cold burglaries in the United States. The legal risk of burglary is pretty low, but in many American households, there are guns. It makes sense that burglaries occur when there is no one in the house (cold).

20.2 Canonical Becker model

This model plays the same role for crime as the AMM model for space. It is potentially offensive.

We have the following assumptions. Every person is a potential criminal and chooses whether or not to commit a crime. We assume all crimes are the same and all decisions are binary (crime or no crime). We are going to monetize the value of committing a crime (creating a supply curve for crime).

We assume first that there are 10 people with values of committing crime spaced evenly between 0 and 10000 USD (at 1000, 2000, ... USD). Assume 100 people at 100 USD increments and assume 1000 people at 10 USD increments.

Each person commits a crime if and only if the benefit is greater than the cost. The number of people with a benefit greater than a value x is $\frac{1}{2}(10000 - x)$. Criminal is caught with probability $p = 1/5$. Penalty from being caught is 25000 USD. Individuals then will commit a crime if and only if the benefit is greater than the probability of arrest multiplied by the penalty. In this case, this is 5000 USD.

If the probability of arrest falls, the number of criminals increases; if the punishment increases, the number of criminals decreases.

20.2.1 Implications of the model

There are two implications of the model:

- **We should boil people in oil for littering.** Mathematically, if we make penalties high enough, no one will commit a crime.

  There are pesky constitutional issues, marginal deterrence (no difference between robbing a bank and jaywalking), and subversion of justice.

- **We should expect everyone in jail today to commit crimes when they are released.** Optima do not change. Perhaps they have acquired criminal skills in prison.

The model has both positive and normative implications, and has been used in both ways. Deterrence v. incapacitation are a big conflict. Explains the historic propensity for there to be more crime in cities. First order explanation is lower punishments; second order explanation is higher benefits of crime.

The optimal penalty equates the cost of punishment which includes prison costs, but also costs to the prisoner. To achieve equivalent deterrence, need to punish more crimes where it is harder to catch the criminal. Punish more when behavior is more elastic/responsive, when crime is more costly to deter more, when criminals are more likely to engage in recidivism.

Note. The race of the victim is impactful on sentencing. In particular, when the offender is black and the victim is non-black, on average, the offender gets a sentence that is 4 years longer than if the victim is black. The gap between female victims and male victims is 5 years.

20.3 Understanding the reduction in urban crime

There are many hypotheses:

- **Spending and the number of police (Levitt).** 25% of New York City reduction via increased number of sworn officers.
- **Incarceration and incapacitation.** This is the Becker-Levitt debate on importance of incentives v. incapacitation.
- **Changing demographics.** Younger people tend to commit more crimes.

  Demographics matter at the individual level, but group changes in age structure are not really big enough.
- **Abortion (Donahue and Levitt).** Rise in abortion decreases crime.
- **Lead consumption.** Declining lead levels decreases crime.

Note. The rise of mass incarceration began with the Three Strikes and Diana Ballasiotes.

Note (Technology and community policing)**.** Ray Kelly (of New York City) and Ed Davis (of Boston) had different approaches to reducing crime and policing. In New York, Kelly helped spur the decline in New York by instituting the Safe Streets, Safe City program, which put thousands more cops on the streets, where

they would be visible to and able to get to know and interact with local communities (throwing more police at the issue). In Boston, community policing was working with the community to try to get the community to tell them who was committing crimes; the way you build trust is going into communities in non-crime contexts.

Boston cops developed the soft skills to dispel protests like Occupy Boston.

Note (Stop and frisk in New York City)**.** John Tebes and Fagan show that stop and frisk are highly concentrated/present in black and Hispanic neighborhoods.

Note (Fryer and Devi (2020))**.** For five investigations that were sparked by nationally visible incidents of deadly use of force, investigations cause statistical significant increases in both homicide and total crime.

20.4 Riots

Riots are different from standard crime models. Benefits are the same as before, but now the probability of arrest falls with the number of criminals (no longer a fixed penalty).

Suppose penalty is 45000 USD and normal probability of arrest is 20%. If the number of criminals/rioters c rises over 1000, the probability of arrest becomes $0.2 \times 1000/c$. This creates scope for multiplicity of equilibria (we can observe this by superimposing the value of crime and expected penalty plots).

Note (Glaeser and Dipasquale)**.** Riots are less common in richer areas, in countries with lower urbanization rates. Homeownership is associated with less rioting. Higher unemployment rates are associated with more rioting.

20.4.1 Concluding thoughts

Crime matters, but what matters more is how safe people *feel* in their cities. Many statistics are city-wide, but the geography of crime matters a lot. There is heterogeneity in where crimes occur in a city. We can observe trends in Chicago, Kansas City, Baltimore, Nashville, where crime increase is extremely localized.

When crime rises in cities, areas that are more disadvantaged are disproportionately affected by crime.

21 Section 7

Section 6 was skipped due to the midterm. Today, we go over the midterm and discuss problem set 4.

The last part of the first question was the hardest part of the exam. More specifically, problem 1.3(b) was particularly difficult. It is strategic to skip the problem if you get stuck.

21.1 Problem 1 (AMM model)

Closed AMM city with 10000 residents, annualized building cost of 3000 USD and agricultural rent of 1500 USD. The number of houses per unit of land is $q = 1$.

Every resident drives to the city five times a week for work and drives to consume leisure twice a week. Annualized marginal cost of one weekday's trip is 0.1 USD.

Recall **location rent** is a person's rent not due to agricultural or construction costs.

Recall that in **spatial equilibrium, everyone across the city has the same utility**. So welfare changes can be measured by looking at what happens to residents at the city center, where commuting costs are 0, because $d = 0$ at the center.

21.2 Problem 2, (Rosen-Roback model)

$N = 10000$ people in the world, and they can decide to live in one of two cities, Coruscant or Trantor. Resident earns 12000 USD in Trantor and 13000 USD in Coruscant. Cost of living in either city consists of rents and congestion costs. Congestion costs for each resident is $0.5 \times N$ USD, where N is the population. Assume people can move freely between two cities without any relocation costs.

Rent in each city goes up with the population. In Trantor, rent for each resident is $0.2 \times N_T$ and in Coruscant, rent is $0.4 \times N_C$.

To solve for **spatial equilibrium** population, we note that we simply solve for the population where the welfare across the two cities are equal. We have the condition that $N = N_T + N_C$.

21.3 Problem 3 (True/false/uncertain)

21.4 Problem set 4 notes

For problems 2 and 3, use expected values.

22 March 28th, 2023

Today, we discuss housing markets.

22.1 Housing markets

In 2019, the United States had 328.2m people, grouped in 128.6m households with an average size of 2.55 people. The 2019 homeownership rate is 65.1%. In the 1980s, number of households grew by 1.25m a year on average; 1.1m a year in the 1990s. Households growth under 600000 per year from 2009-11; more than 1m from 2015-16.

We see that resident population in the U.S. in 2019 is relatively constant for Baby Boomers, Generation X, Millennials, and Generation Z (around 70m).

Note (Millenials and the housing market)**.** There are 72.1m millennials, the largest generation in history. Median income of 25-29 year olds in 2015 was 10% below the same age group in 2000.

We see that for both men and women, approximately 55% of 18-24 year olds are living in their parents' homes; approximately 15% of 25-34 year olds are living in their parents' homes.

We also see that the number of households owned by young adults has remained (roughly) constant since 1980. The number of households owned by older adults (aged 65 or older) has steadily increased (currently 35m) over time.

The percentage of married households has decreased over time while the percentage of nonfamily households has increased over time (from 1950-2022).

In 2015, 16.3% of homeowners moved in the past two years; 51.5% of renters moved in the past two years. Most households move to housing that better matches current needs in terms of structure or costs or to improve neighborhood.

Note (Home ownership)**.** People aged 75 or older is the age group that has the highest percentage of home ownership. We see data in the slides.

U.S. home ownership is definitely not the highest in the world despite being famed and marketed as the home-owning capital of the world. In 1990 and 2000, U.S. homeownership slightly above average of 18 countries; in 2015, U.S. 5.9% below average, fifth lowest homeownership rate among 18 countries.

22.1.1 Measuring housing prices

We can let P be the price of something over time, Q be the quantity and quality of space (hard to measure), and $E = PQ$ be how much we spend. Measuring $\Delta E/E$ is easy but $\Delta P/P$ is hard.

There are two approaches to estimating quality-controlled price oh housing:

- **Hedonics.** We use hedonics with time variables that are indicators for the period each home sells in $D_i = 1$ if sold in period i, etc. Coefficients β_i measure price *level* in that period relative to first period in sample. We model

$$P = \prod_{i=1}^{T} X_i^{\alpha_i} e^{\beta_i D_i}. \tag{62}$$

  We can convert to a linear regression

$$\ln P = \sum_{i=1}^{T} \alpha_i \ln X_i + \beta_i D_i. \tag{63}$$

Note. The issue with the hedonic approach is that it is data intensive. Transaction data readily available but variation in which characteristics are tracked and how far back. Unobserved characteristics can bias estimates.

