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School finance, spatial income segregation, and the nature of communities

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Abstract

In a general equilibrium model that links school and housing markets, a purely public school system (regardless of the degree of centralization) results in substantially more spatial income segregation than a purely private system. However, the combination of a public system with a private school market yields the least residential segregation as housing price distortions from the capitalization of the public system generate incentives for middle and high income private school attendees to live with lower income public school attendees. The impact of vouchers and the sensitivity of results to alternative school production models is also investigated.

1. Introduction

Despite little evidence that spending alone is the key determinant of public school quality, many who are concerned with equity in public education have paid almost exclusive attention to the goal of eliminating differences in per pupil spending across schools and districts. At the same time, there is strong evidence that district and neighborhood based school systems generate incentives that lead to residential income segregation, and there is mounting evidence that such income segregation could perpetuate income inequality.[1] It is therefore puzzling that those concerned with inequities arising out of current education financing institutions have focused so narrowly on per pupil spending differences and not more broadly on the larger equilibrium implications of different types of school finance

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[1] For an analysis of the relationship between local school differences, income segregation and the persistence of income inequality, see Benabou [1,2].

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institutions. This paper analyzes one aspect of these equilibrium implications—the impact of school financing institutions on residential income segregation.

The issue of residential income segregation is important as social science researchers are increasingly focusing on the impact of neighborhood effects and spillovers on long run prospects for children. While some of the literature on neighborhood effects is still in its early stages and while the empirical problems in identifying such effects are still somewhat unresolved, there is widespread belief that such effects exist and are important contributors to long run inequality.[2] If this is indeed the case, then the impact of education finance policy on spatial income segregation may be every bit as important for child outcomes as those factors within schools that are studied more commonly.

For this reason, I will focus exclusively on the general equilibrium effects of school finance institutions on residential segregation. Section 2 begins with a discussion of how residential segregation emerges in a theoretical local public finance model and how policies might be crafted to combat such segregation. Section 3 then introduces a structural model of a decentralized local economy in which households choose where to live, where to send their child to school, and how much political support to provide for public schools that are financed by both local and state governments. The underlying structural parameters of production and utility functions are then calibrated so as to replicate important features of school districts in New Jersey—including the levels of segregation that are observed. Section 4 begins policy simulations with these structural parameters held fixed. First, I compare the degree of income segregation that arises endogenously under centralized versus decentralized public school financing. Second, the role of an independent private school sector is explored, as is the way in which private school attendance differs between a centralized and a decentralized system of public school funding. Motivated by some of the more surprising results from this exercise, Section 5 explores the potential for public support of private schools through vouchers to impact spatial income segregation. Section 6 briefly comments on the difference between school segregation and residential segregation and demonstrates that the previous results are robust to alternative models of school quality. Finally, Section 7 concludes.

2. Segregating and desegregating forces in local public finance model with schooling

Residential income segregation in the real world clearly has many sources, and the extent to which public financing of schools contributes to the observed segregation is difficult to isolate. One possible way to accomplish this is to specify a structural general equilibrium model that includes the most important causal channels leading to income segregation, and then to let the data determine the values of the underlying structural parameters. This is the approach taken in this paper, and I therefore begin with a discussion of how empirically relevant segregating and desegregating forces are generally introduced

[2] Some recent controlled experiments (known as "Moving to Opportunity" programs) in several large US cities are still relatively young but are beginning to suggest neighborhood effects at least in relation to behavior problems (Katz et al. [13]). For some recent analysis of neighborhood effects outside the controlled experiment setting—particularly as they relate to race–ethnicity, see Cutler and Glaeser [5] and Borjas [3].

into structural models that involve school financing institutions. It should be noted at the outset that my focus in this paper is on *income* segregation. Thus, the analysis is relevant to issues involving *racial* segregation only to the extent that such segregation is driven by income differences.

2.1. Causes of residential income segregation

In the framework developed in this paper, residential income segregation has two very distinct sources. First, housing markets are such that different neighborhoods and districts are endowed (through a historical process that is not modeled explicitly) with different distributions of housing and neighborhood quality. Even without public schools, residential income segregation emerges in such a framework as households segregate based on their demand for housing–neighborhood quality. Second, the residential location choice is linked to school quality by the introduction of a public school system in which a child is permitted to attend a particular public school if and only if that child's household resides within that school's exogenously defined district boundary. If local school quality is, in some way, related to the average household income in the district, then differences in public school quality would lead to additional incentives for high income parents to segregate.

Perhaps the easiest way to see the causal link within such a model between school financing institutions and residential income segregation is to begin with a special case of the model in which no such segregation arises—i.e., where both sources of segregation are assumed away. First, such a model would have to contain homogeneous housing stocks in all districts (with no possibility of altering this stock). Second, it would have to assume a public financing system and a school production technology such that all households always have access to the same public school quality regardless of where they live. The only obvious way of accomplishing this would be to assume a centralized and equalized public financing system *as well as* a school production technology whose only input is spending per pupil. Thus, in a world with

(1) no housing–neighborhood differences, with
(2) public schools funded centrally and equally, and with
(3) school quality depending only on per pupil spending,

we would expect no residential income segregation.

An introduction of heterogeneous housing and/or neighborhoods is the most obvious channel for income segregation to emerge as households with different incomes would move to different districts in order to satisfy their different demands for housing–neighborhood quality. An empirically relevant structural model for analyzing the role of schools in residential segregation must therefore begin with a heterogeneous housing stock that exhibits equilibrium price distributions comparable to those observed in the data. The model I present in this paper accomplishes this.[3] But even with housing and neighborhoods

[3] Furthermore, as emphasized later in the paper, by calibrating house quality using housing prices, the model incorporates into "house quality" all factors that enter housing prices—including neighborhood externalities and amenities.

completely homogeneous across districts, a relaxation of either of the other two conditions would also lead to segregation. First, consider a relaxation of the central and equal funding condition to one where high income households—if they segregate—can obtain higher funding levels. The most obvious route to accomplish this would, of course, be through a decentralized system in which funding for local schools is at least in part raised locally.[4] The same could, however, arise within a centralized financing framework if the political process is such that higher income households command more power in the allocation of public resources. In either case, high income households have an incentive to segregate even if housing and neighborhoods in all jurisdictions were the same. A second feature important for an empirically relevant structural model therefore involves the introduction of a state–local public school financing process that mimics what is observed in the world that generates the underlying per pupil spending data used to inform the model. Our benchmark model therefore mimics the school financing system in New Jersey.

Decentralized public school funding is not, however, the only means through which public schools can result in segregation equilibria in models that contain homogeneous housing–neighborhoods. In particular, suppose that the system were completely centralized and equally funded, but school production were such that per pupil spending is not the only determinant of school quality. For instance, if other determinants of school quality are correlated with average household income within a district, then yet a third segregating force has been identified. Examples of how average household income within a district may be correlated with important inputs into education production abound. For example, even if all schools are constrained to spend the same amount of public money per pupil, the quality of inputs purchased by that money may differ substantially. High quality teachers, for instance, may be placed in higher income areas as a form of compensation for their quality (since such compensation typically cannot occur through differential wage payments).[5] Peer effects that are correlated with household income may produce better schools in high income neighborhoods even if all other inputs are identical.[6] High income parents may monitor schools more carefully and thus raise the average and marginal impact of a dollar of per pupil spending.[7] And, high income parents may contribute privately to augment public school budgets.[8] A final important element to the structural model used in this paper therefore involves the introduction of peer effects that can be broadly interpreted to proxy for any combination of effects such as these.

All three of these sources of segregation—housing markets, school spending differences arising from decentralization, and the presence of school inputs (other than spending)

[4] Many local public finance models, starting with Westhoff [27] and Rose-Ackerman [23], have demonstrated this. Recent examples of work that has abstracted away from housing–land heterogeneity of the type I mention but still analyzed models in which segregation arises include Fernandez and Rogerson [10] and Epple et al. [6]. Typically, such models in fact tend toward an extreme form of income segregation unless preference heterogeneity is introduced in addition to income heterogeneity (Epple and Platt [9]).

[5] See, for example, Loeb and Page [14] for evidence of the importance of this effect.

[6] As suggested later in this paper, there is at least some evidence that positive peer effects are indeed correlated with parental income.

[7] McMillan [15] presents evidence suggesting the importance of parental monitoring as well as its correlation with parental income.

