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NOTES

A NOTE ON THE IMPACT OF VOUCHER PROGRAMS WHEN THERE ARE NONLINEAR PEER GROUP EFFECTS

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This study constructs a dynamic model of the coexistence of public and private schools to study the impact of voucher programs when there are nonlinear peer group effects. The government provides public schools as well as tuition vouchers for households attending private schools. School quality depends on expenditure per student and peer quality within the school. When peer quality is nonlinear, more agents will choose public schools if peer quality is more substitutable, whereas more agents will attend private schools if peer quality is more complementary. We find that vouchers will typically create a "cream skimming" effect and the impact of voucher programs on economic performance is sensitive to the way in which peer interactions affect school quality.

Keywords: Growth, Income Inequality, Voucher Programs, Peer Group Effects

1. INTRODUCTION

The provision of vouchers for private schools has attracted considerable debate on the pros and cons of such programs. Supporters of voucher programs claim that they provide the assistance that will allow children from poor families to attend high-quality private schools. On the other hand, those against voucher programs argue that these programs will tend to lower public school quality and worsen the problem of segregation.

Because school quality is determined not only by expenditure per student, but also by the composition of the student body within a school, a study that analyzes the ways in which these two aspects are affected by voucher programs within both public and private schools is a necessary element in the overall evaluation of the consequences of educational reform. In this paper we set out to analyze the

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ways in which voucher programs affect the educational decisions of households when there are peer group effects, and how the accumulation of human capital affects growth and income inequality.[1] To allow for the possibility that high-ability students may contribute more to peer quality, or that low-ability students may, to some extent, bring down peer quality, we adopt a nonlinear function form of peer quality as proposed by Benabou (1996). The assumption of a nonlinear form of peer quality allows for the substitutability or complementarity[2] of an individual's innate ability. The former is referred to in this study as the "role model" peer group effect, whereas the latter is referred to as the "bad apple" type peer group effect.

We construct a dynamic model with the accumulation of human capital being dependent on innate ability, school quality (expenditure per student and the peer quality within the school), parental human capital, and average human capital. The government provides all public schooling and transfers public funds to families attending private schools through voucher programs. Vouchers are defined as a fraction (scale) of public school expenditure per student, and the voucher programs are implemented when the government transfers the tax revenue to the selected households. We simulate our model to evaluate the effects of voucher programs on different scales, examining both linear and nonlinear peer quality, with peer quality being measured by the innate ability of the student body within a school. We find that with nonlinear peer quality, there is an increase in the enrollment rate in public schools, along with an increase in the degree of substitutability or a decrease in the degree of complementarity. That is, more agents will attend public schools if peer quality is more substitutable, and more agents will attend private schools if peer quality is more complementary. An increase in the public school enrollment rate will, in turn, reduce income inequality. When peer quality becomes more substitutable (or less complementary), this will enhance school quality, and thereby lead to an increase in economic growth.

Section 2 presents a model of a mixed educational system with coexistence of public and private schools. In Section 3, we simulate the model and provide our computational results. The conclusions drawn from this study are given in Section 4.

2. THE MODEL

We adopt an infinite-horizon, discrete-time overlapping generations model where agents live for two periods. Each period covers approximately 30 years, corresponding to childhood and adulthood. Every adult (parent) gives birth to a child and there is no population growth; thus, we normalize the population size to one. For family i, earnings for an adult are equal to his/her human capital, h_t^i. Young agents differ from each other by their parental human capital and innate abilities (z_t^i).

We assume that both public and private schools exist in the economy and that parents need to decide which type of school their children will attend. Additionally, if they choose to send their children to private schools, they also need to decide how much they wish to spend on their children's education. We begin by describing the school types and how school quality is determined.

2.1. School Choice

A school (j) is characterized by its quality, and we make the following assumptions about schools:

Assumption (AS1). Schools earn zero profit.

Assumption (AS2). Public schools cannot reject any students who are willing to attend.

Assumption (AS3). School quality is measured by expenditure per student (m_t^j) and quality of students (p_t^j). We use m_t^{rj} and m_t^{uj} to denote expenditure per student for a private school and a public school in period t, respectively.

