Public Education Inequality and Intergenerational Mobility

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Abstract

Public school funding depends heavily on local property tax revenue. Consequently, low-income households have limited access to quality education in neighborhoods with high house prices. In a dynamic life-cycle model with neighborhood choice and endogenous local school quality, we show that this property tax funding mechanism reduces intergenerational mobility and accounts for the spatial correlation between house prices and mobility. A housing voucher experiment improves access to schools, with benefits that can last for multiple generations. Additionally, a policy that redistributes property tax revenues equally across schools improves mobility and welfare. However, the benefits can take generations to be realized.

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1 Introduction

Across the United States, neighborhoods matter for determining intergenerational mobility, the dependence of an individual's economic success on that of their parents. Recent works by Chetty et al. (2014), and Chetty et al. (2018) show that mobility varies substantially within the United States itself, even across small geographic areas. In this paper, we argue that school districts' reliance on funding from local property tax revenue links school resources directly to the socioeconomic status of its neighborhood, and creates disparities in mobility. Intuitively, low-income households have limited access to quality education in neighborhoods with high house prices, which reduces their future incomes. Using a structural model calibrated to school districts in the United States, we quantify the importance of school funding and home values for determining intergenerational mobility.[1]

Using data on intergenerational mobility from Chetty et al. (2018), and school district characteristics, we show that districts with higher house prices had higher mobility, conditioning on parental income. These districts are more expensive and thus, less accessible to low-income families. Next, we study why districts with expensive property offer more opportunity. School revenue data highlights that a significant proportion of district funding is from local property taxes. In addition, districts with higher residential prices collected more revenue per pupil from property taxes. We also find that better-funded districts scored higher on standardized tests.[2]

Building on these facts, our hypothesis is as follows. Districts with higher house prices collect more school revenue, which leads to better academic performance and stronger labor market outcomes. Yet, high property values in well-funded districts limit access to quality schools for lower-income families. Therefore, the relationship between school quality, housing markets, and affordability shapes economic opportunities.

In order to quantify the importance of local school funding for determining intergenerational mobility, we build a heterogeneous agents life-cycle model with human capital accumulation and neighborhood choice. Neighborhoods differ by

[1]Several other papers have focused on the link between school funding and inequality. In the literature review we discuss how our work differs from other works in this area such as: Fernández and Rogerson (1996, 1998), Epple and Romano (2003), Durlauf (1996a,b), Fogli and Guerrieri (2019), Eckert and Kleineberg (2019), and Kotera and Seshadri (2017).

[2]Other studies have shown that increases in per-pupil funding lead to better labor market outcomes. See Jackson et al. (2016), Abott et al. (2020), Miller (2018) for information on how increases in state and local funding improves student outcomes. We discuss these works further in Section 3.

school quality and house prices, which are determined in equilibrium. School quality is determined by per-pupil revenue in the neighborhood, which is collected from a property tax that agents pay on their houses.

In the model, parents choose a neighborhood to live in, taking into account house prices and school quality. Children accumulate human capital from their innate ability, the school quality, and a private education investment by their parent. Once the child becomes an adult, she earns income which is determined by the human capital she gained during her schooling years. Parents are altruistic towards their child, which motivates their willingness to invest in their child's development and to leave them monetary transfers when they become adults.

The neighborhoods in our model represent school districts within a state, and we discipline our parameters by targeting state-level moments such as the intergenerational mobility of income, the Gini coefficient, and the aggregate share of education expenditures, in addition to cross-district income and price ratios. Our main calibration is for New York State, but as a robustness exercise, we show that the model can also be calibrated to fit the data from the ten largest states in the US, as well.

As in the data, the model generates cross-sectional variation in intergenerational mobility: children from low-priced neighborhoods with lower-quality schools have significantly lower mobility. The link between school funding and house prices is key to this result. Children who attend better-funded schools build more human capital, which results in higher income as adults. Consequently, they can afford to live in more expensive neighborhoods, which provides their children with better educational opportunities as well. However, households in lower-priced neighborhoods receive worse education, which produces lower human capital and income. As adults, these households cannot afford to live in neighborhoods with high-quality schools, which hampers their own child's human capital development.

Throughout our structural analysis, we focus primarily on two measures of intergenerational mobility: the probability that a parent in the bottom income quintile will have a child in the bottom income quintile, which we call "the persistence of low income", and, the probability that a parent in the bottom income quintile will have a child in the top income quintile, which we call "economic opportunity."[3] In our counterfactual analysis, we find that holding all else constant, separating the link between school quality and house prices reduces the persistence of low income

[3]The choice of "economic opportunity" terminology is inspired from Chetty et al. (2014) who uses the words "the fraction of children achieving the American Dream" to describe the probability that a parent in the bottom income quintile will have a child in the top income quintile.

by 13 percent for children in the lowest school quality neighborhood. These results suggest that differences in local school quality account for around 32 percent of the cross-sectional variation in the persistence of low income, and around 6 percent of the variation in economic opportunity.

The model is used to evaluate two policies to improve mobility. First, we study a housing voucher program that allows agents to move neighborhoods with higher-quality schools at a subsidized housing price. On average, children whose parents take up the voucher have 27.1 percent higher income as adults. We show that the primary benefits from the voucher arise from being in a neighborhood with a better school, rather than from the income effects of receiving the subsidy. Importantly, we find that the positive impacts of neighborhoods are propagated across generations so that even the great-grandchildren of households who accepted the voucher are better off. The reason is that the children of parents who took the voucher can use their higher income to move to a better neighborhood as well.

Second, we study an environment where school funding is redistributed equally across neighborhoods. We compute the new stationary equilibrium following the policy change, as well as the transition path between the initial and post-policy steady states. When school funding is equalized, persistence of low income in the neighborhood with the worst school quality improves by four percentage points. However, it takes several generations for the mobility benefits of an equal funding policy to be realized. This is both because the incomes of parents exposed to the new policy are not affected by the change, and the policy is a surprise so that parents could not have made prior savings decisions in anticipation of the new school funding environment

Welfare analyses during the transition emphasize that the benefits of the equal school funding policy are highest for middle-income families. Very high income families do not gain as much, since they could afford the best quality neighborhood in the initial steady-state. The poorest families also benefit less because they now have to pay more in house prices. Our analysis underscores that while the equal school funding environment leads to a significant decrease in inequality of income mobility, the interplay between school quality and house prices means that the benefits are dispersed across different households.

The rest of the paper is organized as follows: in Section 2, we discuss the related literature. Section 3 presents motivating evidence and Section 4 outlines the model. In Section 5 we discuss the calibration and model results. In Section 6 we conduct policy experiments and Section 7 concludes.

2 Relation to the Literature

This paper is related to the literature on sorting into neighborhoods and public good provision, notably Benabou (1996, 1994), Durlauf (1996a,b), Fernández and Rogerson (1996, 1998), and Epple and Romano (2003). Our model captures richer features of the human capital accumulation process and the life-cycle. For instance, we have agents of different abilities and we allow parents to invest in the human capital of their child. Parents can also transfer resources to their children. These are dynamic decisions that are important for the future outcomes of children. On the other hand, we abstract from the political economy aspect of the sorting literature and take tax rates as given.

This paper is also close to more recent work on human capital accumulation and life-cycle heterogeneous-agent models. Restuccia and Urrutia (2004) find that about half of the persistence in earnings across generations can be accounted for by investment in childhood education. Lee and Seshadri (2019) use a model with education investment and on-the-job skill accumulation to explain intergenerational elasticities of wealth, income, and college attainment. Daruich (2018) studies the welfare effects of investment in early childhood programs in a general equilibrium setting. Our work differs from these papers in that we explicitly model separate neighborhoods, allowing parents to choose between them. In addition, we incorporate the link between house prices and school funding from local property taxes, to study how it affects mobility. Since local property taxes account for a significant proportion of funding, we feel that it is important to explicitly model how neighborhood choice, house prices, and school funding interact in equilibrium.

Close to our work is a paper by Kotera and Seshadri (2017) that studies how the distribution of public school spending affects intergenerational mobility in the United States. They build a model with human capital accumulation and school district voting on per-pupil spending. However, they assume that the distribution of income across school districts is exogenous, whereas in our case the distribution of income across neighborhoods is endogenously determined: agents have to choose which neighborhood they live in. In a related paper, Durlauf and Seshadri (2018) study the relationship between cross-sectional inequality and mobility with a model of human capital and neighborhood formation. They model neighborhoods as formations of families who set an income requirement, whereas we do so through a housing market clearing condition.

In contemporaneous work, Fogli and Guerrieri (2019) also study the effects of neighborhood segregation on intergenerational mobility. They assume that neighborhood composition affects future incomes directly, although they do not make this mechanism explicit. In contrast, we model the influence of neighborhoods on income directly through the effect of tax revenues from local house prices on school quality. In addition, we study the influence of different mechanisms. We focus on the influence of public school funding while Fogli and Guerrieri (2019) concentrate on the influence of changes in the skill premium.

Other contemporaneous work by Eckert and Kleineberg (2019), studies how spatial inequality in education and labor markets affects intergenerational mobility. In their model, neighborhoods differ by labor market access, school funding, and other amenities. We differ from them in that we investigate how household life-cycle decisions in combination with disparities in school funding affect intergenerational mobility. Parents can transfer resources from one period to the next, knowing that this will influence their child's education through school choice and educational investments. These savings decisions imply that parents with low-ability children but with sufficient resources can significantly improve the human capital of their child. [4] On the other hand, families with very few resources and high-ability children are limited because they cannot afford to live in neighborhoods with good schools.Our study differs from theirs in that we abstract from the spatial dimension of labor markets, but emphasize the relationship between household life-cycle decisions and disparities in school funding.

Finally, related to our question is Biasi (2019), who investigates the effect of having equal per-pupil expenditure on intergenerational mobility using simulated instruments. She uses data on state funding formulas to estimate the effect of increased funding without sorting. Our paper differs from hers in that we take a structural approach to investigating the effect of school funding on mobility that allows us to evaluate the benefits of policies such as housing vouchers and equal school funding.

3 Motivating Facts

Intergenerational mobility varies widely across neighborhoods in the United States, as highlighted by Chetty et al. (2014) for commuting zones and counties, and Chetty et al. (2018) for census tracts. For an individual born in the 1980s whose parent's income falls in the lowest quintile, their own chance of reaching the top quintile ranges from only 2 percent in Greenville, Missouri to 47 percent in Bowman, North Dakota (Chetty et al., 2014). The probability of staying in the lowest

[4]In other work, Caucutt and Lochner (2020) use a life-cycle model with human capital investments to study the importance of credit constraints.

quintile varies from 8 percent, also for Bowman, North Dakota, to 64 percent in Mission, South Dakota (Chetty et al., 2014).

Why is it that some areas propel children from poor families into prosperity whereas in other areas, low-income is persistent across generations? Chetty et al. (2018) find some strong correlates with upward mobility, such as employment rates in the neighborhood, low fraction of single parents, and high test scores. In this paper, we focus on the effects of one particular mechanism in generating variation in mobility. We argue that the relationship between house prices, school funding, and school quality results in vastly different mobility outcomes. Due to the largely decentralized nature of school financing in the United States, a substantial proportion of school revenue is from local property taxes. For this reason, schools in locations with higher house prices benefit from a larger pool of tax revenues. In support of our hypothesis, we bring together data on mobility, school performance, school funding, and house prices. In the next section, we use a structural model to quantify the importance of our mechanism.

