

# Strong Spatial Spillovers Determine Neighborhood Shape and Neighborhood Change<sup>\*</sup>

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## 1 Introduction

Spatial spillovers or externalities are fundamental to both *defining neighborhoods* and understanding *neighborhood dynamics*. According to Galster (2019), neighborhoods are “externality spaces”—geographic areas where “changes initiated by others (people, institutions, governments, nature) [...] are perceived as altering the well-being [an] individual derives from [their] location” (Galster 2019, p. 25).

This conceptualization has two implications: (1) It provides a spatial definition of a neighborhood based on the geographic extent of perceived externalities, and (2) It describes a dynamic process where one person’s choices may impact another person’s well-being, potentially inducing further changes.

This essay explores how the strength of spatial spillovers defines neighborhoods and drives neighborhood change. Following Galster, spatial spillovers are changes initiated by others that are perceived to alter the well-being of nearby individuals.

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Given a change initiated by others, stronger spillovers result in larger impacts on individual well-being. We focus on three main ideas:

- Spillover strength affects neighborhood definition, specifically the geographic clustering of similar households. We refer to this higher-level spatial organization as the *shape* of neighborhoods. Stronger externalities lead to geographically larger, more distinct neighborhood or community clusters.
- Spillover strength influences the pace of neighborhood change. Stronger externalities make neighborhoods more resistant to change, but may also lead to occasional broad and rapid shifts associated with transitions between equilibrium states.
- Spillover strength impacts where change occurs, with stronger externalities making change more likely at cluster edges and in isolated pockets.

That spatial externalities should link both neighborhood formation, the value of neighborhood amenities, and neighborhood change is not entirely surprising (cf. Galster’s definition of neighborhoods as “externality spaces”). Our goal is to formalize these connections in a neighborhood sorting framework where spatial spillovers are a key factor in determining neighborhood shape and neighborhood change. In this way, spatial spillovers are also core to the “associational inequality,” or inequality in lived experience, that results from segregation across identifiable subgroups (Durlauf 1996b; Graham 2018).

To illustrate these points, we develop a simple, computable equilibrium model of neighborhood sorting based on income. Unlike many existing models, ours treats the geographic extent of clustering of similar households—neighborhood shape—as an endogenous outcome, or one determined by the choices of individuals within the model. While inspired by Schelling’s (1971) work on racial segregation, we extend Schelling-like insights to income-based sorting dynamics, reflecting both recent developments in income sorting patterns in US cities and increased scholarly attention (Couture and Handbury 2020; Hwang and Lin 2016).

An important theme is that (general) equilibrium matters. By general equilibrium, we mean a city with many individual submarket locations that are linked through

households' residential location choices and the prices and externalities they induce. As the appeal of an individual location changes—whether because of a localized policy, a change in technology or preferences, or random chance—households adjust their location choices. These equilibrium adjustments may cascade as households re-sort themselves across all of the locations in the city through displacement and demographic change. The result is that the fortunes of a particular location or neighborhood do not solely depend on what happens there. Instead, localized shocks can have global effects.

This equilibrium view of neighborhoods emphasizes decentralized household choices about where to live, aggregated through housing markets, as a key determinant of the fortunes of neighborhoods and cities. A key margin is increasing prices and rents as households compete for space in desirable areas. Then, neighborhood housing prices and rents reflect the valuation of local amenities of (some marginal) households. Stronger spillovers mean that housing prices and rents will reflect more contemporaneous endogenous factors, such as safety, school quality, or shopping opportunities, versus other factors.<sup>1</sup> This process links changes in neighborhood quality of life with demographic change and displacement.

Our model simplifies many real-world complexities like moving costs (Kennan and Walker 2011), housing (Ellen and Haupert 2025), and discrimination (Freeman and Y. Lee 2025) in order to focus on core ideas. We assume households prefer living near higher-income neighbors to enjoy higher-quality endogenous amenities, though we acknowledge this isn't universally true. We assume households are myopic, even as recent work suggests that forward-looking households may amplify the effect of spatial spillovers and increase the multiplicity of possible outcomes (Aliprantis and Carroll 2018; Allen and Donaldson 2020; Brinkman et al. 2023; M. Davis et al. 2024; Fan et al. 2023). We assume that households have complete information, though

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<sup>1</sup>A useful typology is that neighborhood factors can be either first-nature, second-nature, or contemporaneous and endogenous. First-nature factors are physical landscape features endowed by nature, for example, beaches or hills. Second-nature factors are durable fixed investments endowed by past choices, for example, housing or infrastructure. Endogenous factors are neighborhood characteristics that depend on the contemporaneous choices of others. For example, the type and quality of shopping opportunities in a neighborhood may depend on the near-contemporaneous location choices of landlords, retailers, and other households. For a detailed discussion, see Lin and Rauch (2022).

some recent work shows that incomplete information affects neighborhood choices and thus, potentially, amplifies the role of homophily in neighborhood formation (Caetano and Maheshri 2024; Fan et al. 2023; Ferreira and Wong 2020; Simonsohn 2006; Simonsohn and Loewenstein 2006). We abstract from non-market factors in neighborhood evolution, such as institutional factors, government policy, collective action, or informal social codes (Anderson 2013; Einstein et al. 2020; Massey and Denton 1993; Troesken and Walsh 2019, e.g.).

