Zoning: Externalities or Misallocation?*

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Abstract

We study how residential-commercial zoning affects the allocation of urban space. Using property-level data from Taipei and 34 U.S. metropolitan areas, we infer neighborhood-level zoning wedges from the allocation of residents, workers, and floor space. We find substantially greater dispersion in these wedges in U.S. cities than in Taipei, where mixed-use development is pervasive. The inferred wedges increase neighborhood specialization and reduce welfare. We then evaluate whether zoning is aligned with the neighborhood characteristics that would justify intervention. Although zoning is systematically related to comparative advantage, comparative advantage explains only a small fraction of the variation in zoning. The dominant effect of zoning in American cities is therefore not to promote efficient land use, but to increase the segregation of residential and commercial activity across neighborhoods.

Keywords: zoning, price wedges, externalities, resource misallocation, comparative advantages, quantitative spatial analysis

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1 Introduction

Residential-commercial zoning is one of the defining features of urban planning in the United States. Large areas of American cities are reserved primarily for housing, while commercial activity is concentrated in separate districts. Yet many successful cities operate with far weaker restrictions on the mixing of residential and commercial uses. In Taipei, mixed-use development is pervasive and zoning places relatively weak constraints on the allocation of space between residential and commercial activities. We exploit this institutional contrast to infer the effect of zoning on the allocation of residents, workers, and floor space across neighborhoods and to measure their consequences for urban land use.

Our analysis is guided by a model in which neighborhoods differ in productivity and residential amenities. In the absence of zoning, specialization is driven by comparative advantage. Neighborhoods with high productivity relative to amenities specialize in production, while neighborhoods with high amenities relative to productivity specialize in residence. Zoning creates wedges between residential and commercial uses that distort this allocation. We show how these wedges can be inferred from neighborhood-level data on residents, workers, and the allocation of floor space.

We combine property-level data on residential and commercial floor space in Taipei with comparable data for 34 large U.S. metropolitan areas. We begin by documenting a striking difference between Taipei and American cities. Neighborhoods in U.S. cities are substantially more specialized. Residential neighborhoods contain relatively little employment activity, while employment centers contain relatively few residents. In contrast, neighborhoods in Taipei are much more mixed.

We interpret this difference through the lens of the model. Rather than relying on legal zoning classifications, we infer the zoning wedge from the observed allocation of residents, workers, and floor space. We find that the dispersion of these wedges is substantially larger in U.S. cities than in Taipei. The inferred wedges are also economically important. Reducing their dispersion to the level observed in Taipei leads to substantially more mixed-use neighborhoods and higher welfare in the average American city.

The central question, however, is not whether zoning matters, but whether it improves the allocation of urban space. A common justification for zoning is that it corrects externalities generated by the interaction of residential and commercial activity. Under the traditional Euclidean view, zoning should separate land uses to mitigate congestion, noise, and pollution. Under the Jacobs (1961) view, zoning should encourage mixing because the interaction of residents and firms generates positive spillovers.

We evaluate these competing views by asking whether the zoning wedges we measure are systematically related to neighborhood comparative advantage. We find that the systematic component of zoning is more consistent with the Jacobs view than with the traditional Euclidean view: neighborhoods with a comparative advantage in production tend to receive more residential zoning, while neighborhoods with stronger residential amenities tend to receive more commercial zoning. Although this systematic component supports mixed-use development, it explains only a small fraction of observed zoning wedges. The much larger residual component dominates, so the overall effect of zoning in American cities is not to promote efficient land use, but to increase the segregation of residential and commercial activity across neighborhoods. This is the source of the apparent tension between our two main findings: zoning is not, on net, designed to segregate, yet its dominant effect is to do so anyway, because the large unexplained component of zoning swamps the modest mixing-oriented signal.

This paper contributes to the literature on land-use regulation and urban misallocation. A large empirical literature has documented how zoning restricts housing supply and raises housing prices; see Glaeser and Gyourko (2002), Glaeser et al. (2005), and Saiz (2010). A related literature has emphasized how these local constraints generate spatial misallocation and reduce aggregate output; see Herkenhoff et al. (2018) and Hsieh and Moretti (2019). However, this literature has focused primarily on building constraints, such as density limits, height restrictions, and minimum lot sizes, instead of constraints that regulate the allocation of land and space between residential and commercial activities.

Our paper is also related to the theoretical literature on the urban allocation of land to commercial vs. residential activities, including Fujita and Ogawa (1982) and Lucas and Rossi-Hansberg (2002) on equilibrium allocations, and Rossi-Hansberg (2004) on optimal allocations. In particular, Rossi-Hansberg (2004) analyzes how zoning can improve welfare by correcting externalities associated with urban land use. Relative to this literature, our contribution is mostly empirical. We measure the effect of actual zoning as a gap in the shadow price of commercial vs. residential space in a given neighborhood. We then evaluate whether these price gaps align with the neighborhood characteristics that would justify zoning intervention.

The specific quantitative framework we use builds on Allen et al. (2015) and Fajgelbaum and Gaubert (2020). More broadly, our paper relates to the quantitative spatial literature studying the economic consequences of zoning.[1] While this literature has largely mirrored the empirical literature to focus on building constraints, we focus on residential-commercial use restrictions, an area where related work remains relatively thin.

The closest work to ours is Allen et al. (2015), who study optimal zoning in a model featuring productivity and amenity spillovers and apply their framework to Chicago data. Also closely related are Martynov (2022) and Rollet (2025), who incorporate use constraints into quantitative spatial models. However, their primary focuses lie elsewhere: Rollet (2025) emphasizes the fixed costs of redevelopment in the American context and Martynov (2022) highlights how limits on floor area ratios interact with spillovers. Relative to these three studies, our innovation is to compare U.S. cities with Taipei, where mixed-use development is pervasive and residential-commercial zoning is substantially less restrictive. This comparison provides a benchmark for measuring the absolute magnitude of zoning distortions, rather than the effects of marginal changes to existing regulations.

The remainder of the paper proceeds as follows. Section 2 presents the model and its implications for the spatial allocation of space and activity. Section 3 describes the property- and neighborhood-level data for Taipei and U.S. cities, followed by discussions on zoning institutions in Taipei and on evidence supporting its treatment as effectively unzoned in Section 4. In Section 5, we document patterns of neighborhood specialization in American cities and estimate the dispersion in the marginal product of land across uses. Section 6 then uses these estimates to quantify the welfare costs of zoning. In Section 7, we extend the analysis to incorporate externalities and evaluate the effectiveness of zoning in addressing them. Section 8 concludes.

2 Effect of Zoning on Space and Labor Allocation

This section introduces residential and commercial zoning in a model of a city with heterogeneous neighborhoods. In the absence of zoning, neighborhood specialization is driven by comparative advantage in productivity relative to residential amenities. Zoning creates wedges between residential and commercial uses that distort this allocation. The goal is to characterize how comparative advantage and zoning jointly determine the allocation of residents, workers, and space across neighborhoods.

[1] See, for example, He (2024), Liao (2026), Peng (2023), Song (2025), and Veloso (2020).

2.1 Environment

The production technology in neighborhood i is

$$Y_i = \frac{A_i}{\alpha^\alpha (1-\alpha)^{1-\alpha}} L_{Ei}^\alpha H_{Ci}^{1-\alpha},$$

where H_{Ci} and L_{Ei} denote commercial space and effective labor, and A_i is the productivity at neighborhood i. Cost minimization implies that the relative demand for labor and commercial space is:

$$\frac{H_{Ci}}{L_{Ei}} = \frac{1-\alpha}{\alpha} \frac{w_i}{q_{Ci}}, \tag{1}$$

where w_i and q_{Ci} denote the local wage and the price of commercial space. Using this condition, and choosing the production output as the numéraire, the dual of the production technology is:

$$w_i^\alpha = \frac{A_i}{q_{Ci}^{1-\alpha}}. \tag{2}$$

There is a unit measure of workers living in the city, and each worker is endowed with one unit of time. The timing of the location choices is as follows. In the first stage, every worker chooses a neighborhood i to reside in. Labor income of a worker who lives in neighborhood i and works in neighborhood j is $w_j t_{ij} \mu_j$ where μ_j is the worker's idiosyncratic efficiency units from working in neighborhood j, and $t_{ij} \leq 1$ is the remaining time available for work after accounting for the commuting cost between i and j. In the second stage, each worker living in neighborhood i chooses a neighborhood j to work in by solving $\max_j w_j t_{ij} \mu_j$ with the realized draws of $\{\mu_j\}_j$. We assume μ_j's are drawn *i.i.d.* from a Fréchet distribution with shape parameter $\epsilon > 1$ and scaling parameter $\Gamma\left(\frac{\epsilon-1}{\epsilon}\right)^{-\epsilon}$ where $\Gamma(\cdot)$ is the gamma function. The expected income of a person living in i is

$$x_i \equiv W_i + r,$$

where $W_i \equiv \left(\sum_j (w_j\, t_{ij})^\epsilon\right)^{1/\epsilon}$. The first term denotes the expected wage income; the second term denotes property income.[2]

Worker utility is given by

$$U_i = B_i c_i^{1-\gamma} h_{Ri}^\gamma,$$

[2]Property income is given by $r \equiv \sum_i (H_{Ci} q_{Ci} + H_{Ri} q_{Ri})$. This formulation assumes property income is the same for all people regardless of where they live. Think about a mutual fund that owns all properties in the city, and all residents of the city own equal shares of the mutual fund.

where c_i is consumption of the numéraire good, h_{Ri} is residential space, and B_i is the amenity at neighborhood i. In equilibrium, $h_{Ri}L_{Ri} = H_{Ri}$, the total residential space in i. Utility maximization implies the following demand for residential space per resident:

$$\frac{H_{Ri}}{L_{Ri}} = \gamma \frac{x_i}{q_{Ri}}, \tag{3}$$

where q_{Ri} is the price of residential space. We assume workers are ex ante the same. As people are free to choose their residential locations, the expected indirect utility must be equalized across locations in equilibrium:

$$V_i = \frac{B_i x_i}{q_{Ri}^{\gamma}} = \bar{V}, \tag{4}$$

where $\bar{V}$ denotes average utility.[3]

We abstract away from other uses of space beyond residential and commercial, and take the total endowment of space H_i as given. In a laissez-faire equilibrium, the relative supply of floor spaces is increasing in the laissez-faire relative price $q_i \equiv q_{Ci}^{\text{free}}/q_{Ri}^{\text{free}}$, with a constant elasticity κ and a constant supply shifter $S^{1+\kappa}$:

$$\frac{H_{Ci}^{\text{supply}}}{H_{Ri}^{\text{supply}}} = S^{1+\kappa} q_i^{\kappa}. \tag{5}$$

This reduced-form supply curve can be interpreted as the aggregate outcome of heterogeneous parcels that differ in their suitability for residential and commercial use.[4]

We model zoning as a quantity restriction on the ratio of floor spaces: $H_{Ci}/H_{Ri} \in [\underline{\theta}_i, \bar{\theta}_i]$. When the equilibrium H_{Ci}/H_{Ri} falls within $[\underline{\theta}_i, \bar{\theta}_i]$, then the equilibrium price gap is simply the laissez-faire price q_i. However, when zoning binds, the floor space prices adjust such that the relative demand meets the zoning restriction. We denote the resulting price gap

[3]This assumption, together with the equal property income assumption, guarantees that market allocations are welfare maximizing in the absence of externalities; see Allen et al. (2015) and Fajgelbaum and Gaubert (2020).

[4]See Appendix B for a microfoundation. Note that in the extreme case where $\kappa \to \infty$, supply becomes perfectly elastic, and the two types of space become perfect substitutes, implying that q_i is a constant across neighborhoods, S^{-1}. Our formulation allows the two types of space to be imperfect substitutes, implying that q_i varies across neighborhoods.

between the price of commercial vs. residential space as:

$$\tau_i \, q_i \equiv \frac{q_{Ci}}{q_{Ri}},$$

where q_{Ci}/q_{Ri} is the shadow relative price of commercial space to residential space and τ_i is the additional price gap induced by zoning. Since the relationship between the price gap $\tau_i q_i$ and the relative quantity is one-to-one, $\tau_i > 1$ denotes pro-residential zoning and $\tau_i < 1$ is pro-commercial zoning.

The free mobility condition (4) implies that the local wage (2) can be rewritten as:

$$w_i^{\alpha} = \frac{A_i \bar{V}^{(1-\alpha)/\gamma}}{(\tau_i q_i)^{1-\alpha} \, (B_i x_i)^{(1-\alpha)/\gamma}}. \tag{6}$$

The local wage is increasing in local productivity A_i and decreasing in local amenities B_i and the extent of pro-residential zoning (higher τ_i).

2.2 *Equilibrium*

The key implication of the model is that, absent zoning, neighborhood specialization is determined by comparative advantage in production vs. residence. We now characterize how productivity, amenities, and zoning affect the distribution of employment, residents, and space across neighborhoods.

We start with the distribution of residential vs. commercial space. Combining the first-order conditions for production and consumption (1) and (3), we get:

$$\frac{H_{Ri}}{H_{Ci}} = \frac{\gamma \alpha}{1-\alpha} \frac{x_i}{w_i} (\tau_i \, q_i) \, \frac{L_{Ri}}{L_{Ei}}. \tag{7}$$

The left-hand side is the ratio of residential to commercial space. The terms on the right-hand side are the Cobb-Douglas parameters in production and utility (first term), the ratio of income to wages in the neighborhood (second term), the price gap between commercial and residential space (third term), and the ratio of residential population to (effective) employment of the neighborhood (fourth term).

Next, we solve for the distribution of employment. Workers' workplace choices in the second stage imply that the probability that a resident of k chooses to work in i is $\left(\frac{w_i \, t_{ki}}{W_k}\right)^{\epsilon}$.

The employment of location i (in efficiency units) is then:

$$L_{Ei} = w_i^{\epsilon-1} \sum_k \frac{t_{ki}^{\epsilon}}{W_k^{\epsilon-1}} L_{Rk}. \tag{8}$$

In the absence of commuting costs, the employment share is proportional to $w_i^{\epsilon-1}$ because (8) becomes

$$L_{Ei} = \frac{w_i^{\epsilon-1}}{\sum_k w_k^{\epsilon-1}} = \left(\frac{w_i}{W}\right)^{\epsilon-1}. \tag{9}$$

Referring back to the equation for the local wage (6), the employment share of the neighborhood is increasing in its comparative advantage in production relative to residential amenities and in the extent of pro-commercial zoning (lower τ_i), with elasticity $\frac{(1-\alpha)(\epsilon-1)}{\alpha}$.