To start, Figure 1a) illustrates the relationship between house prices and upward income mobility. The measure of mobility we use is the probability that a parent at the 25th percentile of the national income distribution has a child in the top income quintile, from Chetty et al. (2018).[5] School funding is determined at the school district level though, so we take population-weighted averages of census tract outcomes to aggregate up to district. Districts are then ranked within state by their median house value in 1990, and we plot the average mobility outcome by each quintile of median house value.[6] Each line is a different state. The figure shows that children have a significantly higher probability of reaching the top income quintile as house prices rise. Not that this relationship is conditional on parental income. Thus, the children of parents with the same incomes do markedly better in higher-priced neighborhoods.

While higher-priced locations are associated with greater mobility, Figure 1b) shows that households below the national median income are much less likely to live in these neighborhoods. For example, in Michigan, Ohio, and Pennsylvania school districts in the top quintile of house prices are home to fewer than half the number of low-income families as in districts in the bottom quinitle. Thus, access to higher economic mobility appears to be limited for low-income families.

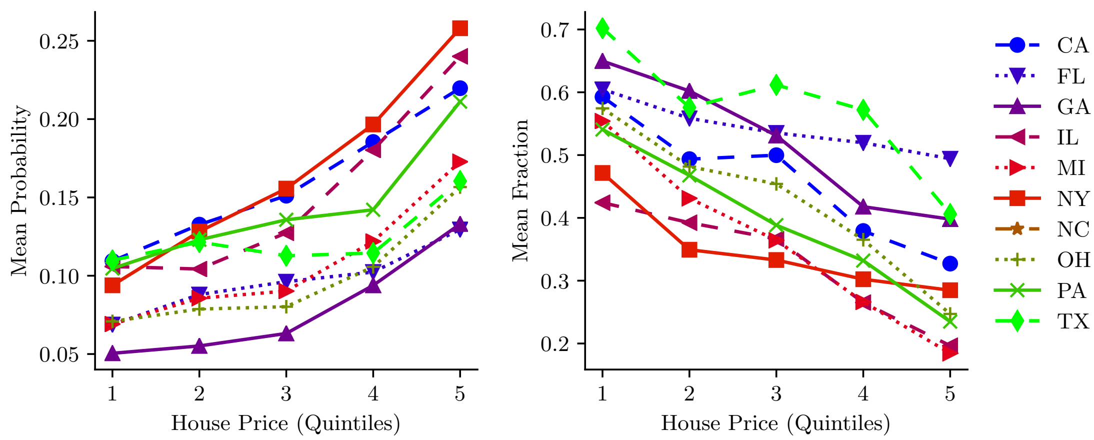
Why is it that higher house price neighborhoods create more opportunity? Here,

[5] Chetty et al. (2018) documents outcomes for children born between 1978 and 1983 at the census tract level.

[6] Median house values for each school district are taken from the 1990 Census, available from the National Center for Education Statistics.

Figure 1: House Prices, Intergenerational Mobility, and Income

(a) $\mathbb{P}(q_5|p_{25})$ (b) Fraction Below Median Income



Note: Figure 1a reports the probability that a child with parents at the 25th percentile of national income becomes an adult in the top 20 percent of the household income distribution for her cohort. This probability is denoted as $\mathbb{P}(q_5|p_{25})$. The data is presented as a bin scatter plot, on the x-axis are the quintiles, by state, for the median house value of school districts, and on the y-axis, is the average probability across school districts in a given quintile that a parent whose income is at the 25th percentile of the income distribution, will have a child in the top income quintile. Figure 1b reports the average fraction of households with incomes below the national median across school districts in a given quintile of median house value. All quintiles and averages are calculated using school district 1990 population weights.
Source: Authors' calculations using data from the 1990 Census, and Chetty et al. (2018).

we show that more expensive neighborhoods have higher school funding, which is associated with better school quality in terms of academic performance. Table 1 reports the average school district share of revenue from local property taxes for 1999 and 2010, for each of the largest 10 states in the US. Districts are weighed by their total student enrollment. The average district in several large states such as Illinois, New York, Ohio, Pennsylvania and Texas receives over forty percent of their funding from local property taxes.

Next, using data on funding and student performance from the early 2010s, we show that property tax revenue for schools is highly correlated with student performance measures at the district level.[7] In Figure 2a) we bin school districts into within-state quintiles by their per-pupil property tax revenue in 2010. On

[7]Ideally we would study this relationship during the late 1980s, so that the timeline matches with the mobility data from Chetty et al. (2018). However, no data is available for test scores during that time frame.

Table 1: Average Share of Public School District Revenue by State

	Share of Revenue from Local Property Taxes	
	1999-2000	2010-2011
California	0.24	0.24
Florida	0.33	0.39
Georgia	0.28	0.31
Illinois	0.47	0.49
Michigan	0.21	0.24
New York	0.46	0.48
Ohio	0.42	0.38
Pennsylvania	0.43	0.45
Texas	0.41	0.41

Notes: Authors' own calculations using data for the 1999-2000, 2010-2011 school years from the National Center for Education Statistics. Each row is the share of revenue from local property taxes for the average school district by state. Averages are weighed by total student enrollment in a district.

the vertical axis is the average school district performance by quintile for Grade 3 Mathematics on the National Assessment of Educational Progress (NAEP) in 2013.[8] Figure 2a) shows a clear positive relationship between per-pupil funding from property taxes and average test scores. Although the relationship illustrated here is not causal, many studies have demonstrated the link between house values and neighborhood school quality. For examples, see Bayer et al. (2007),Barrow and Rouse (2004), Black (1999), Cellini et al. (2010), Clapp et al. (2008), Downes and Zabel (2002), Figlio and Lucas (2004),Kane et al. (2006). Though perhaps obvious, Figure 2b) shows that school districts with higher house values collected more property tax revenue per pupil. This suggests that additional revenue in higher priced locations is not offset by lower tax rates.

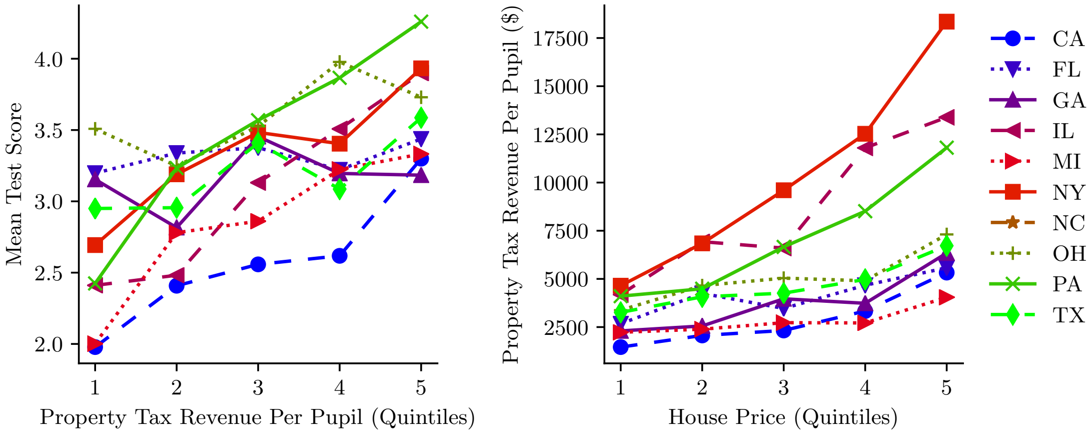
The distribution of per-pupil revenue though, varies widely. In Figures 3a) and 3b) we show the distribution of 2010-11 real per-pupil revenue from property taxes and all sources, respectively. Data on nominal per-pupil revenue is taken from the National Center for Education Statistics. We then deflate revenue using the median

[8]NAEP is a standardized test administered across the United States. The test scores are standardized relative to one grade level differences. For example, a score of two means that the average student in a district performed at the same level on the Grade 3 math test as the average 2nd grade student nationwide. Test score data is from the Stanford Education Data Archive.

Figure 2: House Prices, School Funding, and Test Scores

(a) Average Test Scores

(b) Average Per Pupil Funding From Local Real Estate Taxes



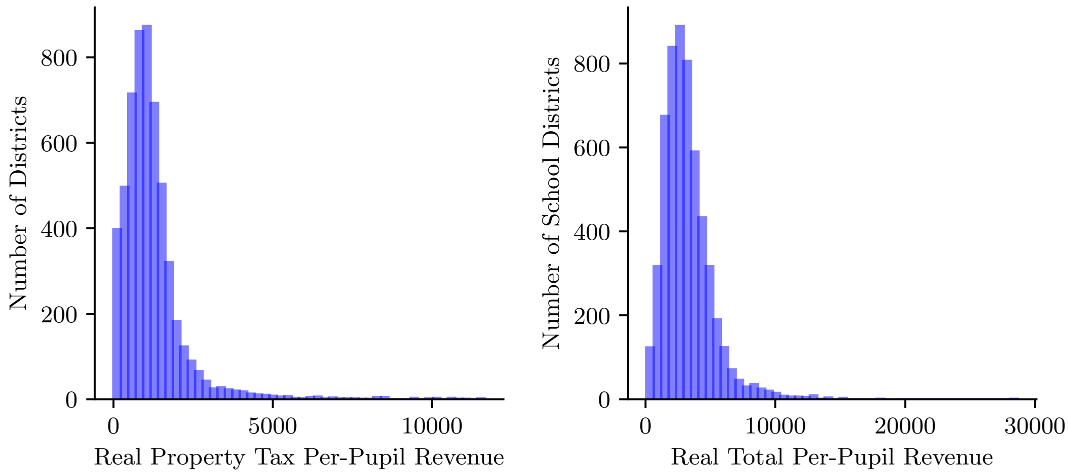
Note: Figure 2a is a bin scatter plot of average test scores and median house values for school districts. The x-axis measures the quintiles, by state, for the median house value of school districts, and on the y-axis, is the average test score across school districts in a given quintile. Test scores are from the National Assessment of Educational Progress (see below for the source). Figure 2b reports the average property tax per pupil for school districts in a given quintile of median house value. All quintiles and averages are calculated using school district 2010 population weights.
Source: Authors' calculations. Test score data is for grade 3 math from 2013, standardized by the Stanford Education Data Archive. Property tax revenue data is for 2010-11 school year from the National Center for Education Statistics. House prices are from the 2010 Census and the National Center for Education Statistics.

county-level house price in order to account for differences in prices across regions. Figure 3a) shows the distribution of real property tax revenue per pupil. There is substantial variation, with a standard deviation of around $1,043. Furthermore, even when considering total revenue per pupil, there is still significant inequality, with a standard deviation of $1,866.

We now summarize the link between school funding and intergenerational mobility. Conditioning on parental income, school districts with more upward mobility have higher house prices. Districts with pricier houses are able to collect more property tax revenue to fund their schools, which in turn is correlated with stronger academic performance. In addition, studies have shown that funding from local and state sources for schools raises graduation rates and future wages. For example, Jackson et al. (2016) study court-mandated reforms in school financing during the 1970s and 1980s that saw states increase the funding they provided to school districts. The authors find that students exposed to these reforms completed more

Figure 3: Real Per-Pupil School Revenues

(a) Property Tax Revenue (b) Total Revenue



Note: Per-pupil revenue from the 2010-2011 NCES survey of school districts deflated by median county house prices. More precisely, real revenue is nominal revenue deflated by a house price index where the least expensive house is normalized to one. States represented here are: California, Florida, Georgia, Illinois, Michigan, New York, Ohio, Pennsylvania and Texas.
Source: Authors' calculations using data from the 2000 Census, and the NCES Common Core of Data

years of education and had higher wages. More specific to the benefits of increased local revenue, Abott et al. (2020) investigate outcomes from tax elections to exceed limits on property tax revenue. In the elections they look at, the increased revenue allowed districts to raise teacher salary and enhance support services. Abott et al. (2020) find that an additional $1,000 in per-pupil spending was associated with a 9 percent increase in graduation rates. In addition, Miller (2018) uses variation in property values to show that the subsequent changes in property tax revenue affect student performance.[9] Here, we will focus on how the inequality in property tax revenue subsequently affects labor market outcomes and intergenerational mobility.