We also abstract from the micro-foundations of these spatial spillovers, which may have significant scientific and policy implications. Micro-foundations specify the sources, forms, and spatial extents of spillovers. These spatial spillovers might be neighborhood effects, as described by Durlauf (2004) or Wilson (1987). They may stem from homophily, or the tendency for people to seek out those who are similar to themselves, where similarity may be defined on a broad range of characteristics. Alternatively, they might be agglomeration externalities, akin to the characterization of the micro-foundations of agglomeration externalities at the regional or local labor market level of *sharing*, *matching*, and *learning* by Duranton and Puga (2004). For example, spatial spillovers may come from economies in the provision of local public goods, such as trash collection or school quality, that come from sharing fixed costs.

Determining the micro-foundations of spatial spillovers, or the precise sources and forms of spillovers, is important but outside the scope of this essay. (Moreover, there is little existing, comprehensive evidence on the sources, forms, and spatial extents of neighborhood-scale spillovers to guide theory.) Different sources of neighborhood externalities may or may not be observationally equivalent. That is, different micro-foundations of neighborhood externalities might lend themselves to very different mathematical characterizations. For policymakers, the identification of micro-foundations may be crucial, as they might result in a different set of implications for how, when, and which neighborhoods change. Further, the form or spatial extent of spillovers may themselves depend on policy.

These caveats aside, the model delivers sharp yet realistic conclusions that structure the connections between spatial spillovers, neighborhood definition, and neighborhood change. By formalizing these connections, we aim to inform future research on quantifying spatial spillovers. Our framework offers new avenues for measure-

ment of these spillovers, such as examining neighborhood formation patterns or the location of changes, complementing existing methods based on housing prices or migration data. In the conclusion, we discuss how this model can inform thinking about neighborhood change in practice and suggest directions for future research. While we don't make specific policy recommendations, we hope to provide a framework for conceptualizing neighborhood shape and change that can be valuable for research and policy discussions.

## 2 Model

We develop a simple computable model of neighborhood sorting. Our simple model is closely inspired by Schelling (1971)'s spatial proximity model. In Schelling's more-famous bounded-neighborhood model, spillovers occur entirely within neighborhoods. In contrast, the spatial proximity model, as in our model, considers spillovers that may affect neighboring locations. A related line of work inspired by Bailey (1959) (Rose-Ackerman 1975; Rosser 1980) uses simple economic models to understand the shape and dynamics of racial segregation. More recent work develops new theory and evidence on these patterns (Cutler et al. 1999; D. Davis et al. 2024; Harari 2024; Zhang 2011). Compared with this literature, our contribution is to emphasize and spell out the role of spatial spillovers in both defining neighborhoods and neighborhood change. We also show that the insights developed in these papers extend from racial segregation to income sorting patterns.

A large literature in economics develops and studies equilibrium residential location models of racial segregation and income sorting patterns (Almagro et al. 2024; Banzhaf and Walsh 2013; Bayer and Timmins 2005; Epple and Sieg 1999). The model we develop is considerably simpler. A related version of our model was developed in S. Lee and Lin (2018). A crucial distinction is that the spatial organization and geographic clustering of similar households, i.e., the shape of neighborhoods, is an endogenous outcome of our model.

## 2.1 Setup

Consider a linear city with  $j = 1, 2, \dots, J$  locations that are ordered in a sequence as in Figure 1. The locations are equally spaced, with the distances between adjacent locations normalized to 1, and with one unit of housing inelastically supplied in each location. Locations could be blocks, census block groups, or census tracts—the important feature is that each location contains many housing units and households.

Neighborhoods  $n = 1, \dots, N \leq J$  are collections of adjacent locations with similar residents, potentially including just a single location. Neighborhoods could encompass many blocks, many census block groups, or even many census tracts.<sup>2</sup> These clusters may be very large in scale, in which case they may be known as communities, districts, quarters, sides (as in the South Side), or zones. That said, in what follows, we use the term “neighborhoods” to refer to this higher-order spatial organization of households across locations, with the acknowledgment that other terms might be more appropriate at different spatial scales.

In general, the dimensions of household similarity that determine neighborhoods may be broad, including race, ethnicity, national origin, family structure, income, education, occupation, workplace, or preferences and tastes. Here, we focus on similarity in household income.

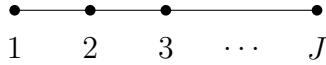


Figure 1: Linear city with  $J$  locations

In each location there is a unit continuum of households, so that in total there is a measure  $J$  of households. Each household  $i$  chooses the location in which they live, and households are heterogeneous in income  $\theta$ , which is exogenous. In each period, each household chooses a location  $j$ , inelastically consumes one unit of housing, pays rent  $R_{j,t}$ , spends the rest of their income on numeraire consumption  $c_{i,t}$ , and receives

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<sup>2</sup>Traditionally, many researchers studying neighborhoods have used census tracts as their unit of analysis, less out of conviction and more out of the convenience and availability of data at this level. Interestingly, at their origin, the Census Bureau relied on local census tract committees in major cities to delineate census tracts according to their “extensive knowledge about the development of an area, its communities and neighborhoods, population shifts, land use, and other information pertinent to establishing or updating small-area geographic units” (U.S. Census Bureau 1994, 3–7).

utility  $A_{j,t} \cdot c_{i,t}$  where  $A_{j,t}$  is the total quality of life in location  $j$  in period  $t$ .

Locations vary in their endogenous total quality of life, which consists of three parts:

$$A_{j,t} = \alpha_j + \sigma \sum_{k \neq j} \rho(\tau_{j,k}) \mathbb{E} \theta_{k,t} + \epsilon_{j,t} \quad (1)$$

First,  $\alpha_j$  is the persistent, exogenous amenity value offered by a home in  $j$  in all periods. This term captures fixed features such as beaches or hills that offer perennial value to households.

