College Enrollment and Attainment: The Roles of Risk, Skill Premia, and Policy*

[PRELIMINARY AND INCOMPLETE: DO NOT CITE]

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Abstract

Despite a seemingly large college skill-premium, close to one-third of all high-school graduates currently do not enroll in any form of college. Moreover, while increases in the skill premium have been accompanied by increases in enrollment since 1980, college attainment has remained flat. In this paper, we provide a simple quantitative explanation for these two facts. We first show that movement in the skill premium from the levels seen in 1980 to those seen in present-day data will, if expected to pervail over working life, alter enrollment rates in the ways observed. We then show that changes in skill premia above current levels will not likely lead to far higher enrollment, and hence will not much change the stock of college-educated workers. This is because failure risk generates asymmetric changes in the net return to college investment coming from any increase in the skill premium: Those with low failure-risk see an increase in expected returns, but at current premia, are already inframarginal, while their high-failure-risk counterparts remain inframarginal. This helps explain what Altonji, Bharadwaj, and Lange (2008b) and others have termed an “anemic” or “limping” response of enrollment and skill formation to changes in skill premia. We show, however, that this not an inevitability: We find that the level of public support for higher-education matters significantly for the roles played by both skill premia and preparedness in enrollment decisions.

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1 Introduction

The college skill premium is large and has been for several decades. At current premia, an individual who completed college would earn over her lifetime nearly twice as much in present value terms as her non-college-educated counterpart.\textsuperscript{1} At least in terms of \textit{ex-post} rewards, therefore, college-level human capital appears to generate an enormous premium, and one that far exceeds that historically available on financial market (traded) equity. At its peak, the financial market equity premium identified by Mehra and Prescott (1985) averaged 6%. By contrast, nearly all estimates of the college premium place its return far higher, having consistently averaged approximately twice that much. Depending on the measure used, returns to college are routinely measured at between 10 and 15\%, (see, e.g. Goldin and Katz (2008), Heckman, Lochner, and Todd (2008)).

A second feature of the higher education landscape concerns the \textit{magnitude} of the co-movement of the skill composition of the labor force and the college premium. When measured by the ratio of average hourly wages of skilled to unskilled workers, the college premium increased by nearly twenty percentage-points between 1980 and 1996 (see Goldin and Katz (2008)). However, the proportion with college education did not follow suit. In fact, the fraction of 25-29 year olds who had attained a bachelor’s degree increased only slightly. Goldin and Katz (2008), for example, document (pp. 249-250) that four-year college graduation rates at the cohort level plateaued for men around 1980, something seen in earlier work of Kane (2001) as well.\textsuperscript{2} The bulk of the change in college attainment over this period is mainly accounted for by the rapid increase of female enrollees. Such changes, however, were arguably part of a more secular trend in both education and labor force participation rates. Averett and Burton (1996), for example, argue that changes in wage premia by themselves had little effect on female enrollment rates over this period.

The broad trends in the skill premium, college enrollment, and stock of young college educated households are shown in Figure 1. At a glance, one sees that even though enrollment is currently at its historically highest level, approximately one-third of all high-school completers still do not immediately proceed to any form of college. It also shows that even though the skill-premium rose significantly, the fraction of people who have attained college by age 25 has not changed significantly over the past three decades.

Bound, Loevenheim, and Turner (2009) report similar results, showing that not only did enrollment rates fail to rise substantially, but that they even \textit{fell} for some groups. Moreover, as documented by these authors, the eight-year completion rate for current cohorts has fallen, with those who do complete appearing to take longer to do so. Goldin and Katz (2008) report that from 1980 to 2005, the mean number of years of schooling grew by only 0.8 years, compared with numbers roughly \textit{three times} as large in the five decades from 1930 to 1980. For all these reasons, the overall response of recent enrollment—and subsequent skill formation—to

\textsuperscript{1}See e.g., Restuccia and Urrutia (2004).

\textsuperscript{2}See, e.g., Kane 2001, Figure 7.
Figure 1: The College Premium, Enrollment, and Attainment

changes skill premium itself is typically described variously as weak, “limping” (Goldin and Katz (2008), p.292), “anemic” (Altonji, Bharadwaj, and Lange (2008)), or reflective of a “supply-side blockage” (Bowen, et al. (2009)).

As long as the return to the marginal decision-maker is well-approximated by the current the skill-premium, the absence of nearly universal enrollment and a substantial increase in the stock of college-educated labor is puzzling. But the return may not, in fact, describe the payoff to the marginal entrant. As increasing numbers of attendees have enrolled in successive years, it is plausible that the proportion of poorly prepared students among the remaining population has grown. Bound, et al. (2009) find, for example, that for the 1992 high-school graduating class in the NELS: 88 dataset, 44% of those in the lowest AFQT mathematics quartile enrolled in college. Yet, only 11.4% the 1992 cohort completed a bachelor’s degree. By contrast, less than twenty years earlier, in 1976, the NLS72 data show that while the enrollment rate for such poorly prepared students was much lower, at only 21.7%, this group completed college at a much higher rate of 25.8%. ³

These facts lead, for two reasons, to the possibility that increases in the skill premium from current levels may not be powerful in spurring overall enrollment rates. First, for the poorly-prepared, the skill premium may be a poor inducement to enroll, as the likelihood of actually obtaining it may be far lower for current

³Though we will not address the issue, Heckman and LaFontaine (2010) describe an even greater barrier to college attainment: when properly measured, high-school completion rates have been stagnant, and lower than previously measured owing the non-equivalence of high-school diplomas and GEDs.
non-enrollees than past ones. And increases in premia from current levels will change expected premia by (much) smaller amounts for such would-be enrollees. Second, given that past cohorts with high completion likelihoods have enrolled at high rates at far lower skill premia, current cohorts with high likelihood of completion are unlikely to be sensitive to further premia: the college premium will simply yield more on an investment they would already have made.4

The aim of this paper is to better understand the role of the skill premium in college enrollment behavior and the skill composition of the labor force, and the importance of risk and higher education policy in affecting this role. In simple terms, we are interested in understanding the shape of the “supply curve of college-educated labor.” We find that it is steep: changes in skill premia away from current levels, all else equal, should not be met with by “large” changes in enrollment. The logic is principally that outlined above, and is the most obvious symptom that widespread inframarginality may indeed be the rule.

Our model suggests, however, that inframarginality is not an inevitability. Rather, it suggests that current behavior, especially the insensitivity of enrollment to changes in skill premia, depends strongly on the level of the premium, and the stance of higher education policy. As for the former, we first show that movement in the skill premium from the levels seen in 1980 to those seen in present-day data will, if expected to prevail over working life, alter enrollment rates in the ways observed. As for the latter, we find that, absent current subsidy policy, the current skill premium is insufficient to generating observed enrollment. This is important given the mixed findings of empirical work on the effect of student aid to alter enrollment (see, e.g. Dynarski (1993)). Our model suggests that direct-subsidies, which keep the cost of public 4-year college relatively low, are important to generating current enrollment rates at current skill premia.5

As seen above, ongoing discussions of enrollment, particularly in popular accounts, current premia are frequently linked to current enrollment decisions. However, it is clear that current skill premia need not have any bearing on current enrollment rates, unless the latter is expected to remain at or near its current level. One cannot speak of enrollment being “high” or “low” with respect to current premia alone. Indeed, the currently observed college premium, precisely because it is historically high, perhaps should not to be expected to prevail over the working lives of current enrollees. An important aspect of our paper is its allowance for the role played by the entire path of future skill premia on current enrollment decisions.

Our approach also emphasizes the role of uninsurable risks associated with the collegiate investment decision. This is motivated by several related pieces of evidence. Most importantly, there is abundant evidence for “completion risk,” as measured by the probability that a student will fail to complete college.4

4 While we do not focus on the issue here, this may be part of why income and inequality and skill premia have risen together over the past three decades (see e.g. Diaz-Jimenez et al. (2011)).

5 Our calculations have some bearing on the nature of marginal returns to education. This is an area where empirical work has constructed measures under increasingly weak conditions, see Carneio, Heckman, and Vytlacil (2011) for a useful explanation of the issues. Our approach, by contrast, imposes substantial structure up front, and seeks to infer the implications for the returns faced by agents at varying levels of failure risk, skill premia, and college costs.
Failure rates at public 4-year colleges, which account for the majority of undergraduate enrollment, are approximately 50% (see e.g. Bowen et al. (2010), Bound, Loevenheim, and Turner (2007), Hendricks and Leukhina (2011)). Second, the uncertainty over eventual completion is not quickly resolved: it takes, between two and three years of foregone earnings and the explicit cost of tuition (see Bowen et al. (2009), and Ozdagli and Trachter (2011)). Third, from all available evidence, the return to partial completion of college is low (i.e. attending but not obtaining a diploma); early documentation includes Psacharapoulous and Layard (1974), and more recently Hungerford and Solon (1987). Lange and Topel (2006) argue forcefully, in turn, that the most reasonable interpretation of this is that students learn about their future productivity, and take the data as suggesting that the bulk of learning takes place in the latter parts of college. The lumpiness of initial investment along with the poor returns to non-completers render failure risk potentially very important to would-be enrollees.

The final category of risk we allow for is that governing the return even upon completing college. On this point, a vast literature, starting perhaps most famously with Lillard and Willis (1978) and continuing to the present (e.g. Heathcote, Storesletten, and Violante (2009)) has documented the presence of significant uninsurable idiosyncratic risk (in addition to aggregate risk) in the returns to human capital. Even the successful college completer is not guaranteed anything. In particular, even college educated households face earnings processes with substantial persistent (and by several accounts, e.g. Hryshko (2010), nearly unit root) uninsurable shocks. It is therefore entirely possible for relatively young college graduates to receive earnings shocks that immediately, and substantially, lower the expected present value of remaining lifetime income. Finally, the persistence of these shocks also makes them inherently difficult to self-insure as well, making the absence of market-based insurance more problematic.