[9] On the other hand, there is little evidence that increases in federal funding translate into changes in student outcomes. For example, Title I is one of the federal government's main education program Gordon (2004), giving resources to districts based on their childhood poverty levels. However, Gordon (2004) finds that local funding crowds out Title 1 revenue, essentially leaving school district finances unchanged. Her results could thus explain why studies such as Van der Klaauw (2008) find negligible effects of Title 1 funding on student achievement.

4 Model

Overview

We build an overlapping generations model with neighborhood choice and human capital formation. Adults raise children and influence their human capital development through the choice of local school and educational investments. Human capital affects the incomes of children when they become adults, which in turn influences their decisions about their own children's education.

The desirability of each neighborhood differs according to house price, local school quality, and an idiosyncratic taste shock. Equilibrium house prices ensure that the demand for housing is satisfied by housing supply in each neighborhood. House prices then affect local school quality through the amount of revenue collected from local property taxes.

Figure 4: Timing of Decisions in the Model

$t = 0$ Ages 1-20	$t = 1$ Ages 21-40	$t = 2$ Ages 41-60	$t = 3$ Ages 61-80
Birth Receive Education Generate human capital	Receive transfer from parent Earn income Save Consume	Child is born Earn income Choose neighborhood Invest in education Save Consume	Earn income Transfer to Child Consume

The timing of household events and decisions is summarized in Figure 4. Agents live for four periods, $t \in \{0, 1, 2, 3\}$. An agent begins life as a child at age $t = 0$. During this stage, she does not consume and makes no decisions. However, at this time a child develops human capital according to her ability, the quality of the school in the neighborhood chosen by her parent, and the educational investments of her parent. Human capital then determines the labor income that is received as an adult. In the first two periods of adulthood $t = 1, 2$, the agent earns labor income and receives utility from consumption. At this time, resources can be transferred to the future by saving in a risk-free bond. In period $t = 2$, the agent gives birth to a child, chooses a neighborhood to live in, and makes an educational investment in her child. In the final period $t = 3$, the agent earns retirement income and may transfer resources to her child.

Neighborhoods and Housing

There are three neighborhoods in the economy, denoted $i \in \{A, B, C\}$. We will refer to A as the neighborhood with the lowest house price, and C as the one with the highest. When an agent chooses a neighborhood to live in, she must purchase one unit of housing at price P_i. House purchase is subject to an exogenously determined property tax, τ. The proceeds of local property taxes are used to finance the neighborhood school. In each neighborhood, housing is supplied elastically according to $S_i = \eta_i {P_i}^{\psi}$, where $\psi > 0$ is the price elasticity of housing supply and η_i reflects land availability.

Human Capital Formation

A child's human capital is influenced by three factors. First, children are born with innate ability a^c, which is persistent across generations. The evolution of ability is described by an AR(1) process,

$$\log a^c = \mu_a + \rho_a \log a + \varepsilon_a,$$

where a is the ability of a child's parent, μ_a is the average of log-ability, ρ_a is the persistence of the ability process, and ε_a is a normally distributed idiosyncratic shock with mean 0 and standard deviation σ_a.

Second, the quality of the school in each neighborhood Q_i is determined by local property tax revenue and funding provided by state and federal sources. Because local tax revenues depend on neighborhood house prices, the component of school quality due to local funding is neighborhood-specific and given by τP_i. The component of school quality due to state and federal funding $\bar{Q}$ is constant across neighborhoods. We assume that the two sources of funding are perfect substitutes with respect to their effect on school quality, so that local school quality is given by the simple linear function $Q_i = \tau P_i + \bar{Q}$.

Finally, parents can make a private investment in their child's education e. This investment summarizes both monetary and time investments made by parents in their children's development.[10]

Human capital, h^c, is then formed by combining a child's ability, school quality,

[10] Daruich (2018) builds a model in which a child's human capital accumulation is a function of her parent's money and time investments. The estimated model places significant weight on monetary investments, and also finds a strong correlation between both monetary and time investments.

and education investments via

$$h^c = a^c Q_i^{1-\gamma} e^{\gamma},$$

where γ is the weight on parental investments in the Cobb-Douglas function over school quality and educational investment. This functional form implies that there are larger returns to private education investments for children with higher school quality and ability.[11]

Income

During ages $t = 1, 2$ agents earn labor income $h\varepsilon_y$ from the combination of their human capital h and a normally distributed idiosyncratic shock ε_y with mean 0 and standard deviation σ_y. At age $t = 3$ agents receive risk-free retirement income κh, which is a fraction κ of the value of their human capital. Thus, retirement income reflects a constant replacement rate over an agent's average pre-retirement income.

Value Function for Adult at $t = 1$

We use the following notation for describing the value functions: $V_{t,i}$ denotes the value function for an adult in time period $t \in \{1, 2, 3\}$ in neighborhood $i \in \{A, B, C\}$. The i subscript is omitted when the neighborhood is not important for decision making. Policy variables are denoted in a similar manner. We use a superscript c for variables associated with the agent's child.

An agent in the first period of adulthood enters with cash-in-hand m_1, human capital h, and ability, a. She chooses how much to save in a risk-free bond z_1, at interest rate r, and how much to consume c_1. She maximizes the sum of current-period utility and the discounted continuation value V_2. The agent's problem is given by:

$$V_1(m_1, h, a) = \max_{c_1, z_1 \geq 0} \{\log(c_1) + \beta \mathbb{E} V_2(m_2, h, a^c)\} \tag{1}$$

$$c_1 + z_1 = m_1 \tag{2}$$

$$m_2 = (1 + r)z_1 + \varepsilon_y h \tag{3}$$

$$\log a^c = \rho_a \log a + \varepsilon_a \tag{4}$$

[11] Aizer and Cunha (2012) report that parents invest more in children with larger human capital endowments. Attanasio et al. (2019) find that parents spend more on their child's education when they believe that school quality is high.

where β is the discount factor, and expectations are evaluated over the child's ability a^c and the idiosyncratic component of income ε_y. Equation (2) is the budget constraint, which allocates current cash-in-hand between savings and consumption. Equation (3) shows that next period's cash-in-hand is the gross return on savings and next period's income, which is given by human capital h and the idiosyncratic income shock ε_y.

Value Function for the Adult at $t = 2$

The adult's problem at $t = 2$ is divided into two subperiods. First, the adult's child is born and its ability is realized, the adult receives idiosyncratic taste shocks over neighborhoods, and the adult chooses one of these neighborhood to live in. Second, the adult consumes, saves, and makes educational investments in the human capital of her child.

Because people choose neighborhoods for a variety of reasons unrelated to house prices and school quality, we assume that agents receive random neighborhood-specific taste shocks $\sigma_\varepsilon \varepsilon_i$ prior to their location decision. The taste shocks are distributed according to the Type 1 Extreme Value distribution, where σ_ε is the scale parameter. The location decision is given by

$$V_2(m_2, h, a^c) = \max \left\{ V_{2,i}(m_2, h, a^c) + \sigma_\varepsilon \varepsilon_i : i \in \{A, B, C\} \right\} \tag{5}$$

where dependence on the state a^c reflects the fact that the agent knows their child's ability at the time of the decision. By exploiting the properties of Type 1 Extreme Value variables,[12] the probability that an agent chooses neighborhood i is

$$Pr(i|m_2, h, a^c) = \frac{\exp\left(\dfrac{V_{2,i}(m_2, h, a^c)}{\sigma_\varepsilon}\right)}{\displaystyle\sum_{j \in \{A,B,C\}} \exp\left(\dfrac{V_{2,j}(m_2, h, a^c)}{\sigma_\varepsilon}\right)} \tag{6}$$

Conditional on the agent's neighborhood decision, the adult chooses savings $z_{2,i}$, consumption $c_{2,i}$, and education investment $e_{2,i}$. The problem for an agent in

[12] For further reference, see McFadden (1978).

neighborhood i is given by:

$$V_{2,i}(m_2, h, a^c) = \max_{c_{2,i}, e_{2,i}, z_{2,i}} \log(c_{2,i}) + \beta V_3(m_3, h^c, a^c) \tag{7}$$

$$c_{2,i} + e_{2,i} + z_{2,i} + P_i(1+\tau) = m_2 \tag{8}$$

$$h^c = a^c Q_i^{1-\gamma} e_{2,i}^{\gamma} \tag{9}$$

$$m_3 = (1+r) z_{2,i} + \kappa h \tag{10}$$

Equation (8) is the budget constraint, which allocates current cash-in-hand between consumption, education investment, savings, and the cost of housing in neighborhood i. Equation (9) describes the child's human capital accumulation. Equation (10) describes next period cash-in-hand, given by the gross return on saving and retirement income.

Value Function for the Adult in $t = 3$

An adult at age $t = 3$ chooses consumption c_3 and transfers to her child z_3, to solve the problem:

$$V_3(m_3, h^c, a^c) = \max_{c_3, z_3 \geq 0} \log(c_3) + \alpha \mathbb{E} V_1(m^c, h^c, a^c) \tag{11}$$

$$c_3 + z_3 = m_3 \tag{12}$$

$$m^c = z_3 + \varepsilon_y h^c \tag{13}$$

where α reflects the strength of the parent's altruism toward their child, and expectations over their child's continuation value V_1 are formed with respect to the child's idiosyncratic income shock ε_y. The budget constraint in Equation (12) allocates cash-in-hand between consumption and transfers. Equation (13) describes the cash-in-hand available to the child, given by the parental transfer and child's income.

Equilibrium

Equilibrium in the model consists of house prices $\{P_A, P_B, P_C\}$, household decision rules for consumption $\{c_1, c_{2,A}, c_{2,B}, c_{2,C}, c_3\}$, savings $\{z_1, z_{2,A}, z_{2,B}, z_{2,C}, z_3\}$, educational investments $\{e_{2,A}, e_{2,B}, e_{2,C}\}$, neighborhood choices $\{\mathbb{1}_A, \mathbb{1}_B, \mathbb{1}_C\}$, and invariant distributions over agents at each age $\{\lambda_1, \lambda_2, \lambda_3\}$, such that:

1. Given prices, the decision rules solve the household decision problems.

2. The distributions over agents satisfy

$$\lambda_1 = \int Q_{3,1} d\lambda_3,$$
$$\lambda_2 = \int Q_{1,2} d\lambda_1,$$
$$\lambda_3 = \sum_{i=A,B,C} \int \mathbb{1}_i Q^i_{2,3} d\lambda_2,$$

where $Q_{t,t'}$ are the distribution transition functions from age t to t', and $Q^i_{2,3}$ are the transition functions from age 2 to 3 for households in neighborhood i.

