

# Macrodynamic Implications of Income-Transfer Policies for Human Capital Investment and School Effort

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The distortion in educational investment in poorer children is often attributed to credit market imperfections and hence to the unequal access of children to educational opportunity. However, the distortion might also be attributable to disincentive effects that cause children to make inefficient use of educational opportunities. This possibility is demonstrated for an overlapping generations economy with multiple family dynasties in which children have random unobservable abilities and base their school effort on their parents' after-tax returns to schooling. Income redistribution can result in suboptimal effort choices that offset the beneficial effects of income transfers and sharply lower social welfare.

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## 1. Introduction

Following the seminal study by Galor and Zeira (1993), the recent literature on income inequality and income growth has focused on microeconomic linkages that permit income distribution to affect aggregate economic activity in the long run. These linkages include capital market imperfections, parental bequests, home environment effects, and nonconvexities in human capital production.

In particular, in the context of a two-period lived overlapping generations economy, Galor and Zeira (1993) show how the initial wealth distribution affects aggregate output and investment as well as sectoral adjustment to exogenous shocks when human capital investment is financed in part by inherited wealth. As in previous studies (e.g., Loury, 1981), credit market imperfections cause the initial wealth distribution to affect short-run economic activity. However, the additional assumption of a nonconvexity in human capital production at the individual level results in nonergodic dynamics, implying that long-run economic activity is affected as well.

Subsequent studies have explored other possible linkages between income inequality and long-run macroeconomic outcomes. For example, Perotti (1993) analyzes the impact of

income distribution on growth in a nonoverlapping generations model when human capital investment is the source of growth and individuals with differential earnings abilities vote over the degree of redistribution in the economy. Human capital investment benefits the investor directly and benefits all other agents indirectly through a production externality. The basic message is that the transmission of this positive production externality can come to a halt if it is too costly for the median voter to sustain. Consequently, economies with different per-capita incomes have very different patterns of income distribution that are most favorable to growth. In particular, Perotti (1993, p. 770) concludes that, in order for his economy to have both the technological and political ability to jump-start growth and to sustain growth once an intermediate level of income is achieved, it must start out with a pretax income distribution that is sufficiently (but not excessively) egalitarian.

In another interesting study, Galor and Tsiddon (1997) focus on the interplay between a local home environment externality—each child's investment in human capital depends on his parent's human capital—and a global technological externality, an adoption rate for new technologies that is positively related to the average level of human capital in society. The implications of this interplay for economic growth and development are explored in the context of a three-period lived overlapping generations economy consisting of multiple family dynasties in which agents differ only with respect to parental levels of human capital. The authors show that income polarization across family dynasties takes place in stages of development when the local externality dominates, since inequalities are induced in the distribution of human capital. On the other hand, income convergence across family dynasties ultimately occurs in stages of development when the global externality dominates.

As a final example, Durlauf (1996a, 1996b) investigates a model of an economy with an imperfect human capital loan market in which families endogenously organize themselves into neighborhoods. The tax base of a neighborhood determines a common level of human capital for each neighborhood child, which in turn affects the future income of the child. Durlauf establishes that initial family income inequalities can persist in this context.

This article explores another potentially important microeconomic linkage through which income distribution might affect long-run macroeconomic outcomes: namely, family circumstances that affect the schooling effort choices of children.

More precisely, previous studies linking income distribution to long-run macroeconomic outcomes through human capital investment have tended to make one of two assumptions. Either children are passive recipients of parental human capital investment (Durlauf, 1996a, 1996b), or children (young agents) are lifetime utility maximizers who own physical resources, possibly augmented by parental bequests, and who decide for themselves how much of these resources to invest in their human capital (Galor and Zeira, 1993; Perotti, 1993; Galor and Tsiddon, 1996).

In contrast, we consider a middle-ground case: while parents are assumed to control all of the physical resources invested in their children's human capital, children nevertheless have some say in the effectiveness of this investment. Specifically, we suppose that human capital investment represents parental investment in the education of children, and we suppose that children choose how much effort to exert in school on the basis of the returns to schooling they perceive their parents to have experienced. As will be more carefully discussed in

Section 4, below, empirical findings suggest the potential importance of examining this middle-ground case.

We then pose the following questions: In the absence of production externalities, will distortions in educational investment in poorer children be due solely to imperfections in the human capital loan market and hence to the unequal access of children to educational opportunity? Or will distortions also be attributable in part to incentive problems that cause the children, themselves, to make inefficient use of the educational opportunities they receive? And to what extent, if any, will these distortions persist over time?

These questions are explored in the context of a two-period lived overlapping generations economy consisting of multiple family dynasties and a government with tax and transfer powers. The ability levels of children are random and unobservable. Each parent, concerned for the utility attained by his child, allocates his after-tax income between his own consumption and investment in his child's human capital. Each child in turn selects a schooling effort level based in part on his parent's investment and in part on his perceived marginal returns to schooling. The latter perception is affected by the marginal returns to schooling attained by the child's parent, so that family circumstances have a direct impact on the child's behavior.<sup>1</sup> Each child's future income is then determined as a function of his ability, his parental investment, and his schooling effort.

We find for this model that the simple equalization of educational opportunity through income transfers to poor families may not result in Pareto optimal human capital investments, even in the absence of production externalities. The crucial observation is that a government income tax policy can bias downward each child's perceived marginal returns to schooling at the same time that it equalizes parental income transfers to children. A small degree of income subsidization for low-income families does increase human capital production, raising GNP and social welfare in both the short run and long run by weakening the constraint imposed by family income on human capital investment. Nevertheless, GNP and social welfare both decline precipitously along with schooling effort as government imposes progressively more egalitarian tax policies, resulting in progressively lower after-tax returns to schooling effort.<sup>2</sup> Moreover, due to free-rider effects, increasing the number of families in existence at each point in time hastens and deepens the decline.

The basic human capital investment framework is set out in Section 2. Section 3 develops a particular model within this framework with functional specifications chosen to match the specifications of Loury (1981) as closely as possible for comparison purposes. Section 4 discusses empirical support for the view taken in Section 3 that family circumstances strongly affect a child's choice of schooling effort. Various dynamic properties of the human capital investment model are analytically derived in Section 5. The results of extensive simulation experiments conducted with this model are reported in Section 6. The final Section 7 gives concluding comments.

## 2. The Basic Economy

This section sets out a human capital investment framework, hereafter referred to as the *basic economy*, that generalizes the model used by Loury (1981) to investigate the relationships among human capital investment, income distribution, and government tax and transfer

policies. Loury assumes that the subsequent earnings of a child are determined by two factors: innate ability and parental investment in the child's education. In the basic economy it is assumed that the child's subsequent earnings are also determined in part by the intensity of effort that the child devotes to his schooling.

Specifically, the basic economy is an overlapping generations economy that begins in period 1 and extends into the infinite future. The economy consists of a consumer sector and a government policymaker with tax and transfer powers. The rate of population growth is constant and equal to zero. Each agent lives for just two periods, a first period (*childhood*) and a second period (*parenthood*). One child is born to each agent at the beginning of his second period of life. The economy has only one consumable resource,  $Q$ , assumed to be completely perishable and divisible. Adopting the standard convention that goods are distinguished by date of availability, the amount of  $Q$  available during period  $t$  represents "good  $t$ ."

In the initial period 1, the population consists of  $N$  parents and  $N$  children, divided into  $N$  parent-child pairings. The  $N$  pairings constitute  $N$  distinct *family dynasties*,  $i = 1, \dots, N$ . Each child born in a subsequent period  $t$  is then assigned to one of the  $N$  family dynasties on the basis of the dynasty belonged to by his parent.

Consider any one family dynasty—say, dynasty  $i$ . Dynasty  $i$  in the initial period 1 consists of one parent  $P_{i1}$  together with his child  $C_{i1}$ . The parent  $P_{i1}$  is assumed to have an exogenously given amount of pretax earnings  $y_{i1}$  measured in period 1 good and is also characterized by an exogenously given intensity of effort level  $n_{i0}$  representing the effort that he put into his schooling as a child. In each subsequent period  $t \geq 2$ , dynasty  $i$  then consists of one parent  $P_{it}$ , born in period  $t - 1$ , together with the child  $C_{it}$  of  $P_{it}$  born at the beginning of period  $t$ .

In each period  $t \geq 1$ , the child  $C_{it}$  is endowed with a random skill level  $\alpha_{it} \in [0, 1]$  for producing  $Q$ , where  $\alpha_{it}$  is assumed to be *unobservable*. In addition, the child receives a certain amount of resources  $e_{it}$  from his parent  $P_{it}$  in support of his education, where  $e_{it}$  is measured in period  $t$  good. The child must decide how much effort  $n_{it}$  he will devote to his schooling. The level of pretax earnings  $y_{i,t+1}$  achieved by the child when he reaches adulthood in the subsequent period  $t + 1$  is assumed to depend positively on all three factors. Formally, the child's income (or human capital production) function takes the form

$$y_{i,t+1} = h(\alpha_{it}, e_{it}, n_{it}), \quad h_1 > 0, \quad h_2 > 0, \quad h_3 > 0, \quad (1)$$

where  $y_{i,t+1}$  is measured in good  $t + 1$ .