Second,  $\mathbb{E}(\theta_{j,t})$  is the average income of location  $j$ 's residents in period  $t$ , an endogenous quantity that is determined in equilibrium. This term intends to capture the value of externalities or endogenous amenities that tend to be positively correlated with household income, such as school quality, public safety, restaurants, and grocery stores.

The model further assumes that location  $j$ 's total quality of life also depends on a weighted average of incomes  $\mathbb{E} \theta_{k,t}$  in *nearby* locations, where  $k \neq j$ .  $\sigma$  parameterizes the strength of spillovers and  $\rho$  describes their attenuation over space, with  $\tau_{j,k}$  measuring the distance between locations  $j$  and  $k$ . For example, the value of a particular block may depend on shopping opportunities or the public safety environment of nearby blocks.

The form and implication of these spillovers is a key focus of this analysis. Assume that a household in  $j$  values the income of their neighbors in immediately adjacent locations  $j - 1$  and  $j + 1$ , or that  $\rho(\tau_{j,k}) = 1$  if  $\tau_{j,k} \leq 1$  but  $\rho(\tau_{j,k}) = 0$  if  $\tau_{j,k} > 1$ . Stronger spillovers correspond to larger values of  $\sigma$ .

Third,  $\epsilon_{j,t}$  captures idiosyncratic amenity shocks to location  $j$  that are specific to period  $t$ . These could be natural shocks, such as localized disasters, or they could be unanticipated localized policy interventions that affect neighborhoods differentially. We assume that  $\epsilon_{j,t}$  are independent and identically distributed with a cumulative distribution function  $G(-\infty, \infty)$ .

Summing up, a type- $\theta$  household solves the following problem in each period:

$$\max_j A_{j,t} \cdot (\theta - R_{j,t})$$

## 3 Neighborhood Shape

### 3.1 Equilibria within a Period

Next, we characterize equilibria within a period. Note that in the utility function, total quality of life and numeraire consumption are complements. This complementarity implies that high-income households are willing to pay more for aggregate amenities. Therefore, high-income households sort into superior total quality of life homes by outbidding low-income households, who are then priced out by equilibrium rents.

The complementarity in utility between total quality of life and numeraire consumption allows for the possibility of multiple equilibria. However, this complementarity is adopted in large part because it helps to ensure the existence of an equilibrium. If these components of utility were substitutes, say, where utility in our example were  $A_{j,t} + c_{i,t}$  instead of  $A_{j,t}c_{i,t}$ , then an equilibrium might not exist. In this case, depending on the parameterization of the model, there are scenarios in which a high-income household in a high quality of life location would prefer to move. If they instead lived in a location with a lower quality of life, the lower price would allow them to increase consumption of the numeraire good. This can result in a problem where high income households are always “chasing” lower rents and so no equilibrium exists.<sup>3</sup>

Rents are determined in equilibrium so that marginal households (i.e., those with incomes at the quantile thresholds  $\bar{\theta}^j = Q(\frac{j}{J})$ ) are indifferent between locations with adjacent rankings in total amenity value. Indexing locations by amenity value by  $j^*$ , note that this equilibrium condition implies a particular pricing function satisfying  $R_{j^*+1,t} = \bar{\theta}^j + \frac{A_{j^*,t}}{A_{j^*+1,t}} R_{j^*,t}$ . This assumption is made for the sake of exposition, as it greatly facilitates the search for equilibria by imposing that population shares are equal across locations. A standard pricing function would have marginal households away from the quantile thresholds, thus generating different population shares in each location.

With each location accommodating a unit measure of households, locations will be perfectly sorted by income on total amenity value. The top  $\frac{1}{J}$  share of households

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<sup>3</sup>See Durlauf (1996a) for a discussion of this “chasing problem.”

by income will live in the top location by total amenities, the second-highest group of households by income will live in the second-best location by total amenities, and so on. Note, however, that the ordering of locations by total amenity value need not coincide with the spatial ordering of locations. This is due to the sorting induced by the exogenous amenity value  $\alpha_j$  and idiosyncratic amenity shocks  $\epsilon_{j,t}$ .

We find equilibria of the model by using the equilibrium condition of perfect sorting by income. For a potential equilibrium sorting pattern of households, we allocate all households with incomes between the  $Q(\frac{j-1}{J})$  and  $Q(\frac{j}{J})$  quantiles of the income distribution to a given location, repeating until all households are in a location. Then we check if locations have the same ordering by income as by total amenity value. If these orderings coincide, then the sorting considered represents an equilibrium of the model. We find the equilibria of the model by repeating this process for all potential equilibrium sorting patterns.

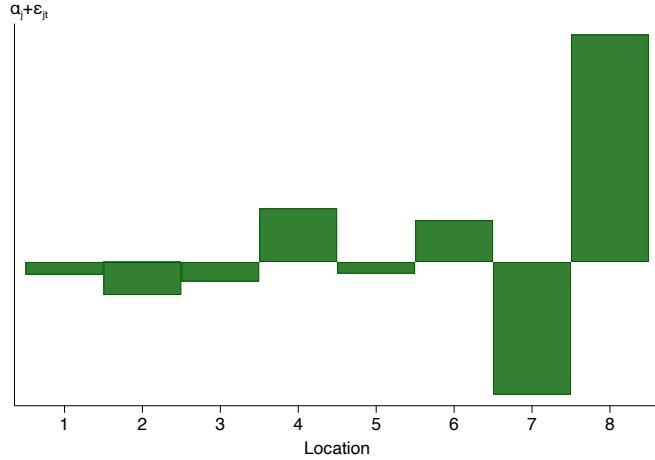
### 3.2 Simulations

Figure 2 shows simulations of equilibrium configurations in environments with eight locations, varying the strength of spillovers  $\sigma$ . Panel 2a displays the simulated exogenous amenities,  $\alpha_j + \epsilon_{jt}$ . These are the “beaches” and “deserts” of each location. Note that for this simulation, location 7 has an especially negative realization and location 8 has an especially positive realization.

