

School Vouchers as a Redistributive Device: An Analysis of Three Alternative Systems

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1. Introduction

Two broad movements can be identified in the public policy debates over financing and provision of K-12 education. The first movement began in the early 1970's with the landmark ruling by the California Supreme Court that found California's system of financing public K-12 education to be unconstitutional. This movement sought to bring about greater equality in educational opportunities by reducing disparities in spending per student across communities. The main route used to accomplish this was by changing the rules used by states to redistribute funding across districts. The second movement began in the 1980's and was largely an outgrowth from a collective sense that the quality of public K-12 education in the US was low. This second movement has advocated increasing the choice of schools available to students with the hope of increasing competition across schools and enhancing efficiency.

An important theme in our previous research has been the observation that parents' inability to borrow against the future income of their children (to allow them to, say, move to a neighborhood with better schools) may result in inefficiently low investment in the human capital of children from poorer families in a quantitatively significant manner (see for example, Fernandez and Rogerson (1996, 1997, 1998)). We will refer to this as the imperfect capital markets perspective on school financing. School choice also relates to this market failure since policies

that facilitate the access of lower-income students to higher quality schools will help overcome this market failure.

Redistribution and other policies that promote greater access to high-quality schools, therefore, can be seen as operating to overcome similar problems. The school choice movement, though, on the whole tends to stress the potential inefficiencies that arise from the provision of school services in a system with a public monopoly.¹ The capital markets approach stresses the unequal educational opportunities individuals may face as a consequence of parental income and imperfect capital markets.

It is important to note that even if schools functioned efficiently, as long as they responded to parental income either as a result of local funding (with wealthier parents living in wealthier communities able to fund higher quality schools) or as a result of profit maximization on the part of private schools (with higher quality schools charging higher prices), then the inefficiency associated with imperfect markets would remain. The objective of this chapter is to examine the consequences of this source of market failure by abstracting away from inefficient provision per se. We do this by assuming that all schools are private and operate in a competitive market. Consequently, the provision of these services is efficient, in the sense that a dollar of education expenditures can buy the same services regardless of family income, holding other potential inputs constant.

We examine the consequences of several voucher programs that serve to redistribute income in a manner that affects the distribution of the quality of education across students. We consider three voucher programs—a lump-sum voucher program in which all households are given a voucher of equal value, a means-tested voucher program in which all households below some threshold are given a voucher of equal value, and a “power-equalizing” voucher which gives all households below some income a voucher that depends both on their income and the amount of their funds they devote to education. As the inefficiency associated with imperfect capital markets is dynamic—there exist profitable investments that are not undertaken because of financing constraints—we examine the consequences of these different education finance systems in a dynamic framework. By relating quality of education to future earnings, our framework allows us to analyze the effects of voucher programs on the distribution of income, both in the short and long run. We can also evaluate the dynamic welfare consequences of these programs. Our main finding is that voucher programs can have a large positive impact on income and welfare.

¹See, for example, Hoxby (2000).

Our analysis concludes with the consideration of endogenously determined parameters in each of the voucher programs. We do this by allowing the specification of the voucher system to be determined by a process of majority vote. Here we find that the outcomes vary quite widely across systems. In particular, the means-tested voucher system leads to very little redistribution relative to the two other systems we analyze.

2. Benchmark Model

The analysis of the effects of different voucher systems is a complex undertaking. Parents can differ in their preferences, education levels, family size, and marital status. Children can differ in ability, temperament and family background. Here we choose to abstract away from these elements to concentrate primarily on the short and long-run consequences of the redistribution implicit in alternative voucher systems.

In this section we describe the model which will serve as a benchmark in our analysis. Our benchmark model is chosen with an eye toward the objective of our analysis as outlined in the introduction. In particular, it is common in current policy debates for proponents of voucher programs to argue that one of the positive effects of vouchers is to increase competition in the provision of educational services and hence raise efficiency. While we believe this may be one of the important consequences of voucher programs in the context of the current institutional context, our objective here is to argue that even in a world in which provision of educational services is efficient, the potential for vouchers to redistribute educational resources is economically important. With this in mind, our benchmark model is one in which educational services are provided efficiently to all families, but there is a complete absence of other mechanisms in place that serve to transfer educational resources across families.

One interpretation of this benchmark corresponds to the well-known Tiebout model of local public good provision. In this model, education services are provided at the local level, financed entirely by local taxation, and individuals sort themselves perfectly into communities. A second interpretation is that there is no public provision of education services, but there is a private market in which all individuals purchase educational services. In both interpretations, of course, the assumption of efficient provision of education services is maintained.

Regardless of which interpretation one adopts, it should be clear that the benchmark is not an attempt to model the current state of education finance

and provision in the US, though the first interpretation does capture some of its elements. In particular, while the existing system in the US does involve local provision of education, it is not entirely financed at the local level. Most states have systems of education finance which effectively transfer resources from wealthier districts to less wealthy districts, though the extent to which this happens varies from state to state. Another feature of reality is that local revenues come largely from the taxation of property whereas the state level resources tend to come from the taxation of income or consumption. Also, while there is sorting of individuals across communities, the sorting is much less than perfect.² And finally, there is substantial evidence to suggest that the efficiency with which educational services are provided varies widely across schools and communities.

The benefit of our simplified setting is that it allows us to focus on the redistributive role of vouchers without concerning ourselves with how different redistributive programs may impact on one another or with the complex interactions among redistributive programs, housing prices, preferences and incomes. While a fully-developed analysis of the impact of a voucher program should incorporate all these elements, we think that such a benchmark is too difficult an undertaking and that a more computational approach would obscure some of the more salient features of the workings of a voucher program. A word of caution though is warranted: to the extent that the current system of finance does involve some redistribution, one should not interpret our results as indicating that vouchers are required to provide redistribution. We note, however, that there is an important distinction between redistributing using vouchers versus redistributing in the existing framework of school finance. Vouchers are targeted to individuals whereas inter-district redistribution is targeted to districts. Because of imperfect sorting of families across districts, redistribution across districts is likely to be less effective in transferring funds to poor individuals. But, perhaps precisely because of this features, vouchers may be less effective when endogenously determined than a system of transfers across districts.

We next turn to a description of the formal structure of the model and of our choice of functional forms and parameter values to be used in the quantitative analysis in subsequent sections. Our choice of parameter values, such as fraction of income devoted to education, is guided by data for the US economy over the last 40 or so years. We have also conducted an extensive sensitivity analysis and

²For example, Epple and Sieg (2000) analyze communities within the Boston metropolitan area and find that sorting according to income is very imperfect. See Fernández (2001) for a review of the literature on sorting and inequality.

found our main findings to be robust to what would be viewed as large deviations in these values, so the reader should not be overly worried about disagreements in the literature about the exact values of these numbers.

Following Fernández and Rogerson (1997a, 1998), we consider the following structure. At any point in time there are a large number of families, each of which (for simplicity) is assumed to consist of one adult and one child. One period later the adult will be deceased and hence leave the model, whereas the child will be in their period of adult life in which they head a family that also has one child. The only distinction between families is that they differ in their level of income, which we denote by y . Each period a family has one decision to make: how to allocate their income between expenditures on consumption and expenditures on the child's education. We assume that parents make all the decisions and have identical preferences over current consumption and their child's future income described by

$$u(c) + Ez(y') \tag{2.1}$$

where c is the household's consumption in the current period and y' is next period's income of the household's child. We include the expectations operator E in front of the function $z(y')$ since, as we will see shortly, the child's future income is stochastic viewed from the perspective of the current period. In general, we assume that the two functions u and z are increasing and concave.

In the first period of life, the child attends school and obtains the quality of education q . In the second period, the now old child receives a draw from the income distribution. This income draw depends on the quality of schooling they received when young and an *iid* shock ξ whose distribution $\Psi(\xi)$ is assumed to be independent of q . Thus, $y' = f(q, \xi)$.