Assumption (AS4). For any level of educational expenditure chosen by a parent, there always exists a private school to accept his/her child.

Assumption (AS5). A private school charges the same tuition for all types of students attending the school. However, a private school can deny admission to maximize its school quality.[3]

Because public schools are provided by the government, attendance at these schools is free. From Assumption (AS1), we know that m_t^{uj} is the same for all public schools and is determined by the government ($m_t^{uj} = m_t^u$). From Assumption (AS2), we can take it that there is only one public school in society.[4] Although households that choose to send their children to private schools need to pay tuition fees, they can also choose the quality of the school. Assumption (AS1) means that all tuition fees charged by private schools will be used to teach students; hence, the level of tuition fees equals the expenditure per student of a private school.

Assumption (AS3) states that aside from the expenditure per student, school quality also depends on the quality of its students (peer quality). We assume that school quality (q_{jt}) is a Cobb–Douglas function of the expenditure per student and peer quality, p_t^j:

$$q_t^j = \left(m_t^j\right)^{\varsigma_1}\left(p_t^j\right)^{\varsigma_2}, \quad \varsigma_1, \varsigma_2 \in (0, 1). \tag{1}$$

The theoretical literature in this area has tended to use innate learning ability or parental human capital as a measure of peer quality. Epple and Romano (1998, 2002) and Caucutt (2002, 2004) both defined peer quality as the average innate ability within a school, in line with equation (2).[5] However, studies by Nechyba (1996), Benabou (1996), and Snipes (1998) assumed that peer quality was determined by parental human capital.[6] Nechyba (1996) defined peer quality as the average parental human capital of students within a school in order to analyze mobility between communities, whereas Benabou (1996) and Snipes (1998) both assumed that peer quality was nonlinear to allow for complementarity or substitutability between individual contributions.

We assume that peer quality is dependent on the individual's innate ability, with the nature of the function for peer quality being a simple version of that defined in Benabou (1996). To allow for the flexibility of peer quality, we define nonlinear peer quality as

$$p_t^j = \left(\int \left(z_t^i\right)^{\theta} g_t^j(z)\, dz \right)^{1/\theta}, \quad \theta \in (-\infty, \infty), \tag{2}$$

where $g_t^j(z)$ is the probability distribution function of innate ability for students attending school j in period t.

The parameter θ controls the complementarity or substitutability of individual innate ability. When $\theta = 1$, peer quality is determined by the average innate ability of students within the same school and is referred as linear peer quality. However, some empirical studies have shown that high and low-ability students may provide unequal contributions to peer quality; Henderson et al. (1978), for example, found that peer quality was nonlinear. They noted that as a result of the concavity of peer quality, the gain for low-ability students would be greater than the loss for high-ability students. Glewwe (1997) expressed an opposing view, arguing that the potential achievements of students with high innate ability would be undermined by students with low innate ability, more than offsetting the gain of low-ability students from high-ability students. Hence, we consider other cases when θ is different from 1. If $\theta > 1$, then the school quality enhancement by students with high innate ability is greater than the diminution by students with low ability. This implies that individual innate ability is more substitutable and this is referred to here as the "role model" type of peer quality. On the other hand, if $\theta < 1$, then the diminution of school quality by students with low innate ability will be greater than the enhancement by students with high ability. This is referred to as the "bad apple" type of peer quality because it implies that individual innate ability is more complementary.[7]

As we will see later, educational expenditure is an increasing function of parental human capital and innate ability.[8] Hence, the educational expenditure of rich, low-ability agents may be the same as that for poorer, high-ability agents; however, Assumption (AS5) indicates that there is no price discrimination between students in a school.[9] Thus a private school accepting poorer, but more able students has no incentive to accept rich, less able students, because of the peer group effects. Because of the homogeneous peer quality of private schools, this will be equal to the innate ability of then students, z_t^i. Therefore, private schools are perfectly segregated and can be characterized by the student type (z_t^i, h_t^i). We use m_t^{ri} to represent the educational expenditure chosen by family i. The peer group effect for private schools and public schools can therefore be written as

$$p_t^j = \begin{Bmatrix} z_t^i \\ p_t^u \end{Bmatrix} \quad \text{if} \begin{cases} j = \text{private} \\ j = \text{public}, \end{cases} \tag{3}$$

where p_t^u represents peer group quality of public schools. After defining the school quality, we are now able to define the accumulation function of human capital.

