Better Late Than Never: Macroeconomic Impact of Intermittent College Enrollment and Tuition Subsidies *

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November 22, 2025

Abstract

People often delay starting college or temporarily leave college to work. To examine the welfare implications of intermittent college attendance, I incorporate flexible age-by-age college enrollment choice in a life-cycle model in general equilibrium. College serves as an investment device for the young and reduces risk for the old. Removing flexible access reduces the total welfare value of college by one quarter. Moreover, higher wealth and better human capital preparedness at age 18 incentivize early-age degree completion. However, accessing college at a later age matters more for those who are initially less advantaged. Thus, policies that alleviate financial costs generate considerable long-term welfare improvements.

JEL classification: E2, I24, J24, J31.

Keywords: Lifecycle inequality, college enrollment, college stopout, school interruption, returns to college, college value, human capital accumulation, investment, risk, insurance, general equilibrium, heterogeneous agent

*This paper benefited from discussions with Christian Bustamante, Sanjay Chugh, Kyle Dempsey, Pok-Sang Lam, Mikhail Golosov, Ben Griffy, Jaroslav Horvath, Felicia Ionescu, Youngsoo Jang, Gabi Xuan Jiang, Basant K. Kapur, Soyoung Lee, Fang Lei, Pascal Michaillat, Urvi Neelakantan, Kirby Nielsen, Tristan Potter, Vincenzo Quadrini, Tony Smith, Stephen Terry, Wei-Yang Tham, Ivan Vidangos, Bruce Weinberg, Erin Wolcott, Zheng Yu, Weilong Zhang, participants at University of Albany seminar, University of New Hampshire seminar, European Winter Meetings of the Econometric Society, LAC-Macro-Labor Workshop and CEF 2022. Remaining errors are mine.

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1 Introduction

Most studies examining college decisions focus on one-time enrollment or dropout in students' early twenties, prior to their entering the labor market. The decision-making largely depends on the expected level and fluctuations of future earnings (e.g. Kim, 2022; Schweri, Hartog, and Wolter, 2011). However, a substantial proportion of the population delay initial entry or complete college over multiple spells while working in between.[1] In the National Longitudinal Survey of Youth 1979 (NLSY79), for example, people access college flexibly throughout their lifetime and transition from college to work and back to college on average 1.7 times. As a result, 16% of all with a bachelor's degree complete college after age 30. Each episode of intermittent college enrollment interrupts a span of labor market activity. What additional factors are people considering while moving between work and college? What role does intermittent college education play in a life cycle with uncertainties? In this paper, I investigate the channels behind college enrollment and completion patterns and evaluate the welfare consequences of having *flexible* access to college through one's life-cycle.

I show empirical evidence that intermittent college attendance is strongly associated with family wealth background and human capital preparedness at age 18, the two initial endowments. Better-prepared individuals from wealthier families are more likely to follow a "traditional" path, finishing college at a younger age with a lower likelihood of interruptions. To uncover the transmission channels from human capital and wealth endowments at age 18 to lifetime welfare, I construct an incomplete market life-cycle model in a general equilibrium setting. The primary source of life-cycle risk comes from the idiosyncratic human capital productivity shock to working individuals, similar to Huggett, Ventura, and Yaron (2011). One main innovation is human capital acquisition: individuals can accumulate human capital through college education at any stage of their working life, in addition to learning on the job. I feed the model with the empirical distribution of individuals on wealth and human capital at age 18 and calibrate it to life-cycle schooling profiles. The model successfully replicates intermittent college attendance patterns across individuals and generates empirically relevant heterogeneous income processes.

After replicating the intermittent college patterns as well as the earnings profile, I calculate the consumption equivalence from the model as a measure of the welfare effect of having flexible college access, a method outlined by Mukoyama (2010).[2] While most of the literature evaluates

[1] Literature refers to a temporary exit from college as stopout, implying a return to college some periods later. This is in comparison to dropout, describing a permanent exit from college before completing the degree (e.g. Light, 1995a,b; Monks, 1997; Dynarski, 2003; Seftor and Turner, 2002; Jepsen and Montgomery, 2012; Johnson, 2013; Arcidiacono, Aucejo, Maurel, and Ransom, 2025; Gurantz, 2019).

[2] I measure the welfare of the flexible access as the consumption equivalence when restricting initial enrollment to college only at age 18 and removing subsequent re-enrollment once a person exits college. Similarly, I measure the gross welfare value of college as the consumption equivalence when college is completely removed.

the financial returns of college[3], the welfare value of having access to college at each age extends beyond its financial value. When there is a relative psychic cost associated with schooling versus working, the utility return of college does not align with its financial return (Belley and Lochner, 2007; Yang and Casner, 2021). Moreover, completing each year of college in a life-cycle setting embeds sequential consequences, such as opening doors to a new career or further educational opportunities, thereby adjusting the rest of the earnings profile (e.g. Bhuller, Mogstad, and Salvanes, 2017; Kunz and Staub, 2020). To the best of my knowledge, this is the first paper that evaluates the welfare value of having access to college at each age.

The primary message of this paper is that allowing for flexible access to college throughout the life cycle has significant welfare gains, especially for initially less advantaged individuals. Average consumer welfare drops by nearly 4% in a counterfactual economy when agents cannot flexibly arrange their college enrollment in the life-cycle. The flexibility of college access accounts for one quarter of the gross welfare value of college. At age 18, individuals with the lowest wealth endowment value flexible college access twice as much as those with the highest wealth endowment, although better-prepared young people with wealthier backgrounds value general access to college more. Throughout the life cycle, having access to college before age 29 yields significantly higher welfare value, whereas later college access provides a more modest welfare benefit.

I explain the heterogeneous welfare value of accessing college over the life-cycle in general equilibrium through three channels: price, investment, and risk propagation. The price channel arises from adjustments in interest and wage rates in a general equilibrium when there is a restriction on access to college. Rather than paying for tuition-related costs, individuals can accumulate more assets, raising the supply of capital. Meanwhile, restricted access to college also lowers the supply of more productive college-educated labor. As a result, the interest rate decreases and the wage rate increases when markets clear, and individuals substitute between human capital and physical capital. Although the idiosyncratic impact depends on each person's wealth and human capital position, the price channel accounts for only a small portion of the aggregate welfare loss from restricting flexible access to college and from removing college entirely.

The investment and risk propagation value of college accounts for the majority of the welfare value. I define the investment value of college as its role in increasing human capital that can be realized in the labor market, following Mincer (1974). In my model, the idiosyncratic productivity shock perturbs a person's human capital.[4] To isolate the shock, I measure the investment value as the consumption equivalence of having access to each additional year of college without exoge-

[3] Barrow and Malamud (2015) and Aina, Baici, Casalone, and Pastore (2018) provide a more recent review of studies on college decisions and returns.

[4] In comparison, most studies following Mincer (1974) and Ben-Porath (1967) examine human capital investment in a risk-free environment. Hartog and Diaz-Serrano (2015) provides a review of the literature and discusses studies that model risk in schooling.

nous uncertainty. Overall, it peaks at age 19 but diminishes quickly and disappears by age 24. This explains why most college enrollment concentrates on the early 20s. Early-age college enrollment also favors those who are initially more advantaged. A larger human capital endowment creates a higher overall investment value in college due to the self-reproductive nature of human capital (Cunha, Heckman, Lochner, and Masterov, 2006). Interestingly, among individuals with similar human capital endowments, the investment value is higher for those with higher wealth endowments. This is because the cost of college is relatively lower for wealthier individuals, and the returns on human capital are higher than those on savings. The initial investment value of college at age 18 is worth nearly 45% of lifetime consumption among individuals with the largest wealth endowment and over 35% for those with the highest human capital endowment.

The risk propagation channel considers the role that college plays in transmitting an exogenous productivity shock in a risk-averse person's lifetime welfare. College education can augment the impact of risk when the productivity shock multiplies a higher level of human capital. College may also reduce the cost of risk if a person chooses to attend college as a response to current and expected future shock.[5] I approximate the risk propagation of college by comparing the welfare cost of risk between models with and without access to college at each age, a method resembling Castex (2017). All else being equal, a larger welfare loss due to risk from a model with access to college indicates a risk augmentation of college; otherwise, it indicates a risk reduction. I find that accessing college before the age of 22 moderately augments the welfare loss of risk, while attending college afterward reduces it. This is because younger individuals typically have lower wealth and higher risk aversion, but as one ages, resources accumulate, and subjective risk aversion tends to decrease. As a result, individuals are more likely to take advantage of college in the event of an adverse shock. The peak of the risk reduction from attending college occurs around age 24, mitigating nearly 35% of the welfare loss from risk. Less-advantaged individuals experience a greater welfare cost in risk from attending college at a younger age. However, having flexible access to college at a later age presents a more significant risk reduction, especially for those with a lower wealth endowment at age 18, even when controlling for the initial human capital endowment.

It is worth noting that one can examine the three channels for college in a model with individuals who only choose to complete college after high school without intermittence. However, allowing for flexible access to college in the model reveals prolonged investment value after age 18 and changing lifetime risk reduction value, which explains the intermittent college enrollment and completion patterns in the data.

The three channels suggest that the heterogeneity of initial wealth and human capital endow-

[5] Meghir and Pistaferri (2011) discuss two directions of college as risk reduction: *Ex-ante*, a person may store current wealth in human capital through education, raising the future human capital stock that dampens the fluctuation of marginal utility. *Ex-post*, one may attend school retooling after negative labor market shocks and skill depreciation.

ments can result in a life-cycle welfare difference due to unequal college valuation and the timing of attendance. A one-standard-deviation increase of wealth endowment at age 18 raises the investment value of college by 0.42 standard deviations and the risk reduction value of college by 0.05 standard deviations. Similarly, a one-standard-deviation increase in human capital endowment raises the investment value by 0.76 standard deviations and decreases the risk reduction value of college by 0.02 standard deviations. The investment value of college is especially effective in encouraging college enrollment and early completion at a young age. The risk reduction value has a moderate impact on promoting college completion. This result suggests that raising initial wealth or human capital endowments can encourage college attendance and completion.

I extend the model to assess two policies that encourage college attendance: a College Promise Program and a tax incentive program. A publicly funded nationwide College Promise Program offers free tuition to all college attendees. It doubles early college completion and drastically increases total college completion from the baseline of 25% to 78%. Though funding the program creates a tax burden, the tripling of college completion rates raises overall welfare by nearly 40%. A tax incentive program provides labor income tax exemption for all part-time student-workers. Compared to the College Promise Program, the tax incentive program targets later college attendance, primarily helps initially less-advantaged people, and is less generous in its benefits. The overall tax burden still increases to fund the exemptions. As a result, it increases college completion by about 17% from the baseline level, and welfare increases by 1.6%.

This paper contributes to the literature examining the causes and consequences of college over the life-cycle. The recent macroeconomic education literature examines the value of college by investigating post-college career trajectories (Kim, 2022; Athreya and Eberly, 2021; Hendricks and Leukhina, 2018; Vardishvili and Wang, 2019; Belley and Lochner, 2007; Arcidiacono, Bayer, and Hizmo, 2010; Stange, 2012). I break down college enrollment through the life cycle and investigate the sequential decisions made each year of college, as well as the option values they create. Rather than estimating the financial returns, this project assesses the welfare valuation of college at each age.

College is a risky investment.[6] It is important to consider the risk and risk attitude in college decisions (Levhari and Weiss, 1974; Hartog and Diaz-Serrano, 2015; Yang and Casner, 2021). Recent studies have constructed measures for risk preference and shown that higher risk tolerance leads to more college education (Belzil and Leonardi, 2013; Brodaty, Gary-Bobo, and Prieto, 2014; Heckman and Montalto, 2018; Kunz and Staub, 2020). This paper focuses on understanding the coexistence of human capital investment and risk avoidance in college education. By endogeniz-

[6]The returns can be unpredictable (Storesletten, Telmer, and Yaron, 2004; Schweri et al., 2011; Lee, Shin, and Lee, 2015; Mazza and van Ophem, 2018), and the time-to-completion can be uncertain (Hungerford and Solon, 1987; Bowen, Chingos, and McPherson, 2009; Hendricks and Leukhina, 2017).

ing college enrollment and exit decisions, I can investigate the interaction of college education and labor market risk in a life-cycle model. My approach assesses the impact of college on risk perception while bypassing the implicit bias and the difficulty in separating the various factors that constitute the risk attitude (Hartog and Diaz-Serrano, 2015).

Germane to my paper, Castex (2017) investigates the risk and returns of college in a partial equilibrium framework with exogenous college completion risk. Inspired by Abbott, Gallipoli, Meghir, and Violante (2019), I find the importance of the price channel in altering the welfare value in general equilibrium. Matsuda (2020) examines the impact of financial aid on endogenous college completion in a general equilibrium setting. Their models do not allow for returning to school after the second stage of the life cycle. My model identifies three channels that influence endogenous schooling decisions and reveals important welfare implications for later-age college access.

Much of the literature discusses the importance of ability and early age human capital preparedness in generating life-cycle inequality (e.g. Keane and Wolpin, 1997; Huggett et al., 2011). Studies argue that college readiness, driven by ability and existing human capital, influences college attendance and completion (Hendricks, Herrington, and Schoellman, 2021; Belzil and Hansen, 2020; Abbott et al., 2019). After controlling for the readiness, wealth background matters less in college decisions. Nevertheless, financial constraints are still a barrier for college (Ozdagli and Trachter, 2011; Johnson, 2013; Hai and Heckman, 2017). This paper contributes to the discussion by demonstrating that wealth is important for human capital acquisition and life-cycle welfare, given its impact on risk attitudes. The unequal wealth endowment at age 18 can translate into significant lifetime welfare inequality, extending through college enrollment and completion.

This paper also contributes to the literature on self-insurance against life-cycle uncertainties and the sources of lifetime inequalities, as discussed by Meghir and Pistaferri (2011) and Huggett et al. (2011). Recently, Chang, Hong, and Karabarbounis (2018) and Chang, Hong, Karabarbounis, Wang, and Zhang (2022) explored the interactions of labor income and financial portfolio risks. Jang (2023) and Jung and Tran (2023) examine the role of health insurance and default choices against health shocks. Kunz and Staub (2020) and Griffy (2021) study the role of job moving against labor market risk. Traditionally, the life-cycle framework implies that one attends school in the first phase of life, after which one supplies labor and largely learns on the job (Ben-Porath, 1967; Mincer, 1974; Rubinstein and Weiss, 2006). This paper models repeated cycles of intermittent college enrollment, viewing college education as a means of self-insurance throughout the life cycle. My result aligns with the general conclusion from Cocco, Gomes, and Maenhout (2005): college at a younger age serves as an investment strategy, while at a later age, it serves as an insurance strategy.

The paper proceeds as follows. Section 2 provides empirical evidence on the intermittent college education profile and the unequal initial distributions from data. Section 3 lays out the theoretical framework. Section 4 discusses the calibration procedure. Section 5 presents the main results. Section 6 explores the mechanism for the main results. Section 7 extends the discussion by examining various policies and robustness checking the results. Section 8 concludes the findings.

2 Empirical facts

In this section, I document an intermittent college education profile in the U.S. I define intermittent college education as an education profile interrupted by gaps of non-enrollment before obtaining the undergraduate degree. This includes delays to college start after high school and stopouts after starting college. About two-thirds of all with a college degree in the U.S. experience some intermittence in college education; over 10% complete their degree after age 35. I link the timing and completion of college to a person's wealth and human capital endowments at age 18 and find that individuals from wealthier families or with higher human capital are more likely to complete college at a younger age.