It is worth stressing that none of our results arise from frictions in credit markets. In the model, households are always capable of financing the entirety of college tuition and fees, as well as room and board. This reflects the net effect of significant policy interventions aimed at ameliorating credit-related impediments to college financing. In particular, the statutory availability of federally subsidized student loans in amounts capable of covering the entire cost of most four-year degree-granting institutions (Stafford loans, plus the PLUS loan program), and the detailed measurement of the strength of borrowing constraints for college-bound households in Carneiro and Heckman (2002), both cast serious doubt on the strength of borrowing constraints.6

However, while the high observed rates of return to investment in human capital cannot easily be ascribed directly to credit market frictions, credit use will still interact with the frictions we emphasize. Bowen et al. (2009) suggest that “borrowing aversion” may play a role in the lack of a response in enrollment to the skill

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6Recent work of Lochner and Monge-Naranjo (2011) suggests that credit constraints have been relevant in the past, but have been relaxed somewhat as the skill premium has grown—making them less relevant now.
premium even when credit availability is generous. Our model allows for borrowing to be risky. Specifically, leverage magnifies the impact of the uninsurable risks already present in the model. For a household with currently low wealth and non-trivial failure risk, for example, financing education with a fundamentally non-contingent instrument, such as debt, magnifies the risk of failure. Were default possible, this is precisely the type of event in which the bankruptcy option would be most beneficial to households. It is therefore critical that U.S. government-guaranteed student loans are explicitly non-dischargeable in bankruptcy. As a result, an enrollee who experiences failure must lower long-run consumption even more than they otherwise might have to, while also smoothing the transition. Ex-ante, the lottery over future consumption (especially in the near-term) induced by debt-financed college enrollment, ceteris paribus, makes college less attractive.

We will show that even without direct credit constraints, students do not always go to college even when the financial returns appear to be positive. Overall, our results help explain both why college enrollment is not universal, even when the rate of return appears to be high, and why enrollment appears insensitive to further increases in the skill premium.

In addition to the work cited above, our work is related to early work of Altonji (1993), Chen (2001), ongoing work of Brown, Fang, and Cocco (2011), and to a recent series of quantitative general equilibrium models of higher education, including important work of Heckman, Lochner and Taber (1998a,b) and Restuccia and Urrutia (2004), as well as He (2005), Akyol and Athreya (2005), Garriga and Keightley (2007), Gallipoli, Meghir, and Violante (2010), Ionescu (2010), Chatterjee and Ionescu (2012), Schiopu (20011), and Castex (2010a, 2010b).

While much of the preceding work studies higher education decisions in settings where enrollees may fail, few papers (e.g. Chatterjee and Ionescu (2012)) feature both failure risk and rate of return risk. An important motivation for our incorporation of substantial rate-of-return risk is the analysis of Carneiro, Hansen, and Heckman (2001). Among other measures, they estimate that less than ten-percent of the present value of earnings can be deemed predictable at the time individuals enroll in college, and also show that risk is such that the ex-post returns to college will be substantially negative for some. In related work, Brown, Fang and Cocco (2011) calculates the present value of a college investment that has already been successfully completed, and studies the role of social insurance policy in insuring the risk of unemployment subsequent to college investment. Moreover, Brown et al. (2011) do not focus, as we do, on the implications of these

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7Recent legislation has allowed for more income-based repayment options to make student loans more equity-like. However, these options are available only under limited circumstances. In practice, the Department of Education does enforce the no-bankruptcy rule, making it the largest U.S. garnisher of wages behind the IRS.

8A paper that is complementary to ours is that of Ionescu and Chatterjee (2010) who study the problem of how to insure against college failure risk, and in turn, show that an insurance program can increase enrollment rates substantially—suggesting that risk is indeed a relevant consideration in enrollment decisions.

9See Stange (2011) for a study of the “real-option” properties of college investment present in models like ours and the ones in the preceding list.

10A related message comes from Brown et al. (2011).
decisions for aggregate enrollment (derived from integrating decisions with respect to the joint distribution of households over the state-vector). Unlike Brown et al. (2011) or Hendricks and Leukhina (2011), a goal of this paper is to uncover the role of subsidy and skill premia in driving enrollment, all else equal, something that has not been tackled in existing work.

Though our model shares features with some of the work cited above, we use it to address a different set of questions than existing work does. Much of the above cited work first specifies policies, and then aims to derive their long-run implications for prices and allocations. Examples include the comprehensive efforts of Garriga and Keightley (2007) and Gallipoli, Meghir, and Violante (2010). By contrast, our interest is in understanding individual investment decisions and their dependence of on a given set of household-level attributes and prices. For a given skill premium (path) and education policy stance, we ask what, when aggregated, optimal decisions should lead one to expect vis-a-vis enrollment and failure for any given cohort, with a view to understanding the role of various forces in individual decision-making. Lastly, in the places where we do vary policy, we stress that our goal is to assess the role extant policies have played in individual decision-making, not to make statements about the effects of those policies in general equilibrium.

2 Model

All agents enter the model as young high-school completers. Their first decision is whether or not to enroll in college. After this, they become workers who make decisions over consumption and savings for the rest of their working lives and then retire. Risk is important in each of these parts of life and initially, individuals face three sources of risk. First, college is a risky investment. All potential enrollees face the chance that their investment in college may not pay off. Most immediately, this risk comes from the positive probability that they will not succeed in obtaining a degree: failure risk. Second, subsequent to completion of college investment, and regardless of its success, households face earnings risk. That is, while mean income will reflect the successful completion of college, or not, households still face income risk throughout working life. Third, all potential enrollees are restricted to the use of pure non-defaultable debt if their personal resources at the time of enrollment are insufficient to finance college investment, exposing poorer enrollees to leverage risk (and moving initially richer ones to wealth positions that are closer, ceteris paribus, to the borrowing constraint). By “leverage risk” we mean the risk of facing potentially very low consumption in the future.

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11 Our analysis is very much in the spirit of Scholz, Seshardi, and Khitatrakun (2006) in that they also study a decision problem (there, in the context of understanding savings behavior) which prices and preference parameters are imposed, and model generated data contrasted with observed data. Our question can be posed analogously to theirs as: “Are Americans Enrolling Optimally in College?”

12 In a careful paper, Castex (2010b) takes an approach similar to ours, but abstracts from both failure risk and earnings risk (and also calibrates wage-offer distributions for would-be dropouts).

13 The vast literature on human capital acquisition has long emphasized its importance (see e.g. Altonji et al. (2008), Goldin and Katz (2008)). Leveling access to education has been viewed as among the least distortionary ways in which to encourage greater equality within society. To the extent that unequal access to human capital acquisition is to blame for subsequent
arising from any sizeable debt burden, should educational investment not pay off. Leverage risk has been fairly topical in recent times (see, e.g. Cunningham and Santiago (2008)), and our model will shed some light on its strength.

### 2.1 Demographics and Preferences

Households are modeled as “Young” for $K$ model periods, where a period will be taken to be a year, to reflect the period between high school and successful college completion. Households then become “Adults” for $J$ periods, which will be set to cover the length of time between the age at college completion and retirement age, at which point they become “Retirees.” Young and Adult households order stochastic processes over consumption using a standard time-separable CRRA utility function. All households discount the future exponentially at a common rate $\beta$. Thus, within period expected discounted utility during pre-retirement life is given as: $E_0 \sum_{j=1}^{J} \beta^{j-1}.x_j$.

As Retirees, households value resources taken according to a “retirement felicity function”, $\phi$, that is defined on wealth $x_R$ taken into retirement, specified further below. Retirement felicity is also modeled as a CRRA function of retirement wealth, and also includes a weighting factor $\nu$, which will be calibrated to ensure wealth accumulation over the life-cycle is plausible. Thus, discounted utility during retirement is given as follows:

$$\phi(a_R) = \nu \frac{a_R^{1-\sigma}}{1-\sigma}$$

This approach is taken in Athreya (2008) and Akyol and Athreya (2011), and offers a convenient way of generating consumption and wealth accumulation during working life that generates the appropriate valuations of the college investment given a young agent’s state. It is particularly useful given our focus on the early-life decision problem of households who face a given skill premium and earnings and failure risk, as such decisions will remain insensitive to the temporally distant events of retirement. All households have a common discount factor $\beta$ and discount exponentially.

The general problem for the Young household is to choose consumption $\{c_k\}_{k=1}^K$ and most importantly, to make risky human capital investment (enrollment) decisions. Their enrollment decisions and the stochastic elements in their environment will leave them, eventually, with a human capital level $h \in \{HS, SC, C\}$, corresponding either to high school completion ($HS$), “some-college” ($SC$), or college ($C$) attainment. To avoid clutter, we will suppress human capital in the notation below wherever it is obvious. The realized inequality in earnings and wealth, expanding educational opportunities directly limits the growing dispersion in income and wealth that now occurs dramatically over the life-cycle (see e.g. Storesletten, Telmer, and Yaron (2004)). Of course, education has also long been viewed as an engine of growth, both through direct effects on the accumulation of a factor of production, but also through indirect “spillover” effects which hold the promise of increasing returns and thereby efficiency gains. Our model addresses the first issue, but abstracts from any growth externalities.
human capital conditional on enrolling will depend on the realization of uncertainty over college completion. Once Adults, households choose consumption \( \{c_j\}_{j=1}^J \), and wealth during working life \( \{a_j\}_{j=2}^J \), and wealth \( a_R \) with which they enter retirement.

Denoting by \( \Theta(\Psi) \) the set of feasible combinations \( \{(c_k, c_j, a_R)\} \), and given initial state \( \Psi \), the household’s optimization problem is then:

\[
\sup_{(c_k, c_j, a_R) \in \Theta(\Psi)} E_0 \sum_{j=1}^{J} \beta^j \frac{c_j^{1-\sigma}}{1-\sigma} + \phi(a_R)
\]

### 2.2 Endowments

All agents are endowed in each period with one unit of time, which they supply inelastically. However, Young and Adult households face stochastic productivity shocks to their labor supply. Because households do not value leisure, they are modeled as simply receiving stochastic endowments of the single consumption good in each period. The income process faced by households in the model is intended to represent precisely those risks which remain, net of (i) taxes, (ii) all private insurance mechanisms and (iii) all non-means-tested public insurance programs, such as the US unemployment insurance system.

A key aspect of our approach is to specify an empirically reasonable description of the risk to income, subsequent to the enrollment decision. The work of Chen (2001, 2008) in particular is suggestive in its assessment of the role played especially by persistent income risk in creating a premium, and thereby being fundamentally in the nature of a compensating differential, for investment in college. We disaggregate log endowments into three components: an age \( (j) \) and human capital-specific \( (h) \) mean of log income \( \mu_j^h \), persistent shocks, \( z_j^h \), and transitory shocks, \( u_j^h \).

