Borrowing Constraints, College Aid, and Intergenerational Mobility

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Abstract

The current level and form of subsidization of college education is often rationalized by appeal to capital constraints on individuals. Because borrowing against human capital is difficult, capital constraints can lead to nonoptimal outcomes unless government intervenes. We develop a simple dynamic general equilibrium model of the economy that permits us to explore the impact of alternative ways of subsidizing higher education. The key features of this model include endogenously determined bequests from parents that can be used to finance schooling, uncertainty in college completion related to differences in ability, and wage determination based upon the amount of schooling in the economy. Because policies toward college lead to large changes in schooling, it is very important to consider the general equilibrium effects on wages. Within this structure, we analyze tuition subsidies such as exist in most public colleges, alternative forms of need-based aid, income contingent loans, and merit-based aid. Each of these policies tends both to improve the efficiency of the economy while yielding more intergenerational mobility and greater income equality. But, the various policies have quite different implications for societal welfare.

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Introduction

Education holds a special position in most societies around the world. Governments quite uniformly subsidize schooling heavily, often making it free to the student. But it is not obvious why governments intervene to this extent, particularly when discussing higher education. Nor is it clear why government might choose one form of college subsidy over another. This paper explores the implications of alternative subsidy schemes both from efficiency and equity perspectives.

On the policy side, suggestions that a government anticipates raising student fees for higher education frequently brings a wave of protests. In the United States, political concerns about rising tuition costs have led the U.S. Congress to hold hearings and contemplate legislation, even though tuition policies are the province of state governments.

Government intervention in education has nonetheless received relatively little research attention, particularly given the magnitude of programs. For K-12 education, government subsidy can be rationalized by arguments about externalities related to socialization, facilitating democratic government, and reducing crime. But such externalities appear considerably less important when considering college education. Our earlier paper(Hanushek, Leung and Yilmaz (2003)) considered pure redistributional motives along with externalities of education in production, but provided limited general support for this form of government subsidization.

A remaining argument for subsidization revolves around capital market imperfections and the inability to borrow against human capital (e.g., Becker 1993[1964] or Garratt and Marshall 1994). Because human capital is not good collateral for loans, individuals can find it difficult to fund college if the family cannot readily self-finance. Further, because any borrowing constraints are likely to be related to parental income, the resulting decisions on college tend to inhibit intergenerational mobility. To the extent that society wishes to disentangle opportunities of individuals from the socioeconomic status of their parents, subsidizing college may directly meet societal goals for distributional outcomes.

The existence and importance of credit constraints has been the subject of debate. In an influential set of papers (Cameron and Heckman 1999, 2001; Caneiro and Heckman 2002), Heckman and his co-authors argue that short run credit constraints are small even if longer run constraints deriving from transmission of achievement are more substantial. As discussed below, while we do not try to estimate the magnitude of these effects, we base our analysis on a presumption that both exist.

This analysis delves directly into the intergenerational outcomes of various college subsidy schemes in the presence of borrowing constraints. But, our previous paper demonstrated that general equilibrium effects are very important to consider, because policies that have significant impacts on college attendance and completion necessarily have direct effects on wages in the economy. Thus, any policy consideration must be embedded within a model that can accommodate aggregate impacts on the economy.

Our objective is to develop a dynamic general equilbrium model that can provide insights into the implications of various college aid policies for both the efficiency of the economy and for the distribution of outcomes over time. We begin in a world where short run borrowing constraints stop some families from making optimal schooling decisions, implying that society will not achieve its first best outcome without some sort of government intervention. Government has, however, a variety of instruments for subsidizing education, and these instruments have different implications for the economy in both the short and long run.

To capture the dynamic nature of the problem, we employ an overlapping generations model where the economy is populated by a continuum of agents who live two periods and are part of a continuum of two-agent families. In each "family" (or "dynasty"), there is an old agent (or "parent") and an offspring (or "child"), and thus the population of the economy is constant over time.

Heterogeneity of agents enters through ability differences that affect both the probability of completing college and subsequent labor market productivity. Agents make optimizing decisions with respect to enrolling in school under uncertainty of successful completion. Each family must, however, fully fund the education of the child, so that in the absence of subsidies the child cannot attend college whenever tuition exceeds the parents educational bequest. The parent passes along both bequests and ability to the child.

The subsidy schemes include a variety commonly policy approaches supports: low tuition, need-based grants, merit awards, and an income contingent loan. While the government can intervene in the college market, it must maintain a balanced budget each period (which is a generation in our two-period OLG model). Government intervention distorts the economy through taxes and through changing college decisions, and there are varying efficiency losses across type of subsidy. This basic economy, which is calibrated to match the stylized facts of the U.S. college market, permits us to trace out the dynamics of the income distribution along with the impacts of government intervention on overall output.

The impact of the different college subsidies on output and social mobility is very different. While each tends to improve output compared to the constrained case, need-based policies lead to significantly greater equality than merit-based policies. Further, targeted need-based policies have desirable properties compared to the most common support for higher education – uniformly reduced tuition at public colleges.

Basic Model of College Attendance and Completion

Individuals are thought of as living for two discrete periods. During the first period of life, individuals make schooling decisions; during the second period, they work at a wage determined by the educational outcome and provide funds for both the consumption and possible schooling of their children. Each family consists of one parent and one child. Wages are determined by an individual's education (college or not) and ability. In each period, the old agent in a typical household is characterized by education status i, $i = e$ (educated), u (uneducated), and ability/productivity x, $x \in [0,1]$. The worker will inelastically supply one unit of her labor and receive after-tax wage income of $(1-\tau)kxw^i$ units of consumption goods, where τ is the income tax rate (if any) and k is a productivity parameter. The parent divides this income between a bequest to her child of b and consumption, c. (Both items are assumed to be non-negative, i.e., $b, c \geq 0$). The child, who is born earlier in the same period, is endowed with ability/productivity x' along with the bequest b. Thus, agents differ in terms of both bequests and ability. We refer to (x', b) as the "type" of the child. To capture the observation that the ability of the parent and the child are correlated, it is assumed that $x'|x$, $x' \in [0,1]$ follows a Markov process. The underlying relationships for ability come from regressions of mother-child ability. The steady state distribution of abililty by education level is shown in the appendix along with the details of the ability regressions and the underlying transmission mechanism.

Individual decisions

The child makes a college attendance decision in the first period. If she decides not to go to college, she consumes all of the parental bequest within the first period and then is employed as an uneducated worker during the second period. If she decides to go to college, she pays tuition, ϕ, and consume the remaining bequest, $b - \phi$, during the first period. Successful completion of college is not guaranteed, however, but depends on her ability. She has a success probability of x' (her abilty). Successful completion yields wages of an educated worker in the following period, while failure leads to wages of an uneducated worker. (Note, however, that ability affects both completion probabilities and subsequent productivity and earnings in a manner similar to Ben-Porath(1970)).

To highlight the importance of the tuition policy, a form of capital market imperfection is assumed. Young agents can only finance their education by bequest. Without governmental intervention, tuition loans are unavailable. Thus, kids with bequest less than the amount of tuition, $b \leq \phi$, have no choice but to remain uneducated. Those who inherit "enough" bequest, $b > \phi$, can consume all the bequest when they are young (leaving them to be uneducated workers when they are old), or they can make the risky decision of going to college. Agents with ability x' have a probability x' of success in college (whereby they would receive after-tax wages of $(1-\tau)\, kx'w^e$ when they are old) but probability $(1 - x')$ of failure (whereby they would receive $(1-\tau)\, kx'w^u$ when they are old). Regardless of their education outcome, they can still consume the after-tuition bequest $b - \phi$ in the first period.

Obviously, the schooling decision crucially depends on the individual's utility function. We adopt a "warm glow" utility function where parents get utility from providing bequests to children but do not explicitly evaluate the future income or utility outcomes for children. To avoid the complication of intertemporal substitution, a semi-linear utility function is assumed,

$$U(c_1', c_2', b') = c_1' + \beta (c_2')^{\alpha} (b')^{1-\alpha},$$

where c_1' and c_2' are first and second period consumption, respectively, β is the discount factor, $0 < \beta < 1$, and b' is the bequest to be left for the child of the young agent.

This simple bequest motive provides for endogenous support of children and their human capital investments. It does not, however, have a parent adjusting support based on the ability of the child (cf. Becker and Tomes (1979, 1986)). It also presumes that the parent is indifferent among the child's choice either to consume the bequest or to invest in further schooling.

The financial constraint on young people who have the ability to attend college but lack the financial means clearly leads to inefficiency in the economy. While we do not analyze it, the first best situation would clearly be making loans available to students facing borrowing constraints (see the appendix). Of course, loans run into significant problems because of the well-recognized lack of collateral. As a result, we concentrate on the analysis of existing types of college aid.

Capital constrained agents

For those who have insufficient bequest, $b \leq \phi$, the lifetime utility without government is easy to calculate. In the first period, she will consume all the bequest, $c_1' = b$. In the second period, the agent trades off second period consumption and the bequest left to her child. Formally, the optimization problem can be stated as

$$\text{max. } (c_2')^{\alpha}(b')^{1-\alpha}, \text{ s.t. } c_2' + b' \leq (1-\tau)kx'w^{u'}.$$

The optimal allocation is easy to see: $c_2 = \alpha(1-\tau)kx'w^{u'}$, $b' = (1-\alpha)(1-\tau)kx'w^{u'}$. In words, it means that the consumption (and bequest) is a fixed fraction of the after-tax income. Hence, the life-time utility for an agent born at time *t*, and endowed with ability x' and bequest *b*, $b \leq \phi$, is $U(c_1', c_2', b'; x', b) \;\; = c_1' + \beta(c_2')^{\alpha}(b')^{1-\alpha} \;\; = b + \beta\alpha^{\alpha}(1-\alpha)^{1-\alpha}(1-\tau)kx'w^{u'}$.

Unconstrained agents

For those who can afford college education, the calculation is a little more complicated. If they choose not to attend college, their lifetime utility will be similar to those who cannot afford college, $U(c_1', c_2', b'; x', b) = c_1' + \beta(c_2')^{\alpha}(b')^{1-\alpha} \; = b + \beta\alpha^{\alpha}(1-\alpha)^{1-\alpha}(1-\tau)kx'w^{u'}$. If they do attend college, their youth consumption is reduced from *b* to $b - \phi$ with certainty. Their second period consumption, however, depends on the education outcome. Formally, the problem is:

$$\text{max. } (c_2')^{\alpha}(b')^{1-\alpha}, \text{ s.t. } c_2' + b' \leq (1-\tau)kx'w^{i'},$$

$i = e, u$. It is easy to check that at the optimum, $(c_2')^{\alpha}(b')^{1-\alpha} = \beta\alpha^{\alpha}(1-\alpha)^{1-\alpha}(1-\tau)kx'w'^{i}$, for an agent with education level *i*, $i = e, u$. Therefore, the expected lifetime utility for an agent attending college becomes $EU^{e}(x', b) = b - \phi + \beta^{*}(x'U^{e'} + (1-x')U^{u'})$, where $\beta^{*} = \beta\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}$, $U^{i'} = (1-\tau)kx'w^{i'}$, $i = e, u$. We assume that youth completely know their own ability and the future wages that will result from having or not having a college education.

Since going to college is a discrete choice, the decision rule here (and later with various education subsidies) can be stated as a simple individual calculation of whether or not her ability is above a minimum feasible investment level. This form of the rule is easy to see because the probability of successful completion of college rises linearly with ability and the optimization involves trading off tuition payments for the expected future income. From the comparison of expected utilities in the two different states, the unconstrained agent attends college if $x' \geq x^{*} = \sqrt{\frac{\phi/w^{e'}}{\beta^{*}(1-\tau)k(1-w^{e'}/w^{u'})}}$.

Importantly, some higher ability children ($x' > x^{*}$) do not attend college because of financial constraints. At the same time, the ability cutoff, x^{*}, for unconstrained children is lower than it would be if the higher ability but constrained children attended (because college wages are higher than would be if there were not financially constrained potential entrants). As a result, a purely private market will lead to nonoptimal outcomes. The school attendance decision is shown schematically in figure 1. Depending on the bequest relative to tuition, there are clear decision regions that optimize for the individual.