2.2. Human Capital Accumulation Function

Following the literature (Glomm and Ravikumar, 1992; Glomm, 1997), we assume that human capital is accumulated according to a Cobb–Douglas learning technology:

$$h_{t+1}^i = z_t^i \left(q_t^j\right)^\gamma \left(h_t^i\right)^\delta H_t^\psi, \quad \gamma, \delta, \psi \in (0, 1). \tag{4}$$

Human capital in the next period depends on innate ability (z_t^i), school quality (q_t^j), parental human capital (h_t^i), and the average human capital of society (H_t). The parameters γ, δ, and ψ are the corresponding elasticities of q_t, h_t, and H_t to future human capital. We restrict all factors devoted to the accumulation of human capital in order to exhibit diminishing returns. Substituting equations (1) and (3) into equation (4), we can rewrite the human capital accumulation function as

$$h_{t+1}^i = \begin{Bmatrix} \left(z_t^i\right)^{1+\gamma_2} \left(m_t^{ri}\right)^{\gamma_1} \left(h_t^i\right)^\delta H_t^\psi \\ z_t^i \left(p_t^u\right)^{\gamma_2} \left(m_t^u\right)^{\gamma_1} \left(h_t^i\right)^\delta H_t^\psi \end{Bmatrix} \quad \text{if} \begin{cases} j = \text{private} \\ j = \text{public}, \end{cases} \tag{5}$$

where $\gamma_1 = \gamma \varsigma_1$ and $\gamma_2 = \gamma \varsigma_2$. We assume that the human capital accumulation function exhibits constant returns to scale (that is, $\gamma_1 + \delta + \psi = 1$) to allow the economy to grow over time.

Let $f_t(h, z)$ represent a joint distribution of human capital and innate ability in period t. The average human capital in this economy is defined as

$$H_t = \iint h_t^i f_t(h, z)\, dh\, dz. \tag{6}$$

We assume that the accumulation of human capital does not affect the realization of innate ability. The distribution of learning ability ($g_t(z)$) is invariant over time and is represented by a lognormal distribution with mean μ_z and variance σ_z^2. The initial distribution of human capital is lognormal with mean μ_{h1} and variance σ_{h1}^2:

$$z_t^i \sim Lognormal\left(\mu_z, \sigma_z^2\right), \quad h_1^i \sim Lognormal\left(\mu_{h1}, \sigma_{h1}^2\right).$$

2.3. Households' Maximization Problem

We assume that parents care about their consumption (c_t^i) and their children's human capital (h_{t+1}^i). All agents have the same utility function over their life cycles, which is

$$u_t^i = c_t^i + \beta h_{t+1}^i, \tag{7}$$

where β represents the number of consumption units that gives the same utility as one unit of a child's human capital.

Parents must pay income tax, and they also have to decide how much they want to spend on consumption (c_t^i) and which type of school their children will attend. We assume that the tax rate is constant ($\tau_t = \tau \quad \forall t$) and that the government runs a balanced budget. Tax revenues are used to support public schools and to reimburse students attending private schools as a lump-sum transfer, by means of vouchers (V_t). Let $e_t^i(j)$ and $V_t^i(j)$ respectively represent the expenditure of households on education and the vouchers they receive in period t. The budget constraint for adults is

$$c_t^i + e_t^i(j) = (1-\tau)h_t^i + \min\left\{e_t^i(j), V_t^i(j)\right\}, \tag{8}$$

where

$$e_t^i(j) = \begin{Bmatrix} m_t^{ri} \\ 0 \end{Bmatrix} \quad \text{and} \quad V_t^i(j) = \begin{Bmatrix} V_t \\ 0 \end{Bmatrix} \quad \text{if} \quad \begin{cases} j = \text{private} \\ j = \text{public.} \end{cases} \tag{9}$$

In equation (8), the term $\min\{e_t^i(j), V_t^i(j)\}$ indicates that vouchers can only be used for education. Under this assumption, the educational expenditure (m_t^{ri}) for those individuals who attend private schools will be greater than or equal to the amount of vouchers.