Calibrating the model requires choosing an education production function. Unfortunately, there is very little consensus on the form the latter should take; indeed a large and controversial literature surrounds this topic. Guided primarily by simplicity, a convenient specification is

$$y' = Aq^\theta\xi$$

which yields an elasticity of future income with respect to education quality that is constant and equal to θ . We assume that ξ is lognormally distributed such that $\log \xi$ has zero mean and standard deviation σ_ξ .

An important (and controversial) empirical issue is what determines school quality. There is a substantial amount of work that suggests that many schools

do not use resources effectively. Moreover, one of the chief motivations for the school choice proponents is that increased choice will spur competition and hence lead to more efficient use of resources in providing education services. As discussed previously, in order to focus our analysis on the finance side of school choice, we have chosen to examine the role for redistributive finance in a world in which educational resources are used efficiently. In addition to school resources, it is also plausible that peer effects and parental attributes also matter.³ To focus the analysis on the different incentives associated with alternative voucher schemes, we assume that peer effects and parental attributes do not affect school quality. We also assume that there are no scale effects in providing education. Hence, in the analysis that follows we will assume that spending on education and quality of education are in fact synonymous.

Evidence presented by Card and Krueger (1992), Wachtel (1976), and Johnson and Stafford (1973) suggest an elasticity of earnings with respect to education expenditures close to 0.2. This analysis would suggest that we set $\theta = .2$ in our benchmark specification. One potentially problematic issue with this procedure is that it abstracts from the potential inefficient use of resources. An alternative approach to calibrating the value of the parameter θ is to target a rate of return to spending on education. A large volume of empirical work suggests that the rate of return to spending on education lies in the range of 5 to 15 percent. In our model this return will vary with the level of spending, but it turns out that a value of $\theta = .2$ implies a rate of return that varies from 4 to 11 percent depending on an individual's spending (and hence income).⁴ In view of this we think the choice of $\theta = .2$ is a reasonable one.

The adult's decision is a choice of the fraction of their income to spend on consumption relative to on their child's education. In formulating this decision it is convenient to define $w(q) \equiv \int_0^\infty z(f(q, \xi))d\Psi$. The function $w(q)$ represents the expected utility that a parent receives from spending q dollars on their child's education. We can now write the decision problem facing a parent as one of choosing how to allocate income y between c and q so as to maximize:

$$U(c, q) = u(c) + w(q)$$

³Several authors have studied peer effects. See de Bartolome (1990) for a survey of the empirical literature and a theoretical model incorporating peer effects. See also Benabou (1993, 1996), Durlauf (1995), Epple and Romano (1996a, 1998), and Caucutt (1997) for other studies incorporating peer effects.

⁴See Fernandez and Rogerson (1997), Table 5, for more detail.

Not surprisingly, the consequences of various redistributive programs will depend upon the income and substitution effects implicit in the utility function U . It is thus instructive to ask whether there are some reasonable restrictions that can be placed upon preferences in order to discriminate among the many possible specifications. As is true in many other contexts, we think that longer-run evidence provides some important information to guide choices. Fernandez and Rogerson (2001) show that across US states the share of personal income devoted to public elementary and secondary education has remained roughly constant over the 1970-1990 period at the same time that income per capita almost doubled. This property will be satisfied if the U takes the form

$$\frac{c^\alpha}{\alpha} + B \frac{q^\alpha}{\alpha} \tag{2.2}$$

for some parameters α and B . This implies a utility function of the form

$$\frac{c^\alpha}{\alpha} + \frac{b}{\alpha} E(y^\gamma) \tag{2.3}$$

for some parameter values γ and b together with the restriction that $\theta\gamma = \alpha$ and $B = bE(\xi^\gamma)$. In the analysis that follows we impose these preferences and assume as well that α is non-positive.

Having chosen the functional form for preferences it remains to assign values to b and α . Given values for all the other parameters, there is a monotone relationship between b and the fraction of income an individual would choose to devote to education. In our benchmark model we choose a value of b so that this fraction equals .041, which is roughly the fraction of aggregate income devoted to K-12 education in the US over the last forty years. This requires b to be given by $b = \frac{[(1-t^*)/t^*]^{\alpha-1}}{A^\gamma E(\xi^\gamma)}$, where $t^* = .041$ is the fraction of income devoted to education. Choosing a value of α is somewhat more difficult. Fernandez and Rogerson (1999) survey several different approaches to picking this value and conclude that values in the range of $[-2, 0]$ are most reasonable. We choose $\alpha = -1$ for our benchmark model.

In order to analyze the model described above we need to specify an initial distribution of income. We denote the initial period by period 0 and let the initial income distribution be described by a density function denoted by $g_0(y)$. Letting $g_t(y)$ be the income distribution of old individuals in period t , an equilibrium generates an income distribution for period $t + 1$, g_{t+1} . Denote this mapping from the income distribution of a given period into the income distribution of the

next period by the function $F(g(y))$. A steady state in this model is given by a distribution of income for the next generation is the same as the distribution of income for the current generation. Note that this does not presume that each child will have the same income as their parent. Because income when old contains a random element this will not be the case. Rather, in a steady state it is the case that for each individual whose income is greater than that of their parent, there is another individual who experiences the opposite movement, and vice versa. Of course, to the extent that educational expenditures are related to parental income, there will be a positive correlation between parental income this period and children's income next period. From a formal perspective a steady state in this model then consists of an income distribution $g^*(y)$ such that $g^*(y) = F(g^*(y))$. In the analysis of alternative voucher systems that follows, we will take the starting position of the economy to be the steady-state for the model just described. We will be interested in solving both for the steady states of the model with different voucher schemes as well as examining the transition path to these steady states.

The final element of the calibration exercise that remains concerns two parameters of the educational production function: A , the constant term in front of the production function and σ_ξ , the standard deviation of the idiosyncratic income shock. Intuitively, the larger is the value of A the greater we expect everyone's income to be next period since it implies a higher expected value of income for any given level of spending on education. The larger is the value of σ_ξ , the more spread out we expect income to be since this variable determines the spread of the random component of income. If this parameter were set to zero, then children's incomes would be perfectly determined by their educational expenditures.

Given the functional forms described above, one can show that the steady-state distribution of income in the benchmark model is also lognormally distributed, with mean and standard deviation determined by the values of A and σ_ξ . To see this consider the decision problem solved by a particular individual with income y_i . Let t_i be the fraction of their income that they devote to education. Then, they solve the following problem:

$$\max_{t_i} u((1 - t_i)y_i) + w(t_i y_i) \tag{2.4}$$

Thus, each individual's value for t_i is given by the first-order condition:

$$-u'(y_i(1 - t_i)) + w'(t_i y_i) = 0 \tag{2.5}$$

Note that (2.5) has individuals set spending on education to equate the marginal

utility of consumption with the marginal utility of education quality (i.e., $u'(c) = w'(q)$).

It is then easy to solve for the dynamic evolution of the economy. One can show that the preferences specified in (2.2) above imply a constant and identical value of t_i across individuals, $t^* = \frac{1}{1+\kappa}$, where $\kappa = (bA^\gamma E(\xi^\gamma))^{\frac{1}{\alpha-1}}$, i.e., all individuals spend the same fraction of their income on education. To solve for the dynamics of the system, note that if a parent's income in period 0 is y_0 , the child's income, y_1 , is given by $\log y_1 = \log A + \theta \log t^* + \theta \log y_0 + \log \xi_1$. Given $\theta < 1$, it follows that $\log y_t$ has a limiting distribution that is normal with mean and standard deviation:

$$\mu_\infty = \frac{\log A + \theta \log t^*}{1 - \theta} \quad \sigma_\infty = \frac{\sigma_\xi}{(1 - \theta^2)^{1/2}} \quad (2.6)$$

We choose A and σ_ξ such that μ_∞ and σ_∞ are reasonable in view of US data over the last forty years. Specifically, we match the mean and median of the US family income distribution as measured in the 1980 Census, respectively 23.1 and 19.9 measured in thousands of dollars.

