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Opting-out of Public Education in Urban Economies

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RESUMEN

En este artículo investigamos cómo la movilidad entre comunidades en sistemas educativos públicos basados en el lugar de residencia influyen en las elecciones de las familias entre educación pública y privada. Con este objetivo, construimos un modelo en el que las familias varían en una única dimensión: ingreso. Familias de ingreso intermedio insatisfechas con su escuela pública local tienen dos opciones: bien emigrar a una comunidad con una escuela pública local mejor, o bien, si el precio de la vivienda allí es muy alto, no cambiar de residencia y adquirir educación privada. Si eligen esta segunda opción, el equilibrio no exhibe estratificación perfecta por ingreso a través de sectores educativos. Además, las escuelas privadas que estas familias eligen son de peor calidad que algunas escuelas públicas.

Palabras clave: educación, jerarquía de calidad de las escuelas, elección de escuela, estratificación, Tiebout.

ABSTRACT

We investigate how mobility among communities in residence-based public education systems influence households' choices among public and private schooling. With this objective, we construct a model in which households differ along a single dimension: income. Intermediate income households unsatisfied with their local public school can either move to a community with a better public school or, if the price of housing there is very high, not move and acquire private education. If they choose the latter, perfect income stratification across educational sectors no longer characterizes equilibrium. Moreover, the private schools these households choose have lower quality than some private counterparts.

Keywords: education, hierarchy of school qualities, school choice, stratification, Tiebout.

JEL classification: H42, H73, I20, R13, R31.

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1 Introduction

During the last decade the controversial debate on the reform of education finance has intensified in many countries. Theoretical and empirical research on the economics of education has shed light on the various sides of this debate. A fascinating branch of research within this field analyses the co-existence of private and public education institutions. The outcome is a voluminous and rapidly growing body of literature that tries to illuminate crucial issues such as the determinants of private school attendance, the impact of private schooling over growth and inequality or the productivity and distributional effects of different school choice policies[1].

The present paper belongs to this literature, focusing on parents' choices among public and private schools. Our objective is to highlight how the interactions among mobility, housing markets and the market for education influence these choices in urban (multi-community) settings. Relatedly, the analysis sheds light on how such interactions affect the distribution of public and private schools along the quality space.

Although our concern is for urban economies, it is useful to briefly discuss some relevant results of single-jurisdiction models. Stiglitz (1974), Epple and Romano (1996a) and De Fraja (2001), among others, investigate different aspects of this issue using this kind of models. Their models all have a one-dimensional characteristics space: agents differ either by ability to earn future income or by income. Better-off agents demand higher quality schooling either because education and ability are complements in the function determining (future) income or because education is a normal good. The public sector faces two constraints: public schools are tutition-free and every pupil in the public system must receive the same level of school quality. The latter restriction leads to the perfect stratification of households across public and private education, with the best-off (either the richest or the brightest) choosing private education of higher quality.

Of course, real world education markets are considerably more complex. Two

[1] Important contributions to this literature include Bearse et al. (2001), Caucutt (2002), Epple and Romano (1996a,b, 1998, 2002b), Glomm and Ravikumar (1992), Hoxby (1994, 2003) and Nechyba (1999, 2002, 2003). De Fraja (2001) provides and insightful survey of this body of literature.

stylised facts of these markets are in direct contradiction with some implications of the models above: in the real world, first, it is frequent to find students from non-affluent households in private schools; and second, public schools are not of homogeneous quality. Once the existence of different quality public schools is recognised, it is reasonable to question if there exist public schools which provide higher quality education than some of their private counterparts. In this sense, an in-depth and careful empirical study by Figlio and Stone (1999) finds that only non-religious private schools are academically better than public schools. Indeed, these authors obtain evidence that religious private schools perform slightly worse than public ones. Only for (urban) minorities, religious private schools outperform public ones. Relatedly, Neal (1997) finds that Catholic schooling increases educational attainment among urban minorities who have access to "poor" public schools.

It is possible to explain our first stylised fact without leaving the single-jurisdiction context. In order to do so, nevertheless, it becomes necessary to resort to models in which agents differ along more than one dimension. One simple explanation is that households have different tastes for education. Clearly, parents with relatively low income but with a strong taste for schooling will demand higher school quality and may opt for a (higher quality) private option. Furthermore, parents with strong preferences for a religious education will probably choose a sectarian private school[2].

The existence of verifiable differences in ability when peer group effects influence students' achievement yields a more subtle and solid explanation. Epple and Romano (1998) show that in this setting, profit maximising private schools make tuition fees decreasing in ability. Thereby, they internalise the positive externalities generated by high ability peers. As a result, households with relatively low income but with students of relatively high ability end up leaving the public sector and purchasing (again, higher quality) private education at subsidized prices.

The focus of this paper is on urban economies with residence-based public schooling systems. Single-jurisdiction models which ignore the role of mobility are not

[2]To our knowledge, Ferreyra (2002) offers the only model that incorporates sectarian private schools and heterogeneous religious preferences. Hers is a multi-community general equilibrium model of school choice and residential location.

adequate for studying these economies. One central characteristic of such systems is the existence of a hierarchy of public school qualities. This is a property of all stable equilibria in urban models with either multiple communities and local school finance (Epple et al., 1993) or neighbourhood schooling and peer group effects (Epple and Romano, 2002a). These models, then, provide a solid explanation for our second stylised fact.

But, does the existence of a hierarchy of public school qualities change the analysis of opting-out? Can it modify how public and private schools compare in quality? Bearse et al. (2001) develop a two-communities dynamic model of opting-out. Their objective is to study the role of private education in the comparison of decentralised mixed regimes to centralised finance and vouchers systems. The model is necessarily simple to be suitable for dynamic analysis: households differ by income, there are no housing markets and communities may impose a proportional income tax. The solution for the decentralised mixed regime provides a negative answer to the questions above: all households with income above a certain threshold consume private education of higher quality than the best public alternative. Those with lower income remain in the public sector and perfectly stratify by income across public schools.