Combining (3), (4), the resource constraints implied by (5),[5] and $\sum_i L_{Ri} = 1$, the residential share of a neighborhood L_{Ri} is equal to $\ell_{Ri}/\sum_k \ell_{Rk}$, where

$$\ell_{Ri} \equiv B_i^{1/\gamma} x_i^{(1-\gamma)/\gamma} H_i^{\frac{\kappa}{\kappa+1}} \left(S^{\frac{\kappa+1}{\kappa}} + (H_{Ci}/H_{Ri})^{\frac{\kappa+1}{\kappa}}\right)^{-\frac{\kappa}{\kappa+1}}. \tag{10}$$

In the absence of commuting cost, expected income x_i is the same in all neighborhoods and given by[6]

$$x_i = x = \frac{1}{\alpha(1-\gamma)} W. \tag{11}$$

Further assume that $\kappa \to \infty$ and $S = 1$. In this case, equations (6) to (11) imply:

$$\ell_{Ri} = \xi_1 B_i^{1/\gamma} H_i - \xi_2 \left(\frac{A_i}{B_i^{(1-\alpha)/\gamma} (\tau_i q_i)^{\alpha/\epsilon+(1-\alpha)}}\right)^{\epsilon/\alpha},$$

where ξ_1 and ξ_2 are positive.[7] The residential share of a neighborhood is increasing in

[5]The neighborhood-level resource constraint is $\left(\frac{H_{Ci}}{S_i}\right)^{1+\frac{1}{\kappa}} + H_{Ri}^{1+\frac{1}{\kappa}} = H_i$.

[6]This is obtained by noting that property income $r \equiv \sum_i (H_{Ci}q_{Ci} + H_{Ri}q_{Ri}) = \frac{1-\alpha}{\alpha}\sum_i w_i L_{Ei} + \gamma \sum_i x_i L_{Ri} = \left(\frac{1}{\alpha(1-\gamma)} - 1\right)\sum_i W_i L_{Ri}$. The first equality follows from the first-order conditions for firms (1) and workers (3). The second equality follows from (8).

[7]$\xi_1 \equiv \left(\frac{1}{\alpha(1-\gamma)} W\right)^{\frac{1-\gamma}{\gamma}}$ and $\xi_2 \equiv \frac{(1-\alpha)(1-\gamma)}{W^{\epsilon}} \left(\frac{\sum_k \ell_{Rk}}{\gamma}\right)^{1+\frac{\epsilon(1-\alpha)}{\alpha}} \left(\frac{\alpha(1-\gamma)}{W}\right)^{\frac{\epsilon(1-\alpha)}{\alpha\gamma}}$.

local amenities B_i and pro-residential zoning. It is decreasing in local productivity A_i and pro-commercial zoning.

In sum, in the absence of zoning and commuting costs, the distribution of employment and residents is entirely driven by the distribution of A/B across neighborhoods. Neighborhoods with a comparative advantage in production (high A/B) are more specialized in production. There are more workers than residents, and more space is allocated for commercial uses compared to residential uses. On the other hand, neighborhoods with a comparative advantage in residential amenities (low A/B) are more specialized in residence. More space is allocated for residential use, and there are more residents than workers.

With zoning, the allocation of space between commercial and residential use and the ratio of workers to residents is not only driven by the distribution of A/B. Pro-residential zoning ($\tau > 1$) increases the share of residents and lowers the share of workers; pro-commercial zoning ($\tau < 1$) results in more workers and fewer residents.

Finally, in the full model with commuting costs, the residential share also depends on local income x_i which is increasing in the neighborhood's proximity to neighborhoods with high wages. In addition, local employment also depends on its proximity to populated neighborhoods.

2.3 *Inference*

The forcing variables in the model are $\{A_i\}$, $\{B_i\}$, and $\{\tau_i\}$. In this subsection, we describe how we will infer these variables from data on the distribution of employment, residential population, and commercial vs. residential space across neighborhoods.

To make clear the intuition behind the inference exercise, consider the model without commuting cost. We proceed in four steps.

First, we infer employment in effective units L_{Ei} from data on the share of workers L_{Ci}:

$$L_{Ei} = L_{Ci}^{\frac{\epsilon-1}{\epsilon}}. \tag{12}$$

Note that $\frac{\epsilon-1}{\epsilon} < 1$. This reflects the effect of selection: the productivity of an average worker declines as more workers choose the neighborhood.

Second, we infer the price gap $\tau_i\, q_i$ from the residential space per resident relative to the commercial space per worker:

$$\frac{H_{Ri}/L_{Ri}}{H_{Ci}/L_{Ei}} = \frac{\gamma\alpha}{1-\alpha}\frac{x}{w_i}(\tau_i q_i) = \frac{\gamma}{1-\gamma}\frac{\tau_i q_i}{L_{Ci}^{1/\epsilon}},$$

where the second equality follows from (9), (11), and (12). Intuitively, pro-residential zoning ($\tau_i > 1$) increases the space-to-labor ratio for residential use compared to commercial use, and vice versa. The key assumption is that the expenditure share on housing γ is the same in all neighborhoods.

Third, we infer the distribution of local amenities B_i from data on residential population and space use. Specifically, the equation for residential population (10) can be expressed as:

$$B_i \propto \left(L_{Ri} \left(S^{\frac{\kappa+1}{\kappa}} + (H_{Ci}/H_{Ri})^{\frac{\kappa+1}{\kappa}} \right)^{\frac{\kappa}{\kappa+1}} H_i^{-\frac{\kappa}{\kappa+1}} \right)^{\gamma}$$

The intuition is that, conditional on the allocation of space in the neighborhood, neighborhoods with more residential amenities (high B_i) attract more residents.

Fourth, we rewrite the equation for the employment distribution (8) as:

$$A_i \propto L_{Ei}^{\alpha/(\epsilon-1)} \left(\tau_i q_i\right)^{1-\alpha} B_i^{(1-\alpha)/\gamma}.$$

The intuition is that, conditional on $\tau_i q_i$ and B_i, more productive neighborhoods (higher A_i) attract a larger share of employment.

With A_i and B_i at hand, we can solve for the laissez-faire relative price q_i by computing a counterfactual equilibrium where $\tau_i = 1\ \forall i$. Then we can isolate the zoning wedge τ_i from the inferred price gap $\tau_i q_i$.

In the full model with commuting costs, we need to take two additional things into account. First, employment in a neighborhood also depends on its distance to populated residential neighborhoods. Second, local income x_i also varies across neighborhoods depending on each neighborhood's distance from high wage neighborhoods, and this variable also matters for the distribution of residential population and for the inference of τ_i from the space to labor ratio for commercial vs. residential use. Appendix C details the inference procedure in the full model with commuting costs.

For the empirical implementation, four parameters need to be determined: $(\alpha, \gamma, \epsilon, \kappa)$. First, we use $(\alpha, \gamma) = (0.8, 0.25)$, following Ahlfeldt et al. (2015). We use the gravity equation in commuting flows to estimate ϵ. Specifically, the model implies that

$$\log L_{ij} = \log\left(\frac{L_{Ri}}{W_i^{\epsilon}}\right) + \epsilon \log w_j + \epsilon \log\left(t_{ij}\right),$$

where L_{ij} is the number of workers living in i and working in j. After replacing the terms for the residential and workplace locations with residence and workplace fixed effects, we get the following estimating equation:

$$\log L_{ij} = \epsilon \log\left(t_{ij}\right) + D_i^{\text{resi}} + D_j^{\text{work}}, \tag{13}$$

where D_i^{resi} and D_j^{work} are residence and workplace fixed effects, respectively. We estimate equation (13) using data on block-group-level commuting flows and commuting times for 2016.[8] The estimated ϵ ranges from 14.63 to 23.98 across U.S. cities. The average of the estimated $\epsilon = 20.08$ is applied to Taipei, as there is no neighborhood-level commuting flows data available.

To estimate κ, we make use of Taipei's institutional feature where the use of floor space is unconstrained.[9] The absence of use-zoning implies that $\tau_i = 1$. Equation (5) then implies the following estimating equation:

$$\log q_i = -\frac{1+\kappa}{\kappa} \log S + \frac{1}{\kappa} \log\left(\frac{H_{Ci}}{H_{Ri}}\right). \tag{14}$$

The left-hand side q_i is the inferred price gap between residential and commercial land. Importantly, we do not need to know κ to measure q_i in Taipei. We can then estimate κ by running a 2SLS regression, instrumenting $\log(H_{Ci}/H_{Ri})$ with $\log(A_i/B_i)$ using data on Taipei's neighborhoods. For all cities, we use the estimated $\kappa = 0.45$ for calculating the wedges τ_i in each neighborhood.[10]

3 Data

This section describes the data used to calculate H_{Ri}, H_{Ci}, L_{Ei}, and L_{Ri} in each neighborhood in U.S. cities and in Taipei, as well as how the commuting times are calculated. We first describe the geographic units of our analysis.

[8] We estimate using a Poisson Pseudo Maximum Likelihood estimator city by city. The data on commuting flows is from LODES for all U.S. cities and neighborhoods in our sample for 2016. The data on working time t_{ij} is calculated as $1 -$ commuting time (See Appendix D).

[9] See Section 4 for more discussion on Taipei's lenient zoning.

[10] We assume $S = 1$. Since our object of interest is the dispersion of $\log \tau_i$ across neighborhoods, this assumption is made without loss of generality because S will only affect the mean of $\log \tau_i$ but not its dispersion.

3.1 Cities and Neighborhoods

For U.S. cities, we focus on MSAs with populations exceeding 1 million. For Taipei, the metropolitan area consists mainly of Taipei City and New Taipei City; hence, we focus on data from these two administrative cities.[11] We consider a neighborhood a geographic unit that can potentially encompass a variety of activities while remaining within walking distance and being supported by available data. For the U.S., a census block is obviously too small. The average area sizes of a census tract and a census block group are 2.21 and 0.73 square kilometers, respectively. Thus, census block groups best approximate our requirement for neighborhoods. For Taipei, the smallest administrative units are indeed called "neighborhoods," and their average area size is 0.34 square kilometers, which is also well within walking distance.

Because counties, which are rather coarse administrative units, are used as the building blocks for MSAs, a typical MSA includes some rural areas. To ensure that we examine "urban" neighborhoods only, we restrict our attention to census block groups with a population density exceeding 1,000 residents per square kilometer or an employment density exceeding 500 workers per square kilometer. For Taipei, we restrict our attention to neighborhoods with a population density exceeding 2,000 residents per square kilometer or an employment density exceeding 1,000 workers per square kilometer. This is because urban Taipei is in a basin, and the thresholds are set such that most neighborhoods in the mountains are excluded. After incorporating these restrictions, there are 1,247 neighborhoods in Taipei. For the U.S., we arrive at 34 MSAs by applying these restrictions; in a median U.S. city, i.e., Atlanta and San Diego, there are 1,058 and 1,068 census block groups, respectively.[12]

3.2 Data on Space and People

Our key data are property-level data on the near-universe of commercial and residential properties in the U.S. provided by Cotality, a major real-estate data provider. The backbone of these data is local tax records complemented with property appraisals (from lenders and

[11] All 12 administrative districts of Taipei City are included, but 10 rural districts of New Taipei City are dropped. There are 31 districts in total, with a population of 6.2 million.

[12] The density thresholds reduce the average number of neighborhoods in a U.S. city by about 16%. City populations are calculated using this narrower definition of an MSA, and there are 36 MSAs with populations exceeding 1 million. For data consistency, we also drop neighborhoods where our data show positive employment but zero commercial space, or positive population but zero residential space. We drop Pittsburgh and Riverside from our sample because their fractions of neighborhoods with such data inconsistency are too high (more than 40%).

insurance companies). We use Cotality's information on land use, property floor area, and the property's geographic coordinates. We then aggregate the property-level data into total floor area for commercial and residential use in each census block group.

The residential population and the employment in each census block group are obtained from the LEHD's Origin-Destination Employment Statistics (LODES). We drop employment in public administration, education, recreation, transportation, warehouses, and industrial uses, as their associated space is not in the commercial or residential categories.

Turning to Taipei, we use the universe of property tax records obtained from Taiwan's Ministry of Finance, which provides property-level information on total floor area, the breakdown of floor area by use, and neighborhood location. Since it is common for a property to have multiple uses and each use is charged a different tax rate, it is important for the Ministry of Finance to get this information correct. We drop the floor areas of non-commercial, non-residential uses, then aggregate the floor space in Taipei into commercial and residential uses for each neighborhood.

We obtain the residential population for each Taipei neighborhood from the Ministry of the Interior's Household Registration Records. Our employment data are from the micro data of the Industry and Service Census by the Directorate General of Budget, Accounting and Statistics. This census is a complete enumeration of all establishments conducted every five years. It also provides the location and the four-digit industry of each establishment, from which we compile total employment in each neighborhood.

We use the year 2016 for all the above-mentioned data for U.S. cities and Taipei.[13] Summary statistics for every city are provided in Appendix Table A.1.

3.3 Commuting Times

Since the time remaining for work t_{ij} is 1 minus commuting time, we need to calculate the neighborhood-level commuting times. For Taipei, where a non-negligible fraction of commuters uses public transit, we consider both private and public transit modes in this calculation. For U.S. cities, we consider only the private transit mode (driving), as public transit accounts for only a small fraction of commuters in most cities.

To obtain driving times in the U.S. and in Taipei, we use the Open Source Routing Machine, a routing tool based on OpenStreetMap. Bilateral travel times for public transportation in Taipei are obtained from a public transportation routing API provided by Taiwan's Ministry of Transportation and Communications. Then, we use a standard discrete-choice

[13] This year is chosen because of the availability of Taiwan's Industry and Service Census.

model to calculate the average commuting time for Taipei. See Appendix D for full details of the commuting time calculation.

4 Flexible Zoning in Taipei

In this section, we provide institutional details about Taipei's zoning and argue that Taipei essentially lacks binding zoning separating residential and commercial uses. Establishing this institutional fact is important because we will use Taipei as a benchmark for our estimates of τ in the absence of zoning.

4.1 Lenient Use Constraints in Taipei

Unlike most U.S. cities, Taipei does not impose a strict separation between residential and commercial activities. In practice, mixed-use development is common, and most neighborhoods permit both housing and employment activities. This feature makes Taipei a useful benchmark for understanding how land and space are allocated when residential-commercial zoning constraints are weak. Appendix E provides additional details on the history and spatial organization of zoning in Taipei.

The key feature of Taipei's zoning system is that residential and commercial designations do not correspond to exclusive uses. The dominant residential zoning categories permit a wide range of commercial activities, including retail, restaurants, offices, and personal services. Residential use is also generally permitted in commercial zones.[14] As a result, both housing and employment activities are allowed in most parts of the metropolitan area.