[8] Brunner and Sonstelie [4] present evidence that this is happening in the centralized California system.

that are correlated with income—are likely to be important in the real world but are difficult to identify separately in a standard empirical framework. As mentioned above, our approach therefore differs from the standard empirical approach in that it begins with the incorporation of these forces into a structural model. It then continues with a calibration of the underlying structural parameters of preferences and production functions in such a way as to replicated the current levels of income segregation as well as other important features of the data. Thus, the data will determine the relative importance of each of these forces, and the calibrated structural model will permit policy simulations to investigate how much segregation can in fact be attributed to the public financing system as well as how much potential for yielding greater desegregation is contained in possible reforms to this system.

2.2. The added complication of private schools

Throughout the discussion above, I have implicitly assumed that public schools provide the only possible alternative to parents and that, to the extent that they choose a school, parents are doing so solely through their residential location choices. In the USA, however, this is clearly not the case as approximately 12–13 percent of parents choose private schools for their children (and an even higher percentage do so in the New Jersey data used to calibrate the model in this paper). The introduction of private schools into a local public finance economy then significantly complicates the theoretical predictions regarding segregation.

Consider, for instance, an economy in which the three segregating forces identified above—housing markets, local school spending, and peer effects—result in districts that offer different qualities of public schooling. It is well understood that such differences in schooling will typically be capitalized into housing prices—thus depressing housing values in poor districts with bad public schools and inflating values in rich districts with good public schools. A household that does not care about public school quality would therefore rationally choose to live in the poor district so long as housing of the desired quality were available in that district. Thus, a household that has chosen private schooling would have an incentive to reside in a bad public school district precisely because of inequities in the public school system. But, to the extent that demand for private schooling comes from relatively higher income households, this suggests the potential for private schools to introduce a *desegregating* force into a segregated local public economy. This effect has been shown to be important for policies such as vouchers (Nechyba [19]), but the extent to which it is important in the absence of vouchers—i.e., in our present system of public and private school finance—remains unresolved.

2.3. Policy options for lowering residential segregation

Aside from the obvious policy option of decreasing the differences of housing stocks in different school districts, the above discussion then gives rise to two alternative options for achieving less residential income segregation through school finance policies. First, it seems that differences of per pupil spending levels that are correlated with differences in district incomes result in greater segregation—which implies that policies aimed at equalizing expenditures should have desegregating effects. Second, policies that insure

a healthy private school market may also play a role in leading to less segregation. Which of these policies is more effective, however, is unclear without an analysis that permits for the full unfolding of general equilibrium effects from each of these two policy alternatives. The structural model employed in this paper provides a framework for conducting just such a general equilibrium analysis. We therefore now proceed to a formal development of this model (Section 3) and then a presentation of policy simulations.

3. Model set-up

The theoretical model on which this paper's simulations are based is essentially that presented in Nechyba [16,19], a model calibrated to data from the USA. The model builds a private school market into a well defined local public goods economy first explored in Nechyba [21], and policy implications from differing school finance systems are explored in that context. The model takes as given the boundaries that divide a fixed set of houses into school districts and places no a priori restrictions on the mix of housing and neighborhood qualities within and across these boundaries. While this allows the model to accommodate the empirically important possibility of the coexistence of rich and poor "neighborhoods" within a single school district—thus allowing for the first of the three segregating effects discussed in Section 2, it does not permit for a change in the inherent desirability of different houses as populations change nor does it permit political jurisdictions to change their boundaries.

Each household is endowed with a house (which can be sold at the market price), a parental income level and an ability level for its one child.[9] Parents take endowments as given and choose

(i) where to live,
(ii) whether to send their child to the local public or a private school, and
(iii) how to vote in local or state elections (depending on the finance regime that is in place),

determining the level of public school spending. The second segregating force—different per pupil spending levels arising from a decentralized political process—is therefore

[9] The assumption of an equal number of children per household is common in this type of model. An alternative way of modeling this would be to include childless households. However, it would then be difficult to specify a political economy model that could approximate the outcomes we observe in the data given that childless couples tend to vote for substantially more public school spending than would be predicted unless such households took into account general equilibrium effects. Given the complexity of the model as it stands, such an extension of the political economy portion of the model is currently not feasible. Furthermore, most households *do* have children at some point in their life-cycle. Thus, including childless couples would require introducing a more dynamic dimension to the currently static model, and it would result in the prediction that households move as children leave the household. This, too, is empirically not generally the case to the extent that the theory might predict—i.e., communities that specialize in servicing solely the elderly are rare. Thus, in the static context of the current model, it seems appropriate to model all households *as if* they had children—thus avoiding the need for a highly complicated political economy model and the explicit inclusion of complex dynamics.

explicitly allowed. Similarly, the third segregating force is introduced through the inclusion of peer effects (in addition to per pupil spending) in the school production function. Private schools are then allowed to compete, and they hold an advantage over public schools in that they can set admissions requirements (related to peer effects). Public schools, however, have to accept all students living within the district. A more formal exposition follows.

3.1. Community structure and households

A fixed school district and neighborhood structure

$$C = \left\{ C_{dh} \;\middle|\; C_{dh} \cap C_{d'h'} = \emptyset \;\forall (d,h),(d',h') \in D \times H \text{ s.t. } (d,h) \neq (d',h') \text{ and } \bigcup_{d \in D, h \in H} C_{dh} = N \right\}$$

is imposed on the set of houses which is represented by the unit interval $N = [0, 1]$.[10] This partitions houses into a set of house–neighborhood types $H = \{1, \ldots, h, \ldots, H\}$ spread over a set of school districts $D = \{1, \ldots, d, \ldots, D\}$, where C_{dh} is the set of houses of type h located in district d, or the set of houses in "neighborhood h" of community d.

Households are endowed with income, a house, a child with some exogenous ability level, and preferences over the consumption set. Both the income and the house endowment, however, can be viewed as private good endowment, except that the value of the house endowment is endogenous. More precisely, it is assumed that there is one and only one house for each household in the model, and neither multiple residences nor homelessness are allowed. Thus, the unit interval $N = [0, 1]$ which represents the set of houses also represents the set of households. Household n is initially endowed with house n. Furthermore, a private good endowment function $z : N \to \mathbb{R}_+$ divides this set of households into a finite set[11] of "income types." Finally, each household $n \in N$ has one child, and ability levels for that child are assigned via a function $a : N \to \mathbb{R}_+$ (which may or may not be correlated with household income).

Each household is assumed to act as one utility maximizing agent with utility function $u^n : D \times H \times \mathbb{R}^2_+ \to \mathbb{R}_+$ that takes as its arguments the district and neighborhood the agent lives in, his private good consumption $c \in \mathbb{R}_+$, and the perceived school quality level $s \in \mathbb{R}_+$ enjoyed by the household's child. In principle, few restrictions on utility functions are necessary for the existence of an equilibrium, inter-jurisdictional spillovers could be added, and preferences may vary across household types (Nechyba [20,21]). The model does not, however, incorporate the choice of whether or not to send a child to school.[12] Instead, parents who value schooling less have only the option of choosing a lower quality school which is cheaper.

[10] More precisely, the set of houses is defined as part of a measure space $(N, \mathbb{N}, \mu)$ where μ is taken to be the Lebesgue measure. All subsets referred to are henceforth assumed to be measurable.

[11] The assumption of finiteness of the number of income types is made for technical reasons related to the existence of an equilibrium. These issues are discussed in detail in Nechyba [21].

[12] In other words, the model assumes that education is compulsory, which then implies that the child's foregone labor income is a sunk cost and not an opportunity cost of going to school.

3.2. Public and private school markets

Both public and private schools face the same technology. They combine per pupil spending with average peer quality to produce the output s that enters the utility functions of the households. This then permits both school-related segregating effects discussed in Section 2. A child's peer quality $q^n : \mathbb{R}_+^2 \to \mathbb{R}_+$ is jointly determined by his parents' income level and his own ability,[13] and the school quality is given by a production function $f : \mathbb{R}_+^{k+1} \to \mathbb{R}_+$ that takes as its arguments per pupil spending as well as k moments of the distribution of household peer quality of the school population. In practice, the model that will be used in most of the simulations restricts itself to one moment of this distribution—the average peer quality. However, additional simulations in which the variance enters are presented in Section 6.