Nechyba (1999) presents a richer (static) model with housing markets. Each jurisdiction has a fixed stock of heterogeneous houses. Households differ by their endowment of income and housing wealth and by the ability of their student. Peer group effects affect students' achievement. This theoretical model serves as the basis for a computational counterpart used in different policy experiments. With regard to our question of interest, Nechybas's model highlights the role of housing heterogeneity in households' choices among public and private schooling. Private schools are used by high income households (with high ability students) who tend to live in low income communities. However, the number of high income households who move to low income districts is limited by the availability of high quality housing there. Some of them, thus, prefer to reside in wealthier communities where high quality housing is more abundant. But because public schooling is also of high quality there, these households do not opt out of the public system.

In this paper we argue that housing markets and mobility may well affect this

choice in another interesting way. We present a new motivation for students of non-affluent households to opt for private schooling and for private producers of education to offer intermediate quality educational services. The intuition is simple: capitalisation of public school quality differentials into housing prices creates an implicit price system for the right to attend public schools. Consequently, households unsatisfied with their local public school may not be able to pay for housing in a community with a better public school. Therefore, they may prefer to purchase private education of intermediate quality without moving to other community.

The rest of the paper is organised as follows. Section 2 introduces the multi-community model with local school finance, opting-out and housing markets. This model draws primarily on research by Epple et al. (1993), Epple and Romano (1996a, 2002a) and by Nechyba (1999, 2002). In section 3 we obtain several results that serve to characterise the equilibrium allocation of households to communities and schools. Section 4, in turn, focuses on the existence of a voting equilibrium within each community. Using all these results, section 5 investigates the question of opting-out in urban economies. To better clarify the intuitions and implications of the analysis, in this section we develop a computational version of the model which we use to construct several examples of equilibrium. Section 6 provides some concluding remarks.

2 The model

The economy is composed of a fixed number of communities, J, with exogenous boundaries, which may differ in the amount of land contained within their limits. Every community has a local housing market. We adopt a simple specification of these markets also found in De Bartolome (1990) and Epple and Romano (2002a): houses are homogenous and each household consumes one (and only one) unit of housing at price p_h^j. Every community j has a backward-L housing supply, horizontal at c (where c is the common construction cost) until community land capacity is reached and vertical at that quantity. Each house requires one lot of land. We assume that the amount of land in the economy is just enough to house the population.

This system of communities is inhabited by a continuum of households, each

composed of one adult, the decision-maker, and one school-aged child. Households are prefectly mobile between communities and only differ in their exogenous endowment of the numeraire: income (y)[3]. Each household belongs to one of I income classes indexed by $i = 1, 2, ..., I$, with $y_1 < y_2 < ... < y_I$. The mass of households is normalised to one and the fraction of them that belongs to each income class i is denoted λ_i.

There are three commodities: education (x), a private composite good, the numeraire (b), and housing. Nevertheless, because all houses are homogenous and each family consumes one unit of housing, this good is not an argument in the utility function that captures preferences over different bundles in the economy.

Assumption 1 *All households have the same preferences represented by a utility function $u(x, b)$, strictly quasi-concave, increasing in both arguments and twice continuously differentiable for all $(x, b) >> 0$.*

Preferences are, therefore, continuous, strictly convex and strictly monotonic. Furthermore, we assume that education is a normal good, which is uncontroversial:

Assumption 2 *Education is a normal good.*

Finally, for technical convenience we adopt:

Assumption 3 $\lim_{x \to 0} u(x, b) = -\infty$ *and* $\lim_{b \to 0} u(x, b) = -\infty$

Assumption 3 ensures that any strictly positive combination of (x, b) is strictly preferred to any bundle with at least one of the goods equal to zero.

With the same preference scheme, Epple and Romano (1994) proved how the normality of education implies that, *along an indifference curve, the marginal utility of the numeraire decreases as the amount of this good rises.* This property of the preference configuration we adopt in the model is essential for obtaining some crucial results in the analysis below without resorting to a separable utility function.

[3] The level of income is thus independent of a household residential location choice. This assumption is typical in multi-community models and makes them most accurate for explaining the workings of urban economies with multiple jurisdictions. See Ross and Yinger (1999) for a recent survey of this literature.

Education is treated as a private good. It is produced from the numeraire, following a technology of production with constant returns to scale with respect to the number of students, n, and the quantity/quality produced per student, x. The cost function $c(x, n) = x \cdot n$ captures this technology. For simplicity sake, it assumes away the influence of peer group effects and other inputs such as student effort[4]. Moreover, because differences in productivity among public and private schools are not of interest to this paper, we assume this technology to be common for all of them.

Every community may impose a proportional property tax on the value of housing and use the proceeds to provide public educational services in quantity/quality E[5]. Each community chooses the pair (E, t), where t stands for the tax rate, through a political process, simplified to majority voting. For simplicity sake, there are no intergovernmental transfers from a central government. Thus, local governments must equilibrate their budget, i.e. they must satisfy the local Government Budget Constraint (GBC). The GBC specifies the maximum level of provision for each tax rate t, given the mass of households in the community (N) and the mass of those using the local public school (n). The GBC is given by the following expression:

$$E = tp_h \frac{N}{n} \tag{1}$$

Besides the public system, there exists a private competitive market for education in which households can acquire any amount/quality of education at competitive price $p_x = 1$. A couple of notes about the coexistence of public and private schools are in place. First, as it is usual in models of education, we consider public and private alternatives as being mutually exclusive. Therefore, a child cannot receive public and private education simultaneously[6]. Second, while households can acquire

[4] The introduction of peer group effects into the model would not alter the essence of the analysis. However, they can make local school finance unnecessary for obtaining the main results of the paper. See the concluding section. On the other hand, papers that consider the role of students effort are still scarce. For a recent contribution revealing the importance of this variable in understanding important issues in the economics of education see De Fraja and Landeras (2002).

[5] Note that because houses are homogenous this is equivalent to a head tax.

[6] The model in Epple and Romano (1996b) investigates a single-jurisdiction economy in which households can supplement the amount of the public service they receive for free from the public sector with extra units purchased from the private sector.

as much private education as they want, regardless of where they live, they can only send their children to a particular public school if they reside and pay taxes in the community where it is located. This residence requirement that characterises the public sector is crucial for the analysis, as will become evident below.

Each adult must adopt the following decisions: (i) choose the community in which to reside; (ii) decide to send her child to the local public school there or to a private school somewhere; (iii) vote on the pair (E, t) in her community; and, if her child attends a private school, (iv) allocate income between private education and numeraire consumption.