The prevalence of these permissive categories implies that a large share of the metropolitan area can be used for either residential or commercial purposes. Of the land zoned for residential or commercial purposes, 69 percent is residentially zoned, and the vast majority

[14] In Taipei City, there are four basic residential zones (R1–R4) and four basic commercial zones (C1–C4). The numbering primarily reflects density limits; the larger the number, the looser the building constraints. Commercial zones generally allow residential uses unless otherwise stated in some specific plans. For residential zones, the numbering also reflects the type of commercial activities permitted. While the R1 category is close to exclusively residential, it accounts for only a small share of residentially zoned land. The dominant R3 category permits a broad range of retail and service activities, including restaurants, offices, and financial services, while R4 is even more permissive. Operating commercial establishments in residential zones is subject to certain conditions—primarily restricting businesses to the first or second floors and requiring adjacent lanes to meet specific width requirements. In practice, however, these width thresholds are easily satisfied. New Taipei City employs a slightly different zoning system, which is even more permissive than Taipei City's. For more details, see Taipei City Government (2021) and New Taipei City Government (2019).

of this land falls within categories that permit substantial commercial activity. New Taipei City applies even weaker use restrictions. Taken together, these regulations imply that zoning places relatively weak constraints on the allocation of space between residential and commercial uses.

4.2 Evidence of Non-binding Use Constraints

The institutional discussion above suggests that residential and commercial activities can coexist in most parts of Taipei. We now examine whether these legal flexibilities translate into weak use constraints in practice.

Using the universe of property-level data from the Departments of Land Administration in Taipei City and New Taipei City and combining the zoning code information that we compiled from government documents, we calculate each property's floor area in each of the following three categories: restricted to residential use, restricted to commercial use, or can be used for either purpose. Having property-level data is important, as it is common for zoning to differ between different floors within the same building. We then aggregate these property-level floor areas in the three categories to the neighborhood level.

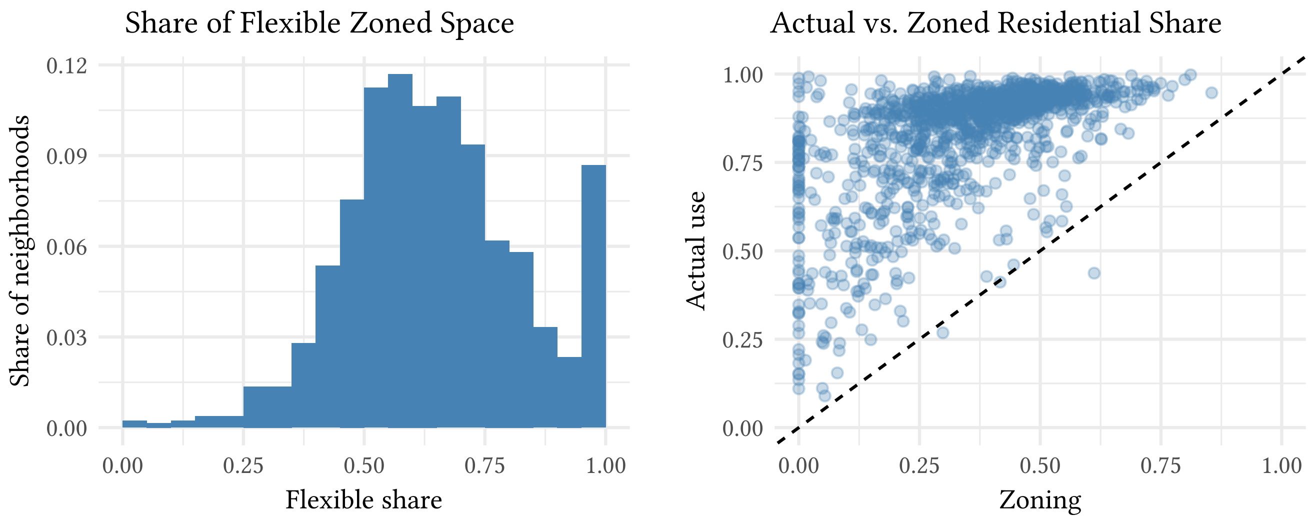
The data reveal three facts that suggest zoning places relatively weak constraints on land use in Taipei.

First, commercial-only zoning is rare. Commercial-only space accounts for only 3.8 percent of total floor space in the metropolitan area. Moreover, 85 percent of neighborhoods contain no commercial-only space, and only 1.8 percent of neighborhoods have more than 30 percent of their floor space restricted to commercial use.

Second, the majority of the space in Taipei is zoned for flexible use, which means it can be used either for commercial or residential purposes. The left panel in Figure 1 shows the distribution of the share of flexible space across neighborhoods. The majority of neighborhoods dedicate most of their space to flexible use, reflecting the prevalence of zoning categories that permit both residential and commercial activities. The figure also shows that flexible use space is dispersed across Taipei's neighborhoods. There are essentially no neighborhoods in which less than 25% of the space is zoned for flexible use.

Third, because of the dominance of flexible use zoning, actual space use is only weakly related to zoning allocations. The right panel in Figure 1 plots the share of floor space used for residential purposes against the share restricted to residential use. If zoning were binding, neighborhoods with more residentially restricted space would exhibit correspondingly higher residential use, and the observations would lie close to the 45-degree line. Instead,

Figure 1: Flexible Use Zoning in Taipei

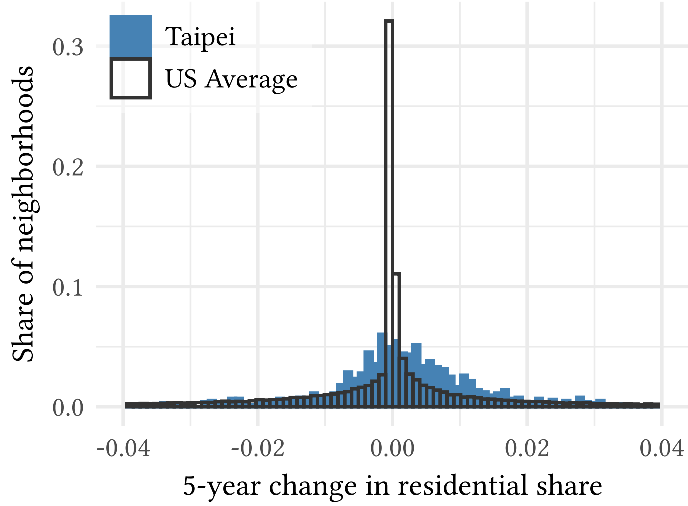


Notes: The left panel shows the share of floor space in each neighborhood zoned for flexible use. The right panel shows the share of space used for residential purposes (y-axis) vs. the share zoned as residential use only (x-axis). The dashed line is the 45-degree line.

neighborhoods with similar zoning allocations display dramatically different residential shares. In particular, among neighborhoods with little or no residential-only space, actual residential use ranges from roughly 10 percent to almost 100 percent. More generally, actual residential use substantially exceeds residential-only zoning in most neighborhoods. These patterns indicate that zoning places only weak constraints on the allocation of space between residential and commercial activities. The weak relationship between zoning allocations and realized use suggests that most variation in residential and commercial activity reflects market forces rather than zoning constraints.

Figure 2 provides complementary evidence from changes over time in the share of residential space in Taipei and in American cities. Residential shares in Taipei change substantially across neighborhoods over a five-year period (2014–2019), indicating that space can be reallocated between residential and commercial uses in response to changing economic conditions. Such adjustments would be difficult to reconcile with binding use constraints but are consistent with a zoning system that permits considerable flexibility in land use. In contrast, the vast majority of neighborhoods in an American city see little change in the share of residential space.

Figure 2: Distribution of Change in Residential Share of a Neighborhood



Notes: The figure shows the change in the share of residential space in a neighborhood over five years (2014–2019). "US Average" is the average of 34 U.S. MSAs.

5 Specialization in American Cities

In this section, we use data on the allocation of space between residential and commercial use and the allocation of workers and residents across neighborhoods to infer two driving forces in the model: (1) the distribution of the price wedge between commercial and residential uses τ across neighborhoods; (2) the distribution of comparative advantage A/B, also across neighborhoods.

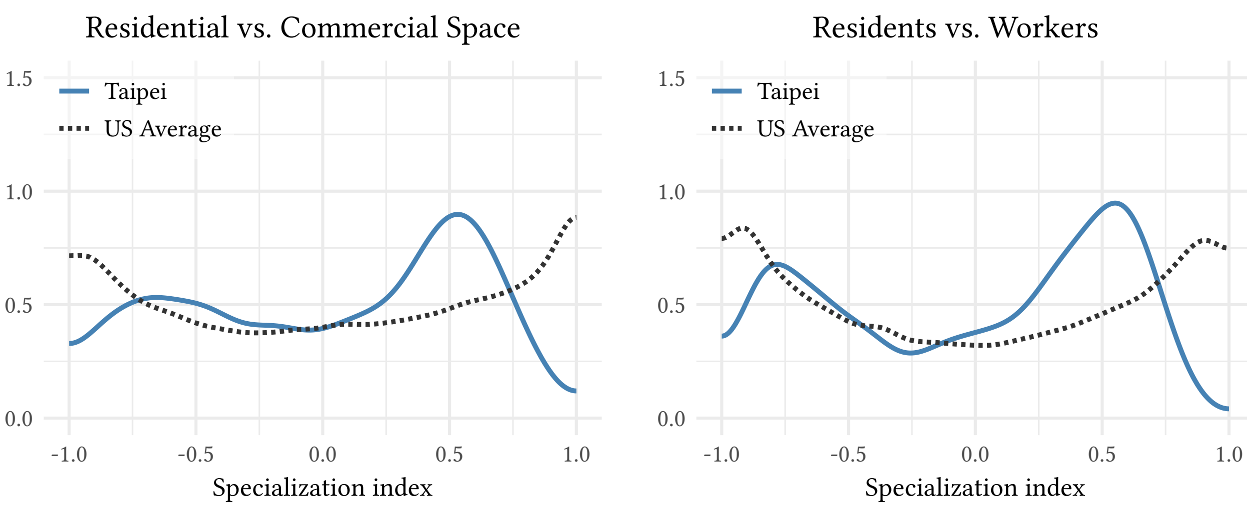
In the model, the specialization of neighborhoods, both in terms of commercial vs. residential space and in terms of workers vs. residents, is driven by comparative advantage in production vs. amenities (A/B) and by the price wedge between residential and commercial space τ. We therefore begin by showing the net effect of these two forces on the extent of specialization of space and workers vs. residents.

We begin by visualizing the specialization of neighborhoods in residential vs. commercial space in Figure 3 (left panel). The figure plots the distribution of $H_{Ri}/H_R - H_{Ci}/H_C$ of each neighborhood, normalized so that the maximum of this index is 1 and the minimum is -1.[15] This index is at a maximum when all the space in the neighborhood is residential space. Its minimum is when all the space in the neighborhood is used for commercial

[15] The index is defined as $(H_{Ri}/H_R - H_{Ci}/H_C)/(H_{Ri}/H_R + H_{Ci}/H_C)$, where H_R is the total residential space in the city and H_C is the total commercial space.

purposes. The index is zero when commercial and residential use are allocated in the same proportion as the city.

Figure 3: Distribution of Specialization of Neighborhoods: Taipei vs. U.S.



Notes: The left panel shows the distribution of $H_{Ri}/H_R - H_{Ci}/H_C$ in each neighborhood, normalized so that the maximum is 1 (complete specialization in residential space) and the minimum is -1 (complete specialization in commercial space). The right panel shows the distribution of $L_{Ri}/L_R - L_{Ci}/L_C$ in each neighborhood, normalized so that the maximum is 1 (neighborhood only has local residents) and the minimum is -1 (neighborhood only has workers). The kernel density in both panels is weighted by the sum of residents and employment $L_{Ri} + L_{Ci}$ in the neighborhood. "US Average" is the average of 34 U.S. MSAs.

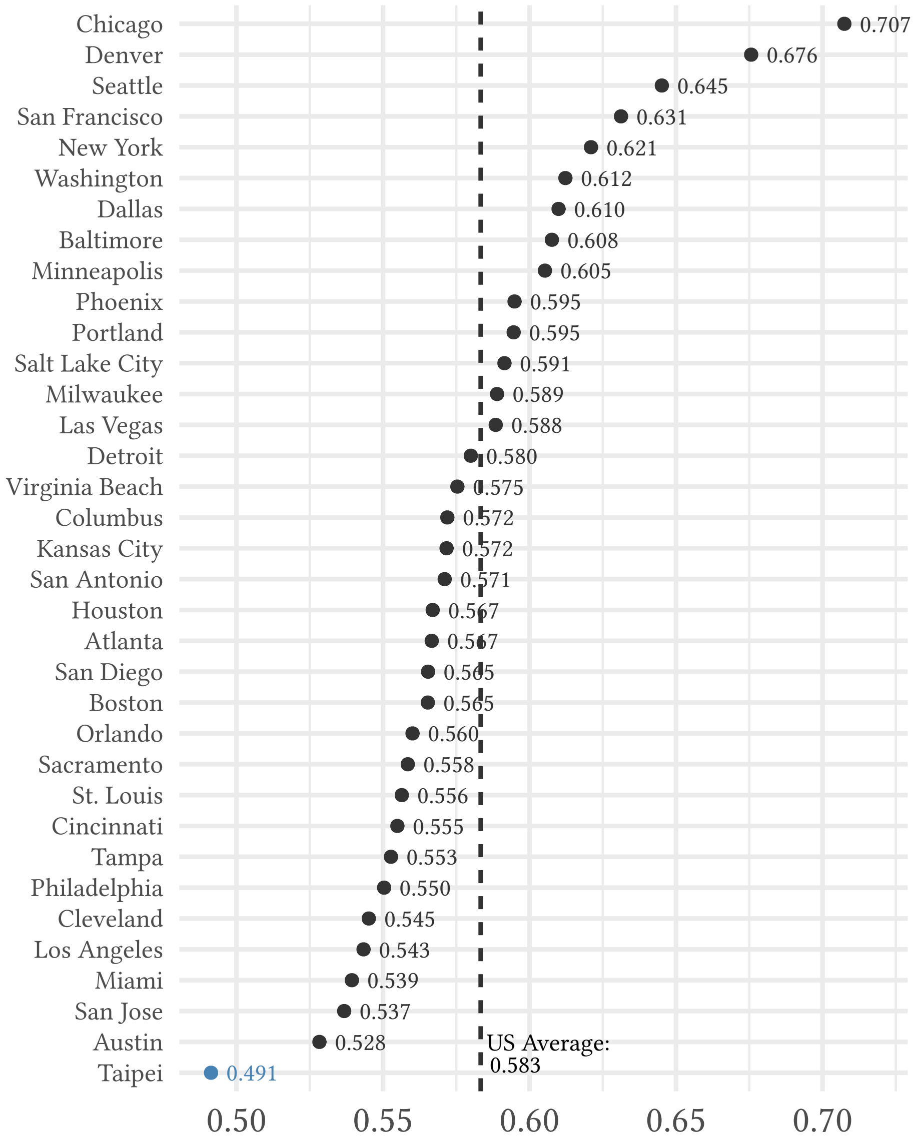
The figure clearly shows the segregation of land use (residential vs. commercial) between neighborhoods in American cities. Note the mass of the distribution at +1, corresponding to neighborhoods where the space is entirely residential, and the mass at -1, corresponding to neighborhoods where space is entirely commercial. Also note the contrast with Taipei, which does not show a similar bimodal distribution. We return in Section 7 to ask whether this segregation reflects deliberate planning or the absence of it.

