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The Supply of College-Educated Workers: The Roles of College Premia, College Costs, and Risk*

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Abstract

Despite a large measured college premium, roughly one-third of all high-school graduates currently do not enroll in any form of college. Moreover, while recent increases in the premium have been accompanied by increases in enrollment, college attainment has remained flat. Our paper studies the roles played by college premia, college costs, and risk, ceteris paribus, for college enrollment and attainment in a simple quantitative model of risky college investment. Our results suggest that most U.S. high-school completers are currently inframarginal with respect to the college premium. We find, however, that the levels of current premia, costs, and uninsurable risks all matter for this. Our results imply that, barring improvements in collegiate preparedness and attrition rates, high and persistent college premia, with high attendant levels of earnings inequality, may accompany the shift in demand towards skilled labor, which recent work (e.g., Autor, Levy, and Murnane (2003)) suggests is under way. **Keywords**: College Enrollment, Skill Premium, Risk. **JEL Codes**: I21, I24, J24

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1 Introduction

The college skill premium is, and has been, large 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.[1] At least in terms of *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 percent. 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 percent and 15 percent or higher, (see, e.g. Goldin and Katz (2008), Heckman, Lochner and Todd (2008), Tables 2a-b).

A second feature of the higher education landscape concerns the 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 20 percentage points between 1980 and 1996 (see Goldin and Katz (2008)). However, the proportion with a completed 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.[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. Second, it shows that even though the skill premium rose significantly over the past two decades, the fraction of people who have attained college by age 25 has changed by just around 4 percentage points.[3]

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 *three times* as large in the five decades from 1930 to 1980. Bound, Loevenheim, and Turner (2009) report similar results, showing that while enrollment rates did rise, completion rates did not, and *fell* for some groups. The eight-year completion rate for current

[1] See e.g., Restuccia and Urrutia (2004).

[2] See, e.g., Figure 7 in Kane (2001).

[3] In the figure, enrollment and attainment rates are based on CPS data. The skill premium is the one measured by Goldin and Katz (2008).

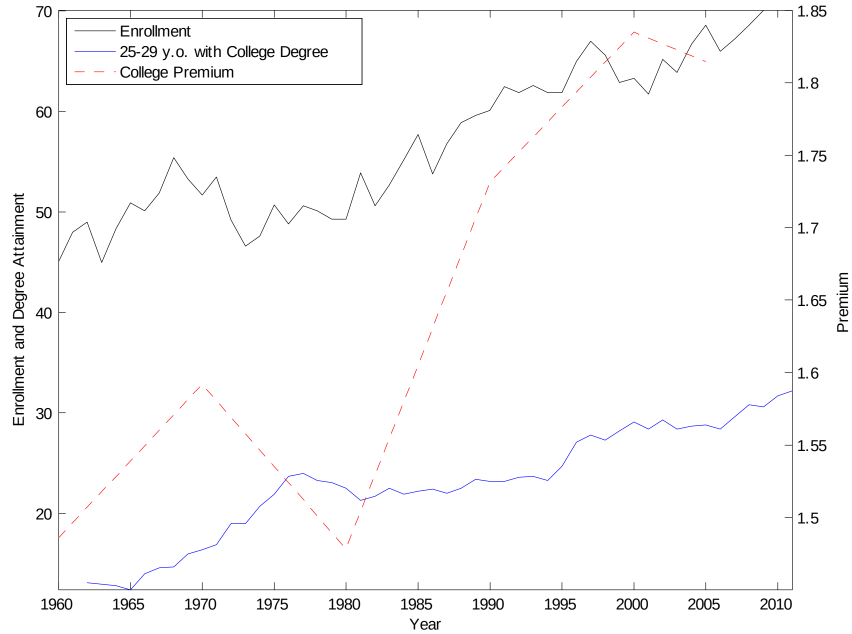

Figure 1: The College Premium, Enrollment, and Attainment

cohorts has fallen, with those who do complete appearing to take longer to do so. For all these reasons, the overall response of skill formation to changes in the skill premium is now 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)).

If the payoff to the marginal decision-maker is well-approximated by the current skill premium, the absence of nearly universal enrollment and a substantial increase in the stock of college-educated labor is puzzling. But as Carneiro, Heckman, and Vytlacil (2011), for example, show, the average return to enrollment does not, in fact, describe the payoff to the marginal entrant. Moreover, this holds even if the mean premium received *upon completion* is the one currently prevailing, because those earning it are those who have successfully completed college.

Completion is related to preparation and household background (see, e.g, Bowen et al. (2009)). As for the former, it appears that the proportion of poorly prepared or poorly "insured" students among potential college enrollees has grown. Bound, et al. (2009) find, for example, that for the 1992 high-school graduating class in the NELS: 88 dataset, 44 percent of those in the lowest AFQT mathematics quartile enrolled in college. Yet, only 11.4 percent of the 1992 cohort completed a bachelor's degree. By contrast, less than 20 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 percent, this group completed college at a much higher rate of 25.8 percent. [4]

[4] Though 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-

These facts lead, for two reasons, to the possibility that increases in the skill premium from current levels may no longer be powerful in spurring enrollment and overall skill formation. 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 non-enrollees than past ones. Importantly, 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.[5]

The aim of this paper is to gauge the role, *ceteris paribus*, of the skill premium in enrollment decisions via a simple quantitative model in which higher education costs, and both completion and rate-of-return risk are allowed to play a quantitatively plausible role. Essentially, we aim to better understand the location and slope of the "supply curve" for college-educated labor. We stress that our paper is not an accounting of recent trends in enrollment, nor does it aim to speak to the effects of changes in higher education policy.[6] Instead, our interest is in individual decisions and the effects of prices, costs, and especially risk–in isolation–on them.

Our approach is very simple: It is to parameterize and simulate a prototypical life-cycle consumption-savings model augmented to allow for risky, lumpy, and irreversible college investment. Our model's proximity to a standard benchmark will allow us to use off-the-shelf parameter estimates nearly everywhere, with only a few specific parameters being calibrated to ensure that the model accounts for salient features of the data, such as enrollment and non-completion rates by AFQT Math scores, skill premia, and wealth near retirement. Our work therefore complements the vast and sophisticated empirical literature on the subject cited above by allowing for a large variety of simple and, especially, non-marginal, counterfactuals. We will use these in an effort to isolate the role of skill premia and a variety of forces that, collectively, influence college investment.

We have three main findings. First, the supply curve of skilled labor appears steep. Our results suggest that most U.S. high-school completers are currently inframarginal with respect to the college premium. In the model, additional increases in skill premia do not by themselves significantly spur enrollment or, more importantly, the stock of skilled labor. This occurs because the effect of increases in skill premia on the returns to college investment depends on the likelihood of *completion.* Higher premia improve returns for the well-prepared, but do not do so for the poorly prepared, and at skill premia close to current levels, the

equivalence of high-school diplomas and GEDs.

[5] 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)).

[6] For the former, see careful papers of Castex (2010a) and Johnson (2011), who study environments similar to ours. Castex (2010a) abstracts from both failure risk and earnings risk (and also calibrates wage-offer distributions for would-be dropouts). Johnson (2011) provides one experiment related to our main focus where he employs his estimates to predict enrollment under alternative skill premia. For rich models aimed at policy analysis, see Heckman, Lochner, and Taber (1998a,b), Garriga and Keightley (2007), Winter (2013), and Abbott et al. (2013).

former would have enrolled anyway. Additionally, those who do enroll in response to higher premia complete at relatively low rates.

Second, our results suggest that the out-of-pocket cost of college matters for the high level of current inframarginality. In the model, at costs higher than currently seen, the current skill premium is far from being capable, all else equal, of generating observed enrollment. This counterfactual experiment is useful 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 explicit college costs, at current skill premia, may be a powerful part of what generates current enrollment rates.[7] An important point here is that the asymmetry of the weak response of enrollment to premia relative to forces that reduce college costs, such as subsidies, arises because the skill premium is obtained only conditional on completion, while reductions in college costs benefit all enrollees. Third, our model suggests that uninsurable risks of failure, and risks to subsequent earnings, both may play an important role. For example, at current skill premia, we find that these risks deter even well-prepared agents from wealth-poor households from enrolling in, and attaining, college.

A longer-run implication of our findings is that when observing a historically high skill premium in place, one should not necessarily expect reversion to the historical mean. In particular, our model suggests that barring changes in the collegiate preparedness of high-school completers, the continuation of current trends in skill-biased technological change such as that arising from falls in the price of computing power (see, e.g., Autor, Levy, and Murnane (2003)), may lead to high and persistent skill premia in the future. Perhaps most consequentially, the muted response of enrollment to such premia means that high and sustained levels of *earnings* inequality are entirely possible, echoing a concern expressed by others earlier, such as Carneiro and Heckman (2002).

Nonetheless, our model also suggests that inframarginality to skill premia is not an inevitability. In the model, behavior depends strongly on both the level of the premium and the price of college. We show that, all else equal, movements in the skill premium from the levels seen in 1980 to those seen in present-day data, if expected to prevail over working life, will increase enrollment rates and attainment in the model broadly in line with the ways observed, while increases in college costs, all else equal, substantially lower enrollment.

As noted, in ongoing discussions of enrollment and attainment, current premia are frequently used as a benchmark. However, it is clear that current skill premia need not have any bearing on college-related decisions, unless the latter is expected to *remain* at or near its current level. 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 who complete college. An important aspect of our paper is its concern

[7] While not our focus, 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 Carneiro, Heckman, and Vytlacil (2011) for a useful explanation of the issues.

with the role played by the entire *path* of future skill premia on current decisions.

Our allowance for uncertainty and uninsurable risks associated with the collegiate investment decision is motivated by several related pieces of evidence. First, there is abundant evidence for "completion-related" risk, as measured by the probability that a student will fail to complete college, in a manner not perfectly anticipated at the outset (see, e.g., Manski and Wise (1983), Manski (1989), Altonji (1993), Stange (2012), or Arcidiacono et al. (2012)). The overall post-secondary non-completion rate is currently approximately 50 percent (Singh (2010), Bowen et al. (2009), Bound, et al. (2009), Hendricks and Leukhina (2011)). Completion risk takes on additional relevance because the uncertainty over eventual completion is not quickly resolved: at four-year institutions, at the median, it takes between two and three years of foregone earnings and the explicit cost of tuition (Bowen et al. (2009), Ozdagli and Trachter (2011)). In addition to taking time, the return to the partial completion of college appears low (i.e. attending but not obtaining a diploma); early documentation includes Psacharapoulous and Layard (1974), and more recently Hungerford and Solon (1987) and Kane and Rouse (2001). Lange and Topel (2006), in turn, argue that a 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.