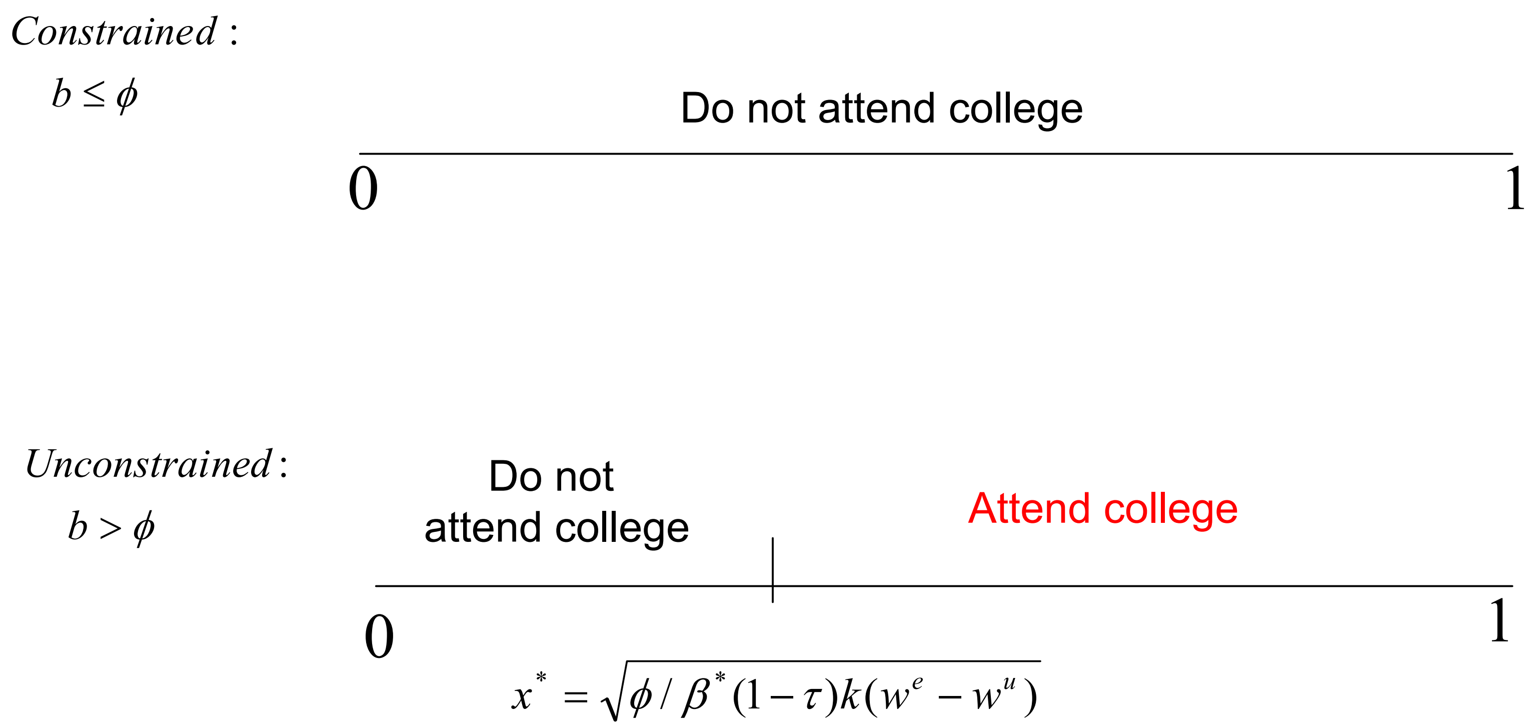


Figure 1: School attendance in no subsidy regime
as a function of ability (x)

College completion and schooling costs

The ability of an individual directly affects the chances of successfully completing college and is therefore a central element of individual decision making. However, the aggregate success probabilities for college attenders have another impact: It affects the cost of providing college and thus the tuitions that must be charged to cover costs.

It is convenient to define a new indicator function, $I^{e'}$, to indicate the education outcome of the young agent. $I^{e'} = 1$ if the child enrolls and succeeds in college and $I^{e'} = 0$ otherwise. Let $f_t(x, I^e)$ represent the amount (or the "measure") of agents with ability x and education outcome I^e at time t and recall that the probability of success for an agent with ability x is also x. By a version of the Law of Large Numbers, the enrollment needed to obtain $f_t(x, I^e = 1)$ successfully educated agents is $f_t(x, I^e = 1)/x$, $0 < x \leq 1$. Therefore, a total enrollment at time $(t-1)$ of $N^r \equiv \int \frac{f_t(x, I^e=1)}{x} dx$ yields a supply of educated (or "skilled") workers at time t of $N^s \equiv \int f_t(x, I^e = 1) dx$. Since the young generation at time t needs to be educated in the same period, a fraction of educated workers are employed in the colleges. We employ a very simple education technology: to educate $N^{r'} \equiv \int \frac{f_{t+1}(x', I^{e'}=1)}{x'} dx'$ young agents at time t (who will participate in the labor market at time $t+1$), $\gamma N^{r'}$ skilled workers need to be sacrificed, $\gamma > 0$. The social costs of producing education are assumed to be entirely these labor costs, and these determine tuition in the free market case.

Wage determination

Wage determination depends on the mix of college completers and noncompleters in the market at any point in time t. Because workers with different abilities have varying skill, we consider the total skilled workers employed in goods production at time t in efficiency units which comes from the total educated adult population less the college teachers: $\mathbb{E}_t^s = \mathbb{E}_t^e - rN^{r'}$, where $\mathbb{E}_t^e = \int kx f_t(x, I^e = 1) dx$. Analogously, the total efficiency units for unskilled labor at time t, which are all devoted to goods production, is $\mathbb{E}_t^u = \int kx f_t(x, I^e = 0) dx$.

The production side of this model economy is kept simple with a CES production function, which depends on both the efficiency units of skilled and unskilled labor,

$$Y_t = A[\xi(\mathbb{E}_t^s)^{(\rho)} + (1-\xi)(\mathbb{E}_t^u)^{(\rho)}]^{1/\rho},$$

where $0 < \xi < 1$, and the elasticity of substitution is $\sigma = 1/(1-\rho)$. Clearly, when $\rho = 0$, this is the Cobb-Douglas case. When $\rho = 1$, $\mathbb{E}_t^s$ and $\mathbb{E}_t^u$ are perfect substitutes, and when $\rho \to -\infty$, the two factors are perfect complements and the production function is Leontief.

The labor market is assumed to be competitive, and the wages are simply the corresponding marginal product,

$$w_t^e = \frac{\partial Y_t}{\partial \mathbb{E}_t^s}, \; w_t^u = \frac{\partial Y_t}{\partial \mathbb{E}_t^u}.$$

The Aggregate Dynamics

The aggregate dynamics of this model are both simple and complicated. They are "simple" because there is no aggregate uncertainty in this model. In fact, with a continuum of agents, the laws of motion for different types are deterministic, despite the fact that there is an idiosyncratic (education) risk for each young agent enrolled in college. On the other hand, the aggregate dynamics are "complicated" because the macroeconomic variables in this model, such as the equilibrium wages, depend on the distribution of the agents. Thus, it is necessary to keep track of the evolution of the distribution in order to characterize the dynamics. Furthermore, there are two endogenous participation constraints in the model: whether the young agent receives a sufficiently large bequest for college ($b \lesseqgtr \phi$) and whether the young agent has enough abilty to make college attendance rational ($x' \lesseqgtr x^*$). In this, both ϕ and x^* are endogenous as they depend on wages that in turn are affected by college attendance decisions.

To fix the idea, let $F_t(x, I^e)$ be a vector representation of the distribution of all different types of agents at time t, $\forall x \in [0,1]$, $I^e = \{1, 0\}$. Then, the evolution of the economy can be captured by a matrix equation

$$F_{t+1}(x', I^{e\prime}) = \Pi_t F_t(x, I^e),$$

where Π_t is the transition matrix of time t, incorporating the information of the transition probabilities of abilities $x'|x$, the wages at time t, the distribution of wealth at time t, and perhaps more sublty, the two previously mentioned endogenous participation constraints at time t. (A description of the determination of the matrix Π_t, which is technically involved, is available from the authors).

Outcomes without Government

Basic calibration of economy

While our main focus is alternative college aid schemes, it is useful to understand the characteristics of this basic economy and the general role for government intervention. We calibrate this basic model to mimic key elements of the U.S. labor and college markets. With no government involvement, expenditure per pupil, which comes entirely from teacher labor costs, equals tuition. The key parameter driving cost is the fraction of educated workers needed for work in the college sector, γ, and this is chosen such that ϕ/w^e – the ratio of tuition to wages of educated workers – is set approximately to be 0.05. Note that a child is financially unconstrained if $\frac{b}{w^e} = (1-\alpha)(1-\tau)x(I^e + \frac{w^u}{w^e}(1-I^e)) \geq \frac{\phi/w^e}{k}$. If we know $\frac{\phi/w_e}{k}$, then we know who is constrained. Moreover, we also know x^*, since $(x^*)^2 = \frac{(\phi/w^e)/k}{\beta^*(1-\tau)(1-w^u/w^e)}$. $\frac{\phi/w^e}{k}$ is set so that the enrollment ratio is about 59% in the stationary equilibrium. The elasticity of substitution parameter, σ, is set to be 2, and the discount factor, β^*, is set to be 0.96, which are in line with the estimates of Cooley and Prescott (1995). The literature on bequest motives is controversial. The value of α here is set to be 0.95, which implies that the agent will leave 5% of their wealth as bequest, which seems to be within the range of the estimates in the literature. Once we know who attends college and the aggregate enrollment ratio, we can use the labor market clearing condition to set the stationary equilibrium wage ratio $\frac{w^e}{w^u} \approx 1.70$. These parameters imply that in equilibrium the fraction of work force in the education sector is given by $\frac{\gamma N^{rr}}{\mathbb{E}^s + \mathbb{E}^u} \approx 1.39\%$.

Economic outcomes

There are two outcomes that could support government intervention in these markets. The overall outcomes are described in figure 2. First, eight percent of all agents are capital constrained – i.e., they would have attended college had their families had sufficient funds to pay for tuition. (The constrained group represents 22 percent of the children from families where bequests are less than tuition). Because of these constraints, the people attending college are lower quality than they otherwise would have been. One implication of this is that the college failure rate of 25 percent is also high, and the costs of providing college education are thus excessive. This simple constraint leads to an overall efficiency loss for the economy of 4.7 percent.

Second, the patterns of economic success tend to have considerable inertia. Figure 2 shows that the schooling outcomes differ dramatically by whether the student faces borrowing constraints or not. The correlation of mother-child income for the population is 0.45, in the range of previous findings by Solon (1992). The probability that a daughter is uneducated given that the mother is uneducated is 0.76, and this only falls to 0.66 after five generations.

Clearly, the financial constraints inhibit the economy from reaching maximum outcomes through purely private decisions. The correlations across generations of education and income may also be a concern to those who wish higher degrees of intergenerational mobility. These two arguments have been used to support a wide variety of educational subsidies by the government, so we turn to details of the alternatives and their impacts.

Different College Aid Schemes

We now consider how alternative government interventions affect these outcomes. The government raises funds for college student aid with a proportional income tax and maintains a balanced budget every period.

Uniform Subsidy

The largest and most common subsidy to college students is the reduced tuition that students receive. Public colleges and universities invariably maintain tuition below production costs, even for nonresidents of the separate states. The government collects a uniform rate of tuition ϕ and a uniform tax rate τ from all agents. The proceeds are used exclusively to cover the costs of education (which is the wage bill for the teachers), as in:

$$\gamma N^{r'} w^e = \phi N^{r'} + \tau(w^e \mathbb{E}^s + w^u \mathbb{E}^u).$$

Notice that, when the income tax rate is zero ($\tau = 0$), the regime is reduced to purely private education as discussed above, and the tuition is equal to the social cost of college education, i.e., $\gamma w^e = \phi$.

Under different tax rates (and thus subsidy sizes), the unconstrained individuals still have the same simple decision rule identified previously. As shown in figure 1, attendance still depends simply on ability relative to the decision point, x^*.