The bottom panels display equilibrium neighborhood configurations by color-coding locations as either high-income (above median income, in green) or low-income (below median income, in orange). In each panel, locations are indexed along the horizontal axis. Each row represents a distinct equilibrium sorting configuration. Panel 2b describes a single unique equilibrium in a simulation with no spillovers. Panel 2c describes the three equilibria in a simulation with moderate spillovers. Finally, Panel 2d describes 31 equilibria in a simulation with strong spillovers.

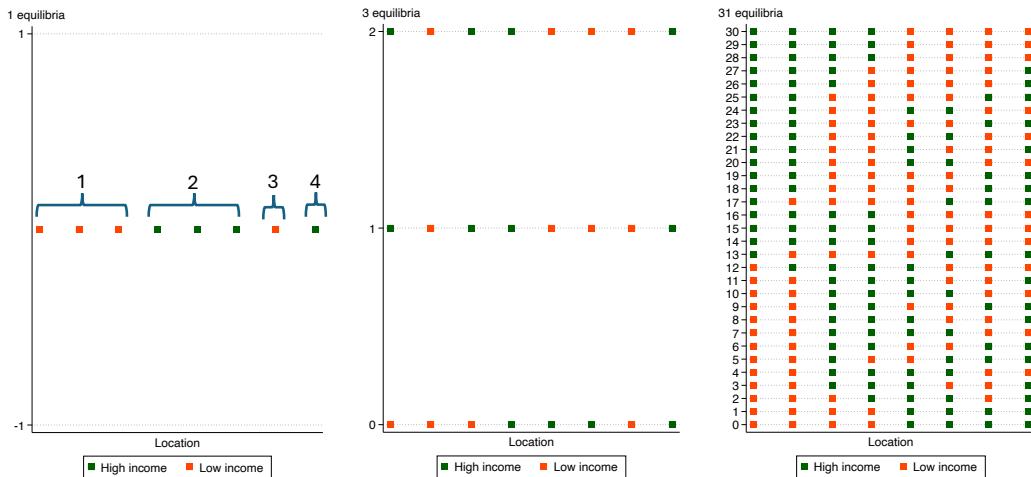
### 3.3 Defining neighborhoods

Define a neighborhood as a spatial cluster of locations in the same quantile of average household income. Let’s begin with the simplest classification—clustering locations



(a) Simulated exogenous amenities

### *Equilibrium neighborhood configurations*



(b) No spillovers

(c) Moderate spillovers

(d) Strong spillovers

Figure 2: Equilibrium Configurations with Eight Locations

Panel (a) shows simulated exogenous amenities for eight locations. Panels (b), (c), and (d) show equilibrium configurations, varying the strength of spillovers from no spillovers to strong spillovers.

into neighborhoods when their average household incomes are above (or below) the city's median. In some ways, this is consistent with ethnographic interview-based mappings of neighborhoods that identify both broad (multi-tract) definitions of neighborhoods and neighborhoods delineated by racial, demographic, and income differences (Hwang 2016). It is also consistent with the close substitutability of contiguous census tracts in households' residential location choice, as evidenced by cross-tract migration flows (Mast 2024), or the spatial contiguity of sorting by race and income (Sharkey 2014). That said, we acknowledge that it might be more appropriate, especially for large clusters, to label these location aggregates with other terms, such as districts or communities.

In Panel 2b, with no spillovers, there are four neighborhoods. These neighborhoods are labeled above braces. Locations 1–3 constitute the first (low-income) neighborhood; locations 4–6 the second (high-income) neighborhood, location 7 is on its own the third (low-income) neighborhood, and location 8 is the fourth (high-income) neighborhood. Note that these patterns are determined uniquely by nature: only simulated exogenous amenities  $\alpha_j$  and shocks  $\epsilon_{jt}$  determine this equilibrium since spillovers are set to zero. High-income households live in the four highest-ranked locations by exogenous amenities.

In Panel 2c, with moderate spillovers, there are three equilibria. There are five neighborhoods in two of the equilibria and four neighborhoods in the remaining equilibrium. Equilibrium 0 is the same as the unique equilibrium obtained in the no-spillover case. Note that in all of the three equilibria, low-income households live in the bottom-ranked location by exogenous amenities (location 7), and high-income households live in the top-ranked location by exogenous amenities (location 8).

In Panel 2d, with strong spillovers, there are 31 possible equilibria. (Equilibrium 2 shows the existence of a similar equilibrium observed in the two other spillover cases. Equilibria that appear to duplicate others represent within-neighborhood reorderings of household incomes.) Often, there are only two neighborhoods: a four-location low-income neighborhood and a four-location high-income neighborhood. In fact, in 20 of the possible equilibria, there are three or fewer neighborhoods. There are some equilibria where high-income households live in the bottom-ranked location by exogenous amenities (location 7); there are other equilibria where low-income

households live in the top-ranked location by exogenous amenities (location 8).

Intuitively, as households care more about the endogenous incomes of their neighbors (in their location and in neighboring locations) versus exogenous amenities, the number of potential equilibria increases since location choices come to have a self-fulfilling quality. In this simulation, endogenous amenities are strong enough to potentially reverse nature. For example, in some equilibria displayed in Panel 2d, high-income households live in inferior natural amenity locations (i.e., location 7). This is possible and sustained as an equilibrium because households care more about the income of their neighbors than they do about the natural amenities of their location.