Second, even conditional on completion there is "rate-of-return" risk. A variety of work, including early analysis of Carneiro, Hansen, and Heckman (2003) estimates that a subantial portion of the present value of earnings can be deemed unpredictable 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.[8] By several accounts households appear to face persistent uninsurable earnings shocks (see, e.g., Hryshko (2010), Storesletten, Telmer and Yaron (2004)). 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. The persistence of these shocks also makes them inherently difficult to self-insure as well, making the absence of market-based insurance more problematic. Few papers feature both failure risk *and* rate of return risk. The exceptions are recent, and include Johnson (2011), Chatterjee and Ionescu (2013), Stange (2012). We will deliberately remain closest, in terms of the model we construct, to the latter three papers.

Two other related papers are those of Brown, Fang and Cocco (2011) and Hendricks and Leukhina (2011). The former calculates the present value of a college investment that has already been *successfully completed*, and studies the role of taxation and social insurance policy in lowering the payoff to college, as well as insuring the risk of unemployment subsequent to college investment. Brown et al. (2011) do not focus, as we do, on completion risk, nor on either the implications of the skill premium for aggregate enrollment (derived from integrating decisions with respect to the joint distribution of households over the state-vector), or on the role

[8] See also, Chen (2001, 2008), and Singh (2010).

of higher education costs in driving enrollment. With respect to failure risk, Hendricks and Leukhina (2011) is relevant. It has the goal of endogenizing dropout behavior and measuring the role of changing underlying ability amongst four-year enrollees over time in the observed skill premium (see also Hendricks (2012), and Chatterjee and Ionescu (2013)). However, unlike our work, or that of Brown et al. (2011), these papers abstract from rate of return risk to human capital. We will show that abstracting from these relevant risks will strengthen our result by rendering essentially all the model's population inframarginal.

It is worth stressing that none of our results arise directly 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, both 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 (2001, 2002), cast doubt on the strength of borrowing constraints for enrollment, and the work of Stinebrickner and Stinebrickner (2007) suggests that short-term credit constraints leave a substantial proportion of college failure unaccounted for.

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 premium even when credit availability is generous. Our model allows for borrowing to be a risky strategy. 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 to note that U.S. government-guaranteed student loans are explicitly non-dischargeable in bankruptcy.[9] 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.[10] 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 far from universal even when the rate of return appears to be extremely high, and

[9] Recent 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.

[10] Ionescu and Chatterjee (2013) studies 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.

why enrollment (to some extent), and attainment (especially), appear insensitive to recent increases in the skill premium.

2 Model

All agents enter the model as young high-school completers. Their first decision is whether or not to enroll in college. After college decisions, agents 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*.[11] By "leverage risk" we mean the risk of facing potentially very low consumption in the future 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 with risk-aversion parameter α. All households discount the future exponentially at a common rate β. Thus, within period expected discounted utility during pre-retirement life is given as: $E_0 \sum_{j=1}^{J} \beta^j \frac{c_j^{1-\alpha}}{1-\alpha}$.

As Retirees, households value resources taken according to a "retirement felicity function", ϕ, that is

[11] 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 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.

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 ν, which will be calibrated to ensure wealth accumulation over the life-cycle is plausible. Thus, discounted utility during retirement is given as follows:

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

This approach 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 β 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 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 Ψ, the household's optimization problem is then:

$$\sup_{(\{c_k\},\{c_j\},x_R)\in\Theta(\Psi)} E_0 \sum_{j=1}^{J} \beta^j \frac{c_j^{1-a}}{1-\alpha} + \phi(a_R) \tag{2}$$

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. We remain entirely standard in our model of earnings, and follow

Hubbard et al. (1994) in specifying log income the sum of three components: an age (j) and human capital-specific (h) mean of log income μ_j^h, persistent shocks, z_j^h, and transitory shocks, u_j^h:[12]

$$\ln y_j^h = \mu_j^h + z_j^h + u_j^h \tag{3}$$

where

$$z_j^h = \rho^h z_{j-1} + \eta_j^h,\ \rho^h \leq 1,\ j \geq 2 \tag{4}$$

$$\ln u_j^h \sim i.i.d\ N(0, \sigma_{u,h}^2),\ \ln \eta_j^h \sim i.i.d.\ N(0, \sigma_{\eta,h}^2),\ u_j^h, \eta_j^h \text{ independent} \tag{5}$$

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,

$$z_1 = \xi \tag{6}$$

where

$$\ln \xi^h \sim N(0, \sigma_\xi^2) \tag{7}$$

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 ξ with distribution $N(0, \sigma_\xi^2)$. In subsequent periods, household non-asset income is determined as the sum of the the unconditional mean of log income μ_j^h, the innovation to the persistent shock η_j^h and the transitory shock u_j^h. 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, 2008), Hubbard et. al. (1994, 1995), and Storesletten, Telmer, Yaron (2004)).

Even where our model implies that increases in skill premia will increase enrollment rates, it also 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 (2012), and Carneiro

[12] Standard specifications of this, are, e.g. Hubbard et al. (1995), Storesletten et al. (2004), Huggett and Ventura (2000).

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.[13]

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.[14] 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.

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 $y_j^h = \exp(\mu_j^h + z_j^h + u_j^h)$. Including this is potentially relevant as it is a source of wealth to households that may be large enough to alter the decisions of 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):

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

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 $a_{\underline{\tau}}$

$$a_R = a_{J+1} + a_{\underline{\tau}} \tag{9}$$

This amount $a_{\underline{\tau}}$ is the wealth level that, when annuitized at the discount rate R^f, and adjusted for the probability of survival for k periods, π_k, yields a flow of income each period equal to the societal minimum consumption floor $\underline{\tau}$.[15] That is, minimal retirement wealth $x_{\underline{\tau}}$ solves:

[13] 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 (2012) 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.

[14] 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.

[15] See again, Athreya (2008) for details.

$$\sum_{k=1}^{K} \frac{\pi_{k\underline{T}}}{(R^f)^k} = a_{\underline{T}} \tag{10}$$

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 π. 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 π, 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 $\{\mu_j^{HS}\}$. For those with “some college," earnings will be drawn from the process with mean profile $\{\mu_j^{SC}\}$. 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 a 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 periods (interpreted as years in the quantitative analysis) of successful completion, agents enter working life as college-educated, and earn an expected payoff (in logs) denoted $\{\mu_j^{C}\}$. The relative size of $\{\mu_j^{SC}\}$ and $\{\mu_j^{C}\}$ are not directly observed, as the latter reflect the selection of households into college. We will therefore calibrate these by assuming that the log premium for some-college and college are each constant relative to high school earnings over the life-cycle (so that we only have two parameters to calibrate for these outcomes), to match observed skill premia.

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 π_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 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 θ 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 $V^S(\cdot)$.

$$V^S(x) = \max(V^E(x), V^{NE}(x)) \tag{11}$$

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 π_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:

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

$$a' > \underline{a}$$

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, *prior to* all subsidies directly received by educational institutions from state, local, and federal sources. Direct subsidies are denoted γ^{direct}, and apply to all enrollees. The term γ^{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 ζ 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 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 τ periods, they receive a partial premium for completing “some-college" (SC). To sum up, outcomes for human capital are given by:

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

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

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

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

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

$$a' > \underline{a}$$

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:

$$V^A(x; j = J) = \max \left[\frac{c^{1-\alpha}}{1-\alpha} + \beta\phi(a_R) \right]$$

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 costs, and the joint density of failure risk and available resources for college. Our approach is extremely straightforward: we assign preference-, income-, ability- and education-cost-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 $\Gamma_1(x_1)$ denote the observed (cumulative) joint distribution of *age-1* Young households over the state vector, $x_{1,}$ and $I(\cdot)$ an indicator function over enrollment in college, we have that aggregate enrollment, denoted Ψ, is given by:

$$\Psi \equiv \int I(V^E(x_1) > V^{NE}(x_1))d\Gamma_1$$

Similarly, given an underlying distribution of non-completion probabilities as a function of the household's state, $f(\pi|x_1)$, the aggregate failure rate is given by:

$$\Pi \equiv \int f(\pi|x)I(V^E(x_1) > V^{NE}(x_1))d\Gamma_1 \tag{12}$$

Importantly, note that the non-completion likelihood $f(\pi|x_1)$ is *endogenous*: it depends on the arrival of outside wage opportunities, household asset holdings, and place (in terms of years completed, for example) in the college regimen.

As a whole, our model of the enrollment decision is sufficiently rich for the questions we ask: 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 the form of a wedge on intermediation.

3 Parameterization

The model requires us to assign values to four groups of parameters: those related to (i) preferences, (ii) education costs, (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 β, and risk-aversion α. Both β and α, though calibrated, turn out to take entirely standard "off-the-shelf" values, at 0.94, and 2, respectively. For the valuation of resources taken into retirement, a_R, we use a simple CRRA specification with curvature α, $\nu\frac{a_R^{1-\alpha}}{1-\alpha}$, and impose the same value. We set $\nu = 3$ to ensure quantitatively appropritе wealth accumulation at retirement.[16]

3.2 Education Costs

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 two years in public four-year colleges, and allow for experimentation by enrollees by offering them the option, conditional on successful completion, to continue to a four-year degree.

3.2.1 Out of Pocket Costs of College

Our approach is to ensure 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. Making college costs higher would make it easier to establish widespread inframarginality at current enrollment rates. We therefore first specify college costs for the first τ 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 four-year college, and roughly \$1250 (\$1994) per year for public two-year colleges. As for the number of years it takes to earn the "some college" premium, we set τ=2. This is line with work of Ozdagli and Trachter (2011), and Hendricks and Leukhina (2011), for example, and can be interpreted as the payoff to a two-year degree.[17]

[16] Naturally enough, ν turns out to be extremely *un*important for the question at hand, simply because retirement valuations are heavily discounted from at the time of the college-enrollment decision.

[17] Because it is not central to our investigation, we have abstracted from heterogeneity among schools. We have parameterized the enrollment decision to a blend of two- and four-year public institutions. Public higher education enrolls the majority of college students (74% in recent NCES data), 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

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 college costs in enrollment. For simplicity, we will vary these costs using a simple parameter γ^{direct}. Three parameters then define education costs: the annual real resource cost of college Φ, γ^{direct} represents the average subsidy 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 two- and four-year colleges, and $\gamma^{need}(x)$, which determines need-based aid 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 percent. Caucutt and Kumar, for example, measure the subsidy at 42.5 percent, which we will apply here, and is close to a more general consensus, Kane (2001), Table 14, for example, suggests a number near 50 percent.[18] Thus, given these estimates, the resource costs of public four-year college for the period targeted in the benchmark model is simply Φ =\$2,500/(1-0.425)$\approx$\$4,350, applying the same subsidy rate to 2-year colleges yields a real resource cost of \$1,250/(1-0.425)$\approx$\$2,175.

To parameterize need-based aid, $\gamma^{need}(x)$, 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 children's college, only 25 percent with high-school seniors had accumulated more than \$10,000.[19] 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

model to allow for this added form of uncertainty is beyond the scope of this paper, but seems worthwhile.

[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 \$3,000) 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 Kane (2001), Table 13.