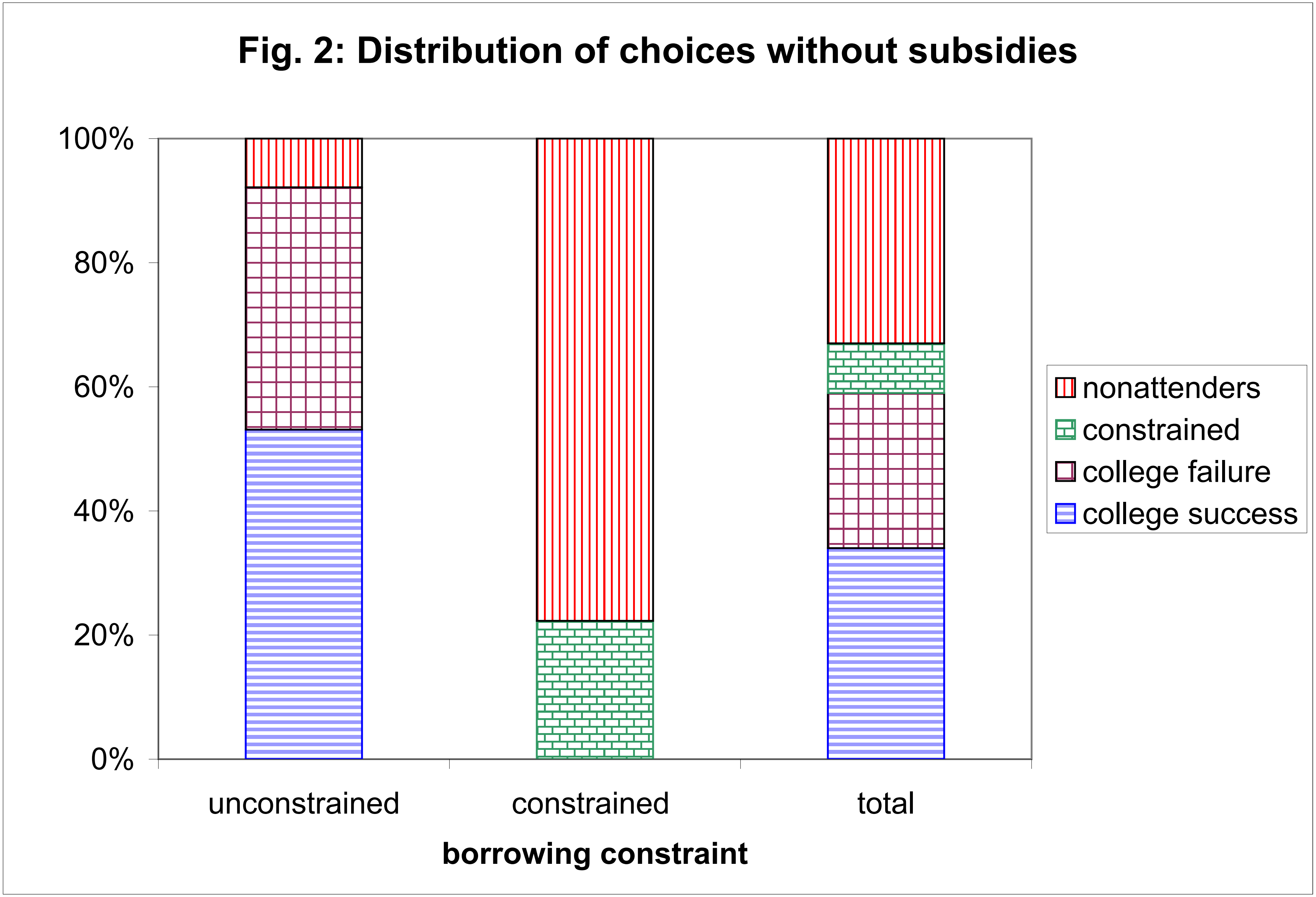


Fig. 2: Distribution of choices without subsidies
100%
80%
60%
40%
20%
0%
unconstrained
constrained
total
borrowing constraint
nonattenders
constrained
college failure
college success

One common element of the various subsidy schemes is that they induce a larger number of childrent to enroll in school. These choices are optimal in an *ex ante* sense, but the higher attendance rates also yield higher failure rates when they induce lower ability agents to attempt college. Thus, in an *ex post* sense, there are greater numbers of people who enter the work phase with the skills of the uneducated but with a tuition bill that must be paid off – making them worse off *ex post* than if they had not attempted college.

Means-Tested Subsidy Schemes

Many college subsidies, however, go beyond the simple uniform tuition cuts and attempt to fine tune the subsidies to the ability to pay of the student/parent. We consider two alternative versions of means-tested subsidies defined by the amount of information about parental ability to pay and by whether the subsidy is constant across individuals or not. In each only those who attend college and are identified as "poor" will be subsidized.

Imperfect information with flat subsidy

We begin with the possibility that the parent's bequest might not be perfectly observable to the government. Here we take to the extreme and assume that the government cannot observe the income of the parents (old agents) but can observe their education levels. In the current setting, high ability people tend to enroll in college and tend to get higher wage (recall that the total wage of an agent is kxw^i, $i = e, u$, which is proportional to the ability). Thus, the group of more educated people and highly paid people overlap significantly in this setting.

Formally, if the parent succeeded in college ($I^e = 1$), then the child is not eligible for the subsidy, and hence the child is required to pay full cost of the college education, $\phi = \gamma w^e$. The children of unskilled parents ($I^e = 0$), however, receive an amount m for enrolling in college, implying their tuition is $\gamma w^e - m$.

Since the subsidy scheme is targeted on those who enroll in college, the utility for those who do not enroll remains unchanged, $EU^u(x', b) = b + \beta^* U^u$, where $U^u = (1-\tau)kxw^u$. The expected utility of children going to college now equals $EU^e(x', b) = b - \phi + m(1 - I^e)$ $+\beta^*(x' U^{e'} + (1 - x')U^{u'})$. It is easy to see that a version of the previous solution holds, with the qualification that both the "threshold level of bequest" and "threshold level of ability" depends on the education level of parents.

There is still a constrained group where tuition less any subsidy exceeds the bequest. For this group, the child does not enroll regardless of ability. This is seen at the top of figure 3. But now the decision rule varies with parental education. For children with an uneducated parent, there is an ability cutoff determining whether attendance is optimal: $x^*(I^e = 0)$. For children with an educated parent, since they must pay the full tuition, there is a different cutoff that is higher: $x^*(I^e = 1)$. The result that $x^*(I^e = 1) \geq x^*(I^e = 0)$, depicted in figure 2, is not surprising. Since kids with educated parents are denied any education subsidy, their financial gains of attending college are less than those for children of uneducated parents, and thus only the more capable ones will try.

The government budget constraint is also simple. Since the kids with educated parents are not eligible for subsidy, the government expenditure is concentrated on those whose parents are unskilled. The total amount of students in this category is represented by

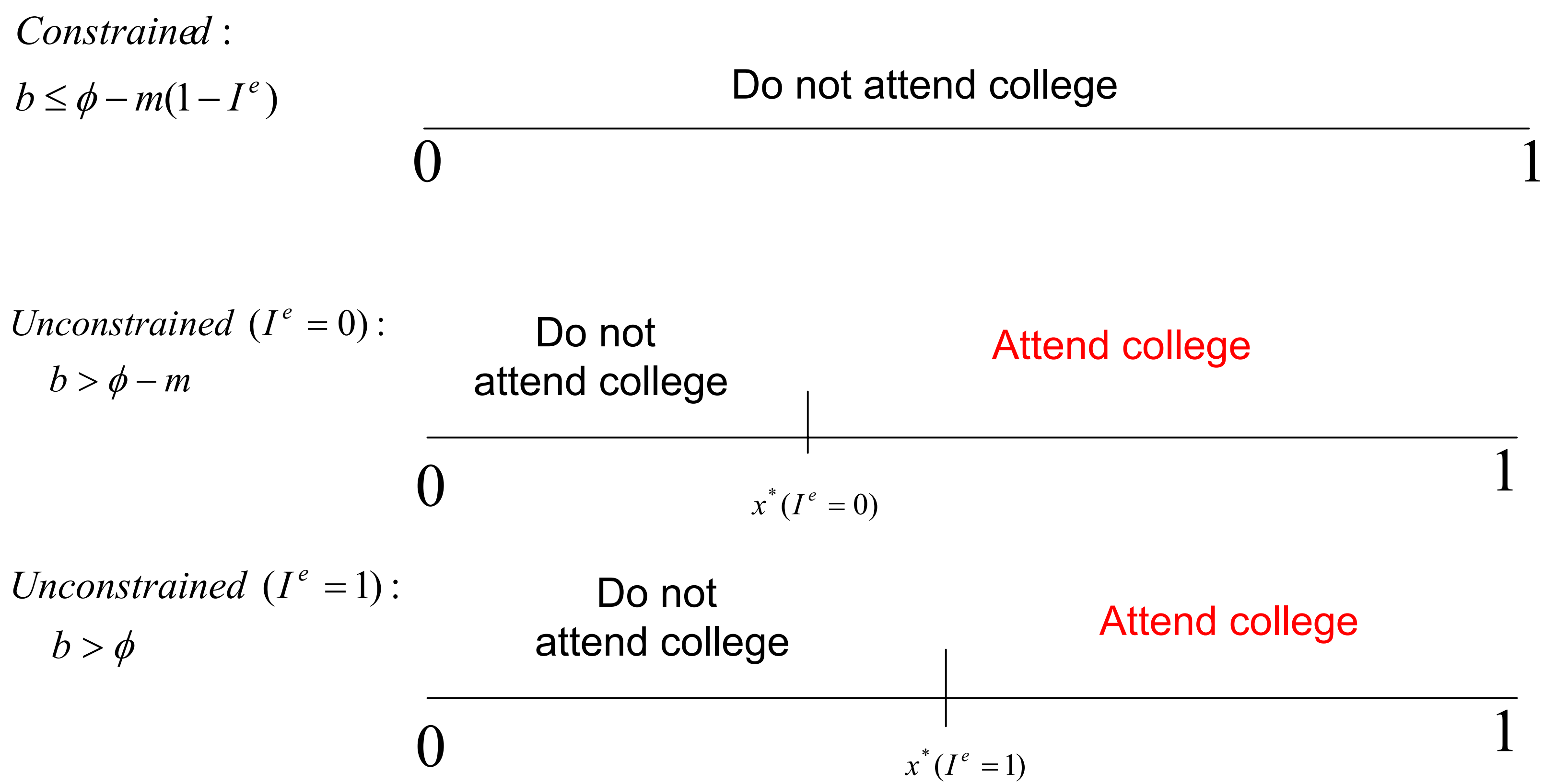


Figure 3: School attendance in constant means-tested regime as a function of ability (x)

$$\int \frac{Prob\Big(\big(x', I^{e'} = 1\big) \ \mid \ (x, I^e = 0)\Big) f_t(x, I^e = 0)}{x'} dx' \equiv N^{r,m'}.$$

Hence, the government budget constraint is

$$mN^{r,m'} = \tau(w^e \mathbb{E}^s + w^u \mathbb{E}^u).$$

Perfect information with variable subsidy

An alternative is to allow the tuition to be (weakly) increasing in wealth. Students who have larger bequests pay more in tuition. In practice, this scheme, which resembles much of the current U.S. aid, will lead to "false reporting" and other information asymmetry problems. Moreover, while ignored here, there are obvious incentives for parents to adjust their bequests, since the government will partially compensate for any lesser funds for the child. In this paper, however, we only want to examine the case where wealth can be perfectly observed and assume away the informational asymmetry issue. This provides the benchmark result for subsidies of the need-based type.