Because households are atomistic, adults behave as price-takers. Consequently, they take all community variables as given. These decisions are made in two stages within a single period. In the first stage, households simultaneously choose communities and schools, taking into account their (correct) expectations over the equilibrium vector of public policies and housing prices $e^* = (E_1, t_1, p_h^1, ..., E_J, t_J, p_h^J)$. In this stage, since the supply of housing is fixed, local housing markets clear. In the second one, once residence and schooling decisions are committed, adults vote on their community education policy. This sequence of decisions is found in Nechyba (1999, 2002) and Epple and Romano (2002a). As we will see later on in the paper, it is essential for solving the non single-peakedness problem that arises in models of public provision of education with opting-out.

Definition 1 Equilibrium. *We define an equilibrium as a partition of households across communities and schools, an allocation* (x, b) *across households and a vector of community policies and housing prices* $e^* = (E_1, t_1, p_h^1, ..., E_J, t_J, p_h^J)$ *satisfying:*

1. Rational choices: *for each household, the pair* (x, b) *is the utility maximising bundle within their choice set. This implies that no household wants to move to another community or to shift school.*

2. Housing market equilibrium: *housing demand equals housing (fixed) supply in every community.*

3. Majority voting equilibrium: *for all* $j = 1, 2, ..., J$*, the pair* (E_j, t_j) *satisfies the local government budget constraint* (GBC_j) *-as specified above- and it is majority-preferred by voters in community* j*, given the partition of households across schools*

and the price of housing in the community. A pair (E_j, t_j) is majority preferred in community j if it is preferred by at least half the electorate of that community in a pair wise contest with any other bundle satisfying the GBC_j.

3 Some results on sorting into communities and schools

Our interest is on empirically relevant equilibria in which all communities have a local public school. Although existence of this kind of equilibrium is not assured[7], for expositional convenience, assumption 4 restricts attention to them:

Assumption 4 *All communities provide public education.*

In order to characterise the equilibrium distribution of households across communities and schools, we first obtain households' induced preferences. From a household point of view, communities are characterised by the combination of expenditures per student (which ascertains the quality of the local public school) and the gross-of-tax price of housing (which determines the maximum feasible level of private consumption in the community). For this reason, we then depict the indifference map in $(E, p_h(1+t))$ space.

On the one hand, if an adult sends her youth to a local public school strict monotonicity assures that she devotes $y - p_h(1+t)$ to consumption of the numeraire. The corresponding indirect utility function is:

$$v(E, y - p_h(1+t)) = u(E, y - p_h(1+t)) \tag{2}$$

Let p be equal to $p_h(1+t)$ and $M(E, y-p)$ be the slope of indifference curves in (E, p) space. This slope is given by:

$$\frac{dp}{dE}|_{v=\overline{v}} = M(E, y-p) = -\frac{v_E(E, y-p)}{v_p(E, y-p)} = \frac{u_1(E, y-p)}{u_2(E, y-p)} = MB_E > 0 \tag{3}$$

It is equal to the marginal benefit of public education in terms of the numeraire (MB_E). Therefore, in response to a marginal increase in E, a household in the

[7] In a multi-community model with fixed housing supply and no private schools, an equilibrium always exists. This is formally proved in Nechyba (1997), using a model very close to ours. See also Fernández (2001). In our model private schools can freely enter the market, though. In such setting, existence of a trivial equilibrium without public schools is also guaranteed (as in Nechyba, 1999).

public sector is willing to accept an increase in the gross-of-tax price of housing equal to the marginal benefit they obtain from public education.

On the other hand, for a decision-maker that prefers to use a private school, the indirect utility function is:

$$w(y-p) = u(x(y-p), y-p-x(y-p)) \tag{4}$$

where $x(y-p)$ is the demand function for private education. In this case, because the child does not attend the local public school, the marginal benefit of public education is zero and, therefore, indifference curves in (E,p) space are flat at each level of p.

For a utility-maximizing household choosing between public and private schooling in a given community, the induced utility function is,

$$V(E, y-p) = \max\left[v(E, y-p), w(y-p)\right] \tag{5}$$

The indifference map in (E,p) space is in figure 1. It is analogue to that in Epple and Romano (1996a). $\hat{E}(y-p)$ is the locus of points at which the household is exactly indifferent between public and private schooling. For each pair $(y-p)$, there is only one level of E at which this is satisfied[8]. Given the gross-of-tax price of housing in the community, p, a household with income y prefers private education for low enough levels of public provision ($E < \hat{E}(y-p)$), is exactly indifferent between the local public school and private schools if $E = \hat{E}(y-p)$, and prefers public education for large enough amounts of public education ($E > \hat{E}(y-p)$). For any indifference curve, the upper contour set is below it and the lower contour set is above it. Lemma 1 analyses the behaviour of $\hat{E}(y-p)$.

Lemma 1 *$\hat{E}(y-p)$ is everywhere increasing in $y-p$.*

[8] Following Epple and Romano (1996a), first note that continuity of $u(x,b)$ implies continuity of $v(\cdot), w(\cdot)$ and $V(\cdot)$. From assumption 3, when $E=0$ every household with income $y > p$ in the community acquires some amount of private education. Moreover, for each pair (y,p), there is a level of E above which the household prefers public education (this is clear because at $E = x(y-p) > 0$, strict monotonicity ensures that $v(\cdot) > w(\cdot)$. Thus, because utility grows continuously with E, there is a unique level of public provision of education for which the household is indifferent between the public and their most preferred private alternative.