A key feature of our benchmark model is that the educational expenditures for a given child must be financed out of the income of their parent. In particular, we are ruling out the possibility that a parent or a child could borrow against the child's future income in order to have greater expenditure on their education when young. We believe this is the most natural assumption to make in the context of K-12 education, but wish to stress it because of its importance to our analysis.

We next turn to the determination of the distribution of education expenditures across individuals under different voucher systems.

3. Voucher Programs

In this section we describe three different types of voucher programs. We focus on the outcomes for the distribution of education expenditures achieved in a given period under each of the voucher systems taking the initial income distribution as given.

3.1. A Lump-sum Voucher System

In this section we consider a voucher system which we refer to as a lump-sum voucher system. Under this system all households receive a voucher of size v_l ,

which they can use only to fund expenditures on education. They are, however, free to spend more than this amount by supplementing this voucher with their own funds.

For any system, we need to describe how the voucher is financed. We assume that this is achieved by proportional (income) taxation at rate τ_l . Requiring the budget to be balanced in every period, we obtain:

$$v_l = \tau_l \mu_y \tag{3.1}$$

where μ_y is mean income in the economy. In this section we assume that the size of the voucher is fixed over time, and hence omit time subscripts to simplify notation.

Consider the choices facing an individual parent in an economy which offers this type of voucher program. Letting t_i denote the fraction of their income that individual i devotes to education over and above the voucher level, we have:

$$\begin{aligned} c_i &= (1 - t_i - \tau_l)y_i \\ q_i &= v_l + t_i y_i \end{aligned} \tag{3.2}$$

Note that because of the balanced budget requirement the voucher program in a given period is effectively summarized by one parameter, either τ_l or v_l . Given a tax rate, τ_l , an individual's preferred choice of t_i is the solution to:

$$\max_{t_i} u((1 - t_i - \tau_l)y_i) + w(v_l + t_i y_i), \quad t_i \geq 0 \tag{3.3}$$

yielding the first-order condition

$$-u'((1 - t_i - \tau_l)y_i) + w'(v_l + t_i y_i) \leq 0 \tag{3.4}$$

with strict equality for $t_i > 0$.

With the restriction on preferences described earlier, one can show that the values of the t_i are increasing in y_i . Moreover, there will be some cutoff value of y which we call \hat{y}_l such that all individuals with $y \leq \hat{y}_l$ choose $t_i = 0$, i.e., all households with income below \hat{y}_l have spending on education that is exactly equal to the size of the voucher. Furthermore, the level of this cutoff value is increasing in the size of the voucher. These results are intuitive. The voucher provides a minimum value of spending on education. If this level is sufficiently large it will exceed the amount that the lowest income families wishes to spend

on education (at a marginal cost of y_i) and hence they may choose not to devote any additional funds to education. Of course, families with more income may still wish to increase the education expenditures. The larger is the size of the voucher, the greater the number of families that will choose not to spend any additional resources on education.

We can also say something about how this program affects the distribution of education expenditures across the income distribution. For example, it is easy to show that anyone who chooses $t_i = 0$ will have a larger expenditure on education under this lump-sum voucher system than in the benchmark model. More generally, one can show that there exists some level of income $\bar{y} > \hat{y}_i$ such that everyone below this value spends more than in the benchmark model while everyone above this level will end up spending less than in the benchmark model.

The properties of this system come from noting that in a system of proportional taxation, all households with income less than mean income pay less in taxes than the value of the voucher they receive. This induces households with income less than mean income to increase their spending on education relative to the benchmark model. The same reasoning does not hold for individuals with income above the mean, as the voucher is effectively redistributing income from these families to those with lower income. Of course, if the voucher level is set sufficiently high, say higher than the maximum amount being spent by anyone in the benchmark model, then spending on education by everyone would increase.

It follows that a lump-sum voucher system tends to compress the distribution of educational expenditures, and (for any voucher amount below the maximum spending on education observed in the benchmark system) this compression will come about both by raising spending at the bottom of the distribution and lowering spending at the top of the distribution. We will see later that the extent of compression from above turns out to be quite small quantitatively, so that the primary effect is to generate compression from below.

3.2. A Means-Tested Voucher

In this subsection we describe a second voucher system, which we refer to as a means-tested voucher. This system is similar to the lump-sum voucher but differs in one feature. Rather than all families receiving a voucher of value v_m , we now assume that the voucher is received only by those households that have income below some cut-off level denoted by y_m . As before, households are free to supplement the voucher if they wish to spend more on education, but the voucher

must be used only for spending on education. As above, the voucher program is financed by a proportional tax on income and the budget is assumed to balance in each period.

The mechanics of this voucher system are quite similar to that described above. The problem faced by a household with income less than the means-tested cutoff y_m is now

$$\max_{t_i} u((1 - t_i - \tau_m)y_i) + w(v_m + t_i y_i), \quad t_i \geq 0 \quad (3.5)$$

yielding the first order condition:

$$-u'((1 - t_i - \tau_m)y_i)y_i + w'(v_l + t_i y_i)y_i \leq 0 \quad (3.6)$$

with strict equality for $t_i > 0$.

On the other hand an individual with income that lies above the means-tested cut-off y_m faces the problem of:

$$\max_{t_i} u((1 - t_i - \tau_m)y_i) + w(t_i y_i), \quad t_i \geq 0 \quad (3.7)$$

yielding the first-order condition

$$-u'((1 - t_i - \tau_m)y_i)y_i + w'(t_i y_i)y_i \leq 0 \quad (3.8)$$

with strict equality for $t_i > 0$.

Assuming that y_m is binding (i.e., some households are not eligible), a voucher of the same size as in the lump-sum system (i.e., $v_l = v_m$) will require a smaller tax to finance it since not all households are receiving the voucher.

Several basic results follow easily. Relative to the benchmark model, all households that have income above the means-tested cutoff will now spend less on education. This is entirely because the tax to support the voucher plan reduces their after tax income. As in the case of the lump-sum voucher system, even conditional on receiving a voucher, a given household's spending on education may either increase or decrease. However, any household who receives the voucher and has income below mean income will necessarily spend more on education.

As above, we conclude that this type of voucher system will also tend to compress the distribution of educational spending. Once again, however, we will see in the quantitative work that the compression from above tends to quite small.

3.3. A Power-Equalizing Voucher

Lastly, we turn to an analysis of another means-tested voucher that we refer to as a power-equalizing voucher system. Like the previous case, this system excludes individuals with income greater than some pre-specified level, but it avoids a troubling aspect of the previous system. In particular, in the means-tested voucher system two families with very similar incomes but that fall on opposite sides of the means tested cutoff level will be treated very differently—one of them receiving a potentially significant transfer while the other receiving nothing. To avoid this type of discontinuity in the value of the voucher, the power-equalizing system presents individuals with a voucher payment that depends both on their income and on the fraction of their income devoted to education. In particular, as we explain in more detail below, this voucher plan will guarantee that a poor family that devotes a certain fraction of its budget to education will end up with the same level of total educational expenditure as a richer family that devotes the same fraction of its budget to educational expenditures. The term “power-equalizing” is used because this voucher guarantees that families which devote the same fraction of their income to education will end up with equal educational expenditures thus equalizing the “power” of their tax efforts. There are of course many ways to alter the means-tested voucher system in order to remove the discontinuity, but we focus on this one because it has parallels with many redistributive tax programs and it has a close analogue in the school finance system literature. Another aspect of this voucher system that differs from those considered previously is that in this system the size of the voucher is dependent on the actions of the family. In particular, a family that devotes no resources to education expenditures is not eligible for a voucher.