2.1 Intermittent college education profile

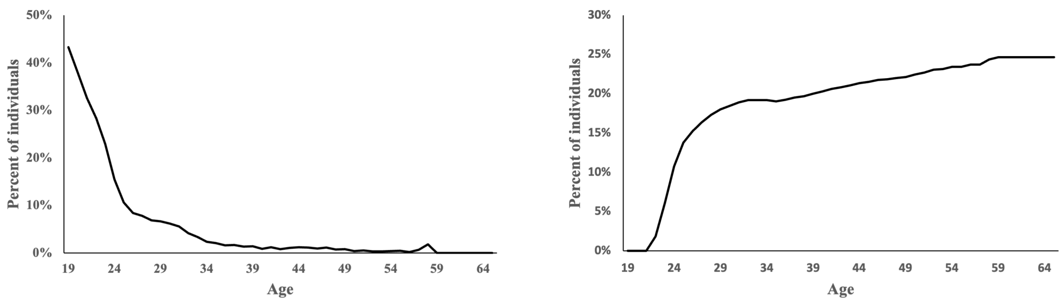
I use data from the National Longitudinal Survey of Youth 1979 (NLSY79) to summarize the life-cycle education profile. Respondents in NLSY79 have been continuously surveyed from 1979, covering an age range from 14 to 59.[7] For college enrollment, I define it as attending formal credited degree-granting college courses for at least five months of a year, and college completion as completing 16 years of education, following the literature (Light, 1995a,b; Monks, 1997; Dynarski, 2003; Seftor and Turner, 2002; Johnson, 2013; Arcidiacono et al., 2025).[8]

Figure 1 plots the life-cycle college enrollment and completion patterns. Panel (a) indicates that the majority of students enroll in college before the age of 23. However, a decreasing but still substantial number of individuals enroll in school after the age of 35. Panel (b) plots the sample share obtaining a bachelor's degree at a given age. The sharp increase starts from age 22 and lasts until age 26. However, a steady addition of individuals obtains a bachelor's degree throughout the life cycle.

[7] See Appendix A for detailed sample construction.

[8] Operationally, I classify a stopout using the monthly enrollment records from the NLSY79. An individual is counted as enrolled in a given calendar year if they attend formal credited degree-granting courses for at least five months. A stopout occurs when someone who previously met this enrollment criterion has at least one subsequent calendar year with no such enrollment and later returns to college. Short breaks within a year, such as a summer term without courses or a one-month gap, do not count as stopouts because they do not violate the five-month annual enrollment threshold.

Figure 1: Life-cycle enrollment and degree attainment



(a) Percent enrolled in school by age (b) Percent completed degree BA by age

Notes: Data come from the NLSY79. Panel (a) plots the average enrollment by age, starting at 19. Panel (b) plots the average bachelor's degree completion by age. Series are smoothed using locally weighted regression with a bandwidth of 0.15.

Table 1 describes respondents' college completion and the timing of completion. About 39% of the sample reported having never enrolled in college. Only 9.3% of the sample completed college by age 22. These are the individuals described by the "traditional" consensus in life-cycle human capital acquisition literature, where one completes formal school training exclusively at the first stage of life. 17% of the sample obtained a college degree after some interruptions, accounting for two-thirds of all with a bachelor's degree. About 35% have college experience but do not complete a degree. Examining all with a college degree, 73% obtain it at an age younger than 25, but over 10% receive it after age 35.

Table 1: College completion and timing

	No college	BA by 22	Interrupted, no BA	Interrupted, with BA
		Full sample (percent)		
Share	38.91	9.29	34.77	17.03
		Of all with BA (percent)		
	$\leq$25	25–30	30–35	>35
Share	72.77	10.82	6.00	10.41

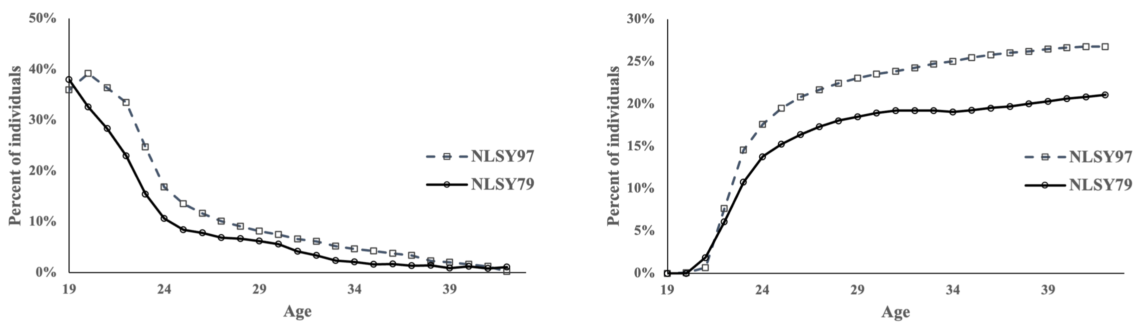
Notes: The top panel reports the unweighted percent of the full sample under each category. The bottom panel reports the unweighted percent of the sub-sample with a bachelor's degree. Results are similar if weighted by person weights.

In Appendix A, I describe the construction of life-cycle college attendance and completion using NLSY79, which follows the 1957–1964 birth cohorts. The early survey rounds track years of schooling but do not explicitly record bachelor's degree attainment. To check robustness, I compare these profiles with NLSY97, which follows the 1979–1984 cohorts and directly records BA completion.

Figure 2 presents the comparison. Panel (a) shows that, at nearly every age from 19 to 40, a larger share of individuals enroll in college in the NLSY97 than in the NLSY79. Panel (b) shows that while both datasets report similar on-time BA completion by age 22, NLSY97 records higher completion rates at every age after 23. This confirms that intermittent and delayed degree attainment is not unique to NLSY79 and, if anything, is more pronounced in later cohorts. These findings are further corroborated by CPS synthetic cohort evidence presented in Appendix B, which shows that degree attainment continues well beyond age 25 and that later-age completion has become more pronounced across more recent cohorts.[9]

Because NLSY79 remains the only dataset that follows individuals across their entire working lifespan, it continues to serve as the primary data source in this paper. At the same time, the comparison suggests that the NLSY79 likely understates the extent of stopout and delayed completion; therefore, the estimates in this paper should be viewed as conservative.

Figure 2: Life-cycle enrollment and degree attainment between NLSY79 and NLSY97



(a) Percent enrolled in school by age (b) Percent completed degree BA by age

Notes: Data come from NLSY79 and NLSY97. Panel (a) plots the share enrolled in college at each age (starting at 18). Panel (b) plots the share attaining a bachelor's degree by age. Series are smoothed using locally weighted regression (bandwidth 0.15). In both panels, the solid line denotes NLSY79 and the dashed line denotes NLSY97.

2.2 Age 18 background conditions

Studies have found the importance of early background experiences in shaping lifetime decision-making and influencing inequalities. For example, Huggett et al. (2011), Hai and Heckman (2017),

[9]A related comparison is with Arcidiacono et al. (2025), who study persistence among four-year entrants in the NLSY97. Their stopout measure captures interruptions only after entering a four-year program and does not include delayed entry or older-age returns. When definitions are harmonized, the estimates are consistent: Table 3 in Arcidiacono et al. (2025) implies that about 25% of four-year entrants ever stop out and roughly 22% of eventual graduates complete via a stopout path. By contrast, my measure includes delayed entry, stopouts, and switches across two- and four-year institutions, and tracks full enrollment histories through age 60, which yields higher rates of intermittence. The two approaches, therefore, capture different margins of the same phenomenon and align once definitions and age windows are matched.

Abbott et al. (2019), Griffy (2021), and Athreya, Ionescu, Neelakantan, and Vidangos (2019) explore the impact of wealth background, human capital, and learning ability differentials across individuals in early adulthood. However, it is challenging to precisely determine the accessibility of wealth for a young adult before the early 20s, especially if they cohabit with their parents. Similarly, human capital and learning ability are theoretical concepts in labor studies that are difficult to measure separately. Literature on life-cycle models often conjectures the distribution of each dimension through a calibration exercise. I follow the spirit of the literature, focusing on the ordinal property of each dimension to maximize the insights from the empirical evidence.

For wealth, I use the average of a respondent's net family income across ages 17-18-19 to approximate one's relative position in the wealth distribution, since the NLSY79 does not provide early-age net wealth measurement. Studies have shown a strong positive correlation between income and family wealth (e.g. Kuhn, Schularick, and Steins, 2020). In addition, averaging net income over three years further smooths out inaccuracies of temporary income fluctuations.

For the dimensions of human capital and learning ability, I use the AFQT (Army Forces Qualification Test) score as an approximation[10]. Literature has long recognized the difficulty in separating innate ability, skill, and human capital (e.g. Schultz, 1961; Lang and Kropp, 1986; Woodhall, 1987; Altonji, Blom, and Meghir, 2012). I take an agnostic stance and consider human capital as anything that enhances an individual's productivity in the labor market, including innate abilities, acquired knowledge and skills, and other factors that contribute to school preparedness and labor productivity from an individual's perspective. AFQT has been widely used as a proxy for human capital, though its accuracy has been criticized (e.g. Schofield, 2014; Rodgers III and Spriggs, 1996; Lang and Manove, 2011; Griliches and Mason, 1972). Nevertheless, it provides a useful approximation of one's relative position in the distribution of human capital that impacts learning in school and labor market earnings (Arcidiacono et al., 2010).

I split each dimension into five equal-valued bins. Table 2 shows the distribution of individuals along the two dimensions. Three patterns emerge. First, both family wealth and human capital conditions at age 18 are unequally distributed. Fewer individuals are in the higher-value bins than in the lower-value bins for both conditions. Second, the wealth dimension is more skewed than the human capital endowment. Third, both conditions are positively correlated, with a correlation coefficient of 0.29. For the top two wealth bins, individuals are more likely to have a high human capital endowment. For those in the lowest two wealth bins, individuals are more likely to have a lower human capital endowment.

[10]The AFQT was administered to the majority of respondents in the NLSY79 in 1980 and has been widely adopted as a standard test for cognitive aptitude.

Table 2: Distribution of individuals across age 18 family wealth and AFQT

		Human capital endowment				
		23.16	25.18	21.41	16.85	13.41
Wealth endowment		1st	2nd	3rd	4th	5th
52.08	1st	15.82	14.46	10.21	7.06	4.54
32.06	2nd	5.70	7.82	7.54	6.05	4.95
11.55	3rd	1.25	2.30	2.80	2.80	2.39
3.62	4th	0.33	0.50	0.59	0.85	1.34
0.7	5th	0.07	0.09	0.26	0.09	0.20

Notes: The rows describe the percent of the sample in each human capital bin, measured by AFQT scores. The values on the first row report the unconditional distribution along the human capital dimension. The columns describe the percent of the sample in each wealth bin, measured by the average of net family wealth at ages 17–19. The first column reports the unconditional distribution on the family wealth dimension. The inner five-by-five matrix describes the joint distribution of human capital and wealth. The 1st bin has the lowest value, and the 5th bin has the highest value.

2.3 Age 18 conditions and intermittent college education

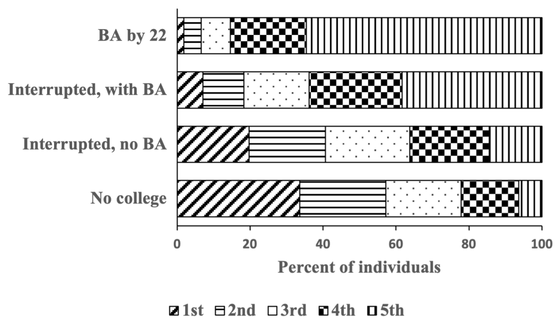
In this subsection, I provide descriptive statistics connecting age 18 endowments to the timing and completion of college. In Figure 3, I split individuals into five human capital and wealth quintiles, rather than equal-valued bins as in Table 2.[11] Panel (a) and Panel (b) describe the various patterns of college completion in relation to age 18 human capital and wealth endowments. Individuals in the top 20% of human capital and wealth endowments are more likely to complete college by age 22. Conversely, individuals at the bottom 20% of human capital and wealth endowments are more likely to never enroll in college. Those from higher human capital and wealth quintiles are more likely to complete a bachelor's degree than those from lower quintiles.

Further examining all individuals with a college degree, in Panels (c) and (d) of Figure 3, those with the highest human capital and wealth endowments are more likely to obtain a degree at a younger age, typically before age 25. By contrast, those from the bottom 20% of the age 18 human capital and wealth endowments are more likely to receive a college degree after age 35.

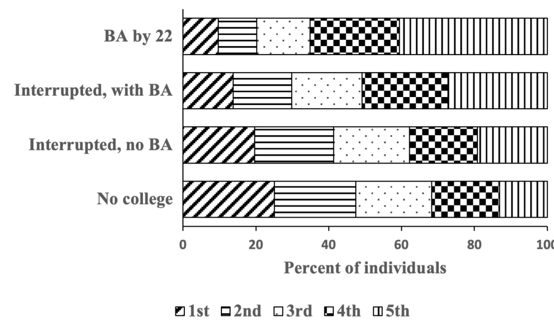
These patterns describe the correlation between intermittent college education and wealth at age 18, as well as human capital endowments. In the next section, I construct a life-cycle model in general equilibrium to examine the theoretical channels through which age 18 endowments translate into college education choices and their welfare implications.

[11] Splitting individuals in equal-value bins shows similar results, but each bin has a different number of individuals because of unequal distribution in the initial conditions.

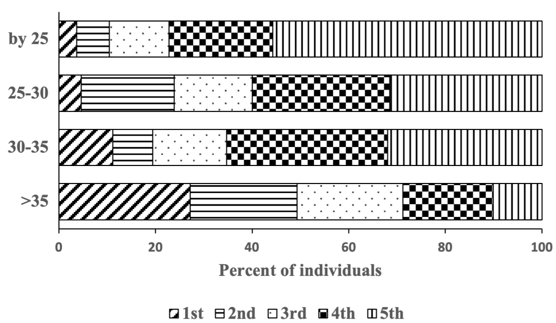
Figure 3: Initial conditions and patterns of intermittent college



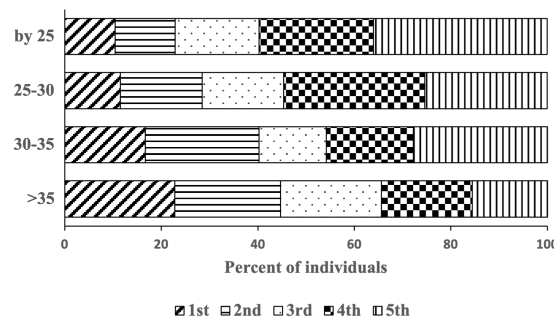
(a) Age 18 human capital and college completion



(b) Age 18 family financial and college completion



(c) Age 18 human capital and BA timing



(d) Age 18 family financial and BA timing

Notes: Panel (a) and Panel (b) show the share of the sample in each education interruption category by quintile. Categories are: completed a bachelor's degree by age 22 (BA by 22), completed with interruptions (interrupted, with BA), some college experience without completing a degree (interrupted, no BA), and never attended college (no college). For example, in Panel (a), the dark blue striped bar marked as 5th in BA by 22 indicates that over 60% of all individuals who completed a BA by age 22 come from the 5th quintile of the human capital endowment. Panel (c) and Panel (d) show the share of the sample in each degree completion–timing category by quintile: by age 25, between ages 25–30, between ages 30–35, and after age 35. Quintile 1 is the lowest 20%, and Quintile 5 is the highest 20%.

3 Model

In this section, I construct a life-cycle overlapping generation model in an incomplete market general equilibrium setting. Each model period is one year. Individuals enter the model at age 19, retire at age 65, and live up to age 85 for a total of 67 years. One representative firm hires effective units of labor and rents capital from individuals to produce a single output.