Proof. Differentiate $v(\hat{E}(y-p), y-p) = w(y-p)$ and solve to obtain:

$$\frac{\partial \hat{E}(y-p)}{\partial y} = \frac{u_2(x(y-p), y-p-x(y-p)) - u_2(\hat{E}(\cdot), y-p)}{u_1(\hat{E}(\cdot), y-p)} > 0 \tag{6}$$

Assumption 3 assures a strictly positive demand for private education when private schooling is chosen. Hence, the latter inequality is guaranteed by the property of diminishing marginal utility proved in Epple and Romano (1994). ■

From lemma 1 it is immediate to establish:

Corollary 1 Within-communities perfect income stratification across schools. *If for any (E_j, p_j) a household with income $\widehat{y}$ residing in community j weakly prefers private to public education, then all households with income $y > \widehat{y}$ $(y < \widehat{y})$ in the community strictly prefer the private (public) sector.*

Proof. Given (E_j, p_j), let $\widehat{y}$ be such that $E_j = \hat{E}(\widehat{y} - p_j)$. Because $\hat{E}(\cdot)$ is increasing in y, all households with income $y > \widehat{y}$, satisfy $E_j < \hat{E}(y - p_j)$, and they strictly prefer a private alternative. Similarly, for all households with income $y < \widehat{y}$, $E_j > \hat{E}(y - p_j)$, and they strictly prefer the public school. ■

Corollary 1 shows that, in equilibrium, mixed communities are characterised by perfect income stratification across schools. Students from relatively low income households attend the local public school while those from households with relatively high income attend a private alternative of higher quality (see figure 2). This result is a standard prediction in the literature (e.g. Epple and Romano, 1996a and Bearse et al., 2001).

Lemma 1 has another important implication: for any level of income, the higher the gross-of-tax price of housing the smaller the amount of public educational services above which the household prefers the local public school. That is to say, other things equal, increases (decreases) in tax rates or *in housing prices* have a direct negative (positive) impact on private school attendance in a given community[9].

In the rest of this section we consider a multi-community setting in which households are freely mobile across communities. Taking the choice of educational sector as

[9] This partially explains the counter-intuitive results over centralisation and private school attendance in Nechyba (2003).

given, we analyse how households allocate themselves to communities. The analysis proceeds as follows. Lemma 2 establishes necessary (but not sufficient) conditions for any vector of public policies and housing prices to be a candidate for equilibrium. Using these restrictions and taking school choices as given, propositions 1 and 2 establish some necessary (but again not sufficient) conditions any allocation of households to communities must satisfy to be a candidate for equilibrium.

Lemma 2 *In equilibrium, for any pair of communities i and j: $E_j > E_i \Leftrightarrow p_j > p_i$ and $E_j = E_i \Leftrightarrow p_j = p_i$.*

Proof. A situation in which $E_j > E_i$ and $p_j \leq p_i$ cannot be an equilibrium because in that case $u(E_j, y-p_j) > u(E_i, y-p_i)$ for all y. Consequently, all households choosing public education in community i would want to move to community j. An analogous argument serves to prove the second part of the lemma. ■

Differences in E are thus capitalised to some extent into housing prices. For any two communities, that with a better public school must also have a higher gross-of-tax housing price in equilibrium. Moreover, those communities with public schools of identical quality must have the same gross-of-tax housing prices in equilibrium.

Proposition 1 *In equilibrium, all households using a private school reside in the community (or group of communities) with the lowest gross-of-tax price of housing.*

Proof. Simply note that by strong monotonicity of preferences, $w(y - p)$ is everywhere decreasing in p. ■

This result is in accordance with the previous literature: an equivalent conclusion is obtained by Bearse et al. (2001) and the same driving force is central in Nechyba's (1999, 2002, 2003) results. Without a link between residential location and school quality, households using a private school are not willing to pay a premium for living in a community with a high-quality public school. Consequently, they choose to live in the community with the lowest gross of tax housing price where they mix with low income households who use the local public school. If high income households are who opt out, then, private education introduces a desegragating force into residence-based public education systems.

Henceforth, we shall assume that all communities differ in their equilibrium level of school quality. All results below extend readily to the case in which some have the same level of public school quality just by considering them a group which is treated as a single community. Let communities be numbered such that $(E_i, p_i) << (E_{i+1}, p_{i+1})$ for all $i = 1, 2, ..., J-1$.

The perfect income stratification of households across locations in residence-based public education systems is a common place in multi-community models. For this result to hold, indifference curves must satisfy a single-crossing condition in community quality-housing price space. In models with divisible housing (e.g. Epple et al., 1993), this condition requires the income elasticity of MB_E to be greater than the income elasticity of housing demand (see Ross and Yinger, 1999). In our model, however, because housing is not malleable the single-crossing condition only requires MB_E to be strictly increasing in income. In Lemma A1 in the appendix we prove that quasiconcavity of the utility function along with normality of education guarantees this slope to be *non-decreasing* in income. Therefore, we need to adopt the following (mild) assumption:

Assumption 5 *$M(E, y-p)$ is strictly increasing in income.*

Proposition 2 *Let $\hat{y}_i^u$ be the income of the richest household in community i consuming public education. In equilibrium: (i) Households using public schools are perfectly stratified by income across communities. (ii) For any pair of communities i and j the following ascending bundles condition is satisfied: $\hat{y}_j^u > \hat{y}_i^u \Leftrightarrow (E_j, p_j) >> (E_i, p_i)$.*

Proof. See appendix. ■

Corollary 2 *Households living in communities 2 to J are perfectly stratified by income across communities.*

Proof. This is a direct consequence of propositions 1 and 2. ■

The existence of perfect income stratification means, first, that communities are populated by households from a single interval of income classes, and second, that

households from a given income class can be living at most in two consecutive communities. Proposition 2 and corollary 2 show that, as in multi-community models without a private education sector, the residence requirement of public schooling constitutes a strong segregating force.

4 The voting problem

Up to this point we have treated the policy variables (E, t) as fixed parameters. Yet, in our model, these variables are endogenous and determined through a political process (majority voting) within each community. In order to solve the voting problem, it is necessary to specify the information voters have and their behaviour. We first assume that voters know the Government Budget Constraint (GBC), which is given by (1). Likewise, we suppose that voters know the identity among net and gross of tax housing prices $p = p_h(1 + t)$. Moreover, because at the voting stage residential and schooling choices are already committed, they take as given the price of housing in their community (p_h), the community total population (N) and the proportion of households using the local public school (n).