Before defining an equilibrium formally, the public choice process that determines x_d—the per pupil public school spending in district d—must be specified. Let $\eta \subseteq N$ be the subset of households that choose to send their children to public school. Then per pupil spending in district d under a system with at least some property tax revenue is

$$x_d = \big(t_d P(C_d) + \mathrm{AID}_d\big)/\mu(\eta \cap J_d),$$

where t_d is the local property tax rate in district d,[14] AID_d is the total central government aid exogenously received by district d, and $P(C_d) = \sum_{h \in H} \mu(C_{dh}) p(C_{dh})$ is the local property tax base. This base varies with the endogenously determined house price function $p : D \times H \to \mathbb{R}_+$ that gives rise to an equilibrium house price vector $p \in \mathbb{R}_+^{DH}$ and thus assigns a unique price to each house type in each district. The formula underlying AID_d may in principle contain a variety of matching and block grant features which are taken into account by voters as they vote on local tax rates. In this paper, however, it is only used in the calibration of the model—all simulations consider only the extremes of local or central government financing.

While voters do take into account central government aid, they are otherwise assumed to be quite *myopic*—i.e., they take community composition and property values as given when going to the polls. Such voter myopia is technically convenient and thus relatively standard in the literature (Epple et al. [6], Rose-Ackerman [23]).[15] Furthermore, although

[13] More precisely, a child is assumed to impact his peers in two ways: first, through his parents' income level and second, through his own ability. The former of these captures the fact that parental involvement and monitoring of schools increases in household income (see McMillan [15]), while the latter captures spillovers within the classroom.

[14] Nechyba [22] shows that the use of property taxes is the dominant local tax strategy in this model.

[15] Nevertheless, it is restrictive in the sense that voters likely do take property values into consideration when voting in local elections. Under voter myopia, expectations about property values are correct only in equilibrium and not off the equilibrium path. In a more complicated model, voters would forecast property values under all conceivable tax rates and spending levels and calculate the impact of each rate on their personal wealth. Computationally, it would not be feasible to conduct this analysis with as rich a type space and with peer inputs playing a role in production. Thus, a methodological trade-off emerges between specifying a relatively rich model in all other respects and keeping the voting assumptions simple or radically reducing that richness and replacing it with a non-myopic voting process. Given the goals of this paper, the former choice seems appropriate. While it does lose some important elements of the voting process, the precise voting model is ultimately not what

the model assumes that voting takes place at the local government level over property tax rates (holding constant the exogenous state aid formula) whenever local funding is supplemented by some state formula, I assume that voting takes place at the state level over income tax rates t_s under a centrally funded system. In that case, per pupil spending is assumed to have been equalized—i.e.

$$x_d = x = \big(t_s z(N)\big)/\mu(\eta \cap J_d), \quad \forall d \in D.$$

In the absence of private schools, a voting equilibrium for a given partition of the population is then obtained relatively easily as myopic preferences over local tax rates are single peaked (Nechyba [21]). With private schools, however, preferences lose the single-peakedness property (Stiglitz [24]) unless an additional myopia assumption—that agents make the choice over private versus public education prior to voting—is made (Nechyba [20]).[16] In addition, the possibility of private schools requires voters to know what types of private schools would be available to them, and at what cost. This is accomplished by assuming the private school market to be perfectly competitive, with each school able to select from its applicant pool. Given the education production technology, no private school can then have multiple types in equilibrium,[17] which implies that all households know that the optimal private school its child could attend is one that spends the household's most preferred amount per pupil (which is equal to tuition) and whose student population is composed of the same peer type. An alternative conceptual approach is to model private schools as clubs of parents who can choose to exclude others and who commit to sharing the cost of the club equally. Either conception—the club model or the perfectly competitive model—yields the same equilibrium (Nechyba [20]).

drives the results here. This is most obvious when comparing results under local and state financed systems in Section 4—where voter myopia is substantially less restrictive for state level voting since such a system treats all districts equally and thus has little impact on property values. The general equilibrium effects discussed in this paper are equally important under both types of systems even though voter myopia is substantially more binding in one case than in the other.

[16] Thus, preferences over taxes for those voters who choose public schools remain single peaked as before, and preferences for voters who chose private schools are single peaked with peak at $t = 0$ (in the absence of state aid) or $t < 0$ (under state aid). As pointed out in Nechyba [20], this leads to the existence of trivial equilibria in which there are no public schools (and, given everyone attends private schools, no public schools arise). In the simulations, however, these trivial equilibria are reported only if there does not exist an equilibrium with public schools.

[17] This is demonstrated in Nechyba [20]. If a private school did have a mix of different types of students, then it would contain students who either had different abilities or had parents with different wealth levels. If the heterogeneity is in the ability dimension, then a new private school could enter, charge the same tuition but restrict its population to only high types. If, on the other hand, the heterogeneity arises from different wealth levels, then at most one household is receiving its most preferred level of per pupil spending. But then there is, once again, room for a new entrant that can cater to the other household. As a result, since there are not set-up costs to schools, a competitive equilibrium is characterized with each household having the option of attending a private school with the same peer type charging the most preferred tuition level for that household. Note that this implicitly also assumes that within any given private school, tuition is the same for all students. Otherwise, price discrimination on the basis of peer quality can arise (assuming that schools can observe peer quality prior to admitting students) (Epple and Romano [7]).

3.3. Equilibrium

Given some exogenous state aid formula, an equilibrium must specify a list $\{J, \mathbf{t}, \mathbf{s}, \mathbf{p}, \eta\}$ that includes a partition of households into districts and neighborhoods J, a tax vector $\mathbf{t} \in \mathbb{R}_+^{D+1}$ with a state income tax rate t_0 and local property tax rates $(t_1, \ldots, t_D)$, local public school qualities $\mathbf{s} \in \mathbb{R}_+^D$, land prices $\mathbf{p} \in \mathbb{R}_+^{DH}$ and a specification of the subset of the population that attends public rather than private schools $\eta \subseteq N$. For the case of a decentralized system with central government aid supplements, we can define such an equilibrium formally as follows.

Definition. A *decentralized equilibrium* is a list $\{J, \mathbf{t}, \mathbf{s}, \mathbf{p}, \eta\}$ such that

(1) $\mu(J_{dh}) = \mu(C_{dh})\ \forall (d,h) \in D \times H$ (every house is occupied);
(2) Property tax rates $(t_1, \ldots, t_D)$ are consistent with majority voting by residents;
(3) $s_d = f(x_d, q_d)$ for all $d \in D$, where $x_d = (t_d P(C_d) + \mathrm{AID}_d)/\mu(\eta \cap J_d)$ (local budgets balance) and $q_d = ((Z(\eta \cap J_d)), (A(\eta \cap J_d)))$;[18]
(4) $\sum \mathrm{AID}_d = t_0 Z(N)$ (the state budget balances);
(5) At prices $\mathbf{p}$, households cannot gain utility by moving and/or changing schools (market clearing); and
(6) No private school can enter and make positive profits (perfect competition).

The theoretical properties of this equilibrium are explored in detail in Nechyba [20] where it is demonstrated that, under relatively weak assumptions, such an equilibrium is guaranteed to exist. Furthermore, with sufficient variation in mean house quality across districts, the equilibrium assignment of agents across neighborhoods and communities is unique with the exception of "trivial equilibria" in which there are no public schools. *Centralized* equilibria supported by state income taxes are defined analogously.

3.4. Functional forms and calibration

Several functional forms have to be assigned in order to operationalize this theoretical model computationally. These include: utility functions u, peer quality functions q, an education production function f, a wealth endowment function z and an ability endowment function a. Unless otherwise specified, the following are the functional forms for the first three of these:

$$u^n(d,h,s,c) = k_{dh} s^{\alpha} c^{\beta} \quad \forall n \in N;$$
$$q(n) = \left(z(n)^{\theta} a(n)^{(1-\theta)}\right)/7.5;[19]$$
$$s = f(x,q) = x^{(1-\rho)} q^{\rho} \quad \text{where } 0 \leqslant \rho \leqslant 1.$$

[18] $Z(J_d) = \int_{Jd} z(n)\,\mathrm{d}n$ and $A(J_d) = \int_{Jd} a(n)\,\mathrm{d}n$ are the average income and the average ability level (respectively) of the population assigned to district d.