As detailed further below, our specification follows Hubbard et al. (1994), and specifies log income for a household with human capital \( h \) to evolves as:

\[
\ln y_j^h = \mu_j^h + z_j^h + u_j^h
\]

where

\[
z_j^h = \rho^h z_{j-1} + \eta_j^h , \quad \rho^h \leq 1, \quad j \geq 2
\]

\[
\ln u_j^h \sim i.i.d \ N(0,\sigma_{u,h}^2), \quad \ln \eta_j^h \sim i.i.d \ N(0,\sigma_{\eta,h}^2), \quad u_j^h, \eta_j^h \text{ independent}
\]

In addition, all household begin life as unskilled households, \( h = HS \), and receive their initial realization of the persistent shock, \( z_1 \), from a distribution with different variance than at all other ages. That is,

\[\text{Standard specifications of this, are, e.g. Hubbard et al. (1995), Storesletten et al. (2004), Huggett and Ventura (2000).}\]
\[ z_1 = \xi \] (6)

where

\[ \ln \xi^h \sim N(0, \sigma^2_\xi) \] (7)

The income process can be interpreted as follows. To reflect heterogeneity prior to any direct exposure to labor market risk, households first draw a realization of the persistent shock \( z_1 \) from the random variable \( \xi \) with distribution \( N(0, \sigma^2_\xi) \). In subsequent periods, household non-asset income is determined as the sum of the unconditional mean of log income \( \mu^h_j \), the innovation to the persistent shock \( \eta^h_j \) and the transitory shock, \( u^h_j \). The shocks to labor earnings during working age will depend on the human capital level of agents, to reflect the fact that the risk-characteristics of labor earnings appear to differ systematically by human capital level (e.g. Cagetti (2000), Chen (2001), Hubbard et. al. (1994, 1995), and Storesletten, Telmer, Yaron (2004)).

Even to the extent that increases in skill premia increase enrollment rates, our model suggests that incremental populations will be less well-prepared than the incumbent population, and will therefore fail at higher rates than the cohorts who enrolled in the pre-increase period. As a result, the effective increase in the stock of skilled labor associated with an increase in the skill premium, all else fixed, will be reduced by this composition effect. This is an issue studied by Hendricks and Schoellman (2009), and Carneiro and Lee (2011), and these authors find that this effect is important in influencing the observed college premium—making it substantially lower than if quality had not deteriorated with increased enrollment.\(^\text{15}\)

An important point about the nature of our analysis is that we presume that households understand the future path of the mean skill premium they can expect to receive at a given future age, and that this average does not vary stochastically (though it can do deterministically). Employing a richer stochastic process that clearly separates the aggregate risks that induce stochastic fluctuations in the mean skill premium, from those coming from genuinely idiosyncratic components, is beyond the scope of this paper.\(^\text{16}\) Our approach is instead geared to shed light on the relative importance of skill premia of a known, but possibly time-varying, variety in the human capital investment decisions of heterogeneous households.

\(^\text{15}\)These authors abstract from earnings risk by positing complete markets, and focus instead on the entirety of schooling decisions given a noisy signal of ability. Hendricks and Schoellman (2009) show that the price of skills have risen even faster than the change in wages, if one views the latter as a product of the price per unit of skilled labor and and the level of skill possessed by a given worker.

\(^\text{16}\)To the extent that future skill premia can fall and rise randomly, we conjecture, but cannot prove, that this will reinforce our results in terms of making more would-be enrollees inframarginal. Under concavity of the value function obtaining to those who enroll, \( V^E(\cdot) \), adding the possibility of skill premium uncertainty makes the ex-ante expected value of enrollment fall, and will further enlarge the gap between the expected value of enrolling to high- versus low-ability of any given current income and wealth levels. However, the net effect on aggregate enrollment is theoretically ambiguous because it depends on the joint distribution of wealth and ability.
2.2.1 Means-Tested Transfer Income

Our model also allows for means-tested transfers, $\tau(\cdot)$, represented as a function of current age $j$, human capital $h$, net assets $x_j$, and income level $y_j^h = \exp(\mu^h + z^h + u^h)$. Including this is potentially relevant as it is a source of wealth to households that may be large enough to alter the decisions related to college investment. In the benchmark model, transfers will not depend explicitly on age. Transfers are specified as in the seminal work of Hubbard et al. (1995):

$$\tau(j, a_j, y_j) = \max\{0, z - (\max(0, a_j) + y_j)\}$$ (8)

2.2.2 Retirement Income

As we stated earlier, households select retirement savings according to the function $\phi(a_R)$. Following Athreya (2008), a household’s wealth level at retirement is then the sum of the household’s personal savings $a_{J+1}$ and the baseline retirement benefit $a_\tau$:

$$a_R = a_{J+1} + a_\tau$$ (9)

This amount $a_\tau$ is the wealth level that, when annuitized at the discount rate $R_f$, and adjusted for the probability of survival for $k$ periods, $\pi_k$, yields a flow of income each period equal to the societal minimum consumption floor $\tau$.\footnote{See again, Athreya (2008) for details.} That is, minimal retirement wealth $x_\tau$ solves:

$$\sum_{k=1}^{K} \frac{\pi_k a_\tau}{(R_f)^k} = \tau$$ (10)

2.3 Young Households and The College Investment Decision

As described above, there are $K$ periods during which a decision maker is “Young.” In the first period, individuals first draw income shocks and a college preparedness level that implies an initial risk of failure in the first year of college, of $\pi$. The income draw $y_j^{HS}$ from the distribution applicable to high-school completers. This informs them of the earnings they would receive if they decide not to enroll in college. If they do not enroll initially, they cannot enroll at a later date. If they enroll in college, they cannot work. If their private wealth is insufficient to fund college investment, households may borrow by using non-defaultable personal debt. As noted at the outset, the risk of non-completion and the risk-aversion of individuals jointly make borrowing risky in terms of the utility of investment in college. We call this “leverage risk.” It implies that access to credit alone may be insufficient to induce enrollment. We will show below that an enrollee’s internal wealth position matters for enrollment even after conditioning on failure risk, and even when borrowing for college is allowed in amounts more than sufficient to fund it entirely externally.
Given knowledge of both the explicit costs of college, as well as the level of earnings that will be foregone, households make the decision to enroll or not in college. If an individual enrolls, they must attend college while facing a risk, in each year, of failing to achieve satisfactory performance. Failure means that one is not allowed to continue in higher education. An enrollee’s failure risk evolves over time, and will be modeled in a simple manner: each year’s failure risk is a fraction $\theta \leq 1$ of the preceding year’s risk. For example, if initial preparedness is given by $\pi$, failure risk in year 2 is simply $\theta \pi$, in year three $\theta^2 \pi$, and so on to $\theta^K \pi$. We will set $K$ further below to represent the median time to college completion (NCES 2001).

In each year, if an enrollee is informed that they will succeed in that year, they have the option, but are not required, to invest another year in college. Not all households who are informed of success may choose to continue. This is because all individuals receive earnings draws in each period, some will elect to leave college, given a sufficiently high and persistent realization of income. In other words, the opportunity cost of college may become too large, ex-post. We refer to such individuals as “dropouts.” In the data, dropouts and failures are likely combined in most measures, especially to the extent that many who leave may do so anticipating failure (see, e.g. Stinebrickner and Stinebrickner (2006)). In the model, however, dropouts and failures are distinct and clearly defined notions.

Those choosing to drop out at any time, and those failing to succeed, both draw income from the shock process applicable to their human capital level. For those who have completed less than $k < \tau^{SC}$ years of college, the wage draw over life comes from the distribution of unskilled agents, and has mean $\{\mu^{HS}_j\}$. For those with “some college” earnings will be drawn from the process with mean profile $\{\mu^{SC}_j\}$. The latter is not a proportional increase in earnings given the time relative to college completion, and reflects the empirical regularity that college dropouts receive only relatively small proportion of the income premium received, on average, by college completers (see Hungerford and Solon, 1989, e.g.) Upon leaving college, Young households transition to being Adults, after which they solve a rather standard life-cycle consumption savings problem in the face of stochastic, education- and age-dependent earnings. After $K$ years of successful completion, agents working life as a College-educated agent, and earn an expected payoff denoted $\{\mu^C_j\}$.

Taken as whole, our environment captures the central features of human capital investment: completion uncertainty, lumpiness, irreversibility, risky returns given completion, and “leverage risk.”

### 2.3.1 Recursive Formulation

The recursive formulation is straightforward. The state of any household can be expressed as follows. First, let $\pi_k$ denote failure risk in the $k$-th year of college. Recall that $a$ denotes household resources at the beginning of the period. Let $k$ denote age while Young. For Young agents the wealth level $a$ should be thought of as the transfer that college-bound children are expect to receive from their parent plus any internal funds they may have for which they do not have to borrow. Next, let $z_k$ and $u_k$ represent the persistent and transitory
shocks to earnings received by households, respectively. Lastly, let \( h \) denote human capital. Since \( \theta \) remains constant and common across all households, it does not enter the state-vector. As a result, the state of a household is summarized by the vector \( x = (k, a, z_k, u_k, h, \pi_k) \). To avoid clutter, in what follows we will refer to the household state by \( x \) alone, with primes denoting one-period-ahead variables.

Three distinct value functions fully describe the household’s problem. In the first period of being Young, all households make the decision to enroll in post-secondary education by comparing the value of enrollment \( V^E(x) \) with the value of not enrolling \( V^{NE}(x) \). If one does not enroll in the first period, one cannot enroll later on. Therefore, we denote the maximal utility attainable by a young agent in the first period of youth by the value function \( V^S(\cdot) \).

\[
V^S(x) = \max(V^E(x), V^{NE}(x))
\] (11)

We use the superscript “S” in \( V^S(\cdot) \) to denote a “successful” college student, which means here that they may choose whether or not to enroll in college in the given period. Trivially, in the first period of decision making, all individuals, being successful high-school completers, have the option to enroll, and are therefore classified as successful. If an individual enrolls, they understand that they will fail with probability \( \pi_k \), in which they will lose eligibility to continue in college, and will therefore attain the conditional expected value available to non-enrollees, given their current persistent income shock \( z \), \( E_z V^{NE}(x') \). If they perform well enough to successfully continue to the following year of instruction, something that occurs with probability \( (1 - \pi_k) \), they realize an expected continuation value, given current persistent income risk \( z \), of \( E_z V^S(x') \).