3.1 Individuals' problem

Every period, Ω of new individuals enter the model, and Ω exit. I normalize the total population to be 1. Therefore, Ω assigns value 1/67. Individuals maximize their expected lifetime utility, given their initial financial wealth, s_0, and initial human capital, h_0.

Table 3 describes the timeline for individuals' life-cycle labor status decisions. From the age of 19 to 65, each individual chooses one of the four discrete decisions e: working full time *emp*, working part-time and schooling part-time *pt*, schooling full time *sch*, and leisure full time *nonemp*. After age 65, one retires and enjoys full leisure activities.

Individuals are also differentiated on how many years of post-secondary schooling one has completed *yr*. The maximum number of full-time education years after high school is set to be 4. Together, individuals are heterogeneous in the idiosyncratic states: $\phi \equiv \{h, s, yr, e, age\}$.[12]

Based on their decisions, individuals evolve on each dimension of the idiosyncratic states every period. We have an endogenous aggregate state μ, which is a probability measure of individuals on each idiosyncratic state. As one retires, labor status and years of education cease to matter. For ease of computation, the distribution of individuals after retirement evolves to μ_{re}, only on $\{h, s, age\}$.

Table 3: Life-cycle time-line

Real age	Model age	
19–65	1–47	Work full time, part time, and school part time; school full time; leisure full time
66–85	48–67	Retired

The source of uncertainty over the life cycle comes from the human capital accumulation shock,

[12] One potential challenge for the project is that it abstracts away from many demographic dimensions of heterogeneity, such as race, gender, geographical locations, industry, etc. With the key question in examining the school option in a general equilibrium framework, the computation capacity leads to the sacrifice of many refined dimensions. As a second-best option, I do not exclude observations on these differences in calibration, as suggested by Borella, De Nardi, and Yang (2018). The calibrated idiosyncratic human capital shock and the psychic cost of schooling help absorb many demographic differences and better reproduce aggregate moments.

ε, which is realized when one is working (full-time or part-time). All shocks are *iid* across individuals and time. Equation (1) describes the extensive margin labor supply and human capital investment decisions before retirement ($age \leq 47$). Individuals maximize lifetime value V by choosing e given the beginning of the period states. V^{emp}, V^{pt}, V^{sch}, and V^{nonemp} describe the values for one's choice of $e = [emp, pt, sch, nonemp]$. Standard concave utility qualities apply. In particular, $V^{emp}, V^{pt}, V^{sch}, V^{nonemp}$ are concave in consumption c; hence $\frac{\partial V^e}{\partial y} > 0$, and $\frac{\partial V^e}{\partial y \partial y} < 0$, where $y \in \{s, h\}$. To ease exposition, we use the prime notation $(\cdot)'$ to denote next-period values. For example, s' and h' represent next-period asset and human capital holdings, while μ' and μ'_{re} denote next-period distributions.

$$V_{age \leq 47}(\phi; \mu, \mu_{re}) = \max\{V^{emp}(\phi; \mu, \mu_{re}), V^{pt}(\phi; \mu, \mu_{re}), V^{sch}(\phi; \mu, \mu_{re}), V^{nonemp}(\phi; \mu, \mu_{re})\}. \tag{1}$$

In addition to the discrete e choice, each individual chooses consumption and saving to maximize the lifetime value. For working individuals, as in Equation (2), human capital accumulates through learning on the job by a fixed parameter A with learning curvature a. Human capital shocks ε perturb the learning efficiency. It is abstracted from various individual-related factors impacting one's productivity. The shock, ε, is *iid* across individuals and time. But given its nature on h, a stock variable for human capital, the impact of ε is persistent.

The labor supply takes from the indivisible labor framework (Hansen, 1985; Rogerson, 1988). The individuals supply a full unit of time to work and receive the disutility of working $disu_w(ft)$. One receives wages paid to the efficient units of labor, h, and interest income, rs, if holding positive wealth (or interest payments if holding negative wealth). Every period, employed individuals pay social security tax at a rate τ and lump sum income tax Υ[13]. If one needs to borrow, the person may borrow a non-defaultable bond with borrowing limit $max(\underline{S}, \underline{s}(\phi, \mu, \mu_{re}))$. $\underline{S}$ is the economy-wide common debt limit. Depending on the individual's current status, a natural debt limit $\underline{s}(\phi, \mu, \mu_{re})$ is set to enforce full repayment by the end of the person's life cycle. If a person's natural debt limit is more strict than the economy-wide limit, the borrowing follows the person's natural debt limit. Regardless of working status or age, everyone receives an equal lump-sum profit rebate from firms, Π.

[13] Υ denotes a net, per-capita lump-sum transfer to households. Negative Υ corresponds to a lump-sum tax; positive Υ corresponds to a rebate.

$$
\begin{aligned}
V^{emp}(\phi;\mu,\mu_{re}) &= \max_{c,s'}\left\{u(c) - disu_w(ft) + \beta\,\mathbb{E}_{\varepsilon'}[V(\phi';\mu',\mu'_{re})]\right\} \\
\text{s.t.}\quad c + s' &= (1+r_{\mu,\mu_{re}})s + w_{\mu,\mu_{re}}h(1-\tau) + \Upsilon + \Pi, \\
h' &= (\varepsilon A h)^a, \\
s' &\geq \max\left(\underline{S},\, \underline{s}(\phi,\mu,\mu_{re})\right).
\end{aligned} \tag{2}
$$

If an individual decides to go to college full-time, the person has to pay a fixed tuition cost, psychic cost, and opportunity cost from giving up current earnings and learning on the job to enroll in school. As in Equation (3), the person incurs disutility $disu_{sch}$ from going to college. The disutility depends on a person's existing human capital, age, current schooling status, years of school completed, and full-time/part-time schooling status. The individual's income only comes from previous savings (or debt if having negative savings) and tax transfer, which must be allocated among consumption, savings (or borrowing) for the future, and tuition payment κ. Human capital moves up by a scaling factor $\Delta(yr)$, a function based on years of education. It is also subject to the learning curvature a.

$$
\begin{aligned}
V^{sch}(\phi;\mu,\mu_{re}) &= \max_{c,s'}\left\{u(c) - disu_{sch}(h,yr,e,age,ft) + \beta\,\mathbb{E}_{\varepsilon'}[V(\phi';\mu',\mu'_{re})]\right\} \\
\text{s.t.}\quad c + s' + \kappa &= (1+r_{\mu,\mu_{re}})s + \Upsilon + \Pi, \\
h' &= (\Delta(yr)h)^a, \\
s' &\geq \max\left(\underline{S},\, \underline{s}(\phi,\mu,\mu_{re})\right).
\end{aligned} \tag{3}
$$

If one chooses part-time work and part-time schooling, as in Equation (4), one incurs disutility from both work and schooling. Human capital accumulates through a combination of on-the-job learning and college education. Human capital shock ε continues to perturb the efficiency of on-the-job learning. One receives half of the wage, w, paid to the efficient units of labor, h, and spends half of the full-time tuition, κ.

$$
\begin{aligned}
V^{pt}(\phi;\mu,\mu_{re}) &= \max_{c,s'}\left\{u(c) - disu_w(pt) - disu_{sch}(h,yr,e,age,pt) + \beta\,\mathbb{E}_{\varepsilon'}[V(\phi';\mu',\mu'_{re})]\right\} \\
\text{s.t.}\quad c + s' + \frac{\kappa}{2} &= (1+r_{\mu,\mu_{re}})s + \frac{1}{2}w_{\mu,\mu_{re}}h(1-\tau) + \Upsilon + \Pi, \\
h' &= \frac{1}{2}\left[(\varepsilon A h)^a + (\Delta(yr)h)^a\right], \\
s' &\geq \max\left(\underline{S},\, \underline{s}(\phi,\mu,\mu_{re})\right).
\end{aligned} \tag{4}
$$

Suppose an individual decides to stay at home, as in Equation (5). In that case, one faces a simple consumption-saving problem with full-time leisure (normalized to zero compared to disutility from school and work). However, human capital depreciates deterministically at a rate of δ_h every period.

$$
\begin{aligned}
V^{nonemp}(\phi;\mu,\mu_{re}) = \max_{c,s'} & \left\{u(c)+\beta\,\mathbb{E}_{\varepsilon'}[V(\phi';\mu',\mu'_{re})]\right\} \\
\text{s.t.} \quad c+s' &= (1+r_{\mu,\mu_{re}})s+\Upsilon+\Pi, \\
h' &= (1-\delta_h)h, \\
s' &\geq \max\left(\underline{S},\, \underline{s}(\phi,\mu,\mu_{re})\right).
\end{aligned}
\tag{5}
$$

After the age of 65, one retires from the labor market, as shown in Equation (6), and no longer chooses to attend college. The distribution of individuals is retrieved to μ_{re}, where individuals are located on age, human capital h, and current level of assets s. One receives social security benefit $B(h)$ and pays income tax Υ. Even though human capital stops evolving after retirement, I set the retirement benefit $B(h)$ as a function of the human capital (representing earnings) by the last age before retirement. At the final age, $age=67$, $V^R_{age+1}=0$, and individuals cannot leave the model with debt.

$$
\begin{aligned}
V^R(h,s,age;\mu,\mu_{re}) = \max_{c,s'} & \left\{u(c)+\beta\,V^R(age+1,s';\mu',\mu'_{re})\right\} \\
\text{s.t.} \quad c+s' &= (1+r_{\mu,\mu_{re}})s+B(h)+\Upsilon+\Pi, \\
s' &\geq \max\left(\underline{S},\, \underline{s}(\phi,\mu,\mu_{re})\right).
\end{aligned}
\tag{6}
$$

3.2 Firm's problem

A representative firm employs efficient units of labor and rents capital for the production of final goods, as shown in Equation (7). Capital K^d comes from individuals' savings s. Capital depreciates at a rate of δ.

$$
\Pi = F(K^d,L^d) - wL^d - (r+\delta)K^d. \tag{7}
$$

The markets operate competitively. We assume a constant returns to scale production technology; firms pay prices at the competitive market rate: $w = MPL$ and $r+\delta = MPK$. Therefore, profits are zero.

3.3 Stationary Equilibrium

Let H be the space of human capital, S the space of assets, and E the space of employment–schooling statuses. Let $\phi_{age} = \{h,s,yr,e\}$ denote the idiosyncratic state of an individual at age age. Let μ and μ_{re} denote the distributions of individuals before and after retirement, respectively. Let Γ

denote the operator that maps the current pre-retirement distribution μ into next period's distribution μ', and Γ_{re} denote the operator mapping the retirement distribution μ_{re} into μ'_{re}. A stationary recursive competitive equilibrium is a collection of factor prices $w(\mu,\mu_{re})$, $r(\mu,\mu_{re})$, decision rules $s_{age+1}(\phi_{age},\mu,\mu_{re})$, $h_{age+1}(\phi_{age},\mu,\mu_{re})$, $e_{age}(\phi_{age},\mu,\mu_{re})$, $c_{age}(\phi_{age},\mu,\mu_{re})$, $yr_{age}(\phi_{age},\mu,\mu_{re})$, and value functions $V_{age}(\phi_{age},\mu,\mu_{re})$ such that:

1. Given (w,r), individuals solve their optimization problem.

2. Factor prices are competitive:

$$w = F_2(K,L), \qquad r+\delta = F_1(K,L).$$

3. Aggregate effective labor supply is:

$$L^s = \sum_{age=1}^{47}\sum_{yr=0}^{4}\int_H\int_S \left(h\mathbf{1}_{\{e=emp\}} + \frac{1}{2}h\mathbf{1}_{\{e=pt\}}\right) \times \mu(age,e,yr,h,s)\,ds\,dh. \tag{8}$$

4. Aggregate savings are:

$$K^s = \sum_{age=1}^{47}\sum_{yr=0}^{4}\sum_{e\in E}\int_H\int_S s\,\mu(age,e,yr,h,s)\,ds\,dh + \sum_{age=48}^{67}\int_H\int_S s\,\mu_{re}(age,h,s)\,ds\,dh. \tag{9}$$

5. Aggregate consumption is:

$$C = \sum_{age=1}^{47}\sum_{yr=0}^{4}\sum_{e\in E}\int_H\int_S c\,\mu(age,e,yr,h,s)\,ds\,dh + \sum_{age=48}^{67}\int_H\int_S c\,\mu_{re}(age,h,s)\,ds\,dh. \tag{10}$$

6. Aggregate tuition costs are:

$$Tuition = \sum_{age=1}^{47}\sum_{yr=0}^{4}\int_H\int_S \left(\kappa\mathbf{1}_{\{e=sch\}} + \frac{1}{2}\kappa\mathbf{1}_{\{e=pt\}}\right)\mu(age,e,yr,h,s)\,ds\,dh. \tag{11}$$

7. Markets clear:

$$L^s = L^d, \qquad K^s = K^d, \qquad Y^s = F(K,L) = Y^d = Tuition + C + \delta K.$$

8. The government budget balances:

$$\sum_{age=48}^{67}\int_H\int_S B(h)\,\mu_{re}(age,h,s)\,ds\,dh + \Upsilon = w\tau L^s.$$

9. Distributions evolve consistently with decision rules:

$$\mu' = \Gamma\mu, \qquad \mu'_{re} = \Gamma_{re}\mu_{re}.$$

4 Calibration

I calibrate two categories of parameters for the baseline model to match the U.S. economy. One set of parameters describes the initial distribution of individuals at age 18 in terms of human capital and wealth dimensions. The other set of parameters is either externally chosen, listed by the end of Table 4, or jointly determined by minimizing the distance between model-generated moments and targeted statistics, as listed in the top panel of Table 4 and in Table D.1. All model-generated moments are calculated by simulating the baseline model 50,000 times.

Table 4: Calibration and targeted statistics

Parameter	Value	Description	Target statistics	Data	Model
Chosen internally					
ψ	0.7741	Disutility of working	Emp-pop ratio	0.61	0.61
a	0.93	Curvature of wage growth	Wage spread expansion	0.01	0.01
A	1.1179	Learning on the job	Lifetime wage growth	1.95	2.41
Δ_1	1.1071	College learning pre BA	Some college premium	1.03	1.03
Δ_2	1.4305	College learning by BA	College premium	1.06	1.04
δ_h	0.0375	Human capital depreciation	Mean unemp. wage loss	0.04	0.05
κ	1.0944	College cost	College spending share	0.14	0.14
δ	0.0715	Capital depreciation	K/Y	3.23	3.23
β	0.9503	Discount factor	Risk free rate	0.04	0.04
ε	(0.7878, 1.2122)	Human capital shock	Wage variance	0.56	0.56
Chosen externally					
τ	0.106	Social security tax			
ω	0.40	Social security income			
α	0.64	Labor share of income			
γ	0.75	Frisch elasticity			
ρ	2.00	Risk aversion			

Notes: This table reports the parameters, their values, and descriptions. The top panel presents the parameters chosen internally through minimizing the distance between model-generated moments and data. The last two columns of the top panel compare the targeted moments between the data and model-simulated values. The bottom panel reports the five parameters chosen externally of the model, their values, and descriptions.

4.1 Initial distribution and grid setup

Table 2 in Section 2.2 describes the empirical initial distribution of individuals on human capital and wealth margins. Literature following Huggett et al. (2011) often constructs a multivariate normal distribution with dimensions that describe wealth, human capital, and learning ability. The mean, variance, and covariance of the distribution are calibrated to generate life-cycle earnings profiles that target their empirical counterparts. Compared to the normal distribution, Table 2 shows that individuals are right-skewed on the support. Given the importance of initial conditions in generating life-cycle profiles, smoothing the patterns from the empirical distribution may have significant consequences for the simulation results. Therefore, I directly feed a more refined distribution from Table 2 into the model.

