THE MACROECONOMIC COST OF COLLEGE DROPOUTS*

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Abstract

Forty percent of full-time, four-year U.S. college students drop out before graduating. While existing research predominantly highlights academic ability and labor market uncertainties as key factors, the role of financial mechanisms remains underexplored despite growing evidence that family wealth significantly influences college success. This paper investigates the extent to which financial constraints, particularly grant amount uncertainty, contribute to student dropout rates. Utilizing four representative longitudinal datasets, I document that a substantial fraction of students experience volatility in grant amounts, predominantly through downward adjustments. These reductions are not attributable to academic performance, are not offset by alternative financial sources, and are strongly linked to dropout decisions. To assess the impact of grant variability on dropout rates and its broader macroeconomic implications, I develop an overlapping generations model that incorporates endogenous college enrollment and dropout decisions. The model introduces grant amount uncertainty as a distinct dropout channel alongside academic ability and labor market uncertainty. Calibration of the model to U.S. reveals that downward revisions of grants alone account for 34% of dropouts, while uncertainty about academic ability explains approximately 10%. The residual dropout rates are attributed to labor market opportunities. In a general equilibrium framework, pursuing a policy that eliminates uncertainty about college aid would increase social welfare by as much as 2.4%, benefiting both college graduates and non-college graduates. The increase stems from lower skill premiums, higher aggregate productivity, and reduced uncertainty. Such a policy is self-financing mainly due to endogenous improvements in skill allocation and associated growth in GDP.

Keywords: Inequality, Financial Aid Uncertainty, College Dropouts, Skill Premium, Financial Constraints, General Equilibrium

JEL: E24, H52, H53, I22, I26, I28

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1 Introduction

Forty percent of full-time, four-year college students drop out before graduating. While much of the existing research emphasizes academic ability and labor market uncertainties as key factors in explaining dropout rates (e.g., Hendricks and Leukhina (2017); (2018)), the role of financial mechanisms has received relatively little attention. However, increasing evidence indicates that family wealth has become a critical factor in college success over the past few decades (Lochner and Monge-Naranjo (2011)). Understanding whether and to what extent financial constraints contribute to student dropout rates is essential, given the significant economic benefits of a college degree—both for individuals, through higher earnings, and for society, through a broader tax base and enhanced economic productivity (Colas, Findeisen, and Sachs (2021)). This paper addresses these gaps by developing a macroeconomic model that explores how financial uncertainty during college influences dropout rates.

Using four representative longitudinal datasets, I first document that a large fraction of students experiences uncertainty in grant amounts as they progress through college, with a notable emphasis on downward adjustments. These reductions are not driven by academic performance, are not compensated by other financial sources, and are strongly associated with dropout decisions. Then, to assess the impact of grant amount variability on dropout rates and understand its broader macroeconomic implications, I develop an overlapping generations model with endogenous college enrollment and dropout decisions. The model adds grant amount uncertainty as a dropout channel alongside academic ability and labor market uncertainty. My findings show that downward revisions of grants alone explains 34% of dropouts, underscoring its importance for policy. Moreover, within a general equilibrium framework, reducing grant uncertainty leads to higher college graduation rates, better ability sorting at college, increased aggregate productivity, and a welfare improvement of 2.4%. This policy is self-financing due to the resulting expansion of the tax base, making it a compelling instrument for improving student persistence. A significant portion of this positive ability sorting arises from general equilibrium effects, particularly through a reduced skill premium, stressing the importance of studying general equilibrium effects when studying large scale policies.

I begin the empirical analysis by revisiting the role of family wealth in recent decades. Using data from the National Longitudinal Surveys of Youth from 1979 and 1997, I find that family wealth has increasingly influenced college enrollment, aligning with Bailey and Dynarski (2011); Belley and Lochner (2007); Lochner and Monge-Naranjo (2011). Importantly, I also show that wealth affects the dropout margin, even after controlling for ability and enrollment. To explain why lower-wealth students are more

likely to drop out, I analyze how students finance their education. I find that grants are a key financial source for these students but exhibit significant volatility—with up to 60% experiencing reductions over the course of college attendance, which are not compensated by other funding sources.

To investigate to what extent students' eligibility explains grant volatility, as well as to explore its impact on dropout rates, I focus on Pell Grants, a core component of financial aid in the United States with standardized nationwide eligibility criteria. Utilizing detailed administrative data from the nationally representative Beginning Postsecondary Students Longitudinal Study (BPS) on first-time, full-time students at four-year institutions, I find that Pell Grant volatility persists even after controlling for academic eligibility requirements. Moreover, I demonstrate that losing Pell support significantly impacts six-year dropout rates,[1] even after controlling for academic progress, enrollment patterns, demographics, family background, ex-ante college ability, and institution type.

The observed uncertainty in Pell Grant amounts can be partly attributed to the complexity and unpredictability of the financial aid determination process, which extends beyond simply meeting student eligibility criteria. The federal application used to determine students' neediness index, so called Expected Family Contribution (EFC), the FAFSA, is central to calculating eligibility for Pell Grants as well as other forms of financial aid. However, annual revisions and the complexity of this system contribute to financial aid unpredictability, an issue widely recognized in both the literature, including Dynarski and Scott-Clayton (2006), Bettinger et al. (2012), Dynarski et al. (2021) and at the federal level. The FAFSA Simplification Act of 2019 explicitly acknowledges these challenges, aiming "to make it easier to apply for Federal student aid [and] to make that aid predictable" through amendments to the Higher Education Act of 1965.[2] Despite this recognition, the successful implementation of these reforms remains pending.

Based on these empirical findings, I ask the following questions: what fraction of the observed dropout rates can be explained by the volatility embedded in the current grant system? What remaining fraction arises due to other factors commonly examined in the literature, such as learning about academic ability and labor market opportunities? Is there a policy space to improve college graduation rates? How costly would such policies be for the economy? Which socio-economic group would benefit from such policies and which group would lose?

To address these questions, I incorporate endogenous education decisions within a general equilibrium full life-cycle framework. The framework comprises three distinct stages: college choice, work, and retirement. Newborn individuals make enrollment decisions based on their initial wealth, prior

[1] The proportion of students who do not complete their degree within six years of enrollment.
[2] https://www.congress.gov/bill/116th-congress/senate-bill/2667/text

beliefs about their abilities, and idiosyncratic productivity shocks. Once enrolled in college, students reassess the value of college and may potentially drop out. Dropout channels include (1) learning about their abilities through grades, (2) labor market productivity shocks, and (3) observing the grant amounts they qualify for in the upcoming period. A key modeling choice that contributes to the macro education and dropout literature is the inclusion of grant uncertainty between academic years. Grant amounts are influenced by two factors: (1) GPA and (2) an exogenous stochastic shock, capturing unexplained variations in the grant system across academic years after controlling for students' eligibility criteria.

The first channel, the GPA-grant relationship, captures the impact of a student's low college GPA on their budget within the current grant system. Therefore, the dropout decision after receiving a low GPA might arise not only from an updated belief about ability, a channel well-explored in the literature, but also from a tightened budget constraint. The second channel, the exogenous stochastic shock, captures the fact that a considerable number of academically-eligible students lose their grants, and may therefore drop out due to borrowing constraints. Thus, the model identifies two new crucial channels that impact college dropout decisions. Neglecting these channels may overstate the role of ability and underestimate financial constraints, potentially overlooking effective policy solutions.

College participation decisions are then integrated within an overlapping generations production economy. Individuals' education choices shape the college wage premium through general equilibrium wage effects as college graduates are imperfect substitutes to both college dropouts and high-school-educated individuals in the representative firm's production function. Given that the college wage premium is a direct source of incentives for pursuing higher education, a general equilibrium framework is essential for an accurate evaluation of the long-run impact of large-scale educational policies.

I calibrate the model to match the key moments of educational attainment in the US, including college enrollment, completion rates, and the skill premiums. To pin down college dropout channels, I proceed as follows. I estimate the uncertainty of grants by quantifying how grants vary across academic years, while controlling for observable eligibility criteria in the data. I obtain GPA thresholds at which students are disqualified from grants from the data. Students' beliefs regarding their abilities are pinned down using empirical estimates from Stinebrickner and Stinebrickner (2014). I base the idiosyncratic component of productivity on data estimates, while I internally calibrate the ability and education contingent labor market fixed effects to match the skill premiums in the data. In validation exercises, the model closely matches untargeted moments, including college participation elasticities in response to subsidy changes, as empirically estimated by Deming and Dynarski (2009) and Scott-Clayton (2011). Additionally, the model captures other untargeted moments, such as college participation patterns by

family wealth and earnings distributions observed in the data.

Using the calibrated model, I first investigate the effects of adverse shocks in college on various wealth-ability groups. Analyzing dropout behavior shows that having high initial wealth or a high ability prior mitigates the pivotal power of adverse shocks that make dropout decisions optimal. However, high-ability asset-poor individuals remain largely vulnerable to the negative shocks to grant availability, as they cannot self-insure and, consequently, drop out. This challenges the prevailing notion that marginal students are exclusively those with lower ability, highlighting instead that their marginal status is due to a combination of both their ability and a low initial wealth. Not overlooking the financial dimension in college dropout decisions is crucial for formulating valid policy recommendations.

To quantify the impact of ability learning, fluctuation in grant amounts, and productivity shocks on dropout rates, I use the model to isolate each factor by eliminating one dropout channel at a time while keeping taxation and skill prices at their benchmark values and quantifying the resulting changes in college participation. I find that eliminating grant uncertainty—ensuring all students retain their initial grant amount—and removing grant GPA contingency together reduce college dropout rates by 43%. Addressing these factors individually lowers dropout rates by 34% and 5%, respectively. On the other hand, I find that learning about ability explains only 10% of the total dropout rates. The finding that a large fraction of students drop out due to the grant system defines a clear scope for policy intervention.

Lastly, I consider alternative governmental policies aimed at reducing grant uncertainty taking into account the general equilibrium effects. I demonstrate that eliminating grant uncertainty—i.e., students receive their initial grant amounts throughout college—enhances aggregate productivity in the long run.[3] This improvement in sorting is due to the fact that more poor, high-ability students can now afford to graduate from college. Under these policy reforms, the welfare of newborns improves by 2.4% and 3.4%. It is worth noting that this increase in welfare is driven not only due to reduced uncertainty individuals face through a stable grant system, but due to increased productivity owing to a higher quality of graduates in the economy. The results also show that eliminating grant system variability is cost-effective for the government. The increased cost of a more stable grant system is offset by an increase in the tax bases of consumption, capital gains, labor income, resulting in the reduction of the budget-balancing tax rate. Interestingly, the long-term effects of the policy reforms reveal a shift in dropout patterns from low-income, high-ability individuals to high-income, low-ability individuals, improving sorting in college due to a reduced skill premium, while the overall dropout rates remain

[3]This could be achieved, for example, by removing annual reapplication requirements. For students experiencing significant changes in family circumstances, adjustments to grant allocations could be delegated to a professional judgment office that colleges usually have.

almost the same as in the status quo. These findings underscore the importance of analyzing grant policies within a general equilibrium framework, as skill-price adjustments strongly influence ability sorting and significantly alter the policy implications.

Related Literature. This paper contributes to several strands of literature. First, this paper builds on recent important contributions in the macroeconomic education literature, including those by Krueger and Ludwig (2013), Krueger and Ludwig (2016), Heathcote, Storesletten, and Violante (2017), Abbott et al. (2019), and Colas, Findeisen, and Sachs (2021). I extend this work by incorporating endogenous dropout decisions—a crucial margin to consider in a macro framework given the high bachelor's degree dropout rates and their significant aggregate implications. This paper fills this gap by modeling various dropout channels, including time-varying grants, and assessing their impact on macroeconomic efficiency within a general equilibrium context.

This paper also contributes to the growing body of research on the determinants of college dropouts, including studies by Lee, Shin, and Lee (2015), Trachter (2015), Ozdagli and Trachter (2015), Arcidiacono et al. (2025), Hendricks and Leukhina (2017), Hendricks and Leukhina (2018), and Matsuda (2020). While these studies primarily focus on the role of learning about one's academic ability and labor market productivity as key factors driving dropout decisions, I complement this literature by identifying and quantifying the financial channel as an additional determinant of dropout, thereby broadening the understanding of dropout drivers beyond academic ability. Furthermore, this paper complements the above studies by employing a general equilibrium framework (with the exception of Matsuda (2020)). This framework is essential for evaluating the wider macroeconomic effects of policy interventions aimed at reducing dropout rates.

A set of papers, such as those by Caucutt and Kumar (2003), Akyol and Athreya (2005), Hanushek, Leung, and Yilmaz (2004), Castex (2017), Athreya and Eberly (2021), and Blandin and Herrington (2022) model dropout as exogenous risk. This paper contributes to this literature by considering endogenous dropout channels. The sequential papers by Ionescu (2011), Chatterjee and Ionescu (2012), and Matsuda and Mazur (2022) address student loans in the context of endogenous dropout risk, while Garriga and Keightley (2007) models endogenous dropout decisions and quantifies the impact of increased subsidy rates on educational attainment and macroaggregates. Differing from the last four papers, this paper allows for factors beyond ability learning to play a role in dropout decisions, specifically the uncertainty about grants and the relationship between grants and academic performance.

This paper also relates to the substantial body of empirical work that examines the relationship between family wealth and college success probabilities. This includes studies by Cameron and Heckman

(1998), Carneiro and Heckman (2002), Cameron and Taber (2004), Belley and Lochner (2007), Lochner and Monge-Naranjo (2011), and Bailey and Dynarski (2011). This paper adds to this literature by documenting an increasing influence of family wealth on college success, consistent with the findings of Belley and Lochner (2007), Lochner and Monge-Naranjo (2011), and Bailey and Dynarski (2011). I contribute to the initial two papers by incorporating an analysis of graduation rates alongside college attendance. Furthermore, I examine education outcomes at a later age (mid-30s). This allows for a more comprehensive understanding of the relationship between wealth and educational attainment, as well as a more thorough comparison between the NLSY79 and NLSY97.

Finally, this paper builds on recent contributions that highlight the complexity of the grant application process, including works by Dynarski and Scott-Clayton (2006), Bettinger et al. (2012), and Dynarski et al. (2021). These studies, using experimental designs such as hiring professional assistance for grant applications or guaranteeing grant availability, demonstrate that increasing certainty in grants fosters higher enrollment and persistence among students. I extend this literature by quantifying grant uncertainty using administrative data and examining the broader macroeconomic implications of large-scale government policies aimed at reducing this uncertainty.

The paper is organized as follows. Section 2 analyzes representative, longitudinal samples of the 1979 (NLSY79) and 1997 (NLSY97) cohorts in order to document that financial background matters in ex-ante college completion probabilities. Then, using the Beginning Postsecondary Education data, the analysis illustrates how uncertain are grants between academic years and its association with dropping out. Section 3 describes the model. Section 4 presents the calibration strategy. Section 5 examines the model's behavior and conducts validation exercises. Section 6 investigates how the dropout decisions of distinct wealth-ability groups are shaped and decomposes the relative importance of each channel in explaining observed dropout patterns in the US. Finally, Section 7 quantifies potential governmental policies that target dropout rates and evaluates its impact on macroeconomic variables, welfare, and sorting.

2 Empirical Analysis

Recent policy recommendations suggest that government efforts should prioritize improving college preparedness for children from lower-income backgrounds rather than expanding federal student aid for the same group. These recommendations are based on influential empirical studies, such as Cameron and Heckman (1998), Carneiro and Heckman (2002), and Cameron and Taber (2004), which found

a limited role for borrowing constraints in post-secondary education. However, these conclusions are drawn from analyses of the National Longitudinal Survey of Youth (NLSY) of 1979, a period when the cost of education was significantly lower.

In this section, I show that financial background has an increasingly important role in predicting college success probabilities, and at present students from economically disadvantaged backgrounds experience uninsured financial shocks at college. Using the most recent NLSY97, I empirically document that family wealth positively affects the probability of college completion, even after controlling for ability and other family characteristics. For completeness, I also examine the NLSY79, confirming the previous findings that in the 80s, family wealth matters less, if at all, in college participation margins. Exploring why poorer students may drop out reveals that their main income source for college is grants – they constitute up to half of their total college budget. I further document that the grant system exhibits significant volatility, as evidenced by the NLSY97 data when analyzing total grants and by the Beginning Postsecondary Education dataset when isolating Pell Grants, even after controlling for students' eligibility criteria. I show that losing grants is associated with higher risk of dropping out controlling for academic progress, demographics, family background, ex-ante college ability, and the type of institution attended.

2.1 The Role of Family Income on College Participation Margins

To examine the family wealth–college participation relationship, I use two longitudinal datasets, the NLSY79[4] (older cohort) and the NLSY97[5] (younger cohort). Both studies collect data on a wide range of topics, including parental background, ability, and education. The NLSY79 study began in 1979 and follows a sample of individuals born between 1957 and 1964. The NLSY97 study began in 1997 and follows a sample of individuals born between 1980 and 1984. I examine the educational outcomes (specifically, whether they ever graduated) at the time of the last interview, when the NLSY97 sample was at least 32 years old, and the NLSY79 sample was at least 49 years old.

For this analysis, I closely follow the methodology outlined in Carneiro and Heckman (2002). I divide each sample into three groups by their ability terciles,[6] and for each group, I regress an outcome

[4]The NLSY79 sample consists of 12686 individuals born between 1957 and 1964, out of whom 6111 belong to a representative, cross-sectional sample, designed to represent the civilian segment of people living in the US in 1979. 5295 respondents are oversampled minorities such as Hispanic or Latino, Black, and economically disadvantaged non-Black/non-Hispanic. The remaining 1280 respondents were drawn to represent the population serving in one of the four branches of the US military. In my analysis, I solely concentrate on a cross-sectional sample.

[5]Similarly, the NLSY97 surveys 8984 individuals, born between 1981 and 1984, out of whom 6748 are a representative, cross-sectional sample.

[6]The ability of individuals is assessed through their AFQT test scores, as detailed in Appendix A.1. Moreover, the robustness of the results is confirmed by alternative measures, such as the PIAT (or Peabody Individual Achievement Test) test

Y_i—a college participation margin (enrollment/dropout)—on the family wealth[7] quartile dummies, X_i, where the highest family wealth quartile X_4 serves as the reference category. The control variables, Z_i, include ex-ante family characteristics such as parental education, family structure, type of household residence, and the number of siblings, with additional controls for gender and race included in all regressions. I exclude respondents with missing AFQT scores and family income data as of the first survey date (or at age 17). A more detailed description of the control variables used in both surveys is provided in Appendix A.2. The regression is specified as follows:

$$Y_i = \alpha + \beta X_i + \beta^f Z_i + \varepsilon_i. \tag{1}$$

Tables I and II present the results. Panel A in Table I shows the gaps in college enrollment, while Panel B shows the gaps in college dropout rates for the NLSY79 sample. Table II provides the same information for the NLSY97 sample, accounting for college quality. Panel A (B) presents the estimates for enrollment at (dropout from) a 4-year college, and Panel C (D) shows the corresponding estimates for any college, without distinguishing between 2- and 4-year institutions.

Comparing the two tables, it can be observed that the estimated effects of family income are significant for the younger cohort but generally insignificant for the older cohort. For the NLSY79 sample shown in Table I, family income plays a small and statistically insignificant role in determining college attendance and completion for the highest ability-lowest family income group. The estimated probability gap of dropping out for this group is 0.13 percentage points higher compared with their richest counterparts, as we can see from Column (3) in Panel B. Nevertheless, a joint F-test – in the last row of each panel – shows that the overall effects are insignificant, as the null hypothesis that all gaps are equal to zero cannot be rejected. This finding is consistent with Carneiro and Heckman (2002), who show that controlling for family background characteristics leaves family income redundant in explaining college participation margins.

In contrast to the older cohort, the role of financial background is instead more pronounced in the younger cohort. In the bottom ability – bottom family wealth group, individuals have a 16 percentage point lower probability of enrollment at a 4-year college relative to the bottom ability – highest wealth quartile family group. For individuals with abilities in the middle and highest terciles, these gaps amount to 26 and 17 percentage points, respectively. Not surprisingly, at the same time, it can be observed that

scores.

[7] While the NLSY97 provides information on both family income and family wealth, I use family wealth as it allows for a more rigorous characterization of the family's financial condition.

the higher is the income group the lower the gap of college participation margins are relative to the reference category.

Next, in panel B, Table II, I examine the probability of dropping out for a bachelor's degree. The table shows that individuals from the middle ability tercile are affected largely by their family income: they are 40% less likely to stay enrolled in college than their rich counterparts. As for the highest ability group, their dropping out probability is still 12% more as compared to their rich counterparts. It is worth noting that significant wealth effects on college dropout probabilities cannot be observed among poor and low ability students (column (1) of panel B, Table II). This can be explained by the fact that only a few students enroll at a bachelor's degree from the ability tercile (67, 48, 34, and 38 individuals respectively from the lowest to the highest family wealth quartiles),[8] and therefore, the estimates for their dropping out probabilities (conditional on enrollment) are imprecise.

When examining participation in any college, including both 2-year and 4-year institutions, a consistent qualitative relationship between family wealth and college outcomes is observed. This is evident from panel C and panel D in Table II. Specifically, family wealth plays a significant role in determining whether students attend college, although the effect may be less pronounced for 2-year colleges due to their lower costs. Overall, the data suggest that family wealth becomes a key factor in determining college participation, regardless of the type of institution attended in the recent years.

In conclusion, the analysis of NLSY79 and NLSY97 data indicates that family income's significance in post-secondary education success has significantly increased over the years, even after accounting for ability. Family income's role is mitigated for the highest ability tercile group across all college participation levels, suggesting that ability is a strong asset for college success. However, high ability alone cannot offset the negative effects of a low financial background on college success probabilities, as seen in the early 1980s. Today, low-income students face decreased college success probabilities, including enrollment and graduation, due to their low-level wealth background.

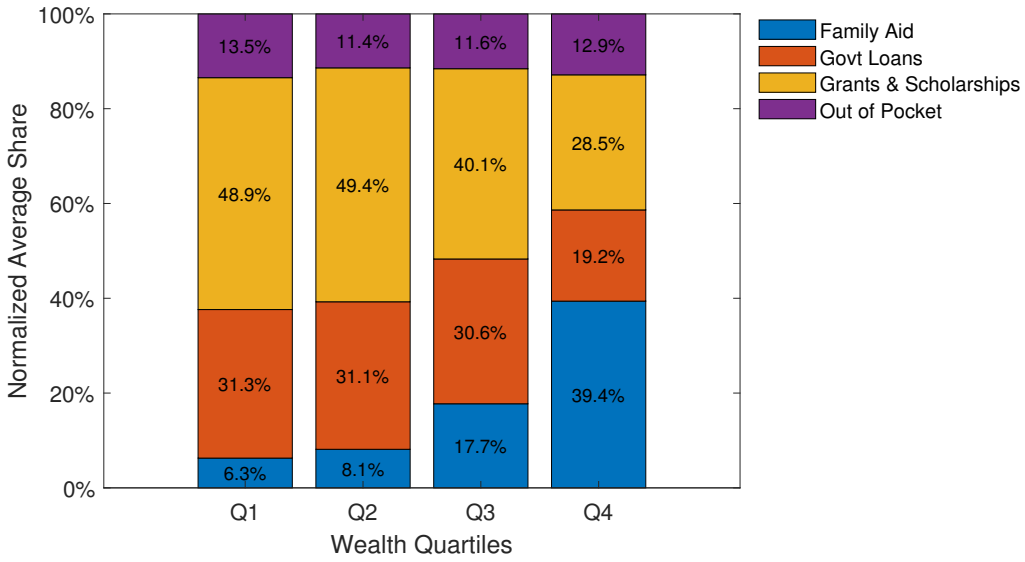
2.2 College Financing Sources and Grant Volatility

To understand why family wealth remains a significant predictor of college completion probabilities, conditional on enrollment, I next explore how students finance their education. Throughout this analysis, I focus on students who enrolled directly in a four-year degree program, aligning with the sample used in the model. The NLSY97 survey groups the sources students use to finance their education into the

[8] In the bottom ability tercile, the number of individuals from the lowest to the highest family quartiles are respectively 155, 120, 69, and 61.

following seven categories: family transfers for education purposes, family loans, financial assistance received from institutional sources such as grants or scholarships (henceforth grants), subsidized or other types of loans, work-study, employer assistance, and out-of-pocket payments.[9]

Figure 1: Sources of Finances by Family Wealth



Notes: Students enrolled in 4-year colleges are categorized into family wealth quartiles. For each quartile, I calculate the annualized average financial contributions from various sources, including family transfers, grants, loans, and out-of-pocket payments. Family transfers make up 6.3% of total college financing for students in the lowest wealth quartile and 39.4% for those in the highest wealth quartile. Grants contribute 48.9% of total funding for the lowest quartile and 28.5% for the highest quartile. The Data: NLSY97 sample.