Suppose the government policymaker at the beginning of period 1 selects a tax policy  $\tau$  for determining the taxes and subsidies to be imposed on the earnings of each parent in each subsequent period. Let  $\tau_{it}$  denote the tax or subsidy level imposed on the dynasty  $i$  parent  $P_{it}$  in period  $t$  under tax policy  $\tau$ , where  $\tau_{it} < 1$  denotes a tax and  $\tau_{it} > 1$  denotes a subsidy (or *negative tax*). The after-tax earnings of  $P_{it}$  then take the form  $\tau_{it}y_{it}$ . It will be supposed that  $\tau_{it}$  is a function of the pretax income  $y_{jt}$  earned by each dynasty  $j$  in period  $t$ , the tax policy  $\tau$ , and the total number of dynasties  $N$ . That is,

$$\tau_{it} = G_i(y_{1t}, \dots, y_{Nt}, \tau, N) \quad (2)$$

for some function  $G_i(\cdot)$ ,  $i = 1, \dots, N$ .

The child  $C_{it}$  must decide what effort  $n_{it}$  he will devote to his schooling. It is assumed that the child is positively influenced in this decision by two factors: (1) the amount of resources  $e_{it}$  that his parent invests in his education and (2) his expected marginal return to schooling effort, denoted by

$$r_{it}^e = (\partial \tau_{i,t+1} y_{i,t+1} / \partial n_{it})^e. \quad (3)$$

Note, in particular, that the child's choice of effort cannot *directly* depend on his ability level, since ability levels are assumed to be unobservable.

Formally, the choice of effort  $n_{it}$  takes the form<sup>3</sup>

$$n_{it} = n(e_{it}, r_{it}^e), \quad n_1 > 0, \quad n_2 > 0. \quad (4)$$

It follows from (4) that a parent can influence his child's schooling effort in two ways. First, a parent can directly transfer resources to his child, as measured by the human capital investment level  $e_{it}$ . Second, as will be clarified below, the information the child obtains about his parent's income and schooling effort can influence the child's expected marginal return to schooling effort. Note, also, that the government tax policy  $\tau$  indirectly affects the child's schooling effort through the investment level  $e_{it}$ , since  $e_{it}$  is allocated out of the parent's disposable income, and  $\tau$  may also influence the child's schooling effort by influencing his expected marginal return to schooling effort.

The parent  $P_{it}$  faces a more complicated decision problem in period  $t$  than his child. Specifically, he must decide how much of his disposable income to devote to his own consumption versus how much to devote to investment in the education of his child. The utility attained by  $P_{it}$  in period  $t$  is assumed to be a function  $U(c_{it}, V_{i,t+1})$  of his own period  $t$  consumption,  $c_{it}$ , and the utility  $V_{i,t+1}$  he anticipates for his child in period  $t + 1$ .

Let  $s_{it}$  denote the state vector describing the situation of the parent  $P_{it}$  at the beginning of period  $t$  in terms of his pretax earnings  $y_{it}$ , his past schooling effort  $n_{i,t-1}$ , and his income tax or subsidy level  $\tau_{it}$ , as well as the government's tax policy  $\tau$  and the total number of dynasties  $N$ . That is, define

$$s_{it} = (y_{it}, n_{i,t-1}, \tau_{it}, \tau, N). \quad (5)$$

It is assumed that the state vector (5) represents all of the information that is potentially available to the child  $C_{it}$  at the beginning of period  $t$ . Consequently, the child's expected marginal return to schooling effort (3) must ultimately be determined as a function of this state vector:<sup>4</sup>

$$r_{it}^e = r^e(s_{it}). \quad (6)$$

It follows from (6) that the child's expectations regarding returns to schooling are potentially affected by the tax policy  $\tau$  as well as by his family's particular tax or transfer level  $\tau_{it}$ . Thus, the tax system can influence the child's schooling effort—that is, his human capital investment decision—by distorting the child's perceived returns to schooling. In contrast, in Loury (1981) the schooling effort of the child is effectively held constant, implying that the tax system cannot influence the human capital investment decision of the child.

Given (1), (4), and (6), the state vector  $s_{it}$  satisfies a recurrence relation of the form

$$\begin{aligned} s_{i,t+1} &= (h(\alpha_{it}, e_{it}, n(e_{it}, r^e(s_{it}))), n(e_{it}, r^e(s_{it})), \tau_{i,t+1}, \tau, N) \\ &\equiv F(\alpha_{it}, e_{it}, \tau_{i,t+1}, s_{it}). \end{aligned} \quad (7)$$

The budget set facing  $P_{it}$  in period  $t$  takes the form

$$B(s_{it}) = \{(c_{it}, e_{it}) \geq 0 \mid c_{it} + e_{it} = \tau_{it} y_{it}\}. \quad (8)$$

The value function  $V_{it}(s_{it})$  for the parent  $P_{it}$  is then defined to be the maximum expected utility attainable by  $P_{it}$  in period  $t$ , given the state  $s_{it}$ . By construction, this value function satisfies a dynamic programming recurrence relation of the form

$$V_{it}(s_{it}) = \max_{c_{it}, e_{it} \in B(s_{it})} E_{i,t}[U(c_{it}, V_{i,t+1}(s_{i,t+1})) \mid c_{it}, e_{it}, s_{it}], \quad (9)$$

subject to  $s_{i,t+1}$  being given by relation (7). The conditional expectation in (9) is taken with respect to the ability level  $\alpha_{it}$  and the tax rate  $\tau_{i,t+1}$  appearing in (7). Note that this construction implies that the parent knows the income function  $h(\cdot)$  and the function  $n(\cdot)$  that determines the effort level of his child.

### 3. An Illustrative Special Case of the Basic Economy

In this section, the dynamic properties of the basic economy are investigated for particular specifications for the income function, the effort function, the utility function, and the tax policy set out in general form in Section 2. These specifications are chosen to match as closely as possible the example studied by Loury (1981, pp. 855–857).

Consider, then, a special case of the basic economy in which the income function (1) for each dynasty  $i$  in each period  $t$  is given by

$$\begin{aligned} y_{i,t+1} &= h(\alpha_{it}, e_{it}, n_{it}) \\ &\equiv \lambda \cdot (\alpha_{it})^m \cdot (e_{it})^u \cdot (n_{it})^v \end{aligned} \quad (10)$$

for arbitrary positive constants  $\lambda$ ,  $m$ ,  $u$ , and  $v$  satisfying  $0 < (u + v) \leq 1$ . Suppose, also, that the effort function (4) for each dynasty  $i$  in each period  $t$  is given by

$$\begin{aligned} n_{it} &= n(e_{it}, r^e(s_{it})) \\ &\equiv (e_{it})^a \cdot (r^e(s_{it}))^b \end{aligned} \quad (11)$$

for arbitrary positive constants  $a$  and  $b$  satisfying  $0 < (a + b) \leq 1$ .

The utility attained by each dynasty  $i$  parent  $P_{it}$  in each period  $t$  is assumed to be given by

$$U_{it} = (c_{it})^\gamma \cdot (V_{i,t+1})^{1-\gamma}, \quad (12)$$

where  $c_{it}$  denotes the period  $t$  consumption of  $P_{it}$ ,  $V_{i,t+1}$  denotes the utility which  $P_{it}$  anticipates for his child in period  $t + 1$ , and  $\gamma$  is an arbitrary constant assumed to satisfy

$0 < \gamma < 1$ .<sup>5</sup> Suppose  $(1 - \gamma)^k \log(V_{i,t+k})$  approaches zero as  $k$  becomes arbitrarily large. If anticipations are correct, implying  $U_{it} = V_{it}$  for all  $t$ , it then follows that

$$\begin{aligned} \log(U_{it}) &= \gamma \log(c_{it}) + (1 - \gamma) \log V_{i,t+1} \\ &= \gamma \log(c_{it}) + (1 - \gamma)[\gamma \log(c_{i,t+1}) + (1 - \gamma) \log(V_{i,t+2})] \\ &\vdots \\ &= \gamma \left[ \sum_{k=0}^{\infty} (1 - \gamma)^k \log(c_{i,t+k}) \right]. \end{aligned} \quad (13)$$

Consequently, the ex post “true” utility of each dynasty  $i$  parent  $P_{it}$  in each period  $t$  is a function of the consumption levels of all current and future members of dynasty  $i$ .