For the support of the human capital dimension, I create 20 equal-valued consecutive bins for the AFQT scores. Each bin is mapped to a grid point between the 21st and 40th positions on the human capital grid. Then, the number of individuals from each bin is assigned to the corresponding grid position.[14]

For the initial wealth dimension, I first split the proxy for family wealth described in Section 2.2 into 20 equal-valued consecutive bins. The first bin holds 8% of the sample, and the second bin holds 18%. According to the Survey of Consumer Finance, 17% of people between the ages of 17 and 19 have negative net worth. To locate zero wealth, I split the first two bins into four equally spaced sub-groups. The first three sub-groups account for 17.57% of the sample. When fitting the initial wealth support into the model on the asset grid, I set the last of the four subgroups at zero and the first three subgroups on three equally spaced grid points below zero. The remaining 18 bins are mapped one-to-one onto grid points valued above zero and equally spaced, with the distance doubling among the first four. In total, the support for initial wealth spans 22 grid points on the asset grid.[15] Same as the fitting of the initial distribution on the human capital grid, I assign the number of individuals in each wealth bin from the data to the initial distribution along each of the 22 grid points for the initial value.

Altogether, the support for the initial distribution is a 20 by 22 matrix. Table C.1 in Appendix C reports the distribution of individuals along the human capital and wealth dimensions following the criteria as above. The vertical dimension represents the human capital margin, and the horizontal dimension represents the wealth margin. I directly import the matrix into the optimization and simulation of the model as the starting age conditions.

4.2 Other parameters

The remaining parameters of the model are derived from an externally chosen set and a calibrated set that minimizes the distance between the model-generated and data moments. The lower portion of Table 4 lists five parameters chosen externally. The first two relate to the tax system, in which

[14] To complete the human capital grid, I reserve 20 grid positions before the lowest initial human capital value to allow for human capital depreciation below it. I assign 60 more grid positions after the highest initial human capital level to allow for human capital accumulation above the highest initial level.

[15] To complete the asset grid, I reserve 20 grid positions before the lowest initial wealth value and 43 additional grid points after the highest initial wealth level for further wealth accumulation.

the government imposes a social security tax on all working individuals before the retirement age of 65 and transfers an annual retirement income to retirees after the age of 65. I follow Huggett et al. (2011) and Huggett and Parra (2010) for the tax system. Social security tax (τ) is imposed at a rate of 0.106. Unlike Huggett et al. (2011), who set a common social security benefit in retirement, I allow a social security benefit ($B(h) = \omega w\bar{h}$). It transfers $\omega = 40\%$ of an individual's end-of-working-age income $\bar{h}w$, allowing the heterogeneity of income to persist into retirement. I set the production function as $Y = L^{\alpha}K^{(1-\alpha)}$. The third parameter, α, governs the labor share of income, set as 0.64.

I parameterize the utility function as a summation of three portions: consumption, labor-leisure, and college psychic cost. The consumption portion is set as $u(c) = \frac{c^{1-\rho}}{1-\rho}$. I select the risk aversion ratio ρ to be 2, a standard value used in the macroeconomic literature, for example, Huggett et al. (2011) and Browning, Hansen, and Heckman (1999). In the labor-leisure portion, $disu_w = \psi\frac{n^{1-1/\gamma}}{(1-1/\gamma)}$. I assign γ, the Frisch elasticity, to be 0.75, which falls within the range of estimations in the literature, as reviewed by Chetty, Guren, Manoli, and Weber (2013).

The remaining parameters are jointly calibrated to minimize the distance between the empirical and model-simulated moments. Motivated by Johnson (2013), Hai and Heckman (2017), Guo (2018) and Abbott et al. (2019), I parameterize the school psychic cost portion of the utility function as $disu_{sch}(h, age, e, yr, ft) = n_{sch}(dis(e, age, yr) - h)$.[16] I assign $n_{sch} = 1$ for full-time college schooling and $n_{sch} = 0.5$ for part-time schooling. The psychic cost is relative to the size of human capital, h, that the person already has, following the self-productive nature of learning[17]. Human capital investment is time-sensitive. Whether it is through learning on the job or college, the rate of accumulation for each mode and the associated psychic cost may differ by age (Cunha et al., 2006). A current student may be more likely to continue enrolling in college than one who is currently away from school.[18] Lastly, if one is near completing a degree, the student may find a different psychological challenge than at the beginning of college. Therefore, I model $dis(e, age, yr)$ to represent a set of parameters describing the relative disutility of schooling by age, years of school-

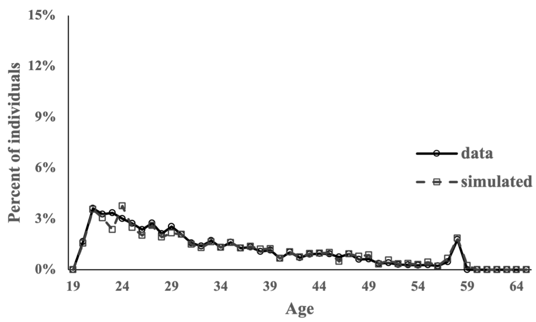
[16]Much macro literature with human capital acquisition only allows for the opportunity cost of learning and does not model a direct cost associated with it (e.g. Huggett et al., 2011; Griffy, 2021). Hsieh, Hurst, Jones, and Klenow (2019) argue that a direct cost is essential in generating asymmetric human capital investment behaviors. Most general equilibrium models with human capital acquisition introduce a direct financial cost to accommodate the argument (e.g. Athreya and Eberly, 2021; Krebs, Kuhn, and Wright, 2015; Lee and Seshadri, 2019; Kim, 2022). Belley and Lochner (2007) demonstrates that additional utility costs allow a model to generate important empirical schooling patterns that are difficult to reproduce. Yang and Casner (2021) provides a further theoretical account showing that the utility cost to the school creates a critical channel linking wealth, precautionary savings, and risk aversion to schooling decisions. Missing such components may create omitted variable bias in the simulation.

[17]See for example Macdonald (1981), Card (1994), Card (2001), Johnson (2013), Hai and Heckman (2017), Guo (2018), Abbott et al. (2019), and Cunha et al. (2006). The higher the human capital, the easier it is to gain more via education.

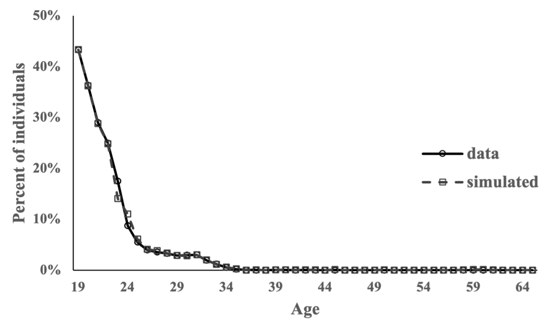
[18]For example, Stinebrickner and Stinebrickner (2012) discusses the signaling one receives while in school and at work, which could propel one to make school-work decisions differently.

ing completed, and continuing enrollment status. The three sets of *dis* parameters for each age are reported in Table D.1 in Appendix D. These parameters are calibrated to target the new and continuing college enrollment and BA attainment statistics at each age, as shown in Figure 4.

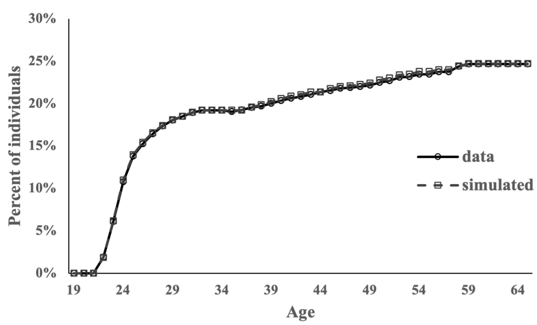
Figure 4: Life-cycle enrollment and degree attainment: data and model moments



(a) New enrollment by age



(b) Continuous enrollment by age



(c) Completed BA by age

Notes: This figure compares model-simulated life-cycle enrollment and degree completion to data. The solid line reports data values, and the dashed line reports model-simulated moments. Panel (a) reports the share at each age newly enrolling in college. Panel (b) reports the share at each age continuously enrolling in college (including full-time and part-time). Panel (c) reports the share at each age with a bachelor's degree.

The rest of the calibrated parameters and their most relevant moments are reported in Table 4. In the labor-leisure portion of the utility function, ψ governs the scale of disutility from working. For simplicity, working time is assumed to be discrete, where $n = 1$ represents full-time working and $n = 0.5$ represents part-time working. I calibrate ψ = 0.7741 to match the employment-to-population ratio calculated using the average CPS data from 1979 to 2016.

Human capital can move along three trajectories: accumulating on the job (or, loosely speaking, "learning" on the job), learning in college, and depreciating while enjoying full-time leisure. Parameter a determines the curvature of all human capital accumulation. Browning et al. (1999) and Huggett et al. (2011) describe the importance of a in generating the rise of dispersion of income over the lifetime. I set a to match the wage dispersion over a lifetime in my calibration, measured as the slope of the variance of log wage from 18 to 65. All wage-related moments are calculated using detrended CPS data from 1992 to 2016.[19] Models following Huggett et al. (2011) use a separate continuous time choice devoted to learning (e.g. Griffy, 2021). The core of human capital production in this model is deterministic, depending on employment status. Parameter A governs the rate of return to learning on the job; Δ's govern the efficiency of college learning, and δ_i governs the loss of human capital from non-employment. To incorporate the "sheepskin" effect of education (Hungerford and Solon, 1987), I let Δ_1 describe the human capital return from each year of college enrollment before graduation, and Δ_2 describe the human capital return when one receives the college degree. Δ_1 calibrates to the age 65 mean earnings ratio between people with some college experience but without a degree and those without college experience. Similarly, Δ_2 calibrates to the college degree premium, calculated as the ratio of the mean earnings at age 65 between all individuals with a college degree and all without college experience.[20] Parameter A helps match the lifetime wage growth, defined as the ratio of mean earnings at age 65 to mean earnings at age 19. Parameter δ_h is used to identify the average depreciation rate of human capital of 4.3% during the first year of non-employment, a value estimated by Dinerstein, Megalokonomou, and Yannelis (2022). The direct tuition-related financial cost of schooling κ is calibrated to match the average post-secondary education cost as a share of output, as estimated by Yum (2023).

Lastly, β calibrates to the annual risk-free interest rate of 0.04, and δ calibrates to the capital-output ratio of 3.23 estimated by Fernandez-Villaverde, Krueger, et al. (2011). The earnings shock, ε, serves as the primary source of life-cycle uncertainty. Similar to Huggett et al. (2011), ε follows an *iid* process across time and individuals, and it describes the risk that affects human capital production on the job. Huggett (1993) calibrates $ln\varepsilon$ to be mean negative to generate the depreciation of human capital. I take an agnostic stand and let it mean zero. To reduce computation burden, I allow only two values of ε and target the overall cross-sectional variations in earnings, calculated using the detrended CPS data.

4.3 Model fit

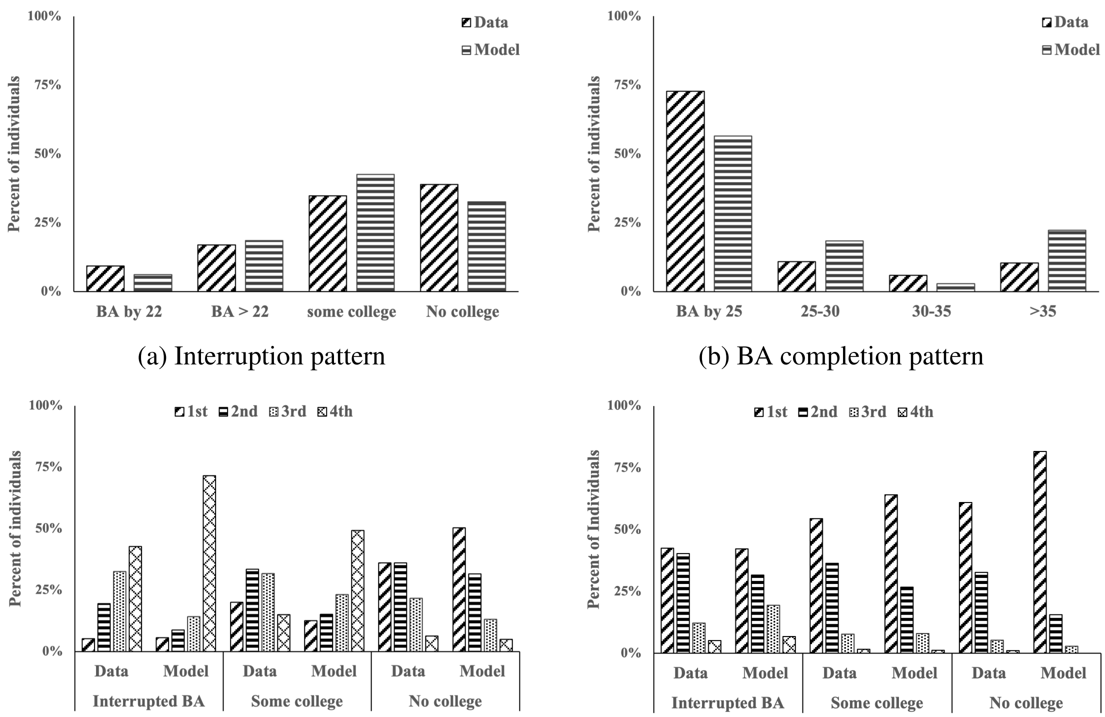
Figure 5 compares a set of untargeted moments between the data and the model simulation. Panel (a) compares college interruption patterns, and Panel (b) compares the ages of individuals completing a bachelor's degree. The model generates patterns similar to those in the data. Panels (c)

[19] I follow Huggett et al. (2011) by removing time and cohort effect from the data and deflating all price variables to the 2009 level.

[20] The college premium is calculated using data from the NLSY79. Because the NLSY79 does not directly record bachelor's degree attainment, the calibration follows the standard convention of treating 16 years of completed schooling as earning a BA. Evidence from the NLSY97 indicates that roughly 10–20% of individuals who accumulate four or more years of college do not ultimately receive a BA, especially among non-traditional students who delay entry or stop out. Calibrating Δ_2 as the premium when an individual reaches 16 years of schooling is therefore a conservative choice. The main welfare results, however, are not sensitive to modest reductions in completion rates, as the gains from flexible access to college remain large and positive.

and (d) further compare the relationship between human capital at age 18 and wealth conditions with college interruption patterns. I split the initial conditions into four equal-valued bins. The patterns to compare are individuals who obtain the BA after some interruptions, individuals with some college experience but not completing the degree, and those without college experience at all. Both the data and model show that those with a higher human capital endowment are more likely to complete a BA and less likely to lack college experience. Similarly, ones with higher wealth endowment are more likely to complete the degree.

Figure 5: Initial conditions and education patterns: data and model moments



(a) Interruption pattern

(b) BA completion pattern

(c) Human capital bins

(d) Wealth bins

Notes: This figure compares data moments to simulated moments from the baseline model. Panel (a) plots the percentage of the sample under each college interruption pattern. Panel (b) plots the percentage of all with a bachelor's degree who complete the degree within each age range. Panel (c) plots the percentage of the sample in each interruption pattern that comes from each of the initial human capital bins. Panel (d) plots the percentage of each interruption pattern that comes from each initial wealth bin.