[19] The function is divided by 7.5 in order to make peer quality similar in magnitude to per pupil spending. This is of no consequence other than that is eases the interpretation of the parameter ρ in the next equation.

The model is calibrated to data on the suburban school districts in New Jersey using a data set described extensively in Nechyba [16,19]. The income endowment function $z : N \to \mathbb{R}_+$ creates 20 income types and replicates a discretized version of the actual household income distribution observed in the data. Incomes in the model therefore range from 1 (corresponding to $10,000) to 20 (corresponding to $200,000), and the measure of agents with different levels of income is given by the observed household income distribution in the data. Each of these 20 income types is initially spread uniformly across all neighborhoods (in all school districts) when house endowments are assigned. The model assumes three school districts of roughly equal size (corresponding to a stylized low income, middle income and high income district in New Jersey), with five distinct neighborhoods or house qualities per district. This causes the initial set of 20 income types to become 300 endowment types, where the distribution of the value of the combined income and house endowments now more smoothly replicates the observed income distribution. Given that this is a static model calibrated to annual data, the "value" of a house is defined as the annualized flow of house–neighborhood services.[20]

Ability endowments take on 5 different possible discrete values which are set to range from 1 to 10.[21] Empirical estimates of the correlation of parental and child income of 0.4 (Solon [25], Zimmerman [26]) are used as a proxy for the correlation of parental income and child ability;[22] i.e., I assign the five ability levels in equal measure but distribute them in such a way as to make the correlation between parental income and child ability equal to 0.4. Given the 300 endowment types specified above, this addition of ability levels generates a total of 1500 types.

The final step in defining a computable general equilibrium version of the theoretical model is to specify the following: the 15 house quality parameters k_{dh}; the Cobb–Douglas preference parameters α and β; the peer quality function parameter θ; and the production function parameter ρ. With little guidance from the empirical literature on the appropriate value for θ, I simply set this parameter equal to 0.5—thus permitting half of the peer effect to come through parental income and half through child ability.[23] The remaining parameters are calibrated according to the methodology outlined in Nechyba [16,19]. Essentially, the parameters α and β are set so as to replicate per pupil spending levels in

[20] It is important to note that, while some low income households are endowed with a high quality house, this does not imply that these low income households actually *live* in that house in equilibrium. Rather, on the way to determining the equilibrium, households buy and sell houses on the market at market prices. Thus, those low income types that are endowed with an expensive house will not remain in that house. The house endowments therefore are just like income endowments except that their value is determined endogenously. In practice, the value of these endowments (i.e., the value of the annual flow of services from these endowments) falls between 0.3 and 3.5 and thus simply serves to smooth out the discretized income distribution.

[21] These values are admittedly arbitrary, but sensitivity analysis has shown that changing either the mean or variance of these numbers has little qualitative or quantitative impact on the results presented in this paper.

[22] One can also interpret the correlation between parental and child income of 0.4 as an upper bound on the correlation between parental income and child ability because of the correlation of school quality and parental income. Sensitivity analysis with versions of the model that drive the correlation to 0, however, suggest this makes little difference for the results I report.

[23] Sensitivity analysis that varies θ between 0 and 1 suggests that the results on spatial segregation reported in this paper are not sensitive to this assumption. For the sake of brevity, this analysis is not reported below.

public schools;[24] the parameter ρ is set to replicate the percentage of households attending private schools;[25] and the house quality parameters (k_{dh}) are set so as to replicate the house price distributions within and across the stylized low income, middle income and high income school districts in New Jersey. Note that this implies that house quality parameters capture anything about houses that is reflected in house prices—*including neighborhood*

Table 1
Parameters of the model

Population	District size	Utility and production function exponents			
N	$\mu(C_{dh})$	α	β	ρ	θ
[0,1]	0.0667	0.22	0.650	0.475	0.5
	Housing–neighborhood quality parameters (k_{dh})				
d	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$
1	0.820	0.882	0.930	0.978	1.021
2	0.872	0.930	1.002	1.032	1.085
3	0.930	0.950	1.063	1.182	1.267

Table 2
Predictions versus data

	Representative school districts		
	Low income ($d=1$)	Middle income ($d=2$)	High income ($d=3$)
Mean property value	\$157,248	\$192,867	\$271,315
Predicted mean property value[a]	\$117,412	\$205,629	\$292,484
Median household income	\$30,639	\$45,248	\$67,312
Predicted mean household income	\$31,120	\$46,216	\$65,863
Per pupil spending	\$6702	\$7841	\$8448
Predicted per pupil spending	\$6652	\$7910	\$8621
Fraction choosing private school	0.21	0.23	0.20
Predicted fraction in private school	0.20	0.23	0.13
Fraction raised locally	0.52	0.77	0.87
Fraction raised locally in model	0.52	0.77	0.87

[a] Calculated from static values assuming 5.5% interest rate.

[24] Given the Cobb–Douglas nature of the utility function, α and β (in conjunction with ρ) are essentially budget shares for the median voter.

[25] The parameter ρ provides the primary competitive advantage to private schools in the model by determining the weight placed on peer quality in the school production process. If it is set close to 1, private schools have such an advantage (given that they can select peers) that public schools cannot survive in the model. If, on the other hand, it is set close to 0, private schools do not have a sufficient advantage over public schools to be able to arise in the model at all. Thus, as ρ rises from 0 to 1, equilibrium private school attendance rises monotonically. Alternative ways to provide sufficient competitive advantage to private schools would include assuming that they use resources more efficiently than the public sector or that they are able to target resources more effectively given the homogeneity of students within a private schools. At the end of the paper, it is demonstrated that such alternative models (which would entail less emphasis on peer effects) do not change the spatial segregation results that are the focus of this paper.

externalities such as local crime. Thus, neighborhood-based peer effects in the benchmark equilibrium are included in the house quality parameters.[26] Table 1 presents the parameters used throughout the simulations (unless otherwise noted), and Table 2 compares some of the model's predictions to analogous features of the data.

4. Public school finance policies and spatial segregation

I begin the computational analysis by asking how school finance policies relate to the degree of residential (or spatial) segregation within and across regions. Central to the findings reported below is the role of capitalization of public choices into private property prices. This capitalization arises endogenously within the model and is essential for supporting an equilibrium in which the public sector is active. Private school markets lessen the power of this force by providing ways for households to de-couple their residential location choices from their school quality choice. Thus, private school markets are critical in the determination of the level of spatial segregation, and, as I discuss in Section 5, the fostering of private school markets can be a useful policy in fostering greater residential integration. Before turning to that, however, I begin in Section 4.1 with a discussion of school finance and the role of private markets, and in Section 4.2 with a more detailed focus on the role of residential mobility in distinguishing forces leading to private school attendance under centralized and decentralized public school funding.

4.1. Centralization, private school markets and segregation

Table 3 illustrates several measures of the degree of segregation induced by different types of school policies. In particular, pure local financing is compared to pure state

Table 3
State vs. local financing and segregation

	Public financing	Average income ($)			Income variance (expressed in multiples of 1000)			Property values[a] ($)		
		Dist. 1	Dist. 2	Dist. 3	Dist. 1	Dist. 2	Dist. 3	Dist. 1	Dist. 2	Dist. 3
No private schools	Local tax	17,628	39,647	85,925	7326	20,408	115,510	5301	10,639	20,457
	State tax	19,875	42,250	81,075	13,581	39,859	141,060	5322	11,507	20,204
Private schools	Local tax	29,725	50,262	63,212	61,810	131,640	135,790	6424	11,038	15,370
	State tax	29,891	51,309	62,000	81,229	107,900	143,680	6177	11,800	16,490
	None	25,700	50,175	67,325	29,221	127,710	141,820	8254	11,844	13,892

[a] Property values here are expressed as annualized flows.

[26] As noted again later, these neighborhood externalities are then assumed to stay fixed as policy simulations are conducted. The key results of the paper, however, are based on simulations in which high income households move into low income districts and vice versa—which would tend to cause more positive neighborhood externalities in poor districts and more negative ones in rich districts—which in turn would lead to even more migration of a similar nature. Thus, the fact that neighborhood externalities are held fixed at the benchmark levels tends to bias most migration estimates downward.

financing of public schools, and the role of private schools is explored in each financing system. The general lessons that emerge from these numbers are:

(1) state financing leads to slightly less residential segregation than local financing;
(2) the existence of a private school market results in substantial declines in residential income segregation regardless of the degree of centralization in the public system; and
(3) the existence of a public school system substantially increases segregation (compared to what one would expect purely from spatial differences in housing quality) in the absence of private school markets but *decreases* spatial segregation in the presence of such markets.