2.4. Government

A survey conducted by West (1997) showed that the amount of vouchers is usually a fraction of the educational cost per student at public schools, with this fraction ranging from 30 to 100%. In this paper we define the scale of voucher programs as the "fraction" (scale) of expenditure per student at public schools, and denote it as υ. We then examine the implications of voucher programs when the scale is equal to 0% (no vouchers) and 50%.

Let d_t^u represent the public school enrollment rate. Assuming that the government runs a balanced budget and the amount of vouchers is equal to a fraction of expenditure per student at public schools, we can write the government's budget constraint as

$$\tau H_t = d_t^u m_t^u + \left(1 - d_t^u\right) V_t = d_t^u m_t^u + \left(1 - d_t^u\right) \upsilon m_t^u. \tag{10}$$

Note that equation (10) shows that once the scale of vouchers is determined, if the budget for the government is balanced, the government cannot control m_t^u.

2.5. Choice of School Type

Under a mixed educational system, parents make school decisions on behalf of their children based on their utility. Without any voucher programs, the lifetime utility for parents who choose private schools for their children is

$$u_{\text{pri}}^i = (1-\tau)h_t^i + \frac{1-\gamma_1}{\gamma_1} m_t^{ri}, \tag{11}$$

where $m_t^{ri} = [\beta\gamma_1 (z_t^i)^{1+\gamma_2} (h_t^i)^\delta H_t^\psi]^{1/(1-\gamma_1)}$.
The lifetime utility for parents who choose public schools for their children is

$$u_{\text{pub}}^i = (1-\tau)h_t^i + \beta z_t^i \tau^{\gamma_1} \left(p_t^u\right)^{\gamma_2} \left(h_t^i\right)^\delta H_t^{\gamma_1+\psi}. \tag{12}$$

Comparing u_{pri}^i with u_{pub}^i, we find that given z_t^i and H_t, $u_{\text{pri}}^i > u_{\text{pub}}^i$ if

$$h_t^i > \left[\frac{\tau^{\gamma_1(1-\gamma_1)}\left(p_t^u\right)^{\gamma_2(1-\gamma_1)}}{(1-\gamma_1)^{1-\gamma_1}(\beta\gamma_1)^{\gamma_1}\left(z_t^i\right)^{\gamma_1+\gamma_2}}\right]^{1/\delta\gamma_1} H_t. \tag{13}$$

On the other hand, given h_t^i and H_t, $u_{\text{pri}}^i > u_{\text{pub}}^i$ if

$$z_t^i > \left[\frac{\tau^{\gamma_1(1-\gamma_1)}\left(p_t^u\right)^{\gamma_2(1-\gamma_1)} H_t^{\delta\gamma_1}}{(1-\gamma_1)^{1-\gamma_1}(\beta\gamma_1)^{\gamma_1}\left(h_t^i\right)^{\delta\gamma_1}}\right]^{1/(\gamma_1+\gamma_2)}. \tag{14}$$

Equations (13) and (14) imply that young agents with high parental human capital, high innate abilities, or both, will attend private schools because their desired educational investment is higher, whereas poor children, or those with lower abilities, will choose public schools. This result is shown in Figure 1 based upon the parameter values calibrated in the next section.

With the existence of voucher programs, some students with low parental human capital, but high innate ability, will switch from public schools to private schools. Hence, the curve representing $u_{\text{pri}}^i = u_{\text{pub}}^i$ in Figure 1 will shift to the left and the area for students attending private schools will become larger. Figure 2 presents school choice under a mixed educational system, when there are no vouchers and when there are vouchers, with a scale of 50%. It shows that voucher programs will conduct cream-skimming because some poor, but smart students will switch from public schools to private schools.

3. EXPERIMENTS

The model having been constructed our intention is to study its long-run implications for growth and inequality. Hence, we simulate the model to quantify the effects of voucher programs on growth and income inequality. Before performing a simulation, we need to calibrate the parameter values.