Figure 1 presents the relative proportion of each source for each family wealth quartile.[10] For poor students, family contributions make up only 6% of their college funding. Most of their financial support comes from grants (49%), loans (31%), and earnings (14%). This means that 94% of their funding relies on external sources that students must qualify for, maintain, or earn. In contrast, wealthier students primarily depend on their parents (39%) for funding, with the remainder coming from grants (29%), loans (19%), and and out-of-pocket payments (13%).

Volatility in Total Financial Aid in the NLSY97. The NLSY97 data reveals significant volatility in student grant aid across academic years. Table III provides a detailed summary, presenting data on college enrollment (column 2), dropout rates (column 3), the fraction of students who experienced reductions in their grant amounts (column 4), the amount of those reductions (column 5), broken down by wealth quartiles. The table shows that enrollment increases, and dropout rates decrease as wealth

[9]Further details about the sources and the data cleaning procedures can be found in appendix A.1.
[10]For clarity, minor sources are excluded from the illustration as they represent only a small fraction of total finances.

increases. Notably, column (4) highlights that up to 60% of students experienced a reduction in their grant amounts at least once during their college careers (excluding dropouts). There is no correlation between grant reductions and family wealth, suggesting that students' financial backgrounds do not explain why students lose grants.

An important question is whether other forms of financial aid—such as loans, parental transfers, and out-of-pocket payments—compensate for these grant reductions, allowing students' overall finances to remain stable throughout college. Table IV presents the changes in other financial sources for students who experience grant reductions. The weak and inconsistent correlations between grant reductions and adjustments in these sources suggest that students lack adequate alternative funding to compensate for lost grants. For example, the correlation between changes in grant amounts and adjustments in other finances pooled together is weak, inconsistent, and often statistically insignificant. Focusing only on family aid (see Table I.4 in Appendix B.1), the data reveals that family contributions also adjust only minimally and inconsistently in response to grant reductions.

Regression Analysis To show the impact of decreased grant aid on the duration of college enrollment, I run the following regression:

$$\begin{aligned}\text{Enrollment in Year 3}_i = \beta_0 + \beta_1 \text{Decreased Grants in Year 2}_i + \beta_2 \text{Wealth Quintile}_i + \\ \beta_3 \text{Ability Quintile}_i + \beta_4 \text{Max Degree of Parents}_i + \varepsilon_i\end{aligned}$$

The dependent variable, *Enrollment in Year* 3, is a dummy variable set to 1 if the individual reaches year 3, conditional on their enrollment in year 2. The key independent variable, *Decreased Grants*, is a binary indicator set to 1 if the student experienced a reduction in grant aid between their first and second years, and 0 otherwise. The regression also controls for wealth quartiles, ability quartiles, the highest degree attained by the student's parents, and gender. The sample is restricted to those who were in college in both year 1 and year 2, and for whom there are no missing values for the relevant variables.

The regression results in Table V indicate that a reduction in grant aid has a statistically significant negative effect on the duration of enrollment, with an estimated coefficient of -0.03 ($p < 0.05$). The magnitude is comparable to ability and wealth quartiles. These findings suggest that students who experience a decrease in grant support are less likely to continue their college education into the third year.

2.3 Pell Grant Volatility, and Its Association with Dropout Rates

To assess whether the observed grant volatility stems from exogenous variations or student behavior—such as enrollment decisions, academic performance, or work choices—I focus on Pell Grants, the largest need-based federal aid program. Pell Grants, with their standardized eligibility criteria, provide an ideal case for analyzing grant volatility after controlling for student eligibility. For this analysis, I use a nationally representative sample of students from the Beginning Postsecondary Students (BPS) study, conducted by the National Center for Education Statistics. The BPS surveys first-time postsecondary students and tracks them over a six-year period. This survey is linked to individual-level data from official records, including college entrance exam scores (from the ACT and College Board), financial aid information (from the FAFSA), and aid disbursement details (from the National Student Loan Data System). Additionally, the BPS provides comprehensive data on enrollment patterns and degree attainment.

Pell Grants, along with all other types of financial aid, are determined through the FAFSA application system. FAFSA is a comprehensive form that collects detailed information about a student's and their family's financial situation and family structure, which is then submitted to the U.S. Department of Education (DOE). The primary purpose of FAFSA is to estimate the Expected Family Contribution (EFC), a need-based index that plays a central role in determining eligibility for Pell Grants and other financial aid. The EFC calculation considers factors such as family income, assets, family size, parents' age, and the number of family members attending college. This calculation is complex, subject to annual revisions, and often influenced by broader economic changes and federal policy adjustments.

Once the EFC is calculated, it is sent to colleges. Independently of the EFC, colleges determine the Cost of Attendance (COA), which includes tuition, fees, room and board, books, and living expenses. The Pell Grant amount is then calculated using the formula: Pell Grant $= \min(\text{ COA} - \text{EFC}, \text{Maximum Pell Grant})$.[11] It's crucial to note that the COA and EFC are independently determined—changes in one do not directly impact the other. This means that while the EFC estimates a student's financial need, the COA reflects the actual costs associated with attending a specific institution.

To remain Pell-eligible for each subsequent academic year, students must meet both financial and academic criteria and refile the FAFSA application annually. Financially, the DOE recalculates students' Expected Family Contribution (EFC) each year to determine their grant eligibility. Students' only control over this process is keeping their annual earnings below approximately \$6,500 to avoid reductions

[11] The maximum Pell Grant amount varies slightly by year. During the 2015–2020 study period, it ranges from \$5,550 to \$5,645.

in their Pell Grants.[12] Academically, students must maintain satisfactory progress, typically defined as a GPA of 2.00 or higher and the completion of at least 24 credit hours within an academic year.

Again for each academic year, colleges redetermine the COA and, using the EFC calculated by the Department of Education, estimate Pell Grant eligibility based on standardized Pell tables issued by the DOE. These tables include 69 COA and 29 EFC brackets, providing a conditional estimate of the Pell Grant. Following this, at least 30%[13] eligible students must complete a detailed verification process by submitting all financial documentation listed in the FAFSA. The final Pell Grant amount is disbursed within ten days of the start of the academic year and may differ from the initial estimate provided.

While students can take steps to influence their Pell Grant amounts, such as maintaining full-time enrollment or managing their earnings, much of the variation arises from factors beyond their control. These include changes in the EFC or Pell formula, which can be influenced by economic volatility, and tuition fees.[14] Recognizing this issue, the federal government enacted the FAFSA Simplification Act of 2019, with implementation planned for the 2023-2024 academic year.[15] The detailed institutional settings, including the financial aid package, EFC calculation, and specific changes introduced by the FAFSA Simplification Act, are provided in Appendix I.

Pell Grants Uncertainty Controlling for Eligiblity Criteria. Using the BPS data, I focus on the 2011-2012 cohort, restricting the sample to first-time, full-time students who enrolled directly in a 4-year college.[16] I first evaluate how many students retain or lose their initial Pell Grants as they progress through college, then analyze how losing these grants affects their likelihood of dropping out.

Tables VI and VII present the grant transition patterns between academic years, both without controlling for eligibility criteria and after controlling, respectively. For illustration, I focus on grant transitions from Year 1 to Year 3 in the main analysis.[17] The rows in each table represent the initial grant brackets in Year 1, while the columns show the probability distribution of grant brackets in Year 3 for students who remained enrolled. For example, Table VI shows that 55% of students who started in the highest grant bracket (Bracket 1) in 2011-12 remained in the same bracket by 2013-14. The remaining 45% transitioned to lower brackets, with 26% falling to the lowest bracket (Bracket 5). Similarly, 94% of students initially in the lowest bracket stayed there, reflecting limited upward mobility in grants.

Table VII contrasts this by controlling for eligibility criteria such as academic progress, enrollment

[12] The exact threshold is not disclosed for students.
[13] Although colleges are required to verify at least 30% of students, many choose to verify all applicants.
[14] Tuition fees are rising more than inflation annually.
[15] However, its rollout faced technical challenges.
[16] For robustness purposes, I also examine the 2003-2004 cohort, and the grants uncertainty remains consistent.
[17] The volatility closely resembles that between Year 1 and Year 2.

status, and student earnings. Under these controls, 71% of students who initially received the highest level of Pell Grants (over $4,500) maintained their grant level by Year 3, while only 12% dropped to the lowest bracket. Conversely, 94% of those starting with the lowest grant level (less than $1,500) remained in that bracket.

To address the concern that students' intrinsic abilities may influence grant volatility, Appendix E shows that volatility is consistent across students with varying high school GPAs, whether they are high achievers or have marginally low GPAs. Additionally, the hypothesis that grant volatility stems from students failing to reapply for aid is unlikely. The literature indicates that only a small fraction of Pell-eligible students fail to reapply for aid (Bird and Castleman (2016)). Furthermore, the transition matrix confirms that students who received grants in one year successfully reapplied for aid in subsequent years.

Since data on the EFC index beyond the initial academic year is unavailable, one potential explanation for this volatility is that parents may have become wealthier and compensated for the changes in grant amounts. However, as previously discussed, evidence from the NLSY97 shows that actual family contributions generally do not offset grant volatility (Table I.4, Appendix B.1). This finding suggests that fluctuations in Pell Grants are not driven by changes in EFC. In the regression analysis below, I introduce additional controls to further demonstrate that family contributions neither account for the loss of Pell Grants nor mitigate its impact.

Regression Analysis. I conduct a regression analysis to examine how reductions in Pell Grants affect college completion. I define dropouts in this dataset as individuals who fail to earn a degree within six years of enrolling in a Bachelor's program. This differs from previous analyses using NLSY97 and NLSY79, which define dropouts over a 20- and 40-year horizon, respectively. The sample is restricted to first-time, full-time students enrolled exclusively in four-year Bachelor's degree programs, focusing on those who received high Pell awards, i.e., more than $4,000 in their initial year. In the first year, 37% of first-time, full-time undergraduate students received Pell awards exceeding $4,000. By the third year, only 22.5% of these students continued to receive this amount. By concentrating on recipients of higher Pell awards, I create a sample where family wealth is more consistent, which helps address potential confounding effects caused by variability in financial backgrounds, as highlighted by Bettinger (2004).[18] I then assess how losing all or part of their grant in the subsequent year t impacts their six-year Bachelor's graduation rates at any four-year degree-granting institution.[19] Importantly, I also exclude students who never enrolled in college in year t, as their financial data for that year is unavailable. This

[18] To understand the overall impact of grant volatility on the representative sample, I then use the quantitative model developed in the paper.

[19] The analysis also tracks whether students transfer to another institution.

exclusion results in a more conservative estimate of the impact of grant loss on dropout rates, as it omits students who may have left due to receiving lower conditional grant offers. Note that actual Pell Grant amounts are disbursed within ten days of the start of each academic year and may differ from the conditional estimates.

The regression is specified in equation 2, where the outcome variable Y_i indicates whether a student fails to graduate by the end of the six-year period, with $Y_i = 1$ representing that the student dropped out. The key variable of interest is how a reduction in Pell Grants during Year t affects the dropout decision. I categorize the reductions into two groups: the first includes students who lost more than two-thirds of their initial Pell Grants (receiving between \$0 and \$2,000), and the second includes those who lost between one-third and two-thirds (receiving between \$2,001 and \$4,000). The reference group consists of students who maintained their full grants (receiving between \$4,001 and \$5,550).[20]

The control variables, Θ_i, account for factors that may influence Pell Grant amounts. These factors include the number of siblings in college during both the initial year and year t, full-time enrollment status in year $t-1$ and t, earnings in year $t-1$, and academic performance in year $t-1$. Lagged academic performance not only affects Pell Grant amounts in year t but also helps mitigate reverse causality bias, as a student planning to drop out may perform poorly, resulting in lower grades. Since students may compensate for reduced grants with loans, I also include loans in year t, including parental PLUS loans, in the regression analysis. Additionally, to control for students ex-ante characteristics, I include high school grades, race, and gender.

$$\mathrm{Y}_i = \beta_1 \mathrm{Pell}_{[0,\$2,000],i} + \beta_2 \mathrm{Pell}_{[\$2,001,\$4,000],i} + \beta_3 \Theta_i + \varepsilon, \tag{2}$$

The results are summarized in Table VIII, showing a statistically significant link between Pell Grant amounts and dropout rates. Students who received \$2000 or less in Pell Grants are significantly more likely to discontinue their education, with a positive coefficient of 0.073 (significant at the 5% level). For those receiving between \$2001 and \$4000, the effect is even stronger, with a coefficient of 0.149 (significant at the 1% level). This difference is partly due to the exclusion of students who never enrolled in year t, many of whom would have had no grants and fallen into the lowest grant bracket. These findings suggest that reductions in Pell Grant amounts are strongly associated with increased dropout rates. The statistical significance of these coefficients indicates that students are unable to effectively offset the variation in Pell Grants through other financial sources, even when controlling for loans in the

[20] For 2017, the maximum Pell Grant is \$5,645.

year of grant loss.

To address the lack of direct data on Expected Family Contribution (EFC) for each academic year, I focus on students with an initial EFC near zero, indicating their receipt of substantial Pell Grants. This approach minimizes the impact of variations in family contributions on Pell Grant amounts. Additionally, I limit the sample to students with substantial unmet financial need—the difference between the Cost of Attendance (COA) and EFC—of at least \$10,000. This ensures that the Pell Grant formula, $\text{Pell} = \max(\text{COA} - \text{EFC}, \text{Maximum Pell Amount})$, remains stable despite minor fluctuations in EFC or tuition, due to the significant unmet need. Regression analysis indicates that reductions in grant aid adversely affect graduation rates, suggesting that family contributions do not adequately offset the loss of grants. Notably, the analysis controls for loans, including parental loans, in year t. Finally, as detailed in the NLSY97 analysis in Appendix B.1, actual family aid exhibits inconsistent and minor responsiveness to changes in grant amounts.

To conclude, the results challenge earlier findings regarding the limited role of borrowing constraints in college attainment Carneiro and Heckman (2002) by demonstrating the increasing influence of family wealth on college success for today's students—a notable shift from previous decades. Evidence from nationally representative datasets highlights that students face significant financial volatility during college, primarily due to the current year-to-year qualifying grant system. Even after controlling for student behavior, academic performance, and background characteristics, reductions in grant amounts are strongly associated with lower graduation prospects. These findings are consistent with Bettinger (2004), who, using unpublished data from Ohio Board of Regents, demonstrates that exogenous factors such as tuition increases or modifications to the Pell Grant formula strongly influence college stop-out behavior. This underscores the importance of considering financial variability when studying college completion and its broader economic implications—an aspect often overlooked in the macroeconomic education literature that aims to explain college participation rates or design optimal education subsidy schemes, including Matsuda and Mazur (2022), Hendricks and Leukhina (2017), Hendricks and Leukhina (2018), Colas, Findeisen, and Sachs (2021), Arcidiacono et al. (2025), Abbott et al. (2019), and Krueger and Ludwig (2016).

In the following quantitative analysis, I incorporate grant variability into a general equilibrium overlapping generations model with endogenous college choice and dropout decisions. This approach will quantify how much of the dropout rate is driven by financial instability and allow for the evaluation of policy impacts while accounting for general equilibrium effects.

3 The Model Economy

I consider an overlapping generations general equilibrium model. The model economy consists of individuals that are heterogeneous with respect to age, wealth, learning ability, education, and labor productivity, firms that produce a final good by hiring labor and capital on competitive spot markets, and a government that operates a tax system and a pension system. The key innovation of the model is the two-period college stage. Individuals make two education-related decisions: first, whether to enroll in college, and, second, whether to continue or to drop out of college. An individual's enrollment decision is based on her prior beliefs about ability and initial wealth. Once in college, a student can drop out, basing her decision on an ability signal (captured by college GPA scores), her labor market productivity, and, a novel dropout channel, the grants available to her. In particular, I model the second-period grant as a function of academic performance measured by the GPA as well as stochastic shocks. These features complement the existing macro literature, which usually models grants as a constant share of the tuition costs over time. As demonstrated in the empirical analysis, grants vary from year to year and have a tendency to decrease over time, thus potentially affecting individuals' willingness to continue college. Furthermore, I model the working and retirement stages to account for the long-term gains of college attendance in life-time earnings and risk. These stages are key in assessing welfare consequences in the long-run and the transitional paths of the general equilibrium.

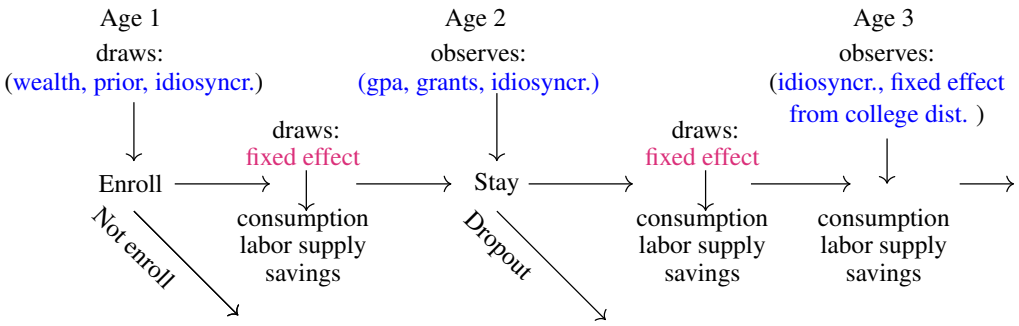
3.1 Demographics

Time is discrete, indexed by t, and it goes forever. At any point in time, the economy is populated by J overlapping generations indexed by $j = 1, 2, \cdots, J$, where J denotes the maximum age. Individuals survive from age j to $j+1$ with probability ϕ_{j+1}. For simplicity, I assume that the survival rate before retirement is equal to one; agents face a death hazard once they retire, i.e., $\phi_j \in [0,1)$ for $j \geq j_r$, where j_r denotes the retirement age. Let N_t denote the initial size of the cohort that enters the economy in period t; N_t grows at a constant rate n, i.e., $N_t = (1+n)N_{t-1}$. The relative share of each age cohort in the population is constant over time since the population growth rate is constant, and the age-specific survival rates are time-invariant. To ease aggregation later on, I define m_j as the population size of the age cohort j relative to the youngest cohort alive in the current period:

$$m_j := \frac{N_{t-j+1}\left(\prod_{i=0}^{j-1}\psi_i\right)}{N_t}.$$

Note that ψ_i captures the mortality risk in age i, discuss further below.

Figure 2: Timeline of Schooling Decisions



3.2 Timeline

In this section, I provide an overview of an individual's life-cycle, with emphasis on the two-period college stage depicted in Figure 2, before describing the main elements of the model.

Individuals enter the economy as high school graduates at age 1. They draw a prior on academic ability and an education-contingent initial wealth endowment,[21] based on which each individual decides whether to enroll into college or not. After enrollment decisions, they observe their productivity in the labor market and correspondingly make consumption-leisure-savings decisions. College lasts two periods. At the beginning of age 2, halfway through college, individuals reflect on their academic abilities, grant amounts, and labor productivity. In light of the incoming information, students update their beliefs on their ability and reassess the value of college. Based on their assessments, they either continue with a college education or drop out.

After the college continuation decision, individuals observe the remaining uncertainty on the labor market and make consumption-leisure-savings decisions accordingly. Those who remain in college are able to graduate. As of period 3, all individuals have finalized their education and earn their education-specific (high school graduate, dropout, or college graduate) wages.

Finally, after working for 24 periods, the individuals retire (i.e., at the age of 66) and live on capital income and pension benefits. Following their retirement, individuals face mortality risk, and they die with certainty at period 40 (at the age of 98 years).

The rest of this section is organized as follows. First, I describe the belief system embedded in the model. Second, I describe the resource cost of college. I then illustrate the household's life-cycle decisions in detail.

[21] Initial wealth is an exogenous way of modeling parental transfers discussed below in details.

3.3 Beliefs about ability

An individual enters the economy with a normally distributed prior about her true (yet unobserved) ability e_i. The mean of the prior is given by $\mu_{e_0,i} = e_i + \alpha_e + \varepsilon_{e_0,i}$. The parameter α_e is a general optimistic bias that one has about true ability, common to all individuals.[22] Optimism is often named as a major determinant in college dropout decisions. Therefore, incorporating this element, allows the model to generate conservative dropout rates with respect to other dropping out channels that are novel to the literature. The noise $\varepsilon_{e_0,i}$ is distributed normally, $\mathbb{N}(0, \sigma^2_{e_0})$. This implies that an individual prior has mean $\mu_{e_0,i}$ and standard deviation σ_{e_0}.

Individuals get their GPAs at the end of the first period of college. A GPA is contingent on heterogeneity, luck, and effort toward college. The first is captured by true ability, e_i, the second by the noise associated with grades, ψ_i, and the third is captured by one minus the time spent working in the labor market in period 1, $1 - l_{1,i}$. The assumption that working while in college may be detrimental to academic performance aligns with the large literature that isolates the causal impact of working hours on education attainment, including Scott-Clayton and Minaya (2016), Stinebrickner and Stinebrickner (2003), Wenz and Yu (2010), Darolia (2014), Bozick (2007). The GPA of an individual i is thus given by:

$$GPA_i = e_i + \lambda_l \max(l_{-1,i} - \underline{l}, 0) + \psi_i, \tag{3}$$

where $\underline{l}$ denotes the threshold amount of working hours that does not harm one's GPA,[23] and $\lambda_l < 0$ captures how strongly working in the labor market affects academic performance. The stochastic part of the GPA, ψ_i, is distributed normally with mean zero, and standard deviation $\sigma_{\psi,i}$. An individual who enrolls in college extracts a signal through GPA in the following manner:

$$\hat{S}_i = GPA_i - \lambda_l \max(l_{-1,i} - \underline{l}_i, 0). \tag{4}$$

Given the signal, she updates her beliefs in a Bayesian fashion given by equations (5) and (6). Since I assume that both the prior and the signal are normally distributed, the posterior is also normally distributed, with mean $\mu_{e_1,i}$ and variance $\sigma_{e_1,i}$.

$$\mu_{e_1,i} = \frac{\sigma^2_{\psi,i}}{\sigma^2_{e_0,i} + \sigma^2_{\psi,i}} \mu_{e_0,i} + \frac{\sigma^2_{e_0,i}}{\sigma^2_{e_0,i} + \sigma^2_{\psi,i}} \hat{S}, \tag{5}$$

[22] Failing to include the optimism parameter would underestimate the role of beliefs in dropout decisions.

[23] That captures the empirical evidence that working for a few hours a week $(15 - 20)$ does not affect negatively on GPA accumulation (Bozick (2007)).

$$\sigma^2_{e_1,i} = \frac{\sigma^2_{\psi,i}}{\sigma^2_{e_0,i} + \sigma^2_{\psi,i}} \sigma^2_{e_0,i}. \tag{6}$$

I assume that the variance of the prior, $\sigma^2_{e_0,i}$, is the same across all individuals, i.e., given the latter, $\mu_{e_0,i}$ is a sufficient statistic for capturing the distribution of the prior beliefs across individuals. In the following, I suppress the subscript i wherever it does not cause confusion.

3.4 Resource Cost of College

Governmental subsidies

In each period of college attendance, there is a resource cost that is incurred and represented by a portion, ι, of the skilled labor wage rate, $w_{t,c}$. Denote the fraction of that cost borne by the government in the first period in college by $z_1(a_c, \mu_{e_0})$. Note that $z_1(\cdot)$ is a function of parental transfers for college purposes, a_c, and an ability prior, μ_{e_0}. In particular, I model merit-based and need-based grants with separable functions, as they exhibit different uncertainty between academic years, i.e., $z_1(a_c, \mu_{e_0}) = z_1^{\text{need}}(a_c) + z_1^{\text{merit}}(\mu_{e_0})$.[24] Note that the government observes the mean of the individual prior, as it is assumed to be shaped by high school grades. The direct cost of attending college in the first period for an individual is therefore $\big(1 - z_1(a_c, \mu_{e_0})\big)\iota w_{t,c}$.

In the second period, students might not get the same grant amount as they did in the first year. This is because in the second period, the grants depend on their academic performance, and the stochastic shocks to their grants, ζ. The stochastic shock is motivated by the empirical analysis in section 2, where I show that even controlling for a set of eligibility criteria, students grants' are still characterized by significant volatility. The second-period grant is summarized as follows:

$$z_2\big(a_c, \zeta, GPA(l_{-1}, \hat{S})\big) = z_1^{\text{need}}(a_c)\mathbb{1}_{GPA \geq \overline{GPA}_{\text{need}}}\zeta + z_1^{\text{merit}}(\mu_{e_0})\mathbb{1}_{GPA \geq \overline{GPA}_{\text{merit}}}\zeta, \tag{7}$$

where $\overline{GPA}_{need}$ ($\overline{GPA}_{merit}$) is the GPA threshold below which students are disqualified from need-based (merit-based) grants.