Further, neighborhoods tend to get larger as the strength of spillovers increases—even without increasing the spatial scope of spillovers. Recall that in these simulations, the spatial scope of spillovers is fixed to a radius of one location. Yet it's common to see equilibrium neighborhood of sizes of three or four locations. This result links some of the interview-based findings on the modest size of households' perceived neighborhoods (and externality spaces) with the large spatial clusters sometimes characterized by both interview- and demographic-based approaches.

In sum, strong spatial spillovers make clusters of similar households that are geographically large in scale. Spillovers make these large neighborhoods or communities even when the spatial scope of spillovers is small.

## 4 Neighborhood Change

### 4.1 Equilibria across Periods

Having explored the range of possible neighborhoods in equilibrium for one parameterization of this model, we now consider how neighborhoods change as the parameterization of the model changes. One way of interpreting this exercise is in terms of dynamics. The precise exercise is as follows: Given an equilibrium, we take new draws of the idiosyncratic location shocks  $\epsilon_{j,t+1}$ . As long as the current equilibrium remains an equilibrium of the resulting parameterization, we select the current equilibrium for  $t + 1$ . This is a form of inertia or history dependence in sorting patterns

over time. Intuitively, “small” localized shocks do not affect neighborhoods; instead they are sustained by endogenous factors associated with the types of households that continue to live there.

On the other hand, when the new locations shocks  $\epsilon_{j,t+1}$  *rule out* the current period  $t$  equilibrium, we find the set of equilibria of the new parameterization and compute the nearest equilibrium in terms of vector distance (i.e., the equilibrium generating total amenities  $\widehat{A}_{j,t+1}$  that minimize  $\sum_j (A_{j,t} - \widehat{A}_{j,t+1})^2$ ). Intuitively, when localized shocks are “large” enough, they unravel historical sorting patterns. Neighborhood change is then the result of idiosyncratic local shocks and the subsequent decisions of households to re-sort across locations.

The reason we discuss these “dynamics” in terms of new parameterizations of the model is that true dynamics would find a transition path from a given current equilibrium to a new equilibrium. Finding a transition path from one equilibrium to another would require specifying agents’ expectations and beliefs about the future along the transition path, and potentially moving costs to further incorporate initial conditions. Most models like the one we study here must place strong restrictions on either the number of neighborhoods in order to preserve truly dynamic beliefs (as in Aliprantis and Carroll 2018; Brinkman et al. 2023; Chyn and Daruich 2022), or else must place strong restrictions on households’ decision-making in order to allow for rich geographic heterogeneity (e.g. Allen and Donaldson 2020). The discussion of related literature in Greaney et al. (2024) presents a nice summary.

## 4.2 Simulations

Next, we explore the implications of spillovers for neighborhood change using simulations in our framework. Recall that the configurations displayed in Figure 2 reflect potential equilibrium configurations for a given set of exogenous amenities  $\alpha_j$  and a given realization of exogenous amenity shocks  $\epsilon_{jt}$ . Take as given that an equilibrium is selected in this period. Then, in the next period, a new set of exogenous amenity shocks  $\epsilon_{j,t+1}$  is drawn, leading to a potentially new set of potential equilibrium configurations. Under our selection rule, we choose the next period’s equilibrium that is closest to the prior period’s equilibrium.

The first thing to note is that, in this framework, neighborhood change is the result of change in general equilibrium. Thus, small shocks can result in large, global changes. Intuitively, a small shock to one neighborhood might not seem consequential. But, if it is large enough to affect the relative attractiveness of this neighborhood compared with others in the city—in particular, given our selection rule, if it rules out the current sorting equilibrium—then the entire household population will re-sort across locations, potentially leading to dramatic changes.

Figure 3 characterizes the dynamics of this model using simulation. We begin with the no-spillovers equilibrium shown previously in Figure 2b: A low-income neighborhood in locations 1–3, a high-income neighborhood in locations 4–6, a low-income neighborhood in location 7, and a high-income neighborhood in location 8. Panel 3a shows this pattern as orange (low-income) and green (high-income) bars. Next, given this starting point in period  $t$ , we simulate 1,000 random exogenous amenity shocks  $\epsilon_{j,t+1}$ . For each of the 1,000 draws in  $t + 1$ , we select the equilibrium configuration that is closest to the prior period equilibrium in period  $t$ . Then, we compare each equilibrium to the prior period equilibrium in period  $t$ . Panel 3a summarizes these 1,000 comparisons for each location. Each bar displays the share of 1,000 simulations that resulted in a change from a high-income to a low-income location, or vice versa. (For ease of visualization, transitions from low- to high-income locations are displayed above zero and those from high- to low-income are displayed below zero.)

A key feature of the no-spillover case shown in Panel 3a is that each location is about as equally likely to change income quantile. Intuitively, without spillovers, the only factor determining the geography of income are the exogenous fundamentals and shocks. Thus, given the random shock process, each location is equally likely to flip from high- to low-income or vice-versa.

Panel 3b shows results for the case with moderate spillovers. We hold constant from the no-spillover case both (i) the initial equilibrium configuration of “LLLH-HHLH” and (ii) the identical set of 1,000 random exogenous amenity shocks  $\epsilon_{j,t+1}$ .