3. Housing markets clear in each neighborhood $i \in \{A, B, C\}$:

$$\int \mathbb{1}_i d\lambda_2 = \eta_i P_i^{\psi}.$$

Model Intuition

To provide intuition for the model mechanisms prior to calibration, here we analyze a simplified version of the model. Agents live for just two periods here - they are born into a neighborhood i with some cash-on-hand, m, and they have a child, whose ability, a^c is known. There are no taste shocks. The agent consumes, invests in the education of her child, and saves for next period. In the second period, the agent transfers all her resources to the child, and the child consumes the transfer plus her human capital. The child's utility is valued by the parent with altruism parameter α. The human capital formation for the child works in the same way as in the full-version of the model, and the child just consumes all her resources next period which is the sum of her bequest and human capital.

Thus, the agent's decision problem in this simplified version is:

$$\begin{aligned}
\tilde{V}_i(m, a^c) &= \max_{c,e,z'} \{\log(c) + \beta\alpha(\log(m' + \mathbb{E}[y]h^c)\} \\
c &= m - P_i(1+\tau) - e - z' \\
h^c &= a^c Q_i^{1-\gamma} e^{\gamma} \\
m' &= z'(1+r)
\end{aligned}$$

With this toy model, we can write the optimal decisions for education investment, e, and savings, z', substituting out c from the budget constraint:

$$\frac{\partial \tilde{V}_i}{\partial z'} := \frac{-1}{m - P_i(1+\tau) - e - z'} + \frac{\alpha\beta(1+r)}{z'(1+r) + \mathbb{E}[y]h^c} = 0$$
$$\frac{\partial \tilde{V}_i}{\partial e} := \frac{-1}{m - P_i(1+\tau) - e - z'} + \frac{\beta\alpha\mathbb{E}[y]}{(z'(1+r) + \mathbb{E}[y]h^c)}\frac{\partial h^c}{\partial e} = 0$$

The derivative $\frac{\partial h^c}{\partial e}$ is $\gamma a^c Q_i^{1-\gamma} e^{\gamma-1}$. The optimal education decision is increasing in cash-on-hand, m, ability of the child a^c, and school quality Q_i. This implies that parents with higher income who sort into better quality neighborhoods will spend more on education, furthering the differences in accumulated human capital between neighborhoods.

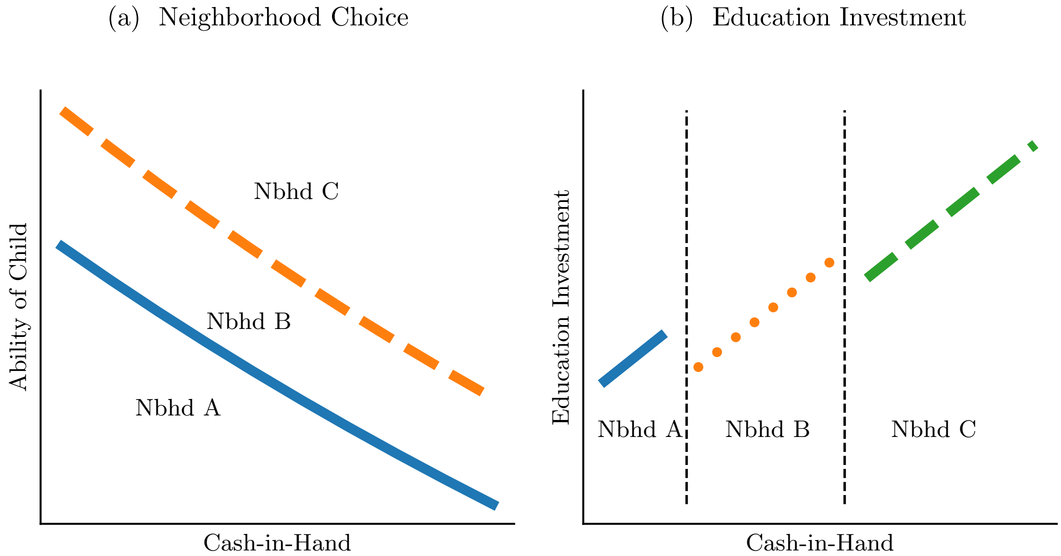
The optimal neighborhood decision, $\mathbb{1}_{i^*}$, can be characterized as:

$$\mathbb{1}_{i^*} = \underset{i^* \in \{A,B,C\}}{\arg\max} \{\tilde{V}_A(m, a^c), \tilde{V}_B(m, a^c), \tilde{V}_C(m, a^c)\}$$

Figure 5a) shows how the neighborhood decision looks for a given level of savings, z', and education investment, e. On the x-axis is cash-in-hand, and the ability of the child is on the y-axis. The dashed and solid lines are the indifference curves between Neighborhoods A and B, and Neighborhoods B and C, respectively. The choice to live in a more expensive neighborhood with better school quality is increasing in the cash-in-hand and the ability of the child. Recall that from the human capital function, the returns to education investment are larger with higher-ability children. Therefore, inequality in public schooling will exacerbate existing differences in children's ability as parents with higher-ability children sort into better neighborhoods.

Figure 5b) illustrates the education investment choice. Given the complementarity between school quality and education investments, and the altruism of parents towards their children, parents who are in better neighborhoods will also invest more in their child's education. Note also that there is a discontinuous drop in education choice for different neighborhoods since agents have to pay for higher housing costs as they move up in neighborhood quality.

Figure 5: Neighborhood and Education Decisions: Toy Model



Note: Figure 5a shows the neighborhood choice given current cash-in-hand, on the x-axis, and ability of child, on the y-axis. The solid curve represents the points at which the agent is indifferent between Neighborhood A and Neighborhood B. The dashed curve shows the points at which the agent is indifferent between Neighborhood B and Neighborhood C. Figure 5b shows the education investment decision for the parent depending on the neighborhood. The solid line is for parents in Neighborhood A, the dotted line for parents in Neighborhood B, and the dashed line for parents in Neighborhood C.

5 Calibration

We calibrate the model to capture the observed relationships between house prices, school revenue, and intergenerational mobility. To take the model to the data, we map model neighborhoods to US school districts. For ease of exposition, we report our main results using data on school districts in the state of New York. However, in Appendix A we re-calibrate the model to match data from each of the ten largest states in the country and show that the model provides a remarkably good fit to each of these states as well.

Census data on local populations, incomes, house prices, and property taxes are available at the school district-level from the National Center for Education Statistics. Cross-sectional mobility and inequality statistics are reported in Chetty et al. (2018) by census tract, and in Chetty et al. (2014) by commuting zone. When computing aggregate statistics from this data, we use population-weighted averages of census tracts or commuting zones across the state. Since school districts are smaller than commuting zones, we compute statistics at the school district-level from population-weighted averages of census tract data.The statistics reported in Chetty et al. (2018) and Chetty et al. (2014) are computed for children born in the 1980s and the outcomes for those children as adults are measured in the 2010s. For that reason we calibrate the model to data from the early 1990s with two exceptions. School financing data is only available from the NCES as of 1997, and information on local property taxes is only available from the 2000 Census. Appendix A describes our data sources in more detail.

Neighborhoods in the model are distinguished by house prices, which are monotonically increasing across neighborhoods with $p_A < p_B < p_C$. We normalize the total population within each cohort to one, and calibrate the model so that Neighborhoods A, B, and C contain 50%, 30%, and 20% of the population, respectively. To map the data to model neighborhoods, all statistics are computed as population-weighted averages of school districts with median house prices below the 50th percentile of prices (Neighborhood A), between the 50th and 80th percentile of prices (Neighborhood B), and above the 80th percentile of prices (Neighborhood C). Note that these house price percentiles are computed as population-weighted percentiles of the median house prices in each school district.

We first set several parameters according to information external to the model environment. These parameters are reported in Table 2. The model period is 20 years. The annual real interest rate r is 2%.[13] The replacement rate of income for retired households κ is 0.494, as reported by the OECD (2019). The property tax rate τ is calculated from the average ratio of median annual property taxes paid to median house prices using data derived from the 2000 Census and provided by the NCES. This yields an annual tax rate of 1.5%.[14] The housing supply elasticity ψ is set to 1.173, which corresponds to the population-weighted median value for all Metropolitan Statistical Areas in New York as reported in Saiz (2010).[15]

We then use a simulated method of moments algorithm to calibrate the remaining parameters $\{\beta, \alpha, \sigma_\varepsilon, \mu_a, \sigma_a, \rho_a, \sigma_y, \gamma, \bar{Q}, \eta_A, \eta_B, \eta_C\}$. Table 11 reports the calibrated value of these parameters, as well as the model fit to the data.

The discount factor β targets a median networth-to-income ratio of 1.711, as reported for households aged 20 to 80 in the 1989 Survey of Consumer Finances (SCF).[16] The altruism parameter α targets the ratio of aggregate within-family

[13]The 20-year interest rate is computed as $r^{20} = (1 + r)^{20} - 1$.

[14]The 20-year tax rate is computed as $\tau^{20} = 20\tau$.

[15]The population-weighted average for the whole country is 1.75.

[16]Note, the 20-year discount factor is given by β^{20}.

Table 2: External Parameters

	Parameter	Value	Source
r	Annual real interest rate	0.030	FRED, 1990
κ	Retirement replacement rate	0.494	OECD (2019)
τ	Annual local property tax rate	0.015	Census, 1990
ψ	Housing supply elasticity	1.173	Saiz (2010)

Notes: The housing supply elasticity is the population-weighted averagefor metrpolitan areas in the state of New York.

transfers to aggregate net worth, which is 0.003 in the the 1986 SCF, and as reported byGale and Scholz (1994). The standard deviation of the taste shock σ_ε determines households' willingness to live in different neighborhoods independent of school quality and house prices. Absent the taste shocks, households strongly sort by income so that poor households live in low-priced neighborhoods and wealthy households live in high-priced neighborhoods. To capture the extent to which the taste shocks weaken this sorting mechanism, we target a median rent-to-income ratio of 0.198 as reported in the 1990 Census.

The ability process and idiosyncratic income shocks govern both the dispersion and intergenerational persistence of household income. The average of the ability process μ_a increases the returns to school quality and educational investments. We use μ_a to target the ratio of median incomes across the most and least expensive neighborhoods, C and A respectively. Using data from the 1990 Census provided by the NCES, we compute this ratio as 1.245. The standard deviation of the ability process σ_a is used to target the Gini coefficient of income. In the model we compute the Gini coefficient for households at age 2. This corresponds to a Gini coefficient of 0.471 among households of child-rearing age, as reported in Chetty et al. (2014). The persistence of ability ρ_a and the standard deviation of the income shock σ_y are used to target statistics on intergenerational mobility. We use the probability that parents in the bottom quintile of the national income distribution have children that remain in the bottom quintile $\mathbb{P}(q_1|q_1)$ and reach the top quintile $\mathbb{P}(q_5|q_1)$. For households in New York, these probabilities are 0.322 and 0.094, respectively (Chetty et al., 2014).

The human capital elasticity of education investment γ targets an aggregate share of spending on education of 0.019, as reported in the 1990 Consumer Expenditure Survey (CEX). In the model, total expenditure is the sum of consumption, housing, and education spending. In the CEX, we compute education spending as the sum of education and reading goods purchased, and total consumption expenditure is aggregate consumption less contributions to pensions and life insurance payments. The calibrated value of γ is 0.198, which implies a human capital elasticity of school funding of around 0.8.[17] The parameter governing funding from non-local sources $\bar{Q}$ is used to target the average fraction of total school revenue contributed by local property taxes. The average fraction across school districts in New York for the 1997 school year is 0.471, as computed from data provided by the NCES.