- **Repeat sale price index.** We only look at homes that sell more than once over the sample time period. Dependent variable is price change between sale dates. Independent variable is a set of dummy variables for each period. Suppose an observation has most recent sale period in period i and prior sale was n periods earlier.

$$\ln P_i - \ln P_{i-n} = \sum_{t=1}^{T} \beta_t \mathbb{I}_t \tag{64}$$

where $\mathbb{I}_t$ is zero for all years *except* for those in the i to $i-n$ interval. β_t correspond to the *inflation rate in prices in that year.*

Note. Requires less data and avoids problem of unobserved characteristics with hedonics, but also ignores lot of transactions.

Note. The Census tracks median price of new homes. We see that the housing prices decreased after 2008 but prices have risen since. The National Association of Realtors (NAR) tracks median price of existing homes. The cost of existing homes has fallen since 2006.

We see that house prices dropped in 2008 but have linearly increased since 2012-Q1.

Note. Pittsburgh, PA housing market has been rising slowly but steadily since 2000. Las Vegas has been on a scary roller coaster.

22.1.2 Financing homeownership

Homes are expensive, majority of homebuyers finance homes with a mortgage. A mortgage is a secured loan. The dominant mortgage in the United States is the 30-year fixed payment mortgage (FPM)

$$\text{PDV} = R\frac{1-[1/(1+i)^n]}{i} \tag{65}$$

where PDV is the present discounted value of the stream of payments, R is the monthly payment, i is the interest rate, and n is the term (360 months). We can also write

$$R = \text{PDV}\frac{i}{1-[1/(1+i)^n]}. \tag{66}$$

FPM is the dominant mortgage in the United States; adjustable rate mortgages (ARM) are widely available.

Initial rate on an ARM is generally lower than on FPM but rate can adjust at specific intervals over the course of the loan. Loaners like AME because there is less risk, so they offer a lower rate.

Note. Total amount paid is higher for AMR than FMR (see plot in slides). Moreover, AMRs were more popular before the fall of housing prices (we observe a kind of periodic application cycle).

Lenders conduct due diligence in qualifying borrowers for a mortgage. This includes (1) looking at debt (mortgage payments, taxes, insurance) to income ratio (cannot exceed 36%), credit history and credit score; (2) property appraisal to ensure property has sufficient value to secure loan.

22.1.3 Government role in mortgage market

Primary mortgage market is the market that provides funds to borrower. Secondary mortgage market is the market where existing mortgages are bought and sold to investors. Active secondary mortgage market means that while housing markets are local in nature, funding for mortgages do not need to be.

Federal role in mortgage market dates back to 1930s: mortgages were provided by local banks funded by short-term deposits; FHA created in 1934 to provide mortgage insurance, created FPM; Fannie Mae created in 1938 to support secondary mortgage market; 1968, Fannie Mae split into Ginnie Mae (federal agency charged with securitizing FHA and VA-insured loans) and Fannie Mae (government-sponsored enterprise (GSE) charged with providing secondary market for conventional loans); 1970, Ginnie Mae created first mortgage-backed security (MBS); 1970, Freddie Mac created as GSE to create secondary market for mortgages originated by thrifts.

Lewis Ranieri developed mortgage-backed securities on Wall Street at Salomon Brothers in late 1970s and 1980s.

Note (GSEs)**.** Fannie Mae and Freddie Mac chartered to provide stable source of mortgage funding through creating standards for mortgage and providing a secondary market. Exempt from state and local corporate income taxes. Securities were not required to be registered with the Securities and Exchange Commission (SEC). Line of credit with the Treasury. There is an implicit guarantee: GSEs could borrow at lower rates than private financial institution and their credit guarantees were more highly valued. GSEs grew rapidly and were very profitable for their shareholders for over three decades.

As housing prices began to collapse, people were defaulting on their loans, which ended up leading to people having trouble raising capital.

They are still a conservatorship: but the reasons are politics. The private market should handle the mortgage market. However, if the private market was in charge of these securities in 2008, the housing crisis would have been a lot worse.

In 2008, GSEs suffered large losses as housing prices dropped and foreclosures increased. Under Housing and Economic Recovery Act of 2008, Fannie MAe and Freddie Mac were placed in conservatorship where they remain. Bailout totaled 191b USD; since then, Fannie and Freddie have paid 290b USD in dividends to the U.S. Treasury.

22.1.4 Federal tax subsidies to homeownership

Mortgage interest is deductible from taxable income. Local property taxes are deductible from taxable income. Capital gains from the sale of a home are exempt from capital gains tax (up to 250000 USD for singles and 500000 USD for married). Impact of these subsidies can be modeled

$$U = (i + t_p)(1 - t_y) - E(\Delta P/P) \tag{67}$$

where U the total annual cost of purchasing 1 USD housing, i the mortgage interest rate, t_p the property tax rate, t_y the marginal tax rate, $E(\Delta P/P)$ is nominal price appreciation.

Note. Homeownership rate is not soaring (even with low cost to capital) because many people cannot afford a down payment.

The rational for federal subsidies is that households that own their income have a greater stake in their community/want to invest more in their communities.

22.1.5 Studies

- **DiPasquale and Glaeser (1999).** Explore if homeowners are better citizens. Using U.S. General Social Survey, estimate impact of homeownership on investments in social capital measured by numm-ber of memberships in nonprofessional organizations, knows the head of school board, knows U.S. representative, votes in local elections, helps solve local problems, owns a gun, and church attendance.

  Results show strong correlation between hoemownership and our measures of good citizenship.

- **Hausman, Ramot-Nyska, Zussman (2021).** Examine impact of homeownership on labor supply and neighborhood quality. Use Israeli government sales of public housing units to existing tenants. Sample from 2000.

  They find that new homeowners increase long-term employment by 5-7% relative to non-buyers. New homeowners increase labor income 12-13% relative to non-buyers. Explanations include: labor supply increases to meet costs of homeownership; owners have greater sense of agency.

Note (Federal Reserve Bank of St. Louis (FRED))**.** We see that single-family construction is still depressed while multi-family construction is back to its historic average.

22.1.6 Supply of housing

The sources of supply include new construction, existing stock, and conversions of existing stock. Higher housing prices have increased new construction. Declines in productivity in the construction sector. Limited research on the micro foundations of housing supply (little data available where the unit of observation is the builder, developer, or investor).

23 March 30th, 2023

Today, we discuss housing bubbles and green cities.

23.0.1 Mancur Olson and the Decline of Nations

Olson's vision is that a stable society sews the seeds of its own demise. See slides for some points on insiders and outsiders. That as institutions begin to develop, things become harder to change because of coalition building and inefficiency.

In cities, we have made it much harder for insiders to be challenged. One area where this is most evident is in housing

Note. We see that in different areas, e.g. San Francisco and New York, we see different protests against building housing, under different slogans and ideologies.

23.1 Housing and green cities

23.1.1 Restrictions at the local level

Localities have long engaged in environment-related regulations (building, water, etc.). Some of these appear to have been successful. Banning the use of coal for domestic heating had less cost than expected; but many of these caus activity to move, sometimes limits impact. Mobility can reverse the intention, moving from greener to browner locales.

Note (Glaeser et al. paper)**.** Glaeser et al. wrote a paper where they move a household with a fixed income and size from one place to another. They estimate their emissions in different places if they make decisions that are typical for their characteristics in those places. They choose **not** to hold housing characteristics constant; they are **not** interested in emissions assuming suburbanites live in high rises.

Assume that carbon emissions are from cars, public transportation, home electricity, and home heating.

They find that there is a negative correlation between the log population and gallons of gasoline consumed.

Note (Weber and Matthews 2008)**.** What happens when we bring green stuff into the city. The idea is that the amount of carbon used to ship in agricultural goods is less than the carbon produced when we put space in between people.

23.1.2 Home heating

Two data sets IPUMS (house-level spending) and RECS (independent provider data). IPUMS is big, RECs is small.

With IPUMS data, we first convert home energy spending into quantities with state-level price data from 2000. We then perform MSA by MSA regressions. For RECS, we convert spending into megawatt hours and MWh into CO2 with emissions data.

Negative correlation between January temperature and natural gas consumption; and positive correlation between July temperature and electricity consumption.

We find that middle America is the worst for carbon emissions and electricity usage; and larger urban areas are among the areas with the lowest emissions.

Relating the data to the Wharton Regulation Index, we see that places that have the lowest emissions are the ones that are the most highly regulated.

Note (China)**.** Carbon emissions from China are relatively low. The thing that predicts household carbon consumption is just how cold a region is.

Note (City-suburb differentials)**.** For each metropolitan area, we calculate the difference between urban and suburban energy use. Can use central dummies to define central city location.

Data is in a table in the slides. We see that there is the most city-suburb difference in carbon emissions in New York City, New York. In Dayton-Springfield, Ohio and Rochester, New York, the suburbs seem to be *more* green than the cities.

We see that it has gotten more expensive to build in cities in the country in post-2013.

We see that there are two correlated trends. Privately-owned single-family units and privately-owned units in buildings with five units or more.

23.1.3 Cap rate formula

Assume we are going to live in a house at time t, but we can either buy or rent.

If we buy, we pay $P(t)$ for the house and then sell for $P(t+1)$ after one period. If we rent, we pay $R(t)$ in rent, invest $P(t) - R(t)$ in bonds, and we have $(1-r)(P(t) - R(t))$, where r is the interest rate.

The no arbitrage equilibrium requires that these returns are equal in expectation.