While it might be expected that state financing will lead to less segregation than local financing, the relatively small magnitude of this effect compared to the huge effect of private schools is surprising, as is the different effect of public schools in a world with and without private school markets.

Consider the first two rows in Table 3. Simulation results in these rows arise from a purely locally financed public school system as well as a purely state financed system—both under the assumption that a private school market is prohibited. The first set of columns then reports average income levels in each of the three school districts, while the second set of columns reports the variance of income *within* each district. What is clear from the first set of columns is that average incomes in District 1 (the poor district) are higher under a state system than under a local system, and average incomes in District 3 (the wealthy district) are lower. Thus, the *inter*-jurisdictional variance of income, or the degree of residential segregation across school districts, is lower under state financing than under local financing, albeit not by much. The second set of rows then reveals the same through a slightly different lense: As the *inter*-jurisdictional variance in incomes declines between local and state financing, so the *intra*-jurisdictional variance within each district rises. Under state financing, we therefore observe an increase in residential mixing between different income groups. This is supported by slightly less variation in property values across jurisdictions (as reported in the last set of columns of Table 3).

The next two rows then report the same variables for simulations that differ from the previous two rows only in that now private school markets are permitted to operate. While the same comparison between local and state financing can be made (again yielding slightly less variation in income across jurisdictions and slightly more within jurisdictions), the striking comparison is not between the local and state tax rows, but rather between these two rows and the previous two where private school markets were not permitted. In particular, the existence of private school markets results in a dramatic lessening of *inter*-jurisdictional variances in income, and a substantial widening of the *intra*-jurisdictional income variance in each district. Similarly, property values in the poor district rise substantially as a result of private school markets, while they fall substantially in rich districts.[27]

[27] It is also the case that property values now exhibit greater inter-jurisdictional variation under state financing than under local financing (which is opposite to what happened when no private sector was allowed). We return to this issue in Section 4.2 below.

Finally, the last row in Table 3 provides a useful benchmark comparison for the previous four rows. In this row, the simulation assumes no public funding (either local or state), with schooling now provided entirely by the private market.[28] Thus, the level of residential segregation in this row is due *solely* to the housing market and is *not* distorted by schooling considerations. A purely public system without a functioning private school market (i.e., the first two rows in the table) therefore leads to substantially more spatial income segregation than what one would expect simply from the segregation due to housing quality differences—regardless of whether the public system is centrally or locally financed. This result is not surprising since a purely public system contains clear incentives for the wealthy to segregate and a mechanism (capitalization) for this segregation to be sustained in general equilibrium. What is more surprising is that—when private school markets are allowed to operate within a public school system (rows three and four), the levels of spatial income segregation *is lower* than what one would have expected purely from the housing markets. The very capitalization that sustains increased segregation as an equilibrium in a purely public system actually causes a decline in segregation when private school markets are permitted to operate. *While wealthy public school attending households continue to have the same incentive to segregate as they did under a purely public system, the private school markets introduce an offsetting incentive for middle to high income households that choose private schools to residentially integrate with low income* (*public school attending*) *households.*

The incentives for segregation are equally visible in the property value column of Table 3. In the last row, property prices are unrelated to public choices within districts and within the state overall (as there are no public schools and no local taxes)—and these are nearly 56 percent higher in the poor district and nearly 47 percent lower in the rich district than they would be under a purely public system without a private sector. While a purely public system therefore vastly depresses property values in poor districts compared to those in rich districts, middle to high income households have no interest of taking advantage of housing bargains in poor districts because it locks them into the poor public schools. A public system with a private sector, on the other hand, has property values that are 16 to 21 percent higher in the poor district and 23 to 33 percent lower in the rich district (depending on whether the system is a state or locally financed one) than they would be under a purely public system, *but* property values are 28 to 34 percent *lower* in the poor district and 11 to 19 percent *higher* in the wealthy district than they would be under a purely private system without school-related distortions. Therefore, while the introduction of a private school market into the public system causes inter-jurisdictional price differences to narrow, property values in the poor district remain relatively depressed—thus allowing middle and high income households to take advantage of housing bargains while sending their children to private schools.

While these results are striking, an important caveat regarding the comparison of the purely private system to purely public or mixed systems is in order. The last row in Table 3

[28] As noted before, an equilibrium with no public schools always exists in the model because of the myopia assumptions in the voting process. Specifically, voters are assumed to vote conditional on their decision to send their children to private or public schools. If there is no public school funding, all parents choose private schools and thus vote for no public school funding.

is useful because if reflects the level of income segregation we should expect just from the *existing* differences in housing quality across districts. These differences in housing quality were calibrated, however, using data from systems that have relied heavily on public schools. How the housing stock would have evolved differently had the system been entirely private from the beginning can simply not be addressed using this model. All we can take from the last row of Table 3 is the benchmark of how *existing housing quality differences* will translate into spatial income segregation in the absence of distortions induced by school finance considerations.

4.2. Private school attendance, mobility, and centralization

Next, I consider in some more detail the role of centralized versus decentralized public school finance in the presence of private school markets. As reported in Nechyba [16], it turns out that the very migration and general equilibrium forces that underlie the results in Table 3 can potentially produce somewhat counter-intuitive results on the degree of private school attendance observed under local and state financing. In particular, while the standard Tiebout literature would suggest that private school attendance will increase as public school spending becomes more centralized (and more equalized), the general equilibrium forces modeled here suggest the opposite might be true *in the presence of well functioning private school markets*. While centralized school finance clearly does cause consumer options within the public sector to narrow, it should be kept in mind that this yields an improvement in schools in poor districts and a decline in rich districts. The first two columns of Table 4 therefore show an increase in private school attendance in the rich district and a decline in the poor district, as public school spending (the second set of columns) becomes more equalized. But much of this change is not due to the changes in the quality of public schools in rich and poor districts but is rather due to the changes in the relative price of living in the poor district.

This is far from obvious at first. In the last set of columns of Table 3 (reproduced in the third set of columns in Table 4), I report the property values under both local and state financing—and these differences do not seem large enough to produce major changes in behavior. However, the opportunity cost of a house in community i under local taxation is the actual house price *plus* the tax payment that is associated with that house. Under state finance, on the other hand, the opportunity cost of the same house is simply the price of the

Table 4
The link between public–private school attendance and migration

	Percent private		Public school spending ($)		Avg. property values[a] ($)		Opportunity cost of house[b] ($)	
Financing	Local	State	Local	State	Local	State	Local	State
District 1	30	22.5	5000	7195	6434	6177	6275	6775
District 2	20	17.5	7326	7195	11,038	11,800	10,412	9632
District 3	10	15	10,215	7195	15,370	16,490	13,899	10,841
Overall	20	18.3	7706	7195	–	–	–	–

[a] Property values are expressed as annualized flows.
[b] $k_{dh} = 0.93$.

house (because the state income tax has to be paid regardless of the choice of house and is thus a sunk cost). The last two columns in Table 4 therefore report the opportunity cost of owning *a house of the same quality* (i.e., of quality $k_{dh} = 0.93$—the only quality level that appears in all three districts (see Table 1)) in each of the three districts—under both local financing and state financing. The cost of such a house in the rich community is therefore 122 percent as high as the identical house in the poor community under local financing, while it is only 60 percent higher under state financing. (Under no public financing, of course, those houses are equally priced in equilibrium.) These magnitudes are certainly large enough to explain substantial differences in behavior of marginal households.[29]

Indeed, it is precisely this change in relative prices when going from a decentralized to a centralized system of public education that explains the bulk of the change in private school attendance. Private school attendance in the poor community falls under centralization not so much because public school quality has improved but rather because some of those households who, under local financing, chose the poor community in order to get a cheaper house and send their children to private schools now move to the richer community because it is substantially less costly under state financing. Of those who move, two thirds still choose private schools once they moved, thus explaining the bulk of the increase in private school attendance in the rich community. Overall, with the parameter values chosen as described in the previous section, the increase in private school attendance in the rich community is insufficient to offset the decline in private school attendance in the poor community—thus leading to the counter-intuitive decline in overall private school attendance under centralization.