The government must select a tax policy that is budgetarily feasible. Since the resource  $Q$  for the basic economy is nonstorable, budgetary feasibility in each period  $t$  requires that the sum of the after-tax incomes of the  $N$  dynasties should not exceed the sum of their before-tax incomes. Letting  $\tau_{it}$  denote the tax or subsidy imposed on the dynasty  $i$  parent  $P_{it}$  in period  $t$ , the condition expressing this feasibility is

$$\sum_{i=1}^N \tau_{it} y_{it} \leq \sum_{i=1}^N y_{it}. \quad (14)$$

It will be supposed that the government selects a tax policy from among a family of feasible tax policies parameterized by  $\tau$ , where  $\tau$  lies in the interval  $[0, 1/N]$ . Specifically, given any  $\tau$  in  $[0, 1/N]$ , and given the pretax income levels  $\{y_{it} : i = 1, \dots, N\}$  of the  $N$  dynasties in period  $t$ , the tax or subsidy level  $\tau_{it}$  imposed on each parent  $P_{it}$  is determined by the relation

$$\tau_{it} y_{it} \equiv [1 - (N - 1)\tau] \cdot y_{it} + \tau \cdot \left( \sum_{j \neq i} y_{jt} \right), \quad i = 1, \dots, N. \quad (15)$$

The tax policies  $\tau$  in  $[0, 1/N]$  all satisfy the budget feasibility condition (14) with exact equality, by construction. Moreover, the tax policies range from “libertarian” to “egalitarian” as  $\tau$  increases from 0 to  $1/N$ . Given the tax policy  $\tau = 0$ , the tax rates  $\tau_{it}$  are identically equal to 1, implying that no redistribution is undertaken. On the other hand, the tax policy  $\tau = 1/N$  is egalitarian in the sense that each of the  $N$  dynasties in each period  $t$  receives precisely  $1/N$  of the total earnings of the  $N$  dynasties. Given any existing configuration of pretax incomes, the tax policy becomes progressively more egalitarian as  $\tau$  ranges from 0 to  $1/N$ , in the sense that the variance of the after-tax incomes across dynasties declines in each period  $t$ .

For later purposes, it is useful to point out the free-riding problem that arises under the egalitarian tax policy,  $\tau = 1/N$ . In this case the after-tax income of each dynasty is given by mean dynasty income. Consequently, an increased effort level by any one dynasty only changes that dynasty’s after-tax income to the extent that it has an effect on mean dynasty income; and, ceteris paribus, the larger is  $N$ , the smaller this effect will be. Consequently, an egalitarian tax policy gives dynasties an incentive to free ride on the effort levels of others, and this free-riding problem worsens as the number of dynasties increases.

More can now be said about  $r_{it}^e$ , the marginal return to schooling effort anticipated by the dynasty  $i$  child  $C_{it}$  in period  $t$ . Recall from relation (3) that  $r_{it}^e$  is assumed to be measured in terms of  $C_{it}$ 's after-tax income earnings for period  $t + 1$ . Let  $r_{it}$  denote the actual marginal return to schooling effort attained by  $C_{it}$  in the subsequent period  $t + 1$ . Using (10) and (15), one has

$$\begin{aligned} r_{it} &= \partial \tau_{i,t+1} y_{i,t+1} / \partial n_{it} & (16) \\ &= \partial [1 - (N - 1)\tau] y_{i,t+1} / \partial n_{it} \\ &= [1 - (N - 1)\tau] \partial y_{i,t+1} / \partial n_{it} \\ &= [1 - (N - 1)\tau] v \cdot [y_{i,t+1} / n_{it}]. \end{aligned}$$

Thus, the *marginal* return to schooling effort,  $r_{it}$ , is proportional to the *average* return to schooling effort,  $y_{i,t+1}/n_{it}$ . Note that  $[1 - (N - 1)\tau]v$  is strictly positive for all  $\tau$  in the admissible range  $[0, 1/N]$ .

As discussed in Section 2,  $r_{it}^e$  must ultimately be describable as a function  $r^e(s_{it})$  of the state vector  $s_{it}$ , where  $s_{it}$  consists of all information available to the child  $C_{it}$  at the beginning of period  $t$ . Consistent with this observation, it will be supposed that the child estimates his own average return to schooling effort,  $y_{i,t+1}/n_{it}$ , in (16) by considering the average return to schooling effort,  $y_{it}/n_{i,t-1}$ , attained by his parent.<sup>6</sup> Thus,

$$\begin{aligned} r_{it}^e &= r^e(s_{it}) & (17) \\ &\equiv [1 - (N - 1)\tau]v \cdot [y_{it}/n_{i,t-1}]. \end{aligned}$$

It follows from (17) that, for *each* child, the expected marginal return to schooling effort declines *ceteris paribus* with increases in  $\tau$ —that is, with increases in the degree of egalitarianism of the government's tax policy. As will be clarified in Section 6, this negative effect can offset the positive effect of income transfers on human capital investment.

Finally, two important restrictions will be placed on the stochastic properties of the model. First, it will be supposed that the random ability levels of children across the dynasties  $i = 1, \dots, N$  are governed by stationary independent probability distributions ( $f_1(\cdot), \dots, f_N(\cdot)$ ) in each period  $t$ . Second, it will be supposed that each parent  $P_{it}$  believes he is unable, by his own actions, to affect the tax or subsidy level to be imposed on his child. More precisely, given any function  $J(\tau_{i,t+1})$  of  $\tau_{i,t+1}$ , it will be supposed that

$$E[J(\tau_{i,t+1}) \mid c_{it}, e_{it}, s_{it}] = E[J(\tau_{i,t+1}) \mid s_{it}]. \quad (18)$$

Thus,  $P_{it}$  believes that his consumption decision  $c_{it}$  and his human capital investment decision  $e_{it}$  are not relevant for estimating the tax or subsidy level  $\tau_{i,t+1}$  to be imposed on his child. Essentially, this reduces to assuming that each parent views himself as being too small to affect government tax policy.

Before developing various dynamic properties for the model set out in this section, it will be useful to examine the empirical support for the view expressed in relations (11) and (17) that a child's choice of schooling effort is strongly affected by family circumstances.

#### 4. Family Effects on Schooling Effort

Beginning with the publication of the Coleman report (1966), researchers have consistently found that parental education and income have strong effects on the level of human capital investment in children. At the same time, school quality indicators have been found to have only a small impact on school attendance or on achievement test scores. Similarly, holding family and neighborhood attributes fixed, measures of the quality of schooling received as a child have been found to have only negligible effects on subsequent adult earnings.<sup>7</sup>

In part, these findings reflect the fact that local taxes support approximately 50 percent of all public expenditures on elementary and secondary schools, so that school quality strongly reflects family and neighborhood decisions regarding human capital investment (Kozol, 1991, pp. 56–57). The evidence also suggests, however, that redistributing income towards poorer school districts has had only negligible effects on human capital investment.<sup>8</sup> Consequently, family background appears to have an independent effect on human capital investment apart from its effect on school quality.

Researchers have also consistently found a strong positive correlation between parent and child lifetime incomes.<sup>9</sup> If children are investing in schooling so as to maximize their lifetime earnings, conditional on complete information about returns to schooling, it is not clear why this should be the case.

Taubman (1989) discusses two possible explanations for this empirical linkage. The first explanation emphasizes the role of children's education as a consumption good for parents. If the education of a child is a normal good, then higher-income families will invest more in their children's education than will poorer families. The second explanation treats the education of a child as an investment good but assumes that poorer families are liquidity constrained and so cannot invest optimally in their children's human capital.

However, the impact of both income and liquidity constraints on educational investments should have been reduced over the course of the century as poverty rates have fallen and as transfers to poor school districts have made budget constraints less binding. Thus, current differences in schooling outcomes between poorer and wealthier families should be less a consequence of family income and liquidity constraints than was true in the past, which may explain why additional transfers of resources to poor school districts have had little apparent effect on schooling outcomes in recent times.

In this article we propose a third possible explanation for the observed linkage between parental and child lifetime incomes: that children condition their expectations of returns to schooling on their parents' returns to schooling. If true, then egalitarian transfers of income to poorer families may bias downward children's expected returns to schooling and reduce children's incentives to invest effort in schooling, even as those transfers remove liquidity constraints on families.

The latter explanation is consistent with recent sociological research into urban underclass isolation. For example, Wilson (1987) has argued that, in neighborhoods with large shares of welfare recipients, "children will seldom interact on a sustained basis with people who are employed or with families that have a steady breadwinner. The net effect is that . . . the relationship between schooling and postschool employment takes on a different meaning.

The development of cognitive, linguistic, and other educational job-related skills necessary for the world of work in the mainstream economy is thereby adversely affected.”

Unfortunately, despite the importance of expectations to the welfare dependency hypothesis, very few empirical studies have focused on the role of expectations in determining schooling effort levels (Manski, 1993). Sandell and Shapiro (1980) and Blau and Ferber (1991) have found that expectations of intermittent employment can cause individuals to select less training-intensive employment. To our knowledge, however, no studies have measured the impact of family or neighborhood transfer payments on the expectation formation of youths. The limited evidence on the role of welfare payments on child schooling effort is not definitive.