23.1.4 Asset market equilibrium

In equilibrium, we must have

$$(1+r)\left[P(t) - R(t)\right] = P(t+1) \implies P(t) = R(t) + \frac{P(t+1)}{1+r}. \tag{68}$$

We can iterate for all future time periods and obtain

$$\boxed{P(t) = R(t)\frac{1+r}{r-g}} \tag{69}$$

where we assume $R(t+1) = R(t)(1+g)$ and g is the growth rate.

There are two views of bubbles:

- **Credit market view.** Interest rates r were low, or approval rates were high or down-payments were low and this caused high prices. The interest r is low.
- **Extrapolation view (Glaeser and Nathanson, 2015).** Beliefs were semi-rational. People have a high expectation about g.

Note. In a rational model, interest rates should not be that powerful, and empirically, they are not.

23.1.5 Momentum and mean reversion

We assume

$$P(t+1) - P(t) = \alpha\left[P(t) - P(t-1)\right] + \beta\left[P(t-1) - P(t-2)\right] + \epsilon. \tag{70}$$

Short-term momentum is when $\alpha > 0$. Longer term mean reversion is when $\beta < 0$.

23.2 Real estate speculation throughout U.S. history

We have the following points:

- America originates in a great land gamble, betting on real estate is intrinsic to national story. Washington and Franklin in Ohio, Robert Morris's bakruptcy.
- Things that look like bubbles ex post often looked pretty reasonable at the time. Morris bought massive amounts of extremely cheap land on the frontier with Dutch financing. Alabama cotton land looked dirt cheap in 1819 relative to cotton prices at the moment.
- Largest error over time is always failure to anticipate the power of supply to determine long-run prices.
- Easy money is necessary but far from sufficient for a bubble.

Note (Chicago)**.** During the construction of the Illinois-Michigan canal, Harriet Martineau famously said that "I never saw a busier place than Chicago was at the time of our arrival (1836). The street were crowded with land speculators, hurrying from one sale to another. ... it seemed as if some prevalent mania infected the whole people. As the gentlemen of our party walked the streets, store- keepers hailed them from their doors with offers of farms and all manners of land lots, advising them to speculate before the price of land rose higher."

We note that the first phase of the Chicago boom was building up (birthplace of the skyscraper), and then building out (as the price of space declines).

We take a look at housing supply and demand in San Francisco and Las Vegas.

23.3 China's housing boom

Rogoff and Yang plot the total share of real estate as a function of GDP across different countries. Real estate value is 25% of China's GDP. Moreover, they show that the housing price decreased dramatically in Tier 3 cities.

Glaeser et al.'s paper shows that development in Chinese Tier 3 cities is developing faster than United States (simulated) "Tier 1" city development. China built more than four times what the United States built during our boom period. The Chinese boom lasted for much longer.

The main players in the Chinese boom are

- **Individual home buyers.** Much less leveraged than the United States; more likely to be middle-aged investors. Less evidence for extrapolation in the data. Understandably optimistic about China's future.
- **Real estate developers.** Chinese real estate developers resemble United States developers. Highly leveraged.

There is a large public sector difference. U.S. public sector is limited; federal government encourages borrowing, local governments restrict building. The Chinese public sector owns all the land, sets all the rules, and controls the banks.

23.3.1 Dealing with bubbles

There are two questions: what do you do when prices are rising steeply; what do you do when prices start falling.

For the first question, we can consider financial regulation (and taxes); for the second question, we can support the financial system, bank runs are more important than moral hazard.

23.3.2 Concluding thoughts

Delinquency soared in 2008 and 2009, and had a real cost: foreclosures. Post-2008, a lot of literature is focused on why the crisis happened. Until recently, there was no data on what happened to the 6m households that went bust.

In a new study by Stanford economist Rebecca Diamond using data from Chicago shows that families that went through foreclosure had costs in addition to financial costs. Diamond looks at what happens to the different costs over different years (dispersed to the families and banks).

24 Section 8

Problem set 4 is due today at 5 PM. Reminder that topics for the policy memo are due tomorrow. Today, we discuss the Becker crime model, the Gordon growth model, and zoning

24.1 Becker crime model

Gary M. Becker is a Chicago school economist, influential in the 1960s. He is credited with broadening the types of things economists do, focusing on topics from markets for goods, stock markets, and trade to social topics like marriage, fertility, etc. He was a pioneer in using the tools of economics to different topics, where people are not motivated by money.

In the Becker model, we have some key assumptions:

1. People derive value from committing crime. We can convert this to dollars.
2. There is heterogeneity in peoples' value of crime. Heterogeneity can come from need or from some perception of getting caught.

   Note. There are studies that show that there is a link between schooling and crime.

3. There is also a social cost to crime, that we can also convert to dollars.

Example 24.1. We consider 100 people who are all considering committing a crime (ordered 1 to 100). The first person will have a value of crime of 100 USD, the second person has a value of 99 USD, and the last person has a value of crime of 1 USD. We can make a plot of this *demand curve*. This is a linear relationship.

Suppose that if people get caught, they will pay a 100 USD fine. If you do not get caught, nothing happens to you. Getting caught is probabilistic, where the probability p of getting caught depends on investment into police and law enforcement or social work, for example.

Suppose a city spends 100 USD for each percent of a criminal being caught. E.g. 1000 USD investment leads to 10% of being caught.

We can consider the **private optimality condition**. In this case, each criminal considers their expected value of commiting a crime. Suppose a person has value of crime v, probability p of getting caught, a fine c. Then a person will commit a crime if

$$v - pc > 0. \tag{71}$$

There is also an **social optimality condition**. In this case, we still weigh the benefit from *stopping the crime* relative to the *cost* of stopping the crime. Let v_c denote the value of crime for the criminal, v_i denote the value of the item, and I be the investment by the city to increase p. Then social optimality prescribes that we stop criminal c when

$$v_i - v_c = I \tag{72}$$

is satisfied.

Note. We can make some modifications, consider if criminals can get their value today but are caught in the future. Suppose these future values are discounted by some discount factor $\delta \in [0, 1]$. Then the condition is

$$v - \sum_{i=0}^{\infty} \delta^i p^i c > 0. \tag{73}$$

In this case, we need to spend more money to disincentivize criminals from committing a crime today.

We note some general properties:

- Increasing the fine increases the coverage and disincentivizes crime. In theory, the optimal fine for society is infinite.

24.2 Gordon growth model

The key assumption in finance (and a lot of economics) is the **no arbitrage condition**. We will use this same idea for the Gordon growth model for houses.

Assume that homeowners can either sell a house today for a price $P(t)$ or sell it next year. In this time, homeowners can rent the house and collect rent $R(t)$. Here, we assume that rent is paid upfront, immediately. Next year, we collect $R(t) + PV$ where PV is the present value. We note that

$$PV(1+r) = P(t+1) \implies PV = \frac{P(t+1)}{1+r} \tag{74}$$

The present value increases over time with interest rate r to yield $P(t+1)$, the value next year. The no arbitrage enforces

$$P(t) = R(t) + \frac{P(t+1)}{1+r}. \tag{75}$$

This applies for all years. More generally,

$$P(t+i) = R(t+i) + \frac{P(t+i+2)}{1+r} \qquad \forall i. \tag{76}$$

We can do some algebra and substitute all equations into Eq. 75 and obtain

$$P(t) = \sum_{i=0}^{\infty} \frac{1}{(1+r)^i} R(t+i). \tag{77}$$

We assume $R(t+i) = (1+g)R(t+i-1)$, that is, $1+g > 1$ is the compounding growth, and obtain

$$\boxed{P(t) = R(t) \sum_{i=0}^{\infty} \left(\frac{1+g}{1+r}\right)^i = \frac{1+r}{r-g} R(t)} \tag{78}$$

assuming that $g < 1 + r$. This is the Gordon growth equation.

Example 24.2. Suppose $r = 1.005, R(t) = 21600, g = 0.012$. We can calculate prices and obtain $P(t) = 529000$ USD per house, which is close to what they are today.

Note. There are two views in the housing bubble. Recall $0 < g < r$. The **extrapolation** view is that $g \to r$ which corresponds with a meteoric rise in price. The **credit market view** is that $g \leftarrow r$ which corresponds with an exponential decay in price.

25 April 4th, 2023

Today, we discuss housing affordability.

25.1 Housing affordability

Housing affordability is often raised as a major policy concern especially in high-cost markets.

Glaeser and Gyourko (2008) identify two affordability problems:

- Poor households with insufficient incomes to afford housing even if inexpensively provided. Problem best addressed by income transfers or housing vouchers.
- Metropolitan housing markets where housing prices and rents have soared making housing unaffordable to middle class households.

  Housing prices increased in markets where new supply restricted by land use regulations (prices significantly higher than construction costs). Local governments are responding to local voter preferences to maintain communities and property values.

Quigley and Raphael (2004) argue that economists are uncomfortable with much of the affordability rhetoric. Rhetoric jumbles a number of disparate issues: distribution of rents, incomes, housing quality, supply of new and rehabbed housing, household choices about how much housing to consume relative to other goods.

25.1.1 Measuring housing affordability

Consumer Price Index (CPI) rent indices show trends for Boston, Chicago, Dallas, and Los Angeles. See slides.