In practice, need-based subsidies vary significantly in details, including typically being very non-linear. We nonetheless focus on the linear case, so that the intuition is more transparent and the calculations are simplified. We characterize tuition as an increasing function of the bequest each child receives,

$$\phi(b) = \phi_1 + \phi_2 b,$$

where $\phi_1 \geq 0$ is the minimum level of tuition to be paid, and ϕ_2, $0 \leq \phi_2 \leq 1$, is the incremental increase in tuition for each additional unit of bequest. It is clear that if $\phi_2 = 0$, the present regime is reduced to the uniform subsidy case. Under this regime, those with too little bequest will be unable to afford college, $b \leq \phi(b) \Leftrightarrow b \leq \phi_1/(1-\phi_2) \equiv \phi^*$. For those who can afford college, $b > \phi^*$, the decision depends on the ability they inherited from parents. The decision rule is a slight modification of the earlier ones, since the attendance cutoff is directly related to the child's bequest: $x' \geq x^*(b)$.

In this case, each agent has a critical value of ability/productivity, $x^*(b)$, that determines attendance, but it is increasing in the level of bequest the young agent receive. An implication is that this scheme will facilitate social mobility in *ex ante* terms because, other things being equal, kids from poor families are more likely to enroll in college with this subsidy (compared to no subsidy). They thus will have a higher chance to become a skilled worker in the later stage of life. In the calibration analysis, we return to check this *ex ante* intuition, qualitatively as well as quantitatively.

The government budget under this subsidy is modified as

$$\gamma N^{r'} w^e = \Phi^n + \tau(w^e \mathbb{E}^s + w^u \mathbb{E}^u),$$

where Φ^n is the total amount of tuition collected under this variable subsidy scheme.

Income-Contingent Loans

Income contingent loans allow young agents to borrow for tuition (though it is not compulsory) with the condition that the repayment depends on their future income. To simplify the analysis, it is assumed that young agents either borrow the full amount of the tuition or do not borrow at all. Young agents who do borrow will consume the bequest inherited from their parents in the first period. In the second period, they repay a fixed fraction of their after-income tax income, $\tau_\gamma * [(1-\tau)kx'w^i]$, $0 < \tau_\gamma < 1$, $i = e, u$. Hence, they are left with only $(1-\tau_\gamma) * [(1-\tau)kx'w^i]$, $i = e, u$, for their second period consumption and the bequest they leave to their kids. Notice that while the *amount of repayment* depends on the second period income (and hence the education outcome), the *repayment as a fraction of the income* is *independent* of the income. Thus, the income-contingent loans formulated here can also be interpreted as a type of "profit-sharing" of the return on individual human capital investment.

The key element of this plan is, however, that the loan pool must maintain a zero balance. Thus, if somebody has a low income and repays less than tuition, there must be others in the loan pool who pay more than they borrowed for tuition, so that the loan pool remains solvent.

To facilitate the discussion, we introduce a new indicator function I^l,

$$I^l = \begin{cases} 1 & \text{if the agent borrows} \\ 0 & \text{otherwise} \end{cases}.$$

We now characterize an individual's type by (x', b, I^l). The expected utility of a young agent depends on whether she attends college and whether she borrows the income-contingent loan (*ICL* henceforth), $EU(x', b) = \max\{EU^e(x', b, 0),\ EU^e(x', b, 1), EU^u(x', b, 0)\}$. The lifetime utility of a young agent under this scheme can be summarized as follows:

$$\begin{aligned} EU^e(x', b, 0) &= b - \phi + \beta^*(x'U^e + (1-x')U^u) && \text{attends college without ICL} \\ EU^e(x', b, 1) &= b + \beta^*(1-\tau_\gamma)(x'U^e + (1-x')U^u) && \text{attends college with ICL} \\ EU^u(x', b, 0) &= b + \beta^*(U^u) && \text{does not attend college} \end{aligned},$$

where $U^i = (1-\tau)kx'w^i$, $i = e, u$.

The decision rules are clear. For young agents who are financially constrained, $b \leq \phi$, attending college without an ICL is not an option, and they only need to evaluate when $EU^e(x', b, 1) > EU^u(x', b, 0)$, which occurs when $x > x^*_{CL} \equiv (U^e - U^u)^{-1}(U^u)\left(\frac{\tau_\gamma}{(1-\tau_\gamma)}\right)$. (We will use "C" for financially constrained, "U" for financially unconstrained, "L" for taking the loan, and "P" for private financing). Notice that x^*_{CL} does not directly depend on ϕ. For the financially constrained agents, the cost of college education is not the tuition ϕ but the additional tax on future income.

For those who are not financially constrained, there are three choices: going to college with an ICL, going to college without an ICL, and not going to college at all. With higher ability, the borrower must repay a larger amount for the tuition loan and will in effect be subsidizing low ability students. Thus, high ability people will finance school privately as long as their ability is above some threshold, x^*_{UP}, that is determined in part by the tuition amount. At the other end, unconstrained students have the same decision rule as constrained with respect to the cutoff between attending with an ICL and not attending, i.e., they attend with a loan if $x' \geq x^*_{CL}$. In between these two is a third decision point for unconstrained students – where they decide between attending with and without an ICL. For ability above this point, x^*_{UL}, they attend without a loan, because taking the loan would entail subsidizing the low ability (low expected wage) people. Below that point, they would take the loan even though they did not need it, because the higher ability people in the loan pool are expected to subsidize them so that their loan repayment is less than the tuition charge.

Figure 4 summarizes the decision rules with an ICL. While the constrained agents have no choice except take the loan if they wish to attend school, unconstrained agents have greater latitude and are thus better off.

There are two possible equilibrium outcomes for the unconstrained. Loosely speaking, when the repayment ratio, τ_γ, is low enough, people who are in the middle of the ability distribution would take ICL. The high ability people would go to college without the ICL, and the low ability people would not go to college at all. When the repayment ratio τ_γ becomes too high enough, even the people in the middle of the ability distribution would not take the ICL, and the loan regime would not include any unconstrained people.

If there is a viable loan pool, there must be some high income participants who participate and who subsidize anybody who repays less than tuition. But, this is just the calculation that unconstrained agents are making. If taking the loan requires repayment of more than tuition, the unconstrained agent will privately finance. The unconstrained agent will participate only if subsidized; this occurs when she has marginally low ability. The only group of agents who will participate and will subsidize the lower ability attendees are the high ability but constrained agents. In other words, the smart poor end up subsidizing the other participants, including the lower ability rich kids.

A completely unrestricted income contingent loan system cannot, however, really operate (at least within the structure of our model). If anybody can join the loan pool, very low ability people will have incentives to "take a chance" on college – because they are highly subsidized and there is no real cost to doing so. Without opportunity costs, which are not a feature of our model, almost everybody could try college attendance in the hopes of getting lucky and completing. Therefore, in our calculations and in reality, an ICL scheme would almost certainly include a separate ability cutoff for eligibility to join the pool.

The aggregate dynamics and government budget constraints are more complicated than the other regimes, since in *ex post* terms, agents differ in three dimensions: ability x, educational achievement I^e, and whether they take loans from the government. The government budget in this scenario is complicated as well as there are in fact two budget constraints. The first constraint is the usual one, that the total expenditure on education does not exceed the sum of the total tuition and the total income collected for schooling. The second constraint is that the total income-contingent loans made in each period do not exceed the total repayment collected.

Merit-based Tuition subsidy

The final alternative we consider is to channel financial aid according to student ability/productivity. A simple parameterization is to allow the tuition to be (weakly) decreasing in ability. Students who have higher ability pay less in tuition, and those who have lower ability will pay more. In practice, this scheme will depend on some “proxy” (such as SAT) because ability is not easy to define, let alone to measure accurately. In this paper, however, we only want to examine the case where ability/productivity is one-dimensional and can be perfectly observed, and we assume away the informational asymmetry issues.

While merit-based subsidy is typically very non-linear (for instance, only the top few students receive scholarship and others receive none), we will focus on the linear case:

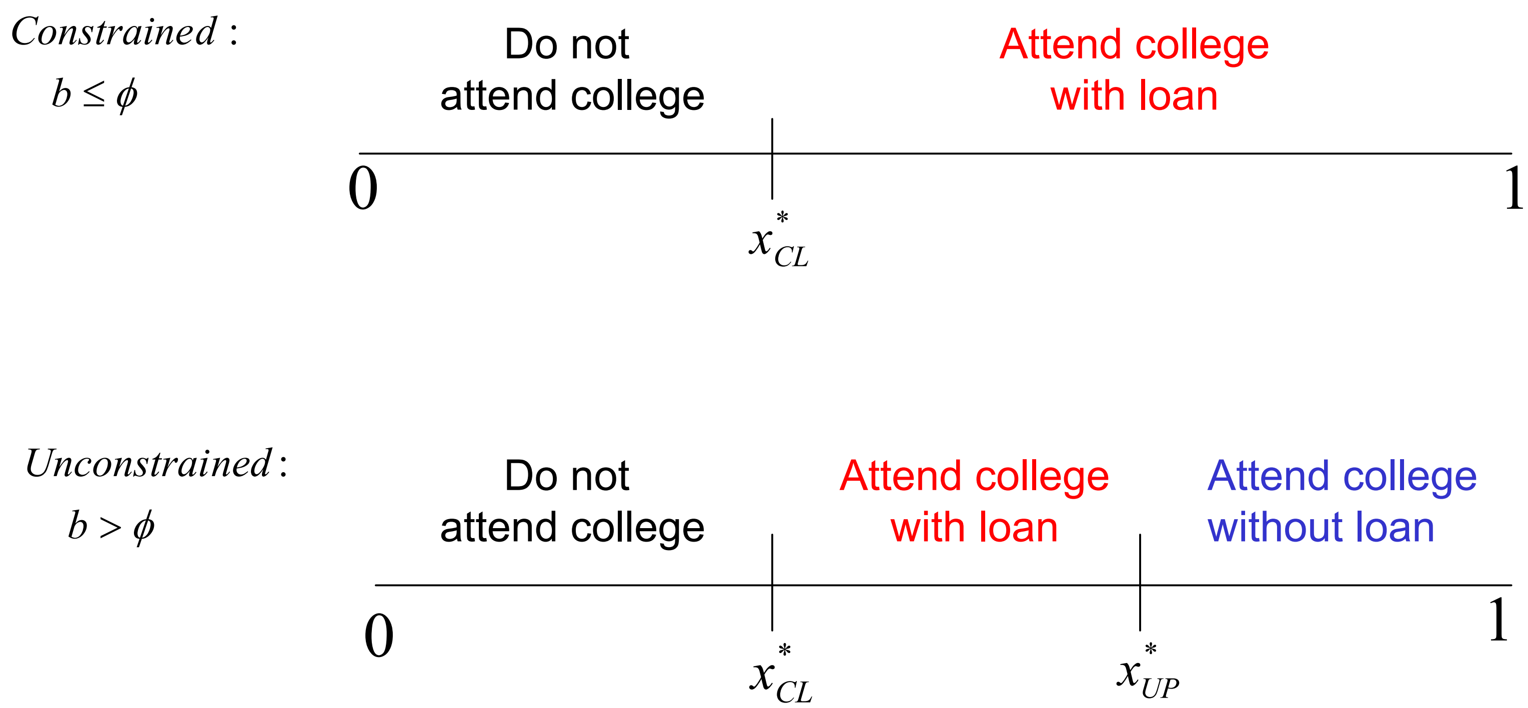


Figure 4: School attendance in income contingent loan (ICL) regime as a function of ability (x)

$$\phi(x') = \phi_3 - \phi_4 x',$$

where $\phi_3 > 0$ is the maximum level of tuition to be paid, and ϕ_4, $0 \le \phi_4 \le 1$, is the incremental decrease in tuition for each additional unit of abilty. The tuition is restricted to be non-negative, $\phi(x') = \phi_3 - \phi_4 x' \ge 0$. If $\phi_4 = 0$, the present regime is reduced to the uniform subsidy case. Under this regime, those with too little bequest will be unable to afford college (when $b \le \phi_3 - \phi_4 x' \equiv \phi^*(x')$. For those who could afford it, i.e, $b > \phi^*(x')$, the decision depends on the ability they inherited from parents. The decision rule is similar to those previously except that tuition varies with ability, leading to a variable attendance rule.

For young agents with higher ability/productivity x', $\phi^*(x')$ is lower, and hence they are more likely to enroll in college. If the ability/productivity of parents and offsprings is positively correlated, education decisions will be correlated across generations. Specifically, because higher ability parents are generally richer, the merit based policy implicitly involves some subsidy to the rich – which is likely to have implications for the income inequality and mobility generated.

