Investment Opportunities and Economic Outcomes: Who Benefits From College and the Stock Market?*

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April 24, 2018

Preliminary and incomplete. Please do not cite.

Abstract

Does the power of college to increase well-being routinely exceed that of other investments, as its uniquely high subsidization suggests? Perhaps not: for roughly 46 percent of individuals, access to college affects well-being negligibly. It is only for those whose initial conditions best poise them for success that college is worth substantially more (11 percent in consumption-equivalent terms). This suggests that investments whose returns do not depend on individual characteristics may be substantially more effective in improving the well-being of some. The stock market, which offers comparably high returns and risk, is a natural alternative. We find that 52 percent of high-school graduates would, all else equal, prefer a stock-index retirement fund to the subsidy currently flowing to college.

JEL Codes: E21; G11; I24;

Keywords: Inequality; Human Capital; Higher Education; Financial Investment

*We are grateful to seminar and conference participants at the Micro Macro Labor Economics at the FRB San Francisco and Brookings Institute in India for helpful comments and suggestions. We thank especially Luigi Pistaferri for detailed input. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Richmond or the Federal Reserve System. All errors are ours.

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1 Introduction

Average returns to college completion are high: in recent decades, the lifetime income of college graduates exceeds that of high school graduates by a factor of roughly two (Goldin and Katz, 2007). Investments in college that end in graduation can thus substantially increase individuals' lifetime consumption and utility. However, the risk of non-completion is significant (Restuccia and Urrutia, 2004; Bound et al., 2010; Johnson, 2013). In recent data, roughly half of all enrollees into public 4-year colleges (who account for roughly two-thirds of all Bachelor's degree enrollees) failed to complete a degree even eight years after initial enrollment (Bound et al., 2010). In addition, partial completion offers relatively little reward. Thus, returns to college depend heavily on the ability to complete it, which in turn relies on *individual-level* characteristics, chiefly the ability to learn and the amount of human capital accumulated through high school.[1] Of particular relevance is the possibility that the returns to college are not high for a significant proportion of individuals.

If the cost of producing college education were low, so too (given competition), would be the private costs to individuals, making the risks just described not especially consequential. But it is not. Jones and Yang (2016) show that the full resource cost of college exceeds 50 percent of GDP.[2] As a result, absent any assistance, investment in college would require either substantial familial resources or well-functioning credit markets, and—given the risk—insurance markets. Heterogeneity in the first and doubts about the latter two (Chatterjee and Ionescu, 2012) have arguably led to the provision of substantial subsidies to encourage investment in college. Support for college takes many forms, including needs- and merit-based grants, subsidized student loans, and, perhaps most importantly, subsidies that *directly* and substantially lower the level of tuition charged by public schools, especially in-state. It is important to note that, unlike the first two sources of support, the direct subsidy increases college affordability for *all* enrollees, with no reference to individual attributes.

A comparable major investment option available to households is the stock market: indexed equity fund deliver ex-post returns with stochastic properties similar to those from college. Mean returns to the stock market appear comparable to those from human capital (Judd, 2000). As for risks, both stocks and college carry risks that are of an order of magnitude higher than the risks to Treasuries. However, there remain two notable difference. First, stock index funds, by construction, and unlike college, deliver returns that are virtually uniform across market participants. Second, stock purchases are not subsidized.

[1]Hendricks and Leukhina (2017) show that college preparation, as measured by transcript data, is a strong predictor of graduation prospects.

[2]This represents college expenditures—the cost of educating students—at private non-profit institutions, which arguably is a good proxy for the total unsubsidized cost of college.

A first goal of this paper is to characterize who, under current conditions, benefits (and by how much), from access to college and the stock market. To do so, we construct a model in which agents have access to empirically accurate representations of college and the stock market. Agents will differ ex-ante in their ability to learn, their initial human capital stock, and their initial financial wealth in a quantitatively disciplined manner. In order to measure the value of access to college and the stock market across the spectrum of individual types, we shut down access to each in turn. These polar cases highlight two things. First, they demonstrate that the benefits of access to college vary substantially. While the mean utility gain (in consumption-equivalent terms) across individuals from access to college is 2.8 percent, the range varies from 0 to 11 percent. In particular, a meaningful proportion of individuals receive little to no benefit at all from access to college. Second, our results suggest that stocks are a valuable investment for many: when access to stocks is taken away, college enrollment increases, clarifying both their substitutability and, via revealed preference, their superiority as an investment option for some agents.

Having established that the gains to college vary substantially across individuals, and that a canonical financial market instrument (indexed stock fund) may be a better investment for some, we then turn to the question of how an alternative regime would be perceived by different individuals across the spectrum of initial conditions or "types." Specifically, we ask: what proportion of individuals would be better served by having the value of the current college subsidy redirected to the purchase of a stock index fund? We show that the answer is "many": 52 percent of US high school graduates would be better off receiving the present value of college subsidies as a managed stock index fund investment available only at retirement.

Taken as a whole, the implications of our findings are twofold: First, current support for college, which is invariant to individual characteristics (i.e., the direct tuition subsidy currently in place), while meant to equalize opportunity, might instead be flowing to those already well-positioned (in the sense of ability, initial wealth, and initial human capital) to benefit from college. This is of course not an indictment of college subsidies as a whole, but simply indirect evidence that benefits may be available from more targeted public support for college. Second, and by contrast, the stock market—rarely viewed as an engine of equality—may actually offer those initially worst-off in college-readiness terms a path to better outcomes.

1.1 Related work

We build on work that is aimed at understanding the role of human capital when the particulars of college education, in terms of its costs as a function of observable enrollee and household characteristics, are modeled explicitly. Important references in this literature include Arcidiacono (2005);

Garriga and Keightley (2007); Johnson (2013) and Altonji et al. (2015). Recent work of Abbott et al. (2013) is clearly relevant as well. They develop a rich representation of higher education, allowing for a variety of salient features—gender, labor supply during college, government grants and loans (including private loans), and heterogeneity in familial resources—that have bearing on the measurement in which we are interested. An important distinction between our work and theirs is their primary focus on policy counterfactuals, which their detailed general equilibrium formulation permits.[3] Our primary focus is instead on individuals, and the question of for whom access to college and/or the stock market improves economic outcomes. As noted above, we therefore adopt a partial equilibrium perspective, and emphasize the derivation of the (not-directly-observable) joint distribution of learning ability, initial human capital stock, and initial financial wealth. These features, as argued above, are critical to accurately assessing individual-level variation in the valuation of the investment opportunities we study.

We are also informed by the work that emphasizes the bias imparted to measured returns to college by the possibility of noncompletion. Hendricks and Leukhina (2014) allow for selection effects and argue that two layers of selection are important: weakly-prepared students disproportionately fail to enroll in college, and those who enroll fail at high rates to complete.[4] Our model allows for both effects to operate, and thereby avoids overstating the payoff to college. With respect to failure risk, our work builds on earlier work of Restuccia and Urrutia (2004), Akyol and Athreya (2005) and Chatterjee and Ionescu (2012).[5] More recently, Athreya and Eberly (2013) demonstrate that college failure risk hinders low-wealth individuals, even relatively well-prepared ones, from enrolling in college.

Our work is also related to an empirical literature that studies various aspects of heterogeneity in the returns to college (see, for instance, Altonji et al., 2012; Card, 2001). This heterogeneity reflects differences in ability, college preparedness, and family background among individuals, as well as differences in field of study and school quality. Our framework allows for heterogeneity in ability and college preparedness, but it does not explicitly allow for field of study or heterogeneity in school quality. However, the two sets of characteristics appear to be positively correlated (Arcidiacono et al., 2012; Hendricks and Schoellman, 2014). Accordingly, heterogeneity in ability and college preparedness in our model will act as a summary measure of all dimensions of heterogeneity in the returns to a college investment.

With respect to stocks, our work follows the literature on portfolio choice in life-cycle models

[3] See also Epple et al. (2013) and Cestau et al. (2015) for analysis of higher education policies in the presence of substantial enrollee heterogeneity.

[4] See also Arcidiacono (2004).

[5] The possibility of college failure has also been evaluated in work of Stange (2012) and Ozdagli and Trachter (2011).

(see, for example, Cocco et al., 2005). In spirit, our work is also closely related to Kim et al. (2013), which also features both education and stock market investment.[6]

The remainder of the paper is organized as follows. Section 2 describes the model and Section 3 the data we use to calibrate it. Section 4 summarizes the calibration and the results are reported in Section 5. Section 6 concludes.

2 Model

Our aim is to quantitatively assess the importance of two specific investments, college and stocks, for economic outcomes. We are interested in how access to these investment opportunities alters outcomes for various types of individuals. We begin with a baseline model that incorporates an array of salient features of both investments. The details are described below.

2.1 Environment

Time is discrete and indexed by $t = 1, ..., T$ where $t = 1$ represents the first year after high school graduation. We allow for three potential sources of heterogeneity across agents: their immutable learning ability, a, their initial stock of human capital, h_1, and their initial assets, x_1. These characteristics are drawn jointly according to a distribution $F(a, h, x)$ on $A \times H \times X$.

Each period, agents choose how much to consume and how to divide their time between learning and earning, as in Ben-Porath (1967). Agents also decide how much of their wealth to allocate to stocks, s, versus bonds, b. The latter may be used to either borrow or save. Debt is not defaultable and is subject to a borrowing limit, $-\underline{b}$, where $\underline{b} > 0$.

Agents work and accumulate human capital using the Ben-Porath technology until $t = J$. Agents can also accumulate human capital by choosing (in the first period) to attend college. College can be financed using wealth, x, unsecured debt, b, and non-defaultable, unsecured student-loan debt, d. Agents retire in period $t = J + 1$, after which they face a simple consumption-savings problem.

To capture an important source of risk to human capital, we assume that agents may fail

[6] Indeed, in Athreya et al. (2015), we incorporate the elements of Kim et al. (2013) in a model with human capital investment (though without 4-year college) and show that it can match important life-cycle observations on household stock market participation. Our model does not allow for heterogeneity in stock returns. Although there is some evidence of persistent heterogeneity in the returns to financial assets (Fagereng et al., 2016), stocks returns depend for the most part on market-level outcomes rather than individual characteristics (Bach et al., 2016). Furthermore, stocks in our framework are primarily meant to provide a stylized, though empirically relevant, alternative to a college investment, such as a low-cost index fund that most households could access.

to complete college.[7] At the end of four years in college, the probability of completion—which depends on the agent's innate ability as well as human capital accumulated to that point—is realized. Those who complete college start their working life with human capital h^{CG}, while those who fail to complete start their working life with human capital h^{SC}, where SC denotes "some college," and those who choose not to go to college start their working life at $t = 1$ with human capital h^{HS}.[8]

2.2 Preferences

Agents maximize the expected present value of utility over the life cycle:

$$\max E_0 \sum_{t=1}^{T} \beta^{t-1} u(c_t), \tag{1}$$

where $u(.)$ is strictly concave and increasing. Preferences are represented by a standard time-separable CRRA utility function over consumption. Agents do not value leisure.