We now describe this plan more formally. Let y_e be the cutoff level of income in this system. Consider a household with income y_i and suppose this household chooses to devote a fraction t_i of its income to education. The voucher system is set up to guarantee all households a minimum base from which to obtain its total expenditures on education that is given by:

$$q_i = t_i \max\{y_i, y_e\}$$

It follows that the actual voucher received by a household with income y_i that allocates a fraction t_i of its income to education is given by:

$$v_e = \max\{t_i(y_e - y_i), 0\}$$

Obviously anyone with income greater than the cutoff level y_e will not receive any voucher. Thus while not guaranteeing any particular level of education spending, the system does guarantee the base which individuals can use to generate education spending.

We assume, as in the previous case, that the required education funds are generated by a state income tax, τ_e , so that private consumption is given by:

$$c_i = (1 - t_i - \tau_e)y_i \tag{3.9}$$

and the tax rate must satisfy the budget constraint:

$$\tau_e \mu_y = \int_{y < y_e} t_i(y_e - y)g(y)dy \tag{3.10}$$

Once again we can characterize how this type of a voucher system will impact on the distribution of education expenditures relative to the benchmark model. It is straightforward to show that any household with income greater than the means-tested cutoff y_e will have lower spending on education than in the benchmark model. And, similar to the situations considered above, any individual with income below the minimum of y_e and mean income will necessarily increase their spending on education. Once again, this type of voucher program serves to compress the distribution of educational expenditures.

We mentioned above that this voucher scheme has parallels in other redistributive programs. One such parallel is a negative income tax program which seeks to guarantee a “reasonable” level of income for someone who satisfies a work requirement. By way of comparison, the voucher program just described attempts to provide everyone who devotes a specified fraction of their income to education a “reasonable” level of educational expenditures.

3.4. Parallels with the School Finance Literature

Before turning to an analysis of the quantitative impact of the various voucher programs just described, we think it is useful to note some parallels between these and several programs that are commonly studied in the literature on school finance. As noted in the introduction, the issue of redistributing resources across school districts has been prominent in public policy discussions of education at least since the landmark Serrano decision in California in 1971. Many states have been forced to restructure their systems of school finance as a result of court orders. The common issue raised in all of these court cases is that children who

grow up in poor school districts (where poor is defined as low property value per person) do not receive an adequate education because of the shortage of funding. In an attempt to deal with this situation various types of programs have been used to redistribute resources from property-rich districts to property-poor districts.

In addressing this issue, a common benchmark is a system of pure local finance in which all school districts are solely responsible for financing their own schools, i.e., there is no redistribution across districts. As previously mentioned, this system has its parallel with our benchmark model, except that in our model there is no longer an entity known as a school district. Instead, each individual is solely responsible for financing their educational expenditures, i.e., there is no redistribution across individuals. Just as property-poor districts are at a significant disadvantage in terms of financing an adequate education in the district system, in our benchmark model it is the income-poor individuals that are at a disadvantage in terms of financing an adequate education.

One popular redistributive school finance system is what is known as a foundation system. In this system, each district is given a fixed amount of money per student in order to help all districts ensure a minimum level of quality. This type of system closely parallels our lump-sum voucher system in which all households are given a fixed amount of money per child in order to help all households afford an education of some minimum level of quality.

Another popular redistributive measure is means-tested transfers to school districts, i.e., all districts whose property base per student lie beneath some cut-off value receive a given grant per student. Our means-tested voucher is obviously the analogous program in our context.

Lastly, the Serrano ruling in California in the early 1970's prompted Coons (1974) to devise a school finance system known as a power equalizing system. The basic idea underlying this system was targeted specifically to the nature of the problem identified by the California Supreme Court. Namely, that even if families in districts with different property value per student chose to tax themselves at the same rate, the children would end up with very different qualities of education because a given tax effort yielded such different revenues in different districts. To remedy this Coons suggested a scheme where districts would be guaranteed a given revenue per unit of tax effort. While such a system does not guarantee a given level of spending in a particular district, it does offer that district a guaranteed yield for its tax effort. Obviously, our power-equalizing voucher system is the analogue of this system.

To summarize, the issue of redistribution in the context of education appears

both in a world in which education is publicly provided and children attend district level schools as well as in a world in which education is privately provided and children can attend any school subject to paying the tuition. Many of the schemes used to redistribute in one context are likely to have interesting counterparts in other contexts as well.

4. Results with Exogenous Policy

In this section we examine the quantitative impact of introducing vouchers of the types discussed previously. We assume that the parameters of these voucher systems are set exogenously and contrast how various parameter values affect the outcomes. Specifically, in the lump-sum voucher plan we consider different settings for the size of the voucher. In the case of the power-equalizing voucher program, we consider different levels for the guaranteed tax base, which is also the cut-off level of income at which households qualify for some voucher. In the case of the means-tested voucher, the program is characterized by two values: the cut-off level of income that determines who receives the voucher and the value of the voucher. Because this system is characterized by two parameters there are obviously many more possibilities to consider when setting parameters exogenously. To simplify matters, in what follows we will report results for a particular one-dimensional family of specifications. We will look at means-tested vouchers that are introduced into the benchmark model with the following characteristic: Let v_m be the size of voucher. Then, we assume that the income threshold is set such that all households who in the steady state of the benchmark model spent less than v_m will be eligible for the voucher.⁵

Before proceeding with the results, it is of interest to first consider some aspects of the benchmark steady-state equilibrium, in particular, the distribution of educational expenditures across families. In considering the impact of various voucher systems it is instructive to see the original distribution of expenditures in order to gauge the number of families that will be directly affected by a given size of voucher system. Recall that in the benchmark steady state all families are spending the same fraction (.041) of their income on education. Hence, the steady-state distribution of education spending mimics the properties of the steady state income distribution. Table One provides a breakdown of the income distribu-

⁵This formulation obviously introduces a discrete jump in spending as a function of income, as those who spent $v_m + \epsilon$, $\epsilon > 0$, get zero and hence in aggregate will end up having lower education spending (despite having higher income).

tion of families by reporting the fraction that fall below certain threshold values relative to mean income.

Table One

income threshold	% of families below threshold
$.25\mu_y$	1.6
$.4\mu_y$	9.72
$.5\mu_y$	18.9
$.75\mu_y$	44.2
μ_y	64.4

So, for example, if we consider a lump-sum voucher of size equal to 25% of average educational expenditures in the original steady state, fewer than 2% of families will be directly affected in the sense that the voucher exceeds their spending in the original steady state. This is significant because, as we shall see in the case of a lump-sum voucher program, the impact of the voucher on families whose original spending exceeded the size of the voucher is minimal. A similar point also applies to the case of the means-tested voucher.

In what follows we will report results about both allocations and welfare, looking at static (initial period) effects, steady state effects and the transition. We begin by analyzing the effects on allocations.

4.1. Allocations

4.1.1. Static Effects

We begin our analysis by examining the static or first period affects of the voucher programs on education spending. Specifically, we take the income distribution corresponding to the steady state of the benchmark model and ask what will happen to the distribution of education expenditures in that period if various voucher programs are introduced. In the case of the lump-sum and the means-tested voucher systems it is useful to measure the size of the voucher relative to mean spending on education in the benchmark steady state. In the case of the power-equalizing voucher it is useful to measure the value of the cutoff relative to mean income in the benchmark steady state. We let $\bar{\mu}_e$ represent mean spending on education in the benchmark steady state and let $\bar{\mu}_y$ represent mean income in the benchmark steady state. Recall that these values are $(.0410)(23.08) = .946$ and 23.08 measured in thousands of dollars. Table Two reports results for each

of the three voucher systems for several cases distinguished by the magnitudes of the program.