5. Fostering private school markets through vouchers

Given the powerful role private markets have been shown to play in a system that is largely publicly financed, I now briefly turn to considering explicit government policies aimed at fostering private school markets. In particular, the role of private school vouchers, with particular focus on their potential to affect spatial segregation, is investigated. This analysis mirrors that conducted in Nechyba [19], but the starting point of the analysis is intended to be more reflective of real world school markets. While Nechyba [19] assumed that private school attendance is zero prior to the introduction of vouchers, the model here is specifically calibrated to reflect actual private school attendance rates in the data.

Table 5 reports simulation results for the poorest and richest districts (District 1 and District 3 in the model) as different kinds and different levels of vouchers are introduced into a locally financed public school system (where roughly 20 percent of parents are already choosing private schools prior to the introduction of the voucher policy). The first five rows of the table consider a policy under which all households are eligible for the private school vouchers. As suggested by the role private schools played in the model even

[29] Note that—while the first column in the last set of columns of Table 4 (labeled "Opportunity cost of house $k_{dh} = 0.93$") includes both the price as well as the property tax payment—this set of columns refers to *one particular house type* that happens to appear in all three jurisdictions ($k_{dh} = 0.93$) and not the jurisdiction *average* as in the previous set of columns. Thus, the second to last and the last set of columns are not directly comparable.

Table 5
Private school vouchers under local public financing

	Voucher	Average income ($)		Property values[a] ($)		Ratio: Dist. 3/Dist. 1		Percent private	
	amount ($)	Dist. 1	Dist. 3	Dist. 1	Dist. 3	Income	Property	Dist. 1	Dist. 3
All eligible	0	29,725	63,212	6424	15,370	2.1266	2.3926	0.3000	0.1000
for voucher	1000	31,925	59,800	7122	14,654	1.8731	2.0576	0.4000	0.1000
	2500	33,425	58,000	9097	14,468	1.7352	1.5904	0.6250	0.2500
	4000	33,125	57,425	8256	13,339	1.7336	1.6157	0.8750	0.3000
	5000	32,900	56,425	8027	11,816	1.7150	1.4720	1.0000	0.3750
Voucher	0	29,725	63,212	6424	15,370	2.1266	2.3926	0.3000	0.1000
targeted	1000	34,050	59,950	7124	14,974	1.7606	2.1019	0.3750	0.1000
to District 1	2500	37,125	54,125	9979	14,804	1.4579	1.4835	0.7000	0.1000
	4000	43,275	52,950	13,741	15,141	1.2236	1.1019	1.0000	0.1750
	5000	44,624	53,632	14,282	15,041	1.2019	1.0531	1.0000	0.1984

[a] Property values are expressed as annualized flows.

without vouchers, the introduction of vouchers is indeed accompanied by a lessening of spatial segregation. The ratio of average income in the richest district to average income in the poorest district, for instance, falls from 2.13 in the absence of vouchers to 1.74 under a $2500 voucher and then remains roughly the same for higher voucher amounts. Similarly, the ratio of average property values in the rich district to those in the poor district falls from 2.39 prior to vouchers to 1.59 for a $2500 voucher and further to 1.47 under a $5000 voucher. For both property values and average incomes, however, the peak in the poor district occurs at a $2500 voucher, with the ratios falling more moderately thereafter.

More striking, however, is the second part of Table 5 which reports simulation results for a voucher program targeted at only the poorest district. Under this program—also financed through a state income tax, only residents of the targeted district (District 1) are eligible for vouchers. This includes any household that resides in the district in the new equilibrium after the policy is implemented and thus includes those who migrate to the district for the purpose of becoming eligible for the voucher. As noted in Nechyba [19], this type of voucher proposal not only divorces the link between the school and the residential location choice which typically disadvantages poorer households, but it creates a new link between residential location and private school voucher eligibility—and this new link is to the advantage of the poorest households when the voucher is targeted to low income districts. This is clearly reflected in the simulation results: The ratio of average income in the richest district to that in the poorest district declines from 2.13 in the absence of vouchers to 1.46 for a $2500 targeted voucher and finally to 1.20 for a $5000 voucher. Similarly, the ratio of property values falls from 2.39 to 1.48 and finally to 1.05 for the same three policy scenarios. This is particularly surprising given the significantly higher housing quality in the rich district relative to that in the poor district (see Table 1)—and it reflects the disappearance of the negative capitalization of District 1's poor public school quality prior to vouchers and the positive capitalization of voucher eligibility under targeted vouchers.

Table 6 replicates the exercise in Table 5 for the case of a centrally financed public school system. With some minor caveats, the story that unfolds is quite similar to that

Table 6
Vouchers under central public financing

	Voucher	Average income ($)		Property values[a] ($)		Ratio: Dist. 3/Dist. 1		Percent private	
	amount ($)	Dist. 1	Dist. 3	Dist. 1	Dist. 3	Income	Property	Dist. 1	Dist. 3
All eligible	0	29,891	62,000	6177	16,490	2.0742	2.6696	0.2250	0.1500
for voucher	1000	33,375	60,350	6215	15,599	1.8082	2.5099	0.3000	0.2500
	2500	34,188	58,254	6431	15,851	1.7039	2.4648	0.3500	0.2750
	4000	33,500	61,225	7710	14,908	1.8276	1.9336	0.6250	0.3000
	5000	28,775	64,875	8327	14,016	2.2546	1.6832	1.0000	1.0000
Voucher	0	29,891	62,000	6177	16,490	2.0742	2.6696	0.2250	0.1500
targeted	1000	33,400	59,645	6242	15,711	1.7858	2.5170	0.3000	0.1250
to District 1	2500	39,326	59,825	6720	15,940	1.5213	2.3720	0.4250	0.1125
	4000	43,202	53,861	8652	16,805	1.2467	1.9423	0.7000	0.1000
	5000	44,225	58,850	12,509	16,100	1.3307	1.2871	1.0000	0.3750

[a] Property values are expressed as annualized flows.

Table 7
Ratio of District 3 to District 1 averages

	No private school markets permitted		Private schools markets permitted									
			No vouchers		Non-targeted vouchers				Targeted vouchers			
					Voucher = 0.25		Voucher = 0.50		Voucher = 0.25		Voucher = 0.50	
	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.
Income	4.874	4.079	2.126	2.074	1.735	1.704	1.715	2.255	1.458	1.521	1.202	1.331
Property	3.859	3.796	2.392	2.667	1.590	2.465	1.472	1.683	1.484	2.372	1.053	1.287

under local financing. The qualitative differences that do appear in Table 6 are primarily due to the more rapid emergence of private schools in rich districts under state financing than under local financing (see the last column in Tables 5 and 6). Overall, the lesson that emerges from both these tables is that the design of even moderate private school voucher proposals can have important implications for the degree of spatial segregation that emerges in the economy.

A more thorough overall picture of how policies regarding public and private school financing can impact the degree of spatial segregation has now emerged. In Table 7, the ratio of rich to poor average district income and property values are provided for all the policy alternatives discussed above. The table is arranged to generally reflect a movement from policies that produce great spatial segregation to policies that tend to reduce such segregation. In particular, the scenario under which private schools are not permitted to operate in a locally financed public school system produces the greatest degree of segregation, followed by a centrally financed public system that does not permit private schools. A dramatic drop in spatial segregation occurs as soon as private schools are allowed to form, with both local and centrally financed systems yielding similar results. A further drop in segregation occurs when general subsidies to private schools through school vouchers are introduced, and the last drop occurs with the introduction of targeted rather than general vouchers. In all these scenarios, the choice between local and central

financing is quite secondary to the choice of how to treat private schools, with policies aimed at the private sector having substantially more impact on spatial segregation.

6. Robustness of segregation results to alternative school competition assumptions

Since the main focus of this paper is the impact of school finance policies on spatial segregation, little attention has been paid thus far to the separate but related issue of school segregation. School segregation is important in this model because peer effects, together with per pupil spending, is assumed to shape parental perceptions of school quality. Peer effects within schools are influenced, of course, by the characteristics of the student population, not by the characteristics of the spatial community within which the school is located. Thus, in the version of the model that was used throughout this paper it is assumed that parents prefer to have their children in schools that not only spend more per pupil but that also serve relatively higher ability children with relatively wealthier parents. In this section, I will discuss two issues that emerge from this way of modeling parental school choice. First, if school quality is indeed determined in this fashion, what is the implication for the distribution of school quality across students under different policies? And second and more importantly for purposes of this paper, to what extent are the main conclusions regarding spatial segregation altered when alternative models of school quality are introduced? I will treat each of these briefly.