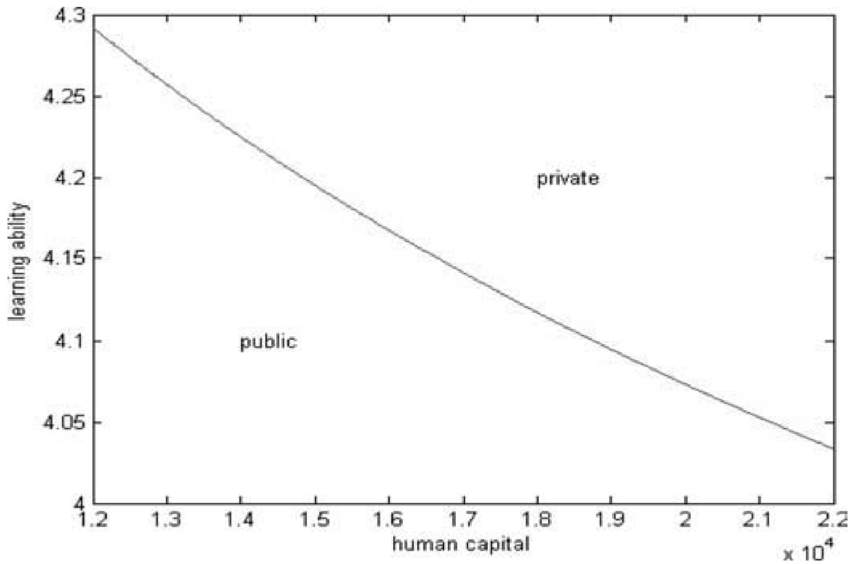

FIGURE 1. School choice.

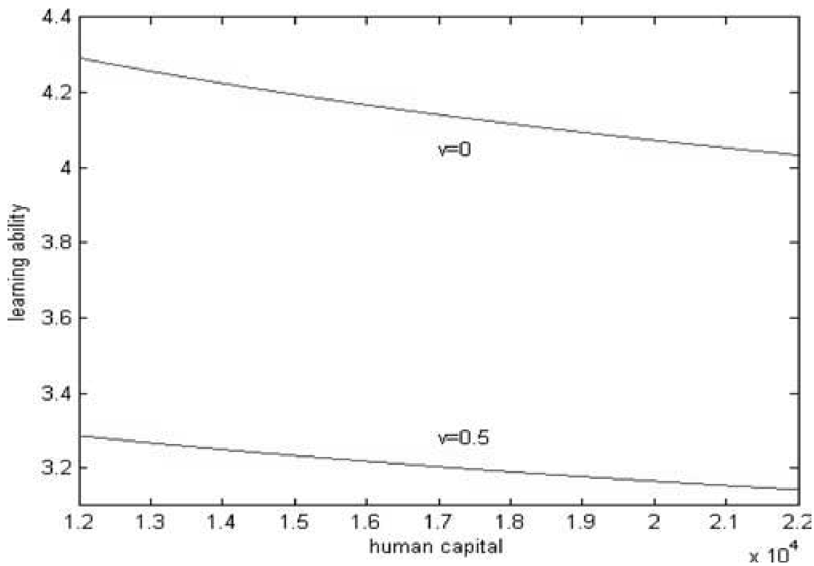

FIGURE 2. School choice with and without vouchers.

3.1. Calibration

The parameter values are calibrated to 1980 U.S. data. We first calibrate values of the parameters for the human capital accumulation function. The parameters γ_1 and δ represent the respective income elasticity of expenditure on education and

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parental income. The results of an empirical study by Johnson and Stafford (1973) showed income elasticity of school expenditure to be 0.198. The number used by Fernandez and Rogerson (1997), based on estimates by Card and Krueger (1992), was 0.2. Because these two numbers differ by only a very small margin, we set γ_1 equal to 0.2. The study by Rosenzweig and Wolpin (1994) also found that a 10% increase in a parent's education would cause a 2.4% increase in his/her child's test score; hence, we set δ as equal to 0.2. Accordingly, ψ is set to 0.6. The parameter γ_2 is calibrated to 0.19 to match the public school enrollment rate, equal to 88%.