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 μ_{a_0}= \$11,000.[20][21]

Households may also borrow to finance college. To set this limit, we are guided by the work of Carneiro and Heckman (2001, 2002) who argue that widespread borrowing constraints for education are implausible, and by the explicit set of guaranteed loan programs to finance any amount in excess of the so-called "Expected Family Contribution."[22][23] 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 $\underline{a} = -K\Phi(1-\gamma^{direct})$. Lastly, the risk-free rate on savings is taken conservatively be 2 percent (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 5 percent. 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, π. 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., Carneiro and Heckman (2002), and Stinebrickner and Stinebrickner (2007)). We follow Bound, et al. (2009) who compute enrollment and non-completion rates by AFQT math quartile.[24] Specifically, we allow all individuals to fall into one of 12 failure levels, $\pi \in \{\pi^{(1)}, \pi^{(2)}, ..., \pi^{(12)}\}$, 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.

[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 (\$9,512 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.

[22] The latter are the so-called PLUS loan programs. See http://www.fafsa.ed.gov/what010.htm

[23] In recent work, Lochner and Monge-Naranjo (2011) argue that credit constraints may be regaining strength, but for the period that we choose as our benchmark, the work of Carneiro and Heckman (2001, 2002) seems decisive. See also Brown, Scholz, and Seshadri (2012).

[24] We stress that we never directly calibrate enrollment rates. Instead, we calibrate the model to match the enrollment and completion, *conditional on AFQT scores.* The resulting aggregate enrollment rate closely matches the one estimated by Bound, et al. (2009), and is slightly higher for the corresponding period than the one based on CPS data shown in Figure 1.

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. Akyol and Athreya (2005) 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 (2010a,b) for the correlation between "Family Income" and "Ability" (as measured by AFQT) in the NLSY79 and 97.[25] As with several other parameters above, our approach is 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.

To summarize, we take higher-education cost parameters directly from data, and calibrate 19 objects to match salient observations. These are: twelve levels of failure risk, $\{\pi^{(i)}\}_{i=1}^{12}$, risk-aversion (α), the retirement valuation constant (ν), households' subjective (and common) discount factor (β), earnings scaling factors (ϑ^C, ϑ^{HS}) that generate premia for some-college and college completers, respectively (two parameters), the rate of decay of failure risk over time (θ) and the wedge on intermediation costs (ξ). Our targets are (i) non-completion rates by AFQT quartile (four targets), (ii) enrollment rates by AFQT quartile (four targets), (iii) mean earnings premia for some-college and college completers (two targets), median time to completion among enrollees (one target), and (iv) medians of wealth accumulation over the life-cycle for college and high-school educated individuals (all remaining targets).[26][27][28]

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

[25] The results are very robust to this parameter. Higher correlations (e.g. 0.7) lower aggregate enrollment very slightly (around 0.5 percent). 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.

[26] Since there are three educational-types in the model, and each type makes wealth accumulation decisions throughout Adult life, this yields a total number of potential targets of $3 \times J \times$ number of wealth moments used. Our wealth targets are median levels of wealth by age and education. Given the period to which our benchmark model applies, we aim to generate median wealth by age for College and High-School graduates in the PSID as summarized in Cagetti (2003), Figure 2. For brevity, the results are not presented here. They are most influenced by the discount factor, β, elasticity of intertemporal subsitition, $1/\alpha$, and the borrowing wedge ξ. It is useful, therefore, to see that the benchmark parameterization is able to employ entirely standard values for these parameters.

[27] Notice that we cannot directly parameterize earnings premia, since those are a function of decisions to enroll and remain in college long enough to complete a degree. This depends on both household wealth and the level of outside income shocks.

[28] Notice that if (i) dropping out were either disallowed, or if the arrival of outside opportunities was such that it was never optimal to drop out once enrolled, (ii) we restricted ourselves to just the four initial non-completion probabilities, and (iii), there was no decline over time in the likelihood of failure, then the probabilities we employed would be completely determined and exactly equal to the conditional probability of not completing college given AFQT quartile. However, we are interested in ensuring that dropping out is front loaded, and that the model is not overly coarse in its representation of failure risk. Therefore, we employ a larger number of initial failure levels to 12, or three per quartile, and model the decay in the likelihood of failure through θ. However, we tie our hands here as well: we require that $\{\pi\}$ be monotone within any quartile and of course that, when aggregated, yields non-completion and enrollment and duration of enrollment that match as closely as possible the data.

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 as unskilled households that depress the skill premium all else equal. In our benchmark, we set the mean levels by age such that we match the targeted skill premium. That is, we locate two scalar coefficients, ϑ^C and ϑ^{SC}, on the mean of log earnings that yields targeted premia for college and some-college individuals: $\mu_j^C = \vartheta^C \mu_j^{HS}$, and $\mu_j^{SC} = \vartheta^{SC} \mu_j^{HS}$. In our benchmark setting, we set γ^C such that enrollees generate an average college premium of approximately 1.75 times that of high-school completers, in line with Goldin and Katz (2006); that is, such that $\frac{E(y^C)}{E(y^{HS})} = 1.75$.[29] 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, ϑ^{SC} such that we generate, after allowing for dropout decisions in the wake of good persistent outside options, we generate an observed premium of $\frac{E(y^{SC})}{E(y^{HS})} = 1.2$, to reflect an average over the various groups in our model who attain "some college" in line with the roughly 10 percent *annual* higher earnings premium for this group estimated by Kane and Rouse (1995) using data on those who attain two-year degrees.

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, as Brown et al. (2011) stress, 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 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.[30]

[29] See Gallipolli et al. (2010), Table 26.

[30] We use:

Parameter\Education Level	HS	Some Coll	Coll
σ_u^2	0.021	0.021	0.021
σ_η^2	0.025	0.025	0.014
σ_ξ^2	0.5	0.5	0.5
ρ	0.95	0.95	0.95

(13)

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.[31] 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.

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.[32] [33] As such, our main finding that, all else equal, local changes in skill premia will not likely alter aggregate enrollment rates, is made more robust.[34]

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

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.

[31] See also Castex (2010b), Table E.2, and Hendricks and Leukhina (2011).

[32] In 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.

[33] This 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 faster than the change in wages, if one views the latter as a product of the price per unit of skilled labor and the level of skill possessed by a given worker. Lastly, see Hendricks and Leukhina (2011) for ongoing attempts to disentangle selection effects embedded in observed skill premia.

[34] 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 *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.

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.[35] 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 parameters:

Table 1: Parameter Values

Parameter	**Value**	**Source**
β, α, ν	0.94, 2,3	Calibrated
$\{\vartheta^C, \vartheta^{SC}\}$	0.85, 0.8	Calibrated
θ	0.5	Calibrated
$\{\pi^{(i)}\}$	See text.	Calibrated
ξ	0.03	Calibrated
$\underline{a}$	$-K\Phi(1-\gamma^{direct})$	Set to ensure universal feasibility of college
$\gamma^{direct}_{benchmark}$	0.425	Caucutt, Kumar (2005), Kane (2001)
γ^{need}	\$2300, \$30,000	www.ed.gov
med_{a_0}, μ_{a_0}	\$3,000, \$11,000	Gallipoli et al. (2010)
$corr$(test score, a_0)	0.3	Castex (2010b)

(14)

4 Results

To begin, we document the fit of the benchmark parameterization along a few dimensions most salient for the questions we are interested in.

4.1 Enrollment and Completion in the Benchmark Economy

In Table 2, we start with non-completion rates by AFQT Quartile, where the "targets" are the measures reported by Bound et al. (2009), Figure 2, Panels C and A, respectively.

Table 2: Non-Completion: Model vs. Data

Non-completion	Model	Target
1st	78.1%	88.6%
2nd	69.3%	70.4%
3rd	52.8%	52.8%
4th	26.7%	27%

(15)

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

We see that the model is able to capture well the non-completion of all four quartiles. And while the model is not able to perfectly match the lowest AFQT quartile, it is close.

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

Table 3: Enrollment: Model vs. Data

Enrollment	Model	Target
1st	43.9%	44%
2nd	65.4%	66.5%
3rd	87.1%	79.7%
4th	93.3%	92.7%

(16)

As before, we see that the model is able to closely match enrollment rates across AFQT quartiles, though it overpredicts somewhat the enrollment rates of the third enrollment quartile. 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).

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

We turn now to the main question of this paper: What should one expect for the response of enrollment and attainment to changes in the skill premium? We start with enrollment. While we have shown that the aggregate enrollment rate appears to be fairly insensitive to further increases in skill premia, this aggregate measure may well capture heterogeneity in the behavior of individuals facing different completion likelihoods. Figure 2 displays the results for this case. To repeat, the results here are for the case where enrollees expect the premium to last their entire working life (we will study a case further below where this assumption is dropped).

We have seen already from Table 4 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. Under the benchmark skill premium of approximately 1.75, our model suggests that for enrollees with completion probabilities in excess of roughly 0.4 will increase enrollment rates by less than 10 percentage points. What is clear from the figure, then, is that the skill premium, at levels in the neighborhood of currently value is a motivating force primarily for poorly prepared enrollees. Lastly, wee see that completion likelihood matters most when the premium is at levels that are low relative to current observations. This is another way of seeing why inframarginality should be relatively widespread. Intuitively, the key to our results is the "flatness" of the majority of the enrollment surface. It is what tells us that most joint distributions of preparedness and households' access to resources will, when evaluated across households, lead to only modest changes in enrollment rates.

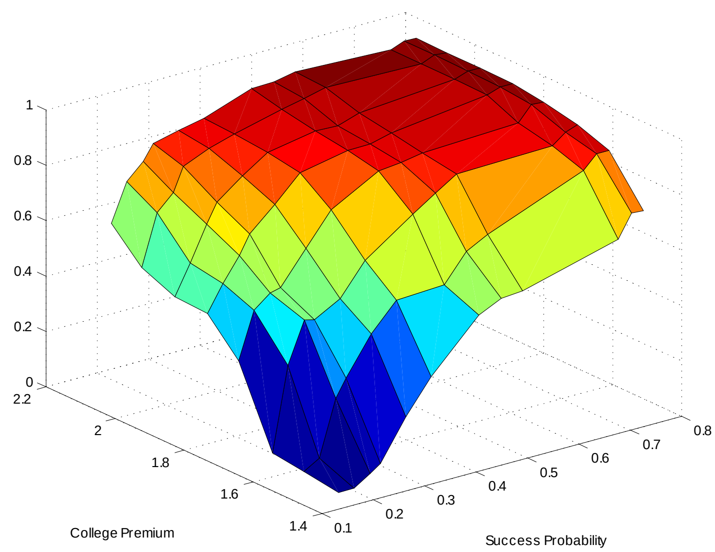

Figure 2: Skill Premia, Preparedness, and Enrollment

We will show later that this finding is robust to a variety of complications that, taken together, cover a fairly comprehensive range of circumstances.