2.3 Human Capital

Agents can invest in their human capital in two ways—by investing in a college education when young and by apportioning some of their available time to acquiring human capital throughout their working lives.

Both within and outside college, agents accumulate human capital using a Ben-Porath technology. However, the incentives to invest in human capital are different in and outside college, for several reasons. First, the rental rate on human capital grows faster for those who complete college, consistent with empirical evidence that shows faster earnings growth for college graduates. Second, college enrollees have access to grant funding, which is not available outside of college, as well as to student loan credit that carries a lower rate of interest than the unsecured credit available to all agents. Access to grants and cheaper credit makes funding consumption while spending time accumulating human capital relatively easier on the college path than on the no-college path. Finally, the opportunity cost of spending time learning is higher on the no-college path than on the college path. Outside college, we assume that earnings are a function of accumulated human capital whereas in college they are not: those who work while in college face a relatively low wage

[7] For example, Bound et al. (2010) report, using NLS72 data, that only slightly over half of all college enrollees graduated within 8 years of enrollment. In addition, according to BPS data, 68.5% of students enroll in four-year colleges, and 89% of college dropouts are enrolled in college for at least three full years.

[8] Note that there is variation in the value of h^{CG}, h^{SC}, and h^{HS} across individuals.

rate that does not differ with the level of human capital. This assumption is consistent with evidence that the jobs that college students hold do not necessarily value students' human capital stocks. In fact, we assume that working takes time away from human capital accumulation, and that accumulating less human capital decreases the odds of completion. This, too, is consistent with empirical evidence that college jobs do they contribute to human capital accumulation and that students who work while in college are more likely to drop out (see Autor et al., 2003; Peri and Sparber, 2007). Consequently, most college students in the model find it optimal to allocate all of their time to human capital accumulation, which is in line with empirical findings that the majority of full-time students do not work while in college (see Manski and Wise, 1983; Planty et al., 2008). College in the model thus represents a device that can greatly accelerate human capital accumulation but harshly penalizes non-corner solutions for time allocation. Taken together, these factors make human capital accumulation more attractive in college than outside of it during the college years.

2.3.1 Ben-Porath Human Capital Investment

During college and while working, agents accumulate human capital Ben-Porath (as in the classic 1967, model):

$$h_{t+1} = h_t(1-\delta) + a(h_t l_t)^{\alpha} \text{ with } \alpha \in (0,1) \tag{2}$$

Human capital production depends on the agent's immutable learning ability, a, human capital, h_t, the fraction of available time put into it, l_t, and the production function elasticity, α. Human capital depreciates at a rate of δ, which we will allow to differ by education groups.

2.3.2 College Investment and Financing

Those who invest in college face the risk of noncompletion, which decreases with the level of human capital accumulated during college. Specifically, the probability of completion, $\pi(h_5(h_1, a, l^*_{1,\ldots,4}))$ is an increasing function of the amount of human capital accumulated after completing four years in college, h_5, which in turn increases with the initial human capital stock, h_1, the agent's learning ability, a, and the amount of time $l^*_{1,\ldots,4}$ that she chooses to allocate to human capital accumulation (versus working) while in college.

Those who work in college earn a wage $w_{col}(a)$ per unit of time worked. We assume that the rate increases with ability in order to prevent low-ability students from enrolling in college only to enjoy earnings during college that are higher than what they would have earned had they not enrolled in college. Working during college diverts time from human capital accumulation and therefore increases the probability of non-completion.

There are several possible sources of college financing: savings, x, borrowing, b, earnings from working while in college, merit- and need-based aid ($\kappa(a, x_1)$), and student loans. Agents are allowed to take out student loans up to $d(x) = \min[d_{max}, max[\bar{d} - x, 0]]$, which represents the full college cost, $\bar{d}$, minus any savings, x, up to a student loan limit d_{max}. They choose the loan amount, d, at the beginning of college and receive equal fractions of the loan each period in college. During college, they pay equal fractions of the direct cost of college, $\hat{d}$. After college, they repay their student loan in equal payments, p, which are determined by the loan size, $d(x)$, interest rate on student loans, R_g, and the duration of the loan, P. Consistent with the data, the interest rate on student loans is $R_f < R_g < R_b$, where R_f is the risk-free savings rate and R_b the borrowing rate on unsecured debt.

The return to human capital is in the form of earnings during working life, which are subject to shocks as described below.

2.4 Earnings

During an agent's working life, their earnings are given by:

$$y_{it} = w_t(1 - l_{it})h_{it}z_{it}$$

where w is the rental rate of human capital, $(1-l_t)$ is the time spent working, and z_{it} is the stochastic component. The latter varies between college graduates, CG, and those with no college, NC (which includes college dropouts and high school graduates). It consists of a persistent component $u_{it} = \rho u_{i,t-1} + \nu_{it}$, with $\nu_{it} \sim N(0, \sigma_\nu^2)$, and a transitory (iid) component $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$. The variables u_{it} and ϵ_{it} are realized in each period over the life cycle and are not correlated.

The rental rate of human capital evolves over time according to

$$w_t = (1 + g)^{t-1}$$

where g is the growth rate. This rate is higher for college graduates than for those with no college.

2.5 Means-Tested Transfer and Retirement Income

We allow agents to receive means-tested transfers, τ_t, which depend on age, income, and assets. Following Hubbard et al. (1994) we specify these transfers as

$$\tau_t(t, y_t, x_t) = \max\{0, \underline{\tau} - (\max(0, x_t) + y_t)\} \tag{3}$$

These transfers capture the net effect of the various U.S. social insurance programs that are aimed at providing a floor on income (and thereby consumption).

After period $t = J$, in which agents start retirement, they receive a constant fraction of their earnings in the last working period, $\varphi^i(y_J + \tau_J)$, which they allocate between risky and risk-free investments. We allow the income replacement rate for college graduates to differ from the rate for all other agents.

2.6 Financial Markets

There are two financial assets in which the agent can invest, a risk-free asset, b_t, and a risky asset, s_t.

Risk-free assets

An agent can borrow or save using asset b_t. Savings will earn the risk-free interest rate, R_f. We assume that the borrowing rate, R_b, is higher than the savings rate: $R_b = R_f + \omega$. Debt is non-defaultable and comes with a borrowing limit $\underline{b} > 0$.

Risky assets

Risky assets, or stocks, earn stochastic return $R_{s,t+1}$ in period $t + 1$, given by:

$$R_{s,t+1} - R_f = \mu + \eta_{t+1}, \tag{4}$$

where η_{t+1}, the period $t + 1$ innovation to excess returns, is assumed to be independently and identically distributed (i.i.d.) over time and distributed as $N(0, \sigma_\eta^2)$. We assume that innovations to excess returns are uncorrelated with innovations to the aggregate component of permanent labor income.

Given asset investments at age t, b_{t+1} and s_{t+1}, financial wealth at age $t + 1$ is given by

$$x_{t+1} = R_j b_{t+1} + R_{s,t+1} s_{t+1}$$

with $R_j = R_f$ if $b \geq 0$ and $R_j = R_b$ if $b < 0$.

2.7 Agent's Problem

The agent chooses whether or not to invest in college (and, if investing in college, how much student debt to take on), how much to consume, how much time to allocate to learning, asset positions in stocks and bonds (or borrowing), and in order to maximize expected lifetime utility.

We solve the problem backwards starting with the last period of life when agents consume all their available resources. The value function in the last period of life is set to $V_T^R(a,h,x) = u(x)$.

Retired agents do not accumulate human capital. They face a simple consumption-savings problem but may choose to invest in both risk-free and risky assets. The value function is given by

$$V^R(t,a,b,s,y_J) = \max_{b',s'}\{\frac{c^{1-\sigma}}{1-\sigma} + \beta V^R(t+1,a,b',s',y_J)\} \tag{5}$$

where

$$\begin{aligned} c + b' + s' &\leq \varphi^i(y_J + \tau_J) + R_j b + R_s s \\ b' &\geq \underline{b} \\ s' &\geq 0 \end{aligned}$$

In the above, $R_j = R_f$ if $b \geq 0$ and $R_j = R_b$ if $b < 0$. The only uncertainty faced by retired individuals pertains to the rate of return on the risky asset.

2.7.1 Problem in Working Phase for those with No College

We use $V_J^R(t,a,b,s,y_J)$ from Equation 5 as a terminal node for the adult's problem on the no college path. We solve

$$V^{HS}(t,a,h,b,s,z) = \max_{l,b',s'}\{\frac{c_t^{1-\sigma}}{1-\sigma} + \beta E V^{HS}(t+1,a,h',b',s',z')\} \tag{6}$$

where

$$\begin{aligned} c + b^{'} + s^{'} &\leq w(1-l)hz + R_b b + R_s s + \tau(t,y,x) \text{ for } t = 1,..,J \\ l &\in [0,1] \\ h^{'} &= h(1-\delta) + a(hl)^{\alpha} \\ b^{'} &\geq \underline{b} \\ s^{'} &\geq 0 \end{aligned}$$

2.7.2 Problem in Working Phase for those who Attended College

As before, we use $V_J^R(t,a,b,s,y_J)$ from the retirement phase as a terminal node and solve for the set of choices in the working phase $j = 5,..,J$ of the life cycle. We further break down the working phase into a student loan post-repayment period and a repayment period. In the post-repayment period, $t = P+1,...,J$, the problem is identical to the one for working adults on the no-college path.

During the repayment period, $t = 5,...,P$, agents have to repay their student loans with a per-period payment

$$p = \frac{d(x)}{\sum_{t=1}^{P-5} \frac{1}{R_g^t}}.$$

The value function is given by

$$V^i(t,a,h,b,s,z) = \max_{l,b^{'},s^{'}} \{ \frac{c_t^{1-\sigma}}{1-\sigma} + \beta E V^i(t+1,a,h^{'},b^{'},s^{'},z^{'}) \}, i = CG, SC \tag{7}$$

where

$$\begin{aligned} c + b^{'} + s^{'} &\leq w(1-l)hz + R_j b + R_s s + \tau(t,y,x) \text{ for } t = P+1,..,J \\ c + b^{'} + s^{'} &\leq w(1-l)hz + R_j b + R_s s + \tau(t,y,x) - p(x_1) \text{ for } t = 5,..,P \\ l &\in [0,1] \\ h^{'} &= h(1-\delta) + a(hl)^{\alpha} \\ b^{'} &\geq \underline{b} \\ s^{'} &\geq 0 \end{aligned}$$

$R_j = R_f$ if $b \geq 0$ and $R_j = R_b$ if $b < 0$.