The government budget under the need-based subsidy is modified as

$$\gamma N^{r'} w^e = \Phi^m + \tau(w^e \mathbb{E}^s + w^u \mathbb{E}^u),$$

where Φ^m is the total amount of tuition collected under merit-based subsidies. (Note that this has the same form as the need-based subsidy with just an alteration of who gets the subsidies).

Equilibrium

For the simulations of the different schemes, we apply a common definition of equilibrium. We also concentrate on the steady state results for our economy.

Definition *The equilibrium of this model economy is a series of wages* $\{w^e, w^u\}_{t=0}^{\infty}$ *and a series of wealth distributions* $\{F_t(x, I^e)\}_{t=0}^{\infty}$ *such that the agents maximize their individual expected utility, the factor markets are cleared, and the government balances its budget.*

Attention is focused exclusively on the case where $w^e > w^u$ with the steady state being:

Definition *A steady state of the model economy is a series of equilibrium such that* $\{w^e, w^u\}$, $\{F_t(x, I^e)\}$ *are all invariant over time.*

Efficiency, Equality and Mobility

There is a major problem in simply looking at the marginal conditions for attendance under the different scenarios. The subsidy programs have large effects on the schooling behavior of the population, and this results in substantial changes in the cost of schooling and in the wages of people who enter the labor market with different skills. Further, when considering the characteristics of intergenerational mobility, it is clear that any changes in patterns accumulate over generations. To deal with these issues, we return to our basic general equilibrium model and simulate the impacts of alternative subsidy schemes. As noted, the prior benchmark indicates that substantial inefficiency exists in the absence of government intervention – because smart poor kids cannot afford schooling and remain uneducated. Moreover, the borrowing constraints tend to lock in family status across generations.

Individual outcomes with different subsidies

We simulate each of the subsidies under a range of tax rates, which index the size of the governmental intervention. In order to provide an understanding of the general equilibrium implications of each of the schemes, we begin with a description of how the uniform tuition subsidy impacts the economy. Figure 5 traces out the patterns of college attendance and completion under different tax rates and tuitions. While tuition starts at 4.9 percent of wages for educated workers, it falls to 1.58 percent at a tax rate of 1.6 percent. This fall in tuition induces a large increase in college attendance – from 59 to 87 percent. A substantial portion of this increase comes from a fall in "constrained" agents (ones who have the required ability to attend optimally but lack sufficient funds to cover tuition), which goes from 28 percent of the low-bequest agents to less than four percent. Figure 5, however, also vividly shows that a large portion of the increase in attendance is translated into failure to complete college successfully. Nonetheless, the successfully completing students increase from 34 percent with no government to 46 percent with a 1.6 percent tax rate for tuition subsidies.

The patterns for the other subsidies lead to somewhat different results. Figure 6 shows the comparable patterns for the need-based subsidies that involve a lump sum distribution to uneducated parents. Compared to the tuition subsidy, the constrained group is driven even lower with a 1.6 percent education tax. It also achieves a higher attendance rate (over 92 percent), but virtually all of this gain comes with from an increase in failed college students. (The linear needs-based plan is hard to distinguish from the lump sum plan. Virtually all of the conclusions remain the same, so we do not separately review those results).

Merit aid produces a strikingly different pattern (Figure 7). The tilting of tuition advantages toward the high ability students induces fewer people to attend and retains more constrained students. As the amount of aid increases, almost the same number of students successfully complete college, but fewer attend in the first place, failures are dramatically less (33 percent at a tax of 1.6 percent compared to 45 percent for the means-tested subsidy), and over five percent of the population remains financially constrained.

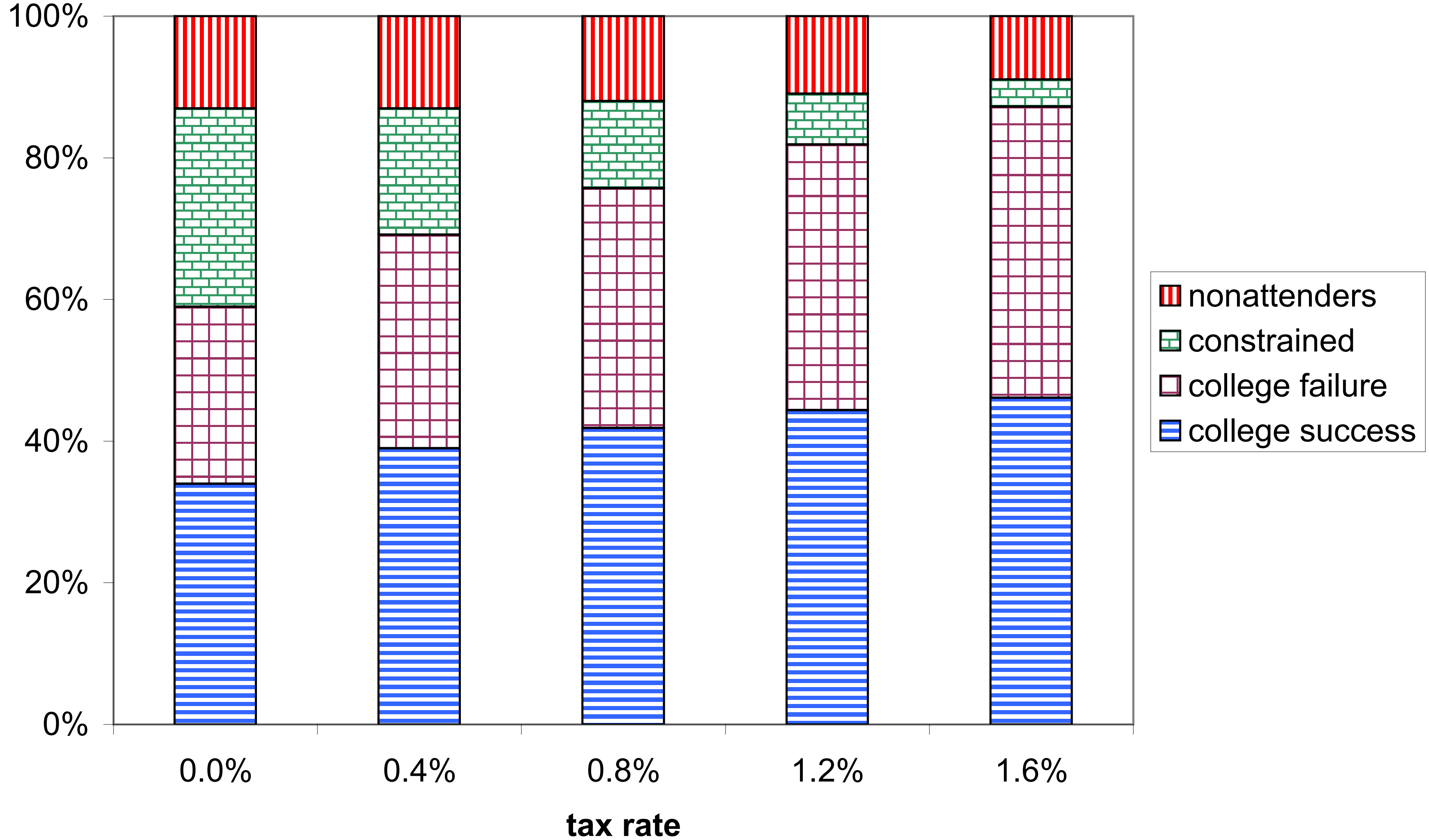
The income contingent loans take a different approach to the problem. If we ignore any potential problems of default, misreporting incomes, and the like, the ICL scheme effectively removes the borrowing constraints. Anybody with sufficient ability can borrow for their tuition with a repayment rate that ensures that the fund is fiscally balanced. Thus, without any government intervention, the economy can immediately improve outcomes and achieve close to maximum efficiency. The program, as noted earlier, does nonetheless have some very specific redistribution involved. Constrained high ability people – people who could not attend college without a loan but have high enough college and labor market opportunites to yield incomes that more than repay their loans – end up subsidizing low ability people (both constrained and unconstrained).

The results of an unsubsidized ICL are shown in figure 8. In these calculations, an ability cutoff of 0.6 is applied to be eligible for participation in the loan pool, and, because of the correlation of mother-daughter abilities, fewer constrained households meet these requirements. With the eligiblity requirement, any agent with ability greater than 0.7 would subsidize eligible borrowers with lower ability. These "taxed" agents are all from the constrained group (because the unconstrained can self-finance and avoid taxation). They end up subsidizing the schooling of a number of lower ability constrained students *and* a larger number of lower ability unconstrained students.

Aggregate outcomes

The question still remains, "What difference does all of this make?" In order to address this larger issue, we turn to the aggregate implications for output, distribution, and