Note several apparent differences in neighborhood and location dynamics in the moderate versus no spillover cases. Aggregating across locations, change is less likely (only one location, 7, experiences a change in income quantile in more than half of the simulated periods). Low-income locations 1, 2, and 3 are significantly less likely

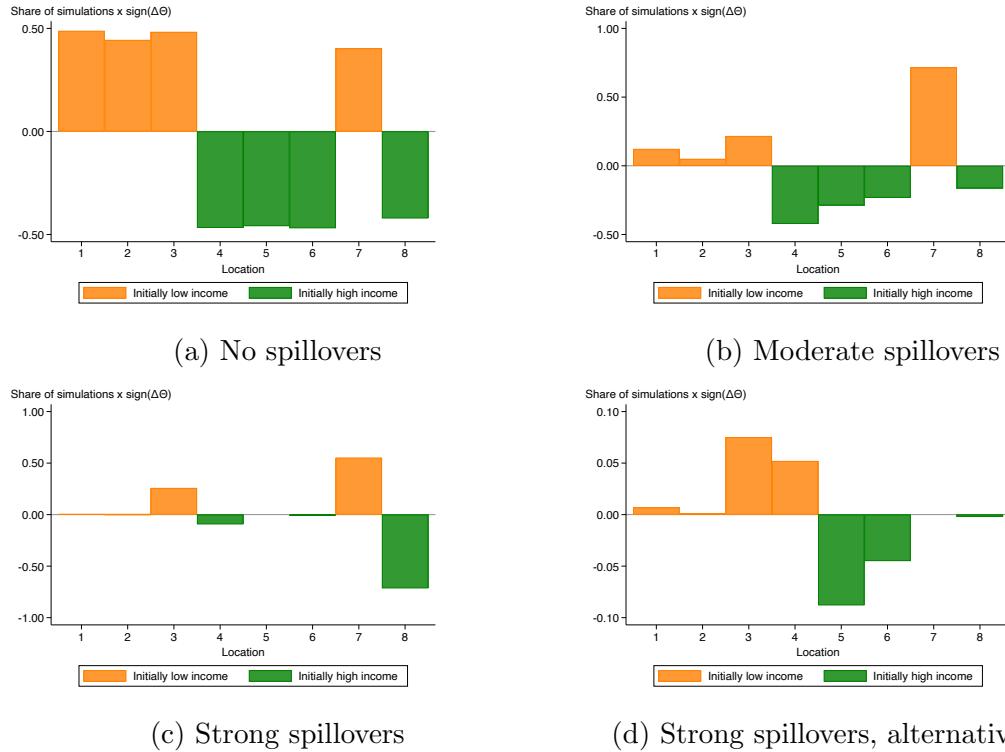


Figure 3: Dynamics, varying spillovers and initial conditions

to transition to high-income locations. Similarly, high-income locations 5, 6, and 8 are significant less likely to transition to low-income locations. However, low-income location 7 is significantly *more* likely to transition to a high-income location. High-income location 4 is about as equally likely as the no-spillover case to transition to a low-income location.

In other words, the larger neighborhoods have become more resilient to random shocks and more persistent. On the other hand, the smaller, isolated enclave (location 7) has become significantly more susceptible to random shocks and prone to dramatic income change. Spillovers make larger clusters more persistent and isolated locations more susceptible to change.

Yet stronger spillovers further illustrate this point, in Panel 3c. Again keeping initial conditions and the random shock draws constant, interior locations—1, 2, and 5—in the larger neighborhoods rarely, if ever see any change. Change instead is concentrated into the two singleton locations—7 and 8.

Interestingly, there's some change observed in the boundary locations of the big neighborhoods: locations 3, 4, and 6. We can observe this pattern more clearly if we change the initial conditions. Suppose we begin with the initial equilibrium configuration of two neighborhoods: a low-income neighborhood spanning locations 1–4 and a high-income neighborhood spanning locations 5–8. Then, run a similar experiment drawing random shocks 1,000 times and selecting the closest equilibrium configuration to this initial one. The results are shown in Figure 3d. Neighborhood changes are often observed at the neighborhood boundary, but almost never in neighborhood interiors. Thus, spillovers concentrate neighborhood change at neighborhood boundaries.

## 5 Discussion

The simple model that we develop omits several channels that are likely important. We assume households prefer living near higher-income neighbors to enjoy higher-quality endogenous amenities, though we acknowledge this isn't universally true. See Galster (2019) and Galster and Turner (2017) for nice summaries of the variety of views and evidence on this point. We have also focused only on neighborhood income sorting. In reality, households may make residential location choices on a broad range of characteristics, including factors that may be more salient such as race, school quality, family structure, or housing.

In our simple model, households do not face moving costs. This simplifies the analysis considerably (see the discussion in section 4.1). If moving was costly, then households would likely factor future conditions into their choices. Recent work suggests that allowing for forward-looking households might serve to amplify the effect of spatial spillovers and increase multiplicity of equilibria (Allen and Donaldson 2020; Brinkman et al. 2023; Fan et al. 2023). Moving costs might also differentially affect the entry and exit of homeowners versus renters and the trajectories of their neighborhoods.

Similarly, households may not have complete information about neighborhood amenities. This incomplete information affects neighborhood choices and thus, potentially, amplifies the role of homophily in neighborhood formation. There is some

recent work with promising steps in this direction (Caetano and Maheshri 2024; Fan et al. 2023; Ferreira and Wong 2020; Simonsohn 2006; Simonsohn and Loewenstein 2006).

Our model and discussion have focused on one source (or one reduced form) of local spillovers. The interactions between multiple dimensions can illuminate patterns in the data, see Quillian (2012) as an example. Future work might specify different micro-foundations and consider their implications (cf. Combes et al. 2012, for an analysis in a similar spirit at the regional or metropolitan scale). There may also be multiple sources of spillovers that operate at different spatial scales, what Galster (2019) refers to as “generality.” We have also specified homogeneity in spatial spillovers—households experience spatial spillovers symmetrically (cf. Galster 2019, who calls this “accordance”). Future work could relax the restrictions that we have made here. To inform this work, more evidence is also needed on the sources, scale, and spatial scope of spillovers. To this end, the increased availability of spatially detailed data, at the block, house, or individual level, will be especially valuable (Couture et al. 2025; Logan and Martinez 2018), as well as data based on ethnography and surveys of residents (Wileden and Talen 2025).