Parental Transfers

I use heterogeneity in initial wealth to capture family wealth effects on college attendance. Individuals draw a college-contingent wealth from an exogenous initial wealth distribution, which captures the gradient of parental contributions for college purposes in the data. Moreover, by continuing college, they

[24] The specific functional form of each type of grant is explained in the calibration section of the paper.

will receive the same amount for the second period of college. Modeling per-period college contingent parental transfers is particularly crucial to analyze dropouts, and it deviates from the macro education literature, which usually models parental contributions as once-and-for-all transfers before college enrollment decisions. Such modeling is problematic when focusing on dropout behavior. To begin with, if all the money is transferred at the age of 18, it underestimates the financial constraints students face during their college years. In addition, it creates a moral hazard problem: by front-loading the transfer, individuals may enroll in college only to receive the transfer and then drop out strategically.[25] However, modeling multi-period endogenous transfers is computationally infeasible. Therefore, I exogenously approximate the parental transfer distribution from the data so that it closely aligns with parental contribution by wealth quintiles. Once individuals receive an initial transfer, they continue to receive the same amount in each subsequent college period, provided they remain enrolled.

Hereby, I address two potential problems which might arise due to not modeling endogenous transfers. First, parents could adjust their transfers if students face financial shocks. However, this concern should not be present in this framework. In the data, the bottom 40% have zero to very little family contribution, and it is not likely that such poor students' parents would be able to hedge against grant shocks.[26] The second potential problem associated with having no endogenous transfers in the model is that parents might crowd out their transfers as a response to the change in subsidy rates. Since the policy experiments of this paper do not change the level of per-period grant, then, this concern is also not of the first order.

3.5 Labor Productivity

The set-up of the productivity process is standard in the overlapping generations literature and closely follows Karahan and Ozkan (2013) and Krueger and Ludwig (2016). Labor productivity for an individual i at age j with education status s is denoted by:

$$h_{j,i} = \varepsilon_j \cdot \exp(\theta_i + \eta_i), \quad \text{where} \quad \eta_i \in \mathscr{H}_s, \quad \theta_i \in \Theta_s, \quad s = \{h, d, c\}.$$

The three elements are: (1) a deterministic, life-cycle productivity profile, ε_j, (2) a productivity fixed effect, θ_i, and (3) a stochastic component, η_i. The distribution of the stochastic component η_i is education-specific $\mathscr{H}_s$, where subscript s indexes for education levels are: $s = h$ for high school graduates, $s = d$

[25] To address this issue, for instance, Colas, Findeisen, and Sachs (2021) incorporate a pecuniary dropout cost to discourage such strategic behavior among college-age individuals.

[26] Their main sources of income are grants, loans, and work.

for college dropouts, and $s = c$ for college graduates. The idiosyncratic shock, η_i, is drawn every time an individual's education status changes, and follows an education-specific Markov process $\pi_s(\eta'|\eta)$ after college. Specifically, at age 1, all individuals draw from the distribution for high school graduates $\mathscr{H}_n$; at age 2, only those who have enrolled in college redraw η_i, from the distribution for college dropouts $\mathscr{H}_d$; at age 3, those who graduated redraw η_i, from the distribution for college graduates $\mathscr{H}_c$;

The distribution of the fixed effect component θ_i is Θ_s, which depends on both education, s, and one's true and yet unknown ability, everyone draws θ_i at age 1, and only those with an education status change redraw during college. In order to ease the state space, the fixed effects have two draws $\theta_s = \{\exp(-\sigma_{\theta_s}), \exp(\sigma_{\theta_s})\}$. The relationship between ability and labor productivity is formalized as follows:

$$\pi\big(\theta_s = \exp(\sigma_{\theta_s})\big) = \omega_s e, \tag{8}$$

where $\omega_h < \omega_d < \omega_c$, i.e., given ability e the higher the education status the higher the probability of drawing higher θ_i. Such a modeling of fixed effects closely follows Krueger and Ludwig (2016) and allows to drop ability as a state variable after college graduation, thereby easing the state space. Without loss of generality, ω_c is set to 1.[27] Once the education level is finalized (i.e. an individual becomes a college dropout or a college graduate), θ_i remains fixed for the rest of the lifespan.

3.6 Government

Before defining the individual's problem, it is useful to introduce how the government operates the fiscal system in the first place. The government collects taxes on household consumption, capital income, and labor income, so as to finance public expenditure G_t, and education subsidies. Consumption and capital income are taxed with flat rates, τ_c and τ_k, respectively. Following Heathcote, Storesletten, and Violante (2010), I consider a potentially progressive labor income tax function:

$$\tau_l(y) = 1 - \lambda y^{-\lambda_m}, \tag{9}$$

where $\tau_l(y)$ is the tax rate at income level y, $\lambda_m > 0$ is a measure of the progressivity of the tax schedule and λ is a parameter that governs the average tax rate (for a given λ_m).

The pension system operates on a pay-as-you-go basis: it collects contributions from the current workers and distributes the revenues directly to the current pensioners. In period t, current workers

[27] Note that those who enrolled in college draw $\theta_i \in \Theta_n$ irrespective of ability. This assumption serves to eliminate learning about one's academic ability through the labor market.

contribute a fraction, τ_p, of their labor income to the pension funds, whereas current retirees receive a pension benefit that is proportional to their average life-time income: $pen_t(s,\theta) = \kappa_s w_{t,s} \bar{L}_t(s,\theta)$, where $\bar{L}_t(s,\theta)$ denotes the average labor supply, in terms of efficiency units, of working-age cohorts with the characteristics (s,θ), $\theta \in \Theta_s$. The budget constraint of the pension system is then given by:

$$\sum_{s\in\{h,d,c\}} \tau_p w_{t,s} L_{t,s} = \sum_{s\in\{h,d,c\}} \sum_{\theta\in\Theta_s} \sum_{j=j_r}^{J} pen_t(s,\theta) m_j(s,\theta), \tag{10}$$

where $m_j(s,\theta)$ is the relative size of age cohort j that falls into the skill category s and has a fixed productivity component θ.

Finally, the government collects accidental bequests in the economy and individuals draw on this pool to determine their parental wealth. This assumption allows for parental transfers in the economy without the need for direct modeling of intergenerational transfers. The description of the government budget constraint is given in equation (26), in section 3.9.

3.7 The Individual's Problem

Next I describe the life-cycle problem of an individual.

Decisions at age $j = 1$

Before making consumption-leisure-savings decisions, an individual observes an idiosyncratic productivity shock, η, draws a prior belief μ_{e_0} about her innate ability, and receives an education-contingent initial wealth $\{a_c, a_h\}$, where a_c captures per-period parental contribution for college-bound individuals, and a_h parental transfers if individuals do not go to college. The enrollment decision is given by:

$$\mathbb{1}(1,a,\eta,\mu_{e_0}) = \begin{cases} 1, & W_c^1(a_c,\eta,\mu_{e_0}) > W_h^1(a_h,\eta,\mu_{e_0}), \\ 0, & \text{otherwise.} \end{cases}$$

The value functions $W_c^1(a_c,\eta,\mu_{e_0})$ and $W_h^1(a_h,\eta,\mu_{e_0})$ denote the expected present values of life-time utilities, respectively, of going to college or not. It follows that the indicator function, $\mathbb{1}(1,a,\eta,\mu_{e_0})$, is equal to 1 when individuals find it optimal to attend college. The two value functions are formally defined as follows:

$$W_c^1(a_c,\eta,\mu_{e_0}) = \mathbb{E}_{\theta'\in\Theta_h} V_c^1\left(a_c,\theta',\eta,\mu_{e_0}\right),$$

$$W_h^1(a_h,\eta,\mu_{e_0}) = \mathbb{E}_{\theta'\in\Theta_h|\mu_{e_0}} V_h^1\left(a_h,\theta',\eta\right),$$

where $V_c^1\left(a_c,\theta,\eta,\mu_{e_0}\right)$ and $V_h^1\left(a_h,\theta,\eta\right)$ are the expected present values of the life-time utilities of an individual who decides to enroll in or stay out of college, respectively. Note that the non-college value function, $V_h^1\left(a_h,\theta,\eta\right)$, does not take an ability prior as a state variable, because beliefs become redundant after drawing the fixed effect. Furthermore, note that for enrolled individuals, the first period fixed effect is independent of ability. This assumption is necessary to avoid learning about ability in the labor market.

After the enrollment decision at age 1, having drawn the fixed effect, θ, individuals solve a standard consumption-leisure-savings problem. For those who decide not to enroll, their recursive problem reduces to the standard consumption-leisure-savings problem defined subsequently in this section (equation 12). Formulated recursively, the college-bound individuals' Bellman equation is as follows:

$$\begin{aligned} V_c^1(a_c,\theta,\eta,\mu_{e_0}) = \max_{a',c,l}\Bigg\{ & u(c,1-\xi(\mu_{e_0})-l)+\beta\int_{\hat{S}}\int_{\zeta}\int_{\eta'\in\mathscr{H}_d} \\ & \max\Bigg(W_c^2\left(a'(a_c),\eta',z_2(a,\zeta,GPA(l,\hat{S})),\mu_{e_1}(\mu_{e_0},\hat{S})\right), \\ & W_d^2\left(a'(a_h),\eta',\mu_{e_1}(\mu_{e_0},\hat{S})\right)\Bigg)d\eta\, d\zeta\, d\hat{S}\Bigg\}, \end{aligned} \tag{11}$$

s.t.

$$(1+\tau_c)c+a'+(1-z_1(a,\mu_{e_0}))\imath w_{t,c} = (1+(1-\tau_k)r_t)a_c+(1-\tau_p)y-y\tau_l(y)+T,$$

$$a' \geq -\underline{A}_1,$$

$$\mu_{e_1} = \frac{\sigma_\psi^2\mu_{e_0}+\sigma_{e_0}^2\hat{S}}{\sigma_{e_0,i}^2+\sigma_\psi^2},$$

$$\sigma_{e_1} = \frac{\sigma_{e_0}^2\sigma_\psi^2}{\sigma_{e_0}^2+\sigma_\psi^2}.$$

The expectations are taken with respect to the distribution of the ability signals, $\hat{S}$, shocks to college subsidies, ζ, as well as the future idiosyncratic labor market shocks, η'. The continuation value for college-bound individuals is the maximum expected utility between two scenarios: (a) stay in college, $W_c^2\left(a'(a_c),\eta',z_2(a_c,\zeta,GPA(l,\hat{S})),\mu_{e_1}(\mu_{e_0},\hat{S})\right)$, or (b) dropping out, $W_d^2\left(a',\eta',\mu_{e_1}(\mu_{e_0},\hat{S})\right)$.[28] Note that a' depends on the parental transfers.[29] Therefore, students internalize the fact that their parents will only contribute financially if they stay in college. The GPA is formed by $\left(l,\hat{S}\right)$ and grants depend

[28] Note that once an individual decides to drop out, the signal, $\hat{S}$, and the subsidies shock, ζ, become redundant.

[29] While students make decisions about their savings, they take into account the expectation that if they continue their education, they will receive parental transfers in the next period, denoted as a_c, reflecting the recurring nature of parental financial support for college-related expenses. Conversely, if they choose to drop out, they will forgo such transfers.

on $\left(a, \zeta, GPA(l, \hat{S})\right)$, as defined in equations (3) and (7), respectively. Finally, note that y defined as $y_1 = w_c h_{1,c}(\theta, \eta) l(1, a_c, \theta, \eta, \mu_{e_0})$ is earnings.

Decisions at age $j = 2$

At the beginning of period 2, students make a dropout decision based on their *GPA*s, the stochastic part of the grants, ζ, and an idiosyncratic part of the labor productivity process, η, now drawn from a dropout wage distribution. The GPA affects posterior beliefs about one's true ability, while simultaneously affecting grant allocation. Therefore, a high GPA enhances the value of college through the following channels (1) lowering the instantaneous utility cost of staying in college (2) increasing expected college returns, and (3) decreasing the probability of losing grants (through GPA requirements). The stochastic shock ζ affects the affordability of college (and, therefore, average returns of college). When $\zeta < 1$, the budget constraint is tightened, and when $\zeta > 1$, the college becomes more affordable and, as a consequence, incentivizes more college attendance. Finally, the idiosyncratic wage shock, η, affects an individual's budget constraint as well as the outside option of college: high η may induce students to drop out as the opportunity cost of college increases, but at the same time, it might motivate students to stay in college as college becomes more affordable. Therefore, the impact of η on college attendance cannot be isolated, and it depends on the other component of state space.

With the realized state vector $(GPA(l, \hat{S}), \zeta, \eta)$, an individual compares the value of college to the value of dropping out and optimally decides whether or not to stay in college. Formally, the decision is summarized as follows:

$$\mathbb{1}\left(2, a, \eta, z_2, \mu_{e_1}\right) = \begin{cases} 1, & \text{if } W_c^2\left(a'(a_c), \eta', z_2, \mu_{e_1}\right) > W_d^2\left(a'(a_h), \eta', \mu_{e_1}\right), \\ 0, & \text{otherwise,} \end{cases}$$

where

$$W_c^2\left(a'(a_c), \eta', z_2, \mu_{e_1}\right) = \mathbb{E}_{\theta' \in \Theta_d | \mu_{e_1}} V_c^2\left(\theta', \eta, z_2, \mu_{e_1}\right),$$

$$W_d^2\left(a'(a_h), \eta', \mu_{e_1}\right) = \mathbb{E}_{\theta' \in \Theta_d | \mu_{e_1}} V_d^2\left(a, \theta', \eta\right).$$

$W_c^2\left(a'(a_c), \eta', z_2, \mu_{e_1}\right)$ and $W_d^2\left(a'(a_h), \eta', \mu_{e_1}\right)$ denote the expected present values of the life-time utilities of staying in college and dropping out, respectively. The probabilities are taken with respect to the fixed labor productivity shocks, $\theta \in \Theta_d$. It leads the indicator function, $\mathbb{1}\left(2, a, \eta, z_2, \mu_{e_1}\right)$, to take the value of 1 if the individual decides to remain in college.

After the dropout decision, individuals make consumption-leisure-savings decisions. This problem

is formulated as follows for college-bound individuals:

$$V_c^2(a,\theta,\eta,z_2,\mu_{e_1}) = \max_{a',c,l}\left\{u(c,1-\xi(\mu_{e_1})-l)+\beta\int_{\eta'\in\mathscr{H}_c}\mathbb{E}_{\theta'\in\Theta_c|\mu_{e_1}}V_c(3,a',\theta',\eta')d\eta\right\},$$

s.t.

$$(1+\tau_c)c+a'+(1-z_2(a,\zeta,GPA(l_{-1},\hat{S})))\imath w_{t,c} = (1+(1-\tau_k)r_t)(a+a_c)+(1-\tau_p)y-y\tau_l(y)+T,$$

$$z_2\big(a_c,\zeta,GPA(l_{-1},\hat{S})\big) = \big(z_1^{\text{need}}(a_c,\mu_{e_0})\mathbb{1}_{GPA\geq\overline{GPA}_{\text{need}}}+z_1^{\text{merit}}(a_c,\mu_{e_0})\mathbb{1}_{GPA\geq\overline{GPA}_{\text{merit}}}\big)\zeta,$$

$$a'\geq-\underline{A}_2.$$

For those individuals who decide to drop out, beliefs about their ability become redundant. Their recursive problem reduces to the standard consumption-leisure-savings problem defined in equation (12).

Decisions at age $j >= 3$

College graduates draw their wage components from the college wage distribution. From age $j=3$ onward,[30] the problem of an individual with an education level $s=\{h,d,c\}$ is as follows:

$$V_s(j,a,\theta,\eta) = \max_{a',c,l}\{u(c,1-l)+\beta\int_{\eta'|\eta}V_s(j+1,a',\theta,\eta')d\eta\}, \tag{12}$$

s.t.

$$(1+\tau_c)c+a' = (1+(1-\tau_k)r_t)a+(1-\tau_p)y-y\tau_l(y)+T,$$

$$a'\geq-\underline{A}_j. \tag{13}$$

[30]For high school graduates, who never enroll, the optimization problem reduces to equation (12) from age $j=1$, and for college dropouts their problem reduces to equation (12) from age $j=2$ onward.

Decisions at age $j >= j_r$

Upon retirement, individuals' labor productivity drops to zero, and, therefore, they live on capital income and pension benefits. The associated Bellman equation is given by:

$$V(j,a,\theta,0) = \max_{a',c} \left\{ u(c,1) + \beta \varphi_{j+1} V(j+1,a',\theta,0) \right\}, \tag{14}$$

s. t.

$$(1+\tau_c)c + a' = (1+(1-\tau_k)r_t)a + pen_t(s,\theta) + T.$$

Individuals after retirement face mortality risk φ_{j+1} in each period. They die with probability 1 at age $j = J$.

3.8 Firms and Production

Firms hire labor and capital on competitive spot markets to produce a final good. The final output is produced according to the standard Cobb-Douglas production function:

$$Y_t = A K_t^{\alpha} L_t^{1-\alpha},$$

where A denotes total factor productivity, and α is a parameter that governs the elasticity of output with respect to capital.

I assume that workers come in two skill types: those with a college degree are referred to as skilled labor, the others (college dropouts and high school graduates) are referred to as unskilled labor. The two skills are imperfectly substitutable to each other, with the substitution parameter ϑ. Aggregate labor, therefore, can be formulated as follows:

$$L_t = \left(\upsilon (L_{t,h} + L_{t,d})^{\vartheta} + (1-\upsilon) L_{t,c}^{\vartheta} \right)^{1/\vartheta}, \tag{15}$$

where $L_{t,s}$ denotes aggregate labor in terms of efficiency units in the different educational groups, s. The parameter υ is calibrated to match the college wage premium in the data.

The assumption that there are only two skill types is based on the proportion of firms that require a "High school degree," "Associate's degree," "Some college, no degree," or "Bachelor's degree and higher" in their job postings. According to Torpey and Watson (2014), only 5% of all jobs require the "Some college, no degree" category of education. This suggests that most individuals with some college

education are employed in positions that only require a high school diplomas.[31]

Finally, assuming perfect competition and constant returns to scale of the production function, the size distribution of firms is indeterminate. Therefore, I will assume the existence of a representative firm without loss of generality. This representative firm takes the wage rates of skilled labor, $w_{t,c}$, unskilled labor, $w_{t,h}$, and the interest rate, r_t, as given.

3.9 Competitive Equilibrium

To define a general equilibrium of the model economy, it is useful to introduce some additional notation. In particular, I define the distribution of individuals on the state space. Let $\mathscr{J} = \{1,2,...,J\}$, $\mathscr{E} = [0,1]$, $s = \{h, d, c\}$, $\mathscr{A} = \mathbb{R}$, $\Theta = \mathbb{R}$ and $\mathscr{H} = \mathbb{R}$ denote the state space for age j, ability e, education level s, wealth a, fixed productivity effect θ and the stochastic productivity component η. And let Σ represent the Borel σ-algebra defined on the product space $\mathbb{X} = \mathscr{E} \times \mathscr{J} \times \mathscr{S} \times \mathscr{A} \times \mathscr{F} \times \mathscr{H}$. Then, for any $X \in \mathbb{X}$, a measure $\phi(X)$ can be properly defined. For ease of notation, let $X(j,s) \in \mathbb{X}$ be the state space of an individual of age j and with education status s, defined by the recursive representation of the individual's problems above.

With this preparation, I now define the stationary recursive competitive equilibrium as follows. A stationary recursive competitive equilibrium is a collection of: (i) decision rules of individuals $\Big\{ \mathbb{1}(1, a_s, \mu_{e_0}, \eta)$, $\mathbb{1}\big(2, a, z, \mu_{e_1}, \eta\big)$, $c(X(j,s)), l(X(j,s)), a'(X(j,s))\Big\}$; (ii) aggregate capital and labor inputs, $\big\{K, L_h, L_d, L_c\big\}$, on the part of firms; (iii) value functions $\big\{V\big(X(j,s)\big)\big\}$; (iv) government policies $\big\{\tau_c, \tau_k, \tau_p, \tau_l(y), pen(s,\theta_s), \kappa_s, z_1, z_2, T\big\}$; (v) prices $\big\{r, w_h, w_c\big\}$; (vi) education system characterized by $\{\iota, \xi(\mu_{e_0}), \xi(\mu_{e_1})\}$; and (vii) a vector of measures ϕ, such that:

1. The decision rules of individuals solve their respective life-cycle problems, and $V\big(X(j,s)\big\}$ are the associated value functions.

2. Aggregate capital and labor inputs, $\{K, L_h, L_d, L_c\}$, solve the representative firm's profit maximization problem, which is fully characterized by the following first order conditions:

$$r = \alpha A k^{\alpha-1} - \delta, \tag{16}$$

$$w = (1-\alpha) A k^{\alpha}, \tag{17}$$

$$w_c = (1-\alpha)(1-\upsilon) k^{\alpha} \left(\frac{L}{L_c}\right)^{1-\zeta} = w \left(\frac{L}{L_c}\right)^{1-\zeta}, \tag{18}$$

[31] Another 6% percent of jobs requires postsecondary non-degree awards, which I have not considered in the model.

and

$$w_h = (1-\alpha)k^{\alpha}(\upsilon)\left(\frac{L}{L_h+L_d}\right)^{1-\zeta} = w(1-\upsilon)\left(\frac{L}{L_h+L_d}\right)^{1-\zeta}, \tag{19}$$

where $k = \frac{K}{L}$, $w = (1-\alpha)k^{\alpha}$, and the college wage premium is therefore given by:

$$\frac{w_c}{w_h} = \frac{1-\upsilon}{\upsilon}\left(\frac{L_h+L_d}{L_c}\right)^{1-\zeta}. \tag{20}$$

3. The labor market for each skill type clears:

$$L_s = \sum_{s=\{h,d,c\}}\sum_{j=1}^{j_r-1}\int_{X(j,s)} h_{s,j}(\theta,\eta)l\big(X(j,s)\big)d\phi\big(X(j,s)\big), \tag{21}$$

4. The capital market clears:

$$K = \sum_{s=\{h,d,c\}}\sum_{j=1}^{J}\int_{X(j,s)} a'(X(j,s))d\phi\big(X(j,s)\big) + A_{init},$$

where A_{init} is the aggregate wealth transfer to the newly arrived generation:

$$A_{init} = \sum_{s=\{h,d,c\}}\int_{X(1,s)} af(s,a)\,d\phi(X(1,s)) + \sum_{s=\{h,d,c\}}\int_{X(2,s)} af(s,a)\,d\phi(X(2,s)), \tag{22}$$

where $\phi(j,s)$ denotes the measure of individuals at age $j = \{1,2\}$ with college decision s and $f(s,a)$ is the distribution from which initial wealth is drawn.

5. The good market clears:

$$Y = C+G+E+I, \tag{23}$$

$$C = \sum_{s=\{h,d,c\}}\sum_{j=1}^{J}\int_{X(j,s)} c\big(X(j,s)\big)d\phi\big(X(j,s)\big), \tag{24}$$

$$E_t = \int_{X(1,c)} \iota w_c d\phi(X(1,c)) + \int_{X(2,c)} \iota w_c d\phi(X(2,c)), \tag{25}$$

where G represents government spending, and I is gross investment.

6. The government budget constraint holds:

$$\tau_c C + \tau_k rA + T_l + (1+r)A_b = G + A_{init} + Z + T, \tag{26}$$

where T_l denotes labor income tax revenues, as given by:

$$T_l = \sum_{s=\{h,d,c\}} \sum_{j=1}^{j_r-1} \int_{X(j,s)} \tau_l(y_s) y_s d\phi(X(j,s)), \tag{27}$$

with $y_s = (1-\tau_s) w_{t,s} h_{s,j}(\theta,\eta) l(j,a,\theta,\eta)$.[32] A_b denotes accidental bequest:

$$A_b = \sum_{s\in\{h,d,c\}} \sum_{j=j_r}^{J} \int_{X(j,s)} a'(X(j,s)) \frac{1-\varphi_{j+1}}{\varphi_{j+1}} d\phi(X(j,s)). \tag{28}$$

Z is the aggregate education subsidies:

$$Z_t = \int_{X(1,c)} z_1(\cdot) \iota w_c d\phi(X(1,c)) + \int_{X(2,c)} z_2(\cdot) \iota w_c d\phi(X(2,c)). \tag{29}$$

7. The pension budget constraint (10) holds.

8. Individual behaviors are consistent with aggregate behavior: measure ϕ is a fixed point of $\phi(X) = \Pi(X,\phi)$, for any $X \in \mathbb{X}$, where $\Pi(X,\cdot)$ signifies the transition function generated by the decision rules of individuals, the process of exogenous states, and the survival probabilities.

9. All aggregate per capita variables increase by the population growth rate, n_p.

4 Calibration

This section discusses the model calibration. A majority of the parameters are either estimated directly from the data or calibrated internally by matching certain aggregate moments in the US data. The remaining parameters are taken from the literature.

Demographics–A period in the model corresponds to two years. New generations enter the economy at the age of 18 and it takes two model periods (four years) to complete college. Individuals retire at the age of 66, and the maximum age is 96. Moreover, the population grows at a constant rate of $n = 1\%$ annually, which is consistent with the long-term population growth rate in the U.S. Likewise, survival probabilities $\{\varphi_j\}$ are computed from the actuarial life Tables for the US.