Fig. 5: Distribution of choices with uniform tuition subsidy



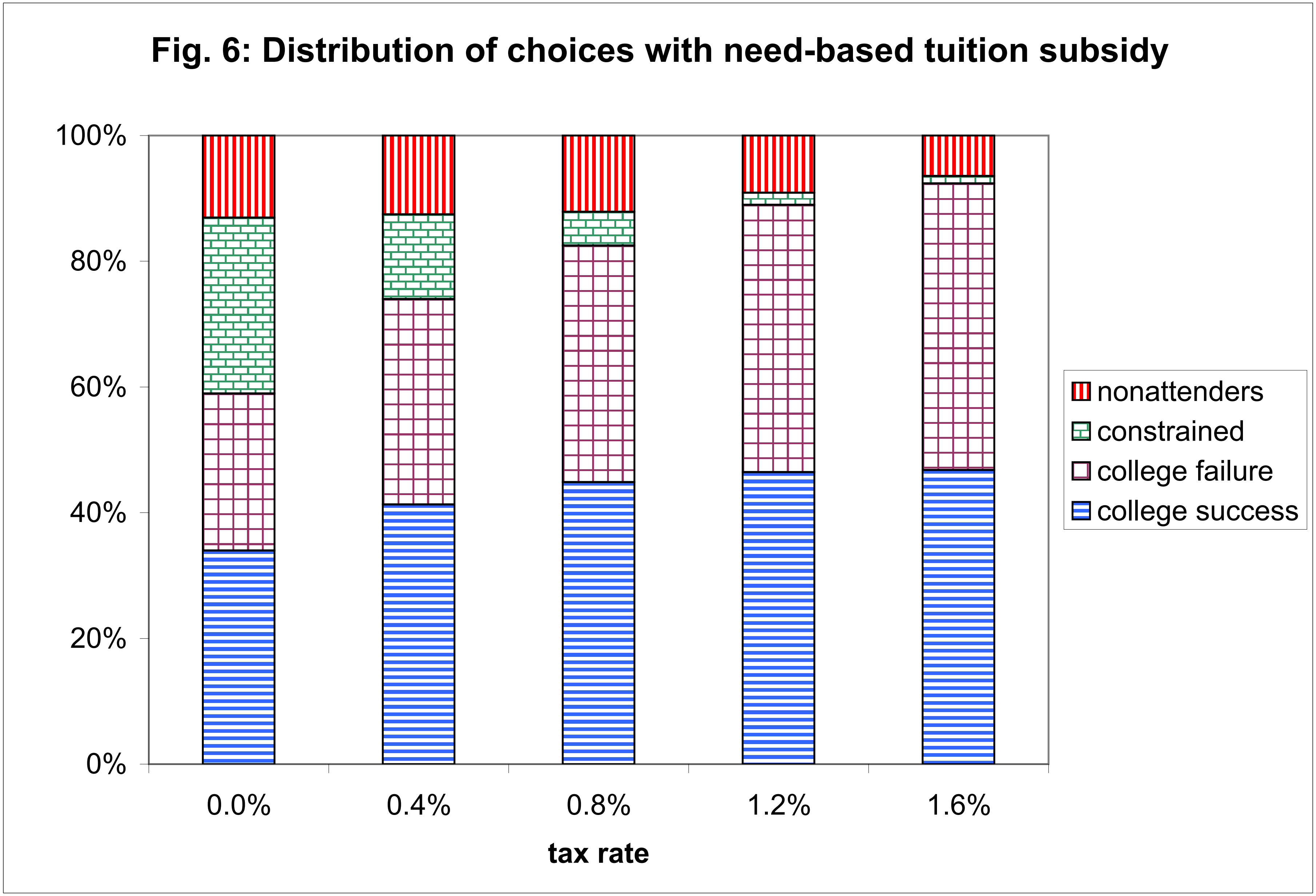
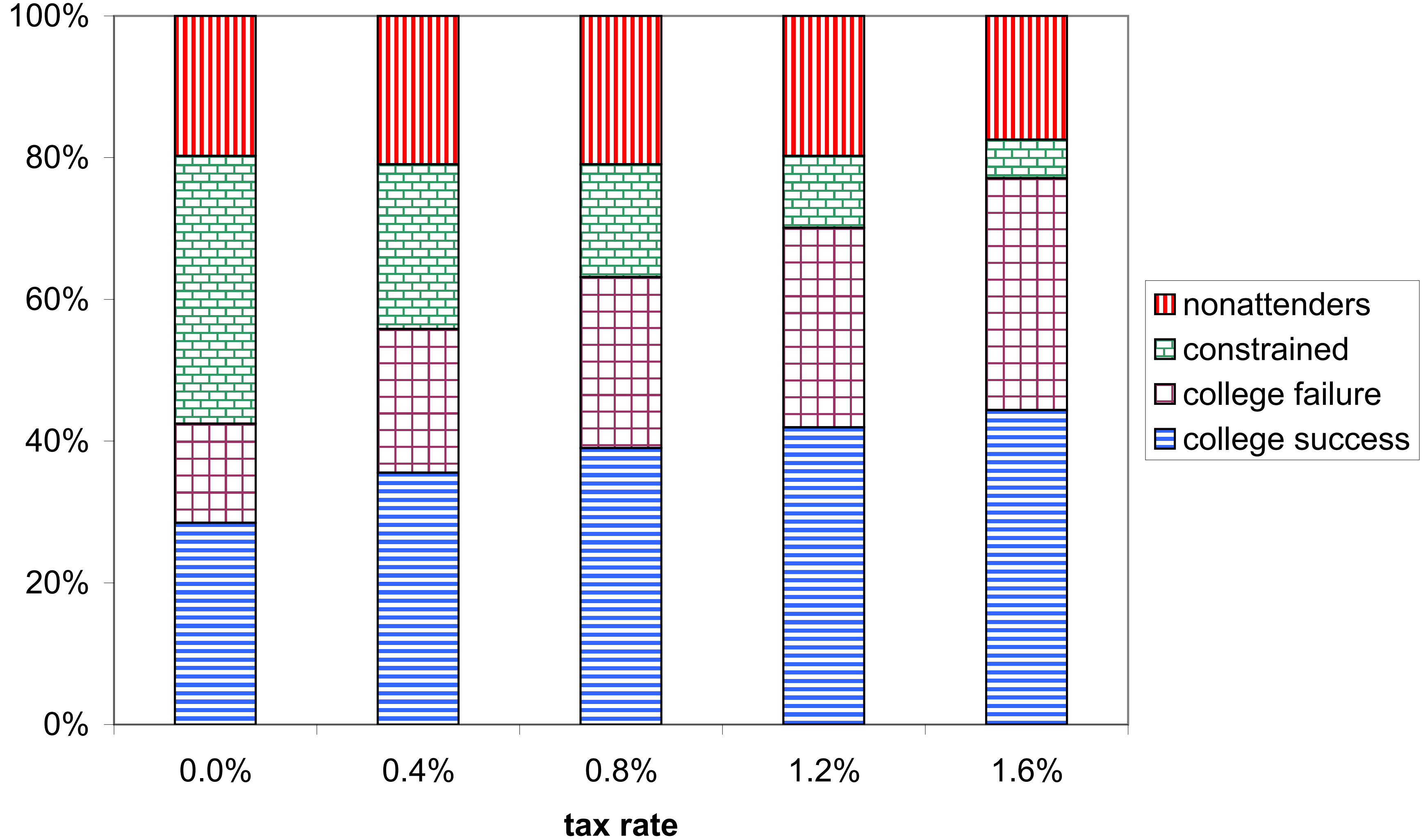


Fig. 6: Distribution of choices with need-based tuition subsidy
100%
80%
60%
40%
20%
0%
0.0%
0.4%
0.8%
1.2%
1.6%
tax rate
nonattenders
constrained
college failure
college success

Fig. 7: Distribution of choices with merit aid



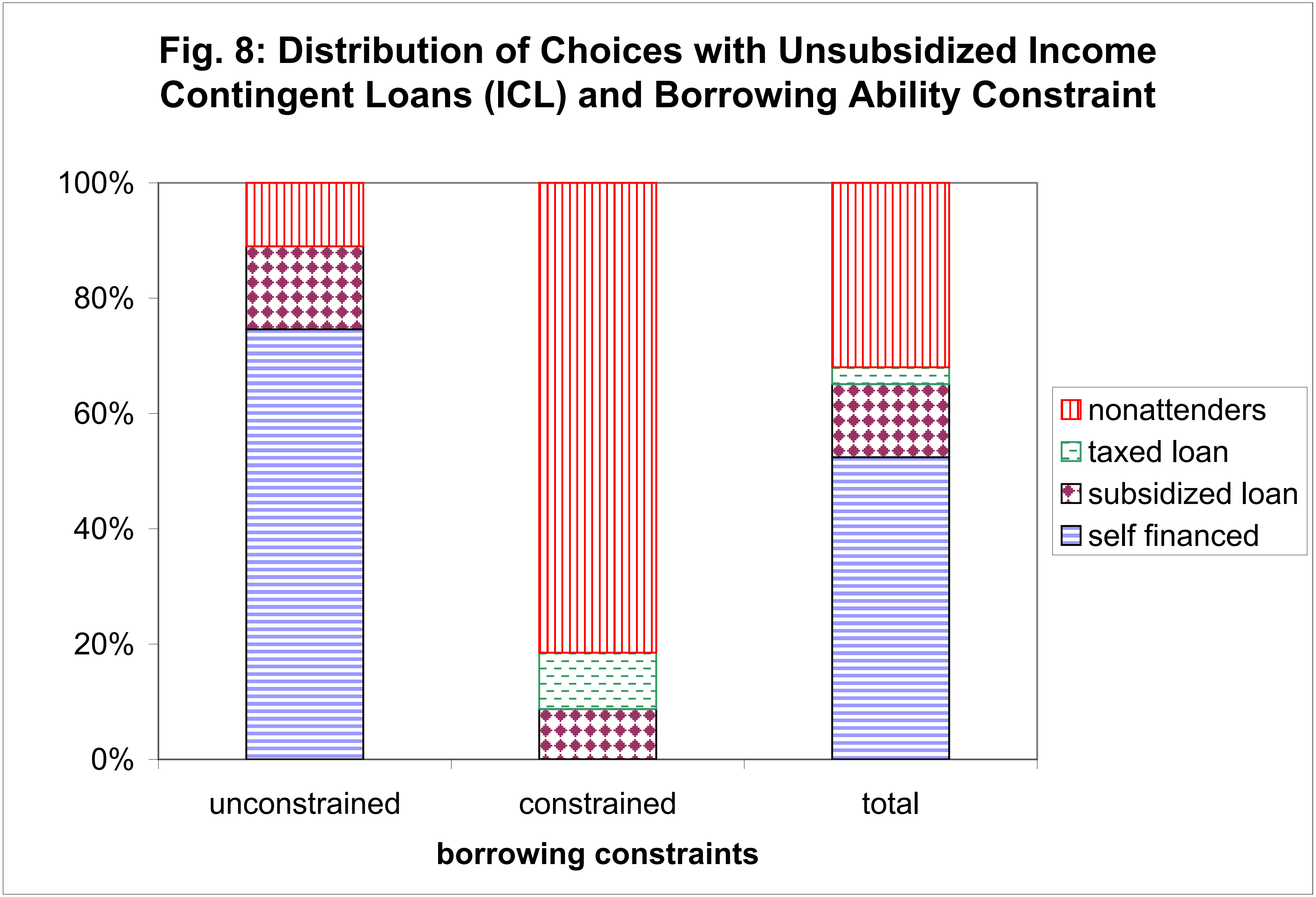


Fig. 8: Distribution of Choices with Unsubsidized Income Contingent Loans (ICL) and Borrowing Ability Constraint
100%
80%
60%
40%
20%
0%
unconstrained
constrained
total
borrowing constraints
nonattenders
taxed loan
subsidized loan
self financed

intergenerational mobility. Before doing that, however, it is useful to note the importance of considering these questions in a general equilibrium setting. Each of these subsidies has large implications for the distribution of workers in the labor market, and this in turn directly affects wages. The increase in college completion (which is approximately the same for each of the need-based and merit-based subsidies discussed when going to a common 1.6 percent tax rate) drives down the wage ratio for college educated compared to uneducated workers from 1.7 to 1.3, leading to a substantially more equal distribution of income. Thus, simply calculating aggregate effects with constant prices would yield very misleading results.

The first aggregate outcome that we note is that each of the subsidies improves the efficiency of the economy by substantially reducing if not eliminating the group of capital constrained potential students. Figure 9 plots the efficiency losses that occur at each tax rate and shows that each of the government interventions leads to improved functioning of the economy. It is of course not necessary that the interventions uniformly improve the economy, regardless of level, because they also introduce their own distortions. Indeed, at the higher levels of tax and subsidy with the uniform tuition reduction, the distortions of the scheme begin to outweigh the gains and efficiency losses increase. Similar outcomes occur for the other subsidies if tax rates and subsidies are allowed to go higher than we present. These increasing distortions occur as tuition approaches zero.

A motivation of government subsidy for college education remains as altering the distribution of welfare in the society. This aspect has two dimensions. First, one might ask whether government policy leads to more equality in addition to the efficiency gains already discussed. Figure 10 provides some insight into this. It plots steady state values of both Aggregate Expected Utility (the sum of utilities in the society) against one minus the gini coefficient. Since the gini measures distance from equality, higher values of 1-gini indicate more equality of utility. In this figure we plot just the effects of uniform tuition subsidies and of merit aid. Interestingly, within the range of taxes and subsidies considered previously, government intervention leads both to higher output and to more equality. The need-based subsidies do, however, consistently lead to more equality than the merit-based subsidy.

Uniform tuition subsidies also dominate merit aid. They can achieve a similar locus of efficiency and equality as need based aid. At lower levels of taxes and program size, however, uniform subsidies yield more inefficiency that need based aid. Income contingent loans lie in between the need based and merit aid loci.

Second, we are interested in the patterns of intergenerational mobility. One simple measure of mobility is the relationship between mother's education and that of subsequent generations. In Figure 11 we plot the probability that a child is educated given that the matriarch is uneducated. We do this for varying numbers of generations and for different tax rates under the uniform tuition subsidy. As the tax rate increases, fewer people are credit constrained, and thus the inertia of having an uneducated parent is partially broken. (The transmittal of ability, however, maintains a certain inertia). The figure shows clearly that mobility increases with more government intervention. At $\tau = .016$, the probability the child of an uneducated mother is educated rises to 0.46 by the fifth generation and stays roughly at that level subsequently.

A second comparison comes from analyzing the different subsidy schemes. In figure 12 we compare the intergenerational mobility that comes from a tax rate of 0.8 percent under the varying governmental interventions. In this, the means-tested programs offer the most mobility, while the merit-based aid, not surprisingly, offers the least.