Finally, the parameters η_A, η_B, and η_C reflect the amount of land available in each neighborhood, but which is independent from the housing supply elasticity ψ. We set these parameters to match the population sizes of Neighborhoods A and B, with the size of Neighborhood C determined residually.[18] Additionally, we target the relative house prices of Neighborhoods B and A.

[17]This is consistent with the results of the empirical work in Jackson et al. (2016). Exploiting exogenous changes in school financing, they estimate that a ten percent increase in school funding is associated with a seven percent increase in earnings.

[18]Note that we could have normalized available land to one, and allowed for heterogeneity in housing supply elasticities ψ. However, the elasticities reported by Saiz (2010) appear to be uncorrelated with population size.

Table 3: Calibration and Model Fit

	Parameter	Value	Moment	Data	Model	Source
β	Discount factor	0.910	Median networth/income	1.711	1.752	SCF, 1989
α	Altruism	0.946	Bequests share of networth	0.003	0.002	Gale and Scholz (1994)
σ_ε	Taste shock	0.309	Median rent/income	0.198	0.197	Census, 1990
μ_a	Mean ability	16.294	Median income, C/A	1.245	1.206	Census, 1990
σ_a	Ability shock	0.153	Gini coefficent, $t = 2$	0.471	0.382	Chetty et al. (2014)
ρ_a	Ability persistence	0.816	$\mathbb{P}(q_1 \vert q_1)$	0.322	0.320	Chetty et al. (2014)
σ_y	Income shock	0.573	$\mathbb{P}(q_5 \vert q_1)$	0.094	0.105	Chetty et al. (2014)
γ	Education elasticity	0.198	Education share	0.019	0.030	CEX, 1990
$\bar{Q}$	Non-local school funds	0.117	Mean local funding ratio	0.471	0.477	NCES, 1997
η_A	Available land, A	2.517	Population, A	0.500	0.501	Chosen
η_B	Available land, B	0.824	Population, B	0.300	0.299	Chosen
η_C	Available land, C	0.359	Price ratio, B/A	1.677	1.677	Census, 1990

Notes: Model is calibrated to both aggregated and local data sources. Local data is computed for the state of New York. Parameter values selected via Simulated Method of Moments.

Model Fit and Neighborhood Characteristics

In calibrating the model, the only cross-neighborhood moments we target directly are the relative populations, prices, and incomes. However, Table 4 shows that the model does a remarkably good job of generating the observed cross-neighborhood distributions of school funding ratios, rent-to-income ratios, and measures of intergenerational mobility. The first row shows that school funding from local property taxes increases significantly as neighborhood house prices rise.[19] The second row shows that median rent-to-income rises across neighborhoods in the model, while in the data, rent-to-income ratios are flat across neighborhoods. This likely reflects differences in the choices of house size and quality, which are not captured by the model.

The second panel of Table 4 shows that in both the data and the model, the probability that a household has children that reach the top quintile of the national income distribution rises rapidly as house prices rise.[20] House prices across neighborhoods generate better opportunities for children at all points in the income distribution: the probability of high child incomes increases with house price for households with parents at the 25th, 50th, and 75th percentiles of the national income distribution. The third panel of Table 4 reiterates this point by comparing transition probabilities across neighborhoods for children with parents in the bottom and top income quintiles. Note that the data for these statistics is not available at the neighborhood level. Recall that we define "persistence of low-income" as the probability that parents in the bottom income quintile have children in the bottom income quintile and "economic opportunity" as the probability that parents in the bottom income quintile have children in the top income quintile. We find that persistence of low-income declines significantly across neighborhoods. In particular, persistence of low-income is 16 percentage points higher in Neighborhood C rather than in Neighborhood A.

Figure 6 emphasizes that the model captures a lot of the cross-neighborhood variation in intergenerational mobility observed in the data. The figure illustrates the transition probabilities $\mathbb{P}(q_5|p_{25})$, $\mathbb{P}(q_5|p_{50})$, and $\mathbb{P}(q_5|p_{75})$ for the three neighborhoods in the model relative to histograms of those transition probabilities across school districts in New York (see Chetty et al., 2018).[21]

[19] See also Figure 2b.

[20] See also Figure 1b.

[21] $\mathbb{P}(q_i|p_j)$ is the probability that a parent in the jth income percentile has a child in the ith income quintile. $\mathbb{P}(q_i|q_j)$ is the probability that a parent in the jth quintile will have a child in the ith quintile. Quintile transition probabilities, such as $\mathbb{P}(q_1|q_1)$ and $\mathbb{P}(q_5|q_1)$ are not available at the school district level, only at the commuting zone level from Chetty et al. (2014).

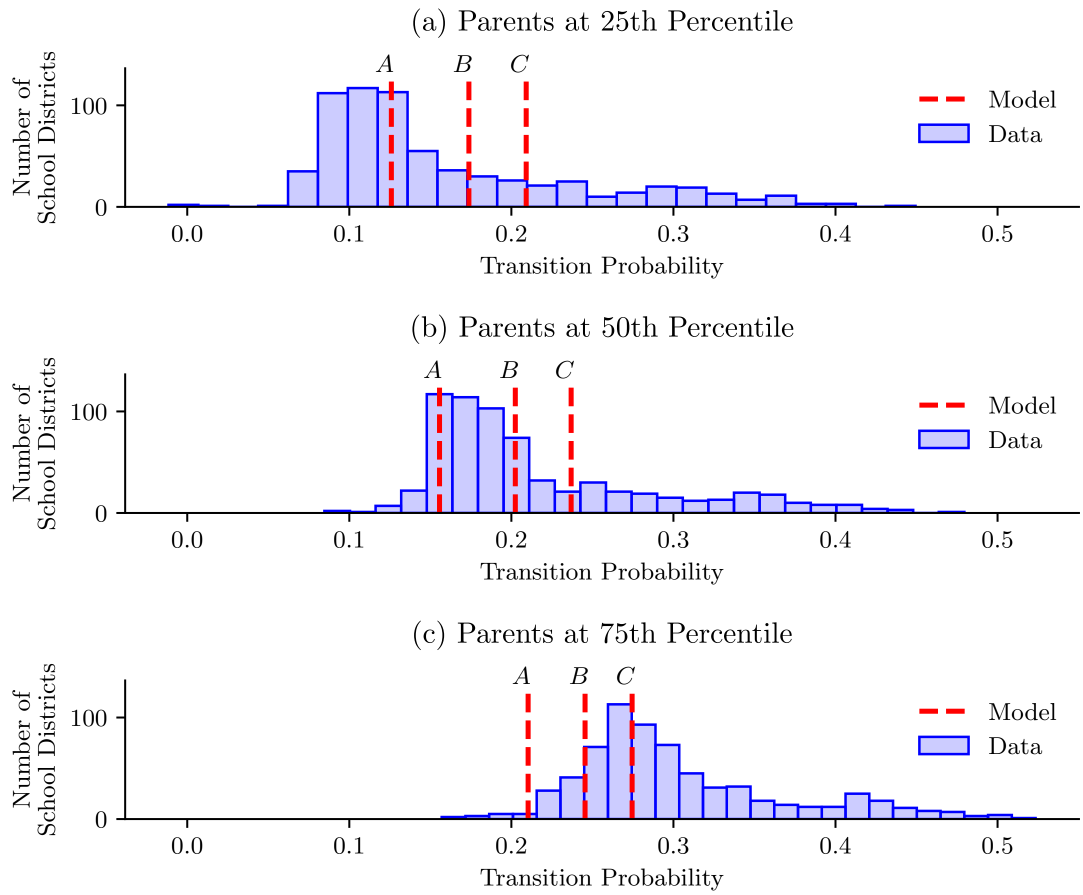
Table 4: Cross-Neigborhood Statistics in the Data and Model

	Nbhd A		Nbhd B		Nbhd C	
	Data	Model	Data	Model	Data	Model
Local funding ratio	0.414	0.395	0.453	0.523	0.682	0.611
Median rent/income	0.198	0.149	0.204	0.227	0.185	0.296
Transition probabilities given parent at percentile p_x						
$\mathbb{P}(q_5 \vert p_{25})$	0.134	0.126	0.166	0.174	0.250	0.209
$\mathbb{P}(q_5 \vert p_{50})$	0.193	0.156	0.209	0.202	0.299	0.237
$\mathbb{P}(q_5 \vert p_{75})$	0.279	0.210	0.272	0.245	0.371	0.275
Transition probabilities given parent in quintile q_x						
$\mathbb{P}(q_1 \vert q_1)$	–	0.371	–	0.268	–	0.217
$\mathbb{P}(q_5 \vert q_1)$	–	0.083	–	0.124	–	0.155
$\mathbb{P}(q_5 \vert q_5)$	–	0.143	–	0.108	–	0.087
$\mathbb{P}(q_1 \vert q_5)$	–	0.261	–	0.301	–	0.333

Notes: Model is calibrated to both aggregated and local data sources. Local data is computed for the state of New York. Transition probabilities across income quintiles are not available at the school district level.
Source: Author's calculations, NCES, Chetty et al. (2014), and Chetty et al. (2018)

The model also provides a good representation of intergenerational mobility across the population. This is illustrated in Figure 7, which compares transition probabilities in the model and data for children with parents in the first and fifth quintiles of the overall income distribution. Note that we directly target the persistence of low income, defined as $\mathbb{P}(q_1|q_1)$, and economic opportunity, defined as $\mathbb{P}(q_5|q_1)$, in the model calibration, but the remainder are untargeted moments. One area in which the model underperforms is in matching the intergenerational persistence of income among the highest income households: the transition probability $\mathbb{P}(q_5|q_5)$ is around 10 percentage points too low in the model. This likely reflects the lack of human capital development in the model beyond school age. For example, college attendance and performance are highly correlated with parental income, and likely exacerbate the persistence of income for high earners, as found in Belley and Lochner (2007). Although college is an important determinant of future outcomes (see Fang, 2006), our model is still able to capture substantial variation in intergenerational mobility. In addition, dynamic complementarity in human capital inputs suggest that the returns to college are positively correlated with the quality of childhood education (Cunha and Heckman, 2007).

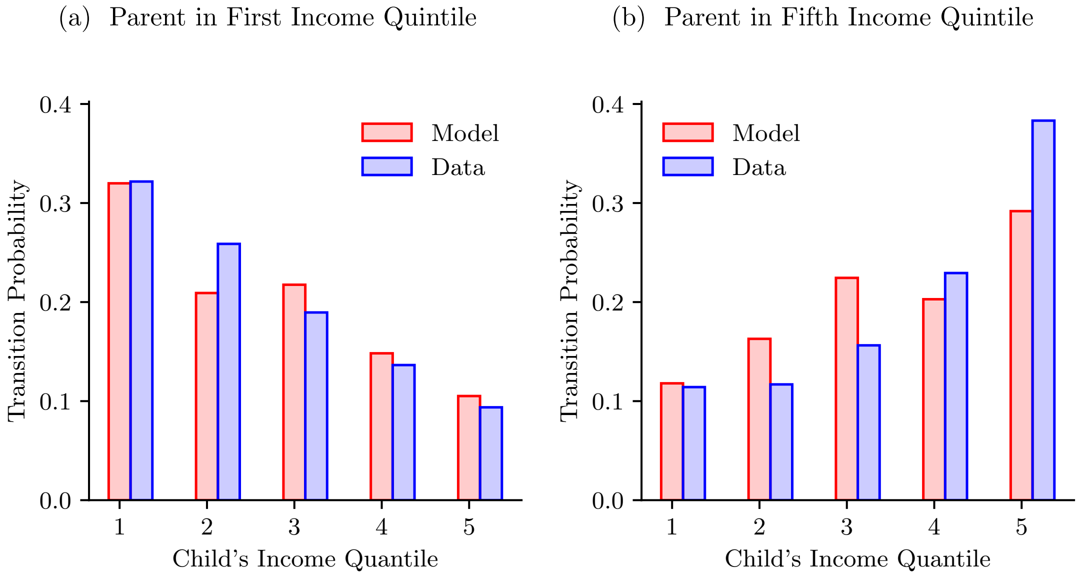
Figure 6: Probability Child Reaches Top Income Quintile by Neighborhood



Note: Probability of attaining the top 20 percent of the income distribution for children with parents at different points in the income distribution. Red dashed lines are the transition probabilities for children in each of the three neighborhoods in the model. The data are histograms over the transition probabilities for school districts in New York.
Source: Authors' calculations, Chetty et al. (2018).