Preferences– I consider a fairly standard utility function:

$$u(c,1-l) = \frac{\left[c^{\nu}(1-l)^{1-\nu}\right]^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}}, \tag{30}$$

[32] Note that I slightly abuse notation in that for college-bound individuals the state space also incorporates prior, posterior of ability and a shock to the grants.

where ν is a taste parameter for consumption and $\frac{1}{\gamma}$ denotes a risk aversion parameter. The two parameters ν and γ determine together (i) the average labor supply, (ii) the intertemporal elasticity of substitution of consumption, and (iii) the Frisch elasticity of labor supply. ν is chosen such that individuals, on average, work one-third of their time endowment. Parameter γ is set to 0.25 so that the risk aversion, $\frac{-cu_{cc}}{u_c} = \frac{1}{\gamma}\nu + 1 - \nu$, is set to ≈ 2, a standard value in the literature.

Technology–The aggregate production function is a Cobb-Douglas form. The capital share α is set to 0.33. Total factor productivity A is normalized to 1. The elasticity of substitution between skilled and unskilled labor is borrowed from Card (2009) and set to 3.33. This estimate is in line with the estimate in Abbott et al. (2019) and those in literature. The discount factor is internally calibrated to target at a capital-output ratio of around 3 as in Krueger and Ludwig (2016). Finally, υ is calibrated internally to match the college wage premium of about 80%, reported in Table 4. The college wage premium is defined as the ratio of the (age-composition-adjusted) average wage between those with a college degree and those with only a high school degree.

Utility Cost of College–Utility cost is one of the critical factors that generate differentiated college attainment rates by ability quintiles.[33] I parameterize the utility cost of attending college as follows: $\xi_1(\mu_{e_{0,i}}) = \exp(b_0 - b_1\mu_{e_{0,i}})$ and $\xi_2(\mu_{e_{1,i}}) = \exp(b_0 - b_1\mu_{e_{1,i}})$. It is important to note that these parameters, b_0 and b_1, are kept constant across college periods. This assumption is crucial. If the coefficients vary across years, they directly influence dropout rates. This influence could obscure the effect of learning about one's ability on the decision to stay in college. I calibrate these parameters internally, calibrating the constant to match the overall enrollment rate in the data while calibrating the slope parameter to match the enrollment rates by ability. The calibrated values are reported in Table XVI, and the results are shown in Figure 3.

Resource Cost of College–To determine the resource cost of college, denoted by ιw_c, I utilize data from the Digest of Education Statistics, which reports that the average annual education cost per student for a four-year college degree was $24,000 in 2016 dollars for the 2011-2012 academic year.[34] This amount is a good approximation of the average cost of college attendance in nonprofit universities, which 95% of undergraduate students attend.[35] To inform the parameter ι, I calibrate it in the benchmark by matching the average cost of education to the GDP during the same years. The resulting calibration

[33] The other three factors are the expected earnings in non-college labor market, the expected earnings in college market, and the time to work at college – all functions of true ability.

[34] Source: https://nces.ed.gov/fastfacts/display.asp?id=76.

[35] The share of the students in public, private for nonprofit, and private for-profit is respectively 0.78, 0.17, and 0.05. Since private for-profit universities have a minimal share of undergraduate students, I drop them from the analysis. Excluding private for-profit universities helps to prevent overinflation of the price of education in the model, as they are the most expensive.

is reported in Table XV.

Borrowing Limits–Borrowing constraints for $j \geq 3$ are set such that borrowers repay at least a minimum amount, P, in each period, and that the loan is fully paid back in 10 years after their graduation.

Initial Wealth–To model the distribution of initial wealth for college students, I rely on the Beginning Postsecondary Education dataset, which provides detailed information about expected parental contribution for enrolled students. To approximate this distribution, I use the modified generalized Pareto distribution and calibrate its parameters internally to match parental contribution moments for the third and fifth quintiles of family wealth. It should be noted that the focus of this study is on initial transfers for early college purposes only, and thus, individuals who do not attend college receive zero initial wealth.

Table IX presents the average parental transfers for college costs in each wealth quintile, which are consistent with the data. The model slightly overestimates the role of parental contribution for the bottom two quintiles, as it is internally matched, and very poor people opt not to go to college in the model. As a result, the bottom two quintiles have more wealth than in the data, leading to a conservative result on how grants uncertainty affects the bottom quintile families.

At the same time, the proportion of college cost financed by parental contributions does not vary significantly based on ability gradient.[36] Therefore, I will not include an external correlation between wealth and ability in the default calibration of the model, as the focus is on the relative importance of each source of college finances. My goal is to examine the individual impacts of each financial source on college costs.

Working Hours in the GPA Function–To account for the negative impact of working full-time on grades, an important parameter is the working impact on GPA, which is captured by equation (3). This parameter is determined using empirical estimates, which vary in the literature. For a benchmark calibration, I rely on Stinebrickner and Stinebrickner (2008), who estimate the impact of studying time on GPA using a compelling identification strategy.

Their findings suggest that studying for one additional hour per day increases GPA by an average of 0.36 points, implying that working for eight hours per day reduces semester GPA by 2.52 (8×0.36). As the time in the model is measured yearly, and only 32 out of 52 weeks are considered as study weeks, increasing work by one hour would reduce GPA by $\frac{32}{52}2.52$. Using a full-time worker hours of 0.35 and a normalized GPA between 0 and 1, I obtain λ_l in equation (3) as -1.11. Additionally, based on studies

[36]Table X provides more detailed information on the relationship between parental transfers and student budget by ability quintiles. Specifically, for each ability quintile, the ratio of parental transfers to student budget remains roughly the same, though the absolute values of parental transfers vary slightly by ability gradient.

such as Bozick (2007), I assume that working below $\underline{l} = 0.1$ (i.e., working 15 hours a week) does not harm GPA.[37]

Government Policy–I set the ratio of government spending to GDP at 17%. The consumption tax rate is estimated to be 7.3% based on the US National Income and Product Accounts data set. The capital income tax rate is taken from Chari and Kehoe (2006). Pension benefits are set to be 35% of the average income within each skill group, consistent with the current social security configuration. The payroll tax rate τ_p is set to balance the pension budget. To parameterize the progressive labor income tax, I rely on the estimate of $\lambda_m = 0.18$ for the measure of progressivity from Ferriere et al. (2023), which is a commonly used value in the literature. The flat part of the labor income tax function, λ, is then set to balance the government budget.

Calibration of the Dropout Channels

In the following subsections, I outline the calibration of the dropout channels: grants system, ability beliefs, and productivity shocks. I pin down grants volatility, ability beliefs, and idiosyncratic labor market shocks from the data, while internally calibrating the ability-dependent fixed effect of productivity shocks to match graduation rates based on individual abilities.

Grants in the First Period of College

To calibrate the grants, I use data from the Beginning Postsecondary Data of the National Center for Education Statistics cohort of 2011-2012. The summary statistics of the distribution of total grants in the first academic year based on ability and wealth are provided in Table X. Note that the grants are presented as a share of student budget.[38]

The table shows that grants are not significantly differentiated based on ability quintiles, with an average of 32% of the total cost. At the same time, grants are strongly differentiated by wealth, with 49% for the lowest income quintile and about 19% for the top income quintile. Table XI decomposes the total grants by its type: merit-based and need-based, confirming that merit based grants are not strongly differentiated by ability quintiles, whereas need-based grants strongly decrease in parental wealth.

Based on the above observations, I model merit and need types separately. I assume that the merit-based grants increase only slightly with ability and have an average value of 13%. The need-based grant

[37] Counterfactual experiments suggest that this particular margin holds limited quantitative significance in explaining the dropout phenomenon within the model. This is attributed to the fact that students internalize the negative consequences of excessive work on their GPA, thereby influencing their eligibility for grants.

[38] The BPS data presents college finances as a share of the student budget, which is a valuable metric for assessing the relative significance of various funding sources for college.

function follows a step function so that it matches its data counterpart by family wealth quintiles. Table XI presents the calibration results alongside their data counterparts. As a validation exercise, in Table XII, I provide the joint distribution of the grants by the wealth and ability distributions in the model and the data. The model successfully generates the comparable shares of college cost financed by grants in each ability-wealth quintile category.

Grants in the Second Period of College

The second-period grant function, equation (7), has two main components to calibrate. First, the GPA thresholds, $\overline{GPA}_{\text{need}}$ and $\overline{GPA}_{\text{merit}}$, below which students lose their respective grants. Second, the stochastic process, ζ.

The need-based GPA threshold is chosen by considering the Satisfactory Academic Progress (SAP) requirements embedded in the current Pell grants, which is 2.00. The merit-based GPA threshold, $\overline{GPA}_{\text{merit}}$, is usually set at a higher level. I choose a threshold of 3.00, which is a lower bound of the eligibility requirement, to maintain merit-based grants in the data. In the BPS dataset, I find that 9 percent of students fail to meet the 2.00 GPA threshold, and 29.9 percent of students fail to meet the 3.00 GPA threshold. Therefore, in the model, I internally calibrate the corresponding thresholds such that the shares of students failing to meet these requirements match the data.

Next, I approximate grant uncertainty in the model. In order to do so, I exploit the residual variation in the Pell grants between academic periods conditional on its size after controlling for all observable eligibility criteria.[39] The uncertainty observed in Pell grants, which account for approximately 50% of need-based grants in the US, can be extended to other types of grants as they depend on the same application system.

Table XIII summarizes grant transitions between model period 1 (year 1 in the data) and model period 2 (year 3 in the data). I approximate the size of need-based grants by five brackets to avoid carrying continuous parental wealth as a state variable between academic periods.[40] Without loss of generality, bracket 1 represents the maximum need-based grant students can get, and is set to 38% of the student budget, in line with the BPS data. Bracket 5 is virtually equal to zero. The size of the grants

[39] The available data, as discussed in the empirical part, does not include information on variations in parental wealth between academic years. However, considering that 30 percent of students who hold Pell grants have a zero expected family contribution (EFC), and EFC is truncated below zero, indicating that students are even more economically disadvantaged than what zero EFC represents (see Kelchen (2015)), it is unlikely that changes in parental wealth significantly contribute to the loss of grants among economically disadvantaged students in subsequent academic years. Existing literature supports this view by suggesting that parental wealth tends to persist between academic years (Hendricks and Leukhina (2017)).

[40] Again, this assumption saves virtual memory computationally, which is highly valuable given the eight state variables during the college years.

in each bracket is presented in the last column of Table XIII. The table shows that the grants in different brackets have different degrees of uncertainty associated with them. As a rule of thumb, the higher the initial amount of the grants, the higher the probability of maintaining it. Using this transition matrix, I recover the stochastic shock, ζ_{ij}, presented by matrix (31) and the probability distribution, $\pi_{\zeta_{ij}}$, presented by matrix (32). The subscript i indicates which grant bracket an individual belongs in the first period and the subscript j indicates which grant bracket she moves in the next period as a result of receiving a shock ζ_{ij}. This happens with a probability $\pi_{\zeta_{ij}}$. If $i = j$ then the individual gets the same grant in both periods.

$$\zeta = \begin{pmatrix} 1.00 & 0.67 & 0.25 & 0.16 & 0 \\ 1.48 & 1.00 & 0.37 & 0.24 & 0 \\ 3.95 & 2.67 & 1.00 & 0.65 & 0 \\ 6.06 & 4.09 & 1.53 & 1.00 & 0 \\ 0 & 0 & 0 & 0 & 1.00 \end{pmatrix} \quad (31) \qquad \pi_{\zeta} = \begin{pmatrix} 0.71 & 0.08 & 0.07 & 0.03 & 0.12 \\ 0.31 & 0.31 & 0.11 & 0.05 & 0.22 \\ 0.14 & 0.09 & 0.23 & 0.09 & 0.45 \\ 0.12 & 0.16 & 0.09 & 0.10 & 0.52 \\ 0.03 & 0.01 & 0.01 & 0.01 & 0.94 \end{pmatrix} \quad (32)$$

Learning Ability and Beliefs

Without loss of generality, I normalize newborns' true ability between 0 and 1, and I assume that it is distributed uniformly across the population. Each individual forms beliefs about their ability based on some signals, described below.

Newborns have a prior about their true ability via their high school grades. These grades are exogenous to the model, with mean μ_{e_0} and variance σ_{e_0}. Generally, high school grades are higher than college grades, which in turn leads students to be overly optimistic about their ability. This has been shown by Stinebrickner and Stinebrickner (2014), who use a longitudinal survey of students' beliefs at Berea College. They show that on average, students expect their college grades to match their school grades. The optimism parameter, α_e, is therefore defined as the difference between the mean belief about future college GPA (which equals to the mean of high school-grades before enrollment), 3.21, and the mean of realized college GPA after the first half of college, 2.97. That leads to: $\alpha_e = \frac{(3.21-2.97)}{4} = 0.06$. Here, the denominator rescales the optimism into the support of the model GPA, which is normalized between 0 and 1.

As for the standard deviation of the prior, I impose a restriction that $\sigma_{e_0} = \sigma_{\mu_{e_0}}$.[41] The latter is the approximate standard deviation of the distribution describing beliefs about grades averaged over the

[41] This assumption is essential due to the lack of available or informative survey data regarding the distribution of an individual's prior by various student characteristics such as wealth and ability.

college enrollees. The parameter is measured in Stinebrickner and Stinebrickner (2014). Following them, $\sigma_{e_0} = \sigma_{\mu_{e_0}} = \frac{0.52}{4} = 0.13$.

After parameterizing the prior distribution, the next step is to determine the signal-noise ratio, that is, to recover the value of σ_ψ. To estimate this parameter, I refer to the weights assigned by students to their prior beliefs relative to the observed signals after each academic year, as documented by Stinebrickner and Stinebrickner (2014). By using the estimated weights and equation 5, I can derive the value of σ_ψ. In the benchmark calibration, I select the estimated weights for the first year, as it corresponds to the point of highest belief revision. This approach allows me to attain the upper bound of dropout rates in relation to the learning ability channel, thereby obtaining a conservative calibration for the model in relation to alternative dropout channels such as grants uncertainty.Table XIV summarizes the calibrated parameters for the prior and posterior distributions.

Labor Productivity

I proceed to calibrate the wage process as follows. I bring into the model the estimates of deterministic-age profile, and AR(1) process exogenously from the data. I calibrate the fixed effects internally to match key moments of wage distributions for different skills, and college participation moments in the data.

Specifically, I assume a deterministic process, ε_j is normalized to one after college graduation and increases by a factor of two until the age of 50. The overall patterns closely follow wage profiles observed in the data (see Ludwig, Schelkle, and Vogel (2012)).

Using the estimates from Abbott et al. (2019), I exogenously calibrate the AR(1) process for both the non-skilled group (high school and dropouts) and the skilled group. Furthermore, I calibrate the fixed effect of high-school graduates based on the initial dispersion of earnings among this group.

The remaining four parameters of the fixed effects in the wage process (ω_h, ω_d, σ_{θ_d}, and σ_{θ_c} in equation (8)) are internally calibrated to match key moments in the data, including the dropout wage premium, college wage premium, dropout rate, and graduation rates by ability quintiles. So, the four parameters are overidentified. The resulting lifecycle profiles are presented in Figure 8 in Appendix F.[42]

[42]It should be noted that all other dropout channels are exogenously calibrated. In an alternative version of the paper, the wage process is calibrated exogenously, while grants' stochasticity is calibrated internally. The results are robust both quantitatively and qualitatively. Specifically, the policy-relevant channel - grants' stochasticity - explains the dropout rates with the same magnitude, allowing the policy impact and welfare results to remain unchanged. However, there is a slight difference in the relative weights of ability beliefs and productivity in explaining dropout rates, with ability belief playing a slightly larger role.

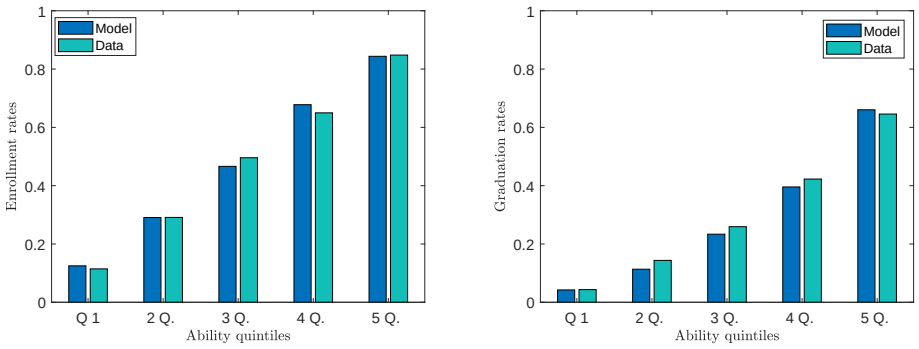
5 Model Fit

5.1 Targeted moments

I next discuss how the model matches the data moments. The targeted moments and their model counterparts are presented in Figure 3, Table IX, and Table XVII. The figure indicates that the model closely matches college participation margins by ability, with both enrollment and graduation rates increasing as ability rises. The economic mechanisms driving these patterns are as follows: the riskiness of attending college decreases, and returns to a college degree increase with ability. Specifically, high-ability students (1) are less likely to receive negative ability signals that could lead to a loss of grants; (2) are less prone to forming posterior beliefs that would make a college degree appear suboptimal; (3) face lower time costs, allowing them more time to work and self-finance during financial setbacks; and (4) anticipate higher returns to a college degree due to the complementarity between ability and education level. These channels collectively contribute to lower dropout rates and higher graduation rates as student ability increases.

Table XVII shows that the model matches the wage premiums, overall enrollment and dropout rates well. The average college wage premium is 80% both in the model and in the data. The average wage premium of dropouts is 20%, which is in line with its empirical counterpart. Additionally, the model matches the capital-output ratio as well as the average percent of total time endowment devoted to the labor market.

Figure 3: Targeted Moments. The Fraction of Enrollment and Graduates in each Ability Quintile. Model vs. Data (NLSY97)



(a) Enrollment rates **(b)** Graduation rates

5.2 Untargeted moments

To evaluate how the model performs, I analyze untargeted moments in several directions. Firstly, I examine how well the model captures college participation margins by wealth. Afterwards, I use the micro-empirical literature estimates to validate the model's elasticities to a change in subsidy rates. This is important because I utilize the grant system as a policy tool in the policy analysis section, and examining these elasticities is crucial to validate the model. Finally, I examine the extent to which the model captures the earnings distribution of the economy.

5.2.1 College participation margins by ability and wealth quintiles

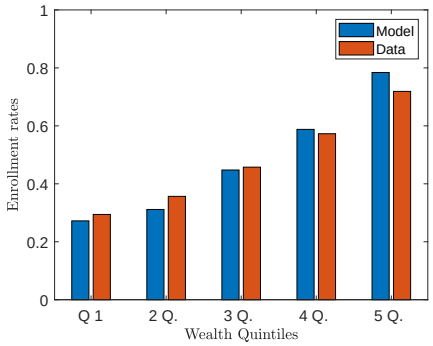
Figure 4 exhibits a set of non-targeted moments in the model: the enrollment (panel a), dropping out (panel b), and graduation rates (panel c) by initial wealth. The figure shows that the model successfully matches these college participation patterns. It is observed that enrollment and graduation rates are increasing in initial wealth. These patterns are driven by the following factors. First, the wealthier the individuals are, the more affordable education becomes. Second, initial wealth compensates for the instantaneous loss of utility from attending college through consumption. Third, the assets enable them to self-insure against adverse financial shocks at college. All of these end up increasing enrollment and graduation profiles while reducing dropout patterns with respect to wealth.

5.2.2 Elasticities of Enrollment and Graduation with Respect to Subsidy Increases

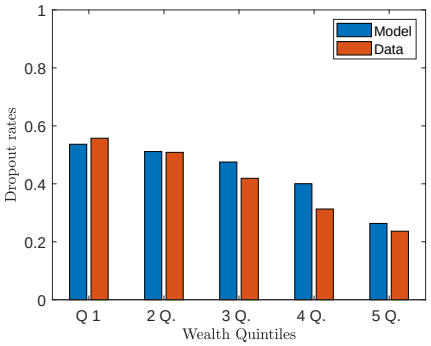
In this section, I analyze the elasticities of college enrollment and graduation rates in response to subsidies within the model. To understand the effect of changes in the price of education on participation, micro-empirical studies have conducted small-scale natural experiments to quantify college participation elasticities. While some studies have focused on the enrollment margin, fewer have examined the impact on the completion margin. Thus, I will explore the effects on both margins separately in order to gain a more comprehensive understanding of the relationship between subsidies and college outcomes in the model, and to compare these outcomes to those estimates.

Using administrative data, Scott-Clayton (2011) quantifies the impact of the introduction of the PROMISE scholarship in West Virginia in 2002 on the college completion margin by exploiting discontinuities in (1) the eligibility formula and (2) the timing of the implementation. The scholarship is worth $2,900 annually on average. It is granted to college entrants with a high school GPA higher than 3.00, a requirement that was met by 40% of college enrollees. To maintain this reward, students were required

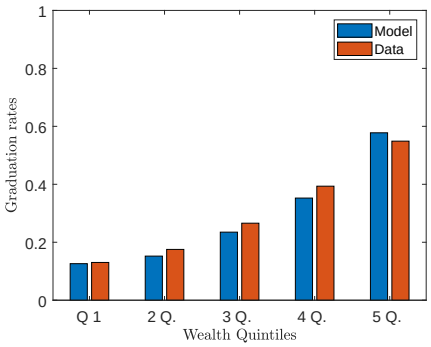
Figure 4: Untargeted Moments. The Fraction of College Entrants, Dropouts and Graduates in each Wealth Quintile. Model vs. Data (NLSY97)



(a) Enrollment Rates



(b) Dropout Rates



(c) Graduation Rates

to earn a GPA above 3.00. The requirement was met by 50% of the students at the end of the fourth year. Scott-Clayton (2011) finds that such an increase in subsidies increased graduation rates by 7pp.

To implement the same exercise in the model, I increase the size of the merit-based grants by $2,900 to those students whose ability prior belongs to the top 40% of the distribution. I allow students to keep the grants in the second half of college if their realized GPA belongs to the top 50% of the grade distribution among those who received the merit-based grant in the first year. I check the model's responsiveness in the partial equilibrium framework, keeping skill prices and the tax system as in the benchmark economy. The results are summarized in Table XVIII. According to my findings this increases college completion by 5 percentage points, which is comparable to 7.51 percentage points found in Scott-Clayton (2011).

As the next step, I test the enrollment margin. As Scott-Clayton (2011) does not examine this margin, I compare the responsiveness of this margin with the large empirical literature summarized by Deming and Dynarski (2009). Their findings propose that a $\$1,000$ reduction in the cost of attending college leads to 3 to 6 percentage points increase in enrollment. Therefore, in the next experiment, I increase subsidies by $\$1,000$ and quantify the impact on college enrollment rates in the next experiment. I find that the model's enrollment rates as a response to this change in subsidies increases by 4pp, completion rates by 2.8pp, well in the range of threir findings. The results are summarized in Table XVIII.

5.2.3 Earnings Inequality: Model vs. Data

In this section, I quantify how far the model goes to generate realistic wage dispersion. This is particularly important as the general equilibrium wages are one of the main drivers of the elasticities of college participation margins in the model. I report different measures of earnings inequality, including wage ratios, Gini coefficients for wage income. I then compare them to pre-tax earnings inequality observed in the data. Table XIX summarizes the results.

The benchmark model generates a Gini coefficient in line with the data. At the same time, the model slightly overshoots overall earnings inequality when measured by the wage ratio between the 90th percentile and 10th percentile of the wage income distribution. Overall, however, the model matches earnings inequality in the data reasonably well.

6 Model mechanism

6.1 Initial wealth, ability, and the decision to Drop Out

In this section, I explore how family wealth and initial ability interact with the decisions to drop out of college. As discussed in section 3, dropping out can be driven by (1) ability signals, (2) shocks to grants, and (3) shocks to labor productivity. The policy functions of dropping out decisions are summarized in Figures 5a, 5b and 5c, respectively.[43] Each figure plots the dropout decisions of an individual with the 10th (top), 50th (middle), and 90th (bottom) percentiles of the initial wealth distribution. The horizontal axis refers to an ability prior, with the vertical axis denoting the college dropout/continuation decisions. The red and blue lines plot the policy functions of dropping out under positive and negative shocks, respectively. The blue shaded area characterizes the region in the ability prior where individuals find it optimal to enroll in college in the first place.

The black shaded area, on the other hand, is the region where students' college dropout decisions depend on the type of the shock they receive, i.e., if they receive a favorable shock, they will remain in college, otherwise they drop out. Note that the black shaded area is conditional on the college enrollment decision. Outside of the black area, individuals decisions to stay in college or to drop out is not contingent on the shocks. To the left of the black shaded area, the individuals either never enrolled or they are determined to drop out after the first period irrespective of the type of the shock. To the right of the black shaded area, the individuals are determined to complete college, irrespective of the shocks. Consider Figure 5a, for instance. A median wealth individual (second panel) with an ability prior of 0.7 is shown in the black region. This implies she will stay in college if and only if she experiences a high shock (a high ability signal) and leave college if she gets a low shock (a low ability signal). On the other hand, an individual with an ability prior of 0.2 within the same wealth group (middle panel, Figure 5a) is not inside the black region. Her education decision is independent of the shock only because she was never a student.[44]

Figure 5a illustrates how ability signals affect the dropout decisions. As discussed above, low ability signals influence the value of college in three ways. They lead to (1) lower GPA, and therefore, increase the utility cost from staying in college, (2) lower expected return on college graduation by lowering the (subjective) probability of drawing a high fixed effect after college graduation, and (3) a higher

[43] When studying each shock, I hold the other shocks fixed. By doing so, I isolate the dropout decisions that are solely driven by the shock under study.