Another measure of affordability is the mean rent to income ratio. We see that poorer people pay a higher proportion of their rent on income (close to 0.8-1). People often talk about the 30% rule for affordability.

25.1.2 Two eras of rental housing

DiPasquale and Murray (2017) divide rental housing into two periods:

- **1940 to 1960.** Real income of renters rose 110%. Relative price of rental housing services dropped 33% (1935 to 1950). Dramatic increase (from 43.6% to 55%) in homeownership rate from 1940 to 1950 and 6.9% increase from 1950 to 1960.

  Higher incomes and lower price of rental housing led to increased housing consumption in this period.
- **1970 to 2010.** They examine rental markets in 18 metropolitan markets over the time span. They find that real incomes of renters (on average) fell 13.8%. Relative price of rental housing (on average) increase 28.7%.

  Expect that with falling incomes and rising prices, housing consumption would decline over the period. Surprisingly, they find rental housing consumption increases (on average) 21.4% over the period.

Note (Implications for affordable housing policy)**.** DiPasquale and Murray (2017) could not explain quality changes with standard demand and supply factors, suggesting a change in preferences.

There is also variation in what people may value. People may tolerate spending more than 30% on housing in exchange for better amenities and benefits.

25.2 Federal housing policy

There are federal subsidies for homeownership:

- Mortgage interest and property tax deductions.
- Capital gains tax exclusions for sale of primary residence.
- Mortgage subsidies through support of GSEs.

Prior to Tax Cut and Jobs Act of 2017, CBO estimated that the mortgage interest and property tax deductions and the capital gains exclusion cost federal government 130b USD. The 2017 law raised the standard deduction and capped the deduction for state and local income and property taxes.

Tax benefits for homeownership are an entitlement program. Any homeowner with deductions in excess of the standard deduction can itemize on their tax return and take the deductions. Tax benefits increase with income and value of home.

25.2.1 Federal assistance to low-income renters

Housing assistance **not** entitlement. only 25% of eligible households receive assistance. 57b USD assistance to low-income renters allocated to

- **Housing Choice Voucher (HCV) program.** 25b USD in 2021. Provides vouchers recipients use to help pay for housing they choose in the private market.
- **Project-based rental assistance (PBRA).** 14b USD in 2021. Provides for federally contracted and subsidized rent in designated buildings that are privately owned and operated.
- **Public housing.** 4b USD in 2021. Provides for federally subsidized rent in buildings that are publicly owned and operated.
- **Other federal housing programs.** 33b USD in 2021. Elderly, disabled, rural renters.

Federal assistance also in the form of Emergency Rental Assistance Program (33b USD) which was a short-term response to Covid-19 pandemic; and Low-Income Housing Tax Credit (LIHTC) (8b USD per year), which provides tax credits to equity investors in low-income housing.

Note. Federal spending on housing assistance sharply increased due to the Emergency Rental Assistance program established in response to Covid-19. See slides.

25.2.2 Demand subsidy: Housing choice voucher

The voucher provided is difference between the fair market rent and 30% of recipient's income. Vouchers provide recipients with flexibility to choose location and housing that meets their needs.

Vouchers are less expensive than providing housing units. Scarce subsidy dollars can serve more households with vouchers than units through a supply-side program.

Local housing authorities inspect units to ensure that unit meets voucher requirements (bedroom size, outlets, living room size, etc.). Landlords are **not** required to accept housing vouchers.

Note. We can observe the effect of housing vouchers on the DiPasquale-Wheaton model. Shifts demand curve up.

25.2.3 Rent control: Local government option to address affordability

Rent control is making a comeback as a result of rising rents. Rent control laws exist in New York, New Jersey, California, Oregon, Maryland, and Washington D.C.

Diamond et al. (2018) estimated the impact of the change in rent control in San Francisco from a ballot initiative imposing rent control on small multi-family units built before 1980. They found that

- Those in rent-controlled units were 19% less likely to move 5 to 10 years after law was changed.
- Owners of rent-controlled buildings were 8% more likely to convert buildings to condos or replace existing structures with new construction which were exempt from control.
- Rent control led to 15% decline in the number of renters living in treated buildings and a 25% reduction in the number of renters living in rent-controlled units, relative to 1994 levels.
- While tenants in rent-controlled units benefit, policy fueled gentrification and decreased rental supply.

  Note. Rental supply comes from new construction, existing stock, and conversions of existing stock.

25.2.4 Filtering as a source of affordable housing

Rosenthal (2014) used American Housing Survey panel data on housing units in 1985-2011 to estimate a "repeat income" model. They track the change in income of residents each time the unit turns over. Results show that

- Rents decline 0.35% per year; home prices decline by 0.84% per year, Thus, a 50 year-old rental unit rents for 83.9% of a new unit while a 50 year-old owner-occupied unit sells for 65.6% of a new home.
- As a housing unit ages, tenant income in a rental unit declines by 2.5% per year; owner income declines by 0.5% for buyers. Thus, a new tenant in a 50 year-old rental unit would have an income that is 30% of a new tenant in a new rental unit. The rate of filtering is slower in high-cost areas.
- Filtering provides a long-term source of affordable housing with the caveat that filtering process is considerably slower in places with high housing prices and rents.

25.2.5 Supply subsidy: Low-income Housing Tax Credit (LIHTC)

LIHTCs are allocated to states based on population. Tax credits provided to developers in exchange for equity in low-income housing production or rehabilitation. Tax credits can be sold to investors through syndication.

In exchange for credits, at least 40% of units must be rented to households making 60% of area median income or 20% rented to households making 50% of area median income. Maximum rent is 30% of area median income.

Eirkson and Rosenthal (2010) suggest that LIHTC units largely crowd out unsubsidized construction. Murray (1999) suggests that subsidized housing serving very low-income households such as public housing add units to the rental stock while subsidized units serving more moderate-income households crowd out private construction.

Note (LIHTC development costs)**.** Over time, the number of LIHTC units produced has declined while the amount of tax credit dollars have increased. Costs of some projects have skyrocketed. 1950 Misson Street in San Francisco cost 600000 USD per unit; Estrella Vista in Emeryville, California cost 700000 USD per unit.

Data on costs at this point are largely anecdotal. Costs increase because of regulations and lengthy permitting processes, design and amenities, little oversight of LIHTC.

Note. In the construction sector, recent work shows surprising decline in productivity in construction sector. Little innovation in housing production due to modular construction, building materials and systems, climate resilience.

25.3 Housing policy in different market conditions

Consider three types of urban housing markets:

- Population declining, housing supply larger than demand, housing inexpensive (Rust Belt).
- Population is growing, housing supply growing, housing is not expensive (Sun Belt).

- Housing demand is growing at a much faster rate than supply, housing is very expensive (cities on both coasts).

Allocating scare subsidy dollars on the basis of population rather than market conditions can result in bad policy decisions such as building new housing in markets with excess supply.

Note. Houses historically the largest single asset of most homeowners and a major source of wealth accumulation over time in most cases. The crash in house prices and loss of jobs in Great Recession resulted in 7.8m foreclosures from 2007 to 2016; in 2017, 4.5m households with mortgages greater than home value.

Collinson et al. estimates that over m evictions from rental housing are filed annually in the United States.

25.3.1 Concluding thoughts

Rents, incomes, and housing quality are important factors in determining affordability. What is a reasonable minimum quality of housing?

Zoning and other land-use regulations including the length of the permitting process contribute to the high cost of housing including the development costs for affordable housing. Standards and the unit inspection process imposed by housing authorities can limit the units available to voucher recipients.

Tax expenditures receive far less scrutiny than direct subsidy programs even though both are taxpayer dollars. More research is required by the construction sector to increase productivity and innovation.

26 April 6th, 2023

Today, we discuss slums, property rights, and neighborhood change.

The primary resources for this lecture are Marx, Stoker, Suri "The Economics of Slums"; Janice Perlman *Favela*, Eric Field's "Entitled to Work: Urban Property Rights and Labor Supply in Peru"; Glaeser, Ponzetto, Shleifer "Securing Property Rights", Ashraf, Delfino, Glaeser "Trust, Institutions and Female Entrepreneurship."

26.1 Slum growth

There are some patterns in urban slum growth we can see from different countries. We see that there is almost no correlation between percentage slum growth and increase in GDP per capita or increase in total urban population.

26.1.1 Canudos War and the first favela

Antonio Conselheiro was a wanderer who traveled around Brazil's poor northeast region and attracts followers. He has 8000 living at Canudos.

Local mayor appealed to the government "hysterically" for help; 30 men are sent and they are killed by supporters of Conselheiro. Canudos settlement grows to 30000 people and government sends 557, they are all defeated.

Finally, government sends 3000 men with howitzers to blast away at the settlement and they succeed, perhaps killing 15000. Government did not pay the soldiers quickly so they settle in Rio, naming their settlement Morro de Favela.

Over time (three generations), living standards improved and most residents saw impressive gains in housing infrastructure, electro-domestic consumer items, education, and occupation.

Note. In Brazil, we see that initial city premium grew as a function of the log of 2002 population in each microregion. We also find that the initial city premium grows with exposure of low-skilled to high-skilled within company at microregion level.