The right panel in Figure 3 shows the distribution of the specialization of neighborhoods in terms of residents vs. workers. The figure plots the distribution of $L_{Ri}/L_R - L_{Ci}/L_C$ of each neighborhood, again normalized so that the maximum of this index is 1 and the minimum is -1.[16] When a neighborhood only has residents, the index is 1, and when a neighborhood only has workers, the index is -1. When a neighborhood has the same number of workers and residents, the index is zero.

Here again the specialization of neighborhoods in American cities, this time in terms

[16] The index is defined as $(L_{Ri}/L_R - L_{Ci}/L_C)/(L_{Ri}/L_R + L_{Ci}/L_C)$, where L_R is the total number of residents in the city and L_C is the total number of workers.

Figure 4: Aggregate Specialization Index in Residential vs. Commercial Space



Notes: This figure shows the aggregate specialization index for commercial vs. residential space calculated as $\frac{1}{2}\sum_i |H_{Ri}/H_R - H_{Ci}/H_C|$.

of residents vs. workers, is quite remarkable. The bimodality of the index is evident. The distribution has substantial mass in both tails, and the contrast with Taipei is clear.

Figure 4 shows the overall degree of neighborhood specialization in a city. For each city, this aggregate specialization index in terms of space use is calculated as the sum of the absolute value of the index shown in the left panel of Figure 3 divided by 2, i.e., $\frac{1}{2}\sum_i |H_{Ri}/H_R - H_{Ci}/H_C|$. This statistic thus ranges from 0 (every neighborhood is mixed use in terms of space) to 1 (every neighborhood is completely specialized in terms of space). The index is 0.58 for the average American city; the highest is 0.71 in Chicago and the lowest is 0.53 in Austin. The same index for Taipei is 0.49, which is lower than the American city that is the least specialized (Austin).

In the model, the distribution of space (commercial vs. residential) and people (workers vs. residents) between neighborhoods is driven by two forces: the dispersion of comparative advantage (A relative to B) between neighborhoods and commercial vs. residential zoning, as captured by the dispersion of τ. We now proceed to decompose these two forces.

Remember τ drives a wedge between the residential floor space per resident and commercial floor space per worker. We therefore start by showing the distribution of the gap in floor space per person in the two uses between neighborhoods. Figure 5 (left panel) shows that the dispersion of this gap is significantly wider in American cities compared to Taipei. Table 1 (column 2) shows the 90-10 gap in the price gap τq implied by the dispersion in the space-to-worker ratio for commercial vs. residential uses. The 90-10 gap in τq is 2.23 in the average American city and 0.97 in Taipei.

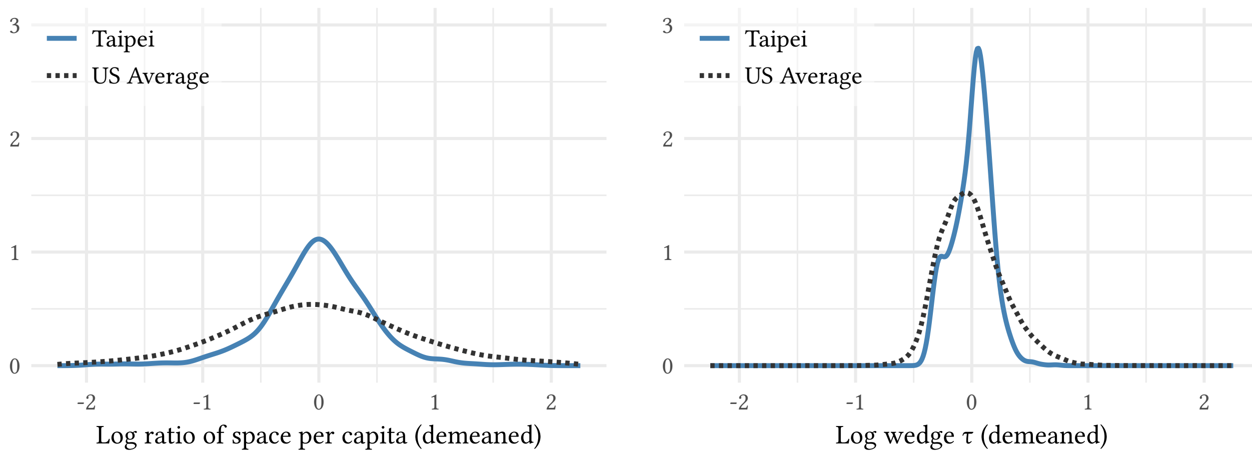
Table 1: 90-10 Gap in Local Space per Capita and Prices, Commercial vs. Residential

		Price Gap	
	$\log \frac{H_C/L_E}{H_R/L_R}$	$\log \tau q$	$\log \tau$
Average U.S. City	2.175	2.227	0.749
Taipei	1.020	0.966	0.443

Notes: The table shows the 90-10 Gap in $\log \frac{H_C/L_E}{H_R/L_R}$, $\log(\tau q)$, and $\log \tau$ across neighborhoods in each city. The average U.S. city is the average of 34 U.S. MSAs.

The dispersion in the price gap τq in American cities comes from dispersion in the laissez-faire price gap, q, and the zoning wedge, τ. Here, we impute q from estimates of $\log A/B$ of each city's neighborhoods and κ estimated from Taipei data following equation

Figure 5: Distribution of Space per Capita and Price Wedge (Residential vs. Commercial)



Notes: The left panel shows the distribution of $\log \frac{H_{Ri}/L_{Ri}}{H_{Ci}/L_{Ei}}$ in each neighborhood. The right panel shows the implied distribution of $\log \tau$ across neighborhoods imputed from equation (7). "US Average" is the average of 34 U.S. MSAs.

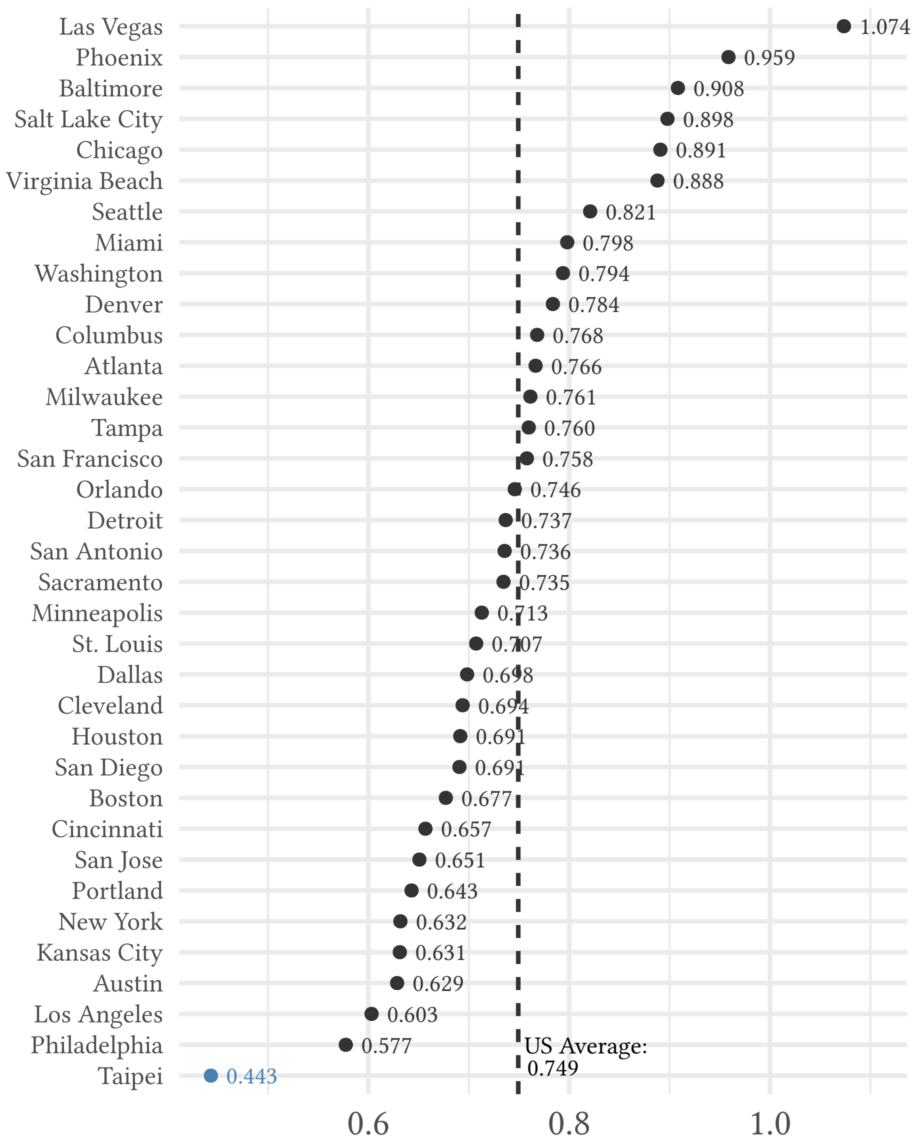
(14). The right panel in Figure 5 shows the dispersion of τ. We make two points. First, the dispersion of τ is significantly smaller than the dispersion of the price gap. This is because τ isolates the effect of zoning from the price gap driven by differences in the relative demand for commercial vs. residential land. Second, the dispersion of τ in American cities is larger than that in Taipei. The 90-10 gap in τ is 0.75 in the average American city and 0.44 in Taipei (last column in Table 1).

Figure 6 shows the 90-10 gap in τ in all U.S. cities. The U.S. city with the most dispersion in τ is Las Vegas, and the city with the least dispersion is Philadelphia. Still, the dispersion of τ in the American city with the least dispersion (Philadelphia) is higher than in Taipei.

Our inference of zoning wedges requires a value for the elasticity of space-use adjustment, κ, which we estimate using neighborhood-level data from Taipei and impose on U.S. cities. A natural concern is that space-use adjustment may be more or less elastic in U.S. cities than in Taipei. To assess the importance of this assumption, we repeat the analysis using values of κ equal to one-half and twice our baseline estimate. The inferred dispersion of zoning wedges changes little under either alternative calibration.[17] Intuitively, changing κ affects not only the supply response of space use but also equilibrium quantity demanded, so laissez-faire relative prices q respond much less than the supply equation alone would suggest. As a result, the inferred dispersion of laissez-faire relative prices—and hence zon-

[17]Cutting κ by one half lowers the 90-10 gap in τ in the average U.S. city from 0.749 to 0.744. Doubling κ raises the 90-10 gap from 0.749 to 0.772.

Figure 6: 90-10 Gap in log τ



Notes: The figure shows the 90-10 gap in log τ in each city.

ing wedges—is locally insensitive to plausible changes in κ.

Although we interpret the higher dispersion in τ in American cities as reflecting zoning, it is possible that it captures other forces. We therefore ask whether the inferred wedges behave as binding zoning constraints should.

The key observation is that zoning shows up as τ only when it works against market forces. Consider a neighborhood with high residential amenities B. In the absence of zoning, such a neighborhood would naturally attract residents and residential space. A pro-residential zoning rule would therefore be largely irrelevant. By contrast, a pro-commercial zoning rule would have to overcome strong market incentives favoring residential use and would therefore generate a large negative value of $\log\tau$. An analogous argument applies to productivity. In neighborhoods with high productivity A, market forces favor commercial activity, so a binding pro-residential zoning constraint requires a large positive value of $\log\tau$.

Figure 7 shows exactly this pattern. Across virtually all U.S. cities, τ is negatively related to residential amenities and positively related to productivity. Thus, the inferred wedges are largest precisely in neighborhoods where zoning would need to work hardest against market forces. This is what we would expect if τ captures binding zoning constraints rather than measurement error or other sources of neighborhood heterogeneity. In Taipei, where residential-commercial zoning is largely absent, these relationships are substantially weaker than American cities.

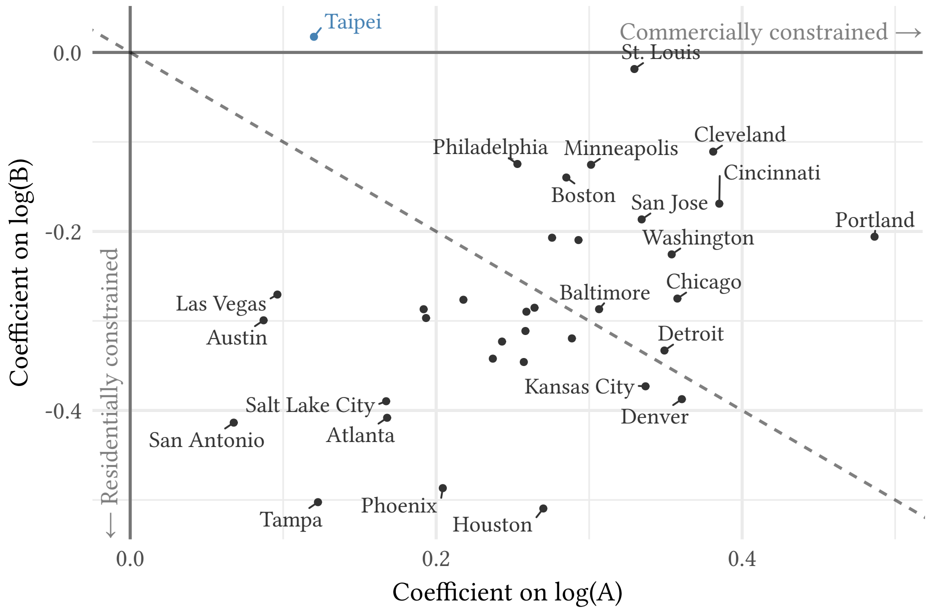
6 The Effects of Effective Commercial-Residential Wedges

The previous section showed that neighborhoods in American cities exhibit substantially greater dispersion in effective commercial-residential wedges τ than neighborhoods in Taipei. We now ask how these wedges affect the spatial allocation of economic activity. Using the estimated productivity, amenities, and wedges, we conduct counterfactual exercises that reduce the dispersion in wedges in each American city to the level observed in Taipei,[18] and examine the resulting changes in neighborhood specialization and welfare.

Taipei provides a natural benchmark because residential-commercial use restrictions are minimal. The dispersion in estimated wedges in Taipei therefore provides an empirical estimate of the baseline dispersion in an effectively un-zoned city. Our counterfactual

[18]To do so, for each American city, we reduce the standard deviation of wedges to that of Taipei while preserving the mean.