Table Two
First Period Effects on Education Spending

A. Lump-Sum Voucher System

$v_l/\bar{\mu}_e$	E/y	cv_e	$\tau_l \times 100$
0	.0410	.594	.00
.10	.0410	.592	0.4
.25	.0410	.588	1.0
.40	.0412	.577	1.6
.50	.0416	.562	2.1
.60	.0423	.541	2.5
.75	.0437	.501	3.1
1.00	.0474	.421	4.1

B. Means-tested Voucher System

$v_m/\bar{\mu}_e$	E/y	cv_e	$\tau_m \times 100$
0	.0410	.594	.00
.10	.0410	.592	.00
.25	.0410	.588	.01
.40	.0412	.577	.13
.50	.0416	.562	.33
.60	.0422	.541	.63
.75	.0436	.501	1.24
1.00	.0471	.421	2.50

C. Power-Equalizing Voucher System

$y_e/\bar{\mu}_y$	E/y	cv_e	$\tau_e \times 100$
0	.0410	.594	.00
.10	.0410	.594	.00
.25	.0410	.593	.00
.40	.0411	.590	.02
.50	.0413	.582	.06
.60	.0416	.572	.13
.75	.0424	.548	.28
1.00	.0441	.504	.64
1.25	.0463	.456	1.09

The first column in each table reports the size of the voucher system. The second column reports the fraction of income devoted to education (E/y). The third column reports the coefficient of variation (cv_e) for the distribution of education spending, i.e., the ratio of the standard deviation of education spending to average education spending. In what follows we will use this as our measure of inequality. The final column in each case reports the tax rate that is required to finance the specified voucher system. Note that the first row in each panel of the table corresponds to the case where there is no voucher system and hence simply reproduces the distribution of education spending in the original steady state.

A few basic patterns emerge. In each case as the magnitude of the voucher system is increased we experience an increase in the fraction of income devoted to education and a decrease in the inequality of education expenditures. These qualitative results are really not that surprising. One of the key impacts of both voucher systems is to raise expenditures on education at the bottom of the distribution. Not surprisingly, this raises overall spending on education and decreases inequality in education spending. However, the quantitative results also produce some findings that are of interest and which are not necessarily expected. For example, in the case of the lump-sum voucher, the above results indicate that unless the size of the voucher exceeds the initial spending for a substantial fraction of the population it has very small effects on total spending on education. To see this, consider the second row of the first panel, which corresponds to a voucher that is equal to 10% of average spending. This is seen not to have an effect on education expenditures, either by way of changing total expenditure or by changing inequality. However, from Table One we know that this voucher exceeds initial spending for less than 2% of the households, and even for them raises their spending by relatively little on average. The basic message is that in order for a lump-sum voucher (or a means-tested voucher) to have any sizeable impact, it must be of a magnitude that exceeds education spending for a significant fraction of the population. Otherwise it simply amounts to a small program of income redistribution. A similar point is holds in the case of the power-equalizing voucher.

Lastly, it is also of interest to draw a few comparisons across the three systems. One point which the table makes quite clear is that the consequences of the lump-sum voucher and the means-tested voucher are virtually identical for education spending. The one difference between the two, not surprisingly, is that the means-tested voucher requires a smaller tax to finance the system. This is a pattern that will be repeated in the remainder of the results as well. Two other important differences are that offering a voucher equal to the expenditure of say the mean

income household will reduce inequality in spending by a much greater amount than will guaranteeing everyone a tax base equal to mean income. The other is that the power-equalizing system seems to provide a steeper drop in inequality per dollar of tax revenue raised than do either of the other two systems.

In order to more fully appreciate the different consequences of the three systems for the distribution of educational expenditures it is of interest to look at these distributions in more detail. In Table Three we report average spending on education by deciles of the income distribution for each of the three systems.

Table Three
First Period Effects on the Distribution of Education Spending
A. Lump-Sum Vouchers

<i>Decile</i>	Size of voucher, relative to mean spending							
	0	.1	.25	.4	.5	.6	.75	1
1st	.315	.317	.323	.382	.473	.568	.710	.946
2nd	.456	.458	.461	.464	.483	.568	.710	.946
3rd	.559	.560	.563	.565	.567	.580	.710	.946
4th	.656	.658	.659	.661	.662	.664	.710	.946
5th	.758	.759	.760	.761	.762	.763	.764	.946
6th	.870	.871	.871	.872	.872	.872	.873	.946
7th	1.004	1.004	1.004	1.003	1.002	1.003	1.002	1.002
8th	1.181	1.180	1.178	1.177	1.176	1.175	1.174	1.171
9th	1.448	1.446	1.443	1.440	1.438	1.436	1.433	1.427
10th	2.196	2.191	2.183	2.176	2.171	2.165	2.158	2.145

B. Means-Tested Vouchers

<i>Decile</i>	Size of voucher relative to mean spending							
	0	.1	.25	.4	.5	.6	.75	1
1st	.315	.315	.320	.381	.473	.568	.710	.946
2nd	.456	.456	.456	.455	.480	.568	.710	.946
3rd	.559	.559	.559	.558	.557	.576	.710	.946
4th	.656	.656	.656	.656	.654	.652	.710	.946
5th	.758	.758	.758	.757	.756	.754	.750	.946
6th	.870	.870	.870	.869	.868	.865	.860	.946
7th	1.004	1.004	1.004	1.003	1.001	1.000	.992	.9832
8th	1.181	1.181	1.180	1.179	1.177	1.173	1.166	1.151
9th	1.447	1.447	1.448	1.446	1.443	1.439	1.430	1.412
10th	2.196	2.196	2.196	2.193	2.189	2.182	2.169	2.141

C. Power-Equalizing Vouchers

<i>Decile</i>	Equalizing factor, relative to mean income								
	0	.1	.25	.4	.5	.6	.75	1	1.25
1st	.315	.315	.317	.345	.386	.424	.475	.549	.612
2nd	.456	.456	.456	.456	.468	.510	.572	.661	.737
3rd	.559	.559	.559	.559	.558	.567	.631	.729	.814
4th	.656	.656	.656	.656	.656	.656	.682	.788	.881
5th	.758	.758	.758	.758	.758	.757	.756	.845	.944
6th	.870	.870	.870	.870	.870	.869	.868	.903	1.009
7th	1.004	1.004	1.004	1.004	1.003	1.003	1.001	.998	1.081
8th	1.181	1.181	1.181	1.181	1.180	1.179	1.178	1.173	1.182
9th	1.447	1.447	1.447	1.447	1.447	1.446	1.444	1.439	1.432
10th	2.196	2.196	2.196	2.196	2.195	2.193	2.190	2.182	2.172

In each panel the first column repeats the results without a voucher program; thus, it simply describes the distribution of spending in the steady state of the benchmark model. Reading across each panel allows one to examine how increasing the magnitude of a given voucher program affects spending at various deciles of the income distribution. A general pattern is that as each voucher program becomes more generous, spending at the bottom part of the income distribution increases whereas spending at the higher end of the distribution tends to decrease. However, the relative order of magnitudes of these two changes is noteworthy. Whereas spending at the bottom of the distribution may double or even triple as we move to the columns at the far right of each panel, the spending at the top of the distribution is decreasing on the order of one percent. Hence, while each of the voucher programs is decreasing inequality in spending by compressing the distribution of spending, this compression is almost entirely acting from below.

Next we compare the lump-sum voucher and the means-tested voucher. We noted previously that both vouchers had virtually identical aggregate effects. If we look at the distributions more carefully, we see that the two vouchers do produce some differences across the distribution, but that these effects tend to roughly cancel in aggregate. For example, consider the case of a voucher which is seventy-five percent of mean spending in the benchmark steady state, i.e., $v_l = v_m = .75\bar{\mu}_e$. For the means-tested case this voucher is available to the bottom forty-four percent of households. In both cases the bottom forty percent of the population spends only the amount of the voucher. However, note that the next decile spends more under the lump-sum voucher than they do under the means-

tested voucher. This reflects the fact that in the means-tested case everyone with income above seventy five percent of mean income is receiving no voucher and hence the only effect on their education spending is due to the imposition of the income tax needed to finance the voucher. In contrast, in the case of the lump-sum voucher, those households with income slightly higher than seventy five percent of mean income still receive a voucher that is large relative to their spending in the benchmark model. This of course must all be allocated to education. However, they still choose to supplement this with a small amount of their own funds. They also face a larger income tax, but for these families the effect of the subsidy to education exceeds the effect associated with the tax rate. However, as we move to higher deciles in the income distribution we see that the relative spending levels are reversed. For the highest decile, spending is greater under the means-tested voucher than under the lump-sum voucher. The reason for this is that for this group the voucher is relatively small compared to education spending in the benchmark model. And, the loss in income due to taxation is much larger. So, the net effect of the tax is much greater for this group. Since the tax is much smaller under the means-tested program, they spend more under this program.