Proposition 3 *Given a partition of households across communities and schools and a vector of housing prices* $(p_h^1, ..., p_h^J)$*, in every community there exists a unique majority voting equilibrium and the median voter is decisive.*

Proof. In order to apply Black's (1948) median voter theorem, voting must be on a one-dimensional issue and preferences must be single-peaked: *One-dimensional voting.* Because p_h and n are given when voting takes place, the GBC establishes a one-to-one relationship among tax rates and per student expenditures in education which is known by voters. *Single-peaked preferences at the voting stage.* For households choosing a private school the peak is at $t = 0$. Since they do not benefit from expenditures on public education, their peak is at the tax rate which maximises their level of disposable income. Households using the local public school, in turn, have their peak at the solution to the problem:

$$\max_t \; u(E, y - p_h(1 + t))$$

s.t. $E = tp_h \frac{N}{n}$

Because $u(x, b)$ is strictly quasi-concave this problem has a unique solution and these households' preferences are also single-peaked. ■

Two comments are in place. First, the sequence of decisions in the model (as in Nechyba, 1999) allows to circumvent the non single-peakedness problem which arises in models of public provision of education when private alternatives are available (Stiglitz, 1974). Second, the voting process in mixed communities exhibits the "ends against the middle" property investigated in Epple and Romano (1996a).

5 Opting-out of public education in urban economies and the hierarchy of school qualities

For expositional convenience and without loss of generality, we set the number of communities, J, equal to 2 for all the analysis below. Proposition 1 entails that the unique residential alternative to be considered for households using a private school is community 1. Thus, we only need compare the schooling-location alternatives "private education-community 1" (PR1), "public education-community 1" (PUB1) and "public education-community 2" (PUB2).

There are two cases in which a household will opt for private schooling in our model. (i) If the household demand for school quality is larger than that offered by the best public school (that of community 2). (ii) If the household is on the margin among both public alternatives but (ii.a) they cannot fulfill their demand for education with the public school in community 1 and, simultaneously, (ii.b) the price of living in community 2 is too high for them. In this case, the household prefers to live in community 1 and to use a private school.

By lemma 1, situations in which there are households that satisfy (ii.a) are clearly possible. Lemma 3 below analyses the choice among PR1 and PUB2 and reveals that it is also possible to find situations in which there are households in case (i) or satisfying (ii.b).

Let $\hat{E}_2(y, p_1, p_2)$ be community 2 level of provision that, given p_1 and p_2, makes households with income y just indifferent between PR1 and PUB2. Following a similar

argument as with $\hat{E}(y-p)$, it can be shown that $\hat{E}_2(y,p_1,p_2)$ is a function, i.e. that for each (y,p_1,p_2) there exists a unique $\hat{E}_2$ for which $v(\hat{E}_2, y-p_2) = w(y-p_1)$[10]. This function is continuous because both $v(\cdot)$ and $w(\cdot)$ are continuous. In (E,p) space its graph coincides with the indifference curve of $v(\hat{E}_2, y-p_2)$ corresponding to a utility level equal to $w(y-p_1)$ (figure 3). By definition, $\hat{E}_2(y,p_1,p_2)$ constitutes a threshold for the choice among PUB2 and PR1. Given the actual level of provision in community 2, E_2, households with income y such that $\hat{E}_2(y,p_1,p_2) > E_2$ strictly prefer PR1, while households with income y such that $\hat{E}_2(y,p_1,p_2) < E_2$ strictly prefer PUB2.

Lemma 3 *For all $p_2 > p_1$, $\hat{E}_2(y,p_1,p_2)$ first decreases with y for $p_2 - p_1 > x(y-p_1)$, reaches a minimum at $y = \underline{\widehat{y}}$ such that $p_2 - p_1 = x(\underline{\widehat{y}} - p_1)$ and then increases with y for $p_2 - p_1 < x(y-p_1)$.*

Proof. Differentiate $v(\hat{E}_2(y,p_1,p_2), y-p_2) = w(y-p_1)$ with respect to y and solve to obtain:

$$\frac{\partial \hat{E}_2(\cdot)}{\partial y} = \frac{u_2(x(\cdot), y-p_1-x(\cdot)) - u_2(\hat{E}_2(\cdot), y-p_2)}{u_1(\hat{E}_2(\cdot), y-p_2)} \tag{7}$$

The numeraire has diminishing marginal utility along indifference curves. Hence, the sign of this derivative will be negative if $y - p_1 - x(y-p_1) > y - p_2$ (i.e. if $p_2 - p_1 > x(y-p_1)$). It will be positive if $y - p_1 - x(y-p_1) < y - p_2$ (i.e. if $p_2 - p_1 < x(y-p_1)$). For every $p_2 > p_1$ there exists a y low enough to make $p_2 - p_1 > x(y-p_1)$. Finally, note that education is a normal good, which makes $x(y-p_1)$ to be rising in income. ■

Lemma 3 shows that for levels of income below $\underline{\widehat{y}}$ the quality of the public school in community 2 that keeps indifference among PUB2 and PR1 is inversely related to income. This implies that, as household income falls, using the local public school in community 2 becomes less and less atractive compared to private schooling. In other words: *lower income households have a stronger taste for private education.* Suppose now that the actual level of provision in community 2 is given by E_2 in figure 2. Note that because $\hat{E}_2(y,p_1,p_2)$ is u-shaped in (y,E) space, this function is above E_2

[10] See footnote 8.

for two income intervals $y < b_2$ and $y > b_3$. All households with income $y > b_3$ are in case (i) above. Households with income $y < b_2$, in turn, satisfy (ii.b). They will opt for a private school if they simultaneously satisfy (ii.a). The examples in table 1 demonstrate that equilibria in which some intermediate income households opt out of public education indeed exist. Before going through them, however, proposition 4 characterises the distribution of public and private schools along the quality space in this type of equilibria.

Proposition 4 *In equilibria in which there are intermediate income households opting for a private school, the hierarchy of school qualities is such that: (i) The private schools attended by households from intermediate income classes are all of higher quality than the public school of community 1 but of lower quality than that of community 2. (ii) The private schools attended by households from high income classes are all of higher quality than the public school of community 2.*

Proof. See appendix. ■

To our knowledge there was no explanation in the literature to the existence of public schools which provide higher quality education than some private counterparts. Proposition 4 provides one. Moreover, it sheds light on why intermediate income households may opt for a private school. The private schools these households attend if they opt out of the public system are of intermediate quality. As the proof to this proposition reveals, the amount of the numeraire they consume is also intermediate (i.e. it is smaller than that feasible in the schooling-location alternative PUB1 but larger than the amount they could obtain choosing PUB2). Therefore, the reason these households have to opt out is the following: they are on the margin among two public alternatives (one providing higher quality public education at a higher implicit price) but they simply prefer an intermediate combination of school quality and numeraire consumption which they can obtain by opting-out. The convexity property satisfied by the preference relation is thus key for these results to hold (see figure 4). Remarkably, they are consistent with the empirical evidence in Neal (1997) and Figlio and Stone (1999) (see the concluding section).