Figure 7: Coefficients from Regression of $\log \tau$ on $\log A$ and $\log B$



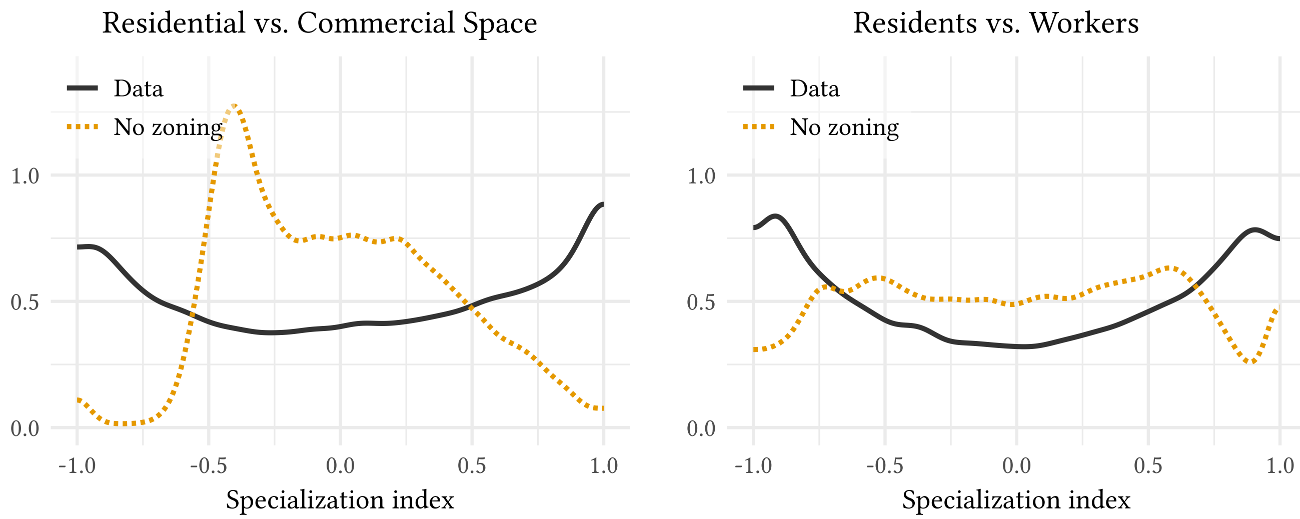
Notes: The figure shows coefficients from regression of $\log \tau$ on $\log A$ and $\log B$. All variables are normalized to have a standard deviation of 1 for every city. The dashed line is the negative 45-degree line.

reduces the dispersion of wedges in each American city to this level while preserving the cross-neighborhood ranking of wedges, yielding a conservative estimate of the effects of residential-commercial zoning.

Figure 8 shows the effect of reducing the dispersion of wedges to that of Taipei on the specialization of neighborhoods in American cities. The left panel shows the specialization of neighborhoods in the average American city in terms of residential vs. commercial space. For comparison, the figure replicates the actual distribution of the specialization of neighborhoods in terms of space use as in Figure 3. The right panel shows the specialization of neighborhoods in terms of residents vs. workers. Again, the figure replicates the actual distribution of the share of residents vs. workers in each neighborhood. Both figures show that the bimodal distribution in the data disappears under the no-zoning counterfactual.

Figure 9 shows the aggregate specialization index of each MSA under the no-zoning counterfactual plotted against the specialization index measured in the data, where the aggregate specialization index for each city is calculated as in Figure 4. Each point in the figure is the aggregate specialization index for one U.S. city. The left panel shows this number for specialization in terms of residential vs. commercial space. The right panel shows this number for specialization in terms of residents vs. workers.

Figure 8: Counterfactual Specialization of Neighborhoods in American Cities with No-Zoning

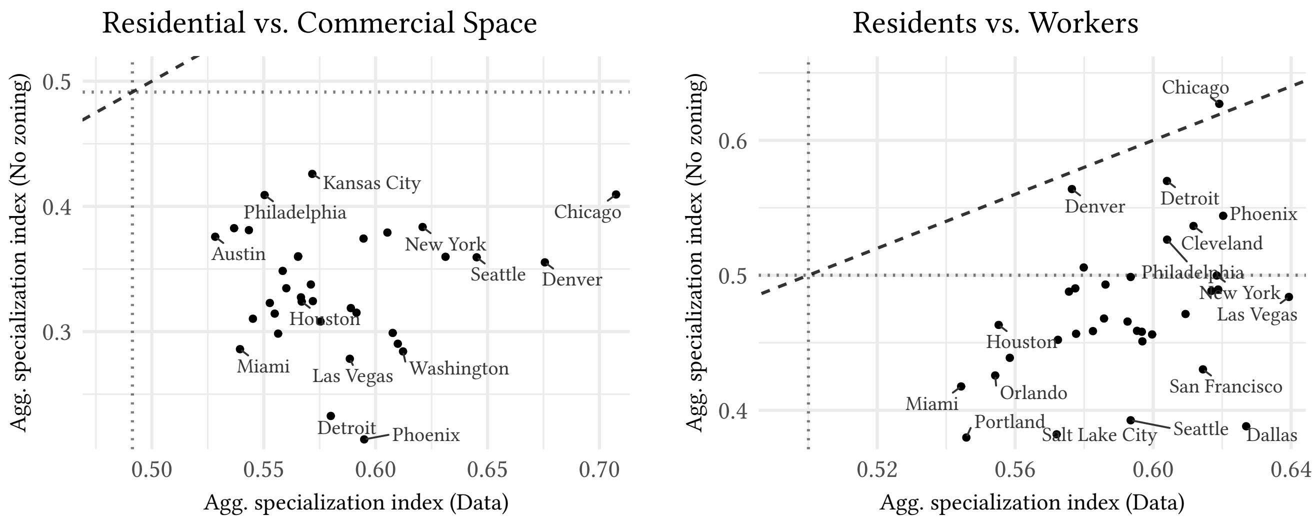


Notes: The figure shows the counterfactual specialization of neighborhoods when the dispersion of τ in each city is set to that in Taipei (see text for details). For comparison, the figure also shows the actual specialization of neighborhoods observed in the data. The left panel shows the city-wise normalized distribution of $H_{Ri}/H_R - H_{Ci}/H_C$; the right panel shows the city-wise normalized distribution of $L_{Ri}/L_R - L_{Ci}/L_C$ in each neighborhood. Both panels weight each neighborhood by the sum of residents and employment $L_{Ri} + L_{Ci}$ in the neighborhood. The figure shows the average distribution across neighborhoods in 34 American MSAs.

The left panel shows that for all U.S. cities, the points lie below the 45-degree line. That is, under the no-zoning counterfactual, every U.S. city would be less specialized in residential vs. commercial space compared to what is observed in the data. The pattern is less stark in the right panel, which shows the aggregate specialization index in terms of residents vs. workers. The majority of U.S. cities lie below the 45-degree line, indicating that the no-zoning counterfactual implies more mixed neighborhoods. Only one city, Chicago, would be slightly more segregated in terms of residents vs. workers under the no-zoning counterfactual.

We end by estimating the effect of eliminating zoning (setting the dispersion of τ in each American city to that of Taipei) on aggregate welfare. The welfare gains from eliminating residential vs. commercial zoning are 9.3% in the average American city. This number ranges widely between cities depending on the distribution of τ, A, and B across neighborhoods. The city with the largest welfare loss from zoning is Chicago (30.3% welfare loss). The welfare loss is still substantial in the city with the smallest welfare loss (San Jose, with a 2.6% welfare loss).

Figure 9: Aggregate Index of Specialization with No-Zoning



Notes: The figure shows the aggregate index of specialization of each city under the no-zoning counterfactual (y-axis) vs. the actual index of specialization of each city (x-axis). The left panel calculates the index of each MSA as $\frac{1}{2}\sum_i |H_{Ri}/H_R - H_{Ci}/H_C|$; the right panel shows $\frac{1}{2}\sum_i |L_{Ri}/L_R - L_{Ci}/L_C|$ in each MSA. The dashed lines are 45-degree lines. The dotted lines indicate the specialization index of Taipei.

7 Is Zoning Well Targeted?

The previous sections showed that zoning wedges are large and materially affect the specialization of neighborhoods. Whether these wedges are socially costly, however, depends on why zoning exists in the first place. A common justification is that zoning corrects externalities that private markets fail to internalize.

This observation suggests a simple question: do the zoning patterns we measure resemble the zoning a planner would choose to address externalities? To answer this question, we consider two leading views of urban externalities. The traditional rationale for Euclidean zoning emphasizes negative spillovers from commercial activity, such as congestion, noise, and pollution. In contrast, Jane Jacobs (1961) argues that mixed residential and commercial uses generate positive externalities through local services, pedestrian activity, and neighborhood vitality. We derive the implications of each view for the optimal pattern of zoning across neighborhoods and compare those predictions to the zoning wedges inferred from the data.

We allow for these externalities by augmenting the model such that local amenity is given by

$$B_i = \bar{B}_i \times \left(\frac{L_{Ri}^{\zeta} L_{Ei}^{1-\zeta}}{H_i} \right)^{\eta}, \tag{15}$$

where $\zeta \in [0, 1]$. Here $\eta > 0$ implies positive externalities from mixed use, whereas $\eta < 0$ implies negative externalities from mixed use. The rest of the model is unchanged.

We have two results of optimal zoning to report for the model with externalities.[19] First, the *sign* of the relationship between the planner's choice of τ and $L_E^{\text{free}}/L_R^{\text{free}}$ is negative when $\eta < 0$ and positive when $\eta > 0$. In words, when there are negative externalities from mixed use, a planner wants more segregated neighborhoods. And when the externalities are positive, the planner wants neighborhoods to become more mixed.

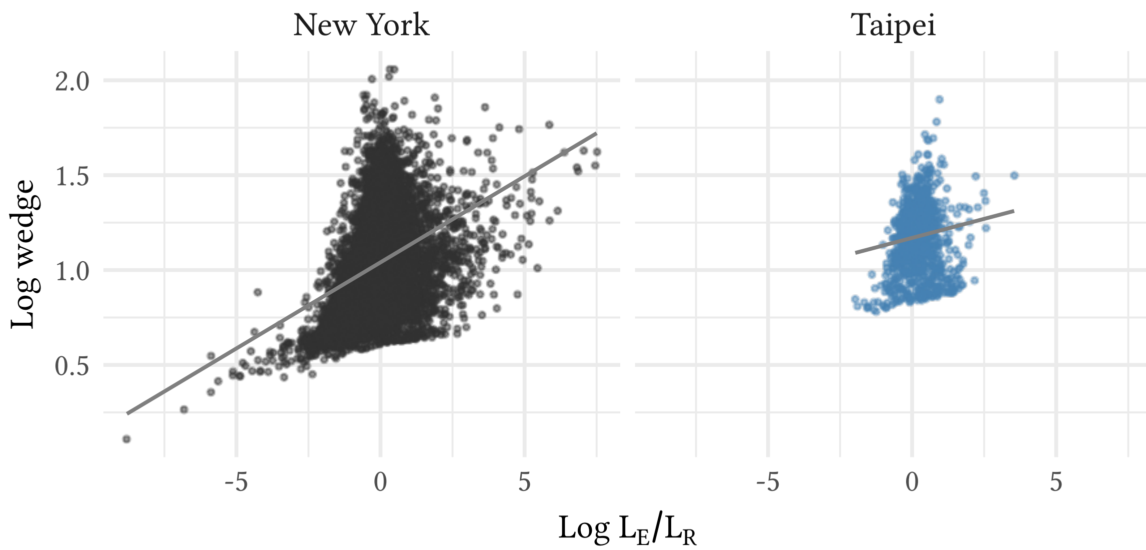
Second, a social planner will set optimal zoning such that τ is a function of the comparative advantage of a neighborhood, as measured by the share of employment and residents under laissez-faire, $L_E^{\text{free}}/L_R^{\text{free}}$. This is the case regardless of the precise model of externalities, so any deviation of τ from $L_E^{\text{free}}/L_R^{\text{free}}$ is a deviation from optimal zoning. Therefore, the slope of the relationship identifies whether zoning promotes mixing or segregation, while the unexplained variation measures the extent of zoning that cannot be rationalized by the externality model. We now examine these predictions empirically.

Figure 10 shows the scatterplot of τ with respect to $L_E^{\text{free}}/L_R^{\text{free}}$ in New York and Taipei. Two facts are evident. First, there is a positive relationship between τ and $L_E^{\text{free}}/L_R^{\text{free}}$ in New York. This is consistent with a model where urban planners in New York are attempting to internalize positive externalities from zoning (as in Jane Jacobs), and inconsistent with the view that planners are trying to internalize negative externalities from mixed neighborhoods. Second, there is a large dispersion of τ from the positive relationship between τ and $L_E^{\text{free}}/L_R^{\text{free}}$ in New York. Importantly, the dispersion is much larger in New York compared to Taipei. This suggests that even when planners in New York are setting zoning rules to create more mixed neighborhoods, this is dominated by zoning that is poorly targeted. The net effect is that poorly targeted zoning fails to internalize positive externalities, on top of the welfare losses from zoning we measured in the previous section.

This pattern is not unique to New York. To demonstrate that this tension between mixing intent and noisy execution is a widespread feature of American urban planning, Figure 11 plots the regression results across all 34 American cities. The left panel shows the R^2 from a regression of $\log \tau$ on $\log(L_E^{\text{free}}/L_R^{\text{free}})$ and the right panel shows the coefficient from the regression. The right panel shows that the coefficient relating zoning wedges to

[19] See Appendix F for details on how the optimal price wedges τ_i of all neighborhoods i are computed.