We use, as our baseline model, an economy with a mixed educational system with linear peer quality and no voucher programs. The distributions that we need to calibrate are lognormal distributions of both innate ability and initial human capital. We calibrate μ_{h1} and σ_{h1} to match the median of U.S. household income (\$17,710)[10] and the Gini coefficient (35.2%)[11] in 1980. Because we assume that the initial human capital stock is lognormally distributed, the median of human capital is $\exp(\mu_{h1})$. Accordingly, μ_{h1} is set to 9.782 and σ_{h1} is set to 0.51. The average annual growth rate of per capita output for the United States from 1960 to 1998 is around 2%. Choosing a mean of innate ability equal to 2.595 approximates the growth rate of income as being equal to $(1.02)^{30}$ and the variance of $\log(z)$ is calibrated so that the Gini coefficient is roughly constant over time.

The discount factor (β) over 30 periods is calibrated to 0.185 so that the quarterly discount factor is around 0.986. The ratio of public spending on education to GNP in 1980 was 6.7%.[12] Accordingly, we set τ equal to 6.7% so that under the baseline model, the ratio of public spending on education to GNP matched the data.

3.2. Simulation Results

Our simulation results show that under our baseline model with linear peer quality and no vouchers, the public school enrollment rate is 87.71%, the peer quality is 2.222, the annual growth rate is 2.282%, and the Gini coefficient is 35.323% at the end of the fourth period (120 years). In this section, we explore the sensitivity of nonlinear peer quality, analyzing both the "role model" and "bad apple" types of peer quality. To study the impacts of the role model type of peer quality, we set $\theta = 1.1$, 1.8, and 2.5. To analyze the impacts of the bad apple type of peer quality, we assign $\theta = 0.9$, 0.2, and -0.5. For each type of peer quality, we study the case both without and with voucher programs with a scale equal to 50%. Tables 1 and 2 present details of economic performance at the end of the fourth period. The variables p and lp represent nonlinear peer quality and the mean ability ($\theta = 1$) within public schools in the fourth period, respectively.

Role Model Type of Peer Quality. Table 1 exhibits the simulation results with the role model type of peer quality. The higher the magnitude of θ, the greater the substitutability for an individual's ability; the substitutability of each individual's innate ability becomes clear when we compare p with lp. As Table 1 shows, p

TABLE 1. Role model type of peer quality

θ	1.1			1.8			2.5		
	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$
Public (%)	87.870	75.360	−14.237	88.460	76.710	−13.283	89.030	77.740	−12.681
p	2.241	1.997	−10.888	2.368	2.096	−11.486	2.491	2.188	−12.164
lp	2.225	1.986	−10.742	2.238	2.008	−10.277	2.250	2.026	−9.956
g	2.286	2.333	2.056	2.299	2.340	1.783	2.311	2.351	1.731
Gini (%)	35.259	36.607	3.823	35.004	36.413	4.025	34.766	36.194	4.107

Note: Definition of variables: % public = percentage of public school enrollment rate in the fourth period; p = nonlinear peer quality in public schools in the fourth period; lp = average innate ability of student body in public schools in the fourth period; g = economic growth rate from the fourth period to the fifth period; Gini (%) = percentage of the Gini coefficient at the end of the fourth period.

TABLE 2. Bad apple type of peer quality

θ	0.9			0.2			−0.5		
	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$	$\upsilon = 0$	$\upsilon = 0.5$	$\Delta\%$
Public (%)	87.570	75.100	−14.240	86.720	73.250	−15.533	85.760	71.150	−17.036
p	2.202	1.970	−10.536	2.068	1.862	−9.961	1.934	1.751	−9.462
lp	2.219	1.981	−10.726	2.200	1.951	−11.318	2.179	1.918	−11.978
g	2.281	2.334	2.324	2.266	2.326	2.648	2.253	2.320	2.974
Gini (%)	35.369	36.620	3.537	35.685	36.855	3.279	36.019	37.067	2.910

Note: For definition of variables, see Table 1.

is higher than lp because high-ability students contribute more to school quality than low-ability students.

For each assigned value of θ, the implementation of voucher programs will increase sorting. It will reduce the enrollment rate and the peer quality in public schools because more able students and children with richer parents will switch to private schools. Consequently, there will be an increase in both growth rate and income inequality.