Finally, we consider the other ways in which neighborhoods in the model differ from each other. Table 5 presents the average characteristics for Neighborhoods B and C relative to Neighborhood A. More expensive neighborhoods attract parents with higher income and wealth. Parents in Neighborhood C, for example, have 20 percent higher incomes and 60 percent more wealth than parents in Neighborhood A. Because a large share of school funding is provided by taxes on local real estate, higher priced neighborhoods have higher quality schools. For example, Neighborhood C has nearly two and half times more local funding than Neigh-

Figure 7: Income Transition Probabilities



Note: Transition probabilities for children with parents in the first and fifth quintiles of the income distribution. Model values computed for the children of parents in the stationary distribution of the model. Data values are the population-weighted averages across commuting zones in New York.
Source: Authors' calculations and data from Chetty et al. (2014).

borhood A. After taking non-local funding sources into account, Neighborhood C has 56 percent greater funding per pupil than Neighborhood A. Since the human capital return to school quality is increasing in child ability, these higher priced neighborhoods tend to attract higher-ability students. Students in Neighborhoods B and C are 5 and 9 percent more able than students in Neighborhood A. Additionally, educational investments are 26 and 41 percent greater in Neighborhoods B and C. This is because students in more expensive neighborhoods enjoy higher school quality, have higher ability, and have wealthier parents.

Overall, Table 5 shows that there is strong sorting across neighborhoods. On average, higher-priced neighborhoods with higher-quality schools attract wealthier families who spend more on education for children with greater abilities. Thus, unequal school quality exacerbates underlying inequalities. To understand how each of these channels contributes to the lack of intergenerational mobility, we next consider the influence of each of the primary mechanisms in the model: school quality, educational investment, child ability, and intergenerational transfers.

Table 5: Neighborhood Characteristics

Neighborhood	Parent Income	Parent Wealth	Child Ability	Education Investment	Local Funding	Total Funding
B	1.12	1.32	1.05	1.26	1.68	1.27
C	1.20	1.59	1.09	1.41	2.41	1.56

Notes: Average within-neighborhood values relative to neighborhood A.

Exploring the Mechanisms

The primary focus of this paper is the link between house prices and the quality of local schools in explaining intergenerational mobility. However, there are four other channels in the model that can affect mobility. Parents can choose how much to spend on educational investments in their children, underlying ability is persistent across parents and children, children receive idiosyncratic income shocks, and parents who receive bequests may use those resources to finance their own child's education. We explore the importance of each of these channels in turn.

In order to quantify the importance of these channels, we conduct counterfactual experiments in which we remove the underlying dispersion that drives each mechanism and investigate how intergenerational mobility changes. In these experiments, prices are left at their equilibrium values and we maintain all household policy decisions so that households do not re-optimize following changes in their environment. The four experiments, in turn, impose: median school quality, median level of education investment, median child ability, and median bequests received by the parents of children going through school.

To measure mobility, we focus on the persistence of low-income and economic opportunity.[22] Table 6 reports the intergenerational mobility statistics across neighborhoods under each of the experiments. The first row reports statistics in the baseline equilibrium. The second row shows how mobility changes when all children are given the median school quality. The persistence of low income in Neighborhood A falls by 13 percent, from 0.37 to 0.32. Meanwhile, economic opportunity Neighborhood A improves: $\mathbb{P}(q5|q1)$ increases by 10 percent, from 0.083 to 0.092. Moreover, equal school quality results in a decrease in the cross-neighborhood

[22] Recall that persistence of low income is defined as: the probability that a parent in the bottom quintile of the income distribution will have a child that grows up to be in the bottom quintile, $\mathbb{P}(q1|q1)$. Economic opportunity is defined as: the probability that a parent in the bottom income quintile will have a child in the top quintile, $\mathbb{P}(q5|q1)$.

Table 6: Counterfactual Model Experiments

	Nbhd A		Nbhd B		Nbhd C	
	$\mathbb{P}(q_1\|q_1)$	$\mathbb{P}(q_5\|q_1)$	$\mathbb{P}(q_1\|q_1)$	$\mathbb{P}(q_5\|q_1)$	$\mathbb{P}(q_1\|q_1)$	$\mathbb{P}(q_5\|q_1)$
Baseline	0.371	0.083	0.268	0.124	0.217	0.155
Median School Quality	0.326	0.092	0.259	0.130	0.222	0.160
Median Education Investments	0.315	0.116	0.276	0.145	0.255	0.162
Median Child Ability	0.274	0.111	0.224	0.151	0.190	0.185
Median Child Income Shocks	0.419	0.023	0.257	0.045	0.189	0.070
Median Parent Bequests	0.371	0.083	0.268	0.124	0.217	0.155

Notes: Each counterfactual experiment takes households in the stationary distribution, manipulates one model mechanism, and measures outcomes for the children of those households. For the school quality counterfactual, school quality for all students is set equal to that of neighborhood B in the baseline calibration. Educational investments, child ability, child income shocks, and bequests received by parents are set to their median values in the baseline calibration.

variation in mobility. The difference in low income persistence, $\mathbb{P}(q1|q1)$, between Neighborhoods C and A falls from 0.154 to 0.104. And the difference in economic opportunity, $\mathbb{P}(q5|q1)$, falls from 0.072 to 0.068. These results suggest that differences in local school quality account for around 32 percent of the cross-sectional variation in the persistence of low incomes, and around 6 percent of the variation in economic opportunity.

The third and fourth rows of Table 6 show that both education investments and the correlation between parent and child ability have large effects on mobility. The effects of equalizing educational investments are of a similar magnitude to the effects of equalizing school quality. The effects of equalizing child ability are somewhat larger than those of equalizing school quality or educational investments. The fifth row of Table 6 shows that idiosyncratic income shocks increase intergenerational mobility. Absent this source of income dispersion, the children of low income households in Neighborhood A are 5 percentage points more likely to have low incomes themselves, and low income children in all neighborhoods are much less likely to reach the top of the income distribution. Finally, the sixth row of Table 6 shows that equalizing the bequests received by parents has essentially no effect on intergenerational mobility.

6 Policy Experiments

Housing Vouchers

Table 7: Housing Voucher Policy Experiments

	Uptake	Parent ΔRent	Parent ΔEducation	Child ΔIncome	Grandchild ΔIncome	Great Grandchild ΔIncome	Child Movers
Moving Voucher	0.34	−3.5	−1.7	27.1	6.9	1.99	0.10
Rent Subsidy	0.22	−27.4	35.5	4.8	1.3	0.39	0.02

Notes: Housing vouchers are only offered to hosueholds in neighborhood A. Vouchers cap rental costs at 30 percent of household income. The moving voucher requires that households move to neighborhood B or C. The rental subsidy voucher does not require that households change neighborhoods. Policies are simulated for 100,000 households. All differences reported as average percentage changes from baseline for treated households (i.e. those that take up the voucher).

One policy intervention that has received widespread attention is the use of housing vouchers.[23] These experiments provide subsidies to households living in poor neighborhoods if they agree to move to neighborhoods with better economic opportunities.[24]. We conduct a housing voucher experiment in the model to study the effects of such a policy on intergenerational mobility. Households living in Neighborhood A are offered a voucher that ensures they spend no more than 30 percent of their income on rent as long as they move to one of Neighborhoods B or C. For comparison, we run a second experiment in which we offer households living in Neighborhood A a rental subsidy that caps spending at 30 percent of income as long as they remain in Neighborhood A. In both experiments, we compare the outcomes of individual households to those under the baseline equilibrium absent the housing vouchers. This holds all other household factors constant, including ability, income shocks, and neighborhood taste shocks. Thus the experiments provide the causal effects of housing vouchers on the future outcomes of children.

Table 7 reports the results of the experiments simulated for 100,000 households. The first column reports take-up rates across households. Note that not all households accept vouchers because some of those living in Neighborhood A already spend less than 30 percent of their income on rent. Thus, we report results for

[23]For example, see Applebaum (2015).

[24]Well-known examples include: the Moving to Opportunity project (see Chetty et al., 2016), the Dallas Housing Authority's Walker Settlement program (see Authority, 2020) and a recent voucher experiment implemented in Seattle (Bergman et al., 2019)

treated households only. The second column shows that both experiments resulted in reductions in rental costs: moving vouchers resulted in a 3.5 percent reduction in rents on average, while the rental subsidy reduced rents by an average of 27 percent. The third column shows that parents receiving vouchers altered their education investment decisions. Moving vouchers lead households to decrease education expenditure by 1.7 percent on average, while the rental subsidy increased education spending by 35.5 percent.

Column 4 of Table 7 shows that moving vouchers generate a significant increase in child incomes. For children whose parents leave Neighborhood A, incomes increase by 27.1 percent. Furthermore, Columns 5 and 6 show that the grandchildren of those families that were eligible for the voucher enjoy 6.9 percent higher incomes, and even the great-grandchildren of those families receive a 2 percent increase in income. Thus, subsidizing households to move to neighborhoods with better schools can have large multi-generational benefits. One of the reasons for these multi-generational effects is that the children exposed to housing vouchers enjoy higher incomes which allows them to move to better neighborhoods as adults. Indeed, the final column of Table 7 shows that 10 percent of the children that would have lived in Neighborhood A as adults move to Neighborhoods B or C after their parents receive housing vouchers.

We find that these intergenerational benefits are due to the increase in school quality that follows receipt of the housing voucher, rather than due to any income effect provided by the voucher. This can be seen by comparing the results to the effects of the rental subsidy experiment, which ensures that households remain in Neighborhood A but receive a reduction in rental costs. The subsidy provides a pure increase in the after-rent incomes of parents, but the effect on future incomes is limited. Average child incomes only increase by 4.8 percent and average grandchild incomes increase by just 1.3 percent. Thus the benefits of a housing voucher program come through the increase in school quality, rather than any increase in after-rent incomes.

Equal Public School Revenue

In this experiment, we redistribute the total revenue received from taxes on local real estate equally among schools. This results in equal school quality across neighborhoods in the model. We then study the equilibrium consequences of shifting from the unequal funding mechanism to the new revenue sharing policy.