To build up the examples in table 1 we develop a computational counterpart to

our theoretical model. In order to solve it, we construct an algorithm that finds all the equilibria of the computational model for any given economy (defined by a utility function, an income distribution function, the cost of construction and the size of communities). Consider a two community economy corresponding to the model in section 2. Suppose households preferences are captured by the following utility function, borrowed from Bearse et al. (2001):

$$U(x,b) = \frac{1}{1-\sigma}\left[b^{1-\sigma} + \delta x^{1-\sigma}\right]; \sigma, \delta > 0 \tag{8}$$

This utility function has the property that the marginal benefit of education in terms of the numeraire has an income elasticity equal to σ. It is separable in (b, x) and strictly concave for $\sigma, \delta > 0$. These two properties guarantee that it satisfies assumption 5. On the other hand, we assume the income distribution function to be a discretised version of a lognormal distribution. In our examples, it has 20 income classes varying from 5 to 100 (thousand of dollars or euros).

Table 1 contains the equilibrium values of key endogenous variables for two different economies and two types of equilibrium in which private education is permitted. Obviously, the first conclusion we draw from the examples is therefore that uniqueness of equilibrium is not guaranteed when private education is allowed for. Ex-ante identical economies can reach very different situations in equilibrium. Type 1 equilibria exhibit perfect income sorting among both educational sectors (i.e. all households in the private sector belong to top income classes and are in case (i)). Equilibria of type 2, in turn, correspond to situations in which some households from intermediate income classes are in case (ii) and choose private education. This type of equilibrium exhibits imperfect income sorting among educational sectors, as there are higher income households who live in community 2 and send their youths to the local public school there[11].

The main difference among type 1 and type 2 equilibria is in how public school quality and gross-of-tax housing prices differ between communities 1 and 2. For both variables the gap is considerably larger in type 2 equilibria. This makes a

[11] It must be noted that, although all the examples in table 1 have multiple equilibria, this is not the case for every economy. To better illuminate the intuitions and implications of the analysis, however, we deliberately present examples in which both type 1 and type 2 equilibria exist.

difference for intermediate income households who are on the margin between both public alternatives. In equilibria of type 2, these alternatives provide them with a bundle of school quality and numeraire consumption far away from their most desired one. They react by opting-out of the public sector in order to obtain an intermediate combination of both goods.

Housing markets play a central role for the existence of type 2 equilibria, though it is possible to find examples in a model without housing[12]. When housing markets impose restrictions to community growth -for whatever reason-, public school quality differentials are capitalised to some extent into housing prices. This increases the implicit price of living in a community with a good public school, which in turn makes the private sector more attractive to every household, including those who want to leave their local public school.

The private education sector differs substantially from one type of equilibrium to the other. In equilibria of type 1 the private schools are all better than any public school. In equilibria of type 2, in turn, the best public school is better than some private alternatives. It may even be at the top of the school qualities hierarchy as in example 2. It is worth noting that in these cases, even the highest income households use this public school and live in community 2. Therefore, the resulting allocation of households across communities exhibits perfect income stratification. Private education, thus, may not produce the desegregation effects alluded in previous research (Nechyba, 1999; Bearse et al., 2001).

6 Concluding remarks

The objective of this paper has been to highlight how the interactions among mobility, housing markets and the market for education influence, first, households choices among public and private schools, and second, the hierarchy of school qualities. To obtain clear-cut results, we constructed a model with homogenous housing in which

[12] We have constructed equilibria of type 2 in a model with head taxation and no housing markets. These examples are available from the author upon request. Using the model without housing in Bearse et al. (2001), however, these authors prove that this type of equilibrium cannot exist with income taxation, at least with their utility function (Bearse et al., 2002.)

households differ along a single dimension: income. In this simple setting we showed how such interactions provide an explanation to the use of private schools by intermediate income households and to the existence of public schools of higher quality than some private alternatives: intermediate income households unsatisfied with their local public school can either move to a district with a better public school or, if the price of housing there is very high, not move and acquire private education of intermediate quality.

These results do not depend on the existence of local school finance but on the residential requirement of public schools. As it is well known, the hierarchy of public school qualities can be the outcome of a centralised system with neighbourhood schooling if peer group effects are important for student achievement. On the other hand, the theoretical findings we have explained are consistent with the empirical evidence in Neal (1997) and Figlio and Stone (1999). These authors obtain that students from urban minorities are who most benefit from religious private education. In Neal's concluding words this is because "*their local public school alternatives are poor*". Moreover, these students opt for private education "*because their families are able to afford the modest tuition that are common in Catholic schools, but (...) can seldom afford housing in the exclusive neighbourhoods with the best public schools*".

The analysis in this paper can qualify our understanding of how public and private schools compete in urban economies. In these settings, private schools compete with different quality public schools for students who neither need be especially bright nor belong to households with a especial taste for education or with a high level of income. Relatedly, some public schools succesfully compete with medium to high quality private schools for advantaged students.

We believe these results to be relevant for several issues in the economics of education literature. Vouchers systems and the so-called cream-skimming effect or the impact of ability tracking programs are two interesting examples. The analysis suggests that models with housing markets, multiple locations and mobility could uncover important caveats on these issues. Empirical investigations on households choices among private and public education and on the impact of public and private schooling on students' achievement could also benefit from our analysis.