We examine the statistics under a mixed educational system, with no voucher program in place, when the substitutability of each individual's innate ability is equal to 1.1, 1.8, and 2.5. As θ increases, there is a rise in the magnitude of the contribution from high-ability students to the public school quality, and thus, more families are willing to send their children to public schools. An increase in θ raises peer quality within a school and hence also raises school quality. Therefore, an increase in θ will also lead to an increase in economic growth. With more students attending public schools due to an increase in θ, there is a corresponding decline in income inequality. A similar scenario can also be found when voucher programs are introduced.

We now turn to an examination of the impacts of voucher programs for various levels of θ. The parameter $\Delta\%$ represents the percentage change in the corresponding statistics, with and without vouchers. Comparing the economic growth before and after the implementation of voucher programs, we find that the higher the level of θ, the smaller the percentage reduction in the public school enrollment rate and the higher the level of income inequality. This is because when θ is high, the human capital accumulation of students remaining in public schools will be enhanced by able students, and hence, more students will remain in public schools after the implementation of voucher programs. Although an increase in θ implies that students in public schools can accumulate more human capital, with a lower percentage increase in the private school enrollment rate, this will reduce the overall increase in economic growth both before and after the implementation of voucher programs.[13]

Bad Apple Type of Peer Quality. In contrast to the role model type of peer quality, when θ is less than 1, school quality is brought down by students with low innate ability, largely offsetting the enhancements to school quality provided by students with high innate ability. The statistics on school quality under the bad apple type of peer quality are provided in Table 2.

The lower the magnitude of θ, the higher the level of complementarity will be for an individual's ability. Due to the impact of the bad apple type of peer quality on school quality, p is smaller than lp, as shown in the table. For a fixed value of θ, the enrollment rate in public schools declines when vouchers are introduced.

The complementary of innate ability within public schools will push high-ability students to leave public schools, thereby further worsening peer quality within public schools. Those attending private schools will accumulate more human capital, whereas those staying in public schools will accumulate less human capital. If the former dominates the latter, then implementation of voucher programs will raise the growth rate, and vice versa. The simulation results show that the implementation of voucher programs will lower peer quality within public schools, while increasing both the growth rate and income inequality in all three cases.

Comparing the statistics under a mixed educational system for different magnitudes of θ, and with no voucher program in place, we find that enrollment in public schools declines with a decrease in θ. A decrease in θ reduces peer quality within a school and hence lowers school quality; as θ decreases, there is a corresponding reduction in the economic growth rate. With fewer students attending public schools, as θ decreases, there is a corresponding increase in income inequality. The story is also very similar under a mixed educational system with voucher programs.

We now turn to an examination of the impact of voucher programs for various levels of θ. Comparing the economic growth rate before and after the implementation of voucher programs, we find that the smaller the level of θ, the greater the percentage increase in the private school enrollment rate and the economic growth rate. This is because when θ is low, the human capital of students remaining in public schools will be lowered by students of low ability. Hence, the implemen-

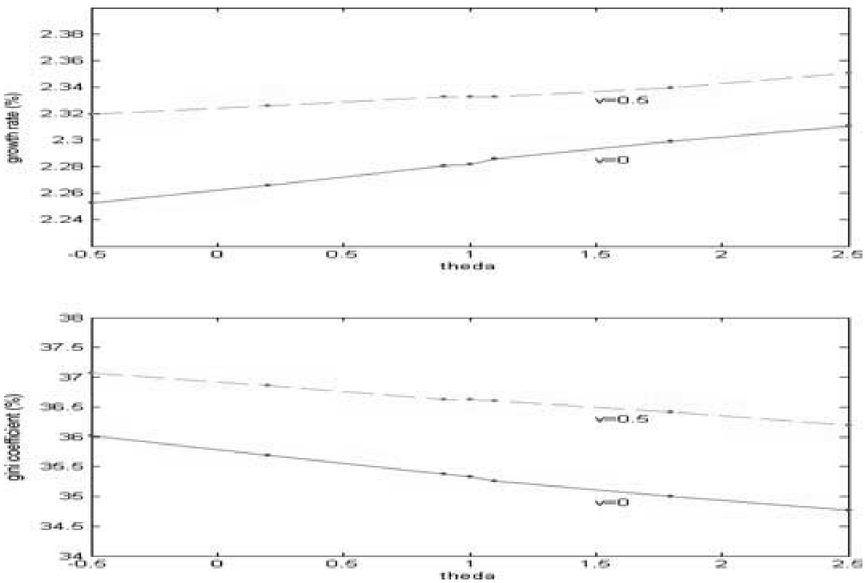

FIGURE 3. Economic performance for different values of θ.

tation of voucher programs will cause more students to leave public schools for private schools and this in turn will, raise the economic growth rate.