The demons of density in slums and favelas are the following:

- **Contagious disease.** Progressive's primary worry.
- **Crime and violence.** Latin America, the United States, and Africa.
- **Long commuting distances.** Often over 1 hour commuting time.
- **Uncertain electricity and other services.**

Note. We find that public goods and amenities across Indian slums varies, but generally, there is poor latrine type, and often no garbage collection.

We also find that violence levels are equal across generation and locations, with the greatest number of crimes comprised of robbery and mugging.

26.2 Property ownership

Typically, slums and favelas were started by squatters on either public or private land. Thus, property rights are poorly defined in these areas. Renting is also a disaster because governments cannot make renters pay.

Note. Economists like property rights because they are incentives for investment, they allow for efficient goods reallocation, they allow for the ability to use property as collateral for businesses (De Soto), useful for imposing obligations on owners, saving self-protection resources (rent-seeking).

There is also widespread interest in regularizing property rights.

26.2.1 The incentives model

This is a model that tells you how much to invest in your building. Assume that benefit for the first dollar invested is 5 USD. The benefit drops by 0.001 USD every 1 USD of investment. After 1000 USD of investment, benefit of the next dollar invested is 4 USD.

Strong (weak) property rights keep returns to investments positive (negative).

Note (Property rights and reallocation)**.** Reallocation with property rights are important. Slums remain in some of the most central urban areas in countries with poor property rights.

Note (Hernando de Soto)**.** Soto finds that the urban poor are sitting on land that is worth a fair amount. This combines with some studies showing the returns to capital among the world's poor are high. This suggests that if poor could take out mortgages on their property, they could become rich; the standard lending system does not do well among the poor and constitutional constraints make lending difficult.

Professor Glaeser is quite skeptical.

26.2.2 Homeownership and urban efficiency

In 1890, homeownership rate in New York City was 6%, and tenements were often quite close to ports, factories, stockyards, and all sorts of pleasant work environments.

In 2011, the homeownership rate in urban India 69% (95% in rural India); 76% in Rio de Janeiro.

Across countries, there is a -0.45 correlation between income and homeownership (Fisher and Jaffe); within countries, the rich own more.

There is huge spatial mismatch at the individual level as measured by 1 hr+ commute times in many developing world cities. Seeming mismatch in the overall location of slums (may be too centralized) and employment centers (may be too decentralized). Mismatch between structure and location: too little density in many centralized locations.

26.2.3 Property rights and structure type

Weak property rights include use, restrict others from entry; strong property rights include sale, rental, and mortgaging rights.

Allowing strong property rights (i.e. alienation) can dismantle weak property rights through a forced sale.

There are two optimal structures:

1. Small self-built shanties.
2. Larger tenements.

Note. There is a complementary structure between type and property rights type. Weak is fine for structure 1 but not structure 2.

Large apartment buildings require complex contracts for land assembly, and laws making rentals (or even harder condominiums) functional.

26.2.4 Simple model of legal regime choice

Property rights defends only the use of current residents and sales to similar people (not to large companies); sale to large companies require larger administrative costs, some abuse risk from forced sales.

Property rights allow the sale to large companies and the production of rental properties. There are much greater administrative costs; much greater risks from forced sales, especially if local governments are going to assist in land assembly.

26.2.5 Trust, cities, gender and the law

Mass urbanization is proceeding quickly and in places with limited rule of law and weak states. The benefits of urban interaction are limited by the ability to work collaboratively and trust one another. Rule of law and urbanization are complements (Hammurabi).

Women disproportionately at risk from male expropriation. Threat of violence looms over inter-gender bargaining. Courts may also be biased against women: O-Ring theory.

Consequently, the benefits of cities can be lower for women.

27 Section 9

There are TeXed section notes in the section slides folder on Canvas.

27.1 Mortgages

Recall that a mortgage is a prolonged loan, where a lender gives the borrower a loan, and the borrower pays back the lender over time. In a mortgage, if the borrower fails to fulfill payments, the lender has the option of taking control of the home.

In last section, we argued that any mortgage as a present value, and a stream of payments in the future, where in the future, the future payments and the present value are equal (with interest) in equilibrium. Recall

$$P(t) = \frac{1+r}{r-g} R(t). \tag{79}$$

An annual, interest rate r_a can be converted to a monthly interest rate r_m via

$$(1+r_m)^{12} = 1 + r_a. \tag{80}$$

A good approximation is simply dividing r_a by 12 for small r_a, that is, $r_a/12 \approx r_m$.

We can find the monthly rent each month (for 360 months) for a house worth 500000 USD (for example). Taking into account for interest, let x be the number of dollars repaid in month 100. Then the proportion of 500000 USD (call this P_{100}) at month 100 has compounded into

$$P_{100} \times (1+r_m)^{100} = x \implies P_{100} = \frac{x}{(1+r_m)^{100}} \approx \frac{x}{1.501}. \tag{81}$$

Because we pay x dollars each month, we can calculate how much each of the x dollars in the next 360 months corresponds to the present (they should add up to 500000 USD):

$$500000 \text{ USD} = \sum_{k=0}^{360} \frac{x}{(1+r_m)^k} = x \frac{1 - \left(\frac{1}{1+r_m}\right)^n}{r_m} \tag{82}$$

where $n = 360$ is the total number of months that we make payments.

This is a case of the **annuity formula**, with general form

$$P = x \frac{1 - \left(\frac{1}{1+i}\right)^n}{i} \tag{83}$$

where n the duration, i the **monthly** interest rate, and x the **monthly** payment. We can use this annuity formula to calculate the monthly payment given the price of a house.

27.2 Momentum and mean reversion

In lecture 17, there is an equation that says housing prices have short-term momentum and long-term mean reversion:

$$P(t+1) - P(t) = \alpha \left[P(t) - P(t-1)\right] + \beta \left[P(t-1) - P(t-2)\right] + \varepsilon \tag{84}$$

There is short-term momentum in the sense that, if price fluctuates upward recently, the price today is likely to continue going up, which translates into $\alpha > 0$.

There is long-term mean reversion in the sense that, if price fluctuates upward in the distant past, the price today is likely to drop to compensate, which translates to $\beta < 0$.

28 April 11th, 2023

Today, we discuss race and segregation in the American city.

28.1 Race and segregation

Slavery in cities is widely studied by Richard Wade (1964) and Claudia Goldin (1976). 5-10% of the slave population is urban before 1850 and declines over the 1850s.

Wade's view is that slavery is not particularly compatible with urbanization because of ease of escape, and difficulty of monitoring urban occupations. Goldin's more empirically-grounded view is that the returns to rural labor were so high that urban slaves were moved to the cotton plantations.

Note (Frederick Douglass)**.** Douglass born a slave in eastern Maryland, earns favor of Lucretia Auld and is chosen to be boyhood companion of rich white boy. Sent to Baltimore to learn how to read. As teenager, tries teaching Sunday school. Owners try to break him and fail; returns to Baltimore instead of sending him south.

Douglass meets Anna Murray and runs away north via train and boat disguised as a sailor. Eventually settles in D.C.

Note (Northern cities before the Great Migration)**.** Many large urban cities experienced booms after the Great Migration. For example, Chicago grew from 958 in 1860 to 30000 in 1900 (1.8% of total population). By 1920, Chicago had 109k people.

Note (W.E.B. DuBois)**.** Born in 1868 to long-standing family tree. Father deserted the family when he was 2, mother could return to Great Barrington, where she had property. DuBois seems to have been treated well. Attended an integrated church, raising money to send him to Fisk in Nashville. He graduates and gets another B.A. at Harvard (under William James). Studies under Schmoller in Berlin and returns to get Ph.D. from Harvard in 1898.

28.1.1 Measuring segregation

There are different measures of segregation. We have the following relationships:

$$\text{Dissimilarity} = \frac{1}{2}\sum_i \left|\frac{g_i}{g} - \frac{\bar{g}_i}{\bar{g}}\right|, \qquad \text{Isolation} = \sum_i \frac{g_i}{g}\frac{g_i}{t_i}, \qquad \text{Isolation (corrected)} = \sum_i \frac{g_i}{g}\frac{g_i}{t_i} - \frac{g}{t} \tag{85}$$

where $g(\bar{g})$ is the total population of the minority (majority), $g_i(\bar{g}_i)$ is the population of the minority (majority) group in city/neighborhood i, t_i is the total population of city/neighborhood i, t is the total population across cities/neighborhoods.

28.1.2 Theories of segregation

There are three theories of segregation:

- **Decentralized racism.** Whites are willing to pay more to live with other whites (Schelling and Tipping models).
- **Centralized racism.** Whites want to live with other whites (maybe blacks do too), and they impose hard legal barriers to enforce racial exclusion.

  Example 28.1 (Centralized racism in the north)**.** Illegal violence in Chicago, Bombing Houses, etc. Buying up American-American property in white neighborhoods (e.g. Hyde Park Improvement Protective Club). Restrictive zoning by race (and overall). Jim Crow rules at many facilities. Restrictive covenants (private contracts that prevent the sale of properties to African-Americans).

- **Ports of entry.** Minorities prefer living with other minorities to share local public goods, local private goods, safety, and so forth.

There are five legal cases that shaped America's cities.