4.2.1 Attainment

We have already shown above that the model implies that aggregate enrollment should be expected to respond nontrivially to changes in the skill premium, especially from (life-long) premia that start at levels below what is currently observed. We then showed that for skill premia close to current level, enrollment, and hence attainment–as defined by the fraction on enrollees who eventually complete college, is unlikely to change. To more clearly display the role of the skill premium in generating actual collegiate attainment, we display next the fraction of college *completers* of a given cohort across various skill premia (that are expected to prevail over their working lives) and initial non-completion probabilities. The attainment rate shown in the figure therefore incorporates both the initial likelihood of success and the enrollment rate of the group with that particular likelihood. As a result, it also depends on the conditional distribution of wealth amongst would-be enrollees with this level of non-completion risk.

Figure 3 is striking in demonstrating that ultimate completion rates amongst enrollees of varying levels of preparedness changes very little–again for any would-be enrollees whose preparedness lies above a fairly low threshold. The extremely low attainment rate amongst the very poorly prepared, especially at very low skill premia, reflects both a very low enrollment rate within this group, and the low completion likelihood of the few who do enter. By contrast, the attainment rate is extremely high for very well-prepared individuals, who enroll *and* complete at very high rates.

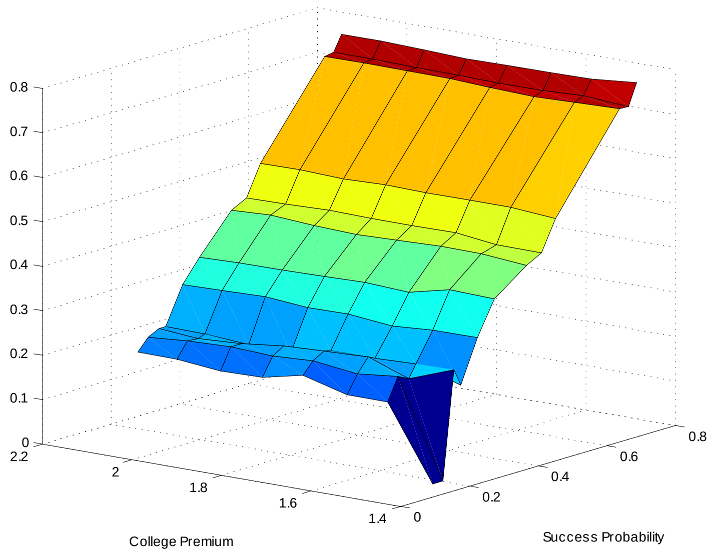

Figure 3: Skill Premia, Preparedness, and Attainment

4.2.2 Aggregate Enrollment, Graduation, and Attainment Across Skill Premia

The model thus suggests that changes in the skill premium should not, by themselves, be expected to significantly alter the stock of high-skilled households. So far, though, we have displayed decision-making across skill premia, but primarily have done so (with the exception of Table 4) conditional on particular levels of preparedness. We now aggregate (integrate) with respect to the joint distribution of household wealth and preparedness to generate aggregate enrollment, graduation, and overall cohort attainment rates across skill premia. Figure 4 collects the results for the behavior of aggregate enrollment, Ψ, graduation (1-Π), as well as attainment.

With respect to enrollment, as we noted earlier, we target enrollment and non-completion rates by AFQT mathematics quantile, as estimated by Bound et al. (2009). These authors also compute enrollment rates for the NLS 72 cohort (who first enroll in college in 1976), and show that this group's enrollment rate was 48 percent (see their Table 1, Panel A) for that year, a time when the skill premium was slightly above 1.5 (see Figure 1 above). The model's predicted enrollment rate for this period was approximately 45 percent. Interestingly, the model generated non-completion rate (which is one minus the "Graduation Rate" in the Figure) at the skill premia of roughly 1.5 is also very close to the 49 percent non-completion in the data for the NLS 72 cohort (see Bound et al. (2009) Table 1, Panel B). Of course, it is important to keep in mind that the model generates enrollment and completion rates based on premia that are expected to last through working life and, crucially, holds all other forces constant. It is not intended as a model of all dates in a particular segment of the higher education time-series landscape. Nonetheless, the behavior of the model does suggest that the model is broadly consistent with data, if households in the data expected skill premia

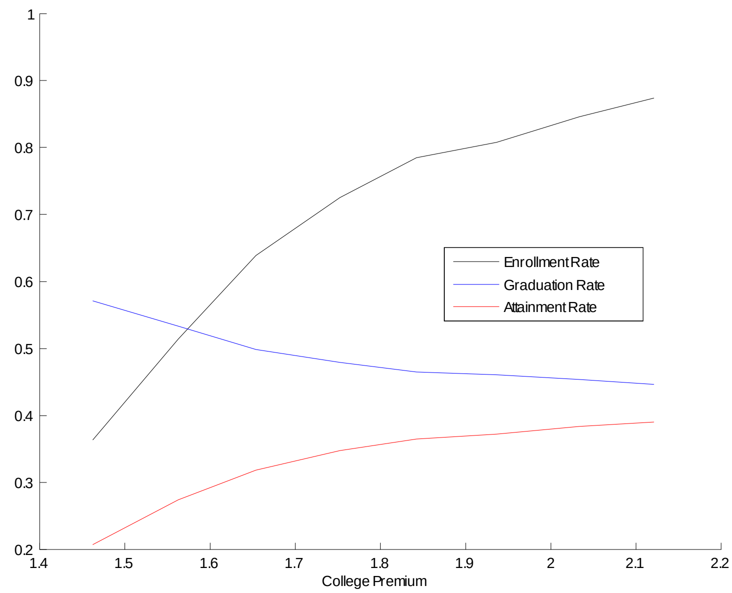

Figure 4: Enrollment, Graduation, and Attainment Rates Across Skill Premia

to be highly persistent.

The model also suggests that under *permanent* skill premia higher than seen today (values of 2.1 or greater, e.g.) enrollment rates will rise roughly 10 percentage points further than currently observed. Notice though that graduation rates will fall to the point where cohort attainment rates under these conditions will look only slightly higher (4-5 percentage points) than their current level. This is because non-completion rates rise as increasingly less well-prepared enrollees "try their luck" with college.

Thus, the model essentially replicates both the level of attainment and the near-absence, at skill levels close to current ones, of any association between the skill composition of the U.S. labor force and changes in the observed skill premium. This is our second main result.[36] Again, while the model was not geared to replicate observed time-series on enrollment, the results are in striking congruence with Figure 1. Indeed, to the extent that the skill premium at each point in recent U.S. history has been perceived as very persistent, the model's predictions are rather consistent with observed outcomes. For our purposes, the key is the decline in slope in enrollment rates as premia near, or exceed, current values, and the attendant flattening of overall attainment rates.

[36] Lastly, with respect to the role of opportunity costs, we note that dropping out is a rare phenomenon, as non-completion rates are very closely tied to initial completion probabilities, for all but the case where the skill premium is relatively low, and the enrollee is among the least prepared. These enrollees are disproportionately likely to find dropping out optimal, and hence complete at rates lower than simply their underlying failure risk, π, conditional on remaining in college.

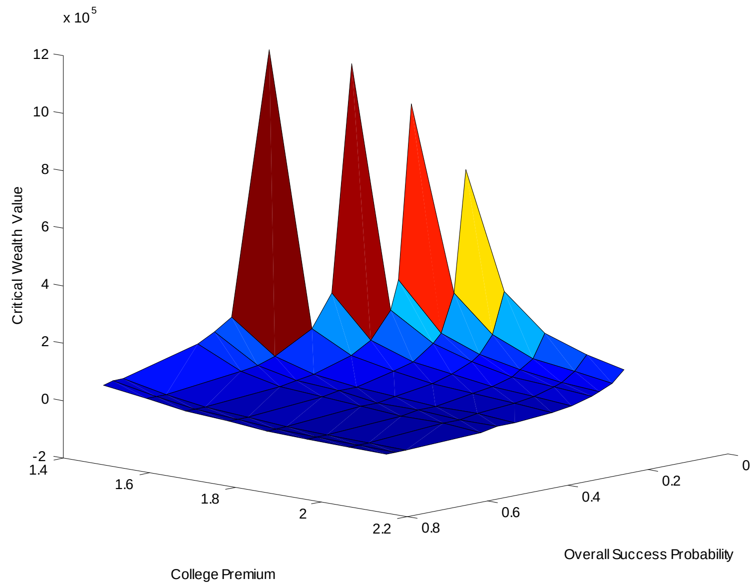

Figure 5: Wealth Thresholds across Premia and Completion Likelihood: Benchmark Model

4.3 The Roles of Preparedness, Premia, and Opportunity Costs: Threshold Wealth Levels

We examine next the role of preparation and premia is driving the threshold level of wealth for enrollment (i.e. the level above which an individual chooses enrollment). Figure 5 displays these thresholds and makes clear that when enrollees face non-completion risk and wage risk simultaneously, these wealth threshold vary systematically with skill premia. In this case, for each level of human capital, we set premia to be the mean value at each age realized under household enrollment decisions in the benchmark economy

Several implications are immediate. First, for those likely to succeed, household financial resources have little implication for enrollment, irrespective of the skill premium. Second, the opposite is true for those who are unlikely to complete college. In this case, relatively unlikely candidates for completion need to be progressively richer to be willing to attend college at progressively lower skill premia. Third, the relatively high aggregate enrollment rate and modest familial resources of the median potential enrollee place limits on the measure of households who are very poorly prepared. That is, Figure 5is conditional on completion likelihood, but has nothing by itself to say about how prevalent any particular preparation level is. However, it makes clear that relatively poor enrollees will not, at current skill premia, be wealthy enough to find college attractive. Lastly, the very fact that there is a clear finite level of wealth above which the investment in college becomes worthwhile, and below which it is not is clear evidence for risk playing a role. We will return to this later.

4.3.1 Opportunity Costs

In presenting results for enrollment, we have looked across skill premia and preparedness levels, but have said nothing, so far, about the role of opportunity costs in enrollment decisions. In settings, like the current higher-education environment, the out-of-pocket costs of college are likely to remain smaller than the earnings foregone by attending college. As a result, differences in enrollment rates across preparedness levels are almost certainly influenced by the foregone earnings sacrificed by poorly prepared enrollees. Figure 6 suggests that this is indeed the case; it plots the level of initial wealth ("a_0" in the model) at which a household becomes indifferent to enrolling or not as a function of two aspects of a potential enrollee's situation: their likelihood of success, and the current realization of persistent earnings. For scale, the median value of the shock is normalized to four, with "1" and "7" representing very unlikely shocks that are plus and minus three standard deviations from the (normally distributed) shocks to the mean of log productivity. It holds the skill premium at the benchmark level. Intuitively, as the outside option to college increases, so should the unwillingness of people to enroll. Moreover, this effect should be more pronounced for those with lower likelihood of success, because the foregone earnings carry lower expected future rewards. This is seen clearly in Figure 6. The "hole" in rear corner of the surface arises simply because households with the best outside option (a three standard deviation increase in log earnings relative to the age-specific means) and very low success likelihoods do not find enrolling at any initial wealth level (at least none on the very expansive grid for wealth levels, in excess of one million dollars we allow).[37]

4.4 The Role of Wage Risk

Thus far, we have focused on the role played by all forms of risk operating simultaneously. In particular, we have examined enrollment decisions and threshold wealth across skill premia in a setting where failure risk and wage risk rendered college investment, and especially borrowing for college, risky. We now shut down all wage risk, and examine the role played by skill premia in driving enrollment. To retain comparability with the benchmark model, we set wages by age equal to mean wages by age arising in the benchmark case.