The value of enrolling is then the solution to the following problem:

\[
V^E(x) = \max \left[ \frac{c^{1-\alpha} - 1}{1 - \alpha} + \beta \left( \pi_k E_z V^{NE}(x') + (1 - \pi_k) E_z V^S(x') \right) \right]
\]

subject to the budget constraint if they enroll:

\[
c + qa' + \Phi \left[ 1 - \gamma^{need}(x) - \gamma^{direct} \right] \leq a_0
\]

\[
a' > a
\]

and where

\[
\pi_{k+1} = \theta \pi_k, \theta < 1
\]

In the budget constraint above, the term \( \Phi > 0 \) above denotes the cost of college, \textit{prior to} all subsidies directly received by educational institutions from state, local, and Federal sources. Direct subsidies are
denoted $\gamma^{\text{direct}}$, and apply to all enrollees. The term $\gamma^{\text{need}}$ denotes further proportional reductions in the private cost of college arising from need-based aid. Lastly, $a_0$ denotes the wealth or resources available to an enrollee (in general, much of this will represent parental resources), and in the event that an agent does not enroll, they can earn $y$ as labor earnings. Insurance markets against income risk are also incomplete, and all agents are endowed with the ability to save their risk-free assets in a form which earns them return $1/q_f$. Agents may also borrow, but will pay a proportional transactions cost $\zeta$ on any debt they accumulate; whereby the implicit interest rate on borrowing is $1/(q_f - \zeta)$. That is:

$$q = \begin{cases} q_f & \text{if } a' > 0 \\ q_f - \zeta & \text{if } a' \leq 0 \end{cases}$$

Dropping out—leaving when one has not failed—is a possibility in our model. This is because all agents receive a productivity draw in each period, even those who succeed in a given year of college may choose to drop out if their outside option is good enough. In this sense, the model isolates genuine dropouts—those who have leave but have the option to continue, from those who leave college as a result of either realized poor performance, or anticipated poor performance, both of which are mixed together in any observed statistics on dropout rates. If an enrollee drops out prior to completing two years of college, they receive no premium, while if they drop out after two years, they receive a partial premium for completing “some-college” (SC).

To sum up, outcomes for human capital are given by:

$$h = \begin{cases} HS & \text{if no enrollment, or fail with } k < \tau \\ SC & \text{if enroll elig with } k \geq \tau \\ C & \text{if enrolled and no-failure after } K \text{ periods} \end{cases}$$

For those choosing to drop out, or those failing, the value function reflects the fact that their decision problem collapses to a standard consumption-savings problem, which satisfies:

$$V^{NE}(x) = \max \left[ \frac{c^{1-\alpha}}{1-\alpha} + \beta E_{x'} V^{A}(x') \right]$$

and the flow constraint they face if they choose to dropout is:

$$c + qa' \leq a + I(k \geq \tau)y^{SC}(x) + I(k < \tau)y^{HS}$$

In the preceding $V^{A}(\cdot)$ denotes the value of being an “adult.” Given the irreversibility of college non-enrollment, there is no difference between this value function and that applying to non-enrollees: Adults are, after all, non-enrollees. Thus, $V^{A}(\cdot) = V^{NE}(\cdot)$. Lastly, in the period immediately prior to retirement, households’ optimal decisions satisfy:
\[ V^A(x) = \max \left[ \frac{e^{1-\alpha}}{1-\alpha} + \beta \phi(a_R) \right] \]

subject to the flow budget constraint

\[ c + a_R \leq a + y^h(x) \]

\[ a_R > 0 \]

### 2.4 Aggregating Individual Decisions to Enrollment and Failure Rates

As clarified at the outset, our primary focus will be on understanding the investment decision of a cohort of young enrollees. To do this, we solve for the flow of new enrollees predicted by our model under a given expected skill premium, educational policy, and the joint density of failure risk and available resources for college. Our approach is extremely straightforward: we assign preference-, income-, ability- and education-policy-related parameters, and then use equation (11) to solve for the household’s optimal enrollment decision. Next, given the joint distribution of ability and income/resources, and remaining household state-variables, we can use equation (12) to immediately determine aggregate enrollment.

The preceding makes clear that the aggregate enrollment flow of any new cohort of Young agents will depend on the joint distribution describing how Young households are distributed over the values of these state variables. Letting \( \Gamma(x) \) denote the observed (cumulative) joint distribution of age-1 Young households over the state vector, and \( I(\cdot) \) an indicator function over enrollment in college, aggregate enrollment, \( \Psi \), is given by:

\[ \Psi \equiv \int I(V^E(x) > V^{NE}(x))d\Gamma \]

Similarly, given an underlying conditional distribution of failure risk as a function of the household’s state, \( f(\pi|x) \), the aggregate failure rate is given by:

\[ \Pi \equiv \int f(\pi|x)I(V^E(x) > V^{NE}(x))d\Gamma \quad (12) \]

### 3 Parameterization

Our model of the enrollment decision is deliberately rich: It allows for the presence of initial uncertainty over collegiate preparedness, its gradual resolution over time, for exit and continuation decisions at a large number of dates (and hence the “option value” aspect to interim levels of education attainment), for stochastic and time-varying opportunity costs of college, for heterogeneity and non-independence in individual resources
and ability, for need-based aid and direct subsidies, for risky and uninsurable returns to any level of human
capital that is successfully acquired, for a life-cycle consumption-savings dimension, and for credit market
frictions in form of a wedge on intermediation.

The model requires us to assign values to four groups of parameters: those related to (i) preferences,
(ii) education cost and education policy, (iii) familial resources (including credit availability) and collegiate
preparedness, and (iv) stochastic processes for earnings as a function of educational attainment.

3.1 Preferences

First, with respect to preferences, there are only two parameters: the annual discount factor $\beta$, and risk-
aversion $\sigma$. Both $\beta$ and $\sigma$ are set at “off-the-shelf” values, at 0.94, and 2, respectively.

3.2 Education costs and education policy

College in our model represents all public higher education institutions, two- and four-year. This is the
relevant set of institutions for three reasons. First, public entities account for the lion’s share of enrollment
(roughly 75% according to NCES 2000 data). Second, even though many will choose to attend more expensive
schools, public higher education clearly remains a budget-feasible option for them. Third, public two year
colleges are cheaper than public year colleges, and allow for experimentation by enrollees by offering them
the option, conditional on successful completion, to continue to a four-year degree. Our approach ensures
that we do not artificially limit enrollment by making the form of college in the model more expensive than
the cheapest alternative available to qualified applicants seeking to attain a four-year college degree. We first
specify college costs for the first $\tau$ years at the public 2-year college rate, followed by the $K - \tau$ years at
the public four-year college rate. In our benchmark model, we use estimates from the College Board (2006)
“Trends in College Pricing” Table 3a, this implies that households face a price, prior to any need-based aid,
of approximately $2,500 ($1994) to attend the last three years of public 4-year college, and roughly $1250
($1994) per year for public two-year colleges.

3.2.1 Subsidy Rates

While the benchmark model only requires specifying the out-of-pocket costs for college, since those are what
concern any given enrollee, we are interested in the role played by educational policy in enrollment. Three
parameters define education policy: the annual real resource cost of college $\Phi$, the average subsidy $\gamma^{direct}
rate that is received by enrollees in the form of tuition and fee levels that are lower than the real resource
costs of delivering education at public 2- and 4-year colleges, and $\gamma^{need}(x)$, which determines need-based
as a function of household type. We employ existing estimates for the direct subsidy to public four year
colleges of in the range of 40-50%. Caucutt and Kumar, for example, measure the subsidy at 42.5%, which
we will apply here, and is close to a more general consensus, Kane (2001), Table 14, for example, suggests a number near 50%. Thus, given these estimates, the resource costs of public four-year college for the period targeted in the benchmark model is simply $2500/(1-0.425) \approx $4350, applying the same subsidy rate to 2-year colleges yields a real resource cost of $1250/(1-0.425) \approx $2175.

To parameterize need-based aid, $\gamma_{\text{need}}(x)$, we follow Clayton and Dynarski (2007) and U.S. Department of Education, and employ a simple linear function with two parameters governed by (i) maximal Pell grant of approximately $2,300 to correspond to data in the year 1993-94 (see, Highlights of the Federal Pell Grant Program) and (ii) a constant reduction in Pell grants as a linear function of family resources, $a_0$, set such that it completely disqualifies households with income greater than approximately $30,000.

### 3.3 Familial resources and collegiate preparedness

To parameterize the distribution of wealth available to potential enrollees, we employ a lognormal distribution of resources available to the student and therefore must assign values to only the mean and median of the distribution of initial wealth for Youths. The available wealth of enrollees will reflect not only their own private resources, if any, but also parental transfers. The latter, however, are not obviously proxied for by parental wealth, since the willingness of parents to make such transfers is not directly observable. For the same reason, the level and covariance of familial resources available to potential enrollees (not just those who ultimately enroll) with any given test score is not well-measured in the data. However, the work of Kane (2001) is informative here; it finds that of those reporting preparing financially for their kids college, only 25% with HS seniors had accumulated more than $10,000. Relatedly, Gallipolli et al (2010) compute the distribution of inter-vivos transfers to the individuals between the ages of 16 and 22. We take the approximate midpoint of their estimates (see their Table 20) for the mean and median across parents of high-school and college-education, and set the distribution of available resources to be lognormally distributed with a median, denoted $med_{a_0} = $3,000, and mean $\mu_{a_0} = $11,000.

---

18 Kane (2001), Table 14, reports that in 1992, the per-student annual subsidy was approximately $4,000 for enrollees from the lowest household income levels, and substantially less (less than $3000) for those coming from higher parental income levels. Since we incorporate need-based aid explicitly into the model, the size of the direct-subsidy measure should reflect the subsidy received by those ineligible for need-based aid.