For example, Currie (1995) reports that white children of welfare recipients are more likely to repeat a grade but that there is no significant effect of welfare reciprocity on black children. Butler (1990) finds that AFDC payments appear to increase the odds that a child will continue beyond high school but also increase the odds that a child will stop after the ninth grade. Both studies use extremely small samples, so conclusions must be drawn with caution. Nevertheless, a conclusion that AFDC payments may raise or lower child educational attainment is not inconsistent with the model to be explored here, in which income transfers simultaneously relax liquidity constraints and lower expected returns to human capital investments.

## 5. Dynamic Properties of the Basic Economy

In this section a number of propositions are established for the basic economy, given the particular functional specifications described in Section 3. It is demonstrated that the parent will invest some positive amount in his child’s human capital regardless of the tax policy. In the long run, however, the expected income and schooling effort levels of each dynasty are strictly *lower* under the egalitarian tax policy than under the libertarian tax policy. Furthermore, the gap between the egalitarian and libertarian income and effort levels increases as the number of dynasties increases. The reason for this is that, for sufficiently large  $t$ , a period  $t$  child’s expected marginal return to schooling effort decreases unambiguously as the number of dynasties increases in the egalitarian economy but is unaffected by the number of dynasties in the libertarian economy. Thus, the economy that attempts to redistribute income equally among all of its citizens is plagued by free-rider effects that drive expected income and schooling effort toward zero as the number of dynasties increases.

The formal statements of these and other propositions are presented and discussed below; see Orazem and Tesfatsion (1997, appendix) for detailed proofs. The first proposition provides a more concrete analytical representation for the recurrence relation satisfied by the value function  $V_{it}(s_{it})$ .

**Proposition 1:** *Suppose the value function for the child  $C_{it}$  on reaching adulthood in period  $t + 1$  can be expressed in the form*

$$V_{i,t+1}(s_{i,t+1}) = (y_{i,t+1})^{\delta_{t+1}} \cdot (n_{it})^{-\theta_{t+1}} \cdot K_i(\beta_{t+1}, g_{i,t+1}) \quad (19)$$

for some nonnegative coefficient vector  $\beta_{t+1} \equiv (\delta_{t+1}, \theta_{t+1})'$  and some function  $K_i(\beta_{t+1}, g_{i,t+1})$  of  $\beta_{t+1}$  and  $g_{i,t+1} \equiv (\tau_{i,t+1}, \tau, N)$  that depends on the probability distribution function  $f_i(\cdot)$  governing ability levels for dynasty  $i$ . Then the value function for the parent  $P_{it}$  of  $C_{it}$  in period  $t$  takes the form

$$V_{it}(s_{it}) = (y_{it})^{\delta_t} \cdot (n_{i,t-1})^{-\theta_t} \cdot K_i(\beta_t, g_{it}), \quad (20)$$

where  $\beta_t \equiv (\delta_t, \theta_t)'$  is a nonnegative coefficient vector that satisfies a matrix recurrence relation of the form

$$\beta_t = \gamma\pi + (1 - \gamma)M\beta_{t+1}, \quad (21)$$

with  $M$  given by

$$\begin{pmatrix} u + (a+b)v & -(a+b) \\ bv & -b \end{pmatrix},$$

and where  $K_i(\beta_t, g_{it})$  satisfies a recurrence relation of the form

$$K_i(\beta_t, g_{it}) = H_i(\beta_{t+1}, g_{it}) \cdot E[K_i(\beta_{t+1}, g_{i,t+1})^{1-\gamma} | g_{it}]. \quad (22)$$

As a corollary to Proposition 1, it can be shown that the period  $t$  optimal consumption and investment levels for the dynasty  $i$  parent are proportional to his period  $t$  after-tax income.

**Corollary 1:** Under the assumptions of Proposition 1, the parent  $P_{it}$ 's optimal choices for human capital investment  $e_{it}$  and consumption  $c_{it}$  take the form

$$e_{it}^o = \tau_{it} y_{it} \cdot (1 - \gamma) w_{t+1} / [\gamma + (1 - \gamma) w_{t+1}]; \quad (23)$$

$$c_{it}^o = \tau_{it} y_{it} \cdot \gamma / [\gamma + (1 - \gamma) w_{t+1}], \quad (24)$$

where  $w_{t+1} \equiv (u + av)\delta_{t+1} - a\theta_{t+1}$ ,  $t \geq 1$ .

As Proposition 1 indicates, the assumption that a parent's utility depends on the utility attained by his child results in a *family* of possible parent value functions parameterized by  $(\beta_t)$ . In particular, given any sequence  $(\beta_t)$  satisfying the recurrence relation (21), the corresponding value function is given by (20). The structure of this value function, and hence also the structure of the optimal human capital investment decision (23) and the optimal consumption decision (24), changes over time unless  $\beta_t = \beta_{t+1}$  for all periods  $t \geq 1$ .

Since the seminal article by Barro (1974), most researchers assuming parental altruism for children (e.g., Loury, 1981) have assumed without comment that each parent  $P_{it}$  has a stationary-structured value function—that is, a value function  $V_i(s)$  that depends on the current state of the economy  $s$  but not on the current time  $t$ . The next proposition establishes that there indeed exists a unique stationary-structured value function for each parent in the illustrative basic economy. For easier comparison with the findings of Loury (1981) and

other previous researchers, it will henceforth be assumed that each parent's value function coincides with this unique stationary-structured value function.

**Proposition 2:** *There exists a unique stationary-structured value function for each parent  $P_{it}$  in the illustrative basic economy: namely, the value function (20) parameterized by the unique stationary solution  $\bar{\beta} = (\bar{\delta}, \bar{\theta})' > 0$  for the recurrence relation (21), where*

$$\bar{\delta} = \gamma[1 + (1 - \gamma)b]\Delta; \quad (25)$$

$$\bar{\theta} = \gamma[(1 - \gamma)bv]/\Delta, \quad (26)$$

and  $\Delta > 0$  denotes the determinant of the matrix  $[I - (1 - \gamma)M]$ .

Given these stationary-structured value functions, it is straightforward to show that each parent's optimal choices (23) and (24) for human capital investment and consumption remain positive as long as he earns a positive after-tax income  $\tau_{it}y_{it}$ .

The next two propositions characterize the long-run behavior of dynasty income and effort levels under libertarian and egalitarian tax policies. For ease of notation, let

$$x_{it} = (\log(y_{it}), -\log(n_{i,t-1}))' \quad (27)$$

denote the indicated logarithmic transformation of the period- $t$  income and effort levels  $(y_{it}, n_{i,t-1})'$  for dynasty  $i$ . Also, let  $E[\cdot | s_1]$  denote an expectation conditional on the period 1 social state vector,

$$s_1 \equiv ((y_{11}, n_{10}), \dots, (y_{N1}, n_{N0}), \tau, N). \quad (28)$$

The expectation is assumed to be taken with respect to the joint distribution for ability levels across dynasties over time.

For the libertarian tax policy  $\tau = 0$ , it follows from (15) that the after-tax income  $\tau_{it}y_{it}$  for each dynasty  $i$  in each period  $t$  satisfies  $\tau_{it}y_{it} = y_{it}$ , implying that no redistribution occurs. The next proposition shows that the expected income and effort levels of each dynasty  $i$ , in log form, converge over time to stationary limiting values under a libertarian tax policy.

**Proposition 3:** *Suppose that government in period 1 implements a permanent libertarian tax policy  $\tau = 0$ , known to all agents in all dynasties. Then for each dynasty  $i$ ,*

$$\lim_{t \rightarrow \infty} E[x_{it} | s_1] = [I - M']^{-1}d_i, \quad (29)$$

where  $M'$  denotes the transpose of the matrix  $M$  appearing in relation (21), and the  $2 \times 1$  vector  $d_i$  has the form

$$d_i = (\log(C) + mE[\log(\alpha_i)], -\log(D))' \quad (30)$$

for constant terms  $C$  and  $D$  that are independent of the number of dynasties,  $N$ . If the stationary probability distributions  $f_i$  and  $f_j$  that govern ability levels for dynasties  $i$  and  $j$  in each period  $t$  are identical, then  $d_i = d_j$ .

In the case of an egalitarian tax policy  $\tau = 1/N$ , it follows from (15) that the after-tax income for each dynasty  $i$  in each period  $t$  satisfies

$$\tau_{it}y_{it} = \sum_{j=1}^N y_{jt}/N \equiv \bar{y}_t, \quad (31)$$

implying that each dynasty receives an equal share of total social income. The next proposition provides a partial characterization of long-run outcomes for this case. More precisely, given the assumption that the expected values for both mean social income and individual dynasty incomes in log form converge over time to finite stationary values, analytical expressions are derived for long-run expected dynasty incomes and effort levels in log form.