4.4.1 Threshold Wealth without Wage Risk

We first examine the role of premia and non-completion likelihoods in driving threshold wealth levels. Figure 7 presents threshold wealth cutoffs for a would-be enrollee who, as before, currently faces the median wage shock as her outside opportunity.

[37] An interesting aspect of this result, that we leave for future work, is measuring the role that attractive outside opportunities played in diverting high-school graduates away from a path into college, and instead into the household construction sector in the lead-up to the Great Recession. Our model suggests that for those not very likely to succeed, the pull of outside wage work will indeed yield large changes in enrollment–especially because the distribution of resources amongst this set is unlikely to have a large median or mean (see e.g. Gallipoli et al. (2010)).

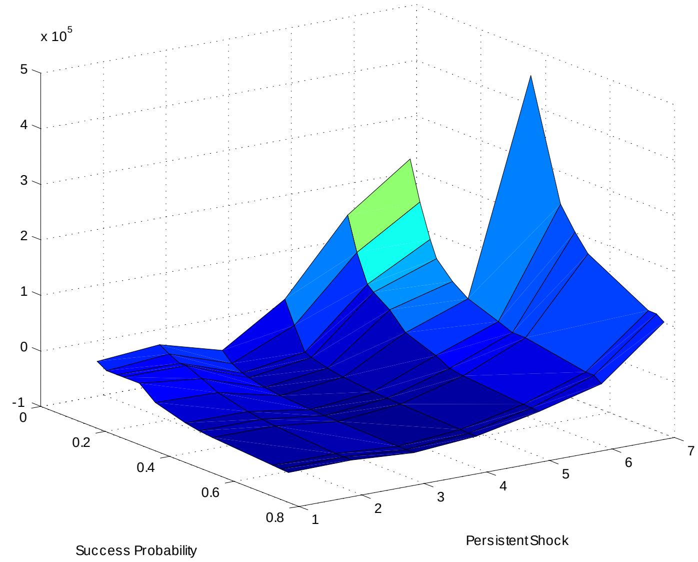

Figure 6: Preparedness, Opportunity Costs, and Threshold Wealth

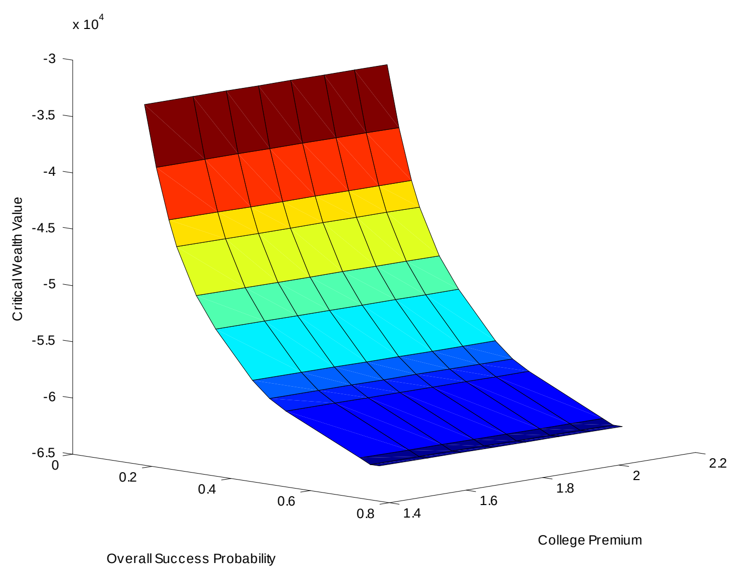

Figure 7: Threshold Wealth: The Roles of Premia and Completion Risk without Wage Risk

Two features are salient. First, the threshold levels of wealth amongst those with low chance of completion are an order of magnitude lower now. Qualitatively, the decline in threshold wealth is of course natural. What is more interesting is the size of the decline. Second, in contrast to Figure 5, we see that in the absence of wage risk, there is no longer any relationship between failure risk and threshold wealth. In other words, conditional on failure risk, one's internal resources play a negligible role across skill premia.

4.4.2 Enrollment and Attainment without Wage Risk

The preceding wealth thresholds, when combined with information on the joint distribution of household wealth and non-completion likelihoods, yields, as before, aggregates for enrollment and attainment. This is presented in Figure 8. When compared with the benchmark case, we see that enrollment in college becomes *universal*. To be clear, this result says that if wage risk disappeared, and all that remained was completion risk, all would enroll. As a result, by comparing with observed enrollment rates of approximately 70 percent, the model suggests that wage risk upon completion of college lowers enrollment by roughly 30 percentage points. This is a very large increase, and it substantiates the idea that were one guaranteed the skill premia at levels even far lower than current ones, attempting college is indeed a "no-brainer."

However, note that the attainment rate is exceptionally low under low skill premia. This occurs because many poorly prepared enrollees "intend" only to obtain the two-year premium–which, absent wage risk, guarantees them a substantial premium for a low opportunity cost. As seen, the graduation rate remains very low under low skill premia, and only later rises to higher levels, as remaining in college for even poorly prepared students becomes worth it (as long as they survive the first two years). Lastly, we see that attainment eventually reaches a plateau, as all young high-school completers enroll, and only leave when they fail. The benchmark calibration suggests that this upper bound is roughly 44 percent. While much higher than the current attainment rate, it is clear that this is a special case. The main message is that wage risk is of clear importance in the power of a given premium to lure enrollees.

4.5 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 a function of

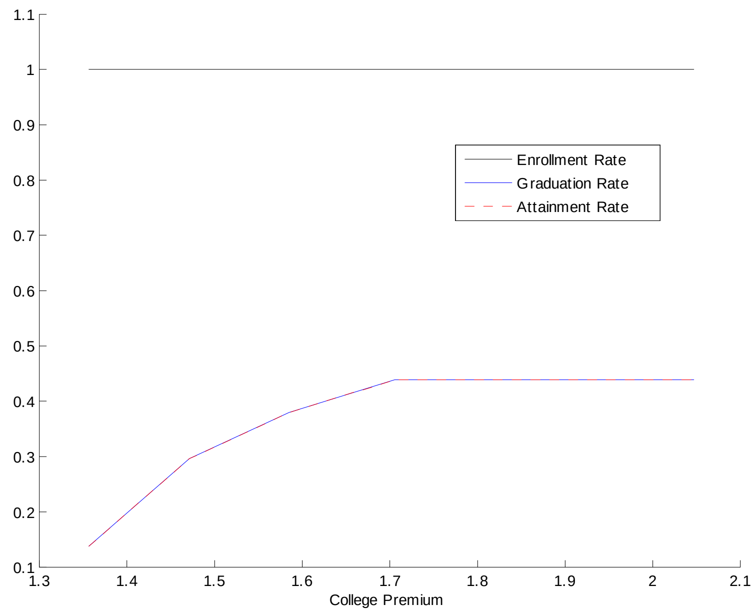

Figure 8: Enrollment and Attainment under the Removal of Wage Risk

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 by 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 10, and then 20 years from college completion.

Table 5: Skill Premia, the Timing of Rewards, and Enrollment

$\frac{E(y^C)}{E(y^{HS})}$\Timing	1-10	11-20	21-30
1.75	71%	69%	68%
1.8	78%	73%	70%
1.9	83%	77%	73%

The message of these results is clear: if potential enrollees do not expect a given skill premium to last for most of their working lives, or if they must wait for the premium to apply, they will respond by substantially less to any given premium. This suggests again that expecting further increases in skill premia to be associated with significant enrollment responses is unlikely to be warranted.

So far, our results suggest 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 in cases where current premia are higher than the historical average, but are expected to fall by the time the cohort reaches late middle-age.[38]

5 A Punchline: Most US High-School Completers are Inframarginal With Respect to the Skill Premium

Taken as a whole, our findings help explain what "anemic" response of enrollment to changes in the skill premium noted at the outset. Moreover, our findings arise from a simple, 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 very."

[38] Part V "Poor Information" in Kane (2001) is instructive as to the likely extent that households 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 disadavantaged backgrounds seemed to systematically overestimate the costs of college.

6 Why are So Many Inframarginal?

We have shown thus far that incorporating quantitatively reasonable heterogeneity in wealth and preparedness into a model of risky college investment can allow us to 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 because of the high current *level* of enrollment rates. And this, in turn, may arise precisely from the very low out-of-pocket price of public college education. In practice, and in the model, the private cost of college to enrollees is dominated by the sizeable subsidy it receives. We now ask about the role being played by college costs 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.

We first evaluate the power of costs 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. We stress, however, that our goal is to assess the effect of the costs of college, all else equal, and not to analyze subsidies, per se. Most obviously, a change in policy might elicit offsetting behavioral responses such as inter-vivos transfers that would change the "initial" wealth distribution of would-be enrollees. It is simply convenient, for comparison with the benchmark economy, to represent different cost regimes in terms of the subsidy that would yield them.

Table 6: Skill Premia and Costs: Benchmark Case

$\frac{E(y^C)}{E(y^{HS})} \setminus \gamma^{direct}$	0	0.15	0.425	0.575	0.65
1.75	53%	56%	73%	75%	78%

We see that under current skill premia, college remains financially attractive at low levels of subsidies, but not nearly so much as under current costs. As we will show below, even highly prepared high completers enroll at less than 100 percent 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. To more closely evaluate the role of wealth, knowing already that it likely plays a role in the benchmark environment, and knowing that it plays a role in counteracting the disincentives to enroll created by high outside wage options, we study threshold wealth across education costs.