2.7.3 Problem in College

For the college phase $t = 1, .., 4$ of the life cycle we first take into account the risk of dropping out from college and use $V^C(5, a, h, b, s, z) = \pi(h_5)V^{CG}(5, a, h, b, s, z) + (1 - \pi(h_5))V^{SC}(5, a, h, b, s, z)$ as the terminal node. The value function is given by

$$V^C(t, a, h, b, s, z) = \max_{l,b',s'} \left[\frac{c^{1-\sigma}}{1-\sigma} + \beta E V^C(t+1, a, h', b', s', z') \right] \tag{8}$$

where

$$\begin{aligned}
c + b' + s' &= w_{col}(1-l) + R_b b + R_s s + \frac{d}{4} - \frac{\hat{d}}{4} + \kappa(a, h_0, x_0) \\
l &\in [0, 1] \\
h' &= h(1-\delta) + a(hl)^{\alpha_{col}} \\
d &\leq \min[d_{max}, max[\bar{d} - x_0, 0]] \\
b' &\geq \underline{b} \\
s' &\geq 0.
\end{aligned}$$

For the college period, the rental rate of human capital is set to a relatively low value (see Section 4), which means that human capital is not productive until graduation. This assumption is consistent with evidence that the jobs college students have do not necessarily value students' human capital stocks, nor do they contribute to human capital accumulation. The set of skills involved in these jobs is different from the one students acquire in college and use after graduation. An implication of this assumption is that in the model college students find it optimal to allocate all of their time in college to human capital accumulation, a result that is consistent with the empirical findings that the majority of full-time college students do not work while in school. Finally, people who choose to work while in school most likely drop out of college, as numerous studies attest.

Agents are allowed to borrow up to the full college cost minus the expected family contribution that depends on initial assets. Agents use the loan amount and initial assets to pay for college expenses while in college. This feature is important, since it prevents college graduates from having an advantage over the no-college group in having access to government borrowing and using it for consumption over the life-cycle. They pay direct college expenses each period while in college.

Once the college and no-college paths are fully determined, agents then select between going to college or not by solving $\max[V^C(1, a, h, x), V^{HS}(1, a, h, x)]$.

3 Data

In order to map our model to data, we use data on annual earnings from the March Current Population Survey (CPS), on financial assets from the Survey of Consumer Finances (SCF), and on college enrollment and completion rates from the Beginning Postsecondary Student Longitudinal Survey (BPS) 2004/2009 and the National Education Longitudinal Study (NELS:1988).

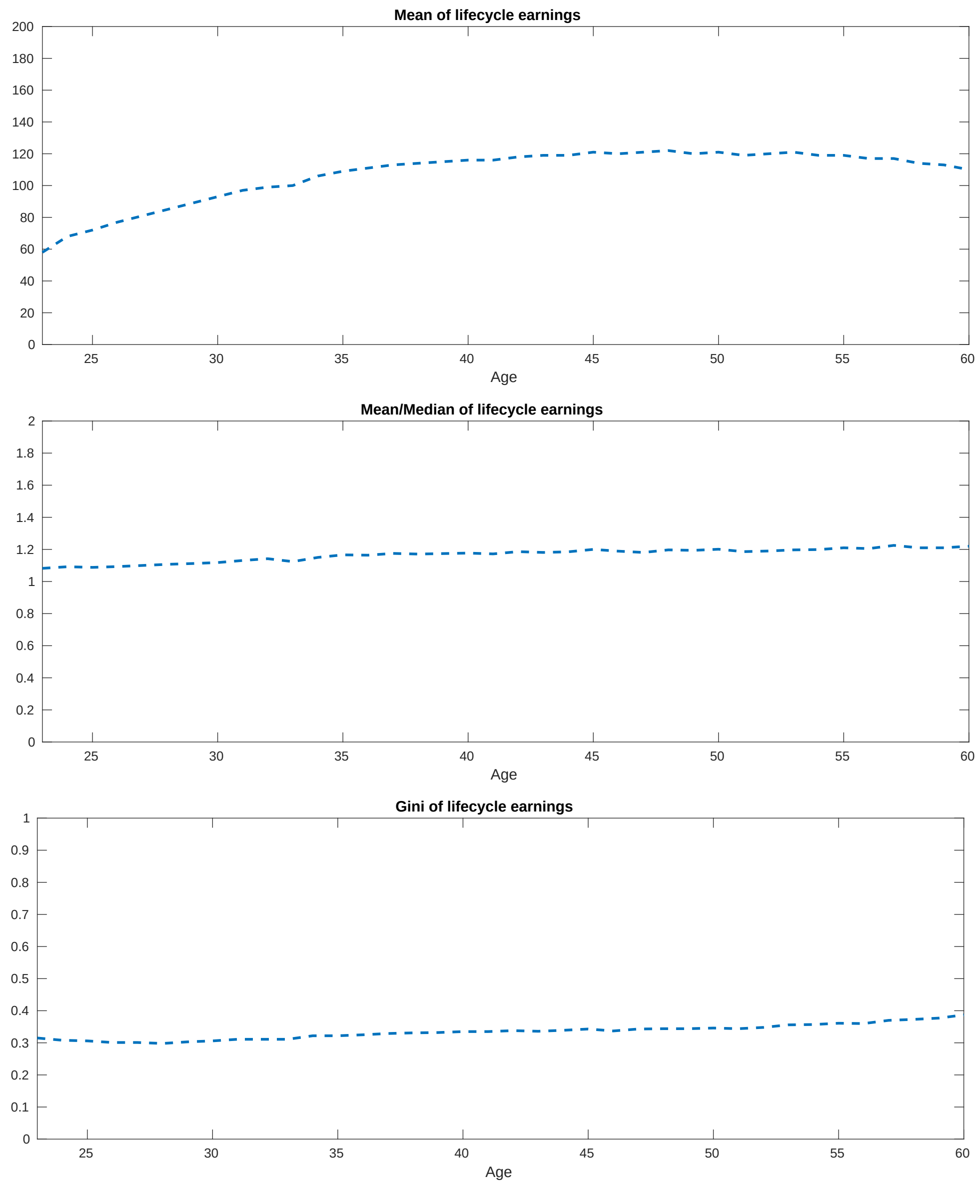
3.1 Life cycle earnings

As described in more detail in the next section, we calibrate our model to match the evolution of mean earnings, earnings dispersion, and earnings skewness over the life cycle. To this end, we first estimate life cycle profiles, for ages 23 to 60 (i.e. the "working life"), of mean earnings, the earnings Gini coefficient, and the mean/median earnings ratio using data from the March CPS, obtained through IPUMS at the University of Minnesota. We use data on annual wage and salary income for male heads of household with at least a high-school diploma (or equivalent) for calendar years 1963-2013 (corresponding to survey years 1964-2014). We restrict our sample to individuals who worked at least 12 weeks in the reference year and earned at least $1,000 (in constant 2014 prices). We use the CPS weights to ensure that each year's sample is representative of the overall U.S. population; additionally, we renormalize the weights in each year in order to keep the population constant at its 2014 value; this way we abstract from issues related to population growth.

We use these data to construct life cycle profiles for mean earnings, the earnings Gini coefficient, and the mean/median earnings ratio. Specifically, for each of these statistics, $s_{t,y}$, we compute $s_{t,y}$ in the data for each combination of age t and calendar year y, and regress $s_{t,y}$ against a full set of year and age indicators.[9] We then take the regression coefficients on the age indicators (we use calendar year 2013 as our base year), and normalize them so that at age 40 the coefficients profile goes through the unconditional average value of $s_{40,y}$ across all years y in our sample. The corresponding normalized age coefficients constitute the life cycle profiles that we use in the calibration. Figure 1 shows the life cycle profiles of mean earnings, the earnings Gini, and the mean/median earnings ratio obtained in this fashion.

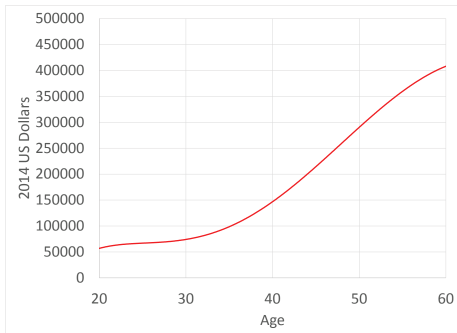
[9]By using a full set of year indicators, this treatment controls for year effects in the construction of the age profiles. We have also computed age profiles controlling for cohort effects, rather than year effects. The behavior of the life cycle profiles is qualitatively similar.

Figure 1: Life-cycle earnings statistics

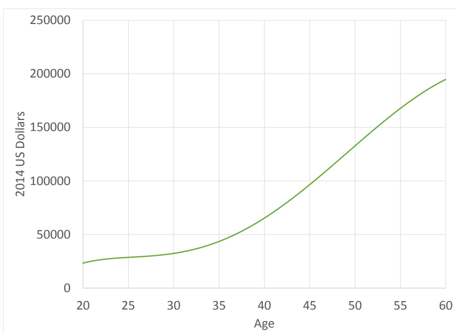


3.2 Life cycle financial assets

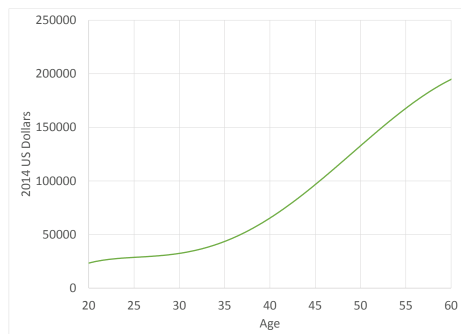
Figure 2: Average Life-Cycle Assets (SCF)



(a) Total



(b) Risky



(c) Risk-free

We use data from the SCF to measure wealth and its composition. Our measure of wealth includes all financial assets. To be consistent with assumptions that we make later, we assume that wealth is comprised of one risky and one risk-free asset. Our measure of risky assets corresponds to a broad measure of households' equity holdings in the SCF, which includes directly held stocks as well as stocks held in mutual funds, IRAs/Keoghs, thrift-type retirement accounts, and other managed assets.