19 See Table 13.

20 These values are also similar to those from the NLSY documented by Johnson (2011), Figures 11 and 12.

21 In their estimates, the median is remarkably stable, varying only from $2,800 to $3,500 when going from the least educated parents (all high-school drop-outs) to the most educated. The results turn out to be robust to substantial variations in the distributions of initial wealth, including ones with a mean as high as $40,000 dollars and a median of $20,000. Higher values appear implausible. Gottschalck (2008), for example, using 2002 Census data reports median net worth, Table (4), for households between 35-44 at $41,191 ($9512 excluding home equity) and that for 45-54 at $82,435 ($18,446 without home equity). But these measures, if used here, would be equivalent to presuming that all parental wealth is liquid, and furthermore, is available to college-bound households (or will eventually become available). Our measure is thus consistent with roughly one-half of these resources being essentially owned by the young enrollee.

Lastly, in life-cycle data, household net worth shows no appreciable drop at the time of a child’s entry to college, e.g. Yang (2006), so it is not clear that we should consider parental wealth as a low-cost method of financing for would-be enrollees.
Households may also borrow to finance college. To set this limit, we are guided by the work of Cameron and Heckman (1998) and Carneiro and Heckman (2002) who argue that widespread borrowing constraints for education are implausible, and by the set of explicit set of guaranteed loan programs to finance any amount in excess of the so-called “Expected Family Contribution.”\footnote{The latter are the so-called PLUS loan programs. See http://www.fafsa.ed.gov/what010.htm} We therefore will set the debt limit to always allow a household to finance the entire cost of college (given the set of subsidies that are in place) and, to reflect current guaranteed loan programs, make the limits common across all households. Given the costs of college inclusive of all subsidies, we set this common borrowing limit at $a = -K \Phi(1 - \gamma_{\text{direct}})$. Lastly, we set the risk-free rate on savings is taken conservatively be 2% (i.e. $1/q=1.02$); higher purely risk-free rates on savings are implausible. For borrowing, we allow for a wedge for intermediation of two percentage points, i.e. $\zeta = 0.03$, meaning that households can borrow at a real interest rate of 3%. This is likely a lower bound on borrowing costs, and is set to reflect access to subsidized college finance, as well as inter-family transfers.

To make the decision regarding college enrollment, households need to make an assessment of their failure risk. In the model, individuals are modeled as knowing their initial failure risk, $\pi$. In the world, this assessment arises from a variety of sources, including prominently a combination of family background, high-school performance, and standardized test scores. (see, e.g., Strinebrickner and Stinebricker (2007)). We follow Bound, Leovenheim and Turner (2009) who compute enrollment and non-completion rates by AFQT quartile. Specifically, we allow all individuals to fall into one of twelve failure levels. That is, $\pi \in \{\pi^{(1)}, \pi^{(2)}, ..., \pi^{(12)}\}$ and calibrate these values.

We do not restrict the distributions of failure risk and household resources to be independent. To allow for dependence in a tractable manner, we assume that these two objects are jointly bivariate lognormal, and therefore must specify a single parameter to describe the dependence of the two marginal distributions. It is plausible that while not perfectly positive, wealth and parental education are strongly correlated, and that the latter is in turn correlated with failure risk (see e.g. Athreya and Akyol (2006) and the references therein). In our benchmark model, we set $corr(\pi, a_0) = 0.3$ in our benchmark, which is the benchmark value assumed in Gallipoli et. al. (2010), and is similar to that measured by Castex (2009) for the correlation between “Family Income” and “Ability” (as measured by AFQT) in the NLSY79 and 97.\footnote{The results are very robust to this parameter. Higher correlations (e.g. 0.7) lower aggregate enrollment very slightly (around 0.5%). This is because high-ability students enroll at very high rates under current subsidies, irrespective of their household resources. A higher ability-wealth correlation would then lead to fewer low-ability households being wealthy than is the case in the benchmark model. Fewer of these households enroll in this case, pushing aggregate enrollment down.} As with several other parameters above, our approach is decidedly conservative. Assuming a higher correlation would once again create a larger population of inframarginal individuals: the rich would be even more disproportionately able, and the poor disproportionately poorly prepared and uninterested in college investments.

\footnote{In recent work, Lochner and Monge-Naranjo (2011) argue that credit constraints may be regaining strength, but for the early 1990s that we choose as our benchmark, the work of Carneiro and Heckman (2002) seems decisive.}
To summarize, we calibrate/parameterize seventeen objects: twelve levels of failure risk, \(\{\pi^{(i)}\}_{i=1}^{12}\), risk-aversion \(\alpha\), and household’s subjective (and common) discount factor \(\beta\), and earnings scaling factors that generate premia for some-college and college completers, respectively (two parameters), and the rate of decay of failure risk over time \(\theta\). Our targets are (i) non-completion rates by AFQT quartile (four targets), (ii) enrollment rates by AFQT quartile (four targets), (iii) earnings premia for some-college and college completers (two targets), and (iv) wealth accumulation over the life-cycle for college and high-school educated individuals (all remaining targets).

### 3.4 Earnings

To address the question of just how “anemic” (or not) the behavior of college enrollment and attainment has been requires us to take a position on what payoffs a potential enrollee should expect, and the extent to which this is well-proxied for by the payoffs accruing to the current set of market participants across differing levels of education. But the observed skill premium that prevails at any date, unless expected to persist over one’s working life, is not a relevant object for enrollment decisions. We take a position that targets a path for earnings that generate skill premia that approximate what prevailed over the period since 1993-2005, which is in the spirit of rational expectations, but does not presume perfect foresight.

However, these premia must be inferred, to the extent that households are influenced by the realization of persistent earnings shocks, they will reflect selection effects. In particular, those with high productivity may decide to leave college, or not enroll at all, but will as a result, have earnings are unskilled households that depress the skill premium all else equal. In our benchmark, we set the mean levels by age such that we match a selected target for the skill premium. In our benchmark setting we target an average college premium of approximately 1.75 times that of HS completers, in line with Goldin and Katz (2006).\(^{25}\) That is, \(\frac{\mathbb{E}(y_C)}{\mathbb{E}(y_{NC})} = 1.75\). A second “price” an enrollee has to understand is the premium, if any, to completing “some college” and then failing to earn a degree, relative to the earnings they would receive as high-school graduates. We set the premium expected by those who enroll and then fail, \(\frac{\mathbb{E}(y_{SC})}{\mathbb{E}(y_{NC})} = 1.2\), to reflect an average over the various groups in our model who attain “some college" in line with the roughly 10% annual higher earnings premium for this group estimated by Kane and Rouse (1995, 2001) using data on those who complete two-year college.

To parameterize income across education, we follow standard estimates in the literature. Because our focus is on the role played by the return to human capital investments, tax policy matters. In particular, the progressivity of U.S. income taxes can exert influence to lower the payoff to human capital because earnings to successful college completers tend to be higher and more compressed (temporally, because of the delay in generating earnings), while those of lower-skilled households are not only taxed at lower rates, but are also

\(^{25}\)See Gallipolli et al. (2010), Table 26.
supplemented by other transfer programs. The estimates of Hubbard, Skinner and Zeldes (1994) use after-tax and transfer income, and also feature a shock-structure for earnings that is now standard. Lastly, their estimates are based on income in a period relatively to close to the calendar period to which we benchmark our model.26

A maintained assumption will be that earnings, conditional on a given level of completed education, do not depend on initial ability (failure-risk). This means, for example, that enrollees can expect to earn a given mean premium conditional on completing, college, irrespective of what their failure probability was at the time of enrollment. We stress that, yet again, our parameter choices here help us avoid overstating our main result that most are now inframarginal with respect to the ex-post rewards to college. To the extent that failure risk (ability) and subsequent earnings conditional on educational attainment are likely to be negatively correlated, if at all, our approach avoids “rigging” the model to deliver widespread inframarginality. Lochner and Monje-Naranjo (2011), Table 1, for example, provide estimates that suggest that ability (as measured by AFQT quartile) does influence average earnings over the life-cycle, even conditional on college completion.27 They find that the direction of this influence is the natural one: the lower one’s failure risk, the higher the payoff conditional on completion. Related work of Cunha and Heckman (2007), (see their Table 1) finds similarly.

Allowing for this co-movement, as with a less conservative approach to failure risk than we use, would simply strengthen our main finding that most households are inframarginal: high ability households, who already overwhelmingly attend, would have even more reason to attend, with the reverse holding true for those with high failure risk.28 29 As such, our main finding that, all else equal, local changes in skill premia

<table>
<thead>
<tr>
<th>Parameter\Education Level</th>
<th>HS</th>
<th>Some Coll</th>
<th>Coll</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_n^2$</td>
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<td>0.021</td>
<td>0.021</td>
</tr>
<tr>
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</tr>
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<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>$\rho$</td>
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<td>0.95</td>
<td>0.95</td>
</tr>
</tbody>
</table>

(13)

All the results here are robust to a much higher level of persistence, including $\rho = 0.99$. This is important because some (e.g. Storesletten, Telmer, and Yaron (2004)) advocate a near-unit root process (see Hryshko (2008) for a discussion of the evidence on persistence). We do not employ this in our benchmark model because it would only make the uninsurable risk faced by households still larger, and we wish to remain conservative along this dimension.

Lastly, the more recent rise in earnings volatility is partially muted by after-taxes and transfers, making the after-tax, after-transfer process of Hubbard et al. (1994) continue to offer a reasonable approximation to household level earnings uncertainty.27 See also Castex (2016b), Table E.2.

28In related work Carneiro and Lee (2011) carefully measure the extent to which the quality of college-students has fallen systematically since the 1960s, and strikingly, imply that the skill premium, if competitively determined in a period-by-period spot market for labor, would actually have been substantially higher were it not for the additional enrollees being of worse average quality. As a qualitative matter, such an effect would be expected to accompany changes in the skill premium for college completion, and indeed, do occur in our model.