6.1 Wealth and Enrollment: Seeing that Risk Matters

Figure 9 is perhaps the most important 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 cost levels. Intuitively, optimal enrollee decision-making leads the lowest line to be associated with the lowest cost, 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 a relatively high-cost investment in college is simply not financially worthwhile. As can be seen from Figure 9, if one fixes a wealth level, then looking across failure risk, we see that for enrollees with a success probability of less than 30 percent, it takes the equivalent of a subsidy in excess of 50 percent 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 occur 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 costs 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 percent), we see that under benchmark costs (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. College costs do not change the qualitative nature of decisions, but alter the threshold level of internal wealth significantly. Under the highest cost regimes, an average would-be enrollee requires approximately $30,000 more internal wealth than she would under the lowest cost setting. This gap persists for even very well-prepared students, but shrinks for those least prepared. Intuitively, as the likelihood of failure grows, lower costs act as a form of wealth, as all households wish to enroll, while costs play little role in altering 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, costs have 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 costs. Interestingly, on this point notice that in contrast to what occurs at very high and low success rates, households are sensitive to costs 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, reductions in costs will operate to make enrollment more attractive via only one channel: a pure "price effect." That

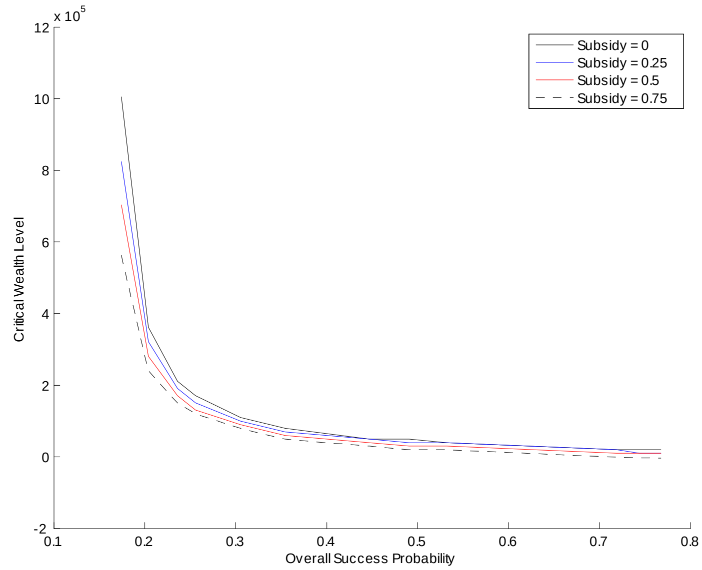

Figure 9: Preparedness and Wealth Thresholds

is, whenever the outcome of the investment is more or less guaranteed, reductions in out-of-pocket costs by definition cannot 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 lower college costs make 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.

6.1.1 The role of college costs without wage risk

To disentangle the role of wage-risk from the possibility of non-completion, we now present the analog of the previous figure for the case where wage risk is removed. As before, in this "no-wage-risk" case, we set premia to be the mean value at each age, for each level of human capital, realized under household enrollment decisions in the benchmark economy. Importantly, in what follows, we examine the implications of removing all wage risk. The thought experiment is one where risk is costlessly removed (as in the classic Lucas (1987) welfare cost of business cycle calculation), and the results are given in Figure 10. We do not alter any of the model's parameters from their benchmark values. Later on, when we study the robustness of our model to misspecification in the riskiness of returns to human capital, we will remove wage risk and recalibrate the model under this alternative.

The implications are immediate: wage risk is a clear deterrent to entry, even though it affects agents of all human capital levels. That is, even though one cannot escape wage risk by rejecting college and remaining a high-school graduate, wage risk deters enrollment. In particular, we see that, holding fixed non-completion risk, the wealth thresholds turn negative. That is, even initially indebted households, if they can

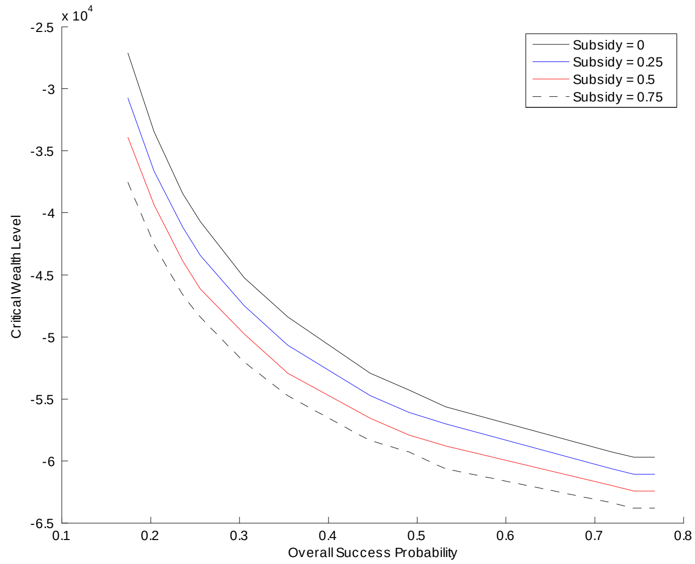

Figure 10: The Role of College Costs without Wage Risk

be guaranteed a premium once they graduate, will choose to enroll. This is far from being the benchmark model, as shown in Figure 9, when the payoffs after graduation were uncertain.

We also see that the gap in threshold wealth levels across subsidies is far smaller in the absence of wage risk than otherwise. Lastly, in the case of those with very poor completion prospects, threshold levels are enormous in the benchmark model, while they remain modest at most when wage risk is removed. Importantly, as we saw earlier, when wage risk is removed, many will enroll at even low skill premia knowing that they will leave after completing two years and acquiring the accompanying premium. When the payoff to even successful completion are risky, however, those with low likelihood of completion can only enroll by borrowing, and hence risk very low consumption even if they graduate. If the latter is unlikely, then ex-ante, households are incurring costs for a modest "some-college" premium that may, ex-post, be wiped out by a single bad realization of the persistent productivity shock.

6.2 Enrollment Responses to Changes in Skill Premia: Costs Matter

The results thus far are suggestive of current levels of costs playing a strong role in driving enrollment, all else equal, and that successive reductions in college costs 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 out-of-pocket costs of college. The results are presented in Figure 11.

Two points follow from the results in this Figure. First, all else equal, out-of-pocket costs of 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 10 percentage points lower than at present. At lower (but still substantial) premia,

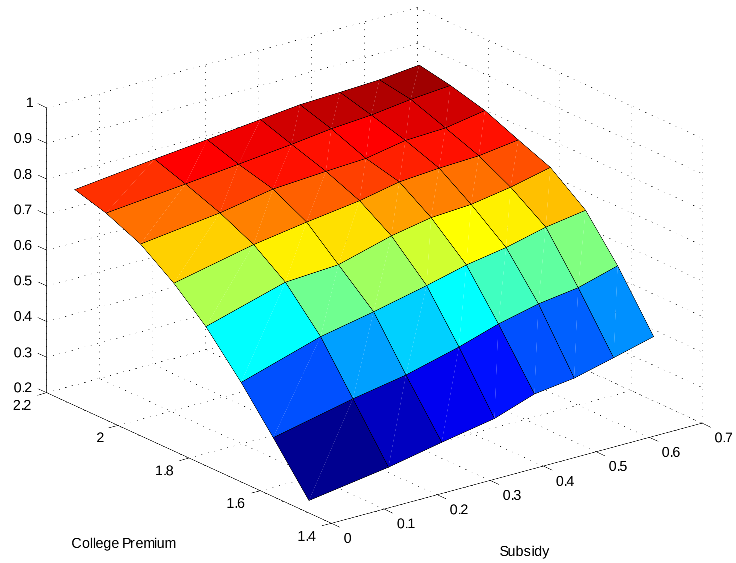

Figure 11: Enrollment Rates across College Costs and Skill Premia

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 percent. Thus, at high costs (e.g., $\gamma^{direct} = 0$), with reasonable measures of the distributions of failure risk and parental resources available to potential enrollees, many households are 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 falls by 3.6 *percentage points* per $1,000 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 $1,000 increase corresponds to approximately 30 percent increase in change in subsidies away from current rates, close to the 57.5 percent case.[39]

Depending on the level of skill premium, this leads to an increase in enrollment of between 4 and 7 percentage points in enrollment rates, and so is similar to empirical estimates. And *holding all else, especially skill premia, fixed at current levels*, the model suggests a sharp increase in college costs would lead to enrollment rates dropping very substantially, to just 53 percent. 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 rose substantially (see Figure 1), was identical to what estimates suggested would be seen from just

[39] Again, we emphasize that our aim is to examine the role of costs and skill-premia, all else equal, and do not intend our experiments to be interpreted as a policy analysis of subsidies per se. We have not allowed for general equilibrium feedback effects, or changes in inter-vivos transfers (see, e.g. Abbott et al. (2013) and Winter (2013)). Yet, our results nevertheless appear informative for such changes.

a \$500 increase in tuition costs.[40]

It is important to be clear on what the preceding result does not say. It does not say that if costs were far higher, that far fewer would enroll. It says that current skill premia, *given resources, and preparedness*, are not enough to induce observed enrollment at higher costs than currently observed. A focus for our paper has been "what is the importance of higher education costs relative to skill premia, in accounting for enrollment?". 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. This in turn makes 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, reductions in costs from high levels to lower ones (e.g., from $\gamma^{direct} = 0$ to 0.425) matter a great deal for household decisions. However, at costs and skill premia near current levels, additional reductions in costs (e.g., from $\gamma^{direct} = 0.5$ to 0.575) do not meaningfully change the response to further increases in the skill premium. This is seen clearly by comparing the bottom two rows of table below. 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 direct costs matter in ways similar to skill premia for enrollment. The enrollment rate under the highest skill premium we study (2.0) and highest college costs ($\gamma^{direct} = 0$) is close to the enrollment occurring under the much lower skill premium (1.7) currently prevailing with the benchmark education cost level. The importance of college costs, ceteris paribus, is a main finding of our model, and is consistent with recent work, particularly that of Johnson (2011).

Relatedly, changes in enrollment are largest when overall education costs are high. The model suggests that under current or lower costs, 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 decrease in college costs—will be only modest increases in enrollment. Moreover, given the increasing marginality of the additional enrollee,

[40] Kane (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)."

the resulting skill formation will likely be even smaller.[41] In sum, the model suggests that increases in skill premia followed by stable enrollment rates may well be a possibility.

6.3 College Costs, 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 percent of college students are enrolled at public colleges and universities (NCES 2010). Having shown that costs, as represented simply by the subsidy rate, influenced the size of the response to skill premia by influencing the size of the marginal population, we now use our model to briefly assess the role played by costs on aggregate enrollment and completion rates under the current skill premium. Recall that in our model, reductions in the cost of college also reduce the risk faced by students. They 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 and failure rates as a function of college costs.

Table 7: Unconditional Enrollment and Failure Rates: Benchmark Skill Premium

Subs. Rate(γ^{direct})	Enroll Rate (Ψ)	Fail. Rate (Π)
0.0	59%	48%
0.15	66%	50%
0.425	73%	52%
0.575	75%	53%
0.65	78%	53%

(17)

This table integrates enrollment decisions over the underlying joint distribution of preparedness and initial wealth available to households of typical enrollment age. The reductions in cost evaluated here are available to all students and, unlike the skill premium, confer benefits regardless of whether or not the student graduates. As more students attend, the selection becomes less favorable, so the aggregate failure rate rises also.

[41] In the longer run, the net effect of the preceding is likely to lead to greater inequality.