[44] If she were enrolled, she would also be part of the black region: she would stay in college if she received a high shock (red line), and leave college if she got a low shock (blue line).

probability of losing the grant.[45] The following observations can be made. First, students from poor backgrounds enroll in college only if their ability prior is high, more than 0.6 in my normalization. This is shown by the shaded area on panel (a), Figure 5a. Second, their decisions to stay in college are altered by negative ability signals – they drop out if they get a low realization of the shock.

Next, I discuss the drop out decisions of median wealth students in the presence of ability signals, which is shown on the middle panel of 5a. It shows that they attend college with a wider ability prior, priors being higher than the bottom 50% percent. When those students get a low grade, they then decide to drop out. Their reevaluation of college stems from, first, the high realized instantaneous utility cost from staying in college (which is a decreasing function in grades), second, the lower expected return to a college degree (due to lower beliefs about ability), and, third, the fact that they owing be eligible for grants going forward. In the next section, I quantify the fractions of students dropping out of college owing to each of these factors.

Furthermore, I examine the behavior of wealthy individuals in response to low and high ability signals, presented in the bottom panel of Figure 5a. First, they enroll in college at any ability priors (the blue shaded area lies along all priors, masked by the gray area). This indicates that the wealthy are quite comfortable exercising the college option regardless of the high monetary and utility costs. However, they remain sensitive to ability signals. Wealthy students with a low ability prior who then earn low grades do not find staying in college optimal. They have a high instant-utility cost from remaining in college, lower expected returns to a college degree, and, to top it off, they can also lose grants due to GPA requirements. These factors, in combination, make dropping out value outweigh the return to a college degree.

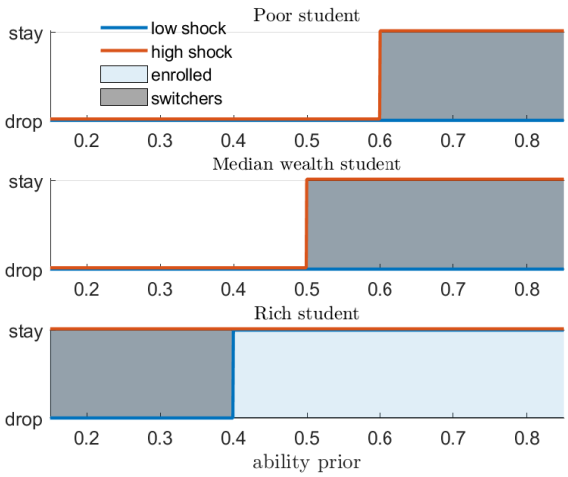
Next, I turn to investigate the impact of grant shocks on college continuation decisions. As shown in equation 7, uncertainty about grants in the current system changes from one year to another due to (i) poor academic performance, and (ii) stochastic shocks. Figure 5b solely shows how the stochastic component of subsidies, ζ, interacts with the college retention decisions. As expected, poor students are particularly sensitive to the adverse financial shocks. The students who have an ability prior between 0.6 and 0.8 will leave college if they get a negative shock to the grants but stay in college otherwise. The dark shaded, i.e., the support of the ability prior at which students leave college if they get a low realization of the shock, extends almost until the very end of the ability support. This means that low-income students cannot afford to attend college without financial assistance, unless they are among the top 20% of the ability distribution. High academic ability lessens the negative effects of a shock in three

[45] Note, if GPA falls below the threshold – $\overline{GPA}_{need}$ or/and $\overline{GPA}_{merit}$, individuals lose their grants.

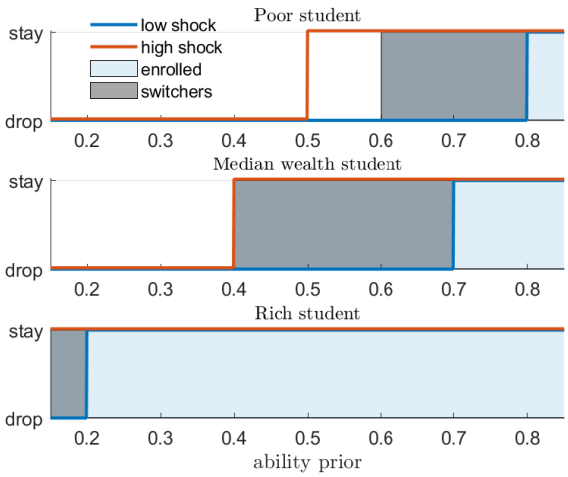
ways: first, students with high ability have a lower opportunity cost of staying in college, leaving them more time to work. Second, they earn more while in college due to their higher productivity in the labor market, which is dependent on ability. Third, they receive higher financial gains post-graduation, as the premium for a college degree is also dependent on ability.

Figure 5: Dropout Decisions by Ability Prior and Initial Wealth

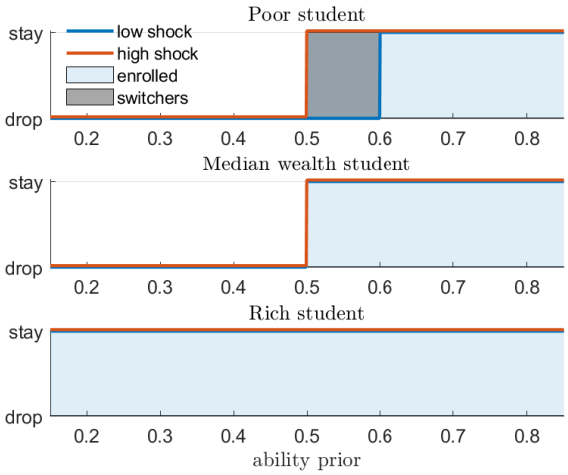
(a) Signals



(b) Shocks to grants



(c) Idiosyncratic productivity shocks



Notes: the y-axis plots the college dropout decision, and the x-axis plots the ability prior support, normalized between 0 and 1. The blue shaded area marks the ability priors in which the individuals find it optimal to enroll in college in the first period. The red (blue) line denotes the dropout decision under the high (low) realizations of the shock (ability signals in panel (a), grants in panel (b), and idiosyncratic productivity in panel (c)) at the beginning of the second college period. The gray shaded area marks the support of the ability prior in which students are sensitive to the shocks, i.e., where they drop out if they get a low shock and stay if they get a high shock. A comparison of the panels highlights that a poor student is more sensitive to the negative shocks of ability signals and grants than a rich student.

The middle panel of Figure 5b exhibits the dropout decisions of the median wealth students. The panel characterizes a large range of ability priors at which students with median ability cannot afford

college if they get a low realization of the grant shocks. If they lose the grants and their prior is not greater than 0.7, they optimally leave college and engage in full-time work. Therefore, individuals with high ability are able to survive in college regardless of financial shocks, unlike those with median ability who cannot afford to graduate without grants. The dark shaded area in the middle panel extends over median ability levels, implying that students of median wealth and high ability are able to insure themselves against adverse shocks for the same reasons as those who are poor and have high ability. The bottom panel of Figure 5b shows that wealthy students are unaffected by adverse financial shocks as long as their ability prior is greater than 0.2. Their ability to easily hedge against the loss of need-based grants can be attributed to their initial wealth, which provides them with financial resources to fall back on. Furthermore, need-based grants awarded to wealthier students tend to be a smaller proportion of the total cost of college than those awarded to students with lower income. Therefore, need-based grants may not create the same financial burden for wealthier students as they do for those who rely more heavily on financial aid.

Figure 5c examines the impact of productivity shocks (η) on the decision to stay in college. Productivity shocks have an ambiguous effect on education decisions. They can motivate some students to stay in college by making education more affordable, while at the same time motivating others to leave college by increasing its opportunity cost. For the state space shown in the figure, it can be observed that the first effect dominates for poor students with ability priors of 0.5 and 0.6. They stay in college in the presence of good productivity shocks, as these make college more affordable. Additionally, it is observed on the figure that median wealth and rich individuals are not affected by the productivity shocks given this particular state. It is worth noting that there is another channel related to the wage process that incentivizes some students to drop out, which is the dropout wage premium incorporated in the expected fixed effect derived from the dropout wage distribution.

This analysis highlights that the placement of uncertainty, within or outside the college context, has a distinct impact on individuals dropout decision. When uncertainty arises from factors external to college, such as shocks to the labor market, its impact on college attendance is ambiguous and context-dependent. However, when an adverse shock stems from within the college system itself, it tends to have an unambiguous negative effect. Therefore, differentiating the sources of uncertainties within the college is important for understanding dropout behavior, indicating to consider this aspect of financial uncertainty at college.

To conclude, this section highlights that both having a high initial wealth level and a high ability prior mitigates the pivotal power of low shocks in college that make college suboptimal. However,

talented poor, and median wealth students largely remain sensitive to the negative financial shocks and unlucky ability signals. This is a potential source of inefficiency, taking into account that ability and education are complements in productivity. In order to gain a better understanding of the magnitude of these shocks and their overall impact on the economy, I will explore distributions in the next section and quantify the percentage of talented students who leave college due to these adverse shocks.

6.2 Decomposing the channels of dropping out

In this section, I explore how the benchmark dropout rates change after eliminating one dropping out channel at a time. This is an important step to analyze the potential scope for policy intervention. As a case in point, if productivity and learning about ability drive a significant amount of dropout decisions, then there is relatively little scope for policy intervention. On the other hand, if grants volatility strongly impacts on dropout decisions, then policy makers can use grants as an instrument to target dropout rates. Throughout these experiments, I consider partial equilibrium outcomes (i.e., keeping prices and the tax system as in the benchmark economy). This is a useful in isolating the effects of each dropping out channel from its interactions with the general equilibrium forces.[46]

The first three experiments delve into the grant system. In the first and second experiments, I study what happens when grants face no stochasticity, $\zeta = 1$, and, what happens when maintaining grants is not GPA-contingent. In the fourth experiment, I study the two in combination, i.e., when the grants stay constant over the two college periods. The fourth experiment assumes that students know their true ability, thus implying that students can predict their grades, utility cost, and face less uncertainty in their post-college labor market outcomes. In the fifth experiment, I isolate the impact of labor productivity shocks on dropout decisions. To achieve this, I recompute the model, eliminating all other types of uncertainties. In practice, this means integrating all previous studies: students possess comprehensive knowledge of their inherent abilities, there are no unexpected changes to scholarships during college education, and scholarships are not dependent on GPA. In this setting, all remaining dropout decisions are prompted by favorable idiosyncratic productivity shocks, η, or the dropout wage premium.

Table XX summarizes the results. The first four rows report the college participation frequencies in the benchmark and the counterfactual experiments, and the last two rows report the average working hours and labor productivity. Labor productivity is defined as the average product of wages and the efficiency units of labor. Note here that the change in labor productivity is solely steered by the change

[46]For instance, when incorporating general equilibrium effects, it becomes impossible to disentangle the specific role of the dropout channel in driving the changes in dropout rates. This is because the dropout rates are also influenced by general equilibrium dynamics, such as changes in skill prices and taxation.

in the efficiency units since wages are set to the benchmark value.

Results from experiments 1 and 2 are presented in columns 2 and 3 of Table XX, respectively. It is observed that eliminating the stochastic part of the grants and the GPA requirements reduces the dropout rates by 33.7% and 4.5%, respectively. As opposed to the experiment of the GPA requirements, average efficiency units of labor increase significantly in the stochastic shock experiment. The difference comes from ability sorting. Removing the uncertain component of scholarships leads to a rise in graduation rates for high-ability individuals, while easing GPA requirements, as anticipated, largely increases graduation rates for individuals with low to medium abilities.[47]

In the third experiment, I find that keeping grants constant across the college periods has the largest effect on college enrollment, and graduation rates. The fifth column of Table XX shows that the aggregate dropout rates fall by 40.9% (about 15pp) and now constitute only 21.4% of total enrollees. As a result, 45 percent of students graduate. I observe that experiment 3 has a stronger impact on the enrollment as well as on the graduation rates than the combination of experiments 1 and 2. This is because there are a set of individuals at risk of losing their grants either by a stochastic shock to their grants, and/or the GPA requirements. Therefore, eliminating only one reason (like in experiments 1 and 2) puts them at risk of losing their grants because of the other. Only when one eliminates both simultaneously do the individuals find it significantly less risky to enroll. Consequently, under this experiment, about 8pp more people enroll in college in comparison to the benchmark economy. Once enrolled, they maintain their grants, and, therefore, find it optimal to graduate. As a result, the graduation rates increase by 13.5pp. This has a strong positive impact on the overall economy. With the increase in the graduation rates, aggregate labor productivity increases by 4%. This result underpins the strong linkage between skilled workers and aggregate productivity in the economy. Note that this exercise defines a clear scope for policy intervention. Given the skill premium and tax system as in the statues quo, if the uncertainty embedded in the current grant system was eliminated, 8pp more students enroll and 14pp more students graduate.

In the fourth experiment, under the complete information scenario, the enrollment rate decreases. There is a set of low ability individuals who do not enroll into college since they are aware of their low academic ability, the high utility cost of attending college, and the low pay-off of a college degree. On the other hand, the high ability individuals want to enroll in college as they know they are academically talented. These countervailing factors result in the number of college entrants remaining virtually the

[47] I discuss ability sorting in details in section 7, where policy experiments are analyzed taking into account the general equilibrium forces.

same. However, since the optimism parameter is also set to be zero with the noise in signals, overall less students enroll. The reduced uncertainty leads the number of college dropouts to decrease by as much as -10.1% (about 3.6pp). Note that, less students, and less graduates reduce efficiency units of labor by -0.1%.

The last experiment, where students do not face any uncertainty (combination of policy 3 and 4) in college but do experience labor productivity shocks, reduces dropout rates by 49.6% and sets it to 18.2%. The students who still drop out find their outside options more attractive even in the absence of ability uncertainty and grant volatility. Despite the absence of ability uncertainty and grant volatility, some students still choose to drop out. This is because they receive a favorable idiosyncratic wage shock, η, which makes the value of the outside option of college more attractive than staying in college. Typically, these students have low to median ability and do not anticipate high post-college earnings due to the complementarity between ability and the college wage premium. Under this experiment, students do not have optimism, so they are more averse to enrolling in college. At the same time, they face a more stable grant system. These two effects result in the overall enrollment rates remaining relatively unchanged. The average efficiency units increase in response to the increase in the quantity and quality of graduates.

Before concluding, it is worth discussing why ability learning alone does not explain the largest share of dropouts. Looking at the data, considerable differences can be observed in enrollment rates by ability (see Table I.2). Only 11% enroll from the lowest ability quintile, while the same fraction is 86% from the highest quintile. This marked difference in the enrollment rates by ability implies that students have a decent prior on their ability when they consider enrollment. Furthermore, when looking at the NLSY97 data, it is evident that low-ability students, as measured by AFQT test scores, make up only a small proportion of enrolled undergraduates. Individuals from the lowest two quintiles of ability comprise just 16% of enrolled students. Therefore, it is clear that low-ability students alone cannot account for the high dropout rates observed in the data. If students were to face more uncertainty, the model would struggle to capture the stark disparity in enrollment rates across ability quintiles, as observed in the data (see Figure 4). This suggests that factors beyond ability learning play a significant role in dropout decisions.

To sum up, this section shows that the college students' financial situation plays a significant role in the decisions to drop out. Therefore, there is scope for an intervention if a government aims to reduce dropout rates caused by financial difficulties. I use this finding in the next section to study potential policies and evaluate their impact on skill allocation, sorting, macroeconomic equilibrium aggregates,

and, finally, welfare gains in the long run.

7 Policy

In this section, I examine governmental policies aimed at the current grant system in a general equilibrium setting. The use of a general equilibrium framework in this analysis is crucial as it enables the examination of the effects of large-scale education policies on the reallocation of skills and the equilibrium skill prices, providing a comprehensive understanding of the long-run dynamics of the economy in response to these policies.

I implement three governmental policies, assuming that each policy lasts forever, and the government balances its budget by the level of the labor income tax schedule, λ, defined in equation 9. In the first policy, the government eliminates the stochastic element in the grant system, leaving the GPA requirements intact. This means that under policy 1, students only lose grants if their GPA drops below the threshold. This eliminates the need for reapplication each academic year and instead, students automatically maintain the grants as long as their GPA requirements are met (which can be checked through their academic transcripts). Under the second policy, the government eliminates the GPA requirements, leaving the stochastic part of the grants as it is in the benchmark economy. This implies that students maintain the grants regardless of their grades; however, they might lose them due to an exogenous shock. Removing the GPA requirements may help students who were too optimistic and initially had high signals to leave college, but it also may lead to high ability students losing grants due to unlucky grades and increasing their own precarity in college. Finally, in policy 3, the government makes grants constant between academic years in both ζ and GPA. Eliminating both sources of uncertainty together would have amplified effects on the college participation margins, because some individuals would have lost grants due to either channel in the benchmark economy.

The rest of the section is structured as follows. In section 7.1, I analyze the changes in college enrollment and dropout rates compared to the benchmark economy. Section 7.2 focuses on the effects of the policies on the sorting of students by ability and wealth within college. In section 7.3, I quantify the impact of the policies on macroeconomic aggregates. Lastly, in section 7.4, I examine the welfare implications of these policies.

7.1 College participation rates in the long-run

Table XXI illustrates the impact of three governmental policies on college participation in a general equilibrium setting. The policies aim to improve the grant system by eliminating the stochastic element and GPA requirements. The results show that these policies lead to higher enrollment and graduation rates, but the magnitude of these effects is less pronounced in the long run compared to the partial equilibrium analysis in section 6.2. The increased enrollment and graduation rates range from 2 to 3 percentage points. The difference in short-term and long-term outcomes is driven by the dynamics of skill prices and taxation in the long run. The reduced uncertainty makes college investment more attractive, leading to more students enrolling and fewer students dropping out. The share of college graduates increases over time, which leads to a gradual decrease in the equilibrium skill premium (by around -2%). This, in turn, increases the option value of dropouts and further decreases the riskiness of college, resulting in moderately higher enrollment and graduation rates while keeping the dropout rates virtually unchanged in the long run.[48] The divergence of the short-run and long-run dynamics emphasizes the importance of explicitly accounting for general equilibrium effects while studying large-scale education policies. While the long-run impact on overall dropout rates may not be strong quantitatively, it has a significant effect on the qualitative aspects of dropouts, resulting in a shift in dropout frequencies from high-ability, low-income students to low-ability, high-income students. Understanding the changing ability composition of dropouts is of intrinsic importance when considering its implications on aggregate productivity, as we will further explore below.

Policy 3, which combines policies 1 and 2, leads to outcomes that are similar to policy 1 but with a larger quantitative impact. In the benchmark economy, there exists a group of individuals who face the risk of losing grants due to both stochastic shocks and GPA requirements. As a result, some of them choose not to enroll in college, and others who do enroll may drop out after experiencing adverse shocks. However, under policy 3, this group of individuals no longer faces grant uncertainty, making college more attractive to them. Consequently, more students decide to enroll in college. Furthermore, policy 3 reduces the college wage premium by up to 2.8%, thereby further decreasing the risk associated with college. These mechanisms amplify enrollment rates by 4.6 percentage points and graduation rates by 2.9 percentage points, resulting in a slight increase in overall dropout rates by 0.2 percentage points. The college and dropout wages are examined in greater detail below.

One model limitation regarding policies 2 and 3 is that if the grant system is unconditional on GPA, students might decrease college effort, a dimension not integrated into the model. In the model, this

[48] These results align with the empirical findings of Dynarski et al. (2021), who by means of experimental settings show that promising constant amount of grants across academic years results in higher enrollment rates.

effect would be captured by an increase in labor supply, specifically by students working more during college. However, quantitatively this channel is found to have a small impact. At the same time, as seen in Table XXI, policy 1, which eliminates only the stochastic part of the grants, already leads to a significant increase in graduation rates that can be achieved in the long run, accounting for up to 70% of the total increase that can be achieved under policy 3. Therefore, policy 1 is already a powerful policy that significantly raises graduation rates compared to policy 3.

7.2 Sorting into college by ability and wealth

Next, I examine how the reforms affect ability and wealth sorting at college. For that purpose, Figure 6 (Figure 7) plots the change in percentage points of college participation margins by ability (wealth) under policies relative to the benchmark. Panels (a) and (b) capture the percentage point deviations in college enrollment and graduation rates, respectively. Policy 1 is captured with blue bars, policy 2 with yellow bars, and policy 3 with red bars.

Figure 6 illustrates that both policy 1 and policy 3 have a substantial impact on sorting, resulting in increased enrollment and graduation rates among higher ability individuals. As expected, policy 2 works in the opposite direction. A comparison of these policies reveals that the key to improving sorting is to remove grants stochasticity. This change benefits low-income students with high abilities, enabling them to graduate successfully, as discussed in section 6.1. Interestingly, the impact of these policies on low-ability students is relatively smaller. There are two reasons for this. First, this group is already susceptible to other types of adverse shocks in college, such as low ability signals and stringent GPA requirements. As a result, the influence of stochastic shocks in explaining their dropout rates is diminished. Second, a larger proportion of this ability group consists of wealthy students, as discussed in section 6, who are less affected by financial shocks to begin with.

Policy 2, which eliminates the GPA requirements, does not significantly change sorting patterns based on ability. Lower-ability levels have a lower risk of losing their grants, leading to a higher chance of graduating, but the overall effect is small. Interestingly, there is a slight decrease in the number of graduates from the top ability quintile. This can be attributed to the fact that none of these students were at risk of losing their grants due to GPA requirements in either scenario. However, they now face a higher opportunity cost of college due to a decrease in the wage gap between attending college and dropping out.

Next, I explore the sorting patterns based on wealth. The analysis shows that removing grant uncertainty primarily assists low income students. As previously discussed, these students are most at risk

of dropping out due to financial uncertainty. Moreover, a noticeable decrease in the graduation rate is observed among the wealthiest quintile. This decrease in the graduation rate is primarily driven by lower ability students, who choose not to graduate due to the decline in the college wage premium. Thus, these policies not only enhance sorting in college by enabling more talented individuals to graduate but also facilitate the exit of less talented individuals from college.

Figure 6: Relative Changes in College Participation Rates Compared to the Benchmark by Ability

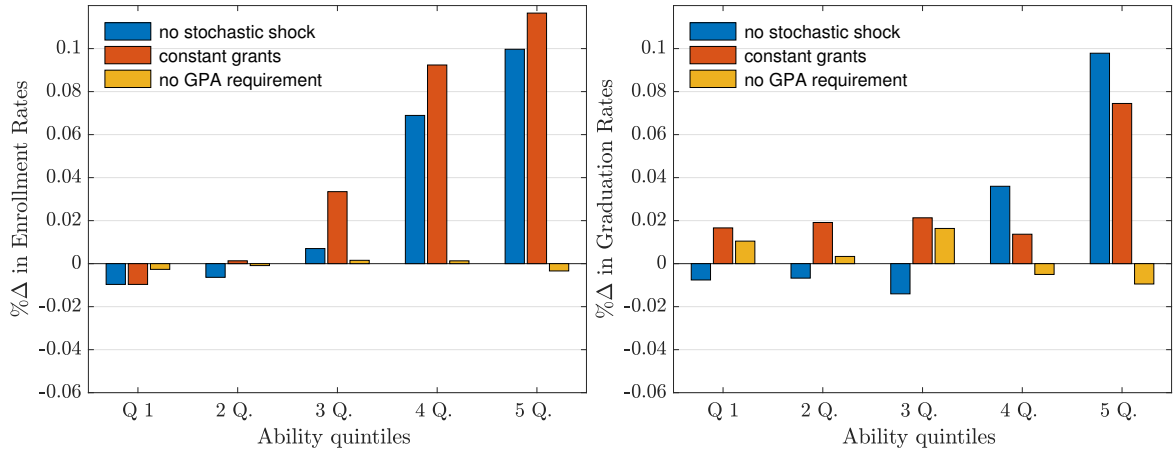
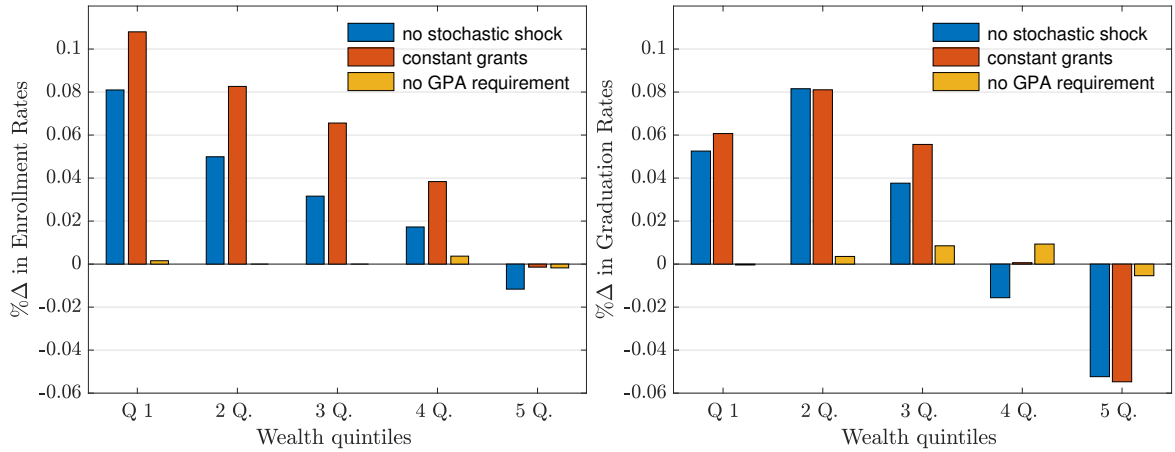


Figure 7: Relative Changes in College Participation Rates compared to the Benchmark by Wealth



7.3 Macroeconomic variables

Here I examine the impact of each policy on the economy in terms of equilibrium aggregates. Table XXII reports the relative changes in key macroeconomic variables under the experiments relative to the benchmark. In this regard, several observations can be made. Under each policy, average labor productivity increases, while average hours worked falls or stays about the same. Importantly, under policy 1 and policy 3, productivity increases by 2.1% and 2.9% respectively. Better sorting in college improves productivity due to the complementarity between ability and college earnings.