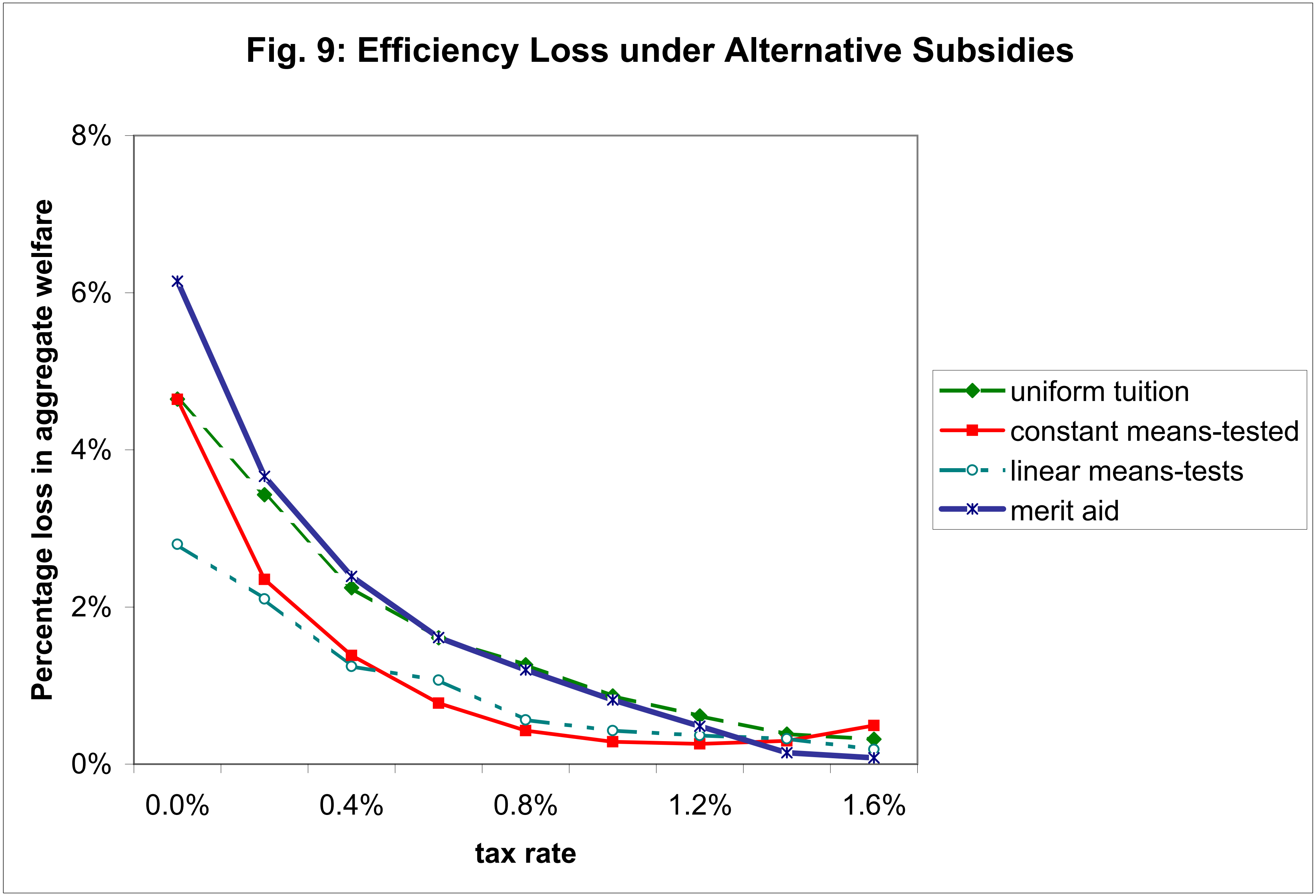


Fig. 9: Efficiency Loss under Alternative Subsidies
8%
6%
4%
2%
0%
Percentage loss in aggregate welfare
0.0%
0.4%
0.8%
1.2%
1.6%
tax rate
uniform tuition
constant means-tested
linear means-tests
merit aid

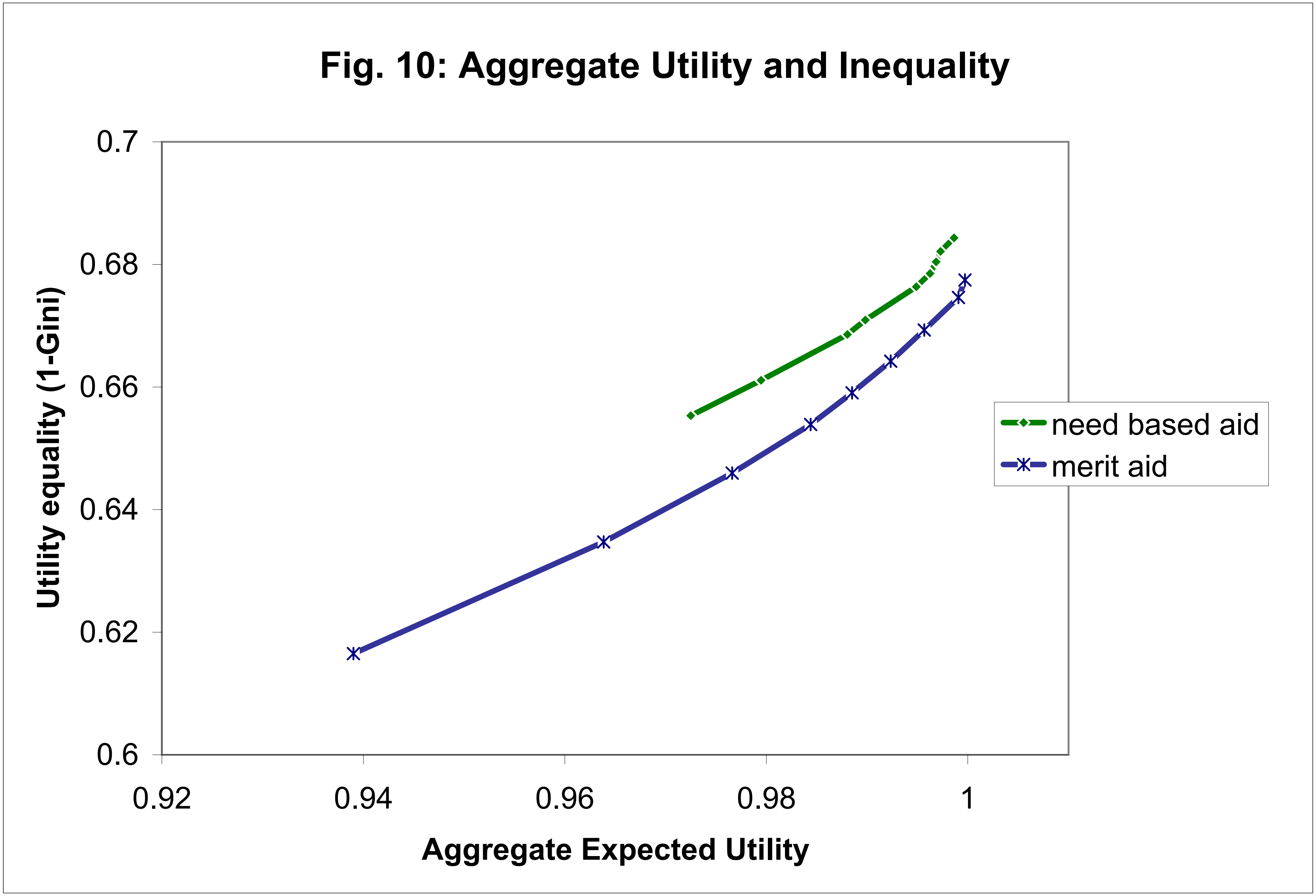
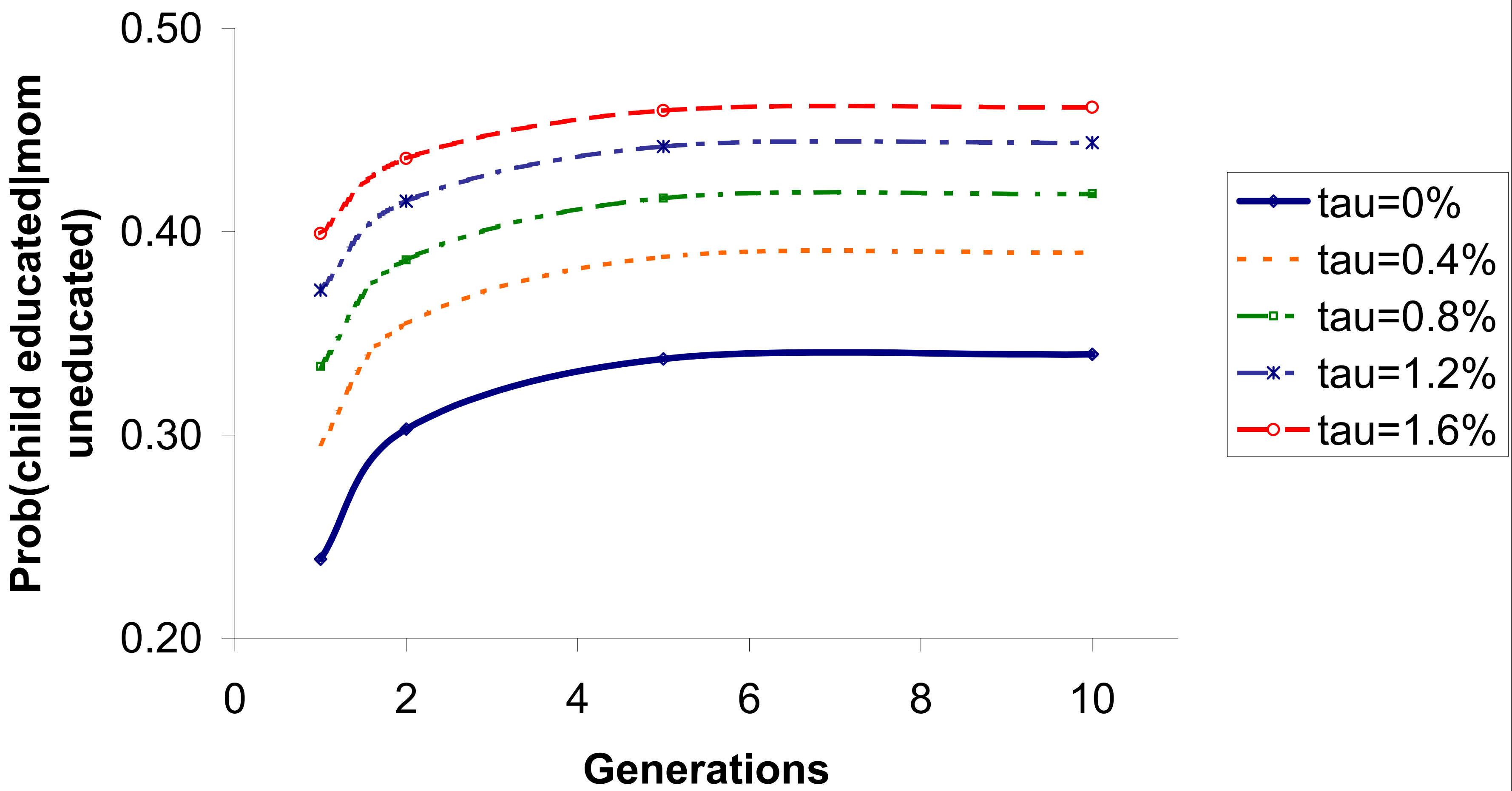


Fig. 10: Aggregate Utility and Inequality
Utility equality (1-Gini)
0.7
0.68
0.66
0.64
0.62
0.6
0.92
0.94
0.96
0.98
1
Aggregate Expected Utility
need based aid
merit aid

Fig. 11: Parent-Offspring Evolution of Education Under Varying Uniform Tuition Subsidies