6.4 Targeted Cost Reductions

The direct costs we have studied so far are, by construction, paid by all enrollees. It is of interest to examine the effectiveness of targeted cost reduction, such as need-based aid, to alter decisions. Our decision model allows predictions about the long-run effects of changes in such aid. Unlike changes in direct college costs, we will interpret these reductions in costs as more directly a policy exercise. The model is likely to generate plausible results for outcomes given the relatively smaller size and limited scope (a focus on low-income, low-wealth households who may be less able to execute the intervivos transfers modeled by Abbott et al. (2013)) of need-based programs. 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.

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 8: Enrollment rate by Preparedness and Pell Grant Max.

Pell Max /(1-π)	0.17	0.24	0.35	0.49	0.77	Ψ
\$1,750	5%	49%	70%	86%	93%	67%
\$2300 (benchmark)	31%	53%	77%	87%	95%	73%
\$3,000	42%	63%	81%	88%	96%	78%

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 costs currently paid by enrollees (recall that it was the cost occurring under the current 42.5 percent subsidy). 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 forces that lower the out-of-pocket costs of college, it appears that enrollment in the data may not be as sensitive to the largest need-based aid program, the Pell grant. Kane (2001), and Hansen (1983) 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.[42] An additional factor that may have played a role is suggested 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 generally stress the use of our model to evaluate long-run changes arising from changes in policy, the results suggest 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, within the model, 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 alone 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 overall tuition and fees 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 the role played by the possibility of failure. In other words, even though skill premia and college costs both seem like equal contributors to the net benefits of college investment, they are not.

7 The Robustness of Widespread Inframarginality

The central claims of this paper are that (i) the proportion of households who are currently marginal with respect to skill premia is small and (ii) the current level of out-of-pocket higher education costs are key to this, all else equal. Our approach was to specify the distribution of non-completion likelihoods in a manner that allowed us, under currently observed skill premia, to match both enrollment and non-completion rates across AFQT quartiles, as measured in Bound et al. (2009). Measured this way, of course, the distribution of preparedness we employ is influenced by both the values of other model parameters, such as discount factors and risk-aversion, and the manner in which college premia depend (or not) on the preparedness of enrollees.

We now demonstrate that both our implications are robust, and are so even though our model employs a variety of assumptions that bias the model away from generating the widespread inframarginality we find. Maybe most importantly, we assume that the observed average premium is the premium for the marginal entrant. The lower the latter is relative to the former, as may plausibly be the case, the easier it will be to

[42] Their findings are very striking: They show that a huge proportion of Pell aid can be accounted for by a very short list of 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!

establish inframarginality. We also do not endow households with wealth levels that are very *low* relative to the best available measures (e.g. Gallipoli et al. (2010)). Nor do we allow college failure risk to resolve itself immediately. Nor do we impose a strong positive correlation between wealth and collegiate preparedness.

These alternatives will generate–as long as we discipline the model to match enrollment and non-completion–higher failure risk than in the benchmark for the already poorly prepared, and lower-than-benchmark levels of failure risk for those at the high end of completion likelihood. In the case of making all households richer than they are now, for example, we would give the (relatively) poor more reason to attend. As a result, any parameterization consistent with observed enrollment and non-completion would lead us to a benchmark calibration with more impatient households, or more badly prepared ones, or both. Both of these would increase insensitivity to the skill premia. Similarly, any model with a higher correlation of wealth and preparedness amongst would-be enrollees than in the benchmark, would lead to a parameterization that implied larger groups of poor, poorly prepared, households as well as a larger group of rich, well-prepared households, with the middle shrinking. More groups of would-be enrollees would then be insensitive to skill premia than in our benchmark economy.

To further evaluate robustnes, we now investigate three main additional dimensions: assumptions on credit markets, on college costs, and on familial resources. Importantly, as alluded to above, in each case where we deviate from the benchmark parameterization, we *recalibrate* model parameters to locate the closest match we can to the targets of the model in terms of enrollment and non-completion by AFQT quartile. We focus attention on the calibrated vector of failure probabilities $\{\pi\}$, while retaining all other parameters at their benchmark levels. Of course, this means that in principle, the vector$\{\pi\}$ will vary across experiments: what is observed is enrollment and non-completion, while underlying preparedness is not, and must be inferred from observed college choices. Once we have recalibrated the model, we use the model to evaluate the sensitivity of enrollment and completion to the skill premium and educational costs. Recall that ensuring robustness of our main results requires that we *do not overstate* the fractions who are either extremely well-prepared, or extremely poorly prepared, since such households will be inframarginal in general.

For robustness to the assumed structure credit-market, we eliminated the wedge on borrowing costs τ (i.e. we set $\tau = 0$). For robustness with respect to college costs, since opportunity costs are important, we allowed households to work half-time while they were enrolled in college without any disutility of effort. For robustness with respect to familial resources, while lowering wealth further is not plausible (the median is only \$3,000), we consider doubling it at both the median and mean. This will imply higher failure risk for poor households, making them more insensitive to the skill premium than in the benchmark case.[43]

[43] Making households richer requires making them less well-prepared or impatient. Otherwise, enrollment rates would counterfactually high. We also check the robustness of the model to the fineness of the partition of failure risks that we allow for, by

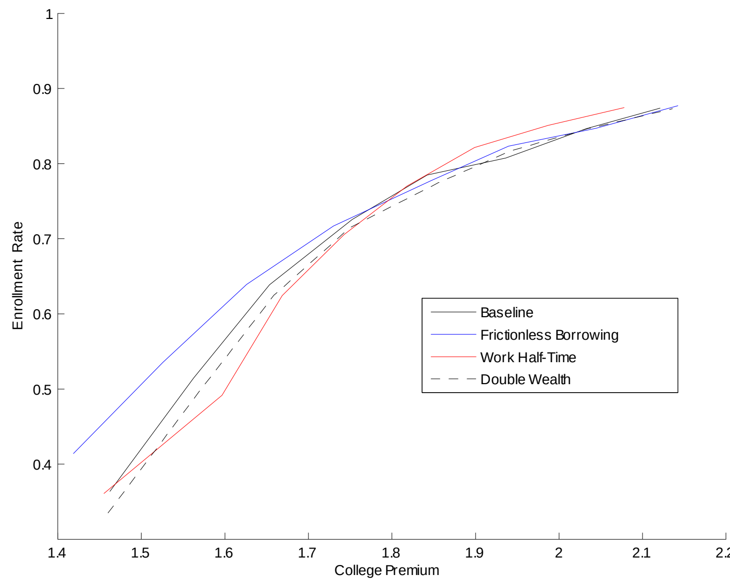

Figure 12: Robustness: Skill Premia and Enrollment Rates

While little is gained by the inclusion of detailed results that turn out to closely mimic the baseline model, we report below a brief set of figures. We first display enrollment behavior across skill premia. Recall that all preferences and educational cost parameters are being held fixed, while the underlying non-completion probabilities across quantiles, $\{\pi\}$, are recalibrated to approximate (given the values of other parameters at the benchmark levels) enrollment under benchmark skill premia. We see that as in the benchmark model, enrollment is responsive to premia lower than ones currently observed, and then becomes sharply less responsive at premia near, or higher than, current levels.

Next, we display the behavior of attainment across premia, and see that it also displays essentially the same behavior.

Given the findings so far, we turn now to a figure that is informative as to the proximate cause of the robustness. This figure displays the implied vector of failure of probabilities across each of the robustness checks. The implication is immediate: this profile changes very little across environments, and therefore, implies that the overall results will remain very stable.

7.1 Robustness and Wage Risk

As a final class of checks on the robustness of the model, we once again remove wage risk from the model. However, in this case, unlike our earlier results, we are interested in the role played by the skill premium under the premise that wage risk is genuinely irrelevant as a consideration. We therefore recalibrate the model in the absence of wage risk, and then study the implications of skill premia and costs for enrollment.

doubling the set of possible values to 24 levels, as well as doubling the correlation between wealth and AFQT scores to 0.6. For brevity, we present the implications of these alternatives for only the implied vector of non-completion probabilities–see below.