This paper aims to examine the risks and consumer welfare values associated with empirically relevant intermittent access to college. From the model setup, college education transforms into welfare through the direct utility value and its interactions with the earnings profile. The earnings profile contains information relevant to schooling, including human capital realizable in earnings, the level of risk and risk perception, and the relative value of human capital to physical assets. Hence, it is vital to validate the baseline model-generated heterogeneous life-cycle earnings dynamics with an empirical estimation. Guvenen (2007), Guvenen (2009), and Guvenen and Smith Jr (2014) categorize two patterns of earnings dynamics from the literature: restricted income process (RIP) and heterogeneous income process (HIP). The following process describes the life-cycle earnings:

$$y_{h,t}^{i} = g(\theta_t, X_{h,t}^{i}) + f(\alpha^{i}, \beta^{i}, X_{h,t}^{i}) + z_{h,t}^{i} + \varepsilon_{h,t}^{i}$$
$$z_{h,t}^{i} = \rho z_{h-1,t-1}^{i} + \eta_{h,t}^{i},\ z_{0,t}^{i} = 0$$

where $\{i,h,t\}$ describes individual, age, and time; $\{\rho, \sigma_\alpha^2, \sigma_\beta^2, \sigma_\eta^2, \sigma_\varepsilon^2, corr_{\alpha\beta}\}$ describe persistence, variances and co-variances of the earnings process. $g(\theta_t, X_{h,t}^{i})$ describes the common variances across individuals. $f(\alpha^{i}, \beta^{i}, X_{h,t}^{i})$ describes individual variations, in which α_i is drawn from a distribution governing initial intercept heterogeneity across individuals; β_i describes slope heterogeneity. $z_{h,t}^{i}$ models the AR(1) process of earnings shocks with persistence ρ and innovation η; $\varepsilon_{h,t}^{i}$ models the transient *iid* shocks across time and individuals.

Following Guvenen (2009), I remove the common variations $g(\theta_t, X_{h,t}^{i})$ through fitting a cubed polynomial of the age to the earnings equation and examining the residual process. I use a minimum distance estimation to find the parameters of the income process. Compared to HIP, RIP removes individual slope differences β. Table 5 compares the benchmark model simulated processes to the estimation from Guvenen (2009). Across all parameters of the statistical earnings process, the baseline model demonstrates a strong ability to reflect the empirical earnings process. This result builds upon Chang et al. (2018) by introducing repeated, lumpy human capital investment decisions that create age- and path-dependent lifecycle risk and portfolio choices.

Table 5: Statistical models of earnings

	ρ	σ_α^2	σ_β^2	$corr_{\alpha\beta}$	σ_η^2	σ_ε^2
RIP model						
Baseline	0.981	0.038	–	–	0.011	0.051
Guvenen (2009)	0.988	0.058	–	–	0.015	0.061
HIP model						
Baseline	0.827	0.125	0.00028	−0.005	0.028	0.025
Guvenen (2009)	0.821	0.022	0.00038	−0.230	0.029	0.047

Notes: This table reports the parameter values from estimating RIP and HIP processes. The baseline is reported by simulating the baseline model 50,000 times and fitting the RIP and HIP process to the simulated heterogeneous earnings profile.

5 Main findings

In this section, I present the main findings of this paper: the aggregate and distributional welfare consequences of having flexible access to college. First, I examine the role of college by comparing aggregate variables between the baseline economy and counterfactuals that restrict college access in general equilibrium. I measure the welfare value using each person's lifetime consumption equivalence between the baseline and the counterfactual economies, and aggregate the results using the average of individuals' welfare measures, as outlined by Mukoyama (2010). A negative consumption equivalence indicates that households prefer the original model, while a positive value indicates that households prefer the counterfactual model. A negative value is interpreted as the percentage of original consumption that households are willing to give up to keep the original setting. A positive value is interpreted as the percentage of original consumption that households need to be compensated to maintain the original setting. Then, I inspect the heterogeneous impact of having access to college on people with different endowments at age 18.

5.1 Aggregate effect of having flexible access to college

In the baseline model, a person can flexibly choose to enroll in college at any age before retirement and leave without completing the degree. I examine the aggregate impact of having such flexible access to college and having college at all in Table 6. The first column reports the baseline values. The second column reports the percentage change of values compared to the baseline model when I shut down flexible access to college. The last column reports the change in values when I remove college from the baseline model completely.

Table 6: Aggregate outcomes: baseline, no flexible access, and no college

	Baseline (levels) (1)	No flexible access (% change from col. 1) (2)	No college (% change from col. 1) (3)
BA attainment/population	0.25	−28.48	–
Employment/population	0.61	4.02	−1.06
Y	6.00	0.41	5.64
K/Y	3.23	0.02	0.41
C/Y	0.76	0.20	1.56
w	1.24	0.24	0.27
r	0.04	−1.25	−1.41
Consumption equivalence	–	−3.74	−14.77

Notes: Column (1) reports baseline outcomes in levels. Column (2) reports percentage changes relative to the baseline when flexible access to college is removed (individuals must enroll at age 19 or not at all; no returning to college is allowed once left). Column (3) reports percentage changes relative to the baseline when college is eliminated entirely. Percentages are shown without the "%" sign.

When I remove flexible access to college, individuals can only have college access right after high school by age 19, and cannot return to college once they leave school. This means that the 19% of individuals who complete college after age 22 in Panel (a) of Figure 5 have to either advance their degree attainment age, choose non-stopping but part-time schooling, or give up college after age 22. As a result, such a restriction reduces total degree attainment by 28%. More people are working, and more assets are being saved as physical capital, leading to a modest increase in output, the capital share, the consumption share, and employment. In the general equilibrium, additional capital supply reduces the interest rate by 1%, while the wage rate increases by 0.2%. The consumption equivalence reduces by 3.7%, indicating that flexible college access embeds important consumer welfare, a dimension in addition to output and consumption.

In the last column, I remove college completely. Individuals can only choose to work or stay at home. As a result, more assets can be accumulated in savings without incurring tuition-related costs, subsequently being converted into production capital. In general equilibrium, the interest rate decreases (by -1.4%), and the wage rate increases (by 0.3%). Consequently, output, capital, and consumption increase more. However, consumer welfare decreases by nearly 15%, representing the gross welfare value of college.

Overall, Table 6 shows a difference in enrollment and degree attainment responses, suggesting the importance of separating an intensive margin, as college enrollment, from an extensive margin, as college degree completion. Moreover, college has a significant impact on consumer welfare for the aggregate economy. When comparing the consumption equivalence between Columns (2) and (3), flexible college access accounts for 25% of the gross welfare value of college.

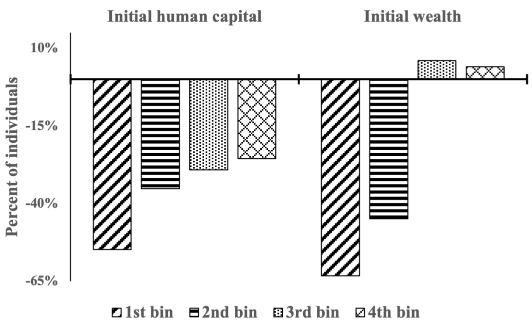
5.2 Heterogeneous impact of access to college

Empirical evidence suggests a connection between initial endowments and college patterns. In this subsection, I examine the heterogeneous value of flexible access to college for individuals with different initial conditions and the alternative heterogeneous behaviors that would occur in a counterfactual without such flexibility. Specifically, I split individuals into four equally valued bins along the initial human capital dimension and four along the initial wealth dimension. I explore the change in degree attainment and welfare for each bin after restricting college access.

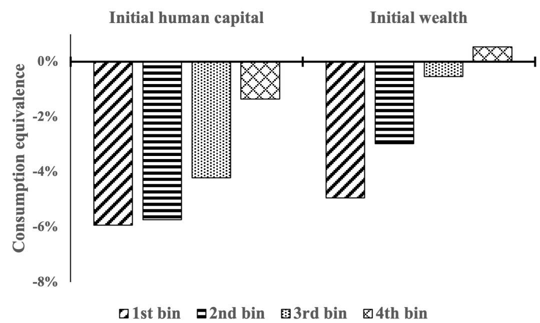
The first row in Figure 6 compares the baseline values to the counterfactual model of removing flexible access to college. Panel (a) examines the changes in degree attainment along the initial human capital and initial wealth margins, and Panel (b) examines the changes in welfare along the initial endowments.

In Panel (a), people with a higher human capital endowment experience a smaller reduction in degree completion compared to those with a lower initial human capital endowment. Individuals in the top two wealth bins have a slight increase in degree completion, whereas those from the lower two bins incur a significant loss in completion. About 60% of those from the lowest bin can no longer complete their degree without flexible access to college. This shows that individuals with the highest wealth or human capital endowment are less affected by flexible access to college.

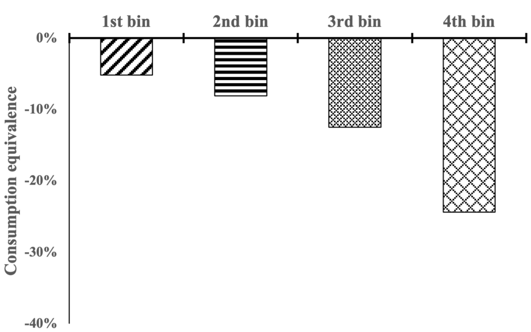
Figure 6: Heterogeneous impact of flexible college access and gross welfare value of college



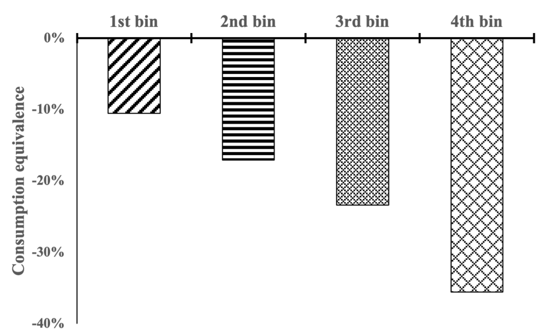
(a) Remove flexible access: changes in degree attainment



(b) Remove flexible access: changes in welfare



(c) Remove college: welfare change by initial human capital



(d) Remove college: welfare change by initial wealth

Notes: Panels (a)–(b) report changes relative to the baseline model when flexible access to college is removed. Flexible access is defined as the ability to enroll after age 19 or to return after leaving. Panel (a) shows degree attainment changes by initial human capital and wealth bins (four equal-valued bins; bin 1 is lowest, bin 4 highest). Panel (b) shows welfare changes measured by consumption equivalence. Panels (c)–(d) report welfare changes when college is removed entirely: Panel (c) by initial human capital bins, Panel (d) by initial wealth bins.

Those with the lowest initial human capital values rely heavily on later and flexible access to college.

In Panel (b), most individuals experience a reduction in welfare in terms of consumption equivalence when flexible access to college is removed. Those from lower human capital and wealth bins pay a higher welfare cost. However, individuals from the highest wealth bin experience a minor welfare improvement, primarily because a higher proportion of them complete college at a younger age, thereby receiving the investment returns from their college education for a longer lifespan.

The bottom row of Figure 6 illustrates the heterogeneous welfare cost when removing college completely from the baseline model. Individuals from the top wealth or human capital bins experience the greatest welfare loss. Comparatively, those from lower wealth or human capital bins generally suffer from less severe welfare loss. This shows a stark contrast to the welfare value for flexible access to college in Panel (b).

The reverse welfare effect between Panel (b) and Panels (c) and (d) of Figure 6 suggests that people with higher initial wealth and human capital endowment value college more, but having flexible access to college matters more to people with lower initial conditions.

6 Mechanism

This section examines the mechanisms by which college value is transformed into lifetime welfare through three channels: price, investment, and risk propagation. I first explore the price channel by comparing the aggregate results between partial and general equilibrium exercises. Next, I distinguish between the college investment and risk propagation channels by identifying the changes in human capital accumulation and risk perception that occur as a result of attending college. Finally, I focus on the heterogeneity of initial endowments while studying investment and risk propagation channels.

6.1 General equilibrium price channel

Table 6 shows that having different levels of access to college affects aggregate asset holdings and the allocation of aggregate labor supply. In general equilibrium, it results in a shift in market-clearing wage and interest rates. To isolate the price channel that impacts college enrollment, degree attainment, and welfare, I show in Table 7 the difference of aggregate variables when restricting college access with the baseline prices and with the new general equilibrium prices.

Columns (1) - (3) in Table 7 present the change of aggregate variables after removing flexible access to college. Overall, the entirety of the decrease in degree completion in Table 6 Column

(2) comes from Column (1) in Table 7. The general equilibrium price effects have only a modest positive impact on the degree of completion and consumption equivalence, modifying the initial loss from Column (1).

Column (1) fixes the interest and wage rates at the baseline level and compares the aggregate variables to the baseline values. This leads to a 32% reduction in degree completion, and consumer welfare decreases by nearly 5%. In Column (2), I relax only the wage rate to the general equilibrium level (about 0.24% higher than the baseline level) when there is no flexible access to college. The interest rate remains at the baseline level. All values in Column (2) are compared to the levels in Column (1) of the experiment. A higher wage rate leads to a higher return on human capital investment, inducing a slight increase in college activities compared to Column (1) (a 0.42% increase in degree attainment). However, the feedback on output and consumer welfare is minimal.

Column (3) allows both prices to adjust to the general equilibrium level. The reported values in Column (3) compare to Column (2) experiment levels.[21] The interest rate is about 1.25% lower than the baseline level. A lower interest rate creates a lower return to assets, incentivizing individuals to substitute capital savings for human capital investment. As a result, degree completion continues to increase by 5% compared to Column (2). The lower interest rate also reduces capital costs to firms. In general equilibrium, both output and the capital-to-output ratio increase by about 1%. Consumer welfare continues to increase by 0.73% from Column (2). This suggests that the general equilibrium price channel only has a negligible impact on the welfare value reported in Table 6.

I conduct a similar comparison in the last three columns of Table 7 to isolate the price channel that leads to the general equilibrium results in Column (3) of Table 6 when college is completely removed from the baseline model. In Column (4) of Table 7, the college option explains 16% of the consumer welfare drop from the baseline mode, holding all prices fixed. When relaxing the wage rate to the new general equilibrium with no college in Column (5) (a 0.27% increase from the baseline wage rate), consumer welfare increases by 0.5% from Column (4). After relaxing the interest rate in Column (6) (with a 1.4% reduction in interest rate), consumer welfare increases by 0.87% from Column (5).

Altogether, Table 7 shows that the price channel from the general equilibrium rearrangement of individuals on human capital and asset holdings has a modicum impact in examining the welfare consequences of college access. The following section examines the channels that account for the majority of the remaining adjustment and welfare throughout the life cycle of college valuation.

[21] Note that Column (3) values in Table 7 are different from Column (2) Table 6. This is because Column (2) Table 6 reports the comparison between values in GE with no flexible college access to values in the baseline level. The same difference holds between Column (6) in Table 7 and Column (3) in Table 6.

Table 7: Aggregate outcomes: partial vs. general equilibrium under restricted college access

	No flexible access			No college		
	Fixed r & w (1)	Fixed r (2)	GE (3)	Fixed r & w (4)	Fixed r (5)	GE (6)
BA attainment/population	-31.87	0.42	4.54	–	–	–
Employment/population	4.15	-0.07	-0.05	-0.23	-0.07	-0.76
Y	-0.84	0.06	1.20	3.09	0.03	2.45
K/Y	-1.14	-0.24	1.42	-1.98	-0.37	2.81
C/Y	0.00	0.06	0.14	0.76	0.03	0.76
Consumption equivalence	-4.69	0.28	0.73	-15.96	0.54	0.87

Notes: All entries are percentage changes; the "%" sign is omitted.
Columns (1)–(3) report changes when flexible access to college is removed (individuals must enroll at age 19 or not at all; no returning once left). Column (1) is relative to the baseline with both r and w fixed. Column (2) is relative to Column (1), keeping r fixed at baseline but allowing w to adjust in GE (about 0.24% above baseline). Column (3) is relative to Column (2), allowing both prices to adjust in GE (about 1.25% lower r and 0.24% higher w than baseline).
Columns (4)–(6) report changes when college is eliminated entirely. Column (4) is relative to the baseline with both r and w fixed. Column (5) is relative to Column (4), keeping r fixed at baseline but allowing w to adjust in GE (about 0.27% above baseline). Column (6) is relative to Column (5), allowing both prices to adjust in GE (about 1.41% lower r and 0.27% higher w than baseline).