**Proposition 4:** *Suppose that government in period 1 implements a permanent egalitarian tax policy  $\tau = 1/N$ , known to all agents in all dynasties. Suppose, also, that for each dynasty  $i$ ,*

$$\lim_{t \rightarrow \infty} E[\log(\bar{y}_t | s_1)] = K_i + \lim_{t \rightarrow \infty} E[\log(y_{it}) | s_1] \quad (32)$$

for some constant  $K_i$ , where the limits in (32) are finite valued. Then for each dynasty  $i$ ,

$$\lim_{t \rightarrow \infty} E[x_{it} | s_1] = [I - M']^{-1}h_i, \quad (33)$$

where  $M'$  denotes the transpose of the matrix  $M$  appearing in relation (21), and the components of the  $1 \times 2$  vector  $h'_i = (h_{1i}, h_{2i})$  take the form

$$h_{1i} = \log(C) + mE[\log(\alpha_i)] - bv \log(N) + [u + av]K_i; \quad (34)$$

$$h_{2i} = -\log(D) + b \log(N) - aK_i. \quad (35)$$

The constant terms  $C$  and  $D$  in (34) and (35) are the same as in (30).

**Corollary 2:** *Suppose the hypotheses of Proposition 4 hold for constant terms  $K_i$  that are independent of the number of dynasties,  $N$ . Then the expected long-run marginal return to schooling effort in log form for each dynasty  $i$  is a strictly decreasing function of  $N$  of the form*

$$\lim_{t \rightarrow \infty} E[\log(r_{it}^e) | s_1] = L_i - R \log(N), \quad (36)$$

where the constants  $L_i$  and  $R > 0$  are independent of  $N$ .

Given the hypotheses of Corollary 2, the following proposition establishes that each dynasty can expect to have a lower long-run income under egalitarianism than under libertarianism.

**Proposition 5:** *Suppose condition (32) holds for constant terms  $K_i$  that are independent of the number of dynasties,  $N$ . Then the expected long-run income and effort levels in log*

form for each dynasty under an egalitarian tax policy  $\tau = 1/N$  are strictly decreasing functions of  $N$ . Moreover, these long-run levels are strictly lower than the long-run levels achieved under a libertarian tax policy  $\tau = 0$  for each  $N > 1$ .

Recall from Proposition 3, equation (29), that each dynasty's expected long-run income in log form is independent of the number of dynasties,  $N$ , when government implements a libertarian tax policy  $\tau = 0$ . Proposition 5 therefore implies that, the greater the number of dynasties, the greater is the extent to which the dynasties are worse off in the long run under egalitarianism than under libertarianism.

The simulation results reported below in Section 6 indicate that, averaged across runs in log form, social income levels, dynasty income levels, and dynasty effort levels all do converge to stationary positive limiting values under the egalitarian tax policy. Moreover, the expected income, effort, and social welfare levels achieved under the egalitarian tax policy fall well short of the levels achieved under the libertarian tax policy, even for  $N = 2$ .

The final proposition of this section provides another interesting check on the validity of the simulation results reported below in Section 6. If average dynasty income constitutes a sufficiently good approximation for the true expected dynasty income for any dynasty  $i$  in any period  $t$ , then the true expected tax/subsidy level  $\tau_{it}$  for dynasty  $i$  in period  $t$  is a strictly increasing function of the tax policy  $\tau$ . That is, the more egalitarian the government's tax policy, the higher the subsidy level (or the lower the tax level) that dynasty  $i$  can expect to receive (or to pay).

**Proposition 6:** *Suppose that average dynasty income in some period  $t$  converges to the true expected income for some dynasty  $i$  in period  $t$ , conditional on the period 1 social state vector  $s_1$ , as the number of dynasties,  $N$ , becomes arbitrarily large. That is, suppose*

$$\lim_{N \rightarrow \infty} \left[ \sum_{j=1}^N y_{jt} / N \right] = E[y_{it} | s_1]. \quad (37)$$

Then for all sufficiently large  $N$ ,

$$\frac{\partial E[\tau_{it} | s_1]}{\partial \tau} > 0. \quad (38)$$

## 6. Simulation Results

The illustrative basic economy outlined in Section 3 is too complex to allow a detailed analytical characterization of the economy's responses to changes in the tax policy  $\tau$ . Simulation experiments were therefore conducted to determine how different tax policies influence economic growth and human capital investment in this economy.

To operationalize the model, specifications are needed for the number of dynasties, the distribution of abilities, and the parameters characterizing the utility, income, and effort functions. The number of dynasties  $N$  was first set at 2. The ability  $\alpha$  of each child in each dynasty was assumed to be distributed uniformly over the range  $(0, 1)$ , implying a mean

ability of .5. The value of  $\gamma$ , the exponent on current consumption in the utility function (12), was set to .5. The parameters of the income function (10) were set at  $\lambda = .5$ ,  $m = .5$ ,  $u = .5$ , and  $v = .5$ . Since  $\lambda$  serves as a scaling variable, we can generate proportionally larger or smaller measures of income without altering the relative levels of the variables by rescaling the value of  $\lambda$ . Finally, the parameters of the effort function (11) were set at  $a = .5$  and  $b = .5$ .

Various parameterizations were tried to determine the sensitivity of the qualitative results to changes in the model parameters. The qualitative results proved to be quite robust to modifications in the parameters.

Each simulation was replicated forty times over a forty-generation horizon. In each run, each dynasty received forty independent draws from the uniform ability distribution, one draw per generation. For all runs, the starting values for parental income and schooling effort were initialized to be one. First, the purely libertarian tax policy ( $\tau = 0$ ) was run. For each dynasty in each year, the simulation generated values for income, consumption, schooling effort, and human capital investment. Then, holding fixed the sequence of ability draws, the simulation was rerun with progressively more egalitarian tax policies, ending with the purely egalitarian tax policy ( $\tau = 1/N = .5$ ). For each tax policy  $\tau$ , we also measured after-tax income and the tax/subsidy position of each dynasty. Finally, gross national products were computed by summing across dynasties at a point in time. Statistical summaries of the simulations are reported in Tables 1 to 4.

Table 1 contains the results from our base run. For each variable, we report the mean and standard deviation taken over forty replications of thirty-nine generations of generated data. The initial generation was deleted since all runs had the same initial levels of income and effort. For the two-dynasty model, this implies 3,120 observations ( $39 \times 40 \times 2$ ). The simple correlation between current and once-lagged variables are also reported to determine the extent to which parent and child outcomes are correlated.

Immediately apparent from Table 1 is that tax policies can increase human capital production, as in the model by Loury (1981). With two dynasties, the tax policy  $\tau$  can vary from 0 to .5. A relatively small tax policy ( $\tau = .04$ ) increases income and parental investment in children. It also reduces the variance in those parental investments across households. By transferring income toward poorer households, poorer parents are able to invest in the education of their high ability children. This reduces the inefficiency in human capital investment caused by the relative overinvestment in the children of high-income parents and the relative underinvestment in children of low-income parents. As a result, the economy as a whole benefits. Moreover, introduction of the tax policy begins to reduce the variance in after-tax income. The reduction in uncertainty about future income and consumption is a second benefit from the tax policy.

The result that tax policies can increase expected GNP is in marked contrast to the implications of the model of King and Rebelo (1990), who found that increasing taxes uniformly reduced GNP growth. Nevertheless, Table 1 also indicates that a moderate tax policy dominates relatively more egalitarian tax policies. Although transfers allow poorer parents to invest more in their children, the income taxes used to finance the transfers also lower the expected marginal returns to these investments for all children. To see this, note that, *ceteris paribus*, an increase in  $\tau$  decreases the child's expected marginal return to

Table 1. Sample statistics and autocorrelation coefficients for variables from the generated sample based on forty iterations of the two-dynasty model over forty generations,  $\gamma = .5$ ,  $u = v = .5$ .<sup>a</sup>