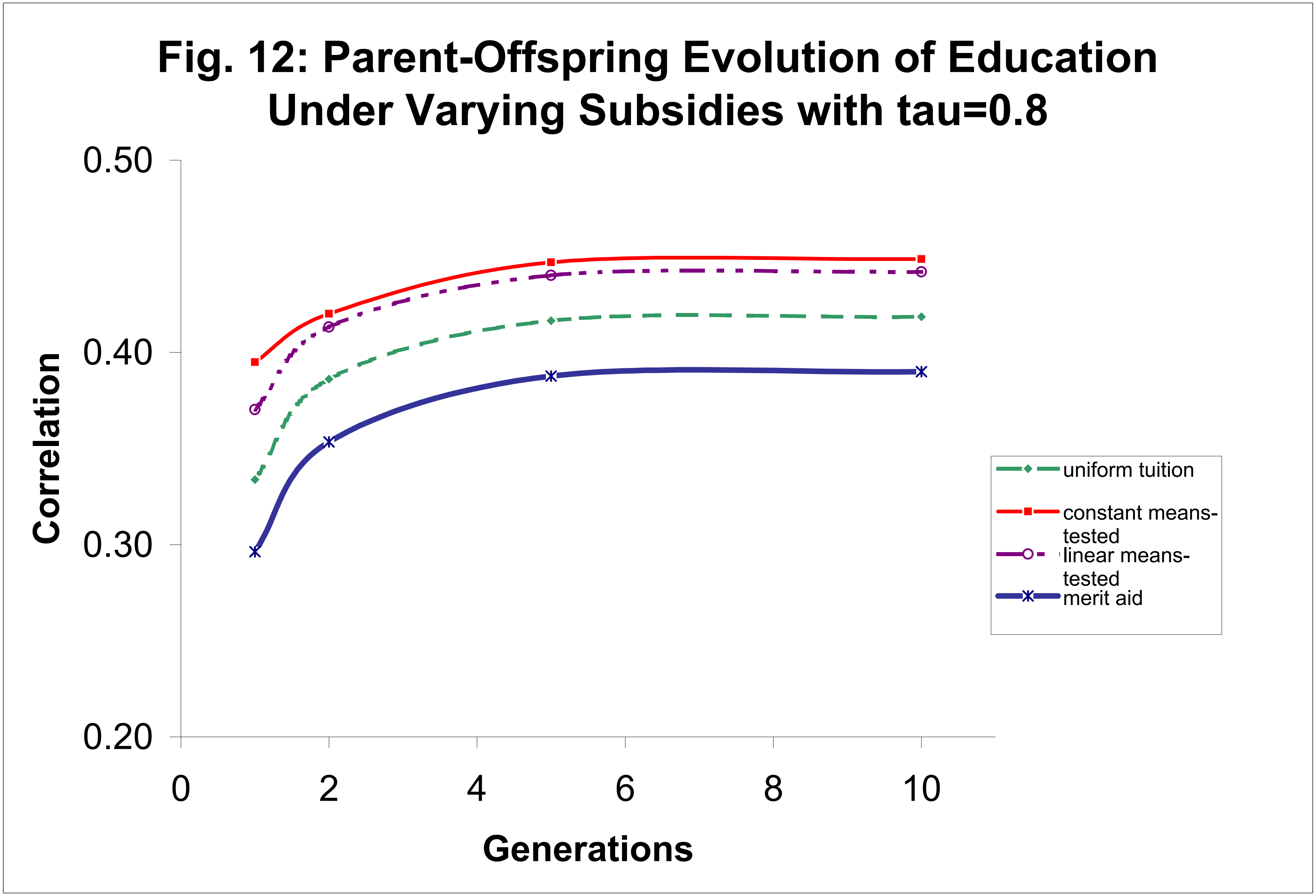


Fig. 12: Parent-Offspring Evolution of Education
Under Varying Subsidies with tau=0.8
Correlation
0.50
0.40
0.30
0.20
0
2
4
6
8
10
Generations
uniform tuition
constant means-tested
linear means-tested
merit aid

Concluding Remarks

In order to understand the potential role of government intervention into college education it is important to consider the implications of borrowing constraints. Without passing judgment on the importance of such constraints, we find that they provide strong justification for some kind of governmental intervention into college finance. At the same time, not all policies have the same benefits. We trace the implications of common policies for both the level and distribution of outcomes in the economy.

A key analytical aspect of this work is the use of a dynamic general equilibrium framework. College policies have significant impacts on the schooling and skills of the workers in the economy, and the impact of these policies on wages cannot be ignored. Moreover, the focus of many policy proposals toward college education is the potential impact on economic mobility across generations. These issues cannot be addressed within the common static, partial equilibrium framework.

Appendix

First Best Policy

In the main model, we have presumed imperfect capital markets. For comparison, we can also consider the following scenario with governemnt-supported tuition loan. For agents who would enroll, suppose that they can borrow against their future, i.e. anybody can borrow as much as they want (say m) and pay back with an interest $(1+r)*m.$ The interest rate r is set to be $1+r=\frac{1}{\beta^*}$, so that borrowings purely for intertemporal substitution of consumption is not profitable. Thus, if an agent would like to borrow for college, it serves only to close the gap between the amount of tuition and the bequest to the child, $m=b-\phi.$ It means that, for an agent who would borrow to go to college, $EU^b(x',b)=b-\phi+m+\beta^*[x'(U^{e'}-(1+r)m)$ $+(1-x')(U^{u'}-(1+r)m)]=b-\phi+\beta^*(x'U^{e'}+(1-x')U^{u'})$, as $\beta^*(1+r)=1,$ which is exactly equal to the expected utility for agents who do not need to borrow. In other words, the existence of government loan *erases the difference* in incentives for those who are financially constrained and those who are not.

A child of type (x',b) attends college if $EU^e(x',b)\geq EU^u(x',b)$ (i.e. $x\geq x^*$). Since the interest rate exactly offsets the discount factor, those who are not financially constrained $(b\geq\phi)$ would not borrow. For a financially constrained agent $(b<\phi)$, the amount of borrowing is $b-\phi.$ And recall that $b=(1-\alpha)(1-\tau)*kx$ $*[w^e*I^e+w^u*(1-I^e)]\equiv beq(x,I^e).$ Let $I^{b\phi}$ be an indicator function, which only takes on value zero and one,

$$I^{b\phi} = \begin{cases} 1 & \text{if } beq(x, I^e) \geq \phi \\ 0 & \text{otherwise} \end{cases} .$$

Hence, the amount of total loans made at time t

$$TL_t \equiv \sum_{I^e \in \{0,1\}} \int\int (1 - I^{b\phi})(b - \phi) \frac{Prob(x', I^{e'} = 1 | x, I^e)}{x'} f(x, I^e) dx dx'.$$

The Transmission of Ability

To determine the transmission of ability, we consider the test scores of parents (mothers) and children. Our data are extracted from NLSY79 and NLSY79 Children Cohorts of National Longitudinal Survey of Youth (NLSY). The NLSY79 is a nationally representative sample of 12,686 young men and women who were 14 to 22 years of age when first surveyed in 1979. The dataset includes the 1980 administration of the Armed Forces Vocational Aptitude Battery (ASVAB), which is used to create Armed Forces Qualifications Test (AFQT) Scores, as well as the highest grade they attended and their age at the time the survey conducted. We converted the AFQT scores in percentiles into the standardized test scores. To eliminate the bias due to age and schooling difference, we calculated the effect of age and schooling and regression adjusted the AFQT scores to their predicted values when young men and women were 23 years of age.

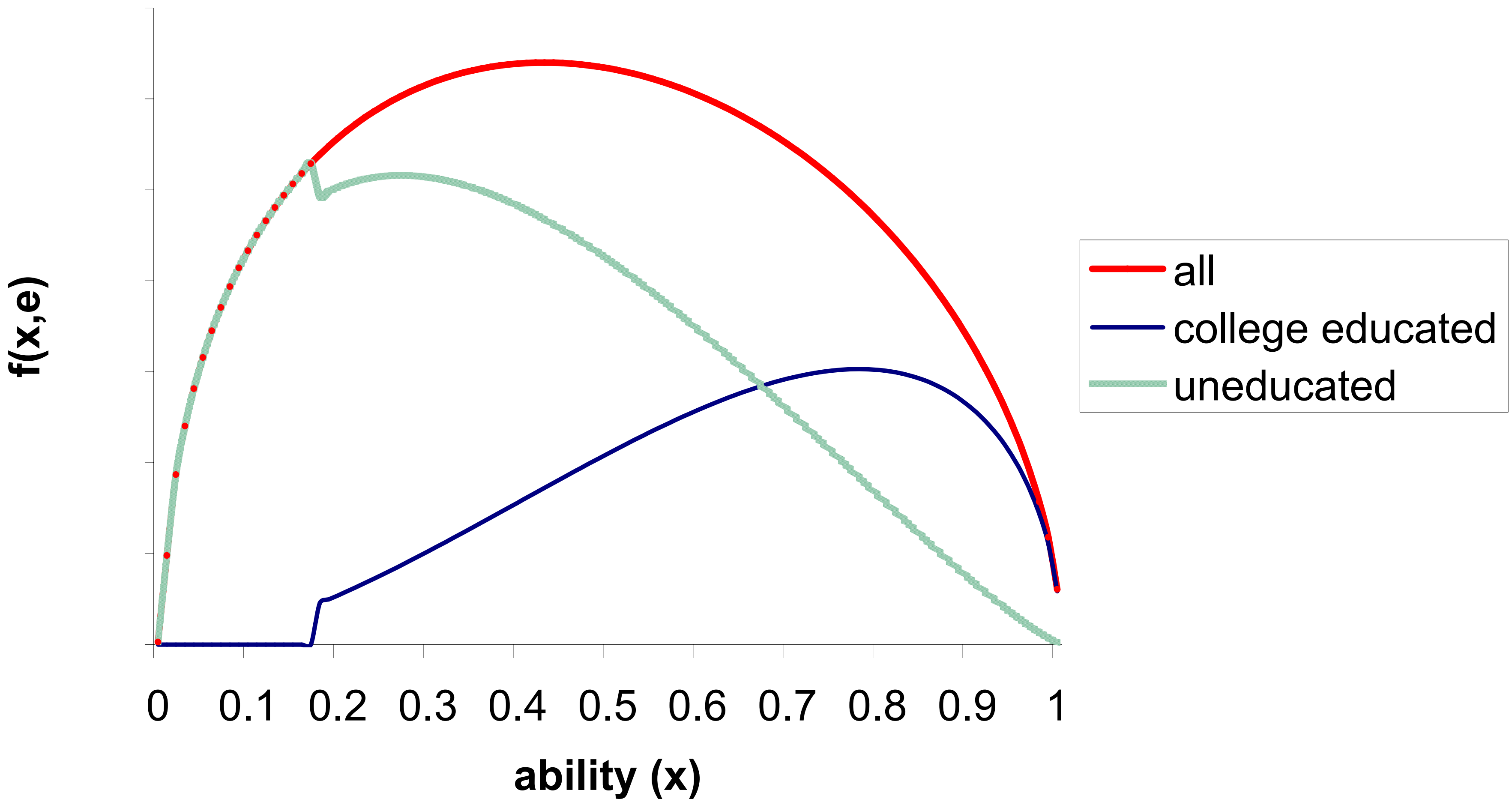
The NLSY79 Child Sample consists of all children born to female NLSY79 respondents who completed an interview during the even-year interviews beginning in 1986. The dataset includes Peabody Individual Achievement Test (PIAT), which measures ability in Math, Reading Recognition, and Reading Comprehension. We used PIAT scores when pupils were 14 years of age and standardized the Math, Reading Recognition, and Reading Comprehension scores to percentiles. As a measure of the ability of a child, the average of those three scores are taken.

We chose family income as a proxy for the family background. Family income is calculated by taking the average of CPI-adjusted income before the year the pupil took the test. We estimated the following Galtonian Regression (1886),

$$x' = \beta_0 + \beta_1 x + \epsilon$$

Table A1 reports the findings where the sample is divided by income quartiles. It is evident that a pupil and her mother's ability are correlated. The smarter a mother is, the more likely the pupil would be of high ability. Regression based on income quartiles provides support for a well-known fact -the importance of family background in the ability formation. Apparently, the mobility of ability is higher for the second and third quartiles. We also looked at the residual plots to confirm that errors are normally distributed. We employ the fact that $x'|x$ has a normal distribution. Figure A1 depicts the steady-state distribution of ability by schooling completion for our model.

Figure A1. Stationary Distributions of Ability by Educational Attainment



	Full	*By Quartile*			
	Sample	*Bottom*	*2nd*	*3rd*	*Top*
Constant	-0.05 (1.62)	-0.31* (4.28)	-0.05 (0.79)	0.05 (1.03)	0.13 (1.84)
Mother's Ability	0.40* (14.1)	0.27* (4.52)	0.35* (5.53)	0.31* (4.82)	0.30* (4.20)
Sample Size	814	301	215	159	139
R^2	0.20	0.06	0.13	0.13	0.11

The point estimates with "∗" are statistically significant at 5% level and the t-statistics are in the parenthesis.

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