Appendix

Lemma A1 *$M(E, y-p)$ is non-decreasing in income.*

Proof. Suppose $\overline{x} = E$ and let y', p' be such that $y' - p' - \overline{x} = y - p$. Then, we can write the derivative of $M(E, y-p)$ with respect to income as:

$$\frac{\partial M(E, y-p)}{\partial y} = \frac{\partial MB_E}{\partial y} = \frac{\partial \left(\frac{u_1(x, y'-p'-x)}{u_2(x, y'-p'-x)} \right)}{\partial y}|_{x=\overline{x}} = \frac{\partial MB_x}{\partial y}|_{x=\overline{x}} \tag{A1}$$

This slope is equal to the derivative of the marginal benefit of education in terms of the numeraire *when the household is not allowed to optimally adjust their level of consumption of education.*

When the household can optimally adjust their consumption of education, in turn, the derivative of the marginal benefit of education is given by:

$$\frac{\partial MB_x}{\partial y} = \frac{\partial MB_x}{\partial x}\frac{dx}{dy} + \frac{\partial MB_x}{\partial y}|_{x=\overline{x}} = 0 \tag{A2}$$

This derivative is always equal to zero: assumption 3 assures the existence of an *interior solution* for the utility maximizing problem of households. At interior solutions, the marginal benefit of education always equals the ratio among prices and therefore does not vary with income.

From (A2), and using assumption 2, we can state the following condition:

$$\frac{\partial M(E, y-p)}{\partial y} = \frac{\partial MB_x}{\partial y}\ |_{x=\overline{x}} > (\geq) 0 \text{ if and only if } \frac{\partial MB_x}{\partial x} < (\leq) 0. \tag{A3}$$

On the other hand,

$$\frac{\partial MB_x}{\partial x} = \frac{u_{11}(\cdot)u_2(\cdot) - u_{12}(\cdot)u_2(\cdot) - u_{21}(\cdot)u_1(\cdot) + u_1(\cdot)u_{22}(\cdot)}{u_2(x, y'-p'-x)^2} \tag{A4}$$

which takes sign from its numerator. Given that $u_2(\cdot) = u_1(\cdot)$ at interior optima, we can multiply every term in the numerator by u_2 or u_1 as convenient to obtain:

$$sign(\frac{\partial MB_x}{\partial x}) = sign(u_{11}(\cdot)u_2(\cdot)^2 - 2u_{12}(\cdot)u_2(\cdot)u_1(\cdot) + u_1(\cdot)^2 u_{22}(\cdot)) \tag{A5}$$

Quasiconcavity of the utility function, in turn, guarantees that:

$$u_{11}(\cdot)u_2(\cdot)^2 - 2u_{12}(\cdot)u_2(\cdot)u_1(\cdot) + u_1(\cdot)^2 u_{22}(\cdot) \leq 0 \tag{A6}$$

which implies that $M(\cdot)$ is non-decreasing in income. ■

Proof to proposition 2. (i) Assumption 5 implies that the indifference curve of a household crosses that of any other household with different income at most once in the (E, p) plane. The crossing is such that the indifference curve of the wealthier household always cuts that of the poorer from below. This single-crossing property, in turn, leads to the following preference ordering proved in Epple et al. (1993), lemma 1: given $(E_i, p_i) << (E_j, p_j)$,

$$v(E_i, y - p_i) \geq v(E_j, y - p_j) \Rightarrow v(E_i, y' - p_i) > v(E_j, y' - p_j); \forall y' < y \qquad \text{(A7a)}$$

$$v(E_i, y - p_i) \leq v(E_j, y - p_j) \Rightarrow v(E_i, y' - p_i) < v(E_j, y' - p_j); \forall y' > y \qquad \text{(A7b)}$$

(A7a) and (A7b) entail that, in equilibrium, for all $i = 2, ..., J$, households with income $y \in (\hat{y}^u_{i-1}, \hat{y}^u_i]$ using a public school reside all in community i.

(ii) By contradiction. Suppose that in equilibrium $(E_j, p_j) >> (E_i, p_i)$ and $\hat{y}^u_j < \hat{y}^u_i$. In that case, the following conditions must hold (a) $v(E_i, \hat{y}^u_i - p_i) \geq v(E_j, \hat{y}^u_i - p_j)$, and (b) $v(E_j, \hat{y}^u_j - p_j) \geq v(E_i, \hat{y}^u_j - p_i)$. From (7a), however, we know that, $v(E_i, \hat{y}^u_i - p_i) \geq v(E_j, \hat{y}^u_i - p_j) \Rightarrow v(E_i, y' - p_i) > v(E_j, y' - p_j); \forall y' < \hat{y}^u_i$And, therefore, (b) cannot hold if $\hat{y}^u_j < \hat{y}^u_i$. ■

Proof to proposition 4. Because $u(x, b)$ is continuous, $v(E, y-p)$ and $w(y-p_1)$ are both continuous in income. Propositions 1 and 2, corollary 1 and lemma 3 then imply that in these equilibria the following is true (see figure 2): (a) It is possible to define three levels of income $b_1 < b_2 < b_3$ (not necessarily coincident with any income class in the discrete income distribution) that make households indifferent among the alternatives PUB1 and PR1 (b_1) and PR1 and PUB2 (b_2 and b_3). (b) Households with income below b_1 live in community 1 and use the local public school there. Households with income between b_1 and b_2 live in community 1 and use a private school. Households with income between b_2 and b_3 live in community 2 and use the local public school there. Households with income above b_3 live in community 1 and use a private school.

With some abuse of notation, let $x_1(y)$ denote $x(y - p_1)$. From normality of education, proposition 4 is true if and only if: $E_1 < x_1(b_1) < x_1(b_2) < E_2 < x_1(b_3)$. We now prove that these inequalities all hold. We will be using that, by assumption

3, $x(y-p) > 0$ for all $y > p$. 1. $E_1 < x_1(b_1)$: Clearly, $b_1 - p_1 > b_1 - p_1 - x_1(b_1)$. Hence, $x_1(b_1)$ must be larger than E_1 for b_1 to satisfy $u(E_1, b_1 - p_1) = u(x_1(b_1), b_1 - p_1 - x_1(b_1))$. 2. $x_1(b_1) < x_1(b_2)$: This follows directly from normality of education. 3. $x_1(b_2) < E_2$ and $x_1(b_3) > E_2$: b_2 and b_3 satisfy $\hat{E}_2(y, p_1, p_2) = E_2$. This implies that $\hat{E}_2(y, p_1, p_2)$ crosses E_2 in (y, E) space twice. By lemma 3, and given $b_2 < b_3$, the first crossing occurs at $y = b_2$ while $\hat{E}_2(y, p_1, p_2)$ falls with income and the second one occurs at $y = b_3$ in the range in which $\hat{E}_2(y, p_1, p_2)$ rises with income. Taking this into account, lemma 3 also implies: $y - p_2 < y - p_1 - x_1(b_2)$ and $y - p_2 > y - p_1 - x_1(b_3)$. Consequently, for households with income b_2 and b_3 to be indifferent among both alternatives E_2 necessarily satisfies: $E_2 > x_1(b_2)$ and $E_2 < x_1(b_3)$. ■