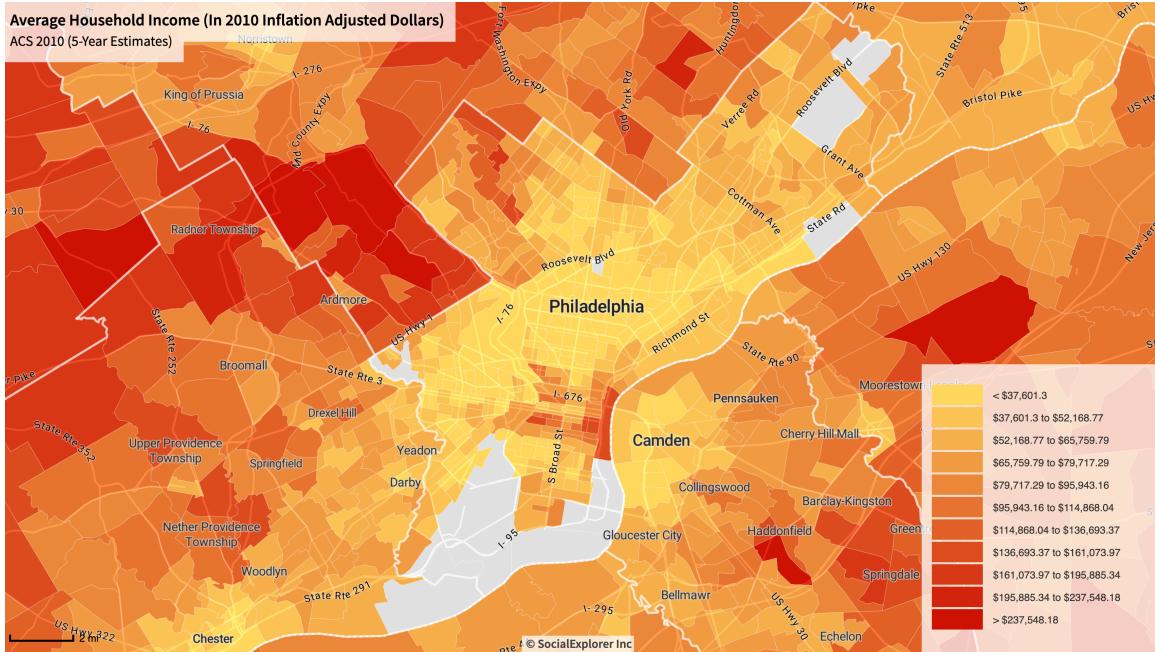
We have also omitted local jurisdictions and amenities or goods that are rationed according to sharp boundaries, e.g., school districts. These boundaries may be important determinants of sorting patterns (Maheshri and Whaley 2024).

Despite the extreme simplifications we have made, the model surprisingly generates predictions that resemble real-world patterns.

First, consider the shape of neighborhoods. Figure 4a shows average household income for Census tracts in the Philadelphia region in 2010, according to the American Community Survey 5-year Estimates. Tracts are colored from low-income (yellow) to high-income (red). Note the small cluster of high-income tracts in central Philadelphia surrounded by large clusters of low-income tracts in north and west Philadelphia and east of Philadelphia in Camden, New Jersey. Large clusters of high-income tracts can be seen farther out, notably in the northwestern suburbs of Montgomery, Delaware, and Chester counties, as well as farther east in New Jersey.

Interestingly, these large clusters—each containing many census tracts—are consistent with the implications of our model with strong spatial spillovers. In contrast,