Variable	Government Tax Policy ( $\tau$ )					
	0	.04	.08	.15	.25	.5
Income ( $y_{it}$ )	11.18 <sup>b</sup> (9.51) <sup>c</sup> [.845] <sup>d</sup>	11.22 (8.79) [.829]	11.00 (8.20) [.817]	10.36 (7.33) [.800]	9.24 (6.25) [.780]	6.17 (3.93) [.729]
Effort ( $n_{it}$ )	2.70 (1.66) [.747]	2.70 (1.52) [.716]	2.64 (1.42) [.696]	2.48 (1.26) [.673]	2.22 (1.07) [.650]	1.48 (.67) [.616]
Tax/subsidy ( $\tau_{it}$ )	1.0 (0) [-]	1.03 (.14) [.470]	1.05 (.22) [.408]	1.08 (.32) [.343]	1.10 (.44) [.273]	1.15 (.73) [.113]
After-tax income ( $\tau_{it}y_{it}$ )	11.18 (9.51) [.845]	11.22 (8.52) [.831]	11.00 (7.77) [.826]	10.36 (6.75) [.826]	9.24 (5.63) [.836]	6.17 (3.51) [.857]
Consumption ( $c_{it}$ )	6.83 (5.81) [.845]	6.86 (5.20) [.831]	6.72 (4.75) [.826]	6.33 (4.13) [.826]	5.65 (3.44) [.826]	3.77 (2.15) [.857]
Investment ( $e_{it}$ )	4.35 (3.70) [.845]	4.37 (3.31) [.831]	4.28 (3.02) [.826]	4.03 (2.63) [.826]	3.59 (2.19) [.836]	2.40 (1.37) [.857]
GNP ( $\sum_i y_{it}$ )	22.35 (13.90) [.852]	22.45 (13.67) [.857]	21.99 (13.23) [.859]	20.72 (12.30) [.860]	18.48 (10.83) [.861]	12.33 (7.02) [.857]

a. All sample statistics computed across forty simulations of the two-dynasty model taken to forty generations. The distribution of  $\alpha$  is assumed to be uniform over (0, 1). The subscripts refer to the  $i$ th dynasty in generation  $t$ .

b. The top number is the average value of the variable.

c. The second number in parentheses is the standard deviation of the variable.

d. The bottom number in brackets is the simple correlation between  $X_{it}$  and  $X_{it-1}$ .

schooling effort in equation (17). As children see the expected marginal return from their human capital investments declining, they apply less effort to their schooling. As seen in Table 1, this reduction in effort begins at relatively modest tax policy levels, and effort continues to decline as the tax policy becomes progressively more egalitarian. In the limit, schooling effort under the perfectly egalitarian tax policy  $\tau = .5$  is only 55 percent of the level under the libertarian tax policy  $\tau = 0$ . As a result, the GNP attained under a policy that guarantees income equality averages just over one-half the level of GNP attained under a policy that involves no income redistribution.<sup>10</sup> These findings are consistent with the predictions of Proposition 5.

Table 1 also tells how a parent's income is related to his child's income. As tax policies become more egalitarian, the correlation between the before-tax incomes of parent and child falls monotonically. The same is not true of after-tax income. The reduction in after-tax

income correlation across generations is more moderate. As  $\tau$  rises from 0 to .15, the correlation coefficient declines by .45 for before-tax income, but by only .19 for after-tax income. Thereafter, while intergenerational income correlations continue to fall for before-tax income, they begin to rise for after-tax income. In the limit, the intergenerational after-tax income correlation under the perfectly egalitarian tax policy  $\tau = .5$  is larger than under the libertarian tax policy  $\tau = 0$ . The depressing effect of the perfectly egalitarian tax policy on human capital investment reduces the rate of growth and the variance in GNP to such an extent that it increases the intergenerational correlation in incomes. Since GNP is shared equally by all households, the intergenerational correlation in dynasty after-tax income is exactly the same as the intergenerational correlation in GNP.

Proposition 6 predicts that dynasties will expect to receive a higher subsidy (or lower tax) from the government as the tax policy becomes more egalitarian. This is clearly borne out in the simulations. The expected value of  $\tau_{it}$  rises from 1.0 to 1.15 as  $\tau$  increases from 0 to .5.

One last outcome from the simulations in Table 1 is that households allocate about 39 percent of their after-tax income to their children and the remainder to consumption. Olson (1983, p. 40) estimated for the United States that two-parent families with two children born in 1980 would allocate about 37 percent of their income to raising their children to age 22. Thus, the parameterizations in Table 1 yield reasonable estimates of parental resource allocations.

It is important to determine the sensitivity of the conclusions derived thus far to changes in the parameters. Simulations were run assuming different values of the parameters of the utility function, the income function, and the number of dynasties. In Table 2, we lower the utility function weight  $\gamma$  on current consumption to .25, thereby raising the utility function weight  $[1 - \gamma]$  on future consumption to .75. As a result, parents increase their investment in their children and the economy grows to almost five times the levels in Table 1. However, none of the qualitative implications change relative to those derived from Table 1. Small tax policies raise expected income and lower the variance in income, but progressively more egalitarian tax policies ultimately lower income, GNP, schooling effort, and human capital investment. Initially, taxes lower the intergenerational correlation in after-tax income, but ultimately the highest intergenerational correlations are found under the perfectly egalitarian tax policy. The share of income devoted to children rises to 59 percent, well above the actual national average in the United States.

In Table 3, the utility parameters are the same as in Table 1, but we increase the income elasticity (that is, the elasticity of a child's income) with respect to parental human capital investment from  $u = .5$  to  $u = .75$  and lower the income elasticity with respect to schooling effort from  $v = .5$  to  $v = .25$ . This change in parameterization leaves the income elasticity with respect to the scale factor  $\lambda$  unchanged at 1; see equation (10). Comparing Table 3 with Table 1, tax policies involving increased income transfers now initially have a relatively larger positive effect on dynasty incomes and on GNP, and the adverse effects of income transfers on these variables do not outweigh the positive effects until later in the progression toward more egalitarian tax policies. Nonetheless, the general Table 1 pattern of results still holds. Perfectly egalitarian tax policies are still dominated by purely libertarian tax policies, and the intergenerational correlation in after-tax income is still highest under the

Table 2. Sample statistics and autocorrelation coefficients for variables from the generated sample based on forty iterations of the two-dynasty model over forty generations,  $\gamma = .25$ ,  $u = v = .5$ .<sup>a</sup>

Variable	Government Tax Policy ( $\tau$ )					
	0	.04	.08	.15	.25	.5
Income ( $y_{it}$ )	55.74 <sup>b</sup> (50.83) <sup>c</sup> [.856] <sup>d</sup>	56.05 (47.25) [.842]	54.90 (44.28) [.833]	51.70 (39.75) [.820]	46.04 (34.04) [.804]	30.51 (21.53) [.763]
Effort ( $n_{it}$ )	8.92 (5.97) [.778]	8.93 (5.55) [.757]	8.73 (5.20) [.744]	8.21 (4.67) [.729]	7.31 (3.99) [.718]	4.86 (2.50) [.709]
Tax/subsidy ( $\tau_{it}$ )	1.00 (0) [-]	1.03 (.139) [.470]	1.05 (.219) [.408]	1.08 (.324) [.343]	1.10 (.444) [.273]	1.15 (.726) [.113]
After-tax income ( $\tau_{it}y_{it}$ )	55.74 (50.83) [.856]	56.04 (45.92) [.846]	54.90 (42.16) [.842]	51.70 (36.97) [.845]	46.04 (31.97) [.857]	30.51 (19.56) [.878]
Consumption ( $c_{it}$ )	22.74 (20.73) [.856]	22.86 (18.73) [.846]	22.39 (17.20) [.842]	21.09 (15.08) [.845]	18.78 (12.69) [.857]	12.44 (7.98) [.878]
Investment ( $e_{it}$ )	33.00 (30.09) [.856]	33.18 (27.19) [.846]	32.51 (24.96) [.842]	30.61 (21.89) [.845]	27.26 (18.42) [.857]	18.06 (11.58) [.878]
GNP ( $\sum_i y_{it}$ )	111.48 (76.43) [.870]	112.09 (75.45) [.874]	109.81 (73.19) [.876]	103.39 (68.18) [.878]	92.08 (60.13) [.879]	61.02 (39.12) [.878]

a. All sample statistics computed across forty simulations of the two-dynasty model taken to forty generations. The distribution of  $\alpha$  is assumed to be uniform over (0, 1). The subscripts refer to the  $i$ th dynasty in generation  $t$ .

b. The top number is the average value of the variable.

c. The second number in parentheses is the standard deviation of the variable.

d. The bottom number in brackets is the simple correlation between  $X_{it}$  and  $X_{it-1}$ .

egalitarian tax policy. The share of household income devoted to children is 45 percent, a bit high relative to the 37 percent reported by Olson (1983).

As the number of dynasties increases, GNP growth should be smoothed since extreme individual ability draws will have a smaller effect on national income. This is shown clearly in Table 4. The coefficient of variation in GNP is about two-thirds the level in Table 1. However, the increase in the number of dynasties also reduces expected marginal returns to schooling effort, consistent with Corollary 2. Individuals have a greater incentive to free ride on the economy as tax policies become more egalitarian. In the perfectly egalitarian regime, schooling effort falls to .64, only 43 percent of the schooling effort in the perfectly egalitarian two-dynasty economy in Table 1. The free-rider problem is so great under the perfectly egalitarian tax policy that GNP with five dynasties is not much larger than with two dynasties, and dynasty average income is less than half that in the two-dynasty economy.