29This is an issue studied by Hendricks and Schoellman (2009) as well. These authors find that this effect is important in influencing the observed college premium—making it substantially lower than if quality had not deteriorated with increased enrollment. These authors abstract from earnings risk by positing complete markets, and focus instead on the entirety of schooling decisions given a noisy signal of ability. Hendricks and Schoellman (2009) show that the price of skills have risen even
will not likely alter aggregate enrollment rates, is made more robust.\textsuperscript{30}

We remind the reader here that our benchmark analysis aims at understanding the enrollment decisions of a given cohort in the face of a constant skill premium that is expected to last with probability one over some or all of working life of the household. An alternative would be go back in time to various dates, assume either that households understand the stochastic process governing skill premia over their lives, or more demandingly, have perfect foresight over the path that will unfold, and compute enrollment rates.\textsuperscript{31}

Given the documented longer-run variations seen in skill premia (see e.g. Goldin and Katz (2008)), and the judgements that households must make regarding the future path premia associated with college documented in Kane (2001), one aspect of our analysis will be to focus on how varying views on the path of premia should matter for enrollment. For example, we will study further below the effect that premia that are expected to be temporary to varying extents will have on enrollment. Before moving to the results, we collect all parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta, \sigma$</td>
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</tr>
<tr>
<td>${\mu_{pit}, \mu_{itc}}$</td>
<td>1.75, 1.2</td>
<td>Calibrated/ HSZ (95), Kane/Rouse (2001)</td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>$\zeta$</td>
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<td>Caucutt and Kumar (2005), Kane (2001)</td>
</tr>
<tr>
<td>$\gamma^{need}$</td>
<td>max. Pell grant: $2300, max. elig. $30,000</td>
<td><a href="http://www.ed.gov">www.ed.gov</a></td>
</tr>
<tr>
<td>$med_{a0}, \mu_{a0}$</td>
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<td>Gallipolli et al. (2010)</td>
</tr>
<tr>
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<td>0.3</td>
<td>Castex (2009)</td>
</tr>
</tbody>
</table>

The reader interested in this approach is directed to Castex (2010b).

\textsuperscript{30}Since we do not allow completion probability to alter the payoffs conditional on succeeding in college, there is no composition effect on relative earnings introduced by our calibration of these payoffs. For example, imposing that enrollees expect an even larger payoff to “some college” will change enrollment, to be sure, but does not lead to a change in the average productivity of any within a group of individuals possessing any given level of education. It only ensures that those who do complete any given level of education get rewarded in ways they expected. To be very clear here, we do not calibrate wage processes in any way to match enrollment, but do so only to match payoffs \textit{conditional} on education levels that are observed in data. As Heckman, Lochner and Todd (2007) stress, these are the ex-post payoffs to human capital acquisition.

\textsuperscript{31}The reader interested in this approach is directed to Castex (2010b).
4 Results

4.1 Enrollment and Completion in the Benchmark Economy [TBC]

To begin, we document the fit of the benchmark parameterization along a few dimensions most salient for
the questions we are interested in. In Table 2, we start with non-completion rates by AFQT Quartile, as
reported by Bound et al. (2009).

<table>
<thead>
<tr>
<th>Non-completion</th>
<th>Model</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>78.1%</td>
<td>88.6%</td>
</tr>
<tr>
<td>2nd</td>
<td>69.3%</td>
<td>70.4%</td>
</tr>
<tr>
<td>3rd</td>
<td>52.8%</td>
<td>52.8%</td>
</tr>
<tr>
<td>4th</td>
<td>26.7%</td>
<td>27%</td>
</tr>
</tbody>
</table>

(15)

Next, we consider enrollment rates by AFQT quartile, in Table 3:

<table>
<thead>
<tr>
<th>Enrollment</th>
<th>Model</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>43.9%</td>
<td>44%</td>
</tr>
<tr>
<td>2nd</td>
<td>65.4%</td>
<td>66.5%</td>
</tr>
<tr>
<td>3rd</td>
<td>87.1%</td>
<td>79.7%</td>
</tr>
<tr>
<td>4th</td>
<td>93.3%</td>
<td>92.7%</td>
</tr>
</tbody>
</table>

(16)

Lastly, while omitted for brevity, the benchmark model replicates closely the paths of net worth over the
life cycle for both High-School educated and College-educated households as measured in Cagetti (2003).
Given our goal of understand the role played by the skill premium and by changes in college costs holding
all else equal, the performance of the benchmark model allows us to proceed.

4.2 The Response of Enrollment and Attainment to Changes in the Skill Pre-

We now turn to the main question of this paper: What should one expect for the response of enrollment
and attainment to changes in the skill premium. The first two rows of the Table 4 below summarizes our
findings:

<table>
<thead>
<tr>
<th>\frac{w_C}{w_H}</th>
<th>1.56</th>
<th>1.64</th>
<th>1.72</th>
<th>1.83</th>
</tr>
</thead>
<tbody>
<tr>
<td>\Psi</td>
<td>44%</td>
<td>57%</td>
<td>66%</td>
<td>73%</td>
</tr>
</tbody>
</table>
The third row of Table 4 directly compares observed enrollment at the approximate dates at which skill premia attained each level. It is a thought experiment aimed at examining the extent to which simple “static” reasoning would have accounted for what was seen. In a clear sense, the relationship is tight. And note that the model is not calibrated to perform well along this dimension—since at each date in the observed time series, a variety of forces are at play. It is interesting, therefore, that the predictions line up as well as they do. Of course, this is also not a test of the model. Rather, it is an indication that observations are consistent with our model, and in particular, with skill premia being viewed by enrollees as persistent.

4.2.1 Enrollment Across Premia and Preparedness

We start with enrollment. Figure 2 displays the results. We display outcomes across observed premia. This is because the data we observe, under the maintained hypothesis that the households vary in their opportunity costs of attending college, is subject to selection effects. That is, in assessing the role of premium in enrollment decisions, the literature cited at the outset universally employs observed premia and asks about its co-movment with enrollment rates.

The final column shows that sustained increases (i.e., those expected to last a working life) in the skill premium of the magnitude observed, say from 1.5 to 1.7, should not be expected to generate an enormous increase in enrollments; our model predicts that, ceteris paribus, enrollment should be ten percentage points higher, going from 0.67 to 0.77. As the skill premium rises further, the response of aggregate enrollment is even smaller: increases in the skill premium from 1.6 to 1.7 to 1.8, raise enrollments by only three to five percentage points for each increment. These modest increases in aggregate enrollments mask some dramatic responses for particular groups, however. For example, taking again the group with failure probability of
66%, the model predicts that enrollment under the higher skill-premium of 1.7 will be 0.56, compared with the enrollment rate of 0.33 predicted to follow from a skill-premium of 1.5.

4.2.2 Attainment

Having noted that enrollment does respond nontrivially to changes in the skill premium, especially from (life-long) premia that start at levels below what is currently observed, we can address the question of how much additional skilled labor gets generated as a result. The answer is: not very much, as shown in Figure. This is a central result of our paper.

[TBC]

4.3 The Roles of Preparedness and Opportunity Costs: Threshold Wealth Levels [TBC]

The next issue is the role played by the foregone alternatives to college. The model implies that such costs can play a nontrivial role. Indeed, this is plausible since the explicit cost of college we presume in the model is very low. As a result, differences in enrollment rate across preparedness levels are almost certainly influenced by the foregone earnings sacrificed by poorly-prepared enrollees. Figure 4 displays the results.

4.4 The Path of Future Skill Premia

Optimal behavior requires agents to forecast future prices, and in particular, future realizations of skill premia. Thus far, we have presented the model’s predictions for changes in enrollment as a function of changes in the skill premium that are expected with probability one to last an enrollee’s entire working life.
But skill premia have moved very substantially over the past 100 years (see, e.g., Goldin and Katz (2008)), and have moved substantially over periods much shorter than most individuals’ working lives. Heckman and Navarro (2006) have argued that individuals may lack the ability to forecast a substantial portion of the payoffs to successful attainment of a given level of human capital. And while our approach employs existing estimates of wage uncertainty, such measures do not allow for average premia to change as function of age or experience. Even abstracting from uncertainty over future premia, therefore, it is of interest to understand the importance of the perceived duration of a given premium. The current premium is very close to historically high levels, and it is not inconceivable that it will drop in the future. In this section, we present results for how enrollment responds when the skill moves up temporarily, and then returns to its benchmark level (approximately 1.5 according to data of Goldin and Katz (2006)) at a date in the future that is known to would-be enrollees.

We examine three cases in which we allow for premia to vary over time, presented below. In the first column, we examine the role played premia that are expected to last for only the first decade of working life. In the second and third columns, we examine the strength of incentives coming from delayed premia of ten, and then twenty years form college completion.

Table 5: Skill-Premia and the Timing of Rewards

<table>
<thead>
<tr>
<th>( \frac{w'}{w_{hs}} )</th>
<th>Timing</th>
<th>1-10</th>
<th>11-20</th>
<th>21-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75</td>
<td>71%</td>
<td>69%</td>
<td>68%</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>78%</td>
<td>73%</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>83%</td>
<td>77%</td>
<td>73%</td>
<td></td>
</tr>
</tbody>
</table>

The message of these experiments is clear: if potential enrollees do not expect a given skill premium to last
for most of their lifetime, they will respond by substantially less. This suggests again that expecting further increases in skill premia to be associated with significant enrollment responses is unlikely to be warranted. Simply, the model suggests that the US is on the fairly “steep part of the supply curve” with respect to production of college graduates. In terms of understanding the enrollment rates that one could expect to be associated with a given path of skill-premia, our model shows that if the skill-premia per unit of time worked is expected to return to its long-run average, then enrollment of cohorts in periods of higher-than-average skill premia may well be lower than when current skill-premia are below their historical averages. In the latter, if premia are expected to revert to higher values in the medium-term future, enrollment amongst current cohorts may well be higher than those where current premia are higher than the historical average and are expected to fall by the time the cohort reaches late middle-age.\footnote{Part V “Poor Information” in Kane (2001) is instructive as to the likely extent that household’s understand the costs and premia that are likely to accrue to them should they enroll and complete college successfully. Among the findings of most interest were that students from more disadvantaged backgrounds seemed to systematically overestimate the costs of college.}

4.4.1 Skill Premia and the Cost of College [TBC]

4.5 A Punchline: Most US Households are Now Inframarginal With Respect to College Investment

Taken as a whole, our findings help explain what Altonji, Bharadwaj, and Lange (2008b) term the “anemic” response of enrollment to changes in the skill premium, and arise from the following simple and intuitive mechanism. The presence of failure risk generates asymmetric changes in the net return to college investment in response to a change in the skill premium. The reason is this: those with low failure risk see a large increase in expected returns, but are inframarginal because they will enroll under most circumstances. Current skill premia are more than ample to induce these individuals to enroll. Those with high failure risk see a much smaller increase in expected returns, meaning that those not currently choosing not to enroll remain largely inframarginal.