Figure 10: Scatterplot of $\log \tau$ on $\log L_E^{\text{free}}/L_R^{\text{free}}$



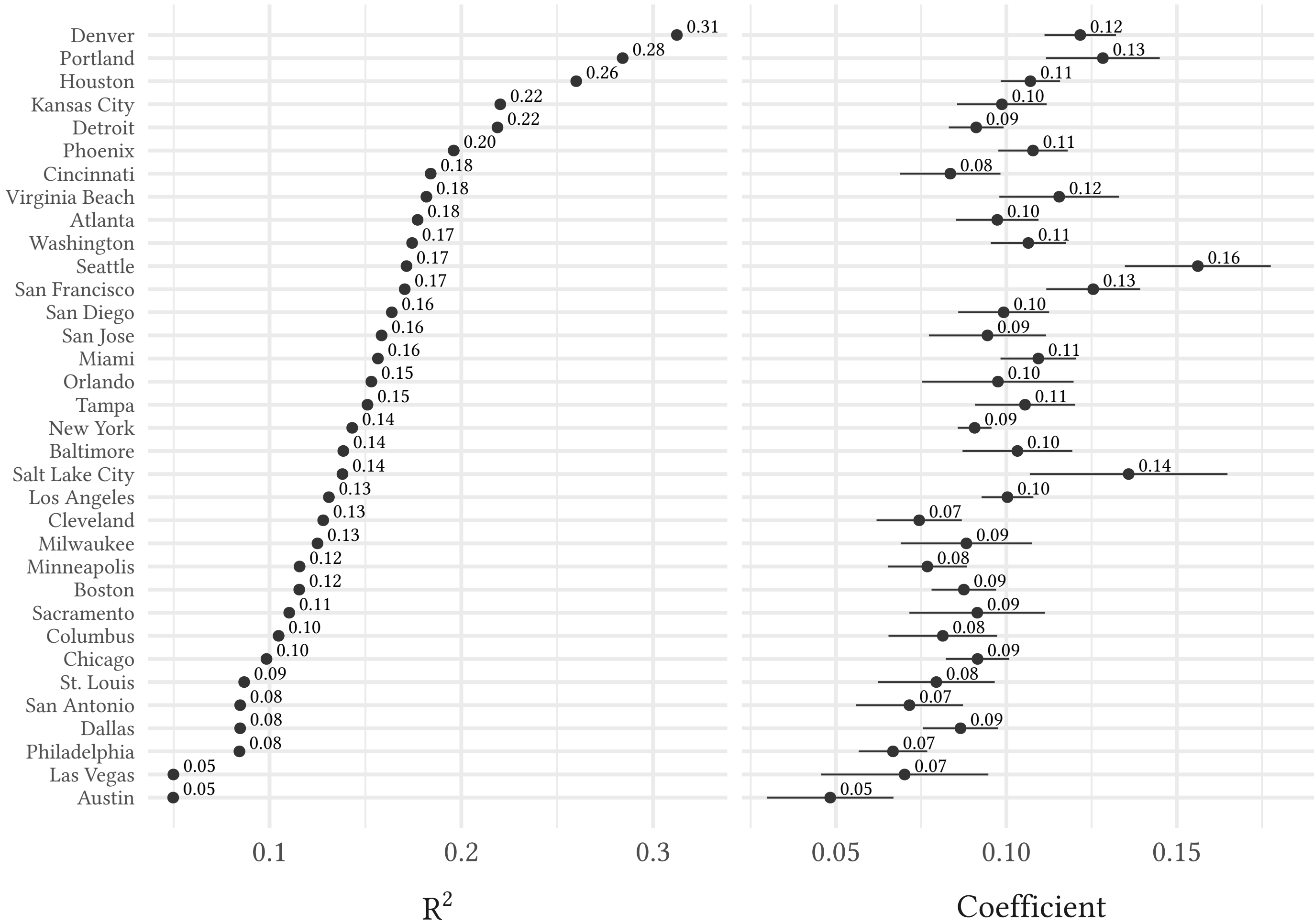
Notes: The figure shows a scatterplot of $\log \tau$ on $\log L_E^{\text{free}}/L_R^{\text{free}}$ (employment-to-population ratio under laissez-faire equilibrium). The grey line indicates a linear fit.

neighborhood comparative advantage is positive in every city. Neighborhoods that would attract relatively more employment under laissez-faire tend to receive zoning that favors residential uses, while neighborhoods that would attract relatively more residents tend to receive zoning that favors commercial uses. This pattern is consistent with the view that planners use zoning to encourage mixed-use development. It is inconsistent with a model in which zoning is primarily intended to separate residential and commercial activities.

At first glance, the greater residential-commercial segregation observed in U.S. cities relative to Taipei shown in Figure 4 might suggest that planners in the U.S. are pursuing Euclidean zoning. However, as suggested by the scatterplot of New York in Figure 10, the left panel in Figure 11 suggests otherwise. Although the systematic component of zoning points toward greater mixing, it explains only a small fraction of the variation in zoning. The much larger residual component dominates, so the net effect of zoning is to increase, rather than decrease, residential-commercial segregation.

To quantify the economic damage of this regulatory noise, we isolate the component of zoning that is not systematically related to neighborhood comparative advantage. If we eliminate only this poorly targeted, residual dispersion—while keeping the systematic, mixing-oriented zoning intact—welfare in the average American city still increases

Figure 11: R^2 and Coefficients of $\log \tau$ on $\log L_E^{\text{free}}/L_R^{\text{free}}$



Notes: The figure shows the R^2 and coefficients of regressing $\log \tau$ on $\log L_E^{\text{free}}/L_R^{\text{free}}$ (employment-to-population ratio under laissez-faire equilibrium). The horizontal bars show the robust 95% confidence intervals of coefficient estimates.

by 2.8%.[20] We remind the readers that when we reduce τ dispersion, both the systematic and the untargeted components, we get a welfare gain of 9.3% in the average American city.

8 Conclusion

This paper examines how residential-commercial zoning shapes the allocation of land and economic activity within cities. We show that neighborhoods in American cities are sub-

[20]We do so by first running a linear regression of $\log \tau_i$ on $\log L_E^{\text{free}}/L_R^{\text{free}}$ for each city. Then we compute the counterfactual welfare of setting wedges to their fitted values, $\hat{\tau}_i$.

stantially more specialized than neighborhoods in Taipei, a city where zoning imposes few restrictions on the mixing of residential and commercial uses. Using a spatial equilibrium model, we infer the zoning wedges needed to rationalize the observed allocation of floor space, residents, and employment across neighborhoods. The inferred wedges exhibit substantially greater dispersion in American cities than in Taipei, and reducing that dispersion to Taipei's level would significantly reduce neighborhood specialization and increase welfare.

We then ask whether the observed pattern of zoning can be justified by the externalities commonly invoked in its defense. The evidence provides some support for the view that planners seek to promote mixed-use development, as pro-residential zoning is positively related to the comparative advantage of neighborhoods in commercial activity. However, this relationship explains only a small fraction of the variation in zoning. Most zoning appears unrelated to the economic characteristics of neighborhoods that would justify intervention. As a result, the dominant effect of zoning in American cities is not to promote mixed-use development, but to increase the segregation of residential and commercial activity across neighborhoods.

More broadly, the results suggest that the economic consequences of zoning arise not only from the magnitude of use restrictions, but also from how those restrictions are targeted. Understanding why zoning is so weakly related to neighborhood comparative advantage, and what political and institutional forces shape its allocation across space, remains an important direction for future research.

Appendices

A Additional Tables

Table A.1: Summary Statistics

		Population L_R	Employment L_C	Residential space H_R		Commercial space H_C	
City	N	SD	SD	Mean	SD	Mean	SD
Taipei	1247	0.037	0.168	205.44	139.26	63.25	135.39
Atlanta	1058	0.052	0.217	116.09	132.78	51.75	115.08
Austin	541	0.099	0.567	100.29	72.11	40.29	121.90
Baltimore	1048	0.058	0.313	76.45	63.21	25.24	95.08
Boston	1978	0.022	0.162	63.89	40.06	27.44	89.57
Chicago	3634	0.015	0.191	61.56	52.90	59.96	954.39
Cincinnati	524	0.110	0.405	69.09	50.60	32.32	83.85
Cleveland	1009	0.058	0.410	64.01	49.33	31.89	136.00
Columbus	766	0.078	0.409	61.49	39.64	27.11	84.28
Dallas	2609	0.022	0.125	88.68	74.77	42.26	131.55
Denver	1107	0.046	0.239	77.50	61.30	56.39	320.83
Detroit	2121	0.029	0.174	63.03	99.60	27.11	86.21
Houston	1921	0.043	0.144	103.96	157.15	35.48	78.91
Kansas City	683	0.082	0.378	67.20	54.50	42.41	107.69
Las Vegas	789	0.086	0.637	85.66	76.51	29.68	123.96
Los Angeles	6197	0.008	0.068	58.11	55.98	21.62	74.14
Miami	2310	0.023	0.113	94.20	81.68	28.00	67.47
Milwaukee	635	0.073	0.532	44.53	23.86	24.96	90.35
Minneapolis	1253	0.041	0.275	77.63	66.14	29.84	184.79
New York	9238	0.005	0.048	57.69	66.06	26.64	261.21
Orlando	471	0.210	0.509	131.11	176.34	47.60	113.34
Philadelphia	2248	0.022	0.166	65.64	54.53	24.83	107.75
Phoenix	1702	0.026	0.169	78.91	71.43	23.16	56.89
Portland	758	0.057	0.316	88.64	57.33	48.01	159.14
Sacramento	762	0.064	0.438	81.31	50.71	29.08	84.69
Salt Lake City	471	0.140	0.618	96.00	92.92	27.19	76.35
San Antonio	852	0.071	0.325	82.28	83.08	30.25	85.70
San Diego	1068	0.060	0.382	74.80	80.48	27.00	75.21
San Francisco	1926	0.025	0.205	69.43	49.09	29.79	112.00
San Jose	702	0.077	0.475	78.75	52.37	24.54	63.58
Seattle	1371	0.030	0.245	89.71	261.23	31.98	104.47
St. Louis	1015	0.059	0.266	74.57	63.13	43.93	192.61
Tampa	1187	0.050	0.234	72.80	66.79	21.88	71.92
Virginia Beach	621	0.078	0.405	76.24	49.30	26.21	66.40
Washington	1641	0.029	0.186	89.93	71.79	52.37	186.56

Notes: This table reports the summary statistics of the number of neighborhoods (N), population, employment, residential and commercial floor space by city. Total population and employment are normalized to 100 for every city. Floor space is measured in 1000 square meters.

B An Assignment Model of Floor Space

Each neighborhood i has a continuum of land with measure T_i and parcels indexed by ω. The landlord assigns each parcel of land to either commercial or residential use to maximize profit. The buildable floor space for parcel ω if assigned to commercial use is $Z_i S \varepsilon_{Ci}(\omega)$, and $Z_i \varepsilon_{Ri}(\omega)$ if assigned to residential use. Z_i captures the building restriction, such as the floor area ratio, that applies to both uses. S is the commercial suitability of land relative to being used for residential purposes, which is assumed to be a constant within a city. $\varepsilon(\omega)$ is an idiosyncratic suitability term drawn *i.i.d.* from a Fréchet distribution with shape $\kappa+1$ ($\kappa > 0$) and scale $\Gamma\left(\frac{\kappa}{\kappa+1}\right)^{-(\kappa+1)}$.

For each parcel ω, the landlord maximizes profit by choosing the use that pays a greater total floor space rent:

$$\max\{q_{Ci} Z_i S \varepsilon_C(\omega), q_{Ri} Z_i \varepsilon_R(\omega)\}. \tag{B.1}$$

By standard Fréchet properties, the available floor space for commercial and residential uses is:

$$H_{Ci} = T_i Z_i S \frac{(q_{Ci} Z_i S)^{\kappa}}{\Phi^{\frac{\kappa}{\kappa+1}}}, \tag{B.2}$$

$$H_{Ri} = T_i Z_i \frac{(q_{Ri} Z_i)^{\kappa}}{\Phi^{\frac{\kappa}{\kappa+1}}}, \tag{B.3}$$

where $\Phi = (q_{Ci} Z_i S)^{\kappa+1} + (q_{Ri} Z_i)^{\kappa+1}$.

The relative supply is then:

$$\frac{H_{Ci}}{H_{Ri}} = S^{\kappa+1} \left(\frac{q_{Ci}}{q_{Ri}}\right)^{\kappa}. \tag{B.4}$$

Finally, since the shares of land assigned to commercial and residential use must sum to unity, $\frac{(q_{Ci} Z_i S)^{\kappa+1}}{\Phi} + \frac{(q_{Ri} Z_i)^{\kappa+1}}{\Phi} = 1$, the implied resource constraint is:

$$\left(\frac{H_{Ci}}{S}\right)^{\frac{\kappa+1}{\kappa}} + H_{Ri}^{\frac{\kappa+1}{\kappa}} = (T_i Z_i)^{\frac{\kappa+1}{\kappa}} \equiv H_i. \tag{B.5}$$

In the extreme case where $\kappa \to \infty$, the relative supply becomes infinitely elastic, and the transformation between two uses becomes frictionless.

C Inference for the Full Model with Commuting Costs

In this section, we describe how we infer the model primitives from observed data on American cities and Taipei using the full model that includes commuting costs. Our goal is to find a set of model primitives $\{A_i, B_i, \tau_i\}$ such that the equilibrium outcomes exactly match the observed data on employment $\{L_{Ci}\}$, population $\{L_{Ri}\}$, and the ratio of per-capita residential floor space to per-worker commercial floor space $\left\{\frac{H_{Ri}/L_{Ri}}{H_{Ci}/L_{Ei}}\right\}$.

We already discussed the intuition for our inference strategy in the main text using a simplified version of the model without commuting costs. The inference strategy for the full model is similar, but we need to take into account the commuting time between neighborhoods to know the employment in efficiency units (L_{Ei}), which differs from what is directly measured in the data—employment in headcount (L_{Ci}). In addition, we need to know the expected income (x_i) across neighborhoods, which is not directly observed in the data.

To begin, we first show that both $\{L_{Ei}\}$ and $\{x_i\}$ can be recovered from the observables $\{L_{Ci}, L_{Ri}\}$, given parameters $\{\alpha, \gamma, \epsilon\}$ and commuting time matrix $\{1 - t_{ij}\}$. Recall that L_{Ei} is given by

$$L_{Ei} = w_i^{\epsilon-1} \sum_k \frac{t_{ki}^{\epsilon}}{W_k^{\epsilon-1}} L_{Rk}, \quad \text{where } W_i \equiv \left(\sum_j (w_j\, t_{ij})^{\epsilon} \right)^{1/\epsilon}. \tag{C.6}$$

Rearranging the equation for the commuting flow from k to i, $\left(\frac{w_i\, t_{ki}}{W_k}\right)^{\epsilon}$, and summing over origins k gives

$$w_i = \left(\frac{L_{Ci}}{\sum_k \frac{t_{ki}^{\epsilon}}{W_k^{\epsilon}} L_{Rk}} \right)^{1/\epsilon}. \tag{C.7}$$

Using the two equations above, L_{Ei} and w_i become implicit functions of observables $\{L_{Ci}, L_{Ri}\}$. In addition, since the expected income is given by

$$x_i \equiv W_i + r = W_i + \left(\frac{1}{\alpha(1-\gamma)} - 1 \right) \sum_i W_i L_{Ri}, \tag{C.8}$$

we can also view it as an implicit function of observables $\{L_{Ci}, L_{Ri}\}$. From now on, we treat $\{L_{Ei}, w_i, x_i\}$ simply as data since they can all be solved from the above equations.

Next, we can back out residential amenity B_i from the observed population and floor space allocation up to some scale using the equilibrium population equation (10):

$$B_i \propto \frac{L_{Ri}^{\gamma}}{x_i^{1-\gamma} H_{Ri}^{\gamma}}. \tag{C.9}$$

And we obtain productivity A_i up to some scale using equations (1) and (2):

$$A_i \propto \left(\frac{L_{Ei}}{H_{Ci}}\right)^{1-\alpha} w_i. \tag{C.10}$$

To fix the scale, we set the average A's and B's across neighborhoods to be unity.

Finally, we can back out the relative price of space $\{\tau_i q_i\}$ from the relative use of residential vs. commercial space per person using (7):

$$\tau_i q_i = \frac{1-\alpha}{\gamma\alpha} \frac{H_{Ri}/L_{Ri}}{H_{Ci}/L_{Ei}} \frac{w_i}{x_i}. \tag{C.11}$$

Given the model primitives $\{A_i, B_i\}$ solved above, we can solve for the laissez-faire relative price of space q_i where the relative supply (5) meets the relative demand (7). Then we can isolate the price wedge $\{\tau_i\}$ from the aggregate $\{\tau_i q_i\}$ solved above.