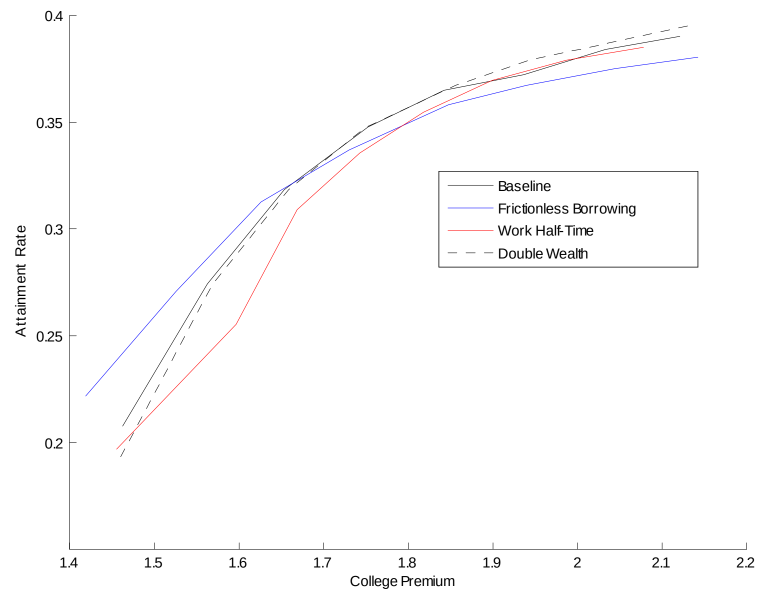

Figure 13: Robustness: Skill Premia and Attainment Rates

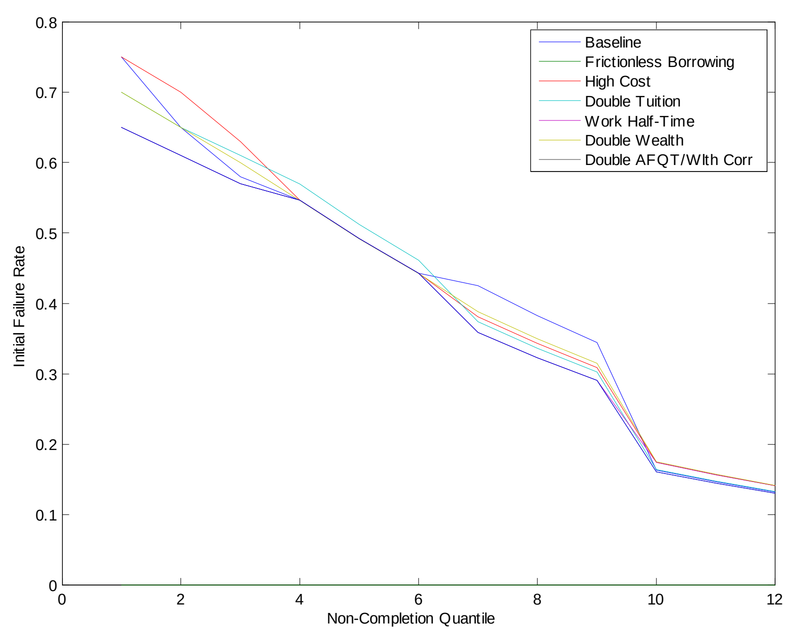

Figure 14: Robustness: Non-Completion Probabilities

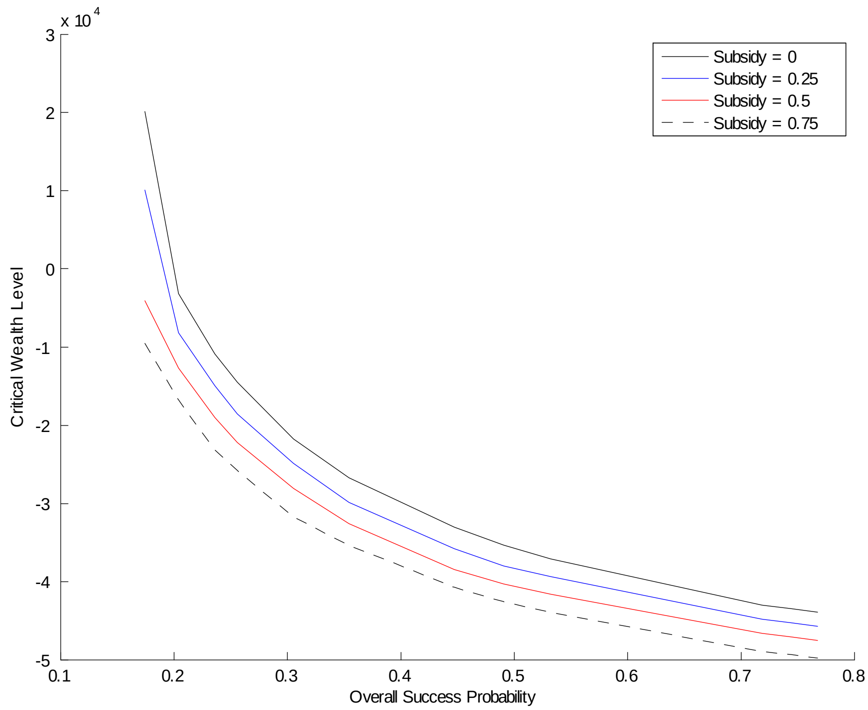

Figure 15: College Costs and Thresholds: No Wage Risk, Recalibrated Model

In Figure 15, we see that the main result of the model is robust–and even more suggestive that risk plays a role–the thresholds here are slightly higher than the case where wage risk was removed but the model was not recalibrated (Figure 10). For ease of exposition, Figure 16 compares the baseline model (specifically, at the baseline education costs) with the recalibrated model absent wage risk. This is natural, as the recalibrated parameters adjust to ensure aggregate statistics in the absence of wage risk, and thereby make college less attractive in other ways. However, we see that the differences are not substantial, and as before, aside from those with virtually no chance of completion, wealth thresholds do not rise asymmetrically across education costs for any given completion probability.

Lastly, in Figure 17 we examine the role of preparedness and the college premium when wage risk is removed, and the model recalibrated. The results mirror those in Figure 7, but for the same reasons as above, lead to threshold wealth levels that are higher than when the wage risk is removed from the benchmark economy.

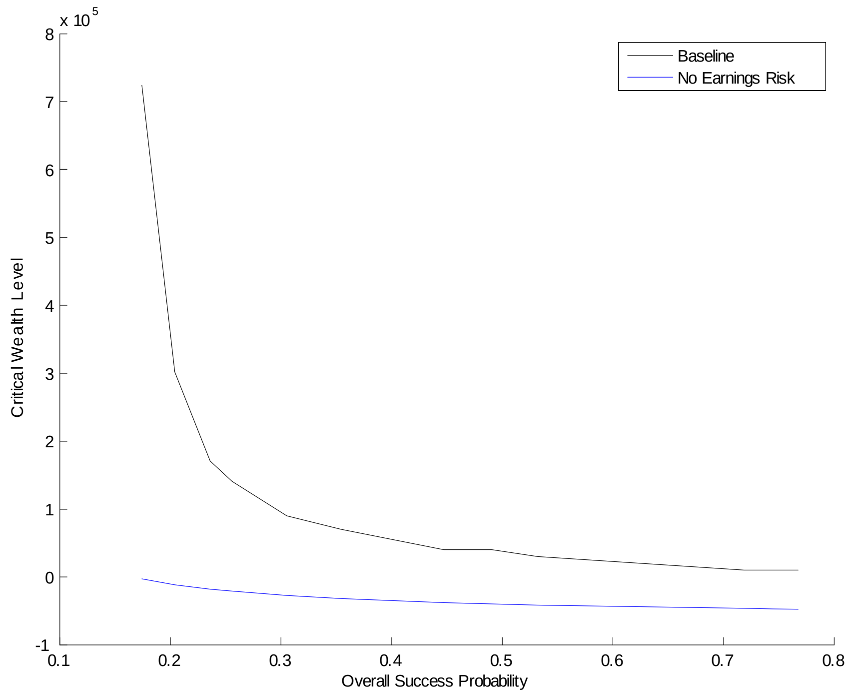

Figure 16: Comparing the Role of Non-completion: With and Without Wage Risk (Recalibrated Model)

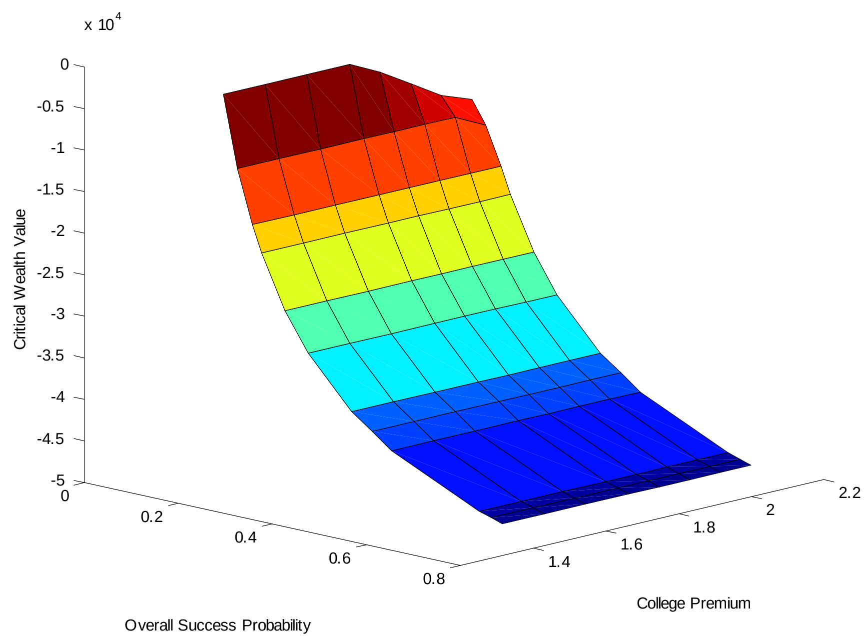

Figure 17: Premia, Non-Completion and Wealth Thresholds: No Wage Risk, Recalibrated Model.

8 Concluding Remarks

In this paper, we have investigated how the skill premium and individual and both aggregate college enrollment and attainment might be related. Our main results are that (i) the responses of enrollment and college attainment to changes in skill premium, while viewed in the literature as surprisingly small, are in fact understandable, and (ii) that risk and education costs play a key role in this insensitivity. We show that empirically reasonable measures of collegiate preparedness and earnings uncertainty, when combined with a plausible underlying joint distribution of preparedness and enrollee resources, lead enrollment and non-enrollment to remain insensitive to changes away from current skill premia. We also show, however, that at lower premia, this is not so, and both wage and non-completion risk are important in driving the absence of widespread inframarginality in these settings. Our results appear robust and have relevance whenever college enrollees are uninsured against failure, face rate-of-return risk, and/or must make leveraged investments in order to attend.

The basic intuition for our results, and their robustness, is simple. The main reason for the weakness of skill premia as a motivator for enrollment is the *asymmetry* it induces in the change in the expected payoff to college for well- and poorly prepared would-be enrollees. Whenever the premium accruing to college completers changes, those with high college completion probabilities see a relatively large change in payoffs, but at levels near current premia, were already planning, in our model, to attend. They therefore either remain inframarginal, or become, in the case of a rise in the premium, even more deeply inframarginal. By contrast, for poorly prepared high-school completers, changes in observed skill premia, even if they were available to marginal entrants, imply a much smaller change in the expected payoff to college. Thus, these model households remain inframarginal, even in the face of large changes in observed premia. This is consistent with a point made forcefully by Carneiro and Heckman (2002): That the inability of children to "buy" the parental environs needed to make college a worthwhile investment is likely a key barrier, as opposed to the ability to borrow to finance an investment whose payoff to the marginal enrollee is well-captured by the observed skill premium. When combined with the current college enrollment rate of greater than 70 percent, it strikes us as plausible that most high-school completers may indeed be currently inframarginal with respect to the skill premium.

Lastly, our results imply that substantial further increases in skill premia arising from increases in demand for skilled workers might indeed occur–the model suggests that high premia need not be met by substantially higher enrollment and completion. In turn, our model implies that barring widespread improvement in the preparedness of high-school completers, or a mitigation of the forces *during* college that lead to very high non-completion rates, high and persistent levels of earnings inequality may plausibly accompany the strong shift in demand towards skilled labor that recent work (e.g., Autor, Levy, and Murnane (2003)) suggests is under way.

Despite the apparent robustness of our main finding, three caveats are in order. First, while rich along several dimensions, our decision model does not distinguish between various subgroups who, for whatever reason, face premia that are systematically lower *conditional* on college completion. For instance, if some minorities face discrimination in the labor market, and are generally less wealthy than average, they may well respond strongly in practice to skill premia. Addressing such heterogeneity seems useful for future work before arriving at definitive assessments on U.S. collegiate inframarginality. Second, we stress that our results should not be taken to mean college policies are misguided. In fact, they suggest nearly the opposite: We find that all else equal (particularly holding fixed inter-vivos transfers), absent forces that keep college costs low relative to the true resource costs of higher education, such as subsidies, the current skill premium will not induce enrollment in the model at the rates observed. That is, our model suggests that the skill premium is not likely an important factor in enrollment *given current policy.* Third, in keeping with our "ceteris paribus" approach, our model holds the preparedness of enrollees fixed. In particular, it does not allow for changes in collegiate preparedness that might arise in response to the skill premium, such as via student effort in school and college, and parental investment early in the lives of children and adolescents. Yet, as James Heckman and co-authors have stressed in a variety of work (e.g. Heckman, Lochner, and Todd (2008)), the marginal returns in these places are very large already, which suggests that our model's implications for enrollment and attainment at counterfactually-high skill premia are likely plausible.

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