The overall importance of failure risk is seen again in the fact that while a substantial proportion of households are inframarginal with respect to the return to college, those who are marginal are overwhelmingly those for whom college investment is genuinely risky—in the sense of carrying a high variance of future utility. Households who are quite sure to fail or quite sure to succeed do not face meaningful risk: the variance of future utility induced by an investment in college is low. And as such, for these households, the mean return will dominate decision making. In turn, further movements in the skill premium are not likely to matter. Specifically, well-prepared enrollees face low failure risk and so already receive a high rate of return from college under any skill premium in the approximate vicinity of the current one. Similarly, the ability of the skill premium to meaningfully alter mean returns for the ill-prepared is minimal. The only remaining question is then: how large is the set of marginal households? The answer provided by the model is: not
5 Why are So Many Inframarginal? Higher Education Policy

We have shown above that incorporating quantitatively reasonable wealth and preparedness heterogeneity into a model of risky college investment can account well for the limited response of enrollment and completion to increases in the skill premium above current levels. But part of the reason might be precisely the very low price of public college education, which in turn arises from the sizeable subsidy it receives. We now ask about the role being played by policy in driving such a large fraction of each cohort of potential enrollees to be inframarginal with respect to changes in the return to college investment. The model suggests that this role is large.

Before addressing the effect of changes in skill premia across different subsidy rates, we first evaluate the power of direct subsidies to alter decision making under a given skill premium (in this case, the benchmark lifetime earnings premium of 1.75). Given our primary focus on understanding the decision-making process leading to college enrollment, we now display enrollment rates and the enrollment decision rule as a function of both subsidies and preparedness.

<table>
<thead>
<tr>
<th>$\frac{w^c}{w^m}$ \ $\gamma_{direct}$</th>
<th>0</th>
<th>0.15</th>
<th>0.425</th>
<th>0.575</th>
<th>0.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75</td>
<td>53%</td>
<td>56%</td>
<td>66%</td>
<td>69%</td>
<td>73%</td>
</tr>
</tbody>
</table>

We see that under current skill-premia, college remains financially attractive at low levels of subsidies, but not nearly so much as under current policy. As we will show below, even highly prepared high-schoolers enroll at less than 100% rates when college is completely unsubsidized. This is a striking reversal of the risk-neutral logic that prescribes enrollment for nearly any enrollee, under current skill premia.

5.1 Wealth and Enrollment: Seeing that Risk Matters

Having described the predictions of our model for the aggregate enrollment behavior of a cohort across subsidies and failure risk, we turn now to understanding the decisions that underlie the aggregates seen earlier. In particular, we show “iso-enrollment” contours across three dimension: failure risk, subsidies, and wealth. Figure 5 is perhaps the most important figure in this paper. It shows the “critical” levels of personal wealth at which investment in college becomes desirable as a function of the failure risk of an enrollee, for a variety of subsidy levels. The lowest line is associated with the highest subsidy rate, and the relationship is monotone. We emphasize three results from this figure.
First, college is not a “no-brainer.” There are many households for whom an unsubsidized investment in college is simply not financially worthwhile. As can be seen from the figure, if one fixes a wealth level, then looking across failure risk, we see that for enrollees with a success probability of less than 30%, it takes a subsidy in excess of 50% before low-wealth households find it worthwhile to invest in college.

Second, wealth and preparedness are very clearly substitutes in influencing the decision to enroll. This is not what would obtain under risk-neutrality: recall that the model does not impose any borrowing constraints. Therefore, conditional on ability, personal wealth would, under risk neutrality play no role in the investment decision. The fact that it seems, on the contrary, to play a substantial role in the enrollment decisions of poorly-prepared households, holding the subsidy fixed, is consistent with risk playing an important role. This link between wealth and enrollment, conditional on ability (failure risk in our setting) is documented clearly by Lochner and Monge-Naranjo (2011).

Moreover, as a quantitative matter, the relationship is highly nonlinear. Starting in the neighborhood of the unconditional mean of failure risk in the economy (approximately 50%), we see that under benchmark subsidy rates (the red line) that an enrollee with no internal wealth would be just indifferent to enrolling or not. But, a less well-prepared student, with a success probability of 0.25, will enroll only if he has in excess of $10,000 in personal wealth. As failure probabilities rise, the requisite internal wealth rises rapidly. Subsidies do not change the qualitative nature of decisions, but alter the threshold level of internal wealth significantly. Under the lowest subsidy rates, an average would-be enrollee requires approximately $30,000 more internal wealth than she would under the most generous subsidy regime. This gap persists for even very well-prepared students, but shrinks for those least-prepared. Intuitively, as the likelihood of failure grows, the subsidy acts as a form of wealth, as all households wish to enroll, while the subsidy can do little to alter the expected net benefit for those likely to fail. Moreover, those with a low likelihood of success will face heavy debts from enrolling unless they have significant internal funds; hence, the vertical distance between critical wealth levels grows with failure risk. For the highest failure risk however, the subsidy has little influence as the expected return is deeply negative.

Third, and perhaps most suggestive of the role of risk is that the gap between critical wealth levels shrinks in either direction of failure risk: as failure becomes either highly probable or improbable. For intermediate ranges, households become sensitive to subsidies. Interestingly, on this point notice that in contrast to what occurs at very high and low success rates, households are sensitive to subsidies in a nonlinear manner, with initial increases doing much more to drive down the critical wealth levels that make enrollment acceptable than they do for those with high success likelihoods. In other words, when success is very likely or unlikely, increases in subsidies will operate to make enrollment more attractive via only one channel: a pure “price effect.” That is, whenever the outcome of the investment is more or less guaranteed, subsidies cannot by
definition have any insurance effects. At intermediate failure likelihoods, however, this is no longer true. Now, in addition to the price effect, we have an insurance effect whereby the subsidy makes a given investment more tolerable. A sense of the size of this insurance effect is captured by the difference in reductions in critical wealth among those sure to succeed, relative to those seen at intermediate values of failure risk.

Since wealth can so strongly influence the enrollment decision, one would expect the financial resources of enrolled students to be very different. We now examine the implications for the mapping from household resources available to a student (proxied by parents’ earnings, expected discounted parental transfers, or wealth) and their enrollment decisions.

[TBC]

5.2 Enrollment Responses to Changes in Skill Premia: Policy Matters

The results thus far are suggestive of current policy playing a strong role in driving enrollment, and that successive increases in subsidies will be met with by shrinking, though strictly positive, changes in enrollment rates. We now turn to the issue of the extent to which enrollment responses to skill premium are altered by the subsidy policy in place. The results are striking, and are presented in Figure 6.

Two points follow from the results in this Figure. First, subsidies to college are important for generating observed enrollment: skill premia do not appear to be capable of accounting for enrollment by themselves. This is clear from the figure: at even historically high skill premia (1.8), enrollment rates are ten percentage points lower than at present. At lower (but still substantial) premia, such as 1.5, the model suggests that barring subsidies, skill premia are nowhere near large enough to induce current enrollment—they are only...
19%. Thus, the unsubsidized cost of college, along with reasonable measures of the distributions of failure risk and parental resources available to potential enrollees, leaves many households unwilling to invest in college—even at skill premia close to long-run averages.

How do our model’s findings mesh with empirical work? Dynarski (1993) finds subsidies to be very important. She studies a relatively natural experiment in which support for 18-22 year-old college enrollees was suddenly eliminated. She finds that enrollment rate by 3.6 percentage points per one-thousand dollars of aid. Kane (1994) and Dynarski (2000) find very similar measures as well. Thus, given the out of pocket costs of college we employ, a $1000 increase corresponds to approximately 30% increase in change in subsidies away from current rates, close to the 57.5% case. Depending on the level of skill premium, this leads to an increase in enrollment of between four and seven percentage points in enrollment rates, and so is similar to empirical estimates. And holding skill premia fixed at current levels, the elimination of direct college subsidies altogether would lead to enrollment rates dropping very substantially, to just 53%. Lastly, Kane (2001) documents that the available evidence taken as a whole suggests that enrollment has long appeared highly sensitive to the costs faced by households. He finds, for example, that the increased enrollment seen in the 1980’s, when skill premia were rose substantially (see Figure 1), was identical to what estimates suggested would be seen from just a $500 increase in tuition costs!33

33Kane (2001) states: “Parents and students appear to be extremely sensitive to tuition policies, at least relative to their responsiveness to the rise in the labor market payoffs to college. Recall from Table 1, there was a 7 percentage point increase in college entry by high school graduates between 1980/82 and 1992, from 68 percent to 75 percent. This seems large, until you realize that the rise in college enrollment witnessed during the Eighties was roughly as large as we might have expected to see in response to a $1000 to $1500 increase in annual tuition, based upon the empirical estimates cited above. For someone who was considering being in school over 4 years, this would have amounted to a $3700 to $5500 increase in anticipated expense over 4 years (using a discount rate of 6 percent).”
It is important to be clear on what the preceding result does not say. It does not suggest that if subsidies were set to zero, far fewer would enroll. It says that current skill premia, absent subsidies, are not enough to induce observed enrollment. Our focus has been on just this: what is the importance of higher education policy relative to skill premia, in accounting for enrollment? The empirical work reflects this premise as well; the subpopulation studied by Dynarski (1993), for example, was small, making the presumption that skill premia would remain fixed in the face of changes in their behavior a reasonable one, and thereby making her estimates comparable to the experiments we perform. Still, given the estimates for the behavior of the marginal productivity of skilled labor as a function of its relative size (see e.g. Caucutt and Kumar (2005)) the skill premium would rise very substantially.

Second, when direct subsidies rise from low levels to higher ones (e.g., from $\gamma^{\text{direct}} = 0$ to $0.425$) subsidies to higher education matter a great deal for household decisions. However, at subsidies and skill premia near current levels, additional subsidization (e.g., from $\gamma^{\text{direct}} = 0.5$ to $0.575$) does not meaningfully change the response to further increases in the skill premium. This is seen clearly by comparing the bottom two rows of the preceding table (??). The message, once again, is that a skill premium of near 1.7 or greater means that a large fraction of households is inframarginal with respect to further increases in expected wages. In other words, both “tails” of the failure risk distribution are inframarginal: those with high failure risk find that an increase in the skill premium only slightly increases the expected return to college enrollment.