For locations that have fully specialized floor space use, the equations above implied by the interior solutions could not be directly applied. In those cases, we manually assign values to the primitives such that those corner cases are consistent with our model. First, we drop the locations with unreasonable values from our data, namely, a location with zero commercial space but positive employment, or a location with zero residential space but positive population. Second, if $H_{Ri} = L_{Ri} = 0$, we let $\tau_i = 0$; if $H_{Ci} = L_{Ei} = 0$, we let $\tau_i = \infty$. In Section 5 where we discuss the distribution of wedges in American cities vs. Taipei, we exclude those extreme values from the analysis. In Section 6 where we conduct counterfactual analyses, we further assume $B_i = \min\{B_k \mid B_k > 0\}$ if $H_{Ri} = L_{Ri} = 0$; $A_i = \min\{A_k \mid A_k > 0\}$ if $H_{Ci} = L_{Ei} = 0$. This is effectively assuming that a fully-specialized commercial neighborhood is a consequence of both its high comparative advantage in commercial activity and an extreme zoning, and vice versa. Once we lift zoning, these fully-specialized neighborhoods will become more mixed-use, but still more specialized than other neighborhoods because of their assumed comparative advantage. In practice, the share of neighborhoods with full specialization is negligible in almost all cities: the highest is Las Vegas (6.2%); all other cities are below 5%, with over half of the 35 cities below 1%.

We have shown that the model primitives $\{A_i, B_i, \tau_i\}$ can be inferred only using data on population ($\{L_{Ri}\}$), employment ($\{L_{Ci}\}$), residential floor space ($\{H_{Ri}\}$) and commercial floor space ($\{H_{Ci}\}$), while taking parameters $\{\alpha, \gamma, \epsilon, \kappa\}$ and commuting time matrix $\{1 - t_{ij}\}$ as given.

D Commuting Times

For the inference of τ_i, we need to compute the working time $t_{ij} = 1 - d_{ij}$, where d_{ij} is the commuting time. Here, we normalize 10 hours to be 1 unit of time endowment, assuming that this represents the maximum time a person can work in a day. To obtain neighborhood-level bilateral commuting times, we consider private and public transit modes for Taipei. For the U.S. cities, only the private mode is considered (the commuting times are driving times). When both modes are considered, there is an estimation procedure for the expected commuting time d_{ij} based on a discrete choice model.

D.1 Travel Times by Mode

To calculate bilateral travel times among neighborhoods, we first specify the geographic centroid of each neighborhood.[21] For both Taipei and U.S. cities, we calculate bilateral travel times by private vehicles, $\tilde{d}_{ij}^{\text{prv}}$, using Open Source Routing Machine (OSRM), a routing tool for driving, walking, and bicycling based on OpenStreetMap data. A known limitation of OSRM is its tendency to underestimate actual travel times because it does not account for real-time traffic conditions. To correct for this, we scale up the OSRM estimates using Google Maps as a benchmark.[22]

For Taipei, bilateral travel times by public transit, $\tilde{d}_{ij}^{\text{pub}}$, are obtained from the Transport Data eXchange (TDX), a routing service provided by Taiwan's Ministry of Transportation and Communications (MOTC). The TDX routing service calculates the shortest travel time using a combination of the rail system,[23] buses, and walking. It allows detailed choices

[21] For neighborhoods in Taipei that include large uninhabitable areas—such as mountains or riverbank parks—we reassign the representative coordinates to a location within the inhabitable portion of the neighborhood. Only 57 out of 1,247 neighborhoods are affected by this adjustment.

[22] For each of the 31 districts in Taipei, we select the neighborhood in which the district office is located. Second, we extract the travel times by driving by querying the Google Maps API for these neighborhood pairs when the travel starts at 10 am on Wednesday. Third, we run a log-linear regression of the Google Maps travel times by driving on OSRM travel times. The two sets of travel times are strongly correlated, with an R-squared of 0.837. Based on the estimated coefficients—0.702 for the slope and 2.532 for the intercept—we adjust all OSRM travel times accordingly. For U.S. cities, we apply the same scaling factor used for Taipei.

[23] The rail system in Taipei includes Mass Rapid Transit (MRT), traditional rail lines, and the high-speed rail.

of parameters such as departure time, maximum transfer time between different modes or buses, and maximum walking time for the first and last miles. We calculate the bilateral travel times for departures at 10:00 a.m. on Wednesdays, a maximum transfer time of 60 minutes, and a maximum walking time of 30 minutes for the first and last miles.[24]

D.2 Expected Commuting Times

Here, we describe how the commuting time d_{ij} is estimated for the cities where both private and public transit are considered. To account for the mode choices, assume that every worker has idiosyncratic draws across all pairs of locations from a Gumbel distribution with a dispersion parameter ν. For a worker living in i and working in j, her probability of choosing mode m is given by

$$P_{ij}^{m} = \frac{e^{-\tilde{d}_{ij}^{m}/\nu}}{\sum_k e^{-\tilde{d}_{ij}^{k}/\nu}}.$$

In our implementation, we consider only two modes: public transport (including the rail system, buses, walking, and bicycles) and private transport (using private vehicles such as cars and motorcycles). As in Allen et al. (2015), the value of ν is chosen so that the model-generated fraction of people choosing to take public transport matches the data counterpart.

For Taipei, the fraction of commuters using public transit is 42.1%. The resulting ν is 0.891. See next subsection for details of this calculation. Note that $1/\nu = 1.12$ is the elasticity of mode choices. We can then compute d_{ij} as the expected travel time for an individual living in i and working in j:

$$d_{ij} = -\nu \log \left[0.5 \times \left(\exp\left(-\frac{\tilde{d}_{ij}^{\text{pub}}}{\nu} \right) + \exp\left(-\frac{\tilde{d}_{ij}^{\text{prv}}}{\nu} \right) \right) \right].$$

Recall that we normalize 10 hours to be one unit of time endowment. Thus, travel times $\tilde{d}_{ij}^{\text{pub}}$ and $\tilde{d}_{ij}^{\text{prv}}$ in hours are divided by 10.

[24] A few neighborhood pairs return no routing results under the above-mentioned setting. There are two reasons: (1) the two neighborhoods are so close that no public transit is provided, as walking is feasible; (2) there are simply no public transit options provided at the specified time, likely because of low demand. For the nearby neighborhoods, the travel time is set equal to the walking time calculated using OSRM in walking mode. For pairs that are not near (with walking times exceeding 30 minutes), we reattempt routing at 10:30 a.m. and again at 11:00 a.m. if still unavailable. Only 20 pairs remain with no results after these steps, so we use the public transit travel times from Google Maps instead.

D.3 Fraction of People Taking Public Transit

The National Travel Survey of Taiwan provides information on mode choices and commuting flows at the district level (the level between neighborhoods and administrative cities). We restrict the sample to our defined metropolitan area (the 31 districts in Taipei City and New Taipei City) and people aged between 20 and 64. We pool the data from 2009-2016 for a larger sample size. The fraction of people taking public transport is 42.1%.

To calculate the fraction of people taking public transport in the model, let I denote a residence district and J denote a workplace district. The fraction is given by

$$S^{\text{pub}}(\nu) = \sum_{I,J} P_{IJ}^{\text{pub}} \pi_{IJ} = \sum_{I,J} \frac{e^{-\tilde{d}_{IJ}^{\text{pub}}/\nu}}{\sum_{k=\text{pub,prv}} e^{-\tilde{d}_{IJ}^{k}/\nu}} \pi_{IJ},$$

where π_{IJ} is commuting flow (as a share) directly available from the National Travel Survey, and $\tilde{d}_{IJ}$ is taken from the population-employment-weighted average of neighborhood-level bilateral travel time as

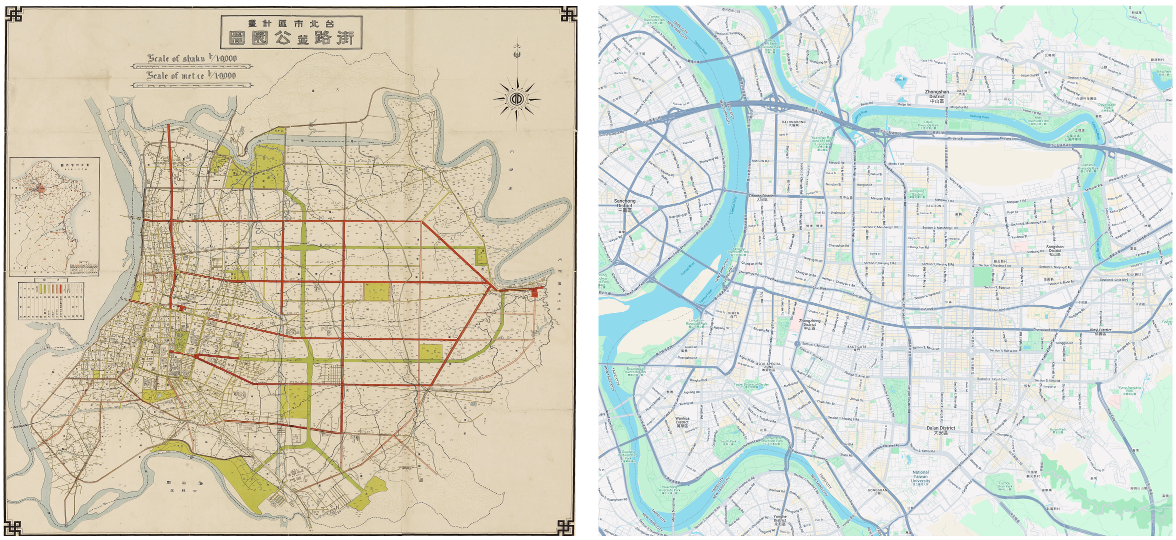
$$\tilde{d}_{IJ}^{\text{pub}} = \sum_{i \in I, j \in J} \frac{L_{Ri} L_{Cj}}{\sum_{i \in I, j \in J} L_{Ri} L_{Cj}} \tilde{d}_{ij}^{\text{pub}},$$

where L_{Ri} and L_{Cj} are the population in neighborhood i and employment in neighborhood j, respectively.

E Historical Background and Spatial Patterns of Taipei's Zoning

Taiwan's urban planning dates back to the early 1900s, beginning in Taipei and Taichung under Japanese colonial rule (Huang, 2000). Early planning focused primarily on infrastructure (such as road networks and sewage systems) and on establishing building standards. Zoning, in terms of land and space usage, began only with the 1936 Taiwan Urban Planning Ordinance, though much of its implementation was delayed until the 1950s due to the Second World War. These early regulations largely followed Japan's 1919 Urban Planning Act, which was notably looser than Western planning frameworks (Sorensen, 2002). Specifically, the regulations often stipulated what was prohibited rather than what was permitted, effectively allowing mixed uses in both residential and commercial zones. As the

Figure A.1: 1932 Taipei City Plan vs. Current Map



A. 1932 Taipei City Plan (Roads and Parks Map) B. Current Roads and Parks (Google Maps, 2026)

Notes: Panel A shows the 1932 City Plan Map of Roads and Parks, whereas Panel B shows the current map from Google Maps (2026) with a similar georeferenced extent. These maps cover the 1932 extent of Taipei City, which is smaller than current Taipei City and the entire metropolitan area. In the historical map, the area along the Tamsui River (the river on the left) and around the Qing dynasty Taipei castle was built up (with a clear depiction of roads and streets), while most of the land east of the built-up areas remained farmland at the time (only planned arterial roads were depicted). The area on the map is now fully developed. The two maps show the striking similarity.

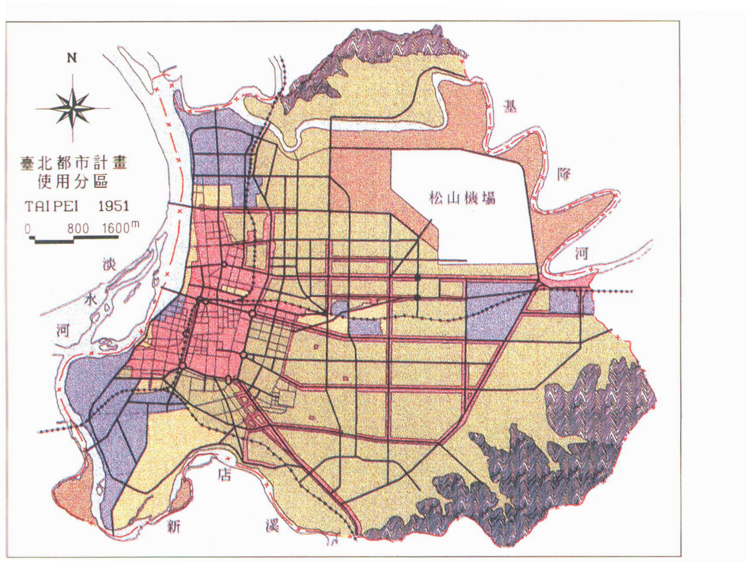
Taipei metropolitan area expanded rapidly after WWII, the urban form and zoning styles established during the colonial era persisted (Huang, 1997, 2000).

To understand the persistence, first note that pre-war Japanese urban planning had already established the legal framework and reserved land for planned development, including road networks and parks. Consequently, it was straightforward for the post-war Kuomintang government to follow and implement these plans without the need for extensive replanning or additional land expropriation. Figure A.1 compares the 1932 city plan map, which illustrates the planned road networks and parks, with a current map from Google Maps as of 2026.[25] The resemblance is striking, with the planned arterial roads successfully materializing into a clearly visible macro-grid.

Secondly, post-war zoning remained as accommodating as the pre-war legal framework, and the interaction between zoning and the road network facilitated the proliferation of mixed-use developments as the city grew rapidly after the war. Figure A.2 presents the

[25]The 1932 City Plan Map covered the extent of Taipei City at the time; while smaller than the present-day boundaries, it remains the economic core of both the current Taipei City and the broader metropolitan area.

Figure A.2: Planned Zoning Map of Taipei City, 1951



Railway — Planned road (< 20 m) — Planned road (> 20 m)

Residential zone — Commercial zone — Industrial zone

Mixed-use zone — Agricultural zone — Hillside land

Notes: The figure is from Huang (2000) who drew the map based on the zoning information from Taipei City Government (1942) (p. 75) and Taipei City Government (1951). The legends are reproduced according to the original map in Huang (2000) and translated by the authors. The commercial zones include the built-up area on the west side (by the river and around the Qing Dynasty castle) and the strip zones along the planned arterial roads. Most of the planned residential zones were still farmland at the time.

1951 zoning map, which combines zoning information from both the pre-war and post-war governments (Huang, 2000). The commercial zones encompassed the pre-war city center (located along the Tamsui River and around the Qing Dynasty Taipei Castle) and all strip zones alongside the planned arterial roads. This figure suggests that pre-war bureaucrats planned the road network assuming an eastward expansion from the city center. They held a monocentric view that the vast farmland east of the core should be developed into residential areas, with residents relying on arterial roads to commute to the city center. As Taipei expanded rapidly during the post-war economic boom, the arterial roads were constructed largely according to this pre-war blueprint. The mega-blocks enclosed by these arterial roads (and the strip commercial zones) subsequently developed into dense residential areas interwoven with smaller grid-style roads, lanes, and alleys.