As in the case of earnings, we construct life cycle profiles of asset holdings, controlling for time effects using 2013 as the base year. The results (in 2014 dollars) are reported in Figure 2[10].

[10] Averages for risky and risk-free assets are taken conditional on ownership

3.3 College enrollment and completion

We use data from the Beginning Postsecondary Student Longitudinal Survey (BPS) 2004/2009 and the National Education Longitudinal Study (NELS:1988) to match enrollment and completion rates. Specifically, we estimate correlations of ability and initial wealth, and of initial human capital and initial wealth, to match college enrollment rates for three groups of initial wealth (expected family contributions) based on NELS:1988 data, and to match college completion rates based on the BPS 2004/2009 data set for students who enrolled in college in the year 2003-2004.

The BPS 04/09 is one of several National Center for Education Statistics (NCES)-sponsored studies that is a nationally representative dataset with a focus on post-secondary education indicators. BPS cohorts include beginners in post-secondary schools who are surveyed at three points in time: in their first year in the National Postsecondary Student Aid Study (NPSAS), and then three and six years after first starting their post-secondary education in follow-up surveys. BPS collects data on a variety of topics, including student demographics, school experiences, persistence, borrowing/repayment of student loans, and degree attainment six years after enrollment. Our sample consists of students aged 20-30 who enroll in a four-year college following high school graduation. For demographic characteristics, we use SAT (and converted ACT) scores as a proxy for ability and expected family contribution (EFC) as a proxy for wealth.

The National Education Longitudinal Study (NELS:1988) is a nationally representative sample of eighth-graders who were first surveyed in the spring of 1988. A sample of these respondents were then resurveyed through four follow-up surveys in 1990, 1992, 1994, and 2000. We use the third follow-up survey when most respondents completed high school and report their post-secondary access and choice. As in the BPS, demographic information, including SAT scores and EFC, are available. We use this data set to compute college enrollment rates by EFC. Our sample consists of recent high school graduates aged 20-30 who have taken the SAT (or ACT).

4 Mapping the model to the data

The parameters in our model include: 1) standard parameters such as the discount factor and the coefficient of risk aversion; 2) parameters specific to human capital and to the earnings process; 3) parameters governing the distribution of initial characteristics; 4) parameters specific to college investment and financing; and 5) parameters specific to financial asset markets. Our approach involves a combination of setting some parameters to values that are standard in the literature, calibrating some parameters directly to data, and jointly estimating the parameters that we do not observe in the data by matching moments using several observable implications of the model.

These parameters are listed in Table 1. We present the details of the calibration in the next section, followed by the model fit relative to data.

Table 1: Parameter Values: Benchmark Model

Parameter	Name	Value
T	Model periods (years)	58
J	Working periods (after college)	34
β	Discount factor	0.96
σ	Coeff. of risk aversion	3
R_f	Risk-free rate	1.02
R_b	Borrowing rate	1.11
$\underline{\text{b}}$	Borrowing limit	\$17,000
μ	Mean equity premium	0.06
σ_η	Stdev. of innovations to stock returns	0.157
α	Human capital production function elasticity	0.7
g_{NC}, g_{CG}	Growth rate of rental rate of human capital	$0.01, 0.02$
δ_{NC}, δ_{CG}	Human capital depreciation rate	$0.021, 0.038$
ψ_{NC}, ψ_{CG}	Fraction of income in retirement	$0.682, 0.93$
$\underline{\tau}$	Minimal income level	$\$17,936$
$(\rho_{NC}, \sigma^2_{\nu NC}, \sigma^2_{\epsilon NC})$	Earnings shocks no college	$(0.951, 0.055, 0.017)$
$(\rho_{CG}, \sigma^2_{\nu CG}, \sigma^2_{\epsilon CG})$	Earnings shocks college	$(0.945, 0.052, 0.02)$
$(\mu_a, \sigma_a, \mu_h, \sigma_h, \varrho_{ah})$	Parameters for joint distribution of ability and initial human capital	$(0.44, 0.75, 77, 33, 0.71)$
$\hat{d}$	Annual direct cost of college	\$7,100
$\bar{d}$	Annual full cost of college	\$53,454
d_{max}	Limit on student loans	\$23,000
w_{col}	Wage during college	\$17,700

4.1 Calibration

4.1.1 Preference parameters

The per period utility function is CRRA as described in the model section. We set the coefficient of risk aversion, σ, to 3, which is consistent with values chosen in the financial literature. We conduct robustness checks on this parameter by looking at alternative values such as the upper bound of $\sigma = 10$ considered reasonable by Mehra and Prescott (1985) as well as lower values such as $\sigma = 2$. The discount factor used ($\beta = 0.96$) is also standard in the literature. We set retirement income to be a constant fraction of labor income earned in the last year in the labor market. Following Cocco (2005) we set this fraction to 0.682 both for high school graduates and for those with some college education and to 0.93 for college graduates.

4.1.2 Human capital parameters and earnings shocks

We set the elasticity parameter in the human capital production function, α, to 0.7. Estimates of this parameter are surveyed by Browning et al. (1999) and range from 0.5 to 0.9. To parameterize the stochastic component of earnings, z_{it}, we follow Abbott et al. (2013) who use the National Longitudinal Survey of Youth (NLSY) data using CPS-type wage measures to estimate parameters for the idiosyncratic persistent and transitory wage shocks. For the persistent shock, $u_{it} = \rho u_{i,t-1} + \nu_{it}$, with $\nu_{it} \sim N(0, \sigma_\nu^2)$ and the transitory shock, $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$, they report the following values: For high school graduates, $\rho = 0.951$, $\sigma_\omega^2 = 0.055$, and $\sigma_\nu^2 = 0.017$; for college graduates, $\rho = 0.945$, $\sigma_\omega^2 = 0.052$, and $\sigma_\nu^2 = 0.02$. We use the first set of values for individuals with no college as well as for those with some college education, and the second set of values for those who complete four years of college.

As previously noted, the rental rate of human capital in the model evolves according to $w_t = (1 + g_i)^{t-1}$. The growth rate g_i is calibrated to match the average growth rate in mean earnings observed in the data. We obtain 0.01 for individuals with no college degree and 0.02 for college graduates.

Given the growth rate in the rental rates, the depreciation rates are set so that the model produces the rate of decrease of average real earnings at the end of the working life. The model implies that at the end of the life cycle negligible time is allocated to producing new human capital and, thus, the gross earnings growth rate approximately equals $(1 + g)(1 - \delta)$. We obtain 0.021 for individuals with no college degree and 0.038 for college graduates.

4.1.3 Distribution of initial characteristics: financial assets, ability and human capital

The distribution of initial characteristics (ability, human capital, and financial assets) is determined by seven parameters. These parameters are estimated to match the evolution of three moments of the earnings distribution over the life cycle (mean earnings, the Gini coefficient of earnings, and the ratio of mean to median earnings) and college enrollment and college completion rates across three wealth groups (proxied by expected family contributions). The estimation proceeds as follows. First, for the distribution of initial financial assets, x_1, we use data from the National Center for Education Statistics (NCES). The appropriate notion of wealth at age 18 is not unambiguous. In particular, while 18-year-olds typically do not have substantial wealth of their own, they may have access to alternative sources of wealth that are not directly measured, most notably, intervivos transfers from their parents.[11] We therefore estimate initial wealth by

[11] [State the percentage of 18-year-olds with zero or low wealth from the SCF.]

applying the college aid formula that determines "expected family contribution" to households in an age range corresponding to the [mean/median] age of parents of college enrollees.[12] Second, we calibrate the joint distribution of ability and initial human capital to match the key properties of the earnings distribution over the life cycle reported earlier using March CPS data. Third, we estimate the correlations of ability and initial wealth, and of initial human capital and initial wealth, to match college enrollment rates based on NELS:1988 data, and college completion rates based on BPS 2004/2009 data.

The dynamics of the earnings distribution implied by the model are determined in several steps: i) we compute the optimal decision rules in the model using the parameters described above for an initial grid of the state variable; ii) we simultaneously compute college, human capital, and financial investment decisions and compute the life cycle earnings for any initial pair of ability and human capital; and iii) we choose the joint initial distribution of ability and human capital to best replicate the properties of earnings from the CPS data.

We search over the vector of parameters that characterize the initial state distribution to minimize a distance criterion between the model and the data. We restrict the initial distribution to lie on a two-dimensional grid spelling out human capital and learning ability, and we assume that the underlying distribution is jointly log-normal. This class of distributions is characterized by five parameters.[13] We find the vector of parameters $\gamma = (\mu_a, \sigma_a, \mu_h, \sigma_h, \varrho_{ah})$ that characterizes the initial distribution by solving the minimization problem:

$$\min_{\gamma} \left(\sum_{j=5}^{J} |log(m_j/m_j(\gamma))|^2 + |log(d_j/d_j(\gamma))|^2 + |log(s_j/s_j(\gamma))|^2 \right)$$

where $m_j, d_j,$ and s_j are the mean, dispersion, and skewness statistics constructed from the CPS data on earnings, and $m_j(\gamma)$, $d_j(\gamma)$, and $s_j(\gamma)$ are the corresponding model statistics.[14]

We then choose the correlations of ability and initial wealth, and of initial human capital and initial wealth, that best replicate college enrollment and college completion rates by wealth levels (see further details in the next subsection).

4.1.4 College parameters

We set the full cost per year of college to $\bar{d} = \$53,454$. The limit and interest rate on student loans are $d_{max} = \$23,000$ and $R_g = 1.06$, respectively. We set the wage during college, $w_{col} = \$17,700$

[12] [Median age of parent at year of first birth from the Census + 18].
[13] In practice, the grid is defined by 20 points in human capital and in ability.
[14] For details on the calibration algorithm see Huggett et al. (2006) and Ionescu (2009).

Table 2: Completion Rates by GPA in College

Completion rate	Grades
0.07	grades C and D
0.30	mostly Cs
0.45	mostly Bs and Cs
0.56	mostly Bs
0.67	mostly Bs and As
0.70	mostly As

(based on NCES data).

Lastly, the probability of college completion, $\pi(h_5)$, is set based on mapping observed completion rates by cumulative GPA scores in the BPS data to h_5 in the model.[15] In the data, we observe the fraction of the student population that obtained each of the sets of grades listed in Table 2. In the model, we divide the distribution of h_5 into groups according to these percentages, and assign each group the completion probability listed in the first column of the table. For example, an agent in the group with the highest level of h_5 will face a 70% probability of completion.