Table 3. Sample statistics and autocorrelation coefficients for variables from the generated sample based on forty iterations of the two-dynasty model over forty generations,  $u = .75$ ,  $v = .25$ ,  $\gamma = .5$ .<sup>a</sup>

Variable	Government Tax Policy ( $\tau$ )					
	0	.04	.08	.15	.25	.5
Income ( $y_{it}$ )	49.74 <sup>b</sup> (78.04) <sup>c</sup> [.913] <sup>d</sup>	53.42 (69.66) [.902]	53.46 (64.51) [.894]	51.27 (58.03) [.884]	46.30 (50.34) [.873]	31.62 (32.96) [.839]
Effort ( $n_{it}$ )	5.49 (5.41) [.859]	5.85 (5.06) [.837]	5.83 (4.79) [.825]	5.57 (4.37) [.814]	5.02 (3.81) [.805]	3.42 (2.47) [.795]
Tax/subsidy ( $\tau_{it}$ )	1.00 (0) [-]	1.04 (.17) [.446]	1.06 (.24) [.385]	1.08 (.33) [.319]	1.09 (.43) [.239]	1.14 (.70) [.055]
After-tax income ( $\tau_{it}y_{it}$ )	49.74 (78.04) [.913]	53.42 (68.00) [.904]	53.46 (62.19) [.904]	51.27 (55.36) [.905]	46.30 (47.78) [.914]	31.62 (31.22) [.928]
Consumption ( $c_{it}$ )	27.49 (43.13) [.913]	29.52 (37.58) [.904]	29.55 (34.37) [.902]	28.33 (30.60) [.905]	25.59 (26.41) [.914]	17.48 (17.25) [.928]
Investment ( $e_{it}$ )	22.25 (34.91) [.913]	23.90 (30.42) [.904]	23.92 (27.82) [.902]	22.94 (24.77) [.905]	20.71 (21.38) [.914]	14.15 (13.97) [.928]
GNP ( $\sum_i y_{it}$ )	99.47 (117.3) [.920]	106.85 (116.1) [.925]	106.93 (112.5) [.926]	102.54 (105.4) [.928]	92.60 (93.81) [.929]	63.25 (62.46) [.928]

a. All sample statistics computed across forty simulations of the two-dynasty model taken to forty generations. The distribution of  $\alpha$  is assumed to be uniform over (0, 1). The subscripts refer to the  $i$ th dynasty in generation  $t$ .

b. The top number is the average value of the variable.

c. The second number in parentheses is the standard deviation of the variable.

d. The bottom number in brackets is the simple correlation between  $X_{it}$  and  $X_{it-1}$ .

Increasing the number of dynasties exacerbates the disincentive effects of egalitarian tax policies.

All of the statistics reported thus far have looked at the generated data over the entire trajectory of forty generations. The analytical results reported in Section 5 predict that these data values should converge in expectation to steady state levels under each of the two tax policy extremes, libertarianism and egalitarianism. In Figure 1, the time path of average GNP is graphed for six tax policies spanning these two extremes. In each case the time paths appear to level off after fifteen to twenty generations. The time paths show very similar GNP levels for the three most libertarian tax policies and then show progressively lower GNP levels for the remaining three most egalitarian tax policies.

Another method for assessing the various tax policies is to measure the expected lifetime utility levels associated with these policies. By relation (13), the log of the true lifetime

Table 4. Sample statistics and autocorrelation coefficients for variables from the generated sample based on forty iterations of the five-dynasty model over forty generations,  $\gamma = .5$ ,  $u = v = .5$ .<sup>a</sup>

Variable	Government Tax Policy ( $\tau$ )					
	0	.016	.032	.06	.10	.20
Income ( $y_{it}$ )	10.99 <sup>b</sup> (9.33) <sup>c</sup> [.849] <sup>d</sup>	11.02 (8.24) [.821]	10.61 (7.34) [.799]	9.54 (6.02) [.764]	7.70 (4.47) [.716]	2.68 (1.32) [.559]
Effort ( $n_{it}$ )	2.67 (1.63) [.748]	2.66 (1.43) [.698]	2.55 (1.27) [.662]	2.29 (1.04) [.613]	1.84 (.762) [.553]	.637 (.211) [.249]
Tax/subsidy ( $\tau_{it}$ )	1.00 (0) [-]	1.05 (.267) [.272]	1.08 (.480) [.195]	1.12 (.764) [.151]	1.17 (1.05) [.125]	1.26 (1.60) [.073]
After-tax ( $\tau_{it}y_{it}$ )	10.99 (9.33) [.849]	11.02 (7.81) [.826]	10.61 (6.65) [.814]	9.54 (5.11) [.809]	7.70 (3.54) [.828]	2.68 (.940) [.871]
Consumption ( $c_{it}$ )	6.72 (5.70) [.849]	6.74 (4.77) [.826]	6.49 (4.06) [.814]	5.83 (3.12) [.809]	4.71 (2.16) [.828]	1.64 (.575) [.871]
Investment ( $e_{it}$ )	4.28 (3.63) [.849]	4.29 (3.04) [.826]	4.13 (2.59) [.814]	3.71 (1.99) [.809]	3.00 (1.38) [.828]	1.04 (.366) [.871]
GNP ( $\sum_i y_{it}$ )	54.97 (24.72) [.890]	55.12 (24.28) [.898]	53.07 (23.03) [.901]	47.72 (20.25) [.902]	38.51 (15.83) [.900]	13.41 (4.70) [.871]

a. All sample statistics taken across forty simulations of the five-dynasty model taken to forty generations. Because the government tax policies can vary from 0 to  $1/N$ , the perfect egalitarian policy is now  $\tau = .2$ . The other tax policies were scaled to be two-fifths of the levels in the two-dynasty models, so that  $\tau = .04$  in the two-dynasty model corresponds to  $\tau = 0.16$  in the five-dynasty model.

b. The top number is the average value of the variable.

c. The second number in parentheses is the standard deviation of the variable.

d. The bottom number in brackets is the simple correlation between  $X_{it}$  and  $X_{it-1}$ .

utility  $U_{i1}$  achieved by a dynasty  $i$  parent in period 1 can be expressed as an infinite discounted sum in log form of all of the instantaneous utilities achieved by dynasty  $i$  parents in periods  $t \geq 1$ . We constructed a truncated approximation for this infinite discounted sum by summing over the instantaneous log-utilities achieved by dynasty  $i$  parents in generations fifteen through thirty-five only. This approximation was exponentiated to reclaim an estimate  $\hat{U}_{i1}$  for  $U_{i1}$ . The expected lifetime utility of a period 1 parent under a given tax policy  $\tau$  was then estimated by first averaging the estimates  $\hat{U}_{i1}$  across dynasties  $i = 1, \dots, N$  for each of forty replications of the economy under the tax policy  $\tau$  and then further averaging these averages over the forty runs. To check the robustness of our expected lifetime utility estimate, we also calculated a second estimate by repeating the same procedure using a truncated approximation that included the instantaneous utilities achieved by dynasty  $i$  parents in generations twenty through forty only.

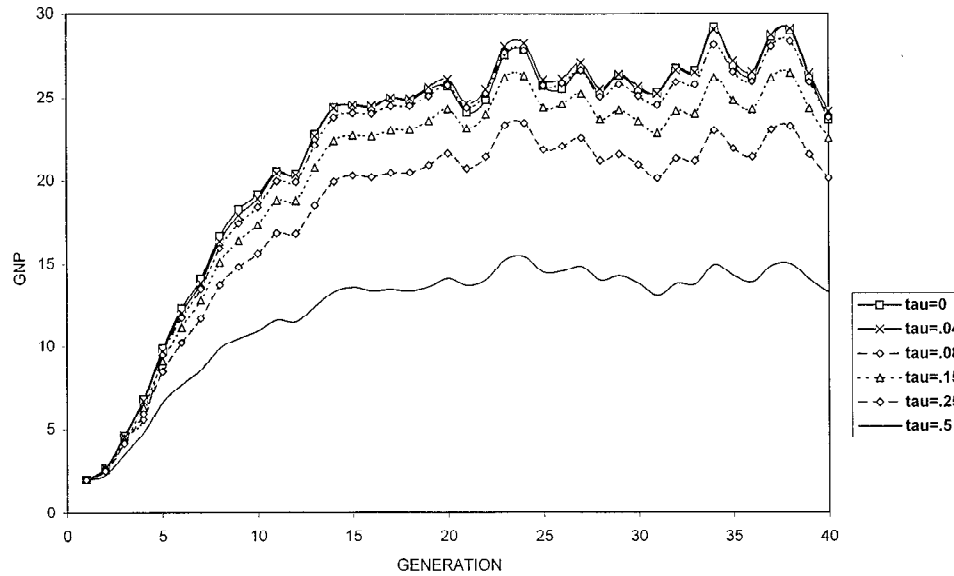


Figure 1. Time path of gross national product as tax policy  $\tau$  varies from 0 (libertarian) to .5 (egalitarian).