6.1. School segregation and the definition of school quality

Given the focus of this paper on spatial income inequality, detailed results regarding winners and losers in terms of school quality are not reported here but discussed elsewhere (Nechyba [17,18]). In general, however, these can be identified quite straightforwardly from the logic contained in the model. In particular, those switching to private schools as a result of a policy change tend to experience higher school quality after the policy is introduced, while those that are left behind tend to experience lower quality. At the same time, because much of the private school attendance results from migration into the poor district, the drop in public school quality tends to be disproportionately larger in rich districts than in poor districts (as the rich districts lose high peer quality students). Thus, inequality increases to the extent that private school students do better as private schools are introduced, but inequality within public schools tends to fall as rich districts experience a greater loss in quality than poor districts. For moderate levels of private school attendance, these forces tend to be of roughly similar magnitudes thus causing overall inequality as measured by the variance in school outcomes to remain relatively unchanged, although that variance is typically higher under local financing than under central financing. As private schools become more dominant under high vouchers, however, inequality as measured by the variance in school quality tends to increase modestly as private schools are more differentiated than public schools, especially those that are state financed. But in all cases, the logic of the model dictates that the level of public school quality tends to fall as private school attendance increases (because private schools initially cater only to the high peer quality children).

As noted in Nechyba [18], however, these results must be consumed with caution. Little is actually known about private school markets, parental perceptions of school quality and how both of these would change under greater private school competition. The modeling in this paper has therefore been cautious in that it has made the worst case assumptions about the process of private school competition. In particular, it is assumed that public schools are using their resources efficiently even in the absence of private school competition, that private schools "skim the cream" off the public schools, that neither public nor private schools innovate in a more competitive environment, etc. In Nechyba [18] it is then demonstrated that different assumptions regarding these aspects of the model will yield substantially more favorable conclusions for the support of private schools. For example, if one assumed that a more homogeneous student population in a school allows for better targeting of resources, then vouchers are shown to increase both the overall level and decrease the variance in school quality. As this is not the focus of our present analysis, I merely note that, while in the model specified in this paper the level of school segregation tends to remain constant or increase modestly with an increase in private school activity, this tendency can be reversed under different (yet plausible) assumptions regarding factors we know currently little about.

6.2. Definition of school quality and spatial segregation

The natural next question, then, is to what extent do different assumptions regarding public and private school behavior impact the conclusions regarding spatial segregation—i.e., are the spatial segregation results regarding centralization of public school financing and support for private schools merely an artifact of the way school quality is modeled? Table 8 attempts to provide an answer to this by comparing results from the previous analysis to results obtained by altering the conception of school quality in the model. In particular, two different types of school quality notions are tested in the simulations. The first alters the way in which peer effects operate by assuming that both the mean and the variance of peer quality within a school matter, with lower variance permitting greater

Table 8
District 3/District 1 variables for different assumptions regarding school quality

	No private school markets permitted		Private schools markets permitted									
			No vouchers		Non-targeted vouchers				Targeted vouchers			
					Voucher = 0.25		Voucher = 0.50		Voucher = 0.25		Voucher = 0.50	
	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.	Local	Cent.
School quality as modeled in this paper (replicated from Table 7)												
Income	4.874	4.079	2.126	2.074	1.735	1.704	1.715	2.255	1.458	1.521	1.202	1.331
Property	3.859	3.796	2.392	2.667	1.590	2.465	1.472	1.683	1.484	2.372	1.053	1.287
Schools become more efficient through curriculum targeting												
Income	4.505	4.188	2.076	2.033	1.798	1.921	1.832	2.119	1.397	1.510	1.193	1.279
Property	3.791	3.586	2.222	2.512	1.553	2.213	1.394	1.762	1.427	2.181	1.081	1.231
Schools become more efficient through more efficient resource utilization												
Income	4.771	3.892	2.231	2.100	1.751	1.691	1.802	2.387	1.424	1.478	1.249	1.414
Property	3.712	3.603	2.469	2.702	1.539	2.568	1.528	1.732	1.329	2.292	1.103	1.302

targeting of resources and thus providing higher quality schools. The second maintains the original conception of peer effects but assumes that, with private school competition, the marginal value of a dollar in the education production function rises (as is found, for example, in Hoxby [12]). The magnitudes of the relevance of peer variance in the first conception of school quality and of school competition in the second is constrained by the need for the benchmark equilibrium to continue to replicate current levels of private school attendance, and I use the midpoint of the plausible range for such effects. More precisely, the school production function for both modifications is altered by a multiplicative constant ϕ that depends on peer variance in one case and private school competition in the other.[30] What is striking about Table 8, then, is that even with these dramatic changes in the way school quality is modeled, the spatial segregation effects mirror those identified earlier (and replicated in the first portion of the table). Thus, while different conceptions of private and public school quality are clearly important for analysis of the level and variance of school quality, very different conceptions of these lead to similar conclusions regarding the general equilibrium impact of policy on spatial segregation.

7. Some common misconceptions and some caveats about the results

Before concluding, it is worthwhile to address a few common criticisms of the type of results reported in this paper and to suggest when those criticisms are appropriate and when they are not. First, a common initial reaction to general equilibrium results that predict migration of private school-attending middle–high income households into low income neighborhoods is that this paper tends to *overstate* such migrations because the approach does not take into account important non-school related aspects of neighborhoods. In contrast, I will argue that the model actually tends to *understate* such migrations. Second, readers might take note of the fact that many high income families in the real world send their children to private schools while living in very good public school districts, an observation which might be taken as evidence against the predictions of this model. In contrast, I will argue that such observations are fully consistent with the model's predictions. Third, it is sometimes noted that the perfectly competitive, profit maximizing private schools that form the private school market in my model are not realistic given that most private schools are religious and presumably not, first and foremost, seeking to maximize profits. While this is certainly true, I will argue that the results of this paper are not fundamentally sensitive to the precise objective function of private schools. At the

[30] In the first case, $\phi = (1 - \lambda_1 * \text{variance})$ for all schools, where λ_1 is calibrated jointly with ρ to match private school attendance rates in the absence of vouchers. Given zero variance in peer quality for private schools, the private school production function is effectively unchanged by this—i.e., $\phi = 1$ in equilibrium for all private schools. In the second case, the constant is $\phi = (1 - \lambda_2 * \text{PUB}^2)$ for public schools and $\phi = 1$ for private schools, where PUB is the fraction of the population attending public schools and λ_2 is calibrated jointly with ρ to match private school attendance rates in the absence of vouchers. In both cases, the size of λ determines the strength of the new effect that is added, and in both cases it becomes impossible to obtain the "right" level of benchmark private school attendance if λ is set too high. The simulations reported here set λ as the midpoint of the interval from 0 to λ', where λ' is the highest possible value for λ that permits the model to replicate the observed level of private school attendance.

same time, I take the opportunity in this section to acknowledge how differences in housing markets are likely to result in different predictions using this same model and how, under certain circumstances, we would not expect the kinds of migration effects that arise in the simulations of this paper.

7.1. Housing quality, neighborhood quality, and migration of "marginal" households

In considering where private school markets are likely to flourish under different types of policies, it is important that the model accurately reflect the distribution of housing qualities within and across districts—and that "housing quality" includes both characteristics of houses as well as characteristics of neighborhoods (such as crime rates, environmental quality, racial composition, etc.).[31] The approach used in this paper to calibrate the housing stock quality in each district is one that does precisely that: by setting house quality parameters in each district so as to ensure that the model replicates the actual housing *prices* observed in the data, *house quality includes everything that is reflected in housing prices* (including house specific characteristics as well as neighborhood amenities and externalities). This is true for the benchmark equilibrium, which implies that the benchmark includes the kinds of factors many readers might worry will keep high income households from migrating to low income areas even if a policy causes them to send their children to private schools.