Next we compare the means-tested voucher with the power-equalizing voucher. The differences are more apparent for larger values of the voucher programs, so once again we focus on the cases where the means tested voucher is seventy five percent of mean spending and the cutoff level is seventy five percent of mean income. What is particularly striking is how different the spending is in the lower part of the distribution. For the lowest decile the means-tested voucher yields spending on education that is more than one-third larger than that under the power-equalizing voucher. The reason for this difference is that under the means-tested voucher these households are receiving a voucher in the amount of .071 that must be used for education. In contrast, under the power equalizing system these households are told that they can raise money for education as if they had a tax base equal to seventy five percent of mean income, but every dollar they devote to education reduces their consumption. However, all families that have income above the fiftieth percentile have greater spending under the power equalizing system than under the means-tested system. None of these household is eligible for a voucher, so the differences are due entirely to the fact that the tax rate is lower under the power-equalizing system. These two observations go hand-in-hand: the reason that taxes are lower in the power-equalizing system is that less money is being redistributed to low income households to be used for education. The key point that this table illustrates, however, is that the largest

difference between the two systems has to do with the differential extent to which the means-tested program will lift the spending of the lowest income households. The different levels of spending among the richer households is in fact less than one-percent.

4.1.2. Steady State Effects

The results in the last section focused on what would happen to current education spending as a result of introducing various voucher systems. However, changes in the level or distribution of current education expenditures will also have impacts on the future level and distribution of income. In fact, one of the main motivations for public concern over the distribution of education spending is that this spending plays a key role in the human capital accumulation of children and thus the future productive capacity of the economy. In this section we focus on the long-run implications for the distribution of income associated with the various voucher programs analyzed previously, i.e., we look at the resulting steady state distributions. Table Four provides the information.

Table Four
Steady State Implications of Vouchers
A. Lump-Sum Voucher

$v_l/\bar{\mu}_e$	$mean(y)$	$sd(y)$	cv_y	E/y	cv_e	$\tau_l \times 100$
0	23.08	13.72	.594	.0410	.594	0.0
.10	23.09	13.72	.594	.0410	.592	0.4
.25	23.13	13.73	.594	.0410	.587	1.0
.40	23.32	13.78	.591	.0412	.572	1.6
.50	23.55	13.87	.589	.0416	.554	2.0
.60	23.84	14.00	.587	.0423	.527	2.4
.75	24.36	14.25	.585	.0437	.480	2.9
1.00	25.29	14.74	.583	.0474	.390	3.7

B. Means-Tested Voucher

$v_m/\bar{\mu}_e$	$mean(y)$	$sd(y)$	cv_y	E/y	cv_e	$\tau_m \times 100$
0	23.08	13.72	.594	.0410	.594	0.00
.10	23.08	13.72	.594	.0410	.594	0.00
.25	23.11	13.72	.594	.0410	.592	0.01
.40	23.29	13.77	.591	.0412	.580	0.13
.50	23.52	13.86	.589	.0416	.562	0.30
.60	23.82	13.99	.587	.0422	.534	0.56
.75	24.34	14.23	.585	.0437	.486	1.05
1.00	25.27	14.73	.583	.0471	.393	2.03

C. Power-Equalizing Voucher

$y_e/\bar{\mu}_y$	$mean(y)$	$sd(y)$	cv_y	E/y	cv_e	$\tau_e \times 100$
0	23.08	13.72	.594	.0410	.594	0.00
.10	23.08	13.72	.594	.0410	.594	0.00
.25	23.09	13.72	.594	.0410	.593	0.00
.40	23.18	13.74	.593	.0411	.588	0.02
.50	23.30	13.78	.591	.0413	.578	0.06
.60	23.46	13.84	.590	.0416	.564	0.12
.70	23.64	13.92	.589	.0421	.547	0.20
.75	23.73	13.96	.588	.0424	.537	0.25
1.00	24.21	14.20	.587	.0441	.486	0.56
1.25	24.68	14.44	.585	.0462	.437	0.93

As before, the first column reports the size of the voucher system. The next three columns report some properties of the steady-state income distribution. The second column reports mean income, the third column reports the standard deviation of income and the fourth column reports the coefficient of variation of income, which we will again use as our measure of income inequality. The final three columns present the same information that was presented in the previous subsection where we focused on the static effects on education spending. Once again the first row of each panel considers the case of no voucher, and hence simply reproduces the benchmark steady state.

Perhaps the most striking result to note here is the size of the potential increases in income that are associated with some of the programs considered above. A lump-sum voucher that was equal to average expenditures in the benchmark steady state leads to an increase in income of roughly 10%! A power-equalizing voucher that assisted everyone with income below the mean would raise income

by more than 6%. And note that the tax rate needed to support this voucher system is just slightly more than one half of one percent. These gains in income are large and point to the potential gains to be obtained by a redistributive education finance system even in a world where all individuals have access to schools that use resources efficiently. We will show later that these large gains in income also represent large gains in average welfare.

Considering the results in more detail, if education expenditures increase and the inequality of those expenditures decreases, we would expect to see these two properties to show up in the distribution of income as well. The above table reveals this to be the case. It is interesting to note, however that the magnitudes of these two effects are quite different. Consider for example the two extreme cases represented in panel A of Table Three, one in which the lump-sum voucher is zero and one in which the lump-sum voucher is equal to mean spending on education in the benchmark steady state. Looking at the expenditure on education there is an increase of roughly 15%, and looking at the decrease in inequality in the distribution of educational spending there is a decrease of roughly 33%. However, whereas the increase in mean income is roughly 10%, the decrease in inequality in the income distribution is only about 1.5%. The reason that inequality in the income distribution decreases by so little relative to the decrease in inequality in the education spending distribution is that differences in education spending account for very little of the variance in the income distribution. Most of the variance is accounted for by the stochastic earnings term ξ . In fact, one can ask what would happen to inequality in the income distribution even if inequality were completely removed from the education spending distribution. Holding mean spending constant, the resulting steady-state income distribution would have a coefficient of variation of .58.

It is also of interest to contrast the differing fiscal requirements of these voucher systems from the perspective of their implications for aggregate income. Table 5 shows the long run consequences in terms of percent increase in aggregate income as a function of the initial (first period) fiscal requirement also expressed as a percentage of aggregate income.

Table 5
Long-Run Effects of Given Expenditure Levels

Required Revenue (% of total income)	% Increase in long-run income		
	lump-sum	means-tested	power-equalizing
.25	.00	1.60	2.60
.50	.04	2.69	4.07
1.00	.21	4.55	6.54

As can be seen the differences are quite striking. Holding the fiscal requirement constant, the lump-sum voucher system produces substantially smaller long run increases in income as compared with the other two systems. The power-equalizing voucher system produces the largest increase per dollar of tax revenue required.

4.1.3. Transition Effects

What is the nature of the transition from the initial steady state to the final steady state? The transition is very fast—the economy moves most of the way to the new steady-state income distribution one period after the introduction of the voucher programs. Rather than present a long list of results for all of the various cases we simply present one case for each of the lump-sum and power-equalizing voucher systems (the results for the means-tested voucher are similar to those for the lump-sum voucher). For the lump-sum voucher we consider the case in which the voucher is equal to mean spending on education, and for the power-equalizing voucher we consider the case in which the equalizing factor is mean income. Period 0 indicates the period in which the voucher is introduced, so that in period 0 the income distribution corresponds to that of the benchmark steady state. Table Six reports the results for several of the variables considered above.