Comparing Table 1 with Table 2, we find that with the same scale of vouchers, the public school enrollment rate is higher under role model peer quality than under bad apple peer quality. This implies that public schools are more preferable when peer quality is more substitutable, as opposed to when it is more complementary. Figure 3 presents the economic growth rate and income inequality in the fourth period for values of θ considered in Tables 1 and 2 when there are no vouchers and when the scale of vouchers equals 50%. It shows that growth rate goes up with an increase in θ whereas Gini coefficient goes down with an increase in θ. The changes of growth rate and Gini coefficient are not very large, because θ increases when $v = 0.5$. However, when there are no vouchers, the impacts of θ are larger. Without vouchers, the growth rate will increase by 2.57%, whereas the Gini coefficient will decrease by 3.6%, when θ increases from -0.5 to 2.5.

Comparing the impacts of voucher programs, we find the vouchers will increase sorting. Furthermore, our simulation results show that sorting will increase the growth rate more in the bad apple case than in the role model case. However, the Gini coefficient will increase more by sorting in the role model case than in the bad apple case. Hence, voucher programs are better to adopt in the bad apple case than in the role model case.

4. CONCLUSIONS

A dynamic model is constructed in this paper, under a mixed educational system, to explore the impact of voucher programs on economic performance when there are nonlinear peer group effects. We find that vouchers will typically generate a cream-skimming effect and the impacts of voucher programs on economic performance are sensitive to the way in which peer interactions affect school quality. Our study indicates that in any future study, more accurate estimation of the human capital accumulation function and peer quality formulation will be necessary.

NOTES

1. Papers studying economic performance under a public and a private education regime include Glomm and Ravikumar (1992), Zhang (1996), and Glomm (1997). The economic performance, when both private and public schools exist, is analyzed by Chen (2005). However, school quality, which needs to be measured by expenditure per pupil and peer group quality, is not considered in any of these studies.
2. Following Benabou (1996), we say that peer quality is substitutable if high-ability students may contribute more to peer quality and peer quality is complementary if low-ability students may contribute more to peer quality.
3. Similar assumptions about tuition and administration policies for private schools can be found in Nechyba (2000). I thank one referee for pointing out that besides an assumption about tuition policy, an assumption about administration policy is also needed.
4. If there are several different public schools in the economy, households will choose to attend the one with better quality. Eventually, the quality of public schools will be the same.
5. Our work differs from their studies in two specific ways: we consider the growth and income distribution implications of voucher programs, and along with the use of mean ability as the peer measure, we also study cases with nonlinear peer quality.
6. In Benabou (1996), the general form of peer quality depends both on parental human capital and the innate ability. However, he simplified peer quality as defined only by parental human capital when conducting the theoretical analysis.
7. Following the literature, we use the terms “role model” and “bad apple” type peer quality to represent the situations for $\theta > 1$ and for $\theta < 1$.
8. This means that a rich student will choose a higher educational expenditure than a poor student with the same innate ability. Also, an able student will choose a higher educational expenditure than a less able student with the same parental human capital.
9. Rothschild and White (1995) and Caucutt (2002) analyzed models where schools could price discriminate among students. The results showed that rich, less able individuals would subsidize poor, able individuals. Our model can be extended to study the situation where there price discriminations among students. However, this would complicate the model, and price discrimination is not the focus of this paper.
10. Data source: U.S. Census Bureau.
11. Data source: Deininger and Squire (1996).
12. Data source: UNESCO, United Nations.
13. This is because only those students with high parental human capital, high ability, or both will choose private schools to accumulate their human capital more rapidly than in public schools.

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