6.2 Channels through the values of college

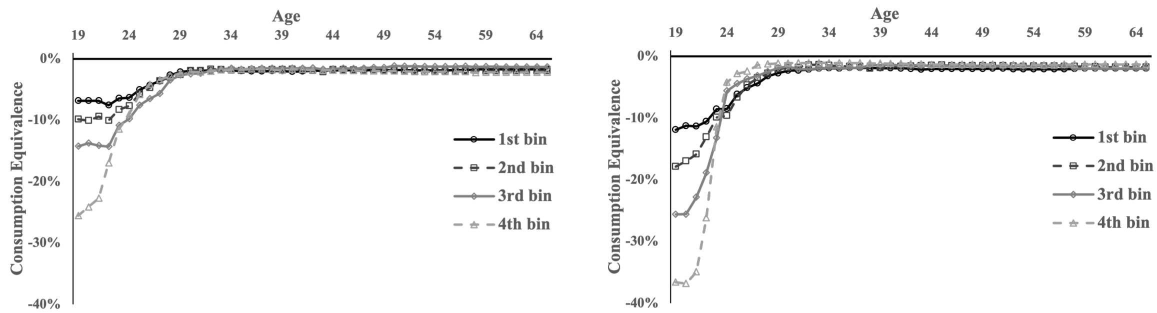
Numerous studies investigate the investment value of school education, a direction initiated by Mincer (1974), Ben-Porath (1967), and Card (1994). More education in schools produces higher human capital, leading to higher labor income. Yet, human capital accumulation resembles physical asset accumulation, in which it embeds important propagation quality to life-cycle risk (e.g. Meghir and Pistaferri, 2011; Barrow and Malamud, 2015). Yang and Casner (2021) provides a theoretical account of how labor market risk and college returns are transmitted to the enrollment decision. In this section, I start by estimating the gross value of college for each age throughout one's life cycle. Then, I decompose this into the investment value and the risk propagation value. A high investment value motivates school learning for young people, while a reduction of risk explains later age schooling. Lastly, I connect the values to initial endowments. The findings explain the heterogeneity in college enrollment and completion patterns.

6.2.1 Gross value of college

I present the gross value of college for each age by the initial conditions in Figure 7. It is measured by the lifetime consumption equivalence when shutting down access to college for each age. All counterfactuals are simulated in partial equilibrium, keeping baseline prices constant. This ensures that, all else being equal, the consumption equivalence comes solely from an individual's valuation of having one additional year of college access.

Panel (a) presents the gross value of college for people in each initial human capital endowment bin, and Panel (b) presents the gross value of college for each initial wealth endowment bin. Across

Figure 7: Heterogeneous gross value of college by age

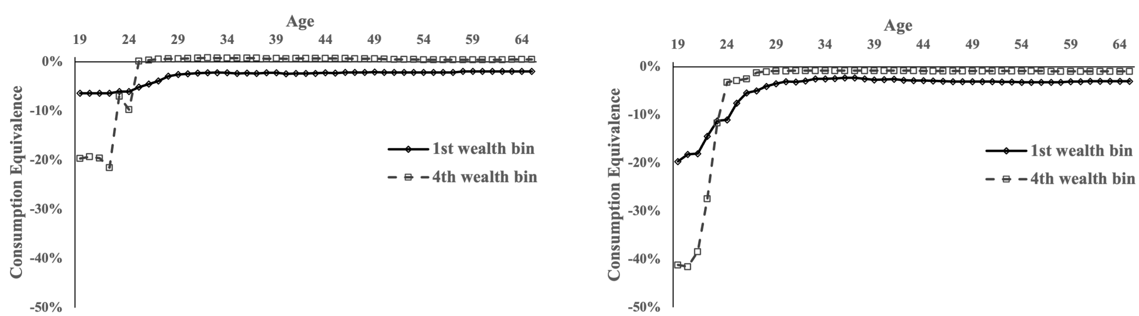


(a) Gross value by initial human capital bins (b) Gross value by initial wealth bins

Notes: Panels plot the consumption–equivalence value of having access to college at each age. Values are calculated by comparing a model without access at a given age to one with access only at that age. Negative values indicate the share of baseline consumption households would give up to retain access. Panel (a) reports values by initial human capital bins; Panel (b) by initial wealth bins.

all human capital and wealth bins, the value of college reaches its peak near age 20 and diminishes quickly until around age 25 to 29. It maintains at a relatively constant near-zero level afterward. This corresponds to Figure 4, where the majority of college enrollment and completion happens before age 30. Individuals with higher initial human capital or wealth have a higher gross value of college at age 19, and their valuation diminishes more rapidly as they grow older. Those at the lowest human capital or wealth bin have the lowest valuation; however, it is still valued at around 10% of their baseline model lifetime consumption at the starting age, and it also decreases more slowly than the rate at the top endowment bins.

Figure 8: Gross value of college by age, conditional on human capital



(a) 1st human capital bin (b) 4th human capital bin

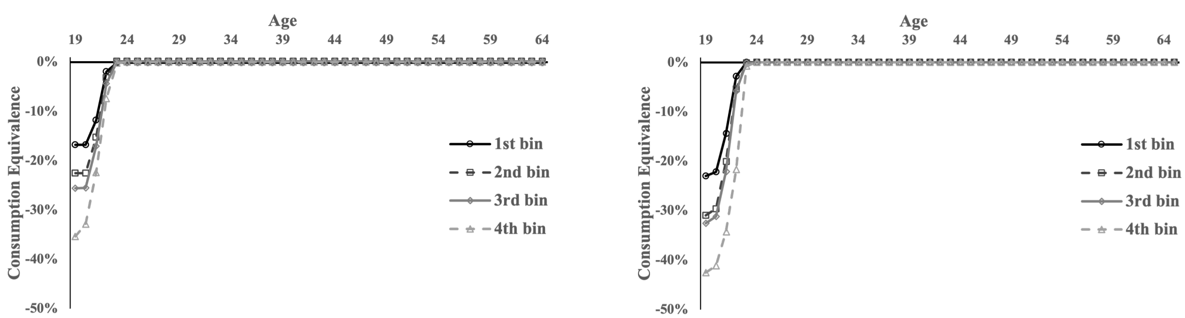
Notes: Panels plot the consumption–equivalence value of having access to college at each age, conditional on initial human capital. Values are calculated by comparing a model without access at a given age to one with access only at that age. Negative values indicate the share of baseline consumption households would give up to retain access. Panel (a) shows values for individuals in the 1st human capital bin; Panel (b) for individuals in the 4th human capital bin. Each panel further distinguishes by initial wealth: solid diamonds denote the 1st wealth bin and dashed squares the 4th wealth bin.

Figure 8 decomposes the interaction between wealth and human capital. For Panel (a), I examine the impact of initial wealth on college valuation for all with the lowest initial human capital. Having access to college has a consistent positive value for individuals from the first human capital and wealth bins. However, individuals value college much more (20% of the baseline value) at age 19 if they are from the fourth wealth bin. Interestingly, their valuation of college quickly disappears after age 24. The same pattern persists when comparing the gross value of college between the first and fourth wealth bins for the fourth initial human capital bin in Panel (b). The difference between Panel (a) and (b) is that individuals with higher initial human capital have a higher lifetime value of college, controlling for initial wealth. In summary, higher initial wealth raises early age valuation and lowers later age valuation of college. Higher initial human capital increases the valuation of college throughout the life cycle.

6.2.2 Investment value of college

I measure the investment value of college in Figure 9 by calculating the consumption equivalence of having access to college at each age while isolating the idiosyncratic human capital shock ε in the model. After removing ε from the baseline model, the remaining welfare value from college comes from human capital production at college, not perturbed by exogenous factors.[22]

Figure 9: Heterogeneous investment value of college by age



(a) Investment value by initial human capital bins (b) Investment value by initial wealth bins

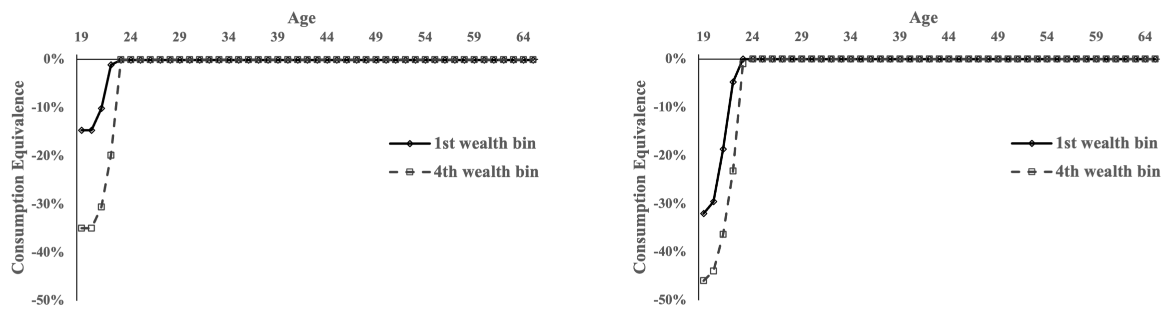
Notes: Panels plot the consumption–equivalence value of having access to college at each age in an environment without exogenous risk. Values are calculated by comparing a model without access at a given age to one with access only at that age. Negative values indicate the share of baseline consumption households would give up to retain access. Panel (a) shows values by initial human capital bins; Panel (b) by initial wealth bins.

The investment value of college essentially mimics the gross value in Figure 7. Individuals with the highest human capital or wealth endowment have the highest investment value. This is because human capital production is a multiplicative process. The higher human capital, the easier it reproduces, corresponding to the self-productive and dynamically complementary qualities

[22]Even though the return to college becomes deterministic, it is still important to measure its value through consumption equivalence rather than monetary return. This is because of the differential utility cost between schooling and working (Belley and Lochner, 2007; Yang and Casner, 2021).

described by Cunha et al. (2006). The investment value of a college education diminishes faster than its gross value and nearly vanishes after the age of 24. This corresponds to the extensive literature on returns to college, where its value motivates early age schooling to accumulate lifetime returns. After a certain age, the lifetime returns of college may be outweighed by its cost (e.g. Becker, 1975). Hence, life-cycle models often consider college only in the first model stage before engaging in the labor market with no repeat afterward (e.g. Heathcote, Storesletten, and Violante, 2010; Kim, 2022).

Figure 10: Investment value of college by age, conditional on human capital



(a) Investment value for 1st human capital bin (b) Investment value for 4th human capital bin

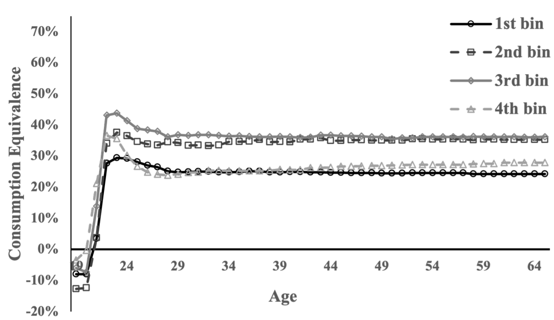
Notes: Panels plot the consumption–equivalence value of having access to college at each age in an environment without exogenous risk, conditional on initial human capital. Values are calculated by comparing a model without access at a given age to one with access only at that age. Negative values indicate the share of baseline consumption households would give up to retain access. Panel (a) shows values for individuals in the 1st human capital bin; Panel (b) for individuals in the 4th human capital bin. Each panel further distinguishes by initial wealth: solid diamonds denote the 1st wealth bin and dashed squares the 4th wealth bin.

Figure 10 examines the impact of initial conditions on investment value. It is worth noting that initial wealth endowment plays a significant role in college valuation, even controlling for human capital endowment. This is because college tuition as a fixed direct cost consists of a smaller share as the wealth endowment increases. However, the lifetime return to human capital dominates the savings return. Panel (a) shows the difference in investment value by wealth for individuals in the first initial human capital bin. Those from the fourth wealth bin have more than double the investment value at age 19 than those from the first wealth bin. The investment value disappears for all after age 24. Panel (b) shows the valuation for all from the fourth human capital bin. It has a similar pattern to Panel (a), although the difference in investment value between the first and fourth wealth bins is much smaller in Panel (b). Overall, individuals from higher initial wealth and human capital bins have a higher investment value in college. After age 24, the investment value disappears for everyone.

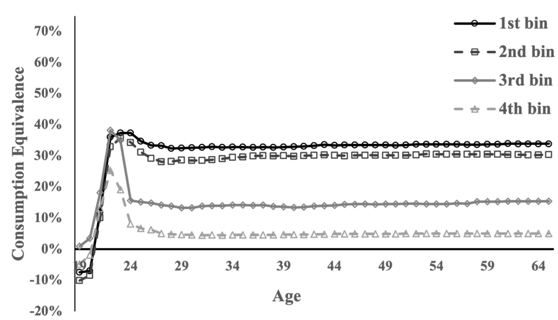
6.2.3 Risk propagation value of college

The difference between the gross value of college and the investment value suggests that risk alters the welfare value of college, an aspect largely omitted by the literature. Without considering flexible access to college, Kim (2022) and Schweri et al. (2011) show that college-educated workers have more volatile life-cycle earnings paths. Yet, Meghir and Pistaferri (2011) project that individuals mitigate life-cycle risk through means of self-insurance, either as *ex-ante* precautionary saving or *ex-post* adjustment. I explore the risk propagation of college by examining the welfare differential of risk between models without and with college. I first measure the risk valuation in models with no college. This is calculated by using the consumption equivalence from a model with risk to a model without risk for each age, and both models have no access to college. I then repeat the calculation for risk valuation, but between two models with access to college. The difference between the two risk valuations reflects the role of college in a risky environment. In a model with risk-averse agents, risk generates welfare loss, measured as a positive value in consumption equivalence by construction. Hence, if the difference in risk valuations is positive, it indicates that a portion of the consumer welfare loss from risk is removed by attending college, showing risk reduction due to college attendance. Conversely, a negative value represents an amplification of risk by college.

Figure 11: Heterogeneous risk propagation of college by age



(a) Risk propagation by initial human capital bins



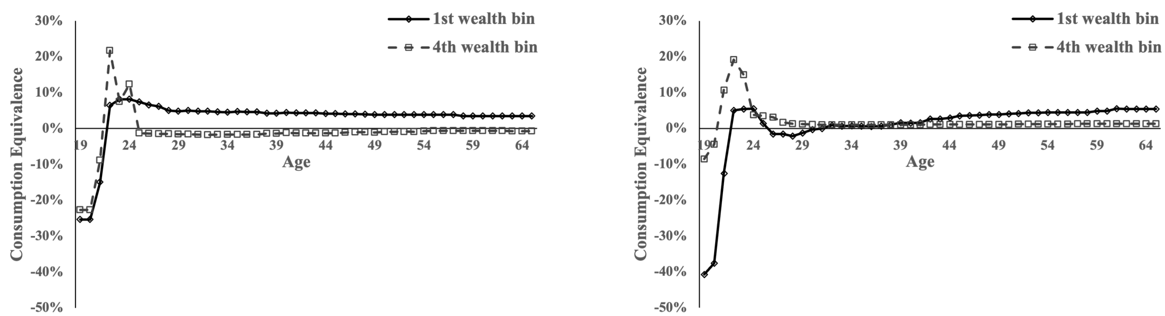
(b) Risk propagation by initial wealth bins

Notes: Panels show how college access changes the welfare evaluation of risk. The measure is the difference in welfare cost of risk, computed from consumption equivalence, between models with college and without college at each age. Negative values mean college amplifies welfare risk, while positive values mean college reduces welfare risk. Panel (a) shows results by initial human capital bins; Panel (b) shows results by initial wealth bins.