Table Six
Transition Paths

A. Lump-sum Voucher, $v_l = \bar{\mu}_e$

<i>Period</i>	<i>mean(y)</i>	<i>sd(y)</i>	<i>cv_y</i>	<i>E/y</i>	<i>cv_e</i>	$\tau_l \times 100$
0	23.081	13.718	.594	.0474	.421	4.10
1	25.166	14.649	.582	.0474	.391	3.76
2	25.286	14.732	.583	.0474	.390	3.74
3	25.294	14.737	.583	.0474	.390	3.74
4	25.294	13.738	.583	.0474	.390	3.74
5	25.294	13.738	.583	.0474	.390	3.74

B. Power-Equalizing Voucher $y_e = \bar{\mu}_y$

<i>Period</i>	<i>mean(y)</i>	<i>sd(y)</i>	<i>cv_y</i>	<i>E/y</i>	<i>cv_e</i>	$\tau_e \times 100$
0	23.081	13.718	.594	.0441	.504	0.64
1	24.039	14.091	.586	.0441	.489	0.57
2	24.190	14.183	.586	.0441	.486	0.56
3	24.210	14.195	.586	.0441	.486	0.56
4	24.212	14.197	.586	.0441	.486	0.56
5	24.213	14.197	.586	.0441	.486	0.56

As already indicated, it is clear that most of the change in the income distribution actually occurs by period one. Subsequently there are relatively minor increases in both mean income and mean educational expenditures (note that even if education spending stays constant as a fraction of mean income that mean income continues to increase), and minor decreases in inequality in both distributions. Given that mean income is increasing it turns out that required tax rates are decreasing over time.

4.2. Welfare

Having analyzed the effects on allocations, we now turn to analyze the welfare effects associated with these changes. In a model such as this in which families are heterogeneous with regard to income and policies have differential effect on households there is no definitive choice for a measure of welfare. If some families are made better off while others are made worse off then one needs to take a stand on how to weigh the two groups. We adopt as a welfare measure the expected utility of a family where the weights on each family's utility is its proportion in the population. This is equivalent to a utilitarian welfare criterion, i.e., one that puts equal weight on all families. We then compute the extent to which the income distribution in the benchmark model would have to be scaled in order to equalize welfare across the comparisons. We make this comparison for each of several periods following the adoption of the various voucher programs.

We should expect that welfare comparisons at different dates will look quite different since income is changing over time. In particular, given that steady-state income is sometimes significantly higher in the economy with vouchers, we would expect welfare to also be substantially higher. Such a comparison of course ignores the fact that in order to get the higher income some redistribution was required (with a welfare cost for some). This element is particularly significant in the first period (period 0) since at that point in time there has not been any increase in mean income and more resources are being devoted to education. Of

course, families do take into account the fact that their children will end up with higher incomes when they assess the utility that they receive from a given voucher program.

Table Seven presents the welfare results.

Table Seven
Welfare Effects

A. Lump-Sum Voucher

<i>period</i>	v_l						
	$.1\bar{\mu}_e$	$.25\bar{\mu}_e$	$.4\bar{\mu}_e$	$.5\bar{\mu}_e$	$.6\bar{\mu}_e$	$.75\bar{\mu}_e$	$1\bar{\mu}_e$
0	1.006	1.014	1.020	1.023	1.024	1.023	1.019
1	1.007	1.018	1.036	1.051	1.067	1.094	1.137
2	1.007	1.019	1.037	1.053	1.071	1.098	1.142
3	1.007	1.019	1.038	1.054	1.072	1.099	1.142
4	1.007	1.019	1.038	1.054	1.072	1.099	1.142
5	1.007	1.019	1.038	1.054	1.072	1.099	1.142

B. Means-Tested Voucher

<i>Period</i>	v_m						
	$.1\bar{\mu}_e$	$.25\bar{\mu}_e$	$.4\bar{\mu}_e$	$.5\bar{\mu}_e$	$.6\bar{\mu}_e$	$.75\bar{\mu}_e$	$1\bar{\mu}_e$
0	1.000	1.006	1.019	1.027	1.032	1.034	1.0330
1	1.000	1.008	1.033	1.053	1.074	1.105	1.152
2	1.000	1.009	1.034	1.056	1.078	1.110	1.156
3	1.000	1.009	1.035	1.056	1.078	1.110	1.157
4	1.000	1.009	1.035	1.056	1.078	1.110	1.157
5	1.000	1.009	1.035	1.056	1.078	1.110	1.157

C. Power-Equalizing Voucher

<i>Period</i>	y_e						
	$.25\bar{\mu}_y$	$.4\bar{\mu}_y$	$.5\bar{\mu}_y$	$.6\bar{\mu}_y$	$.75\bar{\mu}_y$	$\bar{\mu}_y$	$1.25\bar{\mu}_y$
0	1.001	1.005	1.008	1.011	1.015	1.019	1.020
1	1.002	1.012	1.022	1.033	1.050	1.076	1.098
2	1.003	1.013	1.024	1.036	1.054	1.083	1.107
3	1.003	1.014	1.024	1.036	1.055	1.083	1.108
4	1.003	1.014	1.024	1.036	1.055	1.084	1.108
5	1.003	1.014	1.024	1.036	1.055	1.084	1.108

In interpreting these numbers note that a value of 1.020 for a particular period, for example, indicates that income in the benchmark economy would have to be

scaled upward by 2% in order to make individuals indifferent between the steady state in the no voucher world versus having the allocation of resources be given to that in the world with a voucher in the particular time period considered.

A striking finding is that welfare gains are positive in all periods for all voucher plans considered (as indicated by the fact that all numbers are equal to or greater than one). Moreover, the effects are large; in several cases the steady-state welfare gain exceeds ten percent. As suggested above, it is in fact the case that welfare gains in the initial period are quite a bit less than the welfare gains associated with later periods. However, the size of the welfare gain in the period following the introduction of the voucher is already close to the steady state welfare gain. Another finding of some interest is that for the lump-sum voucher the size of the first period gain is not monotone in the size of the voucher. For the values considered in the table it reaches its maximum value for a lump-sum voucher equal to sixty percent of mean spending. Steady state welfare gains are monotone over the range of voucher programs considered here.

4.3. Sensitivity Analysis

The results presented above are for one set of the model's parameter values. To what extent are these results robust? We have carried out an extensive sensitivity analysis of this issue. Rather than provide numerous additional tables we attempt to summarize the main findings. In our calibration we picked the preference parameter α to be equal to -1 , though we stated that the reasonable range was the interval $[-2, 0]$. It turns out that choosing α to be some other value within this interval has very little effect on the quantitative results. We also calibrated the model so that educational expenditures accounted for 4.1 percent of income in the benchmark model. Changing this value within the interval of 3 percent to 5 percent had very little effect on the results.

One parameter value that does affect the results in a significant manner is the educational production function parameter θ . For our results above we assumed $\theta = .2$. Recall that a larger value of θ will imply that additional educational resources have a larger effect on future income. It should come as no surprise that this parameter is important. For example, consider the extreme case in which $\theta = 0$, which implies that educational resources do not matter at all for income. In this case there is no issue of inefficiently low investment by poor families because education ceases to be an investment. Conversely, larger values of θ imply that education offers a higher rate of return and hence is more important as an

investment. We find, not surprisingly, that the effects of vouchers are increased as the value of θ is increased. Moreover, in terms of our income gains and welfare gains, we found that these measures are roughly linear in θ . So, if we were to decrease θ to .1, the income gains and welfare gains would be cut roughly in half, whereas if we were to increase θ to .3, these gains would be increased by fifty percent. We note that if one considers a value of $\theta = .1$, for example, that the implied rate of return to education will be less than five percent, which lies below the accepted range of estimates for this return.