At the same time, it is true that the model holds fixed the house–neighborhood quality levels as migration occurs away from the benchmark. This is problematic in two ways: First, the approach assumes that households cannot improve the house-specific characteristics of houses they purchase; and second, it assumes that neighborhood externalities (like local crime rates) do not change as migration alters the equilibrium distribution of the population. However, in most cases this implies that the model will *understate* the amount of migration that occurs—particularly when the predicted migration is of high income households to low income neighborhoods.

Consider first the restriction that a household cannot improve the house-specific characteristics of a house it purchases. This will imply that certain households will not move as a result of a particular policy because there is no house type (in the jurisdiction that has become more attractive) that is close enough to satisfying the needs of those households. Lifting the restriction that housing cannot be improved through private investment would therefore unambiguously result in more migration.

At the same time, the bias from the restriction that neighborhood-specific characteristics (reflected in house quality parameters) do not change with migration is more ambiguous. For the particular type of migration highlighted in much of this paper, however, it seems likely that migration is biased downward by this restriction to the extent that we believe the migration of higher income families to lower income neighborhoods improves those non-school related amenities in those neighborhoods. For example, when the introduction of

[31] Race is, of course, important in policy discussions, and its explicit inclusion in the model would permit the investigation of questions other than those related to income segregation discussed in this paper. Given the correlation between race and income, such an analysis would complement our focus here but is left for future work.

a school voucher causes middle and high income households (in middle-income districts) who were previously on the margin of choosing private schools in low income districts to migrate to those districts, it is likely that neighborhood amenities in those jurisdictions would improve (while possibly declining in richer jurisdictions). This, in turn, would cause other middle to high income families to find poorer communities sufficiently attractive to migrate.

Of course, migration of high income families to low income neighborhoods will not happen if all housing in low income communities is uniformly bad and cannot be improved. However, the data do not generally support such intra-district homogeneity in housing quality nor the intra-district homogeneity in household income that such housing homogeneity would imply (Epple and Sieg [8]). Thus, in order for the model to accurately replicate the benchmark distributions of household income within and across districts, housing quality heterogeneity within districts is necessary and consistent with the data. But as soon as such housing heterogeneity exists in the benchmark, there necessarily exist households who are on the margin of choosing between two communities—and those households respond to policy changes and set off the migration forces reported in this paper. This is of course not meant to deny that there are examples of districts that indeed are so homogeneously poor in housing quality that migration effects of this kind would not arise (unless private investment in housing were permitted), but the within-district heterogeneity modeled in this paper is the norm rather than the exception. When calibrated to other data sets from other cities and states, similar predictions arise.[32]

7.2. Wealthy "non-marginal" private school attendees in good public school districts

With the emphasis of policy simulations on marginal households that choose to behave differently as a result of a policy change, it is sometimes easy to lose sight of the fact that many of the 1500 households types in the model are not "marginal"—and thus do not change behavior discretely when policy changes. For instance, the simulation results reported in this paper focus on marginal households who choose to reside in good public school districts in order to send their children to those schools under one policy while choosing to reside in bad public districts to send their children to private schools under a different policy.[33] With the introduction of vouchers, we find such marginal middle and high income households switching districts in precisely this way. But this does not, of course, mean that the model precludes the existence of wealthy households that always send their children to private schools from good public school districts where the best housing is available. In fact, the model predicts 13 percent private school attendance in the richest districts under the benchmark equilibrium—and it would predict a percentage closer to 18% if households with incomes above $200,000 were included. Thus, while the focus

[32] Nechyba [19], for instance, uses New York rather than New Jersey data. Ferreyra [11], on the other hand, structurally estimates a modified version of this model for Chicago and finds similar simulated migration patterns for private school vouchers.

[33] Note that such marginal households *must* exist in a model that has a sufficiently rich household type and house type space. In a more restrictive model with only a few household types, we might not expect the presence of such marginal households.

of the policy analysis is clearly on middle to high income households whose behavior is impacted by policy change, the model correctly predicts that very high income households will often live in good public school districts *and* use private schools (especially if their children have high ability).

7.3. Perfect competition and profit maximization in the private school sector

Finally, given that most private schools are religious, it may seem simplistic to assume a perfectly competitive, profit maximizing model for the private school market. (As mentioned in the discussion of the model in Section 3, this is equivalent to a model of private schools as excludable clubs of parents.) This specification of the private school sector is selected in part because it significantly reduces computational complexities that would arise under more complex specifications. It implies that schools do not make profits, and that tuition therefore covers expenses. This, of course, would be true under other objective functions for *non-profit* private schools as well—whether the primary motivation is religious or secular. Furthermore, the forces that are generated by this specification within the larger general equilibrium setting are likely to be similar across alternative specifications of private school objective functions because the key feature of private schools is that they can arise wherever there is demand without restricting admission to those living within a particular district. (This would, for that matter, also be true for public magnet or charter schools that abandon residence-based admission.)

When thinking about the private school sector within a general equilibrium framework, it is also important to keep in mind that private schools must have some advantage over public schools in order to be able to attract parents (in the absence of vouchers). This advantage may arise from the ability to select peers (as in this model), from a better production technology (modeled in Section 6) or from the ability to offer a different kind of education (partially captured in some of the results in Section 6). When combined with the lack of residence-based admission, the results in this paper suggest that any of these advantages lead to similar predictions regarding spatial income segregation. Religious training may be a particularly important component, and this may cause more religious parents to be more attracted to private schools than non-religious parents. While not explicitly modeled here, the specification of a religious dimension to households and schools would simply provide a different kind of competitive advantage to private schools (and thus reduce the need for peer effects or better technologies to play as dominant a role). When the model is modified in this way, however, Ferreyra [11] demonstrates that the basic migration forces remain unchanged.[34]

[34] It could also be noted that it would be imprudent to rely on one particular model of private school markets based on what currently exists and extrapolate from that how private school markets would evolve under a policy such as private school vouchers. While most current private schools are indeed religious, there is no guarantee that this would be the case for new private schools. The expansion of the number of private schools in California following the *Serrano* court decision, for instance, consisted primarily of small schools that were unlike the private schools that existed prior to *Serrano*.

8. Conclusion

This paper focuses on the connection between the institutional set-up of education and the degree of residential income segregation implied by that set-up in equilibrium. With increasing suggestions that such segregation plays a key role in long-run inequality by subjecting children in poor households to adverse neighborhood effects, such an analysis must ultimately become part of the analysis of school finance as it may be every bit as important to eventual student outcomes as those factors within schools which are more typically analyzed.[35] As a preliminary step toward such a more complete analysis, this paper builds a structural model of local public schools, private schools, politics and migration. With key structural parameters matched to data from New Jersey, simulations then reveal the extent to which school finance policy can indeed impact residential income segregation. Surprisingly, however, the level of centralization and equalization of public school financing seems to have relatively little impact on residential segregation, while the presence of an active private school market produces large effects.

The key intuitions emerging from the analysis are closely related to an understanding of capitalization in general equilibrium local public finance models. A purely public school system (regardless of whether it is centralized or decentralized) adds a strong segregating force into a local public finance model by providing higher income households with an incentive to segregate and form better schools. This segregation is supported as an equilibrium by the housing market and particularly by large positive capitalization of good schools into housing prices in rich districts and large negative capitalization of bad schools into housing prices in poor districts. At the same time, when private school markets are introduced into a purely public system, the same capitalization that supports large segregation among those who attend public schools introduces a desegregating force for households that choose private schools and can therefore take advantage of relatively low housing prices in poor districts. Capitalization therefore supports residential income segregation among public school attendees but causes residential integration for private school attending households. In fact, the simulation results in the model suggest that a system that has a mix of public and private schools will—holding housing quality differences constant—result in lower levels of residential income segregation than a purely private system in which school choices do not distort residential choices. The paper goes on to demonstrate how private school vouchers can further lessen residential income segregation and how these segregation results are robust to alternative assumptions about school competition.

[35] While neighborhood based (as opposed to school based) peer effects are not explicitly modeled in this paper, the calibration technique implicitly includes them in the house quality terms. Thus, the present analysis includes neighborhood based peer effects to the extent that they are reflected in housing prices in the benchmark but then holds them fixed as policy simulations unfold. However, the migrations that emerge as private school markets operate are such that these neighborhoods effects would tend to become more positive in low income communities and more negative in high income communities—thus leading to more migration than is currently predicted in the model. The assumption of constant neighborhood effects in the analysis therefore tends to bias the main findings downward leading to lower bound estimates.

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