Coupled with the increase in labor productivity, aggregate output and consumption significantly increase under all policies. The magnitude of these changes closely follows the relative changes in labor productivity across the policies. The increase in average consumption is 2.1%, 0.2%, and 2.8% under policies 1, 2, and 3, respectively. Policy 2 lags behind in terms of ability sorting, which affects its impact on output. Additionally, it is worth noting that the sum of the increase in output across the first two policies is less than the increase under policy 3 (which is a combination of policies 1 and 2). The effect on output is magnified under the latter policy as it specifically promotes higher enrollment rates and, as a consequence, graduation rates.[49]

Next, I analyze the monetary cost for the government to implement each policy compared to the benchmark. To gain some intuition, it is important to note that the increase in output directly influences the cost per student in all economies, assuming that tuition is a fraction of average output. As a result, the government needs to allocate more funds in absolute terms: (1) per student, (2) for a larger number of students, and (3) for an extended duration.

Table XXII shows the percentage change of (1) the absolute cost of education subsidies and (2) education subsidies to GDP ratio. Government spending on education increases by 18.6%, 1.8%, and 25.1% under policy 1, 2, and 3, respectively relative to the benchmark economy. The changing cost for the government is compensated by an increase in output. The ratio increases less than the absolute cost of education for the government (16.1% vs. 18.6% under policy 1, 1.6% vs. 1.8% under policy 2, and 21.6% vs. 25.1% under policy 3). Thus, neglecting the increase in output while accounting for the increased government spending would lead to an overestimation of the cost of the policies.[50]

Now I examine whether the increase in the cost of subsidies constitutes a burden on taxpayers. Table XXII shows that the equilibrium labor income tax rate τ_w decreases rather than increases under policies 1 and 3 – the policies that foster aggregate productivity the most. This is attributed to the increased tax bases in consumption, capital income, labor earnings, and pension contribution, which allows the equilibrium labor tax rate to decrease. In contrast, under policy 2, the equilibrium tax rate stays virtually the same. The results suggest that eliminating the uncertainty embedded in the current grant system is a self-financing policy in the long run, in the sense that the increased subsidies decrease rather than increase the equilibrium tax rates.

Finally, it is important to discuss the wage premiums. The general equilibrium results are largely

[49] As discussed in section 6.2, this effect comes from the fact that eliminating both policies together reduces college riskiness for large share of individuals, and therefore they want to exercise a college option.

[50] Note that I made an assumption that the cost is tied to the aggregate output in the economy. If the absolute cost of education remained the same as in the benchmark, then, in the long run, the price of education would become a significantly lower share of aggregate output, and consequently, for the government the policies would be even cheaper.

influenced by a change in the skill prices and this is the primary factor contributing to the disparity between partial equilibrium and general equilibrium results (Table XX vs. Table XXI). The change in college and dropout wage premiums relative to the benchmark economy are summarized in Table XXIII. The college (dropout) wage premium is defined as the average earnings of a college graduate (dropout) at age 50 relative to the average earnings of the same age high school graduate. Several observations can be gathered here. First, it can be observed that the college wage premium decreases under each policy. The decrease is around 1.7%, 0.7%, and 2.8% under these policies. The decrease in the college premiums follows from the fact that there is a larger share of skilled workers under the reforms relative to the benchmark. The reduction in the college wage premium is closely accompanied by an increase in the dropout wage premium. It increases by 4.9%, 1.1%, and 8.7%, respectively, under policies 1, 2, and 3. The economic mechanism behind this is that the ability composition of college dropouts improves relative to the benchmark economy (as policies increase enrollment at high ability groups), and, as a result, the average labor productivity of this group improves due to ability-dependent labor market outcomes. Therefore, the dropout earnings are higher relative to the benchmark because of the complementarity between education and the fixed effect.

7.4 Welfare

In this section, I examine how increased enrollment, dropout and graduation rates, increased productivity, and the decreased gap in skill prices affect the overall welfare of the economy in the long run.

I explore welfare effects in three distinct ways. First, I examine a welfare measure in terms of consumption equivalence, denoted by ω_{CEV}, showing what percent of consumption should be given to an individual in the benchmark economy to make her indifferent between being born in the pre-reform and the post-reform economy. Second, I decompose the welfare gains into three components: inequality, uncertainty and level effects in the fashion of Floden (2001) and Domeij and Heathcote (2004). Level effects exhibit whether a reform generates additional resources in the economy, i.e., at least one individual can be made better off under the policy, while the others keep the same utility. The uncertainty effects measure the proportion of welfare improvement that results from a reduction in an individual's consumption variability. Inequality effects are measured by comparing how equally consumption is distributed across different groups.[51] Third, I ask how the individual welfare gains change for various wealth-ability groups, i.e., exploring conditional welfare gains. This is useful exercise to see which particular groups lose or win from these policy reforms.

[51] The details about the decomposition of the welfare gains are delegated to appendix G.

Table XXIV summarizes the first set of results. The policies improve utilitarian welfare over the benchmark economy. The welfare gains for newborns are 2.4%, 0.1%, and 3.4%, for policies 1, 2, and 3, respectively. The substantial welfare gains under policies 1 and 3 are consequences of the positive co-movements in the macroaggregates discussed above. An increase in skilled labor fosters labor productivity. That in turn drives the equilibrium output to rise significantly and, therefore, increases average consumption. At the same time, the gap in skilled prices decreases pre-tax income inequality for ex-ante identical individuals. These dynamics result in large utilitarian welfare gains.

The separation of welfare effects shows that the level effect makes a significant contribution to these large welfare gains, as observed in the second row of Table XXIV. The level gains are 2.1%, 0.2%, and 2.8% for policies 1, 2, and 3, respectively. These results come from the fact that all policies yield a substantial increase in aggregate output and consumption.

Regarding the uncertainty effect, the policies yield welfare improvements in terms of uncertainty of 0.5%, -0.2%, and 1%. Two opposing factors influence these outcomes. Firstly, the removal of uncertainty has positive effects. Secondly, reducing uncertainty leads to increased college participation, resulting in greater uncertainty in wage streams during the early stages of the lifecycle when insurance is most challenging. It can be observed that the first effect prevails under policy 1 and policy 3, leading to positive gains of 0.5% and 1% respectively. However, for policy 2, the second effect outweighs the first, resulting in a negative uncertainty effect. Finally, the last row of Table XXIV displays the impact of these policies on welfare inequality. The policies can influence inequality in two directions. The decreased gap in wage premiums should promote more equal welfare. On the other hand, inequality might increase as the policies improve sorting based on skills and ability, which are complementary. It is observed that the second effect dominates under policies 1 and 3, while these two effects cancel out under policy 2, resulting in virtually zero impact on inequality in welfare.

Next, I look at who wins or loses at an individual level. Table XXV provides conditional welfare gains for newborns of various wealth-ability groups. Specifically, I consider students at the 10th, 50th, and 90th percentiles of wealth and ability distributions, resulting in a total of nine different types. Table XXV reports the conditional welfare gains for policies 1 (panel (a)), 2 (panel (b)), and 3 (panel (c)).

First, examining panel (a) in Table XXV indicates that eliminating the stochastic part of the grant system leads all groups but one to win unconditionally on whether they go to college or not. For example, poor and median wealth individuals with low ability, and poor individuals with median ability do not go to college in either case. However, they face welfare gains of about 1.6% in terms of consumption equivalence. In the long term, the benefits are solely due to the rise in their relative wages and the

reduction in average labor taxes. The college-bound individuals win as they face less adverse shocks in college, and the reduced uncertainty promotes their utility gains.

As for the case of the elimination of the GPA requirement (policy 2), panel (b) in Table XXV shows that only two groups, rich - median ability and rich - high ability individuals, lose (by 0.1pp and 0.2pp, respectively). This is because these groups would go to college and graduate in either case. The GPA requirement was not a major concern for them in the benchmark as they have quite a high prior, and the chance of losing grants is minor even in the presence of lower grades. While all other types gain, this group faces a decreased college wage premium (by around 0.7%) as compared to the benchmark case, and this is the driving force of their welfare losses. All other types gain.

Finally, as for the last policy, panel (c) in Table XXV shows that all groups but the top ability–top wealth group are better off relative to the benchmark economy. College-bound individuals win as the policy greatly reduces adverse shocks at college. Non-college individuals win as their wage rate increases. All individuals also enjoy the fact that the budget-balancing tax rate is reduced.

7.5 Hiring Professional Assistance for Grant Reapplication

Next, I will explore a scenario where the grant reapplication requirement remains intact, but students are provided with professional assistants to simplify the application process. This analysis aims to determine the cost-effectiveness of using professional assistance as an alternative policy to reduce grant uncertainty, as discussed in Bettinger et al. (2012). By comparing the cost per student of hiring an assistant with the potential gains in annual earnings per student and the resulting increase in labor taxes, I can evaluate the effectiveness of this intervention.

Assuming the assistance provided by professional assistants is perfect, implementing this intervention would be as effective as removing the entire reapplication requirements at college. This assumption allows me to work with the same policy functions students have under policy 1. Despite the possibility of partial uncertainty still existing in grant applications under this experiment, further analysis, as discussed below, is necessary to evaluate the feasibility and potential impact of this intervention. Appendix H demonstrates that the even improving partial uncertainty can generate significant welfare gains, underscoring its effectiveness.

To estimate the cost of hiring professional assistants, I refer to a study conducted by Bettinger et al. (2012). According to their research, the total cost per applicant for this intervention, including expenses associated with software adoption and call centers, amounts to approximately $87.50. Taking into account the fact that not everyone graduates, the cost per graduate is then calculated to be $137.4

per student.

To evaluate the potential benefits of this intervention, the focus is on the projected increase in average annual earnings for college graduates. On average, this intervention is expected to result in increased earnings of 1.7% per year, equating to a roughly $744 raise. Considering a minimum income tax rate of 20%, the cost per student per year is significantly lower than the benefit the government would receive from the expanded labor income tax base. The analysis suggests that reducing grant uncertainty by employing professional assistants for students could yield substantial benefits in comparison to the cost per student.

By focusing solely on college graduates, the estimated benefits provided may be considered conservative, as they serve as an illustrative example rather than an exhaustive analysis of potential outcomes. However, when accounting for the relative earnings gain of high school students and dropouts, as discussed earlier, as well as the potential increase in tax revenue from sources such as consumption and capital gains, it becomes reasonable to anticipate significantly greater financial gains for the government associated with implementing the policy. This further strengthens the justification for supporting the provision of professional assistants to mitigate grant uncertainty.

Whether through the removal of reapplication requirements or the provision of professional assistance during the application process, these interventions aim to alleviate barriers and enhance access to financial aid. Reducing uncertainties associated with grants has the potential to enhance educational opportunities and outcomes for a broader range of college-age individuals, leading to substantial welfare gains through cost-effective policy tools.

8 Conclusions

This paper examines the reasons why 40% of college students do not complete their Bachelor's degree. I begin with an empirical investigation which reveals three key findings. Firstly, being financially disadvantaged increases the likelihood of dropping out before graduation. Secondly, grants are uncertain from one academic year to the next. Thirdly, losing grants is strongly linked to dropping out of college education. Based on these findings, I develop a quantitative model that incorporates the uncertain nature of grants, as well as other commonly explored factors in the literature, such as beliefs about academic ability and productivity shocks.

I first use the model to identify the students who are most affected by negative grant shocks. The results show that students from the lower half of the wealth distribution are particularly sensitive to the

uncertain grant system. Negative shocks to grants force them to leave college, as they have limited alternative sources of income to self-insure. In contrast, wealthy students are less affected by these shocks and are less likely to drop out of college. Next, I decompose the relative contribution of each dropout factor in explaining the observed college dropout rates, which is an essential step in defining the policy space for the grant system. I find that keeping financial aid constant across academic years can reduce dropout rates by up to 43%, while ability beliefs explain 10% of total dropout rates, with the remaining dropouts attributed to labor market opportunities.

After analyzing the impact of the grant system on college dropouts, I proceed to policy analysis. I find that eliminating uncertainty in grants increases the welfare of newborns by up to 2.4% of their lifetime consumption. This significant gain is due to increased productivity of skilled labor, a decrease in the gap between skill prices, and a redistribution of wealth from high-income to low-income individuals. Eliminating grant volatility also increases the proportion of skilled workers in the economy, which then results in an increase in overall output and consumption. Additionally, reducing uncertainty leads to further welfare gains for risk-averse individuals who are ex-ante identical. Finally, I demonstrate that removing uncertainty in the current grant system is cost-effective for the government, as overall government revenue increases due to increased tax bases in consumption, capital gains, and earnings resulting from a more productive (skilled) workforce.

The findings emphasize the importance of implementing policies aimed at reducing uncertainty in grants, as they can enhance access to financial aid, improve educational opportunities for financially disadvantaged talented individuals, and therefore, improve sorting in college. Therefore, it is crucial to elevate these policy measures in the policy debate surrounding dropout rates, recognizing the positive impact they can have on overall welfare.

Table I: NLSY79 Representative Sample: Gaps in Enrollment and Completion of 4-Year Degrees Conditional on Parental Education, Number of Siblings, Urban, Gender, and Race Dummies.

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3	All
		Panel A _ College Enrollment		
q1	-0.0025	0.0236	0.03740	-0.0842^{***}
Std.Err.	(0.0501)	(0.0443)	(0.0310)	(0.0238)
q2	-0.0141	-0.0843^{**}	-0.0100	-0.0976^{***}
Std.Err.	(0.0490)	(0.0397)	(.0.0260)	(0.0218)
q3	-0.0269	-0.0127	-0.0127	-0.0424^{**}
Std.Err.	(0.0494)	(0.0365)	(0.0221)	(0.0202)
All Gaps = 0	$F(3,1180) = 0.1034$	$F(3,1377) = 0.5258$	$F(3,1487) = 0.959$	$F(2,2876) = 16.4260^{***}$
		Panel B _ College Dropout, Bachelor degree		
q1	0.0543	0.0810	0.1329^{***}	0.1363^{***}
Std.Err.	(0.0846)	(0.0575)	(0.0483)	(0.0329)
q2	0.0552	0.0026	0.0620	$0.0666**$
Std.Err.	(0.0836)	(0.0531)	(0.0402)	(0.0298)
q3	0.0171	0.0277	0.0409	0.0504^{*}
Std.Err.	(0.0829)	(0.0464)	(0.0338)	(0.0261)
All Gaps = 0	$F(3,339) = 0.3148$	$F(3,768) = 0.7448$	$F(3,1269) = 6.3666^{**}$	$F(3,2396) = 12.5304^{***}$

Notes: Ability is measured by Armed Force Qualification Test (AFQT) scores. Within each ability tercile, I regress college enrollment (dropout) on family background and dummies of family wealth quartiles. All gaps are measured relative to the highest family wealth quartile within each ability tercile. q1(q2,q3) denotes gaps in enrollment (dropout) between quartiles 4 and 1 (2,3). Each of the first three columns in these Tables represents a different AFQT tercile. The last column with the title "All" shows the gaps in college enrollment (dropout) for the entire population, without dividing it into different AFQT terciles. The last line of each panel presents a joint F-test that all gaps are equal to zero. *, **, *** denote statistical significance at the 10, 5, and 1 percent, respectively. The methodology is taken from Carneiro and Heckman (2002).

Table II: NLSY97 Gaps in Enrollment Across Family Wealth, Dropout, 2-Year and 4-Year Colleges, Conditioning on Parental Education, Number of Siblings, and Urban.

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3	All
		Panel A _ College Enrollment, Bachelor degree		
q1	-0.1604^{***}	-0.2676^{***}	-0.1728^{***}	-0.2845^{***}
Std.Err.	(0.0459)	(0.04918)	(0.0405)	(0.0267)
q2	-0.1668^{***}	-0.2239^{***}	-0.0359	-0.2162^{***}
Std.Err.	(0.0448)	(0.0437)	(0.0332)	(0.0241)
q3	-0.1518^{***}	-0.1154^{***}	-0.0469^{*}	-0.1227^{***}
Std.Err.	(0.0479)	(0.0410)	(0.0276)	(0.0227)
All Gaps = 0	$F(3,951) = 14.8261^{***}$	$F(3,1031) = 29.4676^{***}$	$F(3,1338) = 11.0536^{***}$	$F(3,3144) = 105.5945^{***}$
		Panel B _ College Dropouts, Bachelor degree		
q1	0.1178	0.4016^{***}	0.1251^{**}	0.2550^{***}
Std.Err.	(0.1182)	(0.0716)	(0.0543)	(0.0396)
q2	0.1569	0.2630^{***}	0.0850^{**}	0.1662^{***}
Std.Err.	(0.1138)	(0.0618)	(0.0410)	(0.0333)
q3	-0.0691	0.1876^{***}	0.0382	0.0912^{***}
Std.Err.	(0.1192)	(0.0530)	(0.0333)	(0.0282)
All Gaps = 0	$F(3,175) = 0.4683$	$F(3,521)^{***} = 32.4386$	$F(3,916)^{***} = 6.6494^{***}$	$F(3,1636) = 42.0546^{***}$
		Panel C _ College Enrollment, 2 year & 4 year		
q1	-0.1819^{***}	-0.1973^{***}	-0.0711^{**}	-0.2213^{***}
Std.Err	(0.0572)	(0.0429)	(0.0287)	(0.0250)
q2	-0.1370^{**}	-0.1417^{***}	-0.0202	-0.1471^{***}
Std.Err.	(0.0558)	(0.0381)	(0.0235)	(0.0225)
q3	-0.1661^{***}	-0.0974^{***}	-0.0162	-0.0909^{***}
Std.Err.	(0.0596)	(0.0358)	(0.0194)	(0.0212)
All Gaps = 0	$F(3,951) = 9.796^{***}$	$F(3,1031) = 20.0448^{***}$	$F(3,1138) = 3.9061^{***}$	$F(3,3114) = 65.7215^{***}$
		Panel D _ College Dropout, 2 year & 4 year		
q1	0.1900^{**}	0.3243^{***}	0.1249^{**}	0.2410^{***}
Std.Err.	(0.0820)	(0.0580)	(0.0488)	(0.0331)
q2	0.2129^{***}	0.2409^{***}	0.0698^{*}	0.1851^{***}
Std.Err.	(0.0780)	(0.0504)	(0.0388)	(0.0288)
q3	0.0756	0.1527^{***}	0.0260	0.0890^{***}
Std.Err.	(0.0844)	(0.0463)	(0.0317)	(0.0257)
All Gaps = 0	$F(3,393) = 5.0246^{**}$	$F(3,774) = 32.1769^{***}$	$F(3,1045) = 5.9862^{**}$	$F(3,2236) = 105.5945^{***}$

Notes: Ability is measured by Armed Force Qualification Test (AFQT) scores. Within each ability tercile, I regress college enrollment (dropout) on family background and dummies of family wealth quartile. All gaps are measured relative to the highest family wealth quartile within each ability tercile. q1(q2,q3) denotes gaps in enrollment (dropout) between quartiles 4 and 1 (2,3). Each of the first three columns in these Tables represents a different AFQT tercile. The last column with the title "All" shows the gaps in college enrollment (dropout) for the entire population, without dividing it into different AFQT terciles. The last line of each panel presents a joint F-test that all gaps are equal to zero. *, **, *** denote statistical significance at the 10, 5, and 1 percent, respectively. The methodology is taken from Carneiro and Heckman (2002).

Table III: Enrollment Outcomes by Wealth Quartile and Volatility of Financial Aid

	(1)	(2)	(3)	(4)	(5)
Wealth	(n)	Enrollment	Dropout	% reduced grants	Avg. Loss (Among Losers)
Q1	825	0.30	0.52	0.60	-3,062 (49%)
Q2	930	0.39	0.44	0.67	-4,708 (67%)
Q3	977	0.53	0.34	0.60	-2,930 (68%)
Q4	1009	0.70	0.24	0.57	-3,333 (65%)
Total	6748	0.46	0.36	0.58	-3,368 (63%)

Notes: The table summarizes enrollment rates, dropout rates, and the volatility of financial aid by wealth quartile. Columns 4 and 5 display the percentage of students who experienced grant reductions and the average loss among those affected. Wealth quartiles are determined by family wealth levels at the time of college entry, with Q1 representing the lowest and Q4 the highest quartile. The Data: NLSY97 sample.

Table IV: Responsiveness of Total Finances (Excluding Grants) to Grant Loss by Wealth Quartiles

Wealth	Avg. Grant Loss	Δ in Total Finances	Correlation	P-Value
Q1	-3,657	-617	0.49	0.00
Q2	-3,726	-124	-0.07	0.45
Q3	-2,824	139	0.04	0.57
Q4	-3,232	-129	0.40	<0.01
NA	-3,436	-513	0.15	0.00

Table V: Regression Results: Impact of Decreased Grants on Enrollment Duration

Variable	**Estimate**	**(Std. Error)**
Decreased Grants	-0.03**	(0.01)
Wealth Q1	-0.05**	(0.02)
Wealth Q2	-0.06***	(0.02)
Wealth Q3	-0.04**	(0.02)
Ability Q1	-0.08**	(0.04)
Ability Q2	-0.06***	(0.02)
Ability Q3	-0.04**	(0.01)
Max Parent Degree (College)	0.04**	(0.01)
Male	0.04***	(0.01)
R^2	0.05	
N	1342	

Notes: The dependent variable is a binary indicator for whether a student was enrolled for more than two years in college. The key independent variable of interest is **Decreased Grants**, which is a binary indicator for whether a student experienced a decrease in grant aid from year 1 to year 2. The model also controls for ability and wealth, categorized into quartiles, with Q4 as the reference group. Other control variables include parental education (*Max Degree of Parents*), gender (1 = Male), the number of household members under 18, and birth year dummies. Clustered standard errors are used at the individual level to account for intra-individual correlations. Significance levels are denoted as follows: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The Data: NLSY97 sample.

Table VI: Grants Transition: Year 1 to Year 3
(Without controlling for academic eligibility criteria)

Grants in Year 1	Bracket 1	Bracket 2	Bracket 3	Bracket 4	Bracket 5
Bracket 1	0.55	0.07	0.07	0.04	0.26
Bracket 2	0.27	0.20	0.11	0.08	0.34
Bracket 3	0.20	0.12	0.14	0.10	0.45
Bracket 4	0.10	0.09	0.07	0.15	0.59
Bracket 5	0.03	0.01	0.01	0.01	0.94

Notes: The sample is restricted to students enrolled in a Bachelor's degree program during the 2011-12 academic year, classified as dependent, and enrolled full-time for at least 8 months in their first year. The grant brackets are as follows: Bracket 1 = $4500+, Bracket 2 = [$3500, $4500), Bracket 3 = [$2500, $3500), Bracket 4 = [$1500, $2500), Bracket 5 = [$0, $1500). Excluding dropouts. The Data: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students: 2012/2017.

Table VII: Grants Transition: Year 1 to Year 3

(Controlling for academic eligibility criteria, earnings, and college enrollment)

Grants in Year 1	Grants in Year 3					Avg. Pell Grant
	Bracket 1	Bracket 2	Bracket 3	Bracket 4	Bracket 5	
Bracket 1	0.71	0.08	0.07	0.03	0.12	5,459.60
Bracket 2	0.31	0.31	0.11	0.05	0.22	3,791.40
Bracket 3	0.14	0.09	0.23	0.09	0.45	2,306.10
Bracket 4	0.12	0.16	0.09	0.10	0.52	1,008.00
Bracket 5	0.03	0.01	0.01	0.01	0.94	0.03

Notes: The sample is restricted to students enrolled in a Bachelor's degree program during the 2011-12 academic year, classified as dependent, and enrolled full-time for at least 8 months in their first year. Additionally, students must have had an income of $6,501 or less in 2013-14, completed a minimum of 24 credits during the 2012-13 academic year, and maintained a GPA of 2.0 or higher in their second year of enrollment. The grant brackets are as follows: Bracket 1 = $4500+, Bracket 2 = [$3500, $4500), Bracket 3 = [$2500, $3500), Bracket 4 = [$1500, $2500), Bracket 5 = [$0, $1500). Source: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students: 2012/2017 (BPS).