It is also of interest to discuss an alternative model specification. We have assumed that there are no channels through which generate intergenerational correlations other than spending on education. In reality one may consider it likely that other channels may also give rise to positive intergenerational correlations of income, such as genetics, or family connections. If for example, ability is partially heritable, then this may give rise to a correlation of the random draws of ξ across generations. The main effect of this modification is that it increases the desire of richer families to invest in their children's education because it raises the rate of return to their education. Similarly, it decreases the rate of return to investing in the education of children from poorer families. However, it remains true that poor families tend to underinvest in education relative to what is efficient because of their inability to borrow against the income of future generations. The new feature that this adds to the analysis is that compressing spending at the top of the distribution becomes more costly, since these are the children with the highest rates of return. Recalling, however that in our simulations we found that vouchers induced very little compression from above, we conclude that allowing for some degree of ability to be heritable across generations is not likely to have a large effect on our findings.

5. Endogenous Choice of Vouchers

In the previous section we traced out the consequences of various voucher programs for allocations and welfare both in the short and long run. In tracing out these consequences, however, we have simply taken the parameters of a given voucher system as exogenous. In reality, once a voucher program is put in place, its parameters are likely to ultimately be chosen through the political process. In view of this it is also important to try and assess the likely outcome of the political process for the magnitude of various voucher programs. This is the issue that we address in this section.

Modelling the political process is of course a challenging endeavor. As is common in the political economy literature, the benchmark that we adopt for our study is that of majority voting. Hence, we will assume that all households participate and are given equal weight in the process. In each period, agents are assumed to choose the parameter that governs the size of the voucher. The analytics of this problem for the lump-sum voucher and the power-equalizing voucher have been studied previously by Fernandez and Rogerson (1999).⁶ We refer the reader to that reference for analytical details on the voting problem.

Here we focus on the outcomes that result from majority voting. In our previous analysis we considered vouchers that were of constant value over time. Once we endogenize the determination of the voucher this will in general not be the case since changes in the income distribution over time may lead to changes in the political outcome over time as well.

We begin with the case of the lump-sum voucher. Results are presented in Table Eight.

Table Eight
Endogenous Choice of Vouchers
Lump-Sum Vouchers

<i>Period</i>	<i>mean(y)</i>	<i>sd(y)</i>	<i>cv_y</i>	$\tau_l \times 100$	$v_l/\bar{\mu}_e$	<i>cv_e</i>	<i>E/y</i>	Δ
0	23.081	13.718	.594	2.75	.671	.523	.0429	1.024
1	23.950	14.024	.582	2.75	.696	.502	.0431	1.080
2	24.142	14.159	.583	2.75	.702	.496	.0432	1.088
3	24.183	14.168	.583	2.76	.705	.495	.0432	1.090
4	24.202	14.170	.583	2.76	.706	.495	.0432	1.091
5	24.202	14.170	.583	2.76	.706	.495	.0432	1.091

The table shows that in the initial period, majority vote leads to a voucher whose value is a fraction .671 of average household education expenditure in the benchmark steady state. The consequences of this for education expenditures can be inferred from the earlier tables which indicate the consequences of a given voucher. Hence, the results here lie somewhere between those reported in Table Two for a lump-sum voucher of sixty and seventy-five percent of mean spending. As before, we still find that the transition to a steady state is quite rapid. The one feature that could potentially be different in this case is that it could be that

⁶That paper considers several school finance systems rather than voucher systems, but as discussed previously there is a mapping between the two.

there are more dynamics introduced by the endogenous choice of the voucher each period. In particular, the size of the voucher increases over time, but otherwise these additional dynamics are not too significant quantitatively. Hence, the economy is most of the way to the new steady state income distribution one period after the introduction of the voucher. As the final column indicates, there are substantial welfare gains associated with the introduction of the voucher plan, both in the short run and the long run. The long run gain exceeds nine percent when expressed relative to steady state income in the benchmark economy.

Next consider the case of the means tested voucher. The political economy of this system is more complicated than the other two systems. The reason for this is that whereas the other two systems were completely summarized by a single parameter, this system is summarized by two parameters. As is well known in the social choice literature, two dimensional problems are much more difficult. In considering the political economy of this system we assume a two stage process. In the first stage the cutoff level y_m is chosen, and in the second stage the size of the voucher is chosen given the value of y_m chosen in the first stage. We find that a majority voting equilibrium exists, and takes the form of having the cut-off level y_m being equal to median income, so that half of the population receives the voucher. The size of the voucher is then decided as the preferred choice of the lowest income individual. We take this individual to be someone with income of 1,000 dollars. This turns out to generate a relatively small amount of redistribution. Results are reported in Table Nine.

Table Nine
Endogenous Choice of Vouchers
Means Tested Voucher

<i>Period</i>	$mean(y)$	$sd(y)$	cv_y	$\tau_m \times 100$	$y_m/\bar{\mu}_y$	$v_m/\bar{\mu}_e$	cv_e	E/y	Δ
0	23.081	13.718	.594	0.62	0.86	.299	.593	.0410	1.021
1	23.156	13.737	.593	0.62	0.86	.300	.593	.0410	1.028
2	23.179	13.740	.593	0.62	0.86	.300	.593	.0410	1.029
3	23.184	13.741	.593	0.62	0.86	.300	.593	.0410	1.030
4	23.185	13.741	.593	0.62	0.86	.300	.593	.0410	1.030
5	23.185	13.741	.593	0.62	0.86	.300	.593	.0410	1.030

As the table indicates the size of the voucher is relatively small—only thirty percent of average educational spending in the original steady state. As we know from Table One, this voucher exceeds spending for only about two percent of all households, and not surprisingly has a fairly negligible effect on the economy.

Lastly consider the case of the power equalizing voucher. Table Ten presents the results.

Table Ten
Endogenous Choice of Vouchers
Power-Equalizing Voucher

<i>Period</i>	<i>mean(y)</i>	<i>sd(y)</i>	<i>cv_y</i>	$\tau_e \times 100$	$y_e/\bar{\mu}_y$	<i>cv_e</i>	<i>E/y</i>	Δ
0	23.081	13.718	.594	1.45	1.44	.432	.0481	1.019
1	24.755	14.471	.585	1.45	1.55	.394	.0490	1.112
2	25.132	14.689	.585	1.45	1.57	.387	.0492	1.129
3	25.208	14.733	.585	1.45	1.57	.385	.0493	1.133
4	25.223	14.742	.585	1.45	1.57	.385	.0493	1.133
5	25.226	14.744	.585	1.45	1.57	.384	.0493	1.133

An interesting finding here is that majority vote leads to a very high value of the equalizing factor y_e : as can be seen this level is 1.44 times mean income. As a result this system brings about considerably more compression in the distribution of education spending than does the lump-sum voucher system. The increase in steady state income is now almost ten percent and the increase in steady state welfare exceeds thirteen percent. Note that although y_e increases over time in absolute terms, in fact it is quite stable relative to mean income over time. As a result of the increase in y_e the convergence to the new steady state is somewhat slower here than in the case of exogenous policy considered earlier.

It is interesting to note that the political economy of these three systems are quite different. We saw earlier that a means tested voucher is able to increase education spending among poorer households equally well as the other two systems, given appropriate choice of program parameters. However, the striking finding in the above analysis is that when choices are made by a process of majority vote, poorer households end up with very little increase in their spending on education relative to the other two systems.

While this finding is significant, it is important to note some qualifications. Majority vote is one mechanism that can be used to generate a solution to a social choice problem. Also, we have abstracted from some features that may generate additional support for redistribution. For example, we have assumed that greater education for poorer households has no benefits for other households. In reality the additional skills accumulated by these households may benefit others as well.⁷

⁷See Benabou (1996) for a model that incorporates this possibility.

With this in mind it is probably best to interpret our results as showing that political economy considerations may imply that the three systems generate quite different outcomes.

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