(a) Average household income in 2010



(b) Change in average household income, 2010–2022

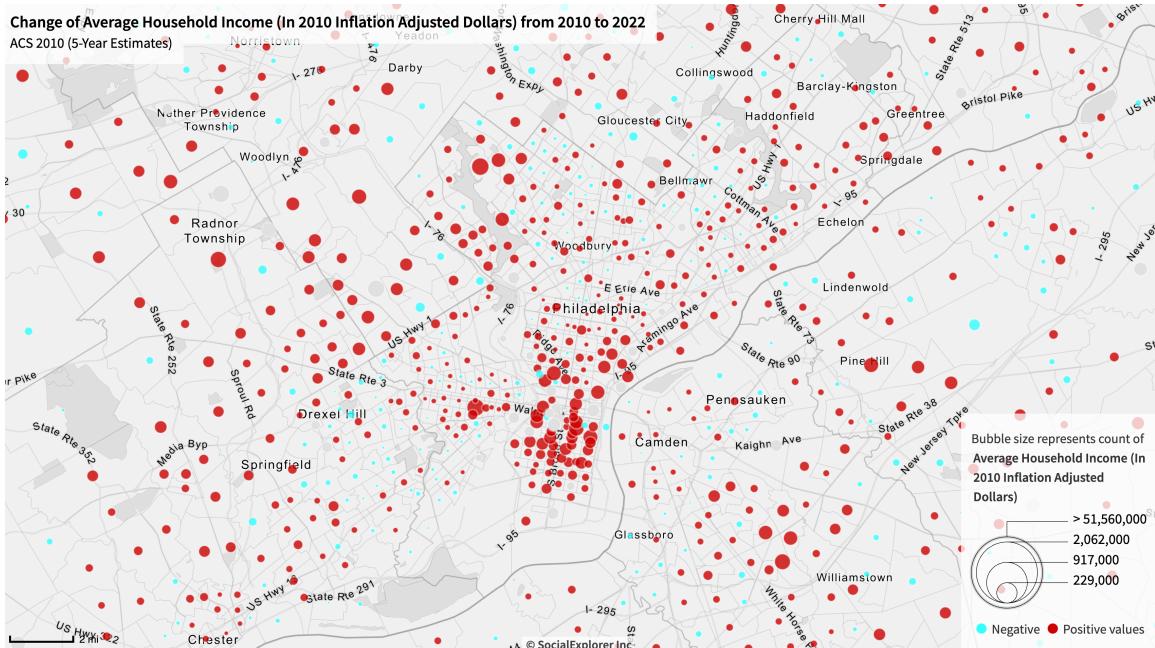


Figure 4: Census tract incomes and changes

Source: American Community Survey 5-year estimates, 2010 and 2022; Social Explorer.

ethnographic studies often observe that households' self-described neighborhoods are quite small—e.g., smaller than a census tract (Coulton et al. 2013; Wileden and Talen 2025). Strong and overlapping spatial spillovers help to reconcile small perceived neighborhoods and large clusters of contiguous locations of similar incomes. Of course, there are other plausible explanations for these patterns. We leave the task of distinguishing the role of spillovers from other factors, such as exogenous amenities or characteristics of the housing stock, to future research.

These observations also accord with migration patterns within U.S. cities. Using granular migration data and a community detection algorithm, Mast (2024) finds clusters of five to ten census tracts that see a disproportionate amount of cross-migration. One interpretation of this result is that households view these groups of census tracts as close substitutes, even if they perceive their own neighborhoods as smaller spatial units.

The model also can help explain and understand patterns of neighborhood persistence and change. Figure 4b shows income changes in census tracts between 2010 and 2022. The sign of the change is indicated by color; blue circles indicate income declines and red circles indicate income growth. The size of the change is indicated by the size of the circle.

Changes appear concentrated near boundaries of clusters defined by 2010 income. In central Philadelphia, low-income census tracts just north, south, and west of Center City experienced the largest increases in income. Tracts in northwest Philadelphia, near high-income suburban tracts, also experienced large increases in income. Conversely, tracts in high-income suburban areas that were closest to low-income areas in the City of Philadelphia and in the southwestern inner suburbs of Delaware County saw the largest declines in income.

This pattern echoes the findings of Guerrieri et al. (2013). In response to a city-wide demand shock, high-income locations expand into lower-income neighborhoods that directly abut the initial richer neighborhoods. D. Davis et al. (2024) show a similar pattern for race-based neighborhood change; In simulations and in mid-century U.S. cities, racial and demographic change occurs at boundaries of clusters. Similar patterns may be expected as a result of climate adaptation (Lamb et al. 2025).

The model's predictions are also consistent with literature findings on neighbor-

hood persistence and change. Persistence in neighborhood status is quite common (cf. Malone and Redfearn 2018; Rosenthal 2008). At a slightly more aggregate spatial level, central cities have been relatively low-income for over a century, even accounting for the recent gentrification of central cities (S. Lee and Lin 2018).

On the other hand, there is evidence of dramatic and rapid neighborhood change in the face of large shocks. In the wake of the Great Migration of African-Americans to northern cities, central cities experienced rapid white flight and demographic change (Boustan 2010; Shertzer and Walsh 2019). Recent rapid gentrification of central city US neighborhoods appears to be the result of a large taste shock for urban living (Couture and Handbury 2020; Hwang and Lin 2016). One interpretation of these historical events is as reflecting shifts between residential sorting equilibria.

## 6 Summary

In this essay, we explored the connections between strong spatial spillovers and both neighborhood shape and neighborhood change using a simple, computable equilibrium model of income sorting.

The model is highly stylized, but it appears to match well some real-world features. One, strong spatial spillovers define large neighborhoods or large clusters of neighborhoods with similar households, even when the spatial scope of externalities is small. Real-world sorting and segregation patterns appear to be at large spatial scales. Two, small shocks can result in large, global changes in spatial patterns of sorting and segregation. Historical episodes such as the recent gentrification of central cities may be consistent with this implication. Three, spatial spillovers make large neighborhoods more persistent and isolated locations more susceptible to change. Statistical evidence appears to support this prediction. Finally, spatial spillovers focus neighborhood change at neighborhood boundaries. This too appears to be consistent with the data.

The extreme simplifications of the model do not lend themselves to explicit policy recommendations. However, this framework can be useful for conceptualizing neighborhood shape and change. Like many economic models, our model builds in a tight connection between location-specific quality of life and sorting and segregation

patterns. As local quality of life in a location improves, high-income households are willing to pay more for housing in that location, out-bidding low-income households. To the extent that real-world housing markets also feature this sort of competition, improvements in local quality of life will be accompanied by similar neighborhood dynamics. The potential for individual choices to either reinforce or unravel policy goals may warrant attention from policymakers.

Our presentation of this model especially emphasizes that spatial spillovers among households, operating in decentralized housing markets, are a key factor in determining neighborhood shape and neighborhood change. To the extent that spatial spillovers are important, our framework suggests that features such as the geographic size and configuration of household clusters, the dynamics of neighborhood formation, and the location of neighborhood change, are informative about the likely responses to localized policies and shocks.

In sum, strong spatial spillovers are central to both neighborhood shape and neighborhood change. The identification of these parameters, then, is fundamental to a range of research questions. Future work might better characterize the nature of these spillovers and better integrate the joint study of these outcomes.

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