4.1.5 Financial markets

We turn now to the parameters in the model related to financial markets. We fix the mean equity premium to $\mu = 0.06$, as is standard in the literature (e.g., Mehra and Prescott, 1985). The standard deviation of innovations to the risky asset is set to its historical value, $\sigma_\eta = 0.157$. The risk-free rate is set equal to $R_f = 1.02$, consistent with values in the literature (McGrattan and Prescott, 2000) while the wedge between the borrowing and risk-free rate is 0.09 to match the average borrowing rate of $R_b = 1.11$ (Board of Governors of the Federal Reserve System, 2014).

We assume a uniform credit limit across households. We obtain the value for this limit from the SCF. The SCF reports, for all individuals who hold one or more credit card, the sum total of their credit limits. We take the average of this over all individuals in our sample and obtain a value of approximately $17,000 in 2013 dollars. Note that, when we take the average, we include those who do not have any credit cards. This ensures that we are not setting the overall limit to be too loose. Lastly, in our baseline model, we assume for the time being that the returns to both risky assets (human capital and financial wealth) are uncorrelated.

[15]We define the completion rate in the data as the fraction of students who had earned a bachelor's degree by June 2009.

4.2 Model vs. Data

We start by presenting the model predictions for targeted data moments for the baseline economy and then by describing model predictions for key non-targeted data moments.

4.2.1 Targeted Moments

This section presents measures of goodness of fit for the baseline model. Figure 3 shows the earnings moments for a simulated sample of individuals in the model versus the CPS data.[16] As the figure shows, the model does a reasonably good job of fitting the evolution of mean earnings over the life cycle, though the model's profile is a bit less hump-shaped than in the data. The skewness of earnings is a touch lower in the model than in the data. And, for the Gini coefficient, the model matches the data quite well, except perhaps in the last few years of the life cycle.

We next look at the model's predictions for college investment behavior by initial wealth. Table 3 shows college enrollment and completion rates by level of initial financial wealth; where "low" refers to the bottom quartile, "medium" to the two middle quartiles, and "high" to the top quartile of the distribution of initial wealth. As can be seen, the baseline calibration captures well the fact that both enrollment and completion rates are strongly increasing in the level of initial wealth.

Table 3: Targeted Moments Data vs Model: Enrollment and Completion

Initial wealth	Benchmark	Data (BPS)
College Enrollment	**54**	**47**
Low	35	34
Medium	55	47
High	74	62
College Completion	**49**	**45**
Low	43	37
Medium	49	45
High	57	60

4.2.2 Non-Targeted Moments

We demonstrate now that our model performs well along relevant non-targeted dimensions. Given our focus on the payoff to investment opportunities, key among these is earnings across education levels over the life cycle. Note that our calibration only targeted overall earnings and not earnings

[16] As a measure of goodness of fit, we use $\frac{1}{3J}\sum_{j=5}^{J}|log(m_j/m_j(\gamma))| + |log(d_j/d_j(\gamma))| + |log(s_j/s_j(\gamma))|$. This represents the average (percentage) deviation, in absolute terms, between the model-implied statistics and the data. We obtain a fit of 8% (where 0% represents a perfect fit).

Figure 3: Life-cycle earnings statistics

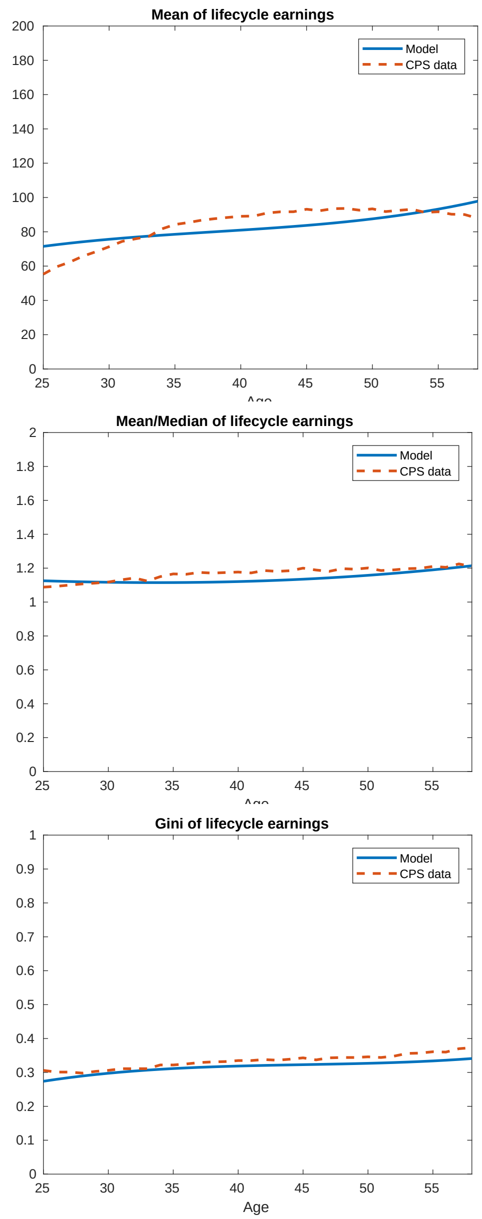
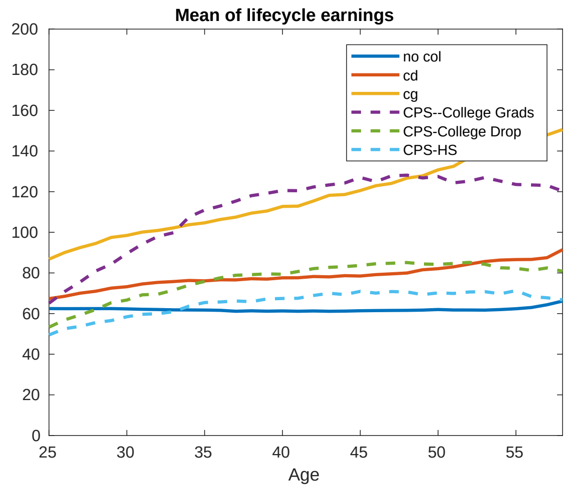


Figure 4: Life-Cycle Earnings by Education Group



by education group. Figure 4 shows that our model nonetheless delivers the pattern seen in the data of mean earnings by education group over the life cycle.

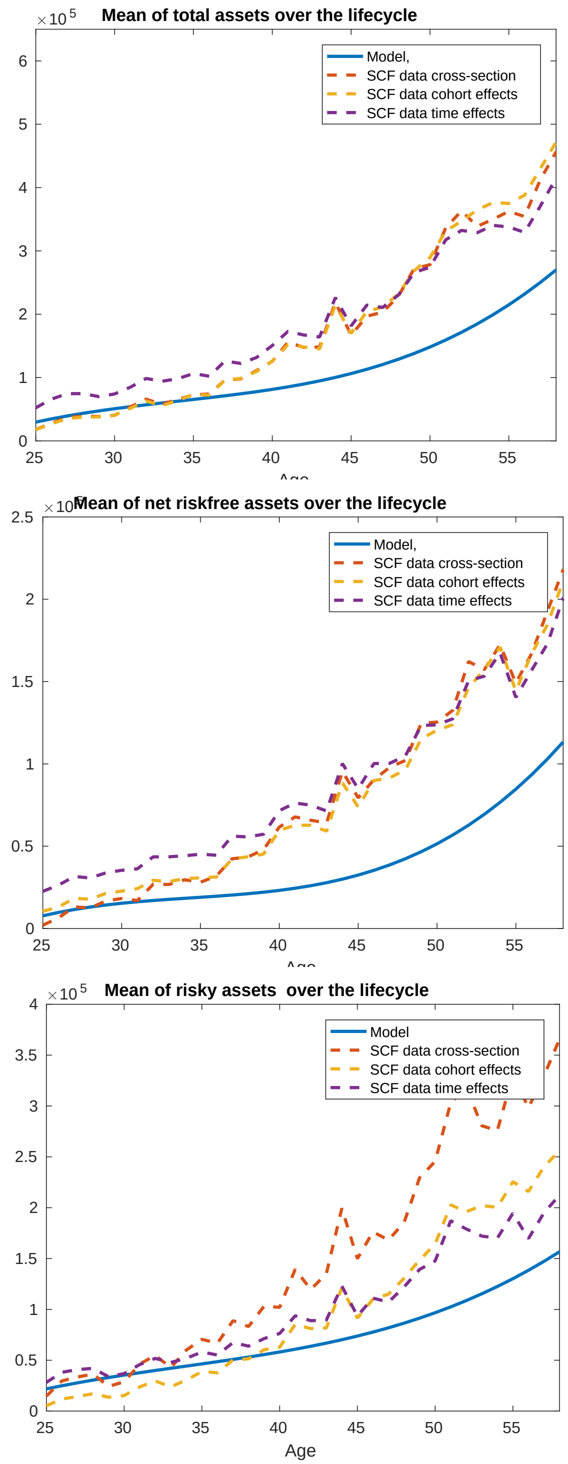
We next examine college enrollment and completion behavior by individual characteristics. As seen in Table 4, the model predicts that both college enrollment and completion rates are increasing in ability and in initial human capital. While there is no direct data counterpart to the notions of ability and initial human capital as represented in the Ben-Porath setting, we see that when college investment behavior is ordered by SAT score—arguably the most widely used measure of college readiness—the model's implications are clearly borne out in the data.