- **Plessy v. Ferguson (1896).** Allowed segregation of public facilities.
- **Buchanan v. Warley (1917).** Stopped racially restrictive zoning.
- **Euclid v. Ambler (1926).** Allowed non-racial zoning as apart of town's police power.
- **Shelly v. Kraemer (1948).** Prevented using the power of the state to enforce racially restrictive covenants.
- **Brown v. Board of Education of Topeka (1954).** Effectively reversed Plessy.

28.1.3 Rise and fall of racial zoning

Baltimore (1910) moves first, incorporating racial zoning. It then spreads to Richmond (1911), Atlanta (1913), and Louisville (1915). Codes upheld by southern courts.

Buchanan v. Warley (1917) in Supreme Court. Buchanan (white) sells to Warley (black) under a set-up condition.

28.1.4 Racial convenants

Covenants built into deeds to restruct the uses of property, for example, building materials in planned communities.

In the 1920s, racial covenants became widespread forbidding the resale of a property to members of different minorities (e.g. Jews, Asians).

Shelley v. Kraemer (1948) in St. Louis held that "restrictive agreements, standing alone, cannot be regarded as violative of any rights guaranteed to petitioners by the Fourteenth Amendment." Covenants are legal (still are) but cannot be enforced by state power.

28.1.5 Fair housing acts and the end of the segregated century

New York City passes Fair Housing Act (Sharkey-Brown-Isaacs Act) in 1957, bans discrimination in building with over 10 homes. The New York City political alliance joins AJC, NAACP, and ACLU.

Stuyvesant Town (built by Met Life in 1940s) was a rallying cry and its density brought together many opponents of segregated housing. Residential discrimination not banned by the Civil Rights Act in 1964.

Takes until 1968 Fair Housing Act for discrimination in housing to be banned within the United States, more or less ending centralized racism.

Note (Political economy of hatred)**.** Group-level hatred is always and everywhere formed by stories of past and future atrocities. Typically, these stories need repetition more than truth.

Right-wing politicians in the South pushed race-hatred in the 1890s. Right-wing politicians in 19th century Europe gave us political anti-Semitism (Lueger, Schonerer, Hitler). Anti-Americanism in parts of the world during the 1990s and 2000s.

29 April 13th, 2023

Today, we discuss municipal government.

29.0.1 Discrimination in housing market redux

Discrimination in housing market banned in United States with the passage of the Fair Housing Act in 1968 in the following ways:

- **Search.** Fair Housing Audits send pair of homebuyers (one white, one minority) with the same income and other qualifications to search for housing. Compare results. Oh and Yinger (2015) find white households more often shown more houses than minority households in the 2012 national audit. Differences are smaller than in prior audots. Minority households more likely to be steered to minority neighborhoods.
- **Lending.** Popick (2022) shows 2-3% difference in denial rate between minority and white applicants after controls. Minority borrowers also pay approximately 6 basis points more in interest rates than similar white borrowers in conventional purchase lending.
- **Appraisal.** Homes in white neighborhoods owned by minority households appraised at lower values. Homes in minority neighborhoods appraised at lower value.

Note. ProPublica bought ads in the housing section on Facebook aimed at excluding minority applicants in 2016 and 2017.

29.1 Municipal government

Municipal governments play important role in public service delivery around the world. Power and responsibilities of local governments vary widely across and within countries.

Unitary government structures are characterized by centralization of power with central government. Subnational governments receive powers and responsibilities from national government. Powers can be changed by national government.

Federal government structures characterized by power sharing between national and subnational governments. In the United States, government functions not assigned to federal government nor prohibited to the states are reserved to the states in Constitution. Cities/municipalities derive their power and responsibilities from the states; cities are not in the Constitution.

Decentralization or devolution of some government responsibilities has become a popular goal in unitary governments in both developed and developing countries.

- Local governments can tailor government programs to more closely match the needs of local citizens (better resource allocation).
- Costs and benefits of government programs more directly understood by citizens leading to better policies.
- Citizens are more engaged in the democratic process; citizens may be more invested in their local communities.

Note. Smaller jurisdictions more responsive to local citizens; larger jurisdictions may have cost savings due to scale economies.

In China, subnational government (SNG) spending accounts for 85% of total spending but SNGs have very little control.

Education is the largest spending category for SNGs globally, followed by general public services which include administrative and tax functions of SNGs.

29.1.1 Fiscal federalism

Oates (1972) lays our economic underpinnings of fiscal federalism. Centralized governments are good for stability, distribution. Decentralizsed governments allow for local and specific public goods, increased innovation due to competition among local jurisdictions, and transparency of costs of public programs.

29.1.2 The United States

The U.S. Constitution grants powers to the federal government. States responsible for any functions and opowers not granted to the federal government and noy explicitly prohibited to the states in Constitution.

Cities are established by states to run services, raise own revenue, and govern themselves. Cities raise their own taxes, can issue debt, and use revenues to pay for the services they were set up to provide. City residents decide how much to raise and spend.

Note. Local government revenue totaled 1.6t USD in 2015; only 12 states permit local governments to levy taxes on income; 38 states permit local sales taxes.

Over half of local spending on education funded by transfers from state and federal governments.

Note. AMM model and others presented in class ignore the role of local jurisdictions. Local jurisdictions vary in the public goods and services provided and the tax rates charged to residents.

Tiebout (1956) argued that in metro areas with a large number of cities and towns, local jurisdictions compete with one another for residents. Households choose the local jurisdiction that offers the level of public goods and service at a tax price that matches preferences. If household is unhappy, they can vote with their feet and move to a jurisdiction that better matches their preferences.

Tibeour assumes the following:

- Large number of jurisdictions with different combinations of public goods/services and tax prices.
- Mobility. Moving is costless.
- All households have complete information about choices.
- No scale economies.
- Local jurisdictions are funded by head taxes.

Town i has N_i residents and provides G_i in public goods, tax T_i is determined by

$$T_i \equiv \frac{G_i}{N_i}. \tag{86}$$

Property taxes are the primarly locally raised revenue source:

$$t = \frac{s}{P}(G - A - N) \tag{87}$$

where t is the town residential property tax rate, G the total town expenditures per household, A the state aid per household, N the non-property tax revenue per household, P the average market value of houses in the town and s the share of property value that is residential.

Note. AMM model shows that price of housing varies across locations with commuting costs. Also shows spatial separation between high income and low-income households.

Now we can consider how households select a town among a continuum of towns. In effect, town replaces a location's commuting cost as a determinant of price.

We assume all houses are uniform, and there are three types of household types: low-income L, medium-income M, and high-income H. Town selection depends on value household places on public services RG and costs the household faces for the public services tP. Then

$$P_j = \frac{R_j G}{i + t} \tag{88}$$

where $j \in \{L, M, H\}$ where R_j is the willingness to pay for town services by each household of each income level. There is an income sorting if $R_L < R_M < R_H$.

We now consider the development of vacant land. Assume houses are identical and cost C to build. p_j is the price of land that makes each household type indifferences across towns with the different service levels; q_j is the lot size demanded by each household type. We have

$$p_j \equiv \frac{P_j - C}{q_j} = \frac{R_j G}{q_j(i+t)} - \frac{C}{q_j} \tag{89}$$

where $j \in \{L, M, H\}$. It is not clear that high-income households will offer more per acre of land than lower-income households. If low-income households live on much smaller lots, they may be willing to pay more per acre. Incentive for high-income households to zone minimum lot size, $q_L = q_H$.

Tibeout predicts that the costs and benefits associated with public services will be capitalized into property values. Empirical studies have estimated the impacts of public services and local property taxes on house prices. Results can be biased due to unobserved characteristics. Black (1999).

Rosen (1982) studied tax rates and house prices in 60 municipalities in the San Francisco metropolitan area 6 months before and 6 months after Proposition 13.

Note. Proposition 13 limited the tax rate on property to 1% of full market value; limited the increase in taxes to 2% per year.

Rosen compared towns with much higher tax rates before implementation of Proposition 13 to towns with lower rates where the impact would be small. Results suggest that a 1 USD reduction in property taxes increased house prices by 7 USD which implies close to full capitalization.

Black (1999) isolated the impact of elementary school test scores on house values by looking at houses on the boundaries of attendance districts in the same school district therefore holding tax rates and other jurisdiction variables constant.

With this narrow geographic definition, coefficient on test scores implies that a 5% increase in test scores increased house prices by 2.1% (3948 USD).

Note. Evidence from both Rosen and Black suggest capitalization of both taxes and public service into house prices.

29.1.3 Property tax classification

28 states have passed legislation that allows cities to tax commercial property at a higher rate than residential property.

In Boston, tax commercial property at a rate 2.4 times that of residential property.

Note (Detroit fiscal problems)**.** In 2014, Detroit emerged from bankruptcy with a plan to cut 7b USD from the city's 18b USD in debt. In 2016, average homestead rate was 34.55 mills and the average homestead rate was 52.95.

Property tax delinquency rate is 54%. Higher tax rates led to falling property values.

Detroit has a city income tax: 2.4% on residents, 1.2% on non-residents who work in the city, 2% on business income. Tax environment provides incentive for residents and businesses to move outside the city. Shrinking tax base results in poor quality services.

30 [TODO] Section 10

31 April 18th, 2023

Today, we discuss the changing roles of office and retail space in cities.