To solve for the new equilibrium, we hold the land supply, η_i, constant in each neighborhood and use the housing supply function to update the number of houses available. We then solve for the new house prices that clear each neighborhood's housing market. Note that absent the neighborhood taste shocks, all households would move to the neighborhood with the lowest prices since school quality is equalized. In our model with taste shocks though, some households prefer more expensive neighborhoods for idiosyncratic reasons. Thus, the new equilibrium can sustain a non-degenerate house price distribution even though school quality is equalized across neighborhoods. Furthermore, note that even though school quality is equalized here, the differences in prices still generate sorting based on parental wealth - for example, only wealthy households will have high enough income to move to Neighborhood C conditional on getting a good taste shock.

Table 8 reports the changes in equilibrium outcomes following the implementation of the tax revenue redistribution policy. With school quality equalized, households move away from the more expensive neighborhoods towards the lowest price neighborhood. Due to inelastic housing supply, the fall in demand for Neighborhoods B and C causes house prices to fall by 1.47 and 4.55 percent, respectively. As demand for Neighborhood A rises, prices rise by 2.6 percent. With the tax rate fixed, these changes in house prices affect school funding. The fall in average house prices causes average funding to decrease by 1 percent. However, funding in Neighborhood A rises by nearly 18 percent, while funding in Neigborhoods B and C falls by 7 and 24 percent, respectively.

The changes in school quality lead parents to adjust their educational investments in their children. Educational investments decline overall and in Neighborhoods B and C. On the other hand, parents in Neighborhood A increase educational investments by 0.67 percent following the improvement in local school quality. The average decline in school quality and educational investments causes lower human capital accumulation, so that average income declines by 1.48 percent. However, the children of parents in Neighborhood A experience a 1.28 percent increase in income relative to the initial steady state.

The redistribution of school funding improves intergenerational mobility for lower-income families. The lower panel of Table 8 reports the change in mobility in percentage points following the redistribution policy. The persistence of low-income, $\mathbb{P}(q_1|q_1)$, decreases by 3 percentage points for all households and by 4 percentage points for households in Neighborhood A. There is a 5 percentage point increase in reaching the top quintile for children in Neighborhood A whose parents are in the 25th percentile rank. Upward mobility outcomes for Neighborhoods B and C decrease slightly, however. For instance, economic opportunity $(\mathbb{P}(q_5|q_1))$ for children in Neighborhood C decreases by 1 percentage point. The equal school funding environment is essentially a redistribution scheme, so that an improvement in mobility for children in the lowest-priced neighborhood comes at the cost of decreases in mobility for households in higher-priced neighborhoods. Nevertheless, the equal funding policy substantially decreases the dispersion in mobility across neighborhoods, where the tie between economic opportunity and where one grows up weakens.

Finally, Table 9 summarizes the steady-state welfare gains of the school funding redistribution policy, conditioning on household incomes and ability in the initial steady-state. We report the consumption equivalent value of the policy change for a household at age $t = 2$ in the initial steady state. More specifically, the consumption equivalent values calculate by how much does an agent need to be compensated in the new equilibrium to be as well off as in the initial steady state. Across the various household groups, the policy change is worth between 0.06 and 0.40 percent of current period consumption, or around 1.2 to 8 percent of annualized consumption. Households with low- to middle-incomes and those whose children have low- to middle-ability gain the most from the policy change. This is because these groups benefit the most from the increase in Neighborhood A school quality.

Table 8: Equal School Funding Policy Experiment

	ΔPopulation	ΔPrice	ΔFunding	Parent ΔEducation	Parent ΔIncome	Child ΔIncome	ΔGini
A	1.49	2.68	17.85	0.65	0.73	1.28	−0.02
B	−0.44	−1.47	−7.02	−2.61	−2.28	−2.44	−0.01
C	−1.05	−4.55	−24.24	−3.92	−4.22	−4.58	−0.01
All	0.00	−2.15	−1.07	−1.91	−1.48	−1.48	−0.02
	$\Delta P(q_1\|q_1)$	$\Delta P(q_5\|q_1)$	$\Delta P(q_5\|q_5)$	$\Delta P(q_1\|q_5)$	$\Delta P(q_5\|p_{25})$	$\Delta P(q_5\|p_{50})$	$\Delta P(q_5\|p_{75})$
A	−0.04	0.01	−0.01	−0.00	0.05	−0.00	0.10
B	−0.01	−0.00	−0.02	0.00	0.02	−0.02	0.08
C	0.00	−0.01	−0.03	0.01	0.00	−0.02	0.07
All	−0.03	0.00	−0.02	0.00	0.03	−0.01	0.09

Notes: Change in equilibrium outcomes following equal distribution of local property tax revenues across all neighborhoods. Populations reported as percentage point changes; prices, funding, education spending, and incomes all reported as percentage changes; all other variables reported as differences in levels. Changes in average child incomes reported for the children of households that located in each neighborhood. Local school funding is total revenue received from local taxes and non-local sources: $\tau p_i + \bar{Q}$.

Thus far in the equal funding experiment we have focused on steady-state comparisons. We now study the transition path from the baseline equilibrium to the one with equal school funding. At time $T = 1$ the economy is in the steady state

Table 9: Welfare Gains from Equal School Funding Policy

	(1)	(2)	(3)	(4)	(5)
CEV (%) by Ability	0.280	0.398	0.398	0.264	0.061
CEV (%) by Income	0.341	0.388	0.380	0.344	0.218

Notes: Consumption equivalent value computed for households at age $t = 2$. The first row computes average welfare gains for households conditional on five values of child abiility. The second row computes average welfare gains for households whose incomes fall within each quintile of the intitial steady state income distribution.

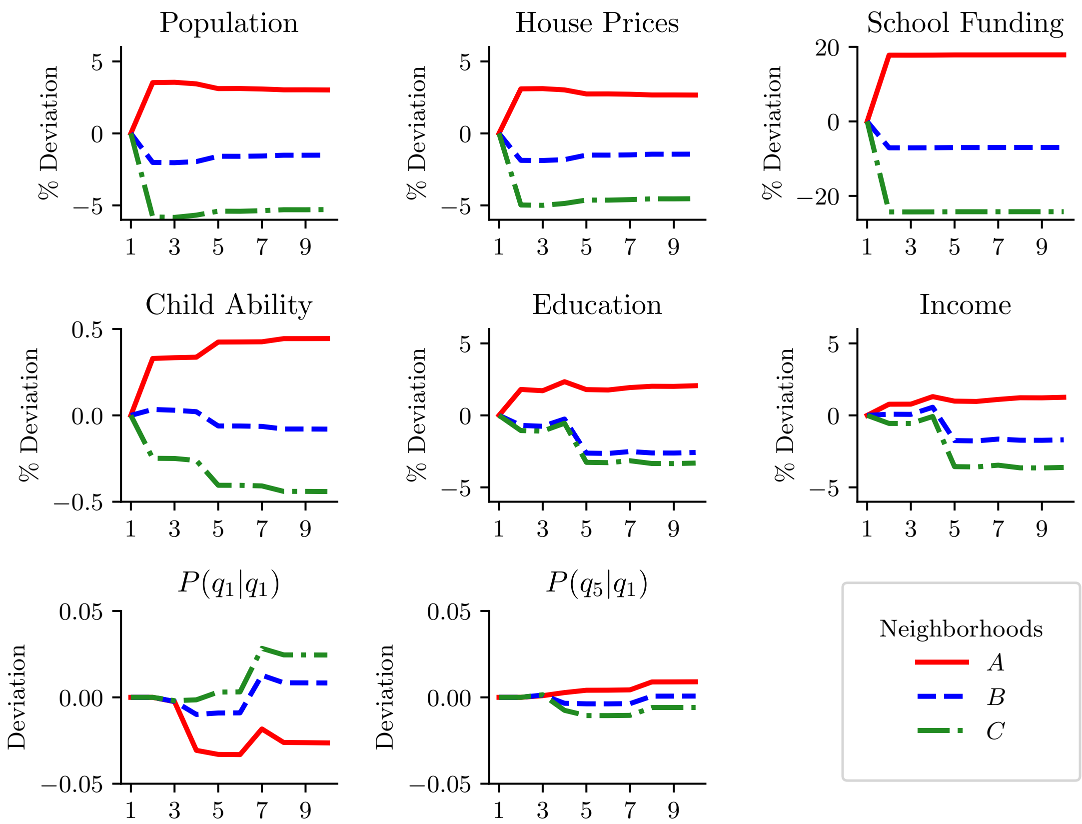
baseline equilibrium. At $T = 2$, the school funding formula changes so that all neighborhoods receive equal funding. This change comes as an unexpected shock to households. Along the transition path, available land in each neighborhood η_i is held constant while the population moves between neighborhoods. House prices adjust so that housing supply satisfies housing demand at every point along the transition. Figure 8 illustrates the transition paths from the initial steady state to the new steady-state equilibrium under the equal funding policy.

A striking feature of the transition dynamics is the slow adjustment of around 5 periods (100 years) to the new steady-state equilibrium. To understand this adjustment process, consider the age structure of households and their decisions.[25] Adults at age $t = 2$ choose a neighborhood and make education investment decisions for their children aged $t = 0$. It then takes two additional periods before those children reach age $t = 2$ and make educational decisions for their own children. The equalization of school funding occurs at period $T = 2$ in the transition path. The children that go through this policy change then become child-rearing adults in period $T = 4$. Thus, the effects of the changes in school quality on human capital accumulation and incomes cannot be observed until this time. Moreover, the parents of this initial cohort are surprised by the policy change. These parents did not have time to make optimal savings decisions for the new school funding environment, and this affects both their neighborhood choices and educational investments. Parents of the second cohort of children ($T = 3$) observe the policy change in advance, and are able to prepare for their expected neighborhood and educational decisions in advance while they are young adults ($t = 1$) in period $T = 2$. Thus, the first cohort of children to take full advantage of the new school funding environment do not themselves become parents until period $T = 5$.

The particular transition dynamics generated by this overlapping generations

[25] See Figure 4.

Figure 8: Transition Paths Following Equal Distribution of School Funding



structure can be seen in the evolution of neighborhood house prices, education spending, household incomes, and intergenerational mobility statistics.[26] First, note that neighborhood populations and house prices overshoot their final steady-state values. The incomes of initial cohorts are not affected by changes in school funding, since they are already adults at the time. Equalizing school funding induces many households to take advantage of the lower house prices in Neighborhood A. When the children of these families grow up, they benefit from the higher human capital accumulation provided by the increase in school quality in Neighborhood A. Some of these children, who now have higher incomes, reallocate across Neighborhoods B and C causing shifts in populations and prices between periods $T = 4$ and 5.

As adults ($t = 2$), the second cohort of children to experience the change in school funding experience significant changes in incomes and also make very differ-

[26] As a reminder, household incomes are calculated for adults at age 2.

ent decisions regarding educational investments. In particular, households living in Neighborhoods B and C from period $T = 5$ onward have significantly lower incomes and invest less in education. The effects of the policy change are then self-reinforcing: lower quality schooling in higher priced neighborhoods leads to lower human capital accumulation; lower future incomes leave less to spend on educational investment at the same time that the fall in school quality lowers the return to educational spending. Also note that the neighborhood sorting channel is weaker than in the initial steady state. Overall, the average ability of children in Neighborhood A rises by 0.5 percent and falls by around 0.1 and 0.5 percent in Neighborhoods B and C, respectively.