Table 4: Non-Targeted Moments: Enrollment and Completions by Characteristics

Characteristic	Ability	Initial Human Capital	Data: SAT scores
College Enrollment			
Low	9	26	53
Medium	63	65	65
High	85	64	85
College Completion			
Low	20	27	30
Medium	42	48	50
High	64	68	69

We now look at the model's predictions for financial wealth. Figure 5 shows the mean wealth accumulation over the life cycle for total assets as well as for risky and risk-free assets. Overall, the model is consistent with the overall trajectory of wealth accumulation but underpredicts mean wealth by age. We note that mean wealth in the US data is strongly influenced by the extreme

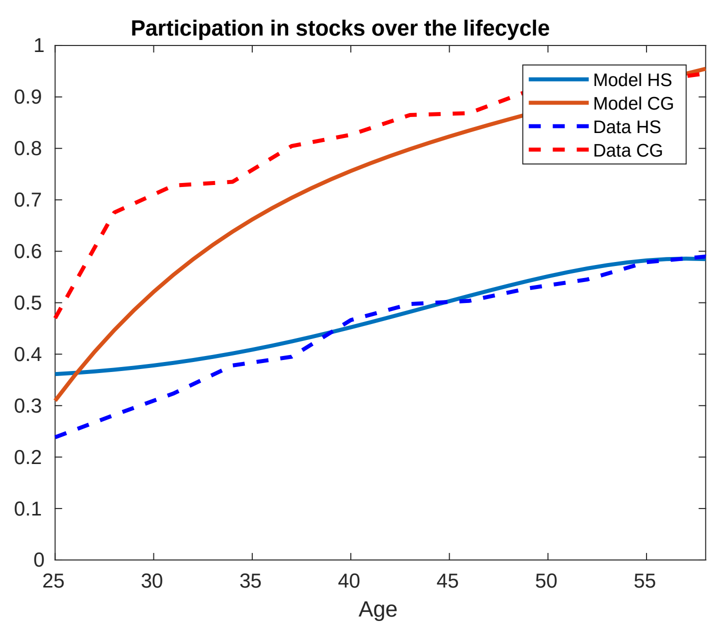
Figure 5: Life-Cycle Wealth Accumulation



right tail of the distribution. Indeed, this has led models aimed at capturing the skewness of wealth to employ earnings processes in which agents receive extremely large but transitory shocks to earnings with extremely low probability (Castaneda et al., 2003). As a result, the presence or absence of such improbable shocks is unlikely to be quantitatively important for wealth at the individual level.

Finally, we observe that our model's prediction for the stock-market participation rate is consistent with the data, over the entire life cycle and by education groups. This result is driven primarily by the presence of human capital. Human capital is an attractive investment early in life, especially for those with a combination of high learning ability and relatively low initial human capital: the opportunity cost of spending time learning—forgoing earnings—is relatively low, the marginal return to learning is high, and the horizon over which to recoup any payoff from learning is long. Further, anticipating rising earnings over the life cycle, households who invest in human capital early in life will desire, absent risk, to avoid large positive net positions in financial assets when young. As they age and accumulate human capital, these households will find further investment in human capital less attractive as the marginal return decreases and opportunity cost increases. These high earners will then accumulate wealth and participate in the stock market at high rates. This mechanism, illustrated in detail in Athreya et al. (2015), delivers a profile of aggregate stock market participation that is consistent with data, as Figure 6 shows.

Figure 6: Stock Market Participation over the Life Cycle by Education Groups



5 Results

A natural way to assess the value of access to college and stocks across individuals is to compare decisions and outcomes in our baseline economy (in which individuals have access to both college and stocks) to those obtaining under two alternatives: (i) an economy with no college and (ii) an economy with no stocks. The decisions we examine include college enrollment and completion (in the no stocks economy) and stock participation rates and portfolio shares (in the no college economy). We then examine the effect of these decisions on outcomes, which include absolute measures of well-being (see section 5.2), such as gains in earnings, wealth, and utility (in consumption terms), and relative measures, such as mobility (see section 5.3). Taken as a whole, the results deliver a clear message: the value of access to college and the stock market varies greatly across individuals.

The presence of substantial heterogeneity in the valuations that individuals place on access to college and the stock market raises a normative question. Would some individuals prefer receiving a subsidy that aids access to the stock market instead of the subsidy currently flowing to college? To answer this, in Section 5.4 we ask who would gain from a setting in which college was no longer subsidized but an equivalent subsidy was instead given in the form of shares in a stock index fund available at retirement.[17] As we will see, the results show that even a constrained subsidy that leaves household with exposure to a risky asset may still be preferable for some.

5.1 Investment Opportunities and Individual Decisions

In order to understand the implications of access for different individuals, we first report how decision-making changes when investment opportunities are taken away. We first compare behavior across types in the benchmark economy to that occurring when stocks become unavailable. Table 5 shows that, absent the option to invest in stocks, college enrollment jumps up, with the jump being most pronounced for members of the lowest quartiles of any of the three dimensions of initial characteristics. As one might expect, completion rates are generally lower, as additional enrollees are drawn from group less likely to be well-positioned to complete college. Working against is the fact that college completion is partially dependent on effort, lowering or even closing the gap in completion rates across the two economies. The "forced migration" to college of those who would otherwise have invested in stocks shows clearly that, despite being subsidized, college is a second-best investment for many in our model.

[17] We impose this restriction because it is trivially the case that all individuals will be better off by receiving the amount of the college subsidy as a transfer at the beginning of life. After all, such a subsidy simply moves individuals from a status quo with in-kind transfers (the college subsidy) to a regime with pure cash transfers.

Table 5: Investment Opportunities and College Enrollment and Completion

	Enrollment		Completion	
Characteristic	Benchmark	No Stocks	Benchmark	No Stocks
Ability				
Low	9	68	20	29
Medium	63	100	42	42
High	85	100	64	65
Initial Human Capital				
Low	26	72	27	27
Medium	65	97	48	39
High	64	100	68	63
Initial Wealth				
Low	35	80	43	40
Medium	55	94	49	44
High	74	100	57	51

We now demonstrate that individual decisions to invest in the stock market change meaningfully when college is unavailable [Table 6 to be completed]. This is particularly true for individuals with high ability and initial human capital. We remind the reader that the removal of college in our model does not mean the removal of the ability to augment human capital. That option is always available through the standard Ben-Porath technology. Thus in our model the removal of college constitutes the removal of the means to accelerate human capital accumulation.

Table 6: Investment Opportunities and Stock Market Participation and Shares

Characteristic	Benchmark	No College	Benchmark	No College
Ability				
Low				
Medium				
High				
Initial Human Capital				
Low				
Medium				
High				

5.2 Lifetime Earnings and Wealth

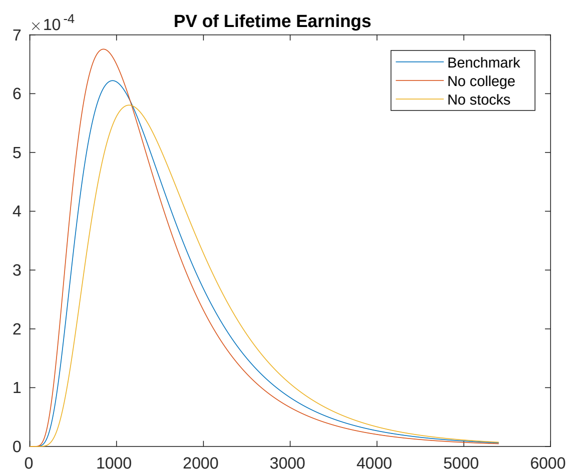
Having examined the changes in decision-making that result from removing access to college or stocks, we now compare the average of type-specific outcomes in the baseline economy to those arising under each of the alternatives in Table 7.

Table 7: Investment Opportunities and Mean Lifetime Earnings, Wealth, and Utility (Relative to Benchmark)

Mean of Lifetime	Benchmark	No College	No Stocks
Earnings	1	0.913	1.11
Wealth	1	0.903	1.12
Utility	1	0.972	0.973

For the average individual, removal of access to college, all else equal, leads to a 9% mean reduction in lifetime earnings and a 10% mean reduction in lifetime wealth. Removal of access to stocks, all else equal, leads to *increases* in both earnings and wealth in excess of 10%. This follows from the changes in decision-making documented above: increased college enrollment and attainment leads to higher earnings. In terms of utility, however, we see that as must be the case, individual, and hence average, utility falls by roughly the same magnitude when agents lose either investment option.

Figure 7: Earnings Distribution Across Economies



The effect of access varies substantially across agent types as Figure 7 shows. To describe who is most impacted, we look at the change in mean earnings across types. For convenience, the results, presented in Table 8, are averaged across all individuals within, respectively, the bottom quartile ("low"), the two middle quartiles ("middle"), and the top quartile ("high") of ability, initial human capital stock, and initial wealth.

Table 8: Heterogeneity in the Value of Stocks and College: Lifetime Earnings

	Benchmark	No College	No Stocks
Ability			
Low	1	1	1.10
Middle	1	0.86	1.19
High	1	0.94	1.03
Initial human capital			
Low	1	0.85	1.06
Middle	1	0.90	1.14
High	1	0.94	1.09
Initial wealth			
Low	1	0.93	1.13
Middle	1	0.91	1.12
High	1	0.90	1.08

Agents at the bottom of the ability distribution, perhaps naturally, experience virtually no loss in earnings when college becomes inaccessible to them. This occurs simply because, as seen in Table 4 so few in this group (9 percent) attended college when it was available. By contrast, those with medium and high ability enroll at far higher rates (63 and 85 percent respectively) and experience greater earnings losses (14 percent and 6 percent respectively). For these groups of agents, the removal of access to college is clearly binding and thus generates significant earnings losses. However, those with the highest ability are able to fairly effectively offset lack of access to college through additional effort in human capital accumulation throughout life. This explains the smaller earnings losses experienced by those in the top quartile of the ability distribution relative to those in the middle two quartiles despite benchmark college enrollment being higher for the former.

Turning next to the consequences of access to college across individuals with different initial human capital, we see that while agents in all quartiles lose from a loss of access to college, those in the lowest quartile lose the most. This is a consequence of the fact that the marginal reward to time spent on human capital accumulation is highest for those in the lowest quartile, in part because of the low opportunity cost of time for this group. As a result, access to college is particularly fruitful for them. For their counterparts with more initial human capital, this effect, while still operative, is muted.

When unpacked by initial wealth, the value of access to college shows less heterogeneity. Enrollees in the lowest wealth quartile are disproportionately those with high ability or low initial human capital within the quartile. These are the types who stand to gain the most from college. However, the majority of low wealth individuals do not enroll in college. As a result, the average loss in earnings is the smallest among wealth quartiles. Conversely, the simple fact that those in the highest wealth quartile enroll at high rates clarifies that college is an investment option whose disappearance matters substantially. This is seen in the fact that the highest earnings loss is borne by individuals in this quartile.

Finally, what are the implications for different types of individuals of the loss of access to the stock market? The rightmost column that earnings in fact increase; this follows from the fact that enrollment in college jumps when stocks become unavailable. The highest earnings gains accrue to agents in the middle of the ability and human capital distribution: with the stock market no longer an option, these individuals enroll in, and by virtue of their attributes, complete, college at relatively high rates. By contrast, notice that those with high ability were enrolling at high rates (85 percent) in the benchmark and thus experience smaller earnings gains. Lastly, with respect to the importance of initial wealth, notice that the earnings gains are again smallest for the most fortunate. This reflects the smaller change in their college enrollment behavior relative to their lower wealth counterparts.

5.3 Mobility

Our analysis above aimed at understanding how different individuals (who vary in their initial conditions) gain in absolute terms from access to the option of a college education and the option to invest savings into high-return equity. We now examine the implications of the investment opportunity set for the probability of moving across the ranks of the (cross-sectional) earnings distributions over the course of the life cycle.