31.1 Commercial real estate

Commercial real estate includes office, retail, industrial, hotels, restaurants. Focus today will be on office, retail, and industrial due to the major disruptions in these markets due to work from home, e-commerce replacing bricks and mortar retail, and distribution centers.

Note (Variation in locations)**.** In Chicago, we find that office buildings are centralized near City Hall and industrial buildings are scattered across the city.

Note (Space demand by economic sector (NAICS))**.** We note that the industrial sector has 958 ft^2 per worker, office is 350 ft^2 per worker.

31.2 Office market

Office locations are traditionally in high demand near the city center near other corporate buildings.

Unlike residential buildings, measuring rent in office buildings is difficulty: there is no information on the type of space, terms of lease, and bargaining. There is no information on types of spaces.

Note. People have done hedonic rent considerations on private signed lease data. Others look at the repeat leases indexes to make meaningful conclusions on measuring rent.

Components of leases are the following:

- **Lease term (length of lease).** These can be 3, 5, 10 years long; 5-year long leases are the most common.
- **Lease steps.** Specified changes in rent during the term.
- **Lease inflation index.** The lease specifies an index that will determine increases in rent due to inflation over the term.
- **Gross rent, net rent.** Gross rent lease, landlord pays utilities and property taxes. Net rent lease, tenant pays utilities and increases in property taxes.
- **Concessions.** Enticements usually offered by landlords such as free first month.

Note (Chicago office rent, distance, and height)**.** In Chicago, we note that office buildings are clustered as a function of distance to the central business district (CBD). There are gaps, but the functional form is an exponential decay. We also see that rent is exponential in the number of floors.

Note (Leasing and owning)**.** Owning is a reflection of corporate *prestige*. Building or buying a building is usually done to make a statement; the naming rights to a building could be purchased without owning the building.

Firm specific capital. Firms often decide to build a building if they have very specific uses; requires unique customization to meet business operations.

Purchase may more easily accommodate eventual plans for expansion.

31.2.1 Market accounting fundamentals

Let v_t be the vacancy rate at time t, C_t be the completions of new space at time t, S_t be the stock of space at time t, and Ab_t be the net absorption of space at time t. Absorption is the quantity of units that the market has absorbed over some time interval.

We define

$$S_{t-1} \equiv S_t - C_t, \qquad \text{Ab}_t \equiv (1 - v_t)S_t - (1 - v_{t-1})S_{t-1}. \tag{90}$$

31.2.2 Impact of remote work pre-Covid

Tension between the benefits of working together face to face and the cost savings and flexibility of home work option. Tension between costs savings from offshore workers and management and language issues.

Some companies reduced work at home programs realizing the benefits of face-to-face interactions among employees; increases in productivity and creativity (Yahoo, Bank of America, Aetna, IBM).

Flexibility of working at home increase employee satisfaction and retention, decreases commuting costs.

Note (U.S. Census Household Pulse Survey)**.** Between August and December 2020, 36.9% of households had at least one household member who did some or all of their typical in-person work from home.

Note. Professional, scientific, and computer-related occupations have the highest shares of postings that offer hybrid or fully-remote work.

31.2.3 Long-term impact of work-from-home post-Covid

Work-from-home will likely remain a factor in how work is done; tensions between the benefits of working face-to-face and flexibility and cost savings of home work option remain.

Vacancy and space available for sublease have increase (New York Times reports 17.2% vacancy rate in Manhattan). Reconfiguration of work space from individual offices to more shared, collaborative space and a smaller footprint.

Rents are beginning to adjust to reflect increase in vacancy (9.1% in asking rents in Manhattan and 17% increase in concessions offered). This may present opportunities for forms price out of some markets.

31.3 Industrial market

The growth in logistics and warehouses has been enormous; driven by many factors including e-commerce. Imports and export markets alone have grown 348% and 292%, respectively.

Note. Across Boston, Chicago, Dallas, and Los Angeles, industrial buildings are scattered across the cities, but are primarily along highways.

31.4 Retail market

Retail is a diverse market. We have our Newbury Streets and our retail centers (malls).

Note. Retail properties are scatter along highways and are roughly evenly distributed in Boston, Chicago, Los Angeles, Dallas.

Classical retail markets assume that retailers compete only over price, and consumers shop where full price including travel is the lowest.

There are also **retail agglomeration** effects: complementary and competitive shopping:

- **Complementary.** Shoppers more likely to come to one store if another is there; shoppers more likely to purchase at store if also purchase at other stores. Clusters save consumers multiple trips.
- **Comparative/competitive.** Shoppers are more likely to come to one store if the other is there; shoppers expect many stores selling similar items (lower prices desirable). Shoppers less likely to purchase at one store if also purchase at the other.

  The cluster attraction effect is greater than the cannibalization effect.

31.4.1 Retail rent

Rental payments are given by

$$\text{rental payments} = R + \max\{0, r(S - B)\} \tag{91}$$

where R is the flat rent per square foot, r is the percentage of sales to be made as a rental payment, S is sales per square foot, and B is the threshold sales per square foot.

Note. This percentage rent is efficient risk sharing. Fixed rent means that the tenant absorbs business risk; variable rent (% shares) shifts some business risk to landlord. With a fixed rent, landlord can lease space to the detriment of existing tenants and face no consequences until their leases renew; with percentage rent, landlord faces immediate loss in rental revenue if his actions in any way hurt the sales of existing tenants.

Virtual shopping provides more choice, better information on products for consumers, unlimited shopping potential, better information to producers for product design, savings in travel time and cost.

Store shopping provides opportunity to see, touch, feel, try on products; and may be quicker acquisition time depending on shipping time.

31.4.2 Impact of disruption in office and retail on cities

Disruption of e-commerce and work-from-home was apparent before Covid.

10b ft^2 of retail and 8000 mi^2 os land in use is being converted to medical clinics, more service-oriented uses, entertainment centers or stores in display centers. Urban retail spaces like Newbury Street or Harvard Square have become more service-oriented over time (hair and nail salons, restaurants, coffee shops, etc.)

Significant rent adjustments could provide opportunities for business previously price out of the market; vacant office space in central business districts may convert to other uses like life science and residential.

The challenges to city government include bringing back vibrancy, local street traffic; urban design that mixes residential and commercial uses; impacts on local property tax revenues and local transit systems as Covid subsidies end.

Note. Property tax is determined not by sales but by rent. Sales are too difficult to determine because transactions are not often.

32 April 20th, 2023

Today, we discuss the future of work and the future of the city.

We see that black mobility decreases with dissimilarity index. GDP per capita increases with population density; Density and metro area mobility is negatively correlated.

32.1 Carlo Ratti, Timur Abbisoav, Arianna Salazar Miranda, etc.

Work by Carlo Ratti, Timur Abbisaov, Arianna Salazar Miranda, and others conduct a study. They use monthly aggregate flows between neighborhoods (CBGs) and individual POIs. Based on mobile GPS tracking data from Safegraph. Covers 11b POI visits during 2019 across 417 cities.

They measure the percentage of trips to *basic amenities* from each home CBG that occur within a 15-minute walk from its centroid.

They show the following:

- Urban residents in the Northeast taking close to 32% of trips to basic amenities locally (within 15 min walk).
- Southern urban residents take 16% or fewer.
- For median urban CBG, only 12% of trips to basic amenities are taken locally.
- New York metro has the highest usage of walkable amenities at 42%.

Local access can explain about 80% of variation in local usage across urban areas.

The use of amenities within a 15 min walk from home generally falls with income. Income remains significant after controlling for car use and other demographic/environment characteristics.

32.1.1 Causal mechanisms

Following Martynov (2022) and Shertzer, Twinamb and Walsh (2019), use 1961 New York City Zoning Resolution in attempt to identify causual mechanisms behind local usage. First, show FAR regulations introduced in 1961 for commercial zoning districts had significant and lasting impacts on differences in local access to amenities across CBGs. They show **large effects of 15-minute access on local usage**.

For low-income CBGs, rising higher local usage associated with a significant increase in experienced segregation, For income above first quartile, no association between 15-minute usage and experienced income segregation.

32.1.2 Non-working demographics

Note. We observe a map showing the rate of non-working prime-aged men in 2015. WE see that there is the highest concentration in Appalachia and the South; also northern California. In 1980, there are much fewer locations where men are not working.

Prime-aged women tend to not work in higher percentages in the West and South.

The percentage of non-working prime-aged men is highly correlated with opioid consumption in 2015.

We find that non-working men have low life satisfaction; improvements in leisure (television, video games) may be linked to decreasing employment.

32.2 Changing regional landscape

Regional heterogeneity in the United States is not new. Joblessness is a new twist; if it involves market failures (Pigouvian externalities or Keynesian stuff), then this should lead us to look at regional policies again.

There are good reasons to think America is becoming less fluid geographically and more European.

There is decline in migration and geographic sclerosis. We also see skilled migration in the United States (college graduates).

Some additional changes:

- **Ganong and Shoag (2017).** Migration (especially less-skilled) is not directed towards high wage areas.
- **Glaeser et al. (2005); Moretti (2016).** Successful areas make it increasingly difficult to build low-cost housing, leading to spatial mismatch.
- **Moretti (2004).** Change in share with college degrees positively correlated with initial share of population with college degrees.
- **Berry and Glaeser (2006).** Income convergence across metropolitan areas or PUMAs has slowed or disappeared entirely.