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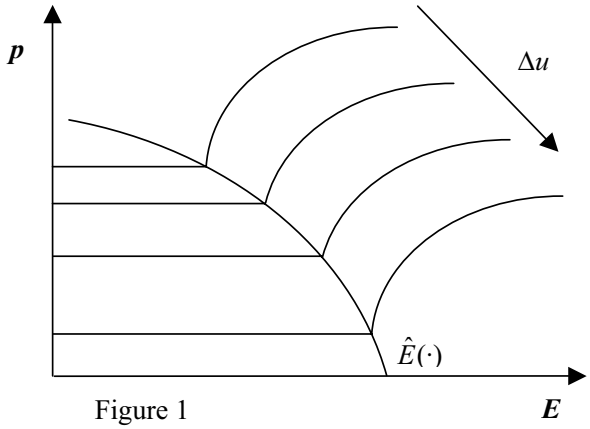

Figure 1

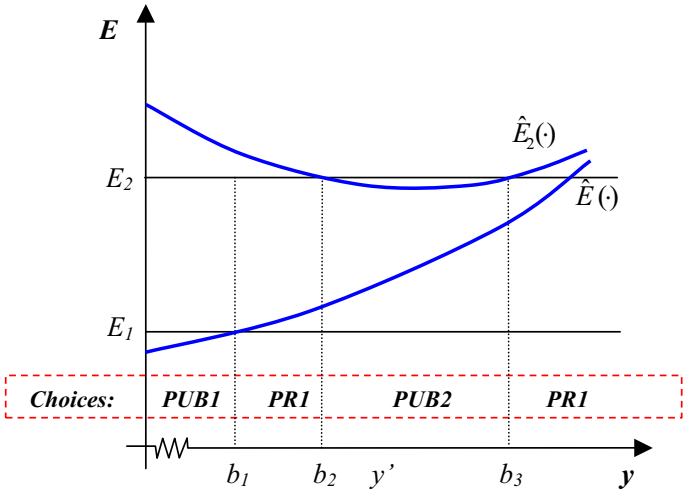

Figure 2

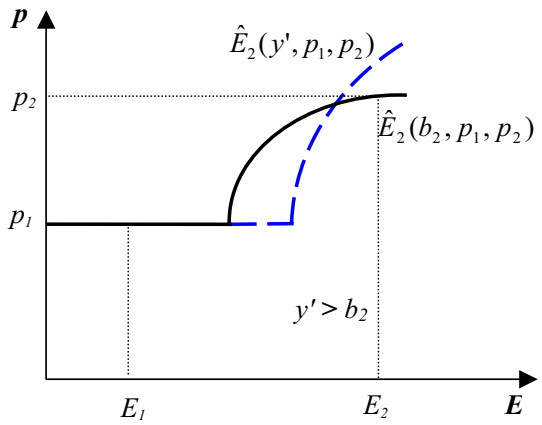

Figure 3

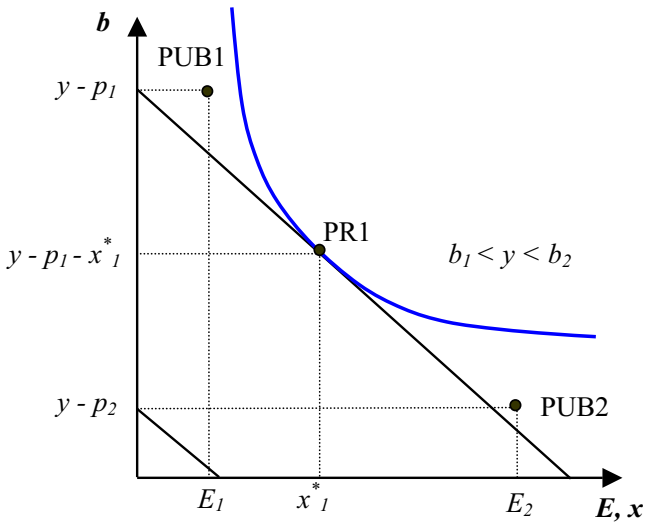

Figure 4

Table 1

	Example 1		*Example 2*	
	Perfect Income Sorting (type 1)	*Imp. Income Sorting (type 2)*	*Perfect Income Sorting (type 1)*	*Imp. Income Sorting (type 2)*
Public policies				
Public school quality 1 (E_1)	1.10	0.94	0.89	0.75
Public school quality 2 (E_2)	2.56	2.96	2.00	2.61
E_2/E_1	2.33	3.15	2.25	3.48
Tax rate 1	0.41	0.32	0.31	0.25
Tax rate 2	0.76	0.92	0.61	0.84
Median voter 1 (mv_1)	30	25	30	25
Median voter 2 (mv_2)	70	80	70	90
mv_2/mv_1	2.33	3.20	2.33	3.60
Gross-of-tax housing prices				
p_1	3.53	3.31	3.29	3.13
p_2	5.93	6.16	5.27	5.70
p_2/p_1	1.68	1.86	1.60	1.82
Private education				
% students in private sector (total)	5.48	11.48	10.26	14.89
% students in private sector (from intermediate income households)	-	9.84	-	14.89
Minimum priv. school quality	3.33	1.99	2.30	1.71
Maximum priv. school quality	3.71	3.72	2.90	2.31
% expendit. in educ.(public)	3.19	2.91	2.21	1.99
% expendit. in educ.(total)	3.66	3.75	2.87	2.79
"Border" incomes				
y_1^*	60	50	65	55
y_2^{**}	60	65	65	80
y_3^{***}	85	95	75	100
Parameters mean y=40.431; median y=35.000; minimum y=5; maximum y=100	σ=1.83; δ=0.0028; construction cost=2.5;N_1=0.83		σ=1.71; δ=0.0026; construction cost=2.5;N_1=0.91	

*y_1: highest income households choosing PUB1; **y_2: lowest income households choosing PUB2;
***y_3: highest income households choosing PUB2

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