The above examination of changes in lifetime earnings and wealth for individuals, by definition, did not require reference to any measures of an economy-wide distribution. Our notion of mobility, however, does, since it requires assigning a location to an individual within a distribution—where the latter is necessarily connected to the *aggregate* of decisions by all in the economy. It should therefore be kept in mind that the measures of mobility we report are those that would emerge from changes in the investment opportunity set, all else equal.

The three panels of Figure 8 show the effect of differential investment opportunities on mobility as measured by the proportions of individuals who migrate, between early working life (age 1) and late working life (age J) between the four quartiles of the earnings distribution. Importantly, because earnings are partly endogenous—they depend on time allocation choices—we define earnings as "potential" earnings: that which would accrue to individuals if they worked full time. This allows for a single notion of earnings for each agent type, defined at the beginning of working life.

We see first that mobility in the benchmark economy is lowest "in the tails": Among those who begin life at either the bottom or the top quartile of earnings, nearly 80 percent remain there at the end of working life. The middle quartiles show substantially more mobility. These patterns are in keeping, qualitatively, with empirical evidence on earnings mobility.

Turning next to the implications for individuals of losing access to college, we see that mobility is even lower at the extremes, especially among the lowest earners. Note though, that in the second quantile, measured upward mobility is slightly higher in the absence of college. This reflects the fact (seen in Figure 7) that the earnings distribution is compressed in the absence of college making the gains in earnings required to move across quartiles smaller.[18]

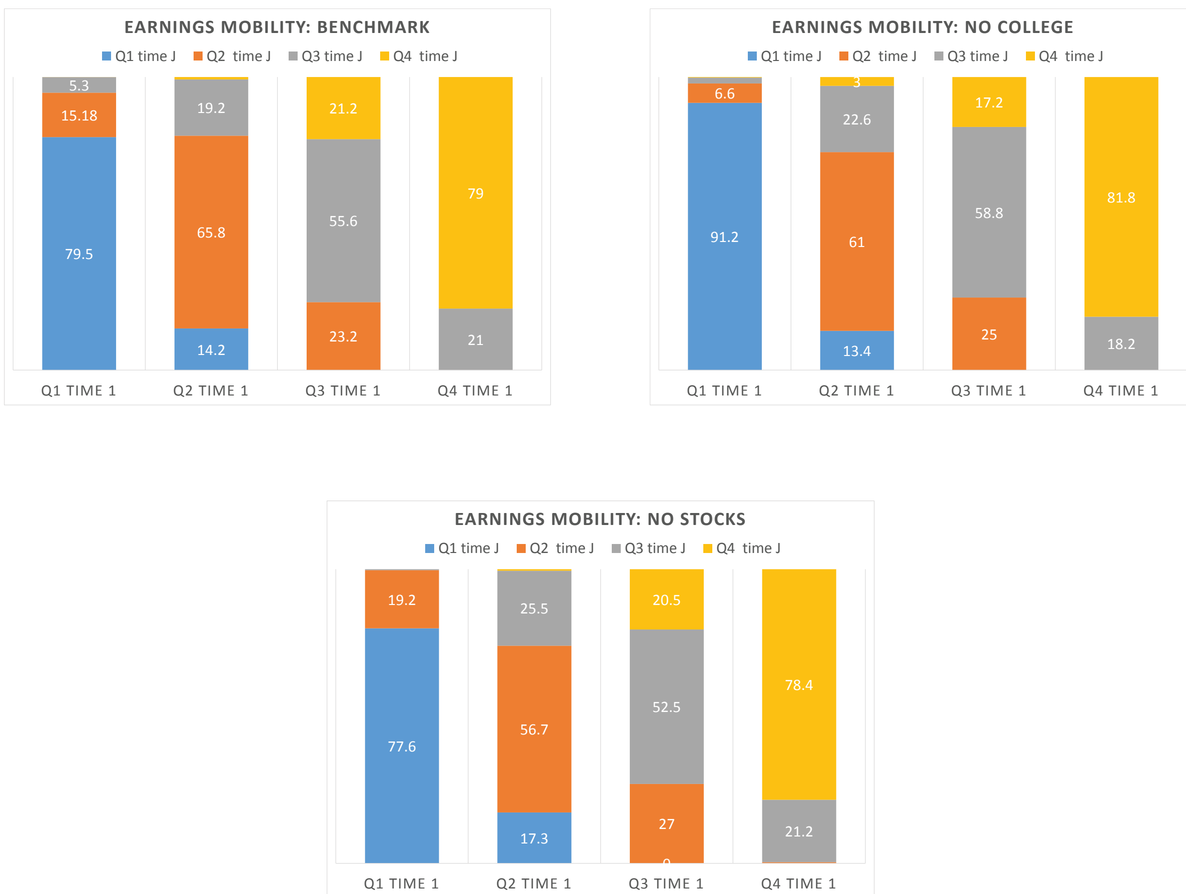


Figure 8: Earnings Mobility Across Environments

Lastly, the implications of access to the stock market for earnings mobility are essentially

[18]Notice, in fact, that for those who start in the second quartile the baseline economy offers essentially zero probability of reaching the top quartile whereas, when college is not available, this probability, while still small, is visibly higher.

minimal, except for those in the second quartile. As described earlier, the absence of stocks leads to higher college enrollment, and therefore slightly higher upward mobility, for those in this quartile.

The results on mobility that we have presented so far are "unconditional" in the sense that they are silent about "who" experiences what change to mobility across the environs under study. In Table 9, we present results organized by each dimension of initial heterogeneity, averaging over all others. For example, the top row of the table shows—for all agents in the bottom quartile of the ability distribution—the probability of reaching the top quartile of earnings at the end of working life conditional on beginning working life in the bottom quartile of earnings. All other rows are defined analogously.

Beginning with ability, we see that across the ability distribution, access to college, perhaps surprisingly, has little impact on mobility. The small differences between the first two columns of Table 9 make this clear. This suggests that the Ben-Porath human accumulation mechanism, available to agents even in the absence of college, preserves mobility patterns. This does not imply that earnings are unaffected: recall from Table 7 that average earnings are nearly 10 percent lower when college is unavailable. The elimination of access to stocks does have effects on measured mobility. As described earlier the absence of the stock market leads to much higher college enrollment across the entire ability distribution, making the probability of upward mobility less disparate across ability types.

Table 9: Upward Mobility and Heterogeneity

	Baseline	No College	No Stocks
Ability			
Q1	0.1	0.2	13.6
Q2	1.5	2.9	20.5
Q3	19.0	15.4	27.5
Q4	79.4	81.5	40.0
Initial Wealth			
Q1	11.0	0.2	13.8
Q2	18.5	3.0	19.3
Q3	27.8	12.3	26.9
Q4	42.7	84.5	39.0

We do not report results by quartiles of initial human capital because human capital and earnings are correlated one-for-one (this follows from our definition of potential earnings), leaving no mass of agents with medium- or high-initial capital in the bottom quartile of earnings by definition. Finally, turning to initial wealth, we see that the absence of college intensifies immobility: those in the lowest quartile of wealth have essentially no chance of reaching the top quartile of earnings while those at the top are virtually assured a place at the top of the earnings distribution. By contrast, when college is available (with or without stocks) initial wealth is far less influential in the likelihood that one reaches the top quartile of earnings.

5.4 The Role of Investment Financing

We now turn to the question of whether some individuals would not be better off receiving the per-capita subsidy currently flowing to college in the form of a stock index fund available at retirement. We implement this by changing the direct cost of college to what it would be were tuition not subsidized. This translates into an increase in college costs of 21,300 in 2014 dollars, which defines the subsidy currently in place. The thought experiment is one where this subsidy is then placed at the beginning of working life into a stock index fund where it then accrues, subject to the same stochastic process governing returns to stocks in the benchmark environment.

Table 10 averages the earnings, wealth, and utility changes experienced by different agent types were they to individually receive the current college subsidy in the form of a stock index fund instead. Perhaps unsurprisingly, we see that the average of earnings changes falls. This is a consequence of the fact that many individuals would choose not to enroll in college absent the direct subsidy (see Table 11). For example, we see that only 4 percent of those with even intermediate levels of ability ("medium"), would enroll in college without the subsidy, compared to the 63 percent in the benchmark economy. These reductions are also seen among individuals poorly positioned for college success: only 5 percent of those with low initial wealth choose to enroll in college compared to 35 percent in the benchmark. Naturally, the vast majority of those best prepared for college in terms of ability enroll in college even when it is unsubsidized (79 percent of them, compared to 85 percent in the benchmark).

These results then explain the dispersion in earnings gains across agent types. We see that for those with low ability, the move to stock subsidies allows them to avoid an often fruitless investment in college (as seen in the low completion rates presented in Table 12), and thereby experience a slight increase in overall earnings. For those with high initial wealth, the stock subsidy provides a cushion that enables agents to work harder to successfully complete college (66 percent vs 57 percent), which translates into a substantial gain in earnings.

Taken as a whole, these results are striking; they suggest the presence of a large population "inframarginal" to college, and hence a large group who would value—often substantially—a transfer in a form other than the current direct subsidy that does not discriminate by type. We stress that this result must be interpreted as a statement about *individuals* under the *current* subsidy regime:

it tells us that many are simply not positioned to derive significant benefits from a program that applies so evenly across all would-be enrollees.

Table 10: Change in Lifetime Earnings, Wealth, and Utility Due to Subsidy Reallocation

	Benchmark	Stocks subsidy
Earnings	1	0.94
Wealth	1	0.93
Utility	1	1.015

Table 11: Change in Lifetime Earnings by Type Due to Subsidy Reallocation

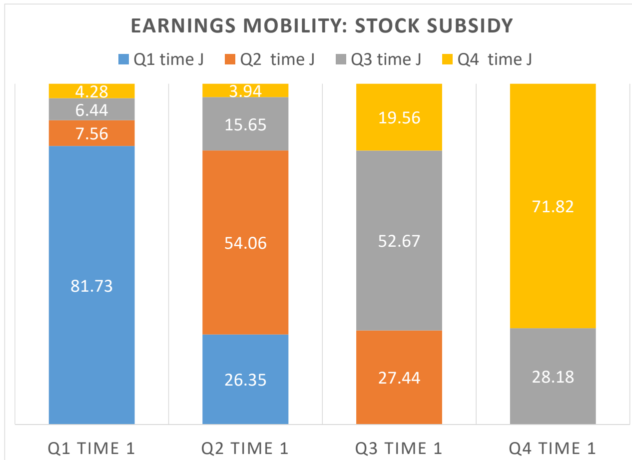
	Benchmark	Stocks Subsidy
Ability		
Low	1	1.02
Middle	1	0.88
High	1	0.97
Initial human capital		
Low	1	1.3
Middle	1	0.83
High	1	0.96
Initial wealth		
Low	1	0.73
Middle	1	0.77
High	1	1.32

Table 10 shows that for the average individual, the reallocation of public support away from college has important implications earnings and wealth. The former is about 6 percentage points lower, and the latter about 7 percentage points lower. The implications for the average individual are consistent with what might be expected given the payoffs to college completion, and the average completion rate among individuals. These results suggests that for the average US individual, the present regime for college subsidies provides a significant boost to lifetime earnings and wealth relative to what an alternative favoring stocks purchases would. Most importantly, notice that despite the average person's earnings being lower, all else equal, in the absence of a college subsidy, utility is higher.