Table 5. Expected dynasty welfare under different tax policies.

Two-dynasty simulation	Government Tax Policy ( $\tau$ )					
	0	.04	.08	.15	.25	.50
$u = v = .5, \gamma = .5$	7.28 <sup>a</sup> (7.04) <sup>b</sup>	7.48 (7.13)	7.43 (7.04)	7.10 (6.70)	6.38 (6.02)	4.22 (4.02)
$u = v = .5, \gamma = .25$	24.24 (22.43)	25.21 (23.09)	25.19 (23.01)	24.22 (22.10)	21.89 (19.98)	14.54 (13.33)
$u = .75, v = .25, \gamma = .5$	25.98 (18.82)	28.30 (19.78)	28.80 (19.92)	28.18 (19.41)	25.89 (17.97)	18.04 (13.08)
Five-dynasty simulation	0	.016	.032	.06	.1	.2
$u = v = .5, \gamma = .5$	7.33 (7.20)	7.49 (7.30)	7.30 (7.09)	6.66 (6.44)	5.41 (5.24)	1.81 (1.80)

a. Top number is the average utility computed over generations twenty through forty across all dynasties.

b. The bottom number in parentheses is the average utility computed over generations fifteen through thirty-five across all dynasties.

Table 5 reports these estimated expected lifetime utilities for a number of different income, effort, and utility parameter specifications. These results generally mimic the results reported above for the simple GNP measure of welfare.

For each reported parameter specification, the perfectly libertarian tax policy ( $\tau = 0$ )

yields higher welfare than the perfectly egalitarian tax policy ( $\tau = .5$ ), but small positive tax policies dominate both of these extreme tax policies. The utility welfare measure does rank modestly egalitarian tax policies (for example,  $\tau = .08$ ) more highly than does a simple comparison of GNP. The reason is that positive tax policies lower uncertainty about income, even if they may slightly lower expected income. Small tax policies have bigger welfare-improving effects as the utility weight  $\gamma$  on current consumption decreases and also as the income function parameter  $u$  increases—that is, as parental human capital investments become more productive. Small tax policies become less welfare-enhancing as the number of dynasties increases.

## 7. Concluding Remarks

This article examines the impact of redistributive income tax policies on human capital investment, per capita GNP, and social welfare in the context of a multidynasty overlapping generations economy. Simulation experiments indicate that modest redistributive tax policies raise human capital investment, per capita GNP, and social welfare by increasing the human capital investments of relatively poor families in their children. Further welfare gains are obtained from the reduction in uncertainty regarding after-tax incomes that results from the implementation of the transfer program.

Nevertheless, the income taxes that fund these transfers also lower children's perceptions of their marginal returns to schooling. The resulting adverse effects on schooling effort quickly overtake the beneficial effects of the transfers as the tax policy becomes progressively more egalitarian. In the limit, a purely egalitarian tax policy lowers schooling effort to such a great extent that per capita GNP and social welfare fall well short of the levels achieved under a purely libertarian tax policy. These adverse effects on schooling effort worsen as the number of dynasties increases. Also, human capital investment and per capita GNP growth are more adversely affected in economies in which parents place a relatively large weight on current consumption and in economies in which parental investments in their children's human capital are relatively less productive.

We believe these findings highlight an important public-policy issue. If children do indeed vary their schooling effort in response to their perceived returns to schooling, then underinvestment in the education of poorer children may be due in part to disincentive problems caused by distortionary taxes that bias downward these perceived returns and lead children to make inefficient use of their educational opportunities.

Clearly, however, these findings must be interpreted cautiously. Additional studies are needed to determine the sensitivity of these findings to alternative model specifications. For example, it would be interesting to examine what happens when ability levels are correlated intergenerationally. In particular, would a higher correlation of innate abilities within families make the social welfare gains of transfers higher? The answer is not immediately obvious. On the one hand, parents would then be more appropriate role models for their children, implying that children who base their expected marginal returns to schooling on the experiences of their parents should have more accurate expectations. On the other hand, income transfers would then be more systematically tilted toward dynasties characterized by lower ability and hence lower pretax incomes, which could reduce overall productivity

and offset the beneficial effects of more accurate expectations.

Also, more work needs to be done to understand the robustness of our findings to alternative empirically plausible modellings of expectation formation by children. Two issues need to be carefully distinguished. First, to what extent should children be presumed to make optimal use of the information they have? And second, what information should children be presumed to have? As previously noted (Manski, 1993), very little empirical evidence currently exists to guide these modelling decisions.

As seen in relation (17), in our current study we simply assume that each child bases his schooling effort decision on the perceived state of his parent: namely, the parent's perceived marginal return to schooling effort. Given this is the only information available to children, it could be argued that each child makes optimal use of his information. As this information set is broadened, however, it might be predicted that each child could form a more accurate assessment of his true marginal return to schooling effort, thus lessening the distortions caused by income transfers. The difficulty is that this broadening could bring into play the true dynamic multiagent path-dependent nature of the economy, making it much more difficult to formulate the child's expectation formation process let alone predict its consequences.

Consider what would happen, for example, if we were to generalize relation (17) to permit each child to determine his expected marginal return to schooling effort on the basis of the average return experienced by *all* parents, not just his own. This represents a significant complication of the model in two respects. First, each child would now somehow have to acquire information on the income and past effort choices of parents in all other dynasties. Second, each child's effort choice would now depend on these income and past effort choices, significantly complicating the nonlinear dynamics governing the economic system. In particular, the implications of these additional interdynasty couplings for long-run macroeconomic outcomes are not at all obvious.

Finally, the robustness of our findings to changes in the assumption that the government permanently maintains a stationary tax policy  $\tau$ , known to all agents, needs to be examined. Once government is free to vary its tax policy, the expectation formation process of parents must be more carefully considered along with the expectation formation process of children.

One potentially fruitful approach to the problem of modeling expectation formation in dynamic multiagent frameworks, such as the basic economy framework studied here, is to let the agents evolve their expectations and learning strategies over time. It is then interesting to see whether agent expectations converge to expectations which are rational in some sense. This is the approach taken in the newly developing field of agent-based computational economics, a specialization to economics of the basic artificial life paradigm (see Tesfatsion, 1997).

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## Notes

1. Similarly, Struefort (1991) assumes that young adults estimate their return to schooling by sampling the return to schooling attained by adult workers in the labor force, where this sampling may be truncated from above due to underclass social isolation. Unlike the model developed here, however, Struefort employs a partial equilibrium framework in which schooling and labor (at each schooling level) are inelastically supplied and all other markets are ignored.
2. Interestingly, as noted above, Perotti (1993) also obtains a hump-shaped relation between initial income equality and long-run national income but via a distinctly different route: the interplay between voter preferences and a production externality.
3. The functional form (4) can be viewed as the reduced-form solution to the following optimization problem for the child: choose an effort level that maximizes expected adult after-tax income, net of effort costs. The child's effort supply function is assumed to be upward sloping in expected marginal return. Parental investments in education are assumed to make schooling easier, increasing the child's supply of effort at every possible level of expected marginal return. The empirical support for this modeling of schooling effort is assessed in Section 4, below.
4. The functional form (6) encompasses everything from rational to adaptive expectations. In Section 3 a specific form for relation (6) will be introduced that will imply that children form their expectations myopically on the basis of the particular circumstances they observe for their parents.
5. If  $\gamma = 1$ , parents place no weight on their progeny, and hence do not invest in education. Given (10), this in turn dooms all future generations to have zero income.
6. In effect, then, each child acts as a "price taker" by assuming that the price (average return) he gains per unit of schooling effort expended is independent of the total amount of effort he exerts. Moreover, each child estimates this price to be the same as the price obtained by his parent. The latter expectational assumption is consistent with the views of Wilson (1987), Case and Katz (1991), and Struefort (1991), among others, who argue that children can have clouded perceptions of the true returns to schooling because their primary source of information is their own immediate family and neighborhood. Nevertheless, as is discussed more carefully in Section 4, additional empirical work is needed to learn how children actually do infer their returns to schooling.
7. Hanushek (1986, 1996) provides exhaustive literature reviews regarding the effects of school quality on school attendance and achievement test scores. Betts (1996) provides a similarly detailed literature review regarding the effects of school quality on earnings.
8. Betts (1996, Table 6–11) provides a review of derivative estimates that have been obtained for the change in years of school resulting from a change in the level of expenditures per pupil. The average estimate is that a one percent increase in per pupil expenditures increases years of schooling by just .04 years.
9. Polachek and Siebert (1993) have extensively reviewed the literature on the economics of earnings. Solon (1992) and Zimmerman (1992) have analyzed the intergenerational correlation of lifetime earnings between fathers and sons.
10. Recall from Section 5 that, even under a perfectly egalitarian tax policy, each parent will still desire to invest a positive amount of resources in his child's education as long as the parent's after-tax income is positive.

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