There are two types of commercial activities: local services and other businesses. Local services tend to operate in proximity to employment and the residential population; thus, lenient zoning permitted them to flourish in both commercial and residential zones.

Conversely, other businesses tended to cluster. Purely commercial buildings (such as office towers) tended to be built in spots (usually around intersections between two arterial roads) where business agglomeration occurred. Because the laws were highly accommodating, a large subset of these commercial activities could even spill over into adjacent residential zones. In other strip commercial zones where the degree of business agglomeration was relatively low, developers often opted to build mixed-use buildings or even purely residential buildings.

Even when the 1973 amendment to the Urban Planning Act required all local governments to strictly enforce zoning (Lai, 1999), municipal ordinances simply became more detailed, largely codifying the mixed-use status quo (as detailed in Section 4). Western-style zoning—characterized by stricter use constraints—only began to influence the cityscape after the 1990s, when opportunities arose to "replot" land on the outskirts of the metropolitan area, mostly transitioning from agricultural or industrial uses. By that time, however, the bulk of the city had already been developed.[26]

F Solving Optimal Zoning in the Model with Externalities

In this appendix, we detail how the optimal price wedges τ_i for all neighborhoods i are calculated.

Consider a social planner who maximizes welfare by setting the floor space prices (q_{Ci}, q_{Ri}), expected income (x_i), labor supply (L_{Ei}), and population distribution (L_{Ri}), subject to the equilibrium constraints defined in Section 2.2.

[26]There are two notable exceptions of replotted areas that were not situated on the metropolitan outskirts: the Xinyi Planning Area and the Neihu Technology Park. These two replotted areas evolved into the city's new central and secondary business districts, respectively.

The planner's objective can be summarized by the following Lagrangian:

$$\begin{aligned}\mathscr{L} = \bar{V} &- \sum_k \lambda_k^V (\bar{V} - V_k) \\ &- \sum_k \lambda_k^H \left[\left(\frac{H_{Ck}}{S} \right)^{\frac{\kappa+1}{\kappa}} + H_{Rk}^{\frac{\kappa+1}{\kappa}} - H_k \right] \\ &- \sum_k \lambda_k^x (W_k + r - x_k) \\ &- \sum_k \lambda_k^{L_E} \left(\sum_l L_{Elk} - L_{Ek} \right) \\ &- \lambda^{L_R} \left(\sum_i L_{Ri} - 1 \right)\end{aligned} \tag{F.12}$$

where the choice variables are $\{q_{Ri}, q_{Ci}, x_i, L_{Ei}, L_{Ri}\}_i$. We define several shorthands for convenience. The probability that a resident of l works in k is

$$\pi_{lk} \equiv \left(\frac{w_k t_{lk}}{W_l} \right)^{\epsilon}. \tag{F.13}$$

The effective labor supplied by residents of l to workplace k is

$$L_{Elk} \equiv t_{lk} L_{Rl} \pi_{lk}^{\frac{\epsilon-1}{\epsilon}}. \tag{F.14}$$

The relative intensity of commercial use to residential use in neighborhood i is

$$\Omega_i \equiv \frac{(H_{Ci}/S)^{\frac{\kappa+1}{\kappa}}}{H_{Ri}^{\frac{\kappa+1}{\kappa}}}. \tag{F.15}$$

And note that combining Equations (1), (3), and (8), the rebate r can be simplified to

$$r = \left(\frac{1}{\alpha(1-\gamma)} - 1 \right) \sum_i W_i L_{Ri} \equiv (\varrho - 1) \sum_i W_i L_{Ri}. \tag{F.16}$$

In Section 7, we discussed how the externalities show up in the model through spillovers in the residential amenities. We can rewrite Equation (15) with a generalized functional form:[27]

$$B_i = \bar{B}_i \left(\frac{L_{Ri}}{H_i}\right)^{\chi_R} \left(\frac{L_{Ei}}{H_i}\right)^{\chi_C}. \tag{F.17}$$

Taking the derivative of the Lagrangian (F.12) with respect to q_{Ri}, q_{Ci}, x_i, L_{Ei}, and L_{Ri}, we have the following first-order conditions:

$$(\partial q_{Ri}): \quad \lambda_i^V \left(-\gamma \frac{V_i}{q_{Ri}}\right) - \lambda_i^H \left(-\frac{\kappa+1}{\kappa} \frac{H_{Ri}^{\frac{\kappa+1}{\kappa}}}{q_{Ri}}\right) = 0 \tag{F.18}$$

$$(\partial q_{Ci}): \quad -\lambda_i^H \left(-\frac{\kappa+1}{\alpha\kappa} \frac{(H_{Ci}/S)^{\frac{\kappa+1}{\kappa}}}{q_{Ci}}\right) - \sum_k \lambda_k^x \frac{\partial W_k}{\partial q_{Ci}} - \frac{\partial r}{\partial q_{Ci}} \left(\sum_k \lambda_k^x\right)$$
$$- \sum_k \lambda_k^{L_E} \left(\sum_l \frac{\epsilon-1}{\epsilon} \frac{L_{Elk}}{\pi_{lk}} \frac{\partial \pi_{lk}}{\partial q_{Ci}}\right) = 0 \tag{F.19}$$

$$(\partial x_i): \quad \lambda_i^V \left(\frac{V_i}{x_i}\right) - \lambda_i^H \left(\frac{\kappa+1}{\kappa} \frac{H_{Ri}^{\frac{\kappa+1}{\kappa}}}{x_i}\right) + \lambda_i^x = 0 \tag{F.20}$$

$$(\partial L_{Ei}): \quad \lambda_i^V \chi_C \frac{V_i}{L_{Ei}} - \lambda_i^H \frac{\kappa+1}{\kappa} \frac{(H_{Ci}/S)^{\frac{\kappa+1}{\kappa}}}{L_{Ei}} + \lambda_i^{L_E} = 0 \tag{F.21}$$

$$(\partial L_{Ri}): \quad \lambda_i^V \chi_R \frac{V_i}{L_{Ri}} - \lambda_i^H \frac{\kappa+1}{\kappa} \frac{H_{Ri}^{\frac{\kappa+1}{\kappa}}}{L_{Ri}} - (\varrho - 1) W_i \left(\sum_k \lambda_k^x\right) - \left(\sum_k \lambda_k^{L_E} \frac{L_{Eik}}{L_{Ri}}\right) - \lambda^{L_R} = 0 \tag{F.22}$$

Solving for the Lagrange multipliers $\lambda_i^H, \lambda_i^x, \lambda_i^{L_E}, \lambda^{L_R}, \lambda_i^V$ from (F.18), (F.20), (F.21), and

[27] To see this, define $\chi_R = \zeta\eta$, $\chi_C = (1-\zeta)\eta$.

(F.22) yields

$$\lambda_i^H = \lambda_i^V \gamma \frac{V_i}{\frac{\kappa+1}{\kappa} H_{Ri}^{\frac{\kappa+1}{\kappa}}}, \tag{F.23}$$

$$\lambda_i^x = -\lambda_i^V (1-\gamma) \frac{V_i}{x_i}, \tag{F.24}$$

$$\lambda_i^{L_E} = \lambda_i^V \frac{V_i}{L_{Ei}} (\gamma \Omega_i - \chi_C), \tag{F.25}$$

$$\frac{\lambda^{L_R}}{\bar{V}} = (\chi_R - \gamma) \sum_i \lambda_i^V + r(1-\gamma) \left(\sum_k \frac{\lambda_k^V}{x_k} \right) - \sum_k \lambda_k^V (\gamma \Omega_k - \chi_C), \tag{F.26}$$

$$\lambda_i^V = \frac{\frac{\lambda^{L_R}}{\bar{V}} L_{Ri} - (\varrho - 1)(1-\gamma) W_i L_{Ri} \left(\sum_k \frac{\lambda_k^V}{x_k} \right) + \left(\sum_k \lambda_k^V \frac{L_{Eik}}{L_{Ek}} (\gamma \Omega_k - \chi_C) \right)}{\chi_R - \gamma} \tag{F.27}$$

To get Equation (F.26), use $\sum_i L_{Ri} = 1$ and $\sum_i L_{Eik} = L_{Ek}$.

Before solving the optimal price ratio q_{Ci}/q_{Ri} from (F.19), we compute several derivatives and identities that are needed for the algebra:

$$\frac{\partial W_k}{\partial q_{Ci}} = -\frac{1-\alpha}{\alpha} \frac{W_k \pi_{ki}}{q_{Ci}}, \tag{F.28}$$

$$\frac{\partial r}{\partial q_{Ci}} = -\frac{1-\alpha}{\alpha} \frac{\varrho - 1}{q_{Ci}} \sum_l W_l \pi_{li} L_{Rl}, \tag{F.29}$$

$$\frac{\partial \pi_{lk}}{\partial q_{Ci}} = -\epsilon \frac{1-\alpha}{\alpha} \frac{\pi_{lk}}{q_{Ci}} \left(\mathbf{1}\{k = i\} - \pi_{li} \right), \tag{F.30}$$

$$\sum_l W_l \pi_{li} L_{Rl} = w_i L_{Ei}. \tag{F.31}$$

Substituting Lagrange multipliers $\lambda_i^H, \lambda_i^x, \lambda_i^{L_E}$ into (F.19), and using $\Omega_i = \frac{H_C}{H_R} \Omega_i^{1/(\kappa+1)} S^{-1}$ and (7), we obtain

$$\frac{q_{Ci}}{q_{Ri}} = \frac{\lambda_i^V + (\epsilon - 1)(1-\alpha) \left[\lambda_i^V \left(1 - \frac{\chi_C}{\gamma \Omega_i} \right) - \sum_k \lambda_k^V \left(\frac{\Omega_k}{\Omega_i} - \frac{\chi_C}{\gamma \Omega_i} \right) \left(\sum_l \frac{L_{Elk}}{L_{Ek}} \pi_{li} \right) \right]}{\alpha (1-\gamma) x_i L_{Ri} S \Omega_i^{-\frac{1}{\kappa+1}} \left[\sum_k \frac{\lambda_k^V}{x_k} \frac{W_k \pi_{ki}}{\sum_l W_l \pi_{li} L_{Rl}} + (\varrho - 1) \left(\sum_k \frac{\lambda_k^V}{x_k} \right) \right]}. \tag{F.32}$$

The system of I equations given by (F.32) replaces the role of laissez-faire supply curve (5) in pinning down the price ratio in the optimal zoning problem.

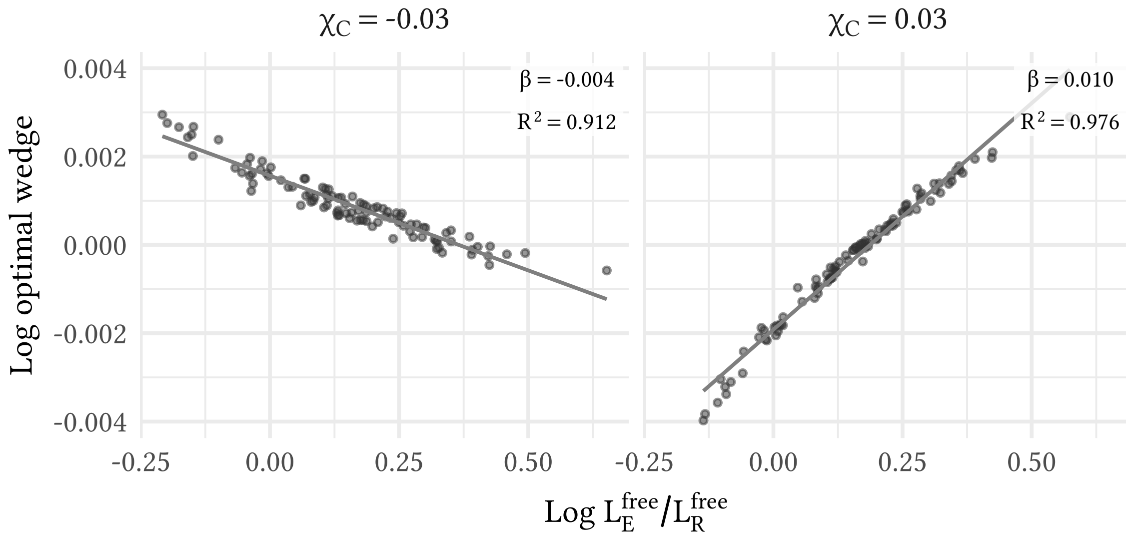
The optimal wedge τ_i^* is simply the gap between the optimal price ratio and the laissez-faire price:

$$\log \tau_i^* = \log \frac{q_{Ci}^*}{q_{Ri}^*} - \log q_i. \tag{F.33}$$

To illustrate the relationship between the optimal wedges τ_i^* and neighborhood characteristics, we solve for τ_i^* in a stylized city with 100 neighborhoods under two scenarios: $\chi_C = -0.03$ which gives a rationale for Euclidean zoning, and $\chi_C = 0.03$ which gives a rationale for mixed Jane Jacobs zoning.[28] Our purpose is to show that a well-targeted zoning policy should strongly correlate with local comparative advantages, as revealed by the employment-residence ratio under a laissez-faire equilibrium. Figure A.3 plots the optimal wedges τ_i^* against $L_E^{\text{free}}/L_R^{\text{free}}$. When the spillovers are negative, the optimal zoning requires a subsidy on commercial land in neighborhoods with a comparative advantage in production (higher $L_E^{\text{free}}/L_R^{\text{free}}$), strengthening the use specialization between neighborhoods. Conversely, when the spillovers are positive, the optimal zoning promotes mixing by imposing a tax on commercial space in productive neighborhoods. Importantly, in both scenarios, the optimal wedges correlate strongly with $L_E^{\text{free}}/L_R^{\text{free}}$, with both R^2's greater than 0.9. Contrasting this with the wedges we observe in American cities shown in Figure 10 and 11, one can see that although the wedges in American cities are positively correlated with $L_E^{\text{free}}/L_R^{\text{free}}$—suggesting mixing intents—the correlation is much weaker than what the optimal zoning would require. This supports our conclusion that even if American cities have some mixing motives in their zoning policies, most of the observed wedges appear to be mistargeted and generate more segregation.

[28]We let $\chi_R = 0$. The distributions of A_i and $\bar{B}_i$ are log-normal with log-mean $\mu = 0$ and log-standard-deviation $\sigma = 0.02$. Off-diagonal entries of t_{ij} are drawn uniformly from $[0.8, 1.0]$ while diagonal entries are set to 1. The other parameters are set to be consistent with our baseline calibration: $\alpha = 0.8, \gamma = 0.25, \epsilon = 20.08, \kappa = 0.45$.

Figure A.3: Scatterplot of optimal log τ^* on log $L_E^{\text{free}}/L_R^{\text{free}}$



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