Figure 11 shows the life-cycle risk propagation value of college. For Panels (a) and (b), college slightly amplifies the cost of risk before age 22. However, college essentially removes the welfare cost of risk, resulting in a risk reduction value between the ages of 22 and 29. After the age of 29, college has a more minor but persistent effect in alleviating the welfare cost of risk. For younger people under the age of 22, their initial endowment has a less significant impact on the risk propagation value of college. For older people, however, college reduces risk loss more for those with smaller initial wealth endowments, and for those with middle levels of initial human capital endowments.

After the age where the investment value of attending college in Figure 9 disappears, the emergence of the risk reduction quality of college explains the importance of welfare gain associated with having flexible access to college, shown in Table 6 and the later age college enrollment in Figure 1.

Figure 12: Risk propagation of college by age, conditional on human capital



(a) Risk propagation for 1st human capital bin (b) Risk propagation for 4th human capital bin

Notes: Panels show how college access changes the welfare evaluation of risk, conditional on initial human capital. The measure is the difference in welfare cost of risk, computed from consumption equivalence, between models with college and without college at each age. Negative values mean college amplifies welfare risk, while positive values mean college reduces welfare risk. Panel (a) reports results for the 1st human capital bin; Panel (b) reports results for the 4th bin. Within each panel, solid diamonds denote the 1st wealth bin and dashed squares the 4th wealth bin.

Figure 12 isolates the interactions of initial endowments in the risk propagation value of college. Panel (a) plots the risk propagation value for the first and fourth wealth bins while limiting the human capital within the first bin. Panel (b) plots them for all from the fourth human capital bin. College provides a more significant risk reduction value to individuals with low initial wealth after the age of 22 in both panels. For younger individuals from lower wealth brackets, college amplifies the risk of loss more, conditional on human capital. Interestingly, for individuals of the same wealth, college provides more significant risk reduction for people with lower human capital.

Overall, having access to college provides a risk-reduction value, reducing the welfare cost of risk to all individuals after age 22. This effect is especially pronounced for individuals with low initial human capital and wealth. This explains the later age enrollment patterns from data and the welfare values of flexible access to college. For individuals under 22, college amplifies risk. In a heterogeneous agent model, Yang and Casner (2021) argue that depending on the relative scale of risk and returns from college, the precautionary savings motive and risk aversion can compound or negate each other in propelling one to enroll in school. The sizable gross value of college in Figure 7 indicates that the investment value outweighs the risk augmentation at a young age.

6.2.4 Removing welfare aggregation in values of college and college attainment

The life-cycle valuations of college measured in Section 6.2.1, Section 6.2.2, and Section 6.2.3 aggregate individuals from each bin for welfare measure, following the average weighting as Mukoyama (2010). In this subsection, I examine the contribution of initial conditions to college value and college timing without aggregation through regression analysis.

First, I explore how each initial endowment impacts the value of college. I run OLS regressions with dependent variables as gross value, investment value, and risk propagation value of college at age 19, the starting age of the model. For each regression, I include independent variables from initial human capital, initial wealth, and the present value of lifetime consumption. The regression results are reported in Table 8. The consumption equivalence calculated for gross value and investment values from Section 6.2.1 and Section 6.2.2 is negative, reflecting the cost of removing college. I take their inverse values so that the explanation of the regression coefficient is consistent with the direction of the risk reduction of college. I also standardize all coefficients to the distribution of each variable for ease of explanation.

Table 8: Regression results: initial endowments and college value

	Gross value (1)	Investment value (2)	Risk reduction value (3)
Human capital endowment	0.316***	0.760***	-0.020***
Wealth endowment	0.196***	0.419***	0.047***
Lifetime consumption	✓	✓	✓
R^2	0.451	0.935	0.128

Notes: This table reports standardized coefficients from regressions on a simulated sample of 50,000 individuals in the baseline model. The dependent variables are gross value, investment value, and risk reduction value of college at age 19. All regressions control for lifetime consumption. *** denotes significance at the 1% level.

Table 8 shows that a one standard deviation increase of initial human capital leads to a 0.32 standard deviation increase of gross value, 0.76 standard deviation increase of investment value, and -0.02 standard deviation decrease of risk reduction value of college. The initial wealth endowment has a sizable positive impact on the gross value and investment value of college, but a much smaller effect on the risk reduction value of college (0.047 standard deviation increase).

Next, I conduct regression analyses linking the investment value and risk reduction value of college for individuals at age 19 to the college intermittence pattern. Table 9 displays the regression results for the dependent variables: college experience, college completion, and age of completion, while controlling for investment, risk reduction values, and lifetime consumption. For the last column, BA completion age, I include only simulated observations of all who completed college.

Investment value plays a dominant role in people's decision to enroll in college. A one standard deviation increase in investment value leads to a 0.55 standard deviation increase in college enrollment. It also has comparable contributions to college completion (a near 0.5 standard deviation increase in BA completion). Investment value also largely contributes to the earlier age of college completion (reduces BA completion age by 0.46 standard deviation). A one standard deviation increase in the risk reduction value raises college attendance by 0.02 standard deviations, BA completion by 0.1 standard deviations, and reduces BA completion age by 0.04 standard deviations.

Table 9: Regression results: investment and risk reduction values and college timing

	College experience (1)	BA completion (2)	BA completion age (3)
Investment value	0.552***	0.496***	-0.464***
Risk reduction value	0.019***	0.099***	-0.038***
Lifetime consumption	✓	✓	✓
R^2	0.364	0.270	0.329

Notes: This table reports standardized coefficients from regressions on a simulated sample of 50,000 individuals in the baseline model. Column (1) uses college experience as the dependent variable, Column (2) uses BA completion, and Column (3) uses BA completion age (restricted to the subsample of individuals with a college degree). All regressions control for lifetime consumption. The investment and risk reduction values are calculated as the relevant value of having access to college at age 19. *** denotes significance at the 1% level.

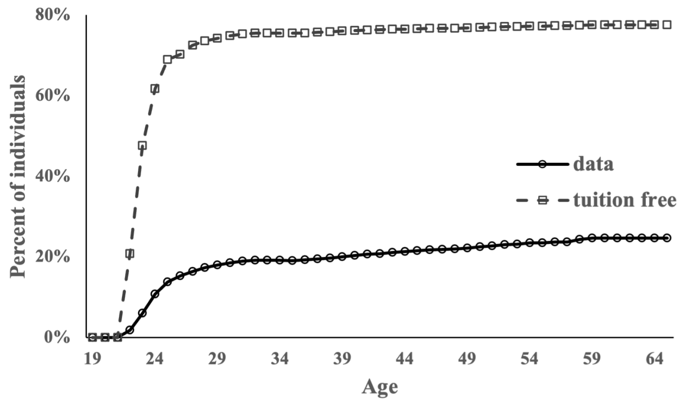
In conclusion, initial human capital and wealth endowments play an important role in college valuation. A more substantial college investment or risk reduction value increases college enrollment, attainment, and early completion. Therefore, policies aiming at improving college attainment should consider the role both endowments play.

7 Extension discussions

7.1 Policy evaluation: College Promise Programs

Growing empirical studies have examined the place-based College Promise Programs that offer tuition coverage to students from certain locations, such as Kalamazoo Promise (Bartik, Hershbein, and Lachowska, 2021), Georgia Hope (Singell Jr, Waddell, and Curs, 2006), Tennessee Promise (Nguyen, 2020), Pittsburgh Promise, and Denver Scholarship (LeGower and Walsh, 2017), etc. Lavy (2021) shows heterogeneous positive long-term gains by gender from a free school program. Miller-Adams (2021) summarizes the literature on various College Promise Programs and argues that they support college attendance and completion, and have positive spillover effects on the implementation region.

Figure 13: Life-cycle degree attainment: data vs. tuition-free program



Notes: Figure compares data to model-simulated life-cycle degree attainment under a tuition-free program, where tuition costs are publicly funded. Solid line denotes data; dashed line denotes model simulation.

In this section, I extend the place-based tuition-free College Promise Program nationwide. While private entities and charitable foundations fund many place-based programs, I experiment with a nationwide public-funded tuition-free program. In my model, all college attendees receive a tuition-free voucher with the value of κ, the baseline model college cost. The total college cost is calculated as the sum of all vouchers redeemed in the economy. Although individual students do not pay for college directly, the government covers the aggregate tuition cost through its tax revenue.

Figure 13 shows that the tuition-free program drastically increases the college completion rate from a young age. About 89% of degree holders complete college before age 25. Although it removes the direct financial cost, attending college still bears opportunity and utility costs. About 22% of the population still does not have a college degree.

Table 10: Aggregate outcomes: baseline vs. nationwide tuition-free program

	Baseline (levels) (1)	Tuition-free (% change from col. 1) (2)
BA attainment/population	0.25	212.79
Employment/population	0.61	−2.87
Y	6.00	−0.86
K/Y	3.23	0.85
C/Y	0.76	0.63
Consumption equivalence	–	39.60

Notes: Column (1) reports baseline outcomes in levels. Column (2) reports percentage changes relative to the baseline when college attendees receive free tuition and the government covers the total tuition cost by balancing the budget. Percentages are reported without the "%" sign.

Table 10 describes the aggregate impact of the tuition-free program. The percentage of college degree holders increases from 25% to 78%. The employment-to-population ratio decreases by 2.9%. However, output only decreases by 0.86%, while the capital-output and consumption-output ratios increase by 0.85% and 0.63%, respectively. This is because individuals save less for tuition and generally have higher take-home labor income because of college completion and skill upgrading from a young age. Though college is funded by public tax revenue, which raises the lump-sum tax by 8%, the nationwide tuition-free College Promise Program brings a nearly 40% welfare increase in general equilibrium.

7.2 Policy evaluation: Tax incentive

Previous sections establish that flexible access to college generates important welfare gains for the aggregate economy, particularly for initially less advantaged individuals. To examine a targeted policy that builds on this channel, I consider a labor income tax exemption for all workers who attend college part-time. Compared to tuition subsidies, this is a narrower but more targeted intervention that lowers the cost of combining work and study without subsidizing full-time students. This measure is implementable within existing fiscal institutions and is designed to encourage college attendance among those who rely most on flexible access.

Table 11: Aggregate outcomes: baseline vs. tax exemption for part-time students

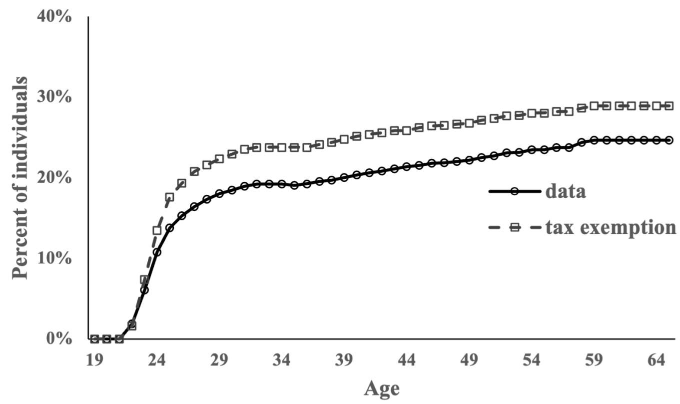
	Baseline (levels) (1)	Tax exemption (% change from col. 1) (2)
BA attainment/population	0.25	16.54
Employment/population	0.61	0.77
Y	6.00	0.09
K/Y	3.23	−0.38
C/Y	0.76	−0.16
Consumption equivalence	–	1.62

Notes: Column (1) reports baseline outcomes in levels. Column (2) reports percentage changes relative to the baseline when the labor income tax is removed for workers who are also part-time students. Percentages are reported without the "%" sign.

Table 11 summarizes the aggregate implications of this policy. Degree attainment rises by 17%, though the increase is more modest than under the tuition-free program in Table 10. Employment, output, and wages move only slightly, while capital–output and consumption–output ratios decline as households save less for tuition. To balance the government budget, the policy is financed by a 2% increase in the lump-sum tax, which absorbs part of the initial benefit. As a result, aggregate welfare in general equilibrium increases by only 1.6%.

While the average effect is small, the policy's main impact is distributional. Figure 14 shows that the tax exemption raises degree completion primarily among individuals aged 24–30, a group with less advantaged backgrounds that would otherwise delay or forego college. Table 12 breaks

Figure 14: Life-cycle degree attainment: data vs. tax exemption program



Notes: Figure compares data to model-simulated life-cycle degree attainment under a tax exemption program, where labor income tax is removed for part-time students. Solid line denotes data; dashed line denotes model simulation.

down outcomes by initial human capital and wealth endowments. It shows that enrollment and degree completion responses to the tax exemption policy are highly concentrated among individuals with low and middle initial human capital and wealth endowments. For example, enrollment increases most strongly in the first and second human capital quintiles (27.5% and 50.0%), and in the first two wealth quintiles (16.7% and 15.0%). By contrast, the highest initial endowment groups exhibit virtually no enrollment response. Degree completion follows a similar pattern, with gains disproportionately accruing to the least-advantaged groups. Nevertheless, the policy still benefits people from high initial endowment bins by encouraging them to complete their degree.

The welfare decomposition reinforces this heterogeneity. In partial equilibrium with fixed wages, interest rates, and taxes, the policy yields sizable welfare improvements, especially for the second and third endowment groups. However, once general equilibrium feedbacks and the associated tax incidence are incorporated, average gains fall to just 1.6% of consumption equivalence. Moreover, the lowest human capital group actually experiences a welfare loss in the general equilibrium. Taken together, the results indicate that while the tax exemption succeeds in shifting educational outcomes for disadvantaged individuals, the overall welfare effects are modest once economy-wide adjustments are considered.

7.3 Robustness: Borrowing limit

This paper examines the impact of college education decisions away from the corner solution by assuming a natural debt limit, whereas much of the literature emphasizes the marginal effects of borrowing constraints (e.g., Hai and Heckman, 2017; Johnson, 2013; Ozdagli and Trachter, 2011; Rothstein and Rouse, 2011; Stinebrickner and Stinebrickner, 2008). In federal student loan policy,

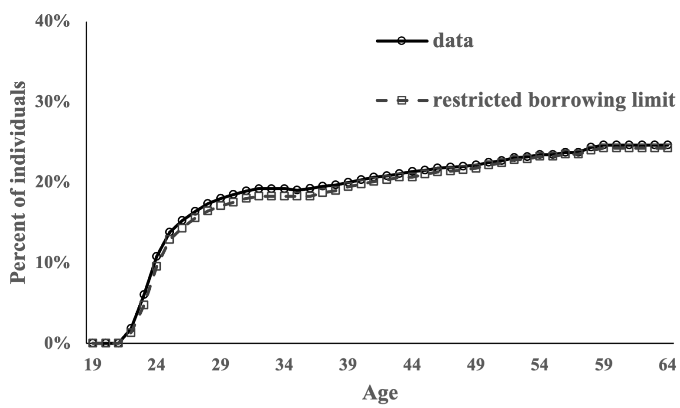
Table 12: Distributional effects: education outcomes and welfare under tax exemption

	Initial human capital				Initial wealth				Average
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	
Education outcomes (%)									
Enrollment	27.5	50.0	16.4	2.3	16.7	15.0	8.2	0.0	14.8
Degree completion	6.9	20.6	14.1	17.3	24.1	25.8	12.7	0.0	16.5
Consumption equivalence (%)									
Fixed r, w, tax	1.1	5.2	4.5	7.9	4.5	6.5	8.0	3.3	5.2
Fixed tax	0.7	5.1	3.9	7.9	4.2	6.3	7.7	3.1	5.0
General equilibrium	-2.3	1.4	0.8	4.3	0.9	2.7	4.4	0.6	1.6

Notes: This table reports changes in education outcomes and welfare by initial endowments relative to the baseline economy under a tax exemption for part-time student-workers. The first panel shows percentage changes in enrollment and degree completion. The second panel reports welfare changes in terms of consumption equivalence (percent of baseline consumption) under three environments: (i) partial equilibrium with fixed interest rates, wages, and taxes; (ii) partial equilibrium with fixed taxes; and (iii) general equilibrium with both prices and taxes adjusting. The "Average" column reports the weighted mean across endowment bins. Percentages are reported without the "%" sign.

the PLUS loan program allows borrowing up to the full cost of attendance minus other aid, with no statutory annual or lifetime cap (Congressional Budget Office, 2017; Cellini, Darolia, and Ritter, 2020). Black, Denning, Dettling, Goodman, and Turner (2023) further analyzes the Grad PLUS program as effectively uncapped borrowing. These features suggest that modeling educational borrowing with a natural debt limit is a realistic benchmark. Nevertheless, I also provide robustness checks by imposing tighter constraints: first, reducing borrowing to 85% of the natural limit, and second, recalibrating the model with a market-based borrowing cap.