Table VIII: Regression Analysis: Dependent Variable - 6-Year Dropout Rates

	Unmet Need COA - EFC > $10,000
Pell ($\leq$ 2000)	0.14***
	(0.04)
Pell (2001 $-$ 4000)	0.132***
	(0.06)
Earnings $t-1$ ($\leq$ 6499)	0.019
	(0.024)
GPA 2014 $>$ 2.25	-0.280***
	(0.071)
Loan Amt 2013-14	-0.000
	(0.000)
Months Enrolled in 2013 $-$ 14 ($\leq$ 7)	0.332
	(0.033)
Siblings in college 2013 $-$ 14	-0.022
	(0.039)
Siblings in college 2011-12	-0.033
	(0.036)
GPA in HS ($<$ 3.5)	0.125***
	(0.033)
Male	0.012
	(0.016)
Nonwhite	0.014
	(0.032)
Coarsened Number of Cases	1200
R^2	0.237

Notes: Linear regression analysis for Bachelor's degree attainment at first institution through June 2017, based on dependent students with the following characteristics: income in 2012, GPA estimate in 2014, Federal Pell Grant amount received in 2013-14, gender, race/ethnicity, Title IV loans (including Parent PLUS) borrowed in 2013-14, number of family members in college in 2013-14, high school GPA, months enrolled during 2013-14, and having siblings in college in 2011-12. The sample is filtered by: dependency status in 2011-12, full-time attendance in 2011-12, Bachelor's degree program in 2011-12, Pell Grant received in 2011-12 ($\geq$ 4000), months enrolled during 2013-14 ($\geq$ 1), full-time enrollment for at least 8 months in 2012-13. The Coarsened Number of cases reflects the coding applied by BPS for data security purposes. The Data: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students 2012-2017 sample.

Table IX: Initial Wealth as a Share of the Student budget. Model vs. Data

Initial transfers					
Wealth Quintiles	Q1	Q2	Q3	Q4	Q5
Data	0.00	0.08	0.31	0.60	0.89
Model	0.05	0.17	0.31	0.53	0.86

Table X: Total Grants as a Share of Total Cost by Ability and Wealth

Data	Total grants (need-based plus merit-based grants)				
Quintiles	Q1	Q2	Q3	Q4	Q5
By ability	0.35	0.31	0.32	0.34	0.35
By wealth	0.49	0.42	0.23	0.20	0.19

Notes: Ability quintiles are measured by SAT grades, and family wealth quintiles are measured by Expected Family Contribution (EFC). Total grants are normalized by a student budget in each respective subgroup. Wealth quintiles are measured by expected family contributions.
Data from the Biginning Postsecondary Education data, the National Center of Education Statistics, cohort 2011-2012.

Table XI: Merit-Based and Need-Based Grants as a Share of Student Budget by Ability and Wealth Quintiles: Model vs. Data

merit-based grants					
Ability Quintiles	Q1	Q2	Q3	Q4	Q5
Data	0.14	0.16	0.13	0.12	0.14
Model	0.13	0.13	0.13	0.13	0.14
need-based grants					
Wealth Quintiles	Q1	Q2	Q3	Q4	Q5
Data	0.38	0.25	0.10	0.06	0.04
Model	0.40	0.26	0.12	0.05	0.03

Notes: the distribution of wealth and ability quintiles are based on among already enrolled students both in the model and in the data. In both cases, the grants are presented as a percentage share of a student budget in each respective subgroup.

Table XII: Grants Distribution by Ability-Wealth Quintile Category: Model vs. Data

(a) Grants distribution in the model

	Ability	Q1	Q2	Q3	Q4	Q5
Wealth Q1		0.53	0.56	0.57	0.58	0.60
Q2		0.41	0.43	0.45	0.45	0.48
Q3		0.28	0.31	0.32	0.33	0.35
Q4		0.24	0.26	0.28	0.28	0.31
Q5		0.20	0.22	0.24	0.24	0.27

(b) Grants distribution in the data

	Ability	Q1	Q2	Q3	Q4	Q5
Wealth Q1		0.48	0.50	0.53	0.58	0.55
Q2		0.40	42	0.42	0.42	0.50
Q3		0.27	0.30	0.31	0.31	0.45
Q4		0.22	0.27	0.30	0.30	0.32
Q5		0.24	0.26	0.25	25	0.32

Notes: Note that the distribution of wealth and ability quintiles are based on among already enrolled students both in the model and in the data. The grants are normalized by a student budget in each respective subgroup.

Table XIII: Grants Transition by Initial Amount Between Academic Years

Grants in Year 1 \ Grants in Year 3	bracket 1	bracket 2	bracket 3	bracket 4	bracket 5	$\frac{\text{need-based grants}}{\text{student budget}}$
bracket 1	0.71	0.08	0.07	0.03	0.12	0.38
bracket 2	0.31	0.31	0.11	0.05	0.22	0.25
bracket 3	0.14	0.09	0.23	0.09	0.45	0.10
bracket 4	0.12	0.16	0.09	0.10	0.52	0.06
bracket 5	0.03	0.01	0.01	0.01	0.94	0.04

Notes: Controlling for academic eligibility criteria, earnings, and college enrollment.

Table XIV: Parameters of Prior-Posterior Distributions

Parameter	Definition	Value
$\sigma^2_{e_0}$	Variance of the prior	0.52
α_e	Optimism parameter	0.24
$1+\sigma^2_{\mu_{e_0}}/\sigma^2_{\psi_i}$	Signal-to-noise ratio	1.34

Table XV: Externally calibrated parameters

Parameter	Description	Value
Demographics		
n	Population growth rate (annual)	1%
φ	Survival probabilities	Actuarial Life Tables
j_r	Retirement age (66 years)	25
J	Maximum age (94 years)	40
Preferences		
γ	Risk aversion parameter	0.25
ν	Leisure parameter (hours worked)	0.374
Technology		
α	Capital share of output	0.33
A	Total factor productivity	1
δ	Depreciation rate (annual)	0.05
ϑ	Elasticity of substitution	0.69
Labor Productivity		
σ_{θ_n}	Fixed effect for non-college	0.059
ρ_c	Persistence parameter, college	0.933
η_c	Stochastic shock, college	0.033
$\rho_{n,d}$	Persistence parameter, dropout & high school	0.906
$\eta_{n,d}$	Stochastic shock, dropout & high school	0.032
Education Costs and Subsidies		
z_1	Subsidy rate, period 1	Section 4
z_2	Subsidy rate, period 2	Section 4
Φ_1	Student loan size (Year 1)	0.396
Φ_2	Student loan parameter (Year 2)	0.791
Government Policy		
g_y	Government spending to GDP ratio	17%
τ_c	Consumption tax	7.3%
τ_k	Capital income tax	28.3%
κ_s	Pension benefits	35%
m	Progressivity	0.1

Table XVI: Internally Calibrated Parameters

Parameter	Description	Value	Target
Discount Factor			
β	Discount factor	0.99	K/Y
Production Function			
υ	Skill-level productivity	0.94	College wage premium
Utility Cost of College			
b_0	Constant in $\xi(\cdot)$	0.45	Total enrollment
b_1	Slope in $\xi(\cdot)$	-0.16	Enrollment by ability quintiles
Education Costs			
ι	Cost parameter ($\frac{tw_{t,c}}{\hat{Y}}$)	0.196	Tuition as a share of GDP
GPA Thresholds			
$\overline{GPA}_{need}$	Need-based threshold	0.1	% with GPA < 2
$\overline{GPA}_{merit}$	Merit-based threshold	0.3	% with GPA < 3
Generalized Pareto Dist.			
p_k	Shape parameter	0.08	Avg. family contribution
p_σ	Scale parameter	0.94	Avg. family contribution
Labor Productivity			
ω_h	Scale, high ability	0.28	Section 4
ω_d	Scale, dropout	0.84	Dropout wage premium
σ_{θ_d}	Fixed effect, dropout	0.072	Total dropout rate
σ_{θ_c}	Fixed effect, graduate	0.084	Grad rates by ability
Government Policy			
τ_p	Payroll tax	0.07	Pension-budget balance
$1-\lambda$	Flat tax on earnings	0.19	Gov. budget balance

Table XVII: Targeted Moments: Model vs. Data

Description	Model	Data	Source
Capital-Output Ratio	3	3	Fernandez-Villaverde and Krueger (2011)
College Wage Premium	1.8	1.8	Lee, Shin, and Lee (2015)
Dropout Wage Premium	1.2	1.2	Lee, Shin, and Lee (2015)
Tuition as a Share of GDP	0.5	0.5	NCES
Total Enrollment	49.4%	49.4%	NLSY97
Total Dropout	36.2%	36.3%	NLSY97
Average Working Time	0.3	0.3	PSID
Student Budget to GDP per Capita	0.5	0.5	NCES
Initial Wealth	Table IX	–	NCES
Enrollment Rates by Ability	Figure 3	–	NLSY97
Graduation Rates by Ability	Figure 3	–	NLSY97

Table XVIII: Responsiveness to an Increase in Subsidies: Model vs. Empirical Estimates

Increase in Subsidies by $2,900		
	Empirical Estimate (Scott-Clayton (2011))	Model (PE)
Change in Enrollment	–	3.6%
Change in Graduation	7.5%	5.0%
Increase in Subsidies by $1,000		
	Empirical Estimate (Deming and Dynarski (2009))	Model (PE)
Change in Enrollment	3% – 6%	4.0%
Change in Graduation	–	2.8%

Notes: The model is used to simulate the effects of increasing subsidies on college enrollment and graduation rates. The estimates are compared to empirical findings from Scott-Clayton (2011) and Deming and Dynarski (2009). The first row analyzes the impact of an additional $2,900 in merit-based grants on college completion. The second row compares the impact of a $1,000 increase in grants.

Table XIX: Earnings Inequality: Model vs. Data

	Model	PSID
Gini	0.4	0.4
P90/P10	6.4	5.2
P90/P50	2.3	2.4
P50/P10	2.9	2.2

Table XX: College Participation Rates: Experiments vs. Benchmark

	Benchmark	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5
		No stochastic shock	No GPA requir.	Constant grants	known ability	residual dropout
Δ in dropout rates	0	-33.7	-4.5	-40.9	-10.1	-49.6
Dropout rates	36.1	24	34.5	21.4	32.5	18.2
Enrollment rates	49.4	55.2	49.5	57.3	44.7	51.2
Graduation rates	31.5	42	32.4	45	30.2	41.8
Δ, Efficiency units,$\hat{L}$	0	4	0.4	4.9	-0.8	3.8
Δ, Hours, $\hat{H}$	0	0	0	-0.1	0.1	0
Δ, Flat tax rate, τ_w	0	-2.9	-0.1	-3.9	-0.2	-3.4

Notes: Counterfactual experiments are implemented in the partial equilibrium, i.e., keeping skill prices and tax system as in the benchmark economy.

Table XXI: College Participation Rates under the Benchmark and Policies.

	Benchmark	No stochastic shock Policy 1	No GPA requirements Policy 2	Constant grants Policy 3
Enrollment rates	49.4	52.5	49.3	54
Graduation rates	31.5	33.6	31.8	34.4
Dropout rates	36.1	36	35.4	36.3
Wage premium	0	-1.7	-0.7	-2.8

Table XXII: Relative Changes in Macroaggregates under Policies Compared to Benchmark

	No stochastic shock	No GPA requirements	Constant grants
	Policy 1	Policy 2	Policy 3
Efficiency units, Labor	2.1	0.2	2.9
Hours	-0.1	0	-0.2
Output	2.2	0.2	2.9
Capital	0.2	0	0.3
Consumption	2.1	0.2	2.8
G edu	18.6	1.8	25.1
G edu/GDP	16.1	1.6	21.6
Interest rate	-0.3	-0.1	-0.6
Flat tax rate	-0.9	0	-1.1

Table XXIII: Wage Premiums and Efficiency Units by Education Level and by Skill Type

	No stochastic shock Policy 1	**No GPA requirements Policy 2**	**Constant grants Policy 3**
College premium	-1.7	-0.7	-2.8
Dropout premium	4.9	1.1	8.7
Efficiency units, graduates	3.0	-0.1	2.4
Efficiency units, dropouts	2.0	1.0	4.9
Efficiency units, high-school	-2.6	-0.2	-3.1

Table XXIV: Welfare Gains under Policies Relative to the Benchmark

	No stochastic shock Policy 1	No GPA requirements Policy 2	Constant grants Policy 3
Welfare	2.4	0.1	3.4
Decomposition of welfare gains			
Welfare Levels, ω_{level}	2.1	0.2	2.8
Welfare Uncertainty, $\omega_{uncertainty}$	0.5	-0.2	1
Welfare Inequality, $\omega_{inequality}$	-0.7	0	-0.8

Table XXV: Conditional Welfare Gains under Policies by Ability and Wealth

	low ability	median ability	high ability
Policy 1 − No Stochastic Shock			
Poor	1.6	1.6	2.7
Median	1.6	1.5	11
Rich	1.6	0.1	0.6
Policy 2 − No GPA Requirements			
Poor	0.1	0.1	0.1
Median	0.1	0.1	0
Rich	0.1	-0.1	-0.2
Policy 3 − Constant Grants			
Poor	1.9	1.9	6.6
Median	1.9	4.3	10.8
Rich	1.9	1	0.3

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Appendix

A NLSY Surveys

The NLSY79 sample consists of individuals born between 1957 and 1964. At the time of the first interview, respondents' ages ranged from 14 to 22. The respondents were 49 to 58 at the time of their last interview, in 2018. Originally, there were 12686 respondents in the sample, out of whom 6111 belong to a representative, cross-sectional sample designed to represent the civilian segment of people living in the US in 1979 and born between 1957 and 1964.[52]

The NLSY97 surveys 8984 individuals who were born between 1981 and 1984. It began in 1997 and is still ongoing. From 1997 to 2011, the survey rounds were taking place annually, and biannually afterwards. Each round thoroughly surveys the respondents about information on their family characteristics, education process, and labor market outcomes.

[52] In my analysis, I focus on a cross-sectional sample consisting of 5295 oversampled minorities, including Hispanic or Latino, Black, and economically disadvantaged non-Black/non-Hispanic individuals. An additional 1280 respondents were specifically selected to represent the population serving in one of the four branches of the US military.

A.1 Data cleaning

Below I carefully describe the methodology I used to construct the dataset.

Financing College. Respondents are supposed to report the amounts they receive from each source for each academic semester. There are 6 main sources: grants, family aid, loans, out of pocket, family loans, and other finances. The finances reported in the NLSY97 are biannual. I convert them into an annual level by considering the overall money students got and the years they attended undergraduate studies.[53]

Ability. Throughout the empirical analysis, I measure ability using two scores: the ASVAB math verbal percentile score and the PIAT (for the Mathematics Assesment subtest[54]) percentile score. While using the first measure, I drop 918 individuals who did not take the ASWAB test. On the other hand, while working with the second measure, I drop 2940 individuals whose PIAT test scores are missing.

Weekly hours. As the measure of hours worked, I take the number of hours students work in the second week of October (week 41) and in the second week of April (week 14) conditional on being enrolled in college. The reason for selecting the middle week of an academic semester as the reference week is to capture the workload during the study period.

A.2 Sample selection in the NLSY79 and NLSY97

The questionnaires within the two surveys are not identical.Therefore, the variables I use in the regressions slightly differ across samples. For the NLSY79, parental education is measured as the number of years they spend in schooling;[55] while the NLSY97 parental education is measured as a binary variable, high school graduate or higher.[56] As for the place of residence, in the NLSY79, I include two variables, urban/rural and south/nonsouth, in the NLSY97 only one variable, urban/rural, as there is no information about south/nonsouth. Furthermore, in the NLSY97, an intact family is measured by whether a youth is living with both parents at age 14. For the NLSY79, the actual number of siblings are reported, while I use the number of youth under 18 for the younger cohort. Finally, as a measure of financial situation in the NLSY97, I use family wealth rather than family income, because it captures the financial state of the household more comprehensively.[57] However, the qualitative findings are robust to the choice between

[53] I construct an average measure of college finances from each source by collecting the total amount they report during their time spent in college, and dividing it by the number of years during which they are enrolled for a degree (excluding years enrolled in a masters or higher degrees).

[54] One of the PIAT subtests, the Mathematics Assessment, was given in Round 1 to all respondents 9th grade or lower, regardless of age.

[55] There is no information what degrees parents actually earned.

[56] I only control for mothers' education, since there are lots of missing information about fathers' education, particularly in NLSY97.

[57] There is no information about family wealth in NLSY79.

those two measures.

B Graduation & Enrollment Rates in the NLSY97

Enrollment & dropout rates. To capture college enrollment and dropout rates in the NLSY datasets I proceed as follows. If a respondent is coded as enrolled in a college in the months of October and April,[58] then she is considered as a college enrollee. I define a dropout as someone who has attended college for at least one semester but has not earned any degree, whether it be a 2-year or 4-year degree. Finally, I summarize all college participation margins in Table I.2 for the cohort of NLSY97, and I.3 for the cohort NLSY79.

Inconsistency in Table I.1. 22 individuals are not coded as enrolled in a 4-year degree institution, however, their degree is reported to be higher than a 2-year college degree. Therefore, when I sum up the dropouts in the lowest row, I find that 22 people are missing. I drop these 22 individuals while restricting my analysis to bachelor degree recipients only.

B.1 Financial Aid Volatility and Parental Transfers

To further isolate whether family transfers adjust in response to changes in grants, Table I.4 presents the change in family aid for those who lose grants. The data indicates that family aid does not sufficiently offset the overall changes in grants. For example, among students in the lowest wealth quintile (Q1), those who lost grants experienced an average grant loss of $3,712 and only a slight increase in family aid of $190. Conversely, students in the highest wealth quintile (Q4) faced an average grant loss of $3,403, accompanied by a minor decrease in family aid of $132. These findings underscore parental wealth does not mitigate the impact of grant losses.

C Federal Financial Aid

C.1 Receiving aid

After refiling the Free Application for Federal Student Aid (FAFSA), a student's financial need is estimated. More specifically, financial need is calculated as the difference between the cost of college attendance (henceforth, COA) and expected family contribution (henceforth, EFC). If the gap is positive, then a student receives a package of financial aid, which is inclusive of three components: Pell

[58] The middle of autumn and spring semesters.

grants, federal loans, and work-study.

1. *Pell Grants*: The rule of assigning Pell grants follows: $\min(COA - EFC, 6905\$) = PELL$, when EFC$>$ 700, Pell$=$ 0 when $COA - EFC < 700$.[59] The average COA reported by the NCES is 24300. That means as long as EFC is less than $17395, students theoretically have a chance to get Pell grants.

2. *Federal Loans:*[60] Loan limits by year of undergraduate studies and by type of loans are given in Table I.5.

3. *Work-study*: Finally, work-study is a program in place in many colleges that let students hold part-time jobs while in school in order to subsidize the cost of education. It is supposed to help students close the remaining financial need that EFC, grants, and loans do not cover. However, in practice, a student is not guaranteed to use this portion of financial aid if campus jobs are not available.

C.2 Staying eligible:

For maintaining eligibility, a student is supposed to follow the following steps:

1. Fill Out the *FAFSA* Form Each Year (17% of students who stay enrolled, and exhibit GPA higher than 3 does not reapply for the Grants. Such students have a higher likelihood of dropping out later on.

2. Recalculating Expected Family Contribution.

3. Meeting Satisfactory Academic Progress (SAP) requirements

    - Cumulative GPA to be higher than 2.0
    - Accomplish 12 credit hours i.e. approximately 12 hours per week classes, plus 24-36 hours work outside the class.

C.3 Measuring SAP in the model

The Satisfactory Academic Progress (SAP) requirements involve qualitative and quantitative measures. The qualitative measure examines the quality of the student's academic performance as measured by

[59] https://ifap.ed.gov/dpcletters/attachments/GEN1804AttachRevised1819PellPaymntDisbSched.pdf
[60] https://studentaid.ed.gov/sa/types/loans/subsidized-unsubsidized

grade point average. The quantitative measure assesses the student's advancement towards completing the required credit hours for earning a degree. This requirement is aligned with being a full-time student, which will be further explained.

In the model, I consider full-time students, i.e., students who attempt full-time credits. The minimum pace requirements, measured earned credits divided by attempted credits, for them to maintain Pell-grants (and most other types of grants) is 67%. Note that failing in 33% of chosen credits yields GPA lower than $\overline{GPA}$ threshold, which, on its own, disqualifies students from grants. Therefore, for full-time students, both the qualitative and quantitative measures of SAP coincide. This enables me to use just GPA requirements in the model to capture whether students are qualified for the grants.

D Working hours and GPAs

There are approximately 19 papers that study how the working hours affect postsecondary educational attainment outcomes measured by GPA, credit accumulation, and persistence in college (summarized in a review paper Neyt et al. (2019)). Understanding the relationship is hard due to high endogeneity between working and studying decisions. Giving a causal interpretation, one must adequately control for all possible confounds.

There has been a series of empirical studies in the literature that attempt to determine the causal effect of working hours on educational attainment using methods such as propensity score matching Scott-Clayton and Minaya (2016), IV (Stinebrickner and Stinebrickner (2003)), FE Wenz and Yu (2010), Darolia (2014), and dynamic discrete choice modeling (Bozick (2007)). All of those papers found negative effects either on GPA or on persistence in college or on both of them together. Besides, working while studying has been associated with psychological and psychosomatic stress (Steinberg and Dornbusch (1991)). The theory of the allocation of time by Becker (1965) suggests that time spent working crowds out time spent on activities that enhance academic performance (i.e., studying, doing homework, and attending classes). There is an obvious trade-off in time allocation between working in the labor market or using this time for studying.

E Grant Loss Consistency Across Academic Performance Levels

In this section, I analyze grant uncertainty while controlling for students' academic ability. Specifically, I compare how grant disbursements evolve for students with top high school GPAs (3.5–4.0) versus those with moderate GPAs (2.5–3.5). Tables I.6 and I.7 present these results. These tables follow a similar

structure to those in the main text (Table VII), but here I add a stratified control based on high school GPA brackets.

The results reveal that students' intrinsic ability, as measured by high school GPA, does not significantly alter the overall pattern of grant persistence. For instance, students in the highest GPA bracket (3.5–4.0) are less likely to retain their maximum grants compared to those in the lower GPA bracket (2.5–3.5). Specifically, only 70% of students in the top GPA group maintain their maximum grants, with 15% transitioning to the lowest bracket. By contrast, 76% of students in the moderate GPA group maintain their maximum grants, with only 11% falling to the lowest bracket.

These findings demonstrate that fluctuations in grant disbursements are not driven by students' academic ability. The proportion of students moving to lower grant brackets remains consistent across ability groups, underscoring the conclusion that grant uncertainty persists irrespective of academic performance.

F Life-Cycle Profiles

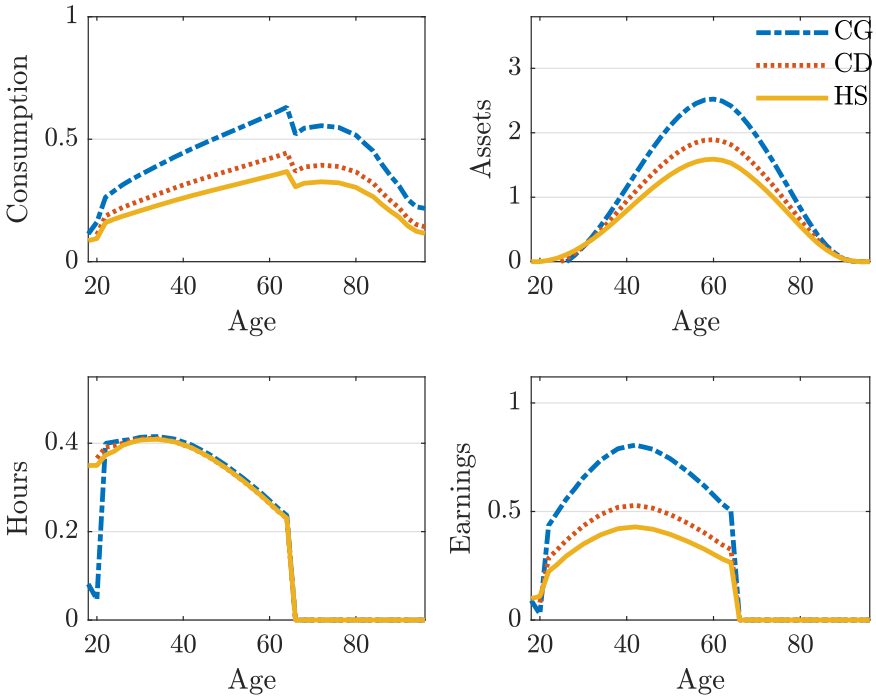
Figure 8 plots the life-cycle profiles of average consumption, asset holdings, hours worked, and earnings for each education level: high school graduates, college dropouts, and college graduates. They exhibit shapes that are typical of any life-cycle model. Consumption rises steadily over the working life for both skilled and unskilled workers. Slightly it dips when workers retire because pension benefits are only a fraction of average earnings. Gradually consumption decreases as they age and face rising death hazards.