However, the goal of this paper has been to capture the heterogeneity in payoffs to college and stock investments that might plausibly arise from heterogeneity in initial conditions. Table 11 therefore unpacks that implications of Table 10 across subgroups in the population.

Table 11 shows that for many subgroups of individuals, earnings would be lower if they were given the stock subsidy rather in place of the college subsidy. However, this is not the whole story.

Figure 9: Earnings Mobility: Stocks Subsidy



Notice that for individuals with the lowest chances of success in college, i.e., those in the lowest quartile of either initial ability or initial human capital, this is reversed. Indeed for individuals who start with very low human capital, the correlation between it and ability dulls the benefits of college very substantially—leading the members of this group to lose almost 30% from the status quo. Similarly, for those in the lowest ability quartile, the status quo leads to a loss, all else equal, of 2 percent. Lastly, and perhaps unsurprisingly, the status quo costs the wealthy the opportunity to further add to their wealth, while those with lower wealth—for whom college was a ticket to high earnings and then high asset accumulation—gain from the status quo. Our findings illustrate that the value of access to college, and therefore the value of even a uniform subsidy, varies dramatically in the cross section. They support the conjecture made at the outset that a subsidy to an alternative investment whose value does not derive from individual characteristics may well be preferred by many.

Table 12: Subsidy Reallocation and College Enrollment and Completion

Characteristic	Benchmark	Stock Subsidy	Benchmark	Stock Subsidy
Ability				
Low	9	0.5	20	0
Medium	63	4	42	43
High	85	79	64	65
Initial Human Capital				
Low	26	1	27	36
Medium	65	16	48	54
High	64	52	68	69
Initial Wealth				
Low	35	5	43	56
Medium	55	20	49	62
High	74	44	57	66

6 Conclusion

Does the power of college to increase well-being routinely exceed that of other investments, as its uniquely high subsidization suggests? Perhaps not: for roughly 46 percent of individuals, access to college affects well-being negligibly. It is only for those whose initial conditions best poise them for success that college is worth substantially more (11 percent in consumption-equivalent terms). This suggests that investments whose returns do not depend on individual characteristics may be substantially more effective in improving the well-being of some. The stock market, which offers comparably high returns and risk, is a natural alternative. We find that 52 percent of high-school graduates would, all else equal, prefer a stock-index retirement fund to the subsidy currently flowing to college.

Our approach in this paper has been to measure, via select counterfactuals, individual-level variation in the valuation of investment opportunities. Our findings are therefore not to be taken as statements about the effects of economy-wide changes to public policy as it relates to college and the stock market. Such exercises, while certainly of interest, would not provide an assessment of investment opportunities for individuals in the status quo, and are therefore left for future work.

References

Abbott, B., G. Gallipoli, C. Meghir, and G. L. Violante (2013). Education policy and intergenerational transfers in equilibrium. Working Paper 18782, National Bureau of Economic Research.

Akyol, A. and K. Athreya (2005). Risky Higher Education and Subsidies. *Journal of Economic Dynamics and Control 29*(6), 979–1023.

Altonji, J. G., P. Arcidiacono, and A. Maurel (2015). The analysis of field choice in college and graduate school: Determinants and wage effects. Working Paper 21655, National Bureau of Economic Research.

Altonji, J. G., E. Blom, and C. Meghir (2012). Heterogeneity in human capital investments: High school curriculum, college major, and careers. *Annu. Rev. Econ. 4*(1), 185–223.

Arcidiacono, P. (2004). Ability sorting and the returns to college major. *Journal of Econometrics 121*(1), 343–375.

Arcidiacono, P. (2005). Affirmative action in higher education: how do admission and financial aid rules affect future earnings? *Econometrica 73*(5), 1477–1524.

Arcidiacono, P., V. J. Hotz, and S. Kang (2012). Modeling college major choices using elicited measures of expectations and counterfactuals. *Journal of Econometrics 166*(1), 3–16.

Athreya, K., F. Ionescu, and U. Neelakantan (2015). Stock market participation: The role of human capital. Working paper, Federal Reserve Bank of Richmond.

Athreya, K. B. and J. Eberly (2013). The supply of college-educated workers: the roles of college premia, college costs, and risk. Working paper, Federal Reserve Bank of Richmond.

Autor, D., F. Levy, and R. Murnane (2003). The Skill Content of Recent Technological Change: An empirical exploration*. *Quarterly Journal of Economics 118*(4), 1279–1333.

Bach, L., L. E. Calvet, and P. Sodini (2016). Rich pickings? risk, return, and skill in the portfolios of the wealthy.

Ben-Porath, Y. (1967). The production of human capital and the life cycle of earnings. *Journal of Political Economy 75*(4), 352–365.

Board of Governors of the Federal Reserve System (2014). Federal reserve statistical release, g19, consumer credit. Technical report, Board of Governors of the Federal Reserve System.

Bound, J., M. F. Lovenheim, and S. Turner (2010). Why Have College Completion Rates Declined? An Analysis of Changing Student Preparation and Collegiate Resources. *American Economic Journal: Applied Economics 2*(3), 129–57.

Browning, M., L. P. Hansen, and J. J. Heckman (1999). Micro data and general equilibrium models. *Handbook of macroeconomics 1*, 543–633.

Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. *Econometrica 69*(5), 1127–1160.

Castaneda, A., J. Diaz-Gimenez, and J.-V. Rios-Rull (2003). Accounting for the us earnings and wealth inequality. *Journal of political economy 111*(4), 818–857.

Cestau, D., D. Epple, and H. Sieg (2015). Admitting students to selective education programs: Merit, profiling, and affirmative action. Technical report, National Bureau of Economic Research.

Chatterjee, S. and F. Ionescu (2012). Insuring Student Loans Against the Financial Risk of Failing to Complete College. *Quantitative Economics 3*(3), 393–420.

Cocco, J. (2005). Portfolio choice in the presence of housing. *Review of Financial Studies 18*(2), 535–567.

Cocco, J., F. Gomes, and P. Maenhout (2005). Consumption and portfolio choice over the life cycle. *Review of Financial Studies 18*(2), 491–533.

Epple, D., R. Romano, S. Sarpça, and H. Sieg (2013). The us market for higher education: A general equilibrium analysis of state and private colleges and public funding policies. Technical report, National Bureau of Economic Research.

Fagereng, A., L. Guiso, D. Malacrino, and L. Pistaferri (2016, November). Heterogeneity and persistence in returns to wealth. Working Paper 22822, National Bureau of Economic Research.

Garriga, C. and M. Keightley (2007). A general equilibrium theory of college with education subsidies, in-school labor supply, and borrowing constraints. federal reserve bank of st. Technical report, Louis Working Paper Series 2007-051A.

Goldin, C. and L. F. Katz (2007). Long-Run Changes in the Wage Structure: Narrowing, Widening, Polarizing. *Brookings Papers on Economic Activity* (2), 135.

Hendricks, L. and O. Leukhina (2014). The return to college: Selection and dropout risk.

Hendricks, L. and O. Leukhina (2017). How risky is college investment? *Review of Economic Dynamics 26*, 140 – 163.

Hendricks, L. and T. Schoellman (2014). Student abilities during the expansion of us education. *Journal of Monetary Economics 63*, 19–36.

Hubbard, R., J. Skinner, and S. Zeldes (1994). Expanding the Life-cycle Model: Precautionary Saving and Public Policy. *The American Economic Review 84*(2), 174–179.

Huggett, M., G. Ventura, and A. Yaron (2006). Human capital and earnings distribution dynamics. *Journal of Monetary Economics 53*(2), 265–290.

Ionescu, F. (2009). The Federal Student Loan Program: Quantitative Implications for College Enrollment and Default Rates. *Review of Economic Dynamics 12*(1), 205–231.

Johnson, M. T. (2013). Borrowing constraints, college enrollment, and delayed entry. *Journal of Labor Economics 31*(4), 669–725.

Jones, J. B. and F. Yang (2016). Skill-biased technical change and the cost of higher education. *Journal of Labor Economics 34*(3), 621–662.

Judd, K. L. (2000). Is education as good as gold? a portfolio analysis of human capital investment. *Unpublished working paper. Hoover Institution, Stanford University*.

Kim, H. H., R. Maurer, and O. S. Mitchell (2013). Time is money: Life cycle rational inertia and delegation of investment management. Technical report, National Bureau of Economic Research.

Manski, C. F. and D. A. Wise (1983). *College choice in America*. Harvard University Press.

McGrattan, E. R. and E. C. Prescott (2000). Is the stock market overvalued? *Federal Reserve Bank of Minneapolis Quarterly Review 24*(4), 20–40.

Mehra, R. and E. C. Prescott (1985). The equity premium: A puzzle. *Journal of Monetary Economics 15*(2), 145–161.

Ozdagli, A. K. and N. Trachter (2011). On the Distribution of College Dropouts: Household Wealth and Uninsurable Idiosyncratic Risk. Working paper series, Federal Reserve Bank of Boston.

Peri, G. and C. Sparber (2007). Task specialization, comparative advantages, and the effects of immigration on wages. Technical report, National Bureau of Economic Research.

Planty, M., W. Hussar, T. Snyder, S. Provasnik, G. Kena, R. Dinkes, A. KewalRamani, and J. Kemp (2008). The condition ofeducation 2008.

Restuccia, D. and C. Urrutia (2004). Intergenerational persistence of earnings: The role of early and college education. *The American Economic Review 94*(5), 1354–1378.

Stange, K. M. (2012). An empirical investigation of the option value of college enrollment. *American Economic Journal: Applied Economics 4*(1), 49–84.