The third row of Figure 8 illustrates the paths of the intergenerational mobility statistics $P(q_1|q_1)$ and $P(q_5|q_1)$ following the policy change. Note that these statistics report outcomes for children as adults ($t = 2$) at a given point in the transition (T), while their parents made schooling decisions two periods prior ($T - 2$). The persistence of low income, $P(q_1|q_1)$, in Neighborhood A falls by 4 percentage points for children first exposed to the school funding policy change. Economic opportunity, $P(q_5|q_1)$, in Neighborhood A also rises slowly over the transition path. Importantly, the full effect of redistributing school funding on intergenerational mobility occurs many generations after the policy is first implemented. This suggests that although the effects of such policies can be large, they cannot quickly resolve a lack of intergenerational mobility.

Finally, Figure 9 reports welfare changes along the transition path following the redistribution of school funding. As in the static welfare analysis, we report the average consumption equivalent value for households at age $t = 2$ relative to their outcomes in the initial steady state, conditional on household incomes and ability in the initial steady-state.[27] Figure 9a shows the welfare gains across the child ability distribution.[28] Households with the highest ability children (a_5) experience the smallest welfare gains, but these gains are front-loaded with no adjustment along the transition path. In contrast, the welfare gains for households with the lowest ability children (a_1) take many generations to be realized. That is, households with low ability children enjoy three times larger welfare gains in the tenth generation than in the first generation after the policy change. Lower-ability children tend to have lower ability and lower income parents. With less resources, these families need more time to adjust their savings and investments to the new

[27]Again, the consumption equivalent values are calculated as the percentage increase in consumption at time T of the transition path that agents needs to be compensated with to be indifferent with the baseline steady-state equilibrium.

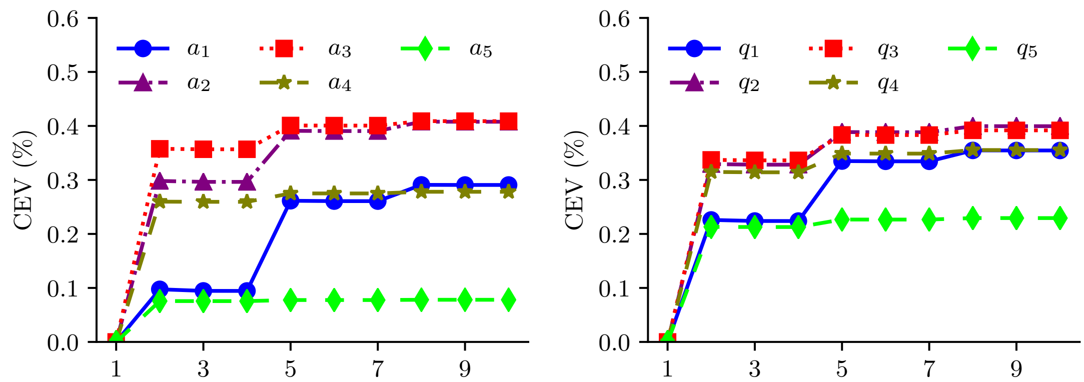
[28]Each point in the distribution corresponds to a grid point in the discretized state space we use to numerically solve the model. Points 1 through 5 correspond to percentiles 6.25, 31.25, 68.75, 93.75, and 100, respectively.

school funding environment. Households with middle ability children enjoy larger gains than high and low ability children, and with much faster convergence to the overall welfare gains than for low ability children.

Figure 9b illustrates very similar results when conditioning on a household's position in the income distribution. Households in the top quintile of the income distribution have the smallest gains, but converge quickly to the long-run value of those welfare gains. Households in the bottom quintile of the income distribution have slightly larger welfare gains, but the long-run gains are not realized until the eighth generation after the policy change. This dynamic assessment of welfare gains suggests that the redistribution of school funding benefits virtually all households, but that those benefits may take time to accrue.

Figure 9: Dynamic Welfare Gains Following Equal Distribution of School Funding

(a) Welfare Gains by Child Ability (b) Welfare Gains by Household Income



Note: Welfare gains for age $t = 2$ households relative to the steady state prior to the equalization of school funding. Figure 9a shows average welfare gains for households at points in the child ability distribution. Figure 9b shows average welfare gains for households whose incomes fall within each quintile of the initial steady state income distribution.

7 Conclusion

In this paper, we present a life-cycle model of human capital formation with neighborhood choice and endogenous school quality. School quality is determined by the revenue from taxes on local property prices. This link between property prices and school quality generates significant variation in income mobility across neighborhoods. Low-income families tend to live in low-priced neighborhoods with little school funding, which leads their children to accumulate less human capital and to have lower incomes than their peers. A counterfactual exercise in which all children receive the median school quality decreases the persistence of low income by 13 percent for families in the lowest priced neighborhood. Thus, breaking the link the between house prices and school quality is crucial for improving intergenerational mobility.

We explore two experiments in the model that aim to improve mobility and the outcomes for children. First, we offer housing vouchers to households living in the lowest priced neighborhood to move to neighborhoods with higher quality schools. The voucher program significantly increases the future incomes of children exposed to higher quality schools. Moreover, the benefits of moving neighborhoods can last for several generations: we observe significant increases in the average incomes of grandchildren and great-grandchildren of those households that moved. The main benefits of the voucher stem from the fact that future generations can also afford to live in higher school quality neighborhoods as well. Second, we study a policy that redistributes local revenues equally across schools. This equalization of school funding causes a significant reduction in cross-neighborhood differences in income mobility. Dispersion in low-income persistence across neighborhoods falls by four percentage points, and the range in economic opportunity falls by two percentage points. The children of households living in the lowest-priced neighborhoods benefit the most from such a policy change. However, it takes several generations to converge to the new steady-state following the introduction of the policy, as incomes and optimal savings rates respond to the change in house prices and school qualities. As a result, both the improvements in economic mobility and the welfare benefits from the policy can take many years to materialize.

A Appendix

Data Sources

The National Center for Education Statistics (NCES) provides data from the Census and American Community Survey (ACS) aggregated at the school district level. Data on populations, median house values, median household incomes, and median gross rents are available for the 1990 and 2000 Census; median real estate taxes are available from the 2000 Census; populations are available from the 1990 and 2010 Census; and median house values, median household incomes, and median gross rents are available for the 2009-2013 ACS. All data is available for download at the NCES website: https://nces.ed.gov/programs/edge/Home.

Data on neighborhood mobility and covariates is taken from the "Opportunity Insights" project, available online at https://opportunityinsights.org/. The estimates we use are reported in Chetty et al. (2018). Mobility outcomes are available for children born between 1978 and 1983, pooled across race and gender within each census tract. Tract ID numbers follow the 2010 Census definitions. Income is defined at the household level.

We aggregate census tract outcomes up to the school district level using the 2013 Geographic Relationship File from the NCES. This data is available online at https://nces.ed.gov/programs/edge/Geographic/RelationshipFiles. We compute school district-level variables as the population-weighted averages of those census tracts falling within each school district. We use population counts from the 1990 Census.

Data on school financing is available from the NCES.[29] We collect per-pupil financing from local and state sources for each school district for the year 2010-2011 and merge it to the other district information.

Model Robustness

[29] See https://nces.ed.gov/ccd/elsi/tableGenerator.aspx

Table 10: Calibrated Model Parameters for Each State

	Parameter	CA	FL	GA	IL	NC	NY	MI	OH	PA	TX
β	Discount factor	0.931	0.921	0.946	0.901	0.900	0.910	0.904	0.918	0.918	0.947
α	Altruism	0.503	0.940	0.809	0.695	0.943	0.946	0.700	0.502	0.502	0.909
σ_ε	Taste shock	0.393	0.102	0.073	0.274	0.140	0.309	0.109	0.140	0.140	0.273
μ_a	Mean ability	20.236	16.013	20.878	30.906	7.003	16.294	20.261	25.223	25.223	11.373
σ_a	Ability shock	0.418	0.069	0.315	0.490	0.288	0.153	0.650	0.362	0.362	0.432
ρ_a	Ability persistence	0.625	0.599	0.716	0.644	0.771	0.816	0.513	0.518	0.518	0.660
σ_y	Income shock	0.548	0.977	0.506	0.535	0.489	0.573	0.487	0.508	0.508	0.851
γ	Education elasticity	0.110	0.404	0.187	0.102	0.312	0.198	0.163	0.475	0.475	0.259
$\bar{Q}$	Non-local school funds	0.193	0.112	0.321	0.268	1.335	0.117	1.334	0.568	0.568	0.068
η_A	Available land, A	0.911	4.757	1.409	0.468	5.204	2.517	1.514	0.287	0.719	60.212
η_B	Available land, B	0.341	2.225	0.283	0.119	1.723	0.824	0.343	0.073	0.173	12.952
η_C	Available land, C	0.160	1.096	0.036	0.038	0.662	0.359	0.102	0.021	0.055	2.549

Notes:

Table 11: Model Fit for Each State

	California		Florida		Georgia		Illinois		North Carolina	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
Median networth/income	1.711	1.738	1.711	1.729	1.711	1.685	1.711	1.719	1.711	1.619
Bequests share of networth	0.003	0.001	0.003	0.028	0.003	0.007	0.003	0.004	0.003	0.002
Median rent/income	0.209	0.217	0.206	0.123	0.171	0.133	0.166	0.143	0.166	0.142
Median income, C/A	1.446	1.456	1.221	1.207	1.786	1.855	1.908	1.932	1.451	1.454
Gini coefficent, $t = 2$	0.512	0.439	0.531	0.546	0.499	0.421	0.446	0.499	0.458	0.409
$\mathbb{P}(q_1\|q_1)$	0.302	0.393	0.307	0.240	0.336	0.435	0.344	0.458	0.388	0.451
$\mathbb{P}(q_5\|q_1)$	0.102	0.063	0.061	0.162	0.043	0.046	0.070	0.037	0.046	0.033
Education share	0.019	0.015	0.019	0.072	0.019	0.062	0.019	0.009	0.019	0.041
Mean local funding ratio	0.276	0.375	0.357	0.234	0.296	0.350	0.483	0.656	0.000	0.052
Population, A	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.501
Population, B	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.299
Price ratio, B/A	1.690	1.690	1.284	1.284	1.505	1.505	1.768	1.768	1.300	1.300

	New York		Michigan		Ohio		Pennsylvania		Texas	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
Median networth/income	1.711	1.752	1.711	1.643	1.711	1.660	1.711	1.661	1.711	1.637
Bequests share of networth	0.003	0.002	0.003	0.004	0.003	0.000	0.003	0.000	0.003	0.060
Median rent/income	0.198	0.197	0.172	0.065	0.164	0.114	0.171	0.086	0.174	0.332
Median income, C/A	1.245	1.206	1.976	1.821	1.836	1.722	1.902	1.762	1.772	1.761
Gini coefficent, $t = 2$	0.471	0.382	0.391	0.466	0.407	0.475	0.401	0.477	0.512	0.579
$\mathbb{P}(q_1\|q_1)$	0.322	0.320	0.356	0.435	0.393	0.465	0.345	0.474	0.288	0.329
$\mathbb{P}(q_5\|q_1)$	0.094	0.105	0.061	0.050	0.056	0.030	0.086	0.029	0.088	0.089
Education share	0.019	0.030	0.019	0.019	0.019	0.048	0.019	0.049	0.019	0.079
Mean local funding ratio	0.471	0.477	0.182	0.140	0.441	0.416	0.430	0.408	0.434	0.526
Population, A	0.500	0.501	0.500	0.500	0.500	0.499	0.500	0.500	0.500	0.499
Population, B	0.300	0.299	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.301
Price ratio, B/A	1.677	1.677	1.735	1.735	1.434	1.434	1.745	1.745	1.475	1.475

Notes:

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