Wealth exhibits the typical hump-shaped profile. For young individuals who are not attending college, the initial wealth is slightly positive. College students, on the other hand, take out loans and, therefore, have negative wealth. On average, it takes about eight years to pay off student loans.

Labor supply does not differ much across skill types. At the age of one, when the young generation enters the workforce, both college-bound and non-college-bound individuals have low labor supply. This is evident in the case of college students as they spend time attending college. For those who are not attending college, the relatively low level of labor supply reflects their low productivity, which is in line with the data. In the second period, college students work less in comparison to the first period. This can be explained by considering that the selection into college already shows up in the second period: richer and more able students remain in college. Consequently, they need to work less to self-finance college.

Finally, the life-cycle earnings profile also matches the data pretty well. Earnings are relatively

Figure 8: Life-cycle Profiles of Average Consumption, Asset Holdings, Hours worked, and Earnings for College Graduates, College Dropouts, and High School Graduates



low for young individuals as they enter the economy. Notably, college students have limited time for work, while those who are not in college have low productivity. As a result, college-educated workers experience a more rapid increase in earnings compared to those without a college education (both high school graduates and dropouts). Average earnings decline gradually before retirement and drop to zero at the time of retirement. Though the wage rate for dropouts is the same as high school graduates, they still earn more than their non-college counterparts. This is because dropouts have higher probabilities of drawing a high fixed effect of θ (see Section 4).

G Decomposition of the Welfare Gains

For the decomposition, it is useful to define certainty-equivalent bundles. The bundle characterizes the constant amount of consumption and work hours an individual can consume and work for throughout her lifetime to achieve the same lifetime utility, $V(\cdot)$, as she has in the uncertain world. Formally, the derivation of certainty equivalent bundles proceeds as follows.

$$\sum_{t=1}^{J} \beta^{t-1} \varphi_t U(\tilde{c}, 1-\tilde{l}) = V(\{c_t, l_t\}_{t=1}^{J}), \tag{33}$$

where for notational simplicity, I suppressed the state space. For each point of a state space of newborns, $(1, a, \eta, \theta, \mu_{e_0})$, there is an associated bundle $(\tilde{c}, \tilde{l})$ that solves equation (33). Since there are two unknowns and one equation, there is a continuous set of $(\tilde{c}, \tilde{l})$ that solves the equation. To tackle this issue, in practice, I set the certainty equivalent working hours, $\tilde{l}$, to average hours in the economy. Then, it becomes possible to easily solve the remaining unknown, $\tilde{c}$, as follows:

$$\tilde{c} = \left(\frac{V(\{c_t, l_t\}_{t=1}^J)(1-\frac{1}{\gamma})}{\sum_{t=1}^J \beta^{t-1} \varphi_t} \right)^{\frac{1}{\nu(1-\frac{1}{\gamma})}} \frac{1}{(1-\tilde{l})^{\frac{1-\nu}{\nu}}}. \tag{34}$$

Finally, it is useful to define average certainty equivalent hours, $\tilde{H}$ and consumption, $\tilde{C}$:

$$\tilde{H} = \int \tilde{l}(1, a, \theta, \eta, \mu_{e_0}) \, d\phi(1, a, \theta, \eta, \mu_{e_0}), \tag{35}$$

$$\tilde{C} = \int \tilde{c}(1, a, \theta, \eta, \mu_{e_0}) \, d\phi(1, a, \theta, \eta, \mu_{e_0}). \tag{36}$$

Given the following variable set in each economy $\left(\tilde{c}, \tilde{l}, \tilde{C}, \tilde{H}, V(\cdot), C, H \right)$, I am equipped to decompose the welfare gains in level, ω_{level}, uncertainty, $\omega_{\text{uncertainty}}$, and, inequality, $\omega_{\text{inequality}}$, effects.

Level effect. To isolate the level effects, I compare the average consumptions between economies A and B, while controlling for the possible differences in leisure across these two economies. To compensate leisure differences, I calculate a 'leisure-compensated' consumption bundle, $\hat{C}^B$, for economy B:

$$V\left(\{\hat{C}^B, L^A\}_{t=1}^J \right) = V\left(\{C^B, L^B\}_{t=1}^J \right). \tag{37}$$

Given the utility form in equation (30), it can be shown that:

$$\hat{C}^B = C^B \left(\frac{1-L^B}{1-L^A} \right)^{\frac{1-\nu}{\nu}}. \tag{38}$$

Then, the gains in welfare due to the level effect is calculated as:

$$\omega_{\text{level}} = \frac{\hat{C}^B}{C^A} - 1. \tag{39}$$

Uncertainty effect. The cost of uncertainty, $p_{uncertainty}$, in economy i is defined as a fraction of consumption an individual would be willing to give up to avoid all uncertainty facing in her consumption

path. It solves the following equation:

$$V\left(\left\{(1-p^{i}_{uncertainty})C^{i},H^{i}\right\}_{t=1}^{J}\right)=V\left(\left\{\tilde{C}^{i},\tilde{H}^{i}\right\}_{t=1}^{J}\right). \tag{40}$$

After calculating $p^{i}_{uncertainty}$ for $i\in\{A,B\}$, the welfare gain in reduced uncertainty in economy B relative to economy A is defined as follows:

$$\omega_{\text{uncertainty}}=\frac{1-p^{B}_{\text{uncertainty}}}{1-p^{A}_{\text{uncertainty}}}-1. \tag{41}$$

Inequality effect. The cost of inequality, $p_{inequality}$, answers what fraction of consumption an individual should give up to be indifferent between being born into economy i and into economy where everyone consumes and works the same amount. For that purpose, the value of average certainty equivalent bundles and average values of certainty equivalent are compared. Formally, this is summarized as follows:

$$V\left(\left\{(1-p_{\text{ineq}})\tilde{C},\tilde{L}\right\}\right)=\int V\left(\tilde{c}\left(1,a,\theta,\eta,\mu_{e_0}\right),\tilde{l}\left(1,a,\theta,\eta,\mu_{e_0}\right)\right)d\phi\left(1,a,\theta,\eta,\mu_{e_0}\right) \tag{42}$$

It follows that the welfare gains in reducing inequality in economy B relative to economy A for an individual with a state space $(\cdot)$ is given by:

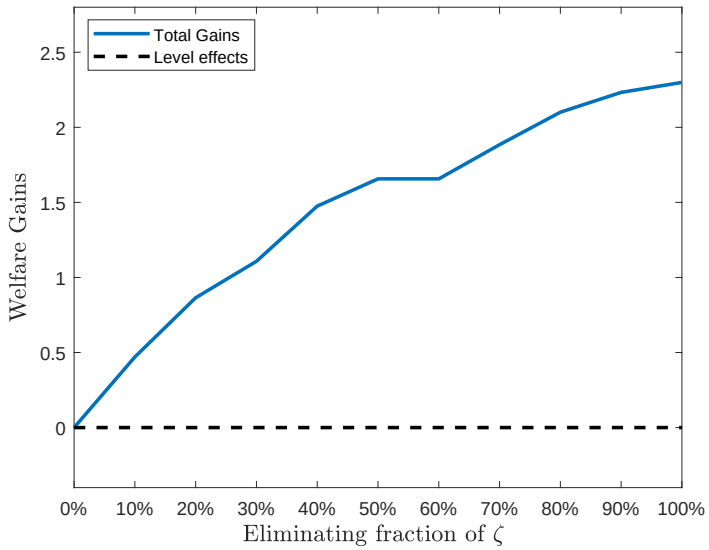
$$\omega_{\text{inequality}}=\frac{1-p^{B}_{\text{inequality}}}{1-p^{A}_{\text{inequality}}}-1. \tag{43}$$

Finally, following Floden (2001), it can be shown that $\omega_{CEV}\approx(1+\omega_{level})(1+\omega_{inequality})(1+\omega_{uncertainty})-1$.

H Robustness of Welfare Gains to the Elimination of Grants Uncertainty

In this section, I discuss the robustness of the results on the welfare gains of policy 1. I am mainly interested in how robust the welfare gains are when only the fraction of the stochastic shock, ζ, is eliminated. This clarifies whether a policy that is successful in decreasing at least a partial amount of the uncertainty would still yield welfare gains. Figure 9 summarizes the results. It exhibits the welfare gains as a function of the standard deviation of ζ. Specifically, the X-axis refers to the fraction of the uncertainty eliminated, and Y-axes presents the welfare gains in terms of consumption equivalence. The figure plots the total gains in terms of consumption equivalence. It can be observed that the total and level gains increase as the variance of the stochastic shock decreases.

Figure 9: The Effects of Eliminating Fraction of the Stochastic Shock in the Grant System



I Institutional Settings

The process of obtaining financial aid begins with the U.S. Department of Education determining the Expected Family Contribution (EFC)[61] upon the FAFSA submission.

Central to federal financial aid eligibility is the Expected Family Contribution, derived from data provided via the Free Application for Federal Student Aid (FAFSA). This figure serves as an index of a family's financial strength, incorporating taxed and untaxed income, assets, family size, and the number of household members attending college. ***The EFC only depends on Financial State of family.*** [62]

the primary factors influencing a student's Pell Grant amount are the Expected Family Contribution (EFC) and academic performance. However, the EFC is determined by a complex set of rules that

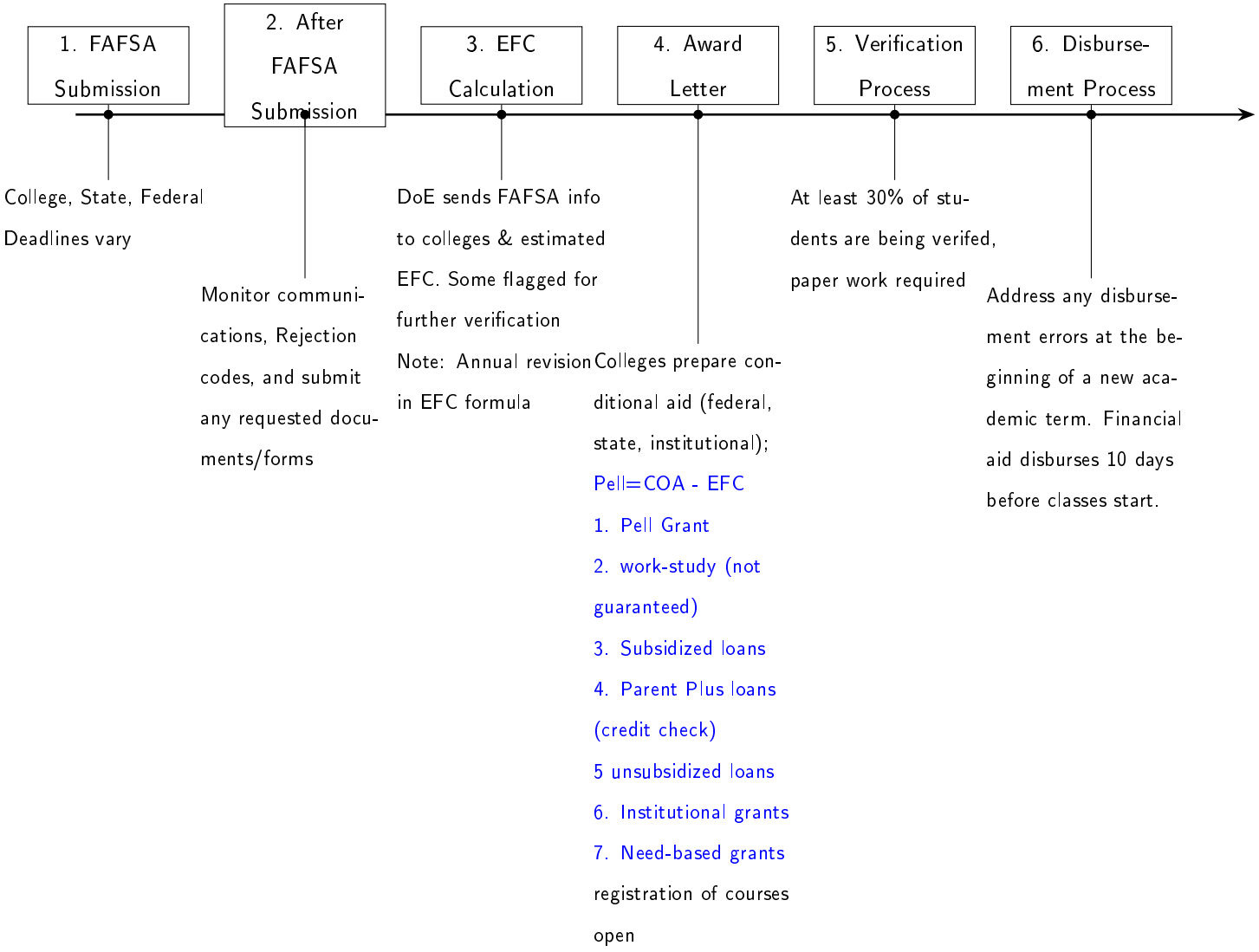
[61] In 2023, the EFC will be replaced by the Student Aid Index (SAI) under the FAFSA Simplification Act. This change aims to address the confusion associated with the term "Expected Family Contribution," which is commonly misunderstood as either the financial responsibility of the family to fund education or the amount of federal aid a student will receive. The revision of this system is anticipated to clarify these misconceptions and emphasize the actual purpose of this number, which is to assist in financial aid assessments.

[62] In order to explain brief summary of the process, the computation of the Expected Family Contribution (EFC) starts with evaluating the total income of the family, encompassing both taxable and nontaxable earnings. Subsequently, deductions are made for taxes, essential living expenses, and a safeguarding allowance for savings, resulting in the disposable income, which is then taken into account for college contributions. Furthermore, the assessment includes an examination of assets such as savings, investments, and property (excluding the primary residence). A segment of these assets, based on a safeguarding allowance tied to the parents' age, is exempt from the EFC assessment. The remaining portion is evaluated at a predefined rate to contribute to the EFC. For students, their income and assets play a more significant role in the computation. A student's income, following deductions similar to those for parents but adjusted to individual requirements, influences their EFC. Student assets are appraised at a fixed percentage, directly increasing the EFC, reflecting the expectation that students should allocate a larger share of their savings towards educational expenses. This methodology aims to strike a balance between the family's financial capacity and the need for assistance, ensuring that the EFC truthfully represents their feasible contribution to college costs. Specifically, the financial need is determined as the variance between the cost of college attendance (hereafter COA) and the Expected Family Contribution (hereafter EFC). If this difference is positive, the student qualifies for a financial aid package, comprising Pell grants, federal loans, and work-study opportunities.

consider parental and student assets, income, and other financial factors, many of which are beyond the student's control. The calculation of EFC involves not only current income but also the appreciation of assets, changes in family size, and other nuanced criteria, making it subject to fluctuations due to external economic conditions and federal policy adjustments.

Note that, based on economic fluctuations, the EFC formula is revised annually, thus adds the exogenous unpred ictability beyond the other bureaucratical process described below.

After the Department of Education computes the EFC, this value, together with the comprehensive financial and personal details provided through the FAFSA, is disclosed to the colleges. Subsequently, the financial aid office of each college reviews this information to craft a personalized *conditional* financial aid package for the student, including federal, state, and institutional aid. The conditional financial aid award outlines her cost of attendance and the financial resources available to her. There are four categories of federal aid based on financial need (Pell grants, subsidized loans, work-study) and two categories of federal aid not based on need (Direct Unsubsidized Loans, Direct Plus Loans), as outlined in Table I.8. This package is designed to cover the anticipated cost of attending college, *encompassing tuition, fees, accommodation, meals, textbooks, and other educational expenses.*



After the conditional financial aid and admission, the university then works out the official financial aid offer. Following this, there is an additional step, commonly known as verification, that colleges must complete before students are guaranteed any grants. The Department requires colleges to authenticate the accuracy of the submitted information, flagging 30% more of applications for additional verification–a process that colleges are expected to undertake. This verification process may involve confirming income, pension and IRA disbursements, household size, the number of college students in the family, high school completion, and educational objectives. Pell Grant disbursements are withheld until the verification process is completed. While colleges are mandated to verify a portion of flagged applications, many opt to verify all flagged cases to ensure the accuracy and integrity of the financial aid procedure.

The following outlines crucial steps in the financial aid process and potential barriers encountered after FAFSA submission. This post-submission phase, often overlooked, is as complex as the initial

application, which has significantly drawn both scrutiny and legislative response, culminating in the FAFSA Simplification Act.

1. **Rejection Codes** Initially, some students are notified by the U.S. Department of Education that their EFC cannot be determined due to "reject codes," indicating missing or conflicting information essential for assessing aid eligibility. Common reasons for reject codes include absent signatures or reported tax payments surpassing reported earnings. To proceed, students must rectify these discrepancies; 80 percent succeed in resolving these issues and obtaining their EFCs.

2. **Verification Process** (Only 2 percent fail despite being initially eligible based on certain data.) The verification process further complicates the application process. This stage necessitates colleges to gather documents validating the accuracy of information provided through the FAFSA.

3. **Additional Documentation** Some colleges request documents beyond those required by the federal government as part of the financial aid procedure. These may include student surveys, signed acknowledgments of understanding aid eligibility criteria, or copies of driver's licenses, among others.

4. **Eligibility Checks** Before disbursing federal aid, colleges must conduct a final review of a student's eligibility. This involves confirming the student's enrollment in eligible classes and academic programs, as well as satisfactory academic progress. These checks, often automated through college software, can lead to "disbursement errors" if issues are detected. Additionally, some colleges impose their own requirements for aid applicants, such as submitting additional documentation to understand financial aid rules or provide identification to prevent identity theft.

Policy Recognition The complexity inherent in the financial aid application process, I Reject codes, verification, extra documentation, and eligibility checks represent significant hurdles.

The "FAFSA Simplification Act of 2019"[63] highlights the recognition of the complexity and unpredictability students face in the financial aid process. The act seeks to streamline the application process, improve predictability, and enhance accessibility to aid by simplifying need analysis, adjusting the Pell Grant program, and establishing clearer guidelines.

[63]The first rollout of these changes, scheduled for 2024–2025, was unsuccessful due to logistical challenges with the website.

Table I.1: Education Attainment in the NLSY97 Data

	2-year[64]	4-year	Any degree
Enrollments	20.10 (1806)	42.87% (3852)	62.97% (5658)
Dropouts	78.02% (1409)	39.72% (1530)	46.06% (2606)
Graduates	21.98% (397)	60.28% (1530)	53.94% (3052)

Table I.2: Enrollment, Graduation, and Dropout Rates by Ability and Wealth (NLSY97)

College participation rates by ability quintiles						
	Quint 1	Quint 2	Quint 3	Quint 4	Quint 5	All
Bachelor degree						
Enrollment rates	0.12	0.30	0.52	0.66	0.86	0.49
Graduation rates	0.05	0.15	0.29	0.44	0.65	0.31
Dropout rates	0.57	0.52	0.45	0.33	0.25	0.36
Any degree						
Enrollment rates	0.33	0.60	0.73	0.84	0.94	0.69
Graduation rates	0.10	0.24	0.39	0.55	0.72	0.40
Dropout rates	0.69	0.60	0.47	0.35	0.23	0.42
College participation rates by wealth quintiles						
Bachelor degree						
Enrollment rates	0.29	0.36	0.46	0.57	0.72	
Graduation rates	0.13	0.18	0.27	0.39	0.55	
Dropout rates	0.56	0.51	0.42	0.31	0.24	
Any degree						
Enrollment rates	0.51	0.57	0.67	0.75	0.87	
Graduation rates	0.21	0.26	0.36	0.49	0.63	
Dropout rates	0.60	0.55	0.46	0.34	0.27	

Table I.3: Enrollment, Graduation, and Dropout Rates by Ability and Wealth (NLSY79)

College participation rates by ability quintiles						
	Quint 1	Quint 2	Quint 3	Quint 4	Quint 5	All
Bachelor degree						
Enrollment rates	0.22	0.41	0.57	0.73	0.91	0.57
Graduation rates	0.05	0.12	0.20	0.34	0.58	0.26
Dropout rates	0.78	0.70	0.64	0.53	0.37	0.54
Any degree						
Enrollment rates	0.22	0.41	0.57	0.73	0.91	0.57
Graduation rates	0.10	0.20	0.32	0.47	0.65	0.35
Dropout rates	0.57	0.50	0.43	0.36	0.29	0.39
College participation rates by family income quintiles						
Bachelor degree						
Enrollment rates	0.46	0.49	0.53	0.62	0.75	
Graduation rates	0.17	0.19	0.22	0.29	0.43	
Dropout rates	0.63	0.62	0.59	0.53	0.43	
Any degree						
Enrollment rates	0.46	0.49	0.53	0.62	0.75	
Graduation rates	0.25	0.27	0.30	0.40	0.52	
Dropout rates	0.46	0.45	0.43	0.35	0.31	

Table I.4: Responsiveness of Family Aid to Grant Loss by Wealth Quintiles

Wealth Quintiles	Grant Loss	Δ in Family Aid	Count	Correlation	P-Value
Q1	-3,712	190	61	-0.114	0.391
Q2	-4,319	-253	116	0.00372	0.969
Q3	-2,669	-562	149	0.0808	0.353
Q4	-3,403	-132	211	0.364	0.00

Table I.5: Federal Loan Limits

Year	Subsidized Loan Limit ($)	Total Loan Limit ($)
First Year	3,500	5,500
Second Year	4,500	6,500
Third Year and Beyond	5,500	7,500

Notes: The interest rate for both types of loans is 5.05%.

Table I.6: Grants Transition: Year 1 to Year 3

(GPA∈[2.0 3.5] in second year; Controlling for academic eligibility criteria, earnings, and college enrollment)

Grants in Year 1	Bracket 1	Bracket 2	Bracket 3	Bracket 4	Bracket 5
bracket 1	0.76	0.06	0.04	0.03	0.11
bracket 2	0.26	0.27	0.10	0.09	0.28
bracket 3	0.19	0.13	0.27	0.04	0.37
bracket 4	0.15	0.10	0.08	0.21	0.46
bracket 5	0.02	0.01	0.01	0.01	0.94

Notes: The sample is restricted to students enrolled in a Bachelor's degree program during the 2011-12 academic year, classified as dependent, and enrolled full-time for at least 8 months in their first year. Additionally, students must have had an income of $6,501 or less in 2013-14, completed a minimum of 24 credits during the 2012-13 academic year, and maintained a GPA of 2.0 or higher in their second year of enrollment. The grant brackets are as follows: Bracket 1 = $4500+, Bracket 2 = [$3500, $4500), Bracket 3 = [$2500, $3500), Bracket 4 = [$1500, $2500), Bracket 5 = [$0, $1500). Source: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students: 2012/2017 (BPS).

Table I.7: Grants Transition: Year 1 to Year 3

(High School GPA>3.5 ; Controlling for academic eligibility criteria, earnings, and college enrollment)

Grants in Year 1	Bracket 1	Bracket 2	Bracket 3	Bracket 4	Bracket 5
bracket 1	0.70	0.08	0.05	0.02	0.15
bracket 2	0.37	0.26	0.01	0.12	0.25
bracket 3	0.11	0.16	0.13	0.12	0.48
bracket 4	0.00	0.04	0.11	0.10	0.75
bracket 5	0.02	0.01	0.01	0.01	0.95

Notes: The sample is restricted to students enrolled in a Bachelor's degree program during the 2011-12 academic year, classified as dependent, and enrolled full-time for at least 8 months in their first year. Additionally, students must have had an income of $6,501 or less in 2013-14, completed a minimum of 24 credits during the 2012-13 academic year, and maintained a GPA of 2.0 or higher in their second year of enrollment. The grant brackets are as follows: Bracket 1 = $4500+, Bracket 2 = [$3500, $4500), Bracket 3 = [$2500, $3500), Bracket 4 = [$1500, $2500), Bracket 5 = [$0, $1500). Source: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students: 2012/2017 (BPS).

Table I.8: Summary of Federal Aid Types

Aid Type	Description
	Need-Based Aid
Federal Pell Grants	Awarded to undergraduate students demonstrating exceptional financial need. Grants don't have to be repaid. Eligibility partly determined by an EFC of less than $17,395 with the average COA reported by the NCES as $24,300.
FSEOG	The Federal Supplemental Educational Opportunity Grant is available at participating schools for students with significant financial need.
Direct Subsidized Loans	Available to undergraduate students with financial need. The government covers interest while the student is in school.
Federal Work-Study	Offers part-time jobs for undergraduate and graduate students with financial need, allowing them to earn money to help pay education expenses. Availability of positions can vary, and NOT guaranteed.
	Non-Need-Based Aid
Direct Unsubsidized Loans	Available to both undergraduate and graduate students; interest accrues during all periods.
Direct PLUS Loans	Includes Grad PLUS Loans for graduate students and Parent PLUS Loans for parents of dependent undergraduate students. Higher interest rates than most federal loans and requires a credit check.