We see that income convergence has declined (Berry and Glaeser 2006; Ganong and Shoag 2017); persistence of not working rates.

Geographic sclerosis may not be an excuse for revisiting place-based policies:

- Subsidizing declining places keeps people in dysfunctional local economies.

  Note. This is less important with lower migration rate.

- Subsidizing any place leads to capitalization in rents. The poor tenant who does not like contemporary art may well hurt by the Bilbao Guggenheim.

  Note. As people are less mobile, this may be less important.

- Some place-based policies can create pockets of high unemployment and low human capital.
- Infrastructure place-based policies can lead to monumental waste.

32.3 Urban rebirth: Economic considerations for reconstruction in Kharkiv and Ukraine

We see that per-capita GDP is positively correlated with the share of the population with bachelor's degrees.

Note. Zoom means more competition for global talent, not an end to face-to-face contact.

There are five interconnected strategies:

- Strengthening the universities and connecting them to talent. Research communities not university clusters.
- Using the physical city as a talent magnet. The vision of the master plan.
- Empowering entrepreneurship with one-stop permitting and regulatory reform.
- A Kharkiv that is green, both in operation and in innovations.
- Attracting external capital. Strengthening institutions that protect investors and perhaps getting the European Union to provide insurance for investors against future conflict.

Note. We end with the note that cities are resilient; Kharkiv will rebuild and thrive, stronger than it ever did before.

33 Section 11

Today's section is cancelled due to Peleg's health. See section notes for notes.

34 [TODO] April 25th, 2023

35 Section 12

Today is the final section, we do a final exam review. We note that there are section slides that give a comprehensive review and starting point for studying for the final exam.

35.1 Logistics

The final exam is on May 5th, 2023 at 2 PM EST. It will be three hours long. Some general advice: write something for every question. Partial credit is generous and will get credit for writing down assumptions, problem set-up, or anything else that will provide partial credit. T/F/U questions will be graded based on the quality of the explanation. There will also be short essay questions, in addition to two (2) analytic questions and true/false questions.

Note (AMM and Rosen-Roback models)**.** Two models that are important to remember are the **AMM model** and the **Rosen-Roback model**.

35.2 Entrepreneurial choice model

We did not go over this in class, but recall solving for the steady state of a skilled population share s:

$$s = p_s(s + (1 - s)sp_b). \tag{92}$$

Generally, a steady state is where the exit of skilled people is equal to the entry of skilled people.

Note. We will not be expected to derive anything or work with the functional form, just the general idea.

35.3 Becker crime model

In the Becker crime model, we have a bunch of people who are potential criminals, who all have different values of committing the crime. **An individual is indifferent about committing a crime whenever benefit b is equivalent to expectation of being caught (penalty c multiplied by probability of being caught p)**, or where

$$b = pc. \tag{93}$$

Society can increase penalties or increase probabilities to reduce crime.

Some important assumptions:

- Binary decision about whether to commit a crime, no variation in the types or intensity of crimes committed.
- No decisions about repeated offenses.
- Assumptions about social cost of detection versus penalty (about how costs are distributed and calculated).

Extending the model to account for these issues lead to additional predictions:

- Punish more when crime is more costly to deter more.
- Punish more when criminal is more likely to engage in recidivism.
- Punish more when behavior is more elastic or responsive.

35.3.1 Crime model and riots

In a riot, we think that probability of detection or arrest is decreasing in the number of participants. Both the benefit and expected penalty from crime are falling with number of criminals, which creates scope for multiplicity of equilibria.

Note. In lecture, on equilibrium results in no riot; one results in mid-sized riot (unstable); one results in a large riot.

35.4 Tipping model of spatial segregation

Willingness-to-pay (WTP) to live in an area falls in the share of the other group living in that area. Initially assume symmetric WTP of the two groups.

In initial graph, integrated equilibrium is unstable (any shift in blue/green share moves the area to a segregated equilibrium). Even when both groups would prefer some integration, discriminatory preferences in housing markets may still lead to social segregation.

Note (Theories of segregation)**.** There is **centralized segregation** (policy-based and enforced segregation), **decentralized segregation** (driven by preferences of individuals without the presence of legalized segregation), and **port of entry** (minorities prefer living with other minorities to share local public goods, local private goods, safety, and so forth).

35.5 Gordon growth model and property price capitalization

The assumption is that prices today are the sum of rents today and (discounted) prices tomorrow.

$$P(t) = R(t) + \frac{P(t+1)}{r}. \tag{94}$$

After iterating, we obtain

$$P(t) = R(t) + \frac{R(t+1)}{1+r} + \frac{R(t+2)}{(1+r)^2} + \cdots \implies P(t) = \sum_{i=0}^{\infty} \frac{R(t+i)}{(1+r)^i} \tag{95}$$

with a closed form given by

$$P(t) = R(t)\frac{1+r}{r-g} \tag{96}$$

where r is the interest rate and g is the rent growth rate for time t. We assume $r > g$. We note that we assume $R(t+1) = (1+g)R(t)$.

Note. Peleg would not spend time on optimal FAR.

35.6 Evaluating policies

In general, we want to think about the following when evaluating policies:

- **Maximizing total welfare.** Costs and benefits can be monetary, time, or even hedonic. Distinguish between policies that redistribute vs. generate additional aggregate welfare.
- **Market failures usually motivate government intervention.** Externalities suggest that optimal social welfare may differ from equilibrium welfare.

  An particular case of this is **public goods**. Public goods may not be provided privately due to free rider problem.

- **Behavioral responses matter.** Three examples:
  - **Fundamental law of traffic congestion.** Idea that when we add capacity, traffic tends to increase to compensate and does not change congestion.
  - **Paper and trees.**
  - **Migration in response to local green regulations.** One of the worst things that the United States does is that it limits construction in mild-temperature areas.
- **Politics and institutions can limit effective policy.** Political and institutional inefficiency due to corruption and bureaucracy.

35.6.1 Land use controls

Zoning is used to correct externality from congestion (cutting off air and light, pollution). First case of zoning is in New York City.

This can lead to under-provision of housing because most benefits of building additional housing are for people who do not yet live there. Usually, people who make the decision will not benefit; people who benefit tend not to live in these neighborhoods.

Another form of zoning is **fiscal zoning**, where localities impose measures like minimum lot sizes to attempt to attract residents who will be fiscal positives.

35.7 Housing policy

An example of where we should know the institutional setting. The U.S. provides 130b USD in subsidies to (primarily) homeowners, allow families to deduct interest rates on their houses (mortage interest rate deduction). The government also provides 51b USD in low-income support to renters which takes two forms: (1) housing vouchers, (2) low-income housing tax credit (LIHTC).

- **Demand subsidies (housing vouchers).** Allow flexible location choice. Increase rents, particularly when supply is inelastic (Diamond and McQuade, 2017).
- **Supply subsidies.** Potential positive externalities from increased house prices and lower crime rates in the low-income neighborhoods. Concerns that this might crowd out unsubsidized construction.

  LIHTC taps the private market to build private housing which the government pays for via tax credits.
- **Rent control.** Economists tend not to like rent control. Apartments may be converted to owner-occupied housing, or investment in the area may be reduced.

  This often generates spatial mismatch over time, between where people live and where they should be living. Discrepancies come of shifted income or changes in size of families.

Housing supply has an inelastic component and an elastic component. Supply may be inelastic because existing supply exceeds demands.

Note (Congestion tax)**.** We should be able to interpret congestion tax plots.

35.8 Place-based policies (PBP)

Standard economist intuition is that we should target people, not places. There are pros and cons to PBPs. Some advantages include:

- People are becoming less mobile and not moving to the best places. Regional incomes have stopped converging.

- Inelastic housing supply may contribute to this.
- Agglomeration externalities.
- Different elasticities should mean different policies.

Some disadvantages:

- Subsidizing declining places keeps people in dysfunctional local economies.
- Subsidizing any place leads to capitalization in rents.
- Enormous potential for waste (People Mover in Detroit).

Some policies include:

- **Attracting business and production subsidies.** This seems to be expensive to generate jobs this way. Government spends a lot of money to generate a few high-paying jobs.
- **Subsidizing employment.** Working has positive externalities, potentially especially in West Virginia, so we should subsidize (spatial bonus).

35.9 T/F/U practice

Autonomous vehicles will reduce congestion. Uncertain. While people will be able to commute faster, more people may use autonomous vehicles because these reduce the costs of driving. Don't want to incentivize people to move to WV, so cut back total bundle while subsidizing work (spatial tilt).

Competition between localities for an Amazon headquarters is a zero sum game. False/uncertain. Competition reveals willingness to pay and reveal which location can be most complementary/create greatest surplus when Amazon moves there. This ensures efficient location choice and is not zero-sum.

Sport stadiums help poor people by encouraging economic development. False/uncertain. Stadiums and teams employ often few people, who might not live locally. Local residents' expenditures at stadium are substitutes for other local spending.

America's low unemployment rate means that we do not have a joblessness problem. False. Unemployment numbers only capture people actively looking for work. Can still have joblessness problem in the form of people dropping out of labor force.

Capital cities are larger in democracies, because cities are good for democracy. False. Capital cities are larger in dictatorships than in established democracies, but they are also larger in unstable or new democracies.