One way of summarizing the information above is that subsidies matter in ways similar to skill premia for enrollment. The unsubsidized enrollment rate under the highest skill premium we study (2.0) is close to the enrollment obtaining under the much lower skill premium (1.7) currently prevailing with the benchmark subsidy. The importance of subsidies an important finding of our model, and is consistent with recent work, particularly that of Johnson (2011). The model suggests vert strongly that the private (out-of-pocket) costs of college are of primary importance.

Relatedly, changes in enrollment are largest when overall education subsidy policy is very stringent. The model suggests that under current or higher subsidization rates, changes in skill premia should not be expected to bring forth important changes in enrollment: the marginal households have been exhausted. One implication of this finding is that if one views a substantial component of increases in skill-premia as arising from shifts in the “demand” for skilled labor inputs, then it is likely that the net result—barring an increase in subsidization— will be only modest increases in enrollment. Moreover, given the increasing marginality of the additional enrollee, the resulting skill formation will likely be even smaller. In sum, the model suggests that increases in skill premia followed by stable enrollment rates may well be a possibility.

34In the longer run, the net effect of the preceding is likely to lead to greater inequality.
5.3 Subsidies, Grants, and Aggregate Enrollment and Failure Rates

Historically, the most important policy aimed at encouraging college enrollment has been the creation of public college and universities that feature heavily subsidized tuition, and living expenses. In fall 2010, 74% of college students are enrolled at public colleges and universities (NCES 2010). Having shown above that subsidies governed the size of the response to skill premia by governing the size of the marginal population, we now use our model to briefly assess the likely role being played by subsidy policies on aggregate enrollment and completion rates under the current skill premium. Recall that in our model, direct subsidies will not only reduce the cost of college, but will also reduce the risk faced by students. Subsidies reduce the amount of wealth devoted, or the amount of borrowing required, to finance college. Given precautionary motives to avoid low-wealth states, this alters the risk associated with college attendance. Both effects will be larger for students who are wealth-poor, less-well-prepared, or both. Lastly, the fact that wealth matters for decisions holding ability fixed, as is documented most recently in Lochner and Monje-Naranjo (2011), indicates further that decentralized outcomes may well be inefficient.

The enrollment rates as a function of wealth and preparedness, along with the underlying behavior of the joint distribution of preparedness and initial wealth imply the following for aggregate enrollment rates and failure rates, as a function of subsidies.

<table>
<thead>
<tr>
<th>Subs. Rate($\gamma^{direct}$)</th>
<th>Enroll Rate ($\Psi$)</th>
<th>Fail. Rate (II)</th>
<th>Avg. Fail. Prob ($\mu_{II}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>59%</td>
<td>48%</td>
<td>31%</td>
</tr>
<tr>
<td>0.15</td>
<td>66%</td>
<td>50%</td>
<td>33%</td>
</tr>
<tr>
<td>0.425</td>
<td>73%</td>
<td>52%</td>
<td>35%</td>
</tr>
<tr>
<td>0.575</td>
<td>75%</td>
<td>53%</td>
<td>35%</td>
</tr>
<tr>
<td>0.65</td>
<td>78%</td>
<td>53%</td>
<td>36%</td>
</tr>
</tbody>
</table>

This table integrates enrollment decisions over the underlying joint distribution of preparedness and initial wealth available to households of typical enrollment age. This subsidy is universally available to all students, and (unlike the skill premium) is received regardless of whether or not the student graduates. As more students attend, the selection becomes less favorable, so the aggregate failure rate rises also. This suggests that while enrollees may be willing to enroll, that taxpayers as a whole may lose, a question we now turn to.

5.4 Need-Based Aid

The direct subsidies we have studied so far are, by construction, received by all enrollees, and so are a blunt policy instrument. It is of interest to examine the effectiveness of need-based aid to alter decisions. Our decision model allows predictions about the long-run effects of changes in such aid. As mentioned in the
Calibration section, we employ a simple representation, based on Dynarski and Clayton (2008) that provides a good approximation of need-based aid. Specifically, all households face a maximum amount of need-based aid (what they would get if their familial resources

The overall impact of the Pell program depends on the characteristics of the joint distribution of wealth and standardized test scores. The following Table shows the results for these values of the Pell program for all the agent types in the economy. Given the positive correlation between wealth and collegiate preparedness, the recipients of need-based aid will disproportionately be drawn from a relatively less well-prepared population. The following Table shows the model’s predictions for the response of enrollment by failure-risk type to systematic increases in the generosity of the Pell Grant program. Each row of the table gives the enrollment rate for a given maximum Pell grant, varying across failure probabilities in each column. The final column integrates over the distribution of failure probabilities to give the aggregate enrollment rate.

<table>
<thead>
<tr>
<th>Pell Max (1-π)</th>
<th>0.17</th>
<th>0.24</th>
<th>0.35</th>
<th>0.49</th>
<th>0.77</th>
<th>Ψ</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,750</td>
<td>5%</td>
<td>49%</td>
<td>70%</td>
<td>86%</td>
<td>93%</td>
<td>67%</td>
</tr>
<tr>
<td>$2,300 (benchmark)</td>
<td>31%</td>
<td>53%</td>
<td>77%</td>
<td>87%</td>
<td>95%</td>
<td>73%</td>
</tr>
<tr>
<td>$3,000</td>
<td>42%</td>
<td>63%</td>
<td>81%</td>
<td>88%</td>
<td>96%</td>
<td>78%</td>
</tr>
</tbody>
</table>

The results in the final column suggest that under the benchmark parameterization, modest increases in need-based aid of the magnitude we have observed can, holding all else fixed, be expected to generate modest increases in enrollment. Of course, general equilibrium effects may further limit the response to such policies. The issue here is that the increase in need-based aid is small compared to the subsidy already available (42.5% in the benchmark). Once again, these results highlight the inframarginality to college investment of most households. Students with low wealth and a good chance of success are already enrolled, while those with weak preparedness tend not to enroll (see the first two columns). Yet, need-based aid is powerful in inducing poorly prepared students to enroll.

While our model suggests that all sources of aid, especially need-based aid such as Pell grants may be playing an important role in current enrollment decisions, it appears that enrollment may not be as sensitive to the largest need-based aid program, the Pell grant. Kane (2001), and Hansen (19830 and Kane (1995) find little effect from changes in the Pell grant, for example. Part of the reason may be the low take-up rates making them a poor substitute for direct reductions in the cost of tuition. Clayton and Dynarski (2006), for example, present a very detailed description of the various barriers in even communication information on the existence of Pell grants, in addition to the complex aid application process to would-be enrollees from poor families. Our model does not address such issues, but suggests that the gains from efforts to better inform such households may be significant.\footnote{Their findings are very striking: they show that a huge proportion of Pell aid can be accounted for by a very short list of

32
by the work of Turner (2000), who finds that colleges may have adjusted tuition rates in ways that largely offset actual changes in the Pell grant system.

Lastly, while we do not use our model to evaluate long-run changes arising from changes in policy, we have nonetheless shown that the riskiness of college investment (in terms of the expected utility it confers) is strongly dependent on the interaction of failure probability with the cost of college and a household’s initial wealth. In particular, it is only when current skill premia are combined with observed rates of subsidies and need-based aid that one generates reasonable enrollment rates. The gross insufficiency of the skill premium to spur enrollment may initially be surprising, but follows naturally from the presence of risk and heterogeneity in household wealth and preparedness. This relative importance of subsidies and grants—which are received irrespective of education-investment outcomes—over skill premia—which are received only upon successful completion—is a telltale symptom of failure risk.

6 Additional Remarks/Conclusion [TBC]

In this paper, we have studied a rich model of the individual enrollment decision to understand quantitatively the role of three central forces: the skill premium, students’ ability to complete college successfully, and the stance of higher-education policy. We have shown, via a completely standard consumption-savings setting, that the response of enrollment and skill formation/college attainment to changes in skill premium that have been viewed in the literature as surprisingly small, are in fact, understandable. We show that, at current skill premia, empirically reasonable measures of failure risk and earnings uncertainty, along with a realistic underlying joint distribution of wealth and college-completion ability, are sufficient deterrents to enrollment, especially whenever potential students are uninsured against failure or must make leverage themselves to investment in human capital.

The main reason for this is the asymmetric change in the payoff to college arising from a given change in the skill premium. Highly able students see a relatively large change in payoffs, but at levels near current premia, are already planning to attend, and so do not alter their aggregate reaction. Similarly, low-ability individuals see a much smaller change in the payoff coming from any change in skill premia since they are unlikely to complete, and hence also are inframarginal. Our findings also indicate a strong role for higher education policy in modulating the effect of a given change in preparedness, or of a change in skill premia.

Two caveats are in order. First, we have assumed that the skill premium, and indeed all of the parameters in the model, are fixed and known to potential students in advance. Uncertainty about the skill premium, even if it is mean-preserving, will further deter enrollment given the risk aversion of households. Moreover, the mild negative correlation we impose between failure risk and initial family wealth means that a greater family characteristics—while the application form asks for an enormous amount of additional input, some of which is accompanied by threats of incarceration for misrepresentations!
share of poorly-prepared households will face increased leverage risk, making observed enrollment given our benchmark model’s prediction, if anything, puzzlingly high. The financial aid policy parameters are also fixed. However, subsidy parameters are only relevant for the period while an individual is in college, and so this imposes a weaker assumption than the lifetime skill premium we have assumed. However, we do assume that loans continue to be non-dischargeable and that other long run features of student lending do not change.

Second, we have also abstracted from substantial and interesting heterogeneity among schools. We have parameterized the enrollment decision to a blend of two- and four-year public institution. Public higher education enrolls the majority of college students (74% of all college students), so we view this parameterization as capturing the cost structure facing the marginal student deciding whether or not to enroll in college. Those who enroll in more expensive schools face higher costs, so we assume that they would surely have enrolled in the “cheaper” school that we model and hence this variation does not change our calculations of the enrollment rate. Nonetheless, the structure we employ could be used to model the distribution of students across schools, where the returns to attending various schools could vary along with their costs. Finally, as we noted, we study a problem in which households expect the skill premium to remain fixed. The important variation in this object seen in the past several decades means that large changes in the conditional return to college may occur from year to year. Expanding the model to allow for this added form of uncertainty is beyond the scope of this paper, but seems worthwhile.
References


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