Figure 15: Life-cycle degree attainment: data vs. restricted borrowing



Notes: Figure compares data to model-simulated life-cycle degree attainment under a borrowing constraint that reduces the debt limit to 85% of the natural level. Solid line denotes data; dashed line denotes model simulation.

Overall, the borrowing limit does not significantly impact the education and aggregate variables in my model. Figure 15 plots the college degree attainment over the lifecycle. With a tight borrowing limit, the optimal degree completion at each age does not have an observable difference from the data moments, which the baseline model in Figure 4 replicates. Moreover, Table 13 reports the aggregate moments between the baseline model and the model with restricted borrowing. Tightening borrowing constraints directly impacts capital accumulation, leading to significant responses in the interest rate and capital-output ratio. With more difficult access to financial resources, total college completion rates decrease by 2%. This estimation follows the literature on the impact of borrowing and student loan limits (e.g., Abbott et al., 2019; Hai and Heckman, 2017).

Table 13: Robustness: borrowing constraint and aggregate outcomes

	Baseline (levels) (1)	Restricted borrowing (% change from col. 1) (2)
BA attainment/population	0.25	−2.12
Employment/population	0.61	−0.49
Y	6.00	−0.34
K/Y	3.23	−1.41
C/Y	0.76	−0.02
w	1.24	−0.41
r	0.04	2.16

Notes: Column (1) reports baseline outcomes in levels. Column (2) reports percentage changes relative to the baseline when the borrowing limit is reduced to 85% of the natural debt limit. Percentages are reported without the "%" sign.

We also recalibrate the baseline model to incorporate a more restrictive, market-based borrowing limit. Kim (2022) documents that 8% of households in the 2004 Survey of Consumer Finance (SCF) report zero or negative assets. Using a related life-cycle college decision model, Yum (2023) calibrates the borrowing limit to the average debt in equilibrium, which is approximately 1% of the five-year GDP per capita. Following this approach, we set the borrowing limit to 21.67% of the natural debt limit. In the recalibrated baseline, 5.3% of individuals hold non-positive assets, and the average debt-to-GDP ratio is 0.8%, both of which are broadly consistent with the evidence in Kim (2022) and Yum (2023), while the model continues to match the other key targets reported in Section 4.

Table 14 reports the aggregate effects of college under this tighter borrowing limit. Most outcomes remain close to the main results in Table 6, but the welfare implications change markedly. Restricting flexible access to college now reduces welfare by 8.6% of consumption, compared to 3.7% in the baseline model, while removing college entirely reduces welfare by only 9.1%. BA attainment also falls by 52% in the restricted-borrowing economy, nearly double the 28% decline observed in the baseline model. Together, these results imply that flexible access accounts for the majority of the welfare value of college in the restricted-borrowing setting. The mechanism is intuitive: with limited borrowing ability, households, especially those from disadvantaged backgrounds, cannot fully insure against shocks through asset markets or shift resources from future assets to current human capital investments. Later-age college opportunities, therefore, play a much stronger role in alleviating these constraints and generate a disproportionately large welfare gain.

Table 14: Robustness: aggregate outcomes under a market-based borrowing limit

	Recalibrated Baseline (levels) (1)	No flexible access (% change from col. 1) (2)	No college (% change from col. 1) (3)
BA attainment/population	0.25	−51.99	–
Employment/population	0.62	1.89	−2.58
Y	5.75	1.45	4.00
K/Y	3.28	0.05	0.07
C/Y	0.76	−0.44	0.94
w	1.25	0.00	0.01
r	0.04	0.01	−0.01
Consumption equivalence	–	−8.57	−9.05

Notes: Column (1) reports baseline outcomes in a recalibrated economy with a market-based borrowing limit (set to 21.67% of the natural debt limit). Column (2) reports percentage changes relative to this baseline when flexible access to college is removed (individuals must enroll at age 19 or not at all; no returning once left). Column (3) reports percentage changes relative to this baseline when college is eliminated entirely. Percentages are reported without the "%" sign.

7.4 Robustness: Schooling uncertainty

An extensive literature documents the various sources of risk embedded in college education (e.g., Bound, Lovenheim, and Turner, 2010; Light and Strayer, 2000; Stinebrickner and Stinebrickner, 2012, 2014). Compared to labor market risk, Yang and Casner (2021) argue that the relative risk between school and work matters. In the main model, I construct and calibrate the labor market risk ε relative to the college risk to examine the risk propagation and investment qualities of college education against labor market risk. As a robustness check, I introduce a tuition shock ε_κ that approximates the various uncertainties associated with college attendance.[23] The tuition shock adopts from Yum (2023). The mean of ε_κ calibrates to the average education cost as a share of output, and its variance calibrates to the percentage of students completing college without gap and stopout.[24] In this setting, ε_κ removes its relevance from the labor productivity shock ε in the main model, leaving ε to capture the absolute labor market risk.

[23] In previous versions, I also introduced a utility shock if one attends college to model the schooling uncertainty. After recalibration, the results stay the same. Additionally, I adopt a tuition shock exercise because the tuition shock also reflects the variations in college costs, as noted by Fu (2014).

[24] Different from my calibration, Yum (2023) calibrates the variance of tuition shock to college wage premium. To ease computation, I use two values from the distribution of ε_κ: $\kappa_l = 0.3199$ and $\kappa_h = 1.1020$. The rest of the model recalibrates to the set of data moments as in Section 4.

Table 15: Robustness: aggregate outcomes with tuition shock

	Baseline with ε_κ (levels) (1)	No flexible access (% change from col. 1) (2)	No college (% change from col. 1) (3)
BA attainment/population	0.25	−18.79	–
Employment/population	0.61	3.53	−0.55
Y	6.00	−1.19	5.59
K/Y	3.23	−0.37	0.08
C/Y	0.76	1.02	1.04
w	1.24	−0.17	0.10
r	0.04	0.54	−0.68

Notes: Column (1) reports baseline outcomes in the alternative calibration with a tuition shock, ε_κ. Column (2) reports percentage changes relative to this baseline when flexible access to college is removed (individuals must enroll at age 19 or not at all; no returning once left). Column (3) reports percentage changes relative to this baseline when college is eliminated entirely. Percentages are reported without the "%" sign.

Column (1) of Table 15 presents the recalibrated aggregate moments with tuition shock, ε_κ. Column (2) reports the counterfactual values once removing flexible access to college from Column (1), and Column (3) removes college completely. Compared to the main results in Table 6, removing college and removing flexible access to college have smaller impacts on the aggregate economy. This is because removing the college options disproportionately removes the associated ε_κ in Table 15, while the results in Table 6 maintain the relative labor market risk ε with the counterfactuals. Nevertheless, the changes in aggregate variables stay relatively similar to Table 6.

8 Conclusion

This paper has shown that post-secondary education in the United States is rarely completed in a single uninterrupted spell. Using the NLSY79, I document that most individuals experience delays or interruptions before earning their college degrees, and that the timing of completion is closely linked to initial endowments of wealth and human capital at age 18. Individuals from wealthier families and with stronger preparation are more likely to complete college earlier. In contrast, those with fewer resources or weaker preparation often rely on later access to higher education.

To interpret these patterns and evaluate their implications, I develop a life-cycle general equilibrium model that allows for endogenous entry and exit from college at each age. The model highlights that flexible access to college generates substantial welfare gains: removing the ability to re-enter college reduces the welfare value of higher education by more than one-quarter. Importantly, the benefits of flexibility are distributed unevenly. While early and uninterrupted completion is most valuable for advantaged individuals, later access provides a critical risk-reduction role for the less advantaged, enabling them to mitigate adverse shocks and improve long-run outcomes.

Examining the mechanism, I find three channels through which flexible access to college impacts the economy: price, investment, and risk propagation. In general equilibrium, allowing flexible access to college alters the distribution of individuals on human capital and wealth, and encourages more degree attainment. The price channel describes the general equilibrium adjustment of factor prices, resulting in substitutions between human capital investment and physical asset accumulation. As such, the price channel accounts for only a small portion of the welfare values of having college access. The investment value of a college education raises human capital, which is realizable in the labor market and yields higher wage income. The investment value is high for individuals under 24, but it disappears afterward. The value of college for the remainder of one's life cycle comes from risk reduction. Having access to college at a later age reduces life-cycle welfare loss to risk. Initially wealthier and more prepared individuals have a higher investment value of college, hence are more likely to complete college without interruptions. Initially less-advantaged individuals find sizable risk reduction value from attending college, especially at a later age; therefore, flexible access to college benefits them more.

The analysis also points to policy implications. A nationwide tuition-free program substantially raises degree attainment and generates large welfare gains, particularly by facilitating earlier and more widespread completion. A narrower intervention, exempting part-time student-workers from labor income tax, also increases attendance, especially among older and less-advantaged individuals, but delivers smaller aggregate gains. Together, the results suggest that policies lowering financial barriers and preserving flexibility in college access can meaningfully improve both equity and efficiency.

In sum, flexible access to college is not only a feature of actual schooling patterns but also a key determinant of welfare outcomes. Its value differs across the life cycle and across initial conditions, suggesting the importance of designing education and financial policies that accommodate diverse pathways to college completion.

Appendix A NLSY79 and data construction for education pattern

The NLSY79 is a uniquely available, nationally representative longitudinal survey that has been interviewing respondents aged 14-22 from 1979 to the present, spanning almost the entire working life of the interviewees. Thereby, it provides details of heterogeneous decision-making information to discipline this study. Following Light (1995a) and Light (1995b) in constructing the panel from NLSY79, I select sample years from 1979 to 2016. I restrict the sample to respondents younger than 20 years old in 1979, the starting year of the survey. I exclude those without AFQT scores, a key variable for further comparisons. Due to inconsistencies in degree reporting, high school graduation is loosely defined as having a high school diploma or having completed the highest degree between 11 and 13 years of education, if high school degree information was not reported. I use monthly college enrollment and current enrollment information to track one's college enrollment status and stop-out/drop-out history. Since I only consider formal college enrollment, enrollment periods of less than five months are excluded from the definition of "enrolled in the year." I also utilize reports on college enrollment, including retrospective and ongoing highest degree completed variables, as well as full-time and part-time college enrollment, to cross-validate each person's college enrollment history. I only consider a 4-year college degree and above as having a college degree and do not differentiate between 2-year degrees and college dropouts. This is a reasonable simplification. According to Athreya and Eberly (2021), the 4-year college degree wage premium is 1.74 over a high school degree, while the premium for some college is only 1.2; similarly, Kane and Rouse (1995) reports a 2-year college degree premium of about 1.1.

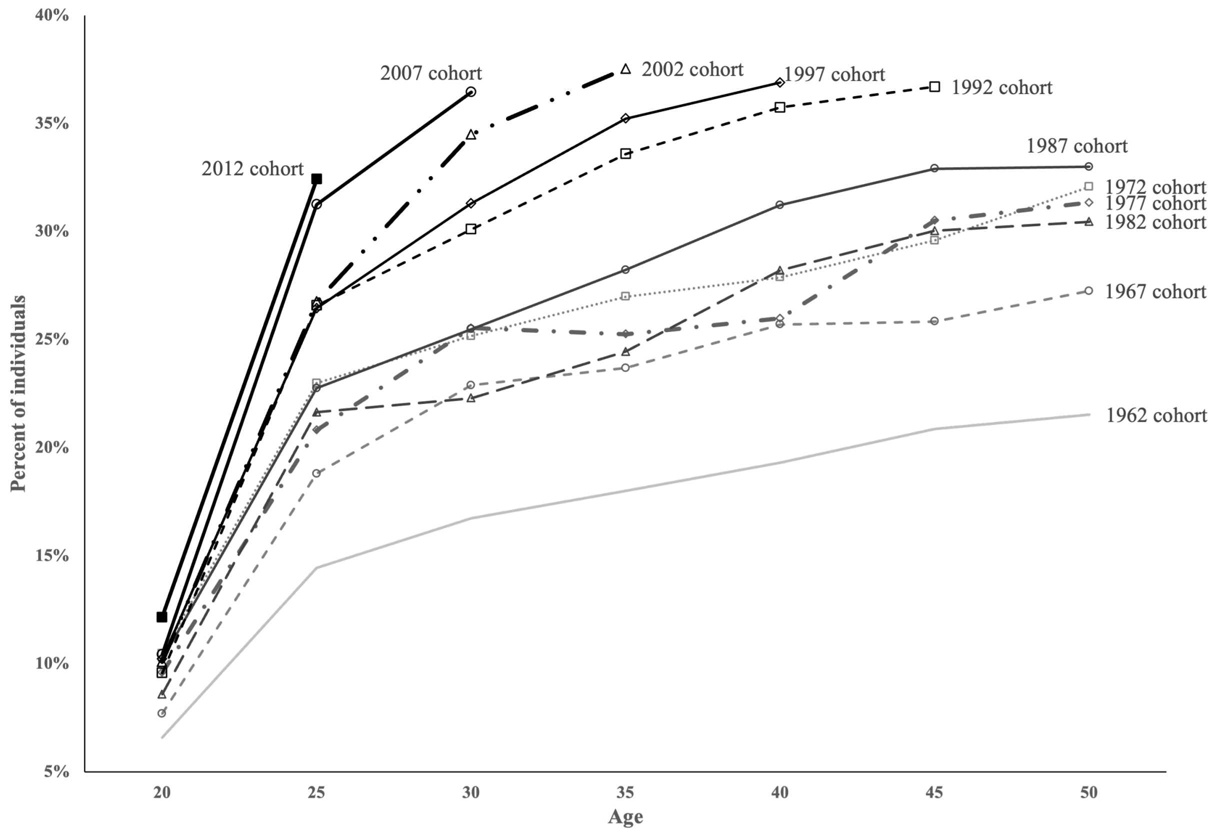
Appendix B Additional Evidence from CPS Synthetic Cohorts

To complement the comparisons between NLSY79 and NLSY97, I also construct synthetic cohorts using the Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC). For each five-year interval from 1962 to 2016, I group individuals aged 20–25 at the survey year into a cohort and track the percentage reporting at least a bachelor's degree as the cohort ages. For example, the "1962 cohort" includes individuals aged 20–25 in 1962, while the "2007 cohort" includes those aged 20–25 in 2007.

Figure B.1 presents the results. Three patterns stand out. First, each successive cohort has higher college attainment across the life cycle than the one before. For instance, by age 30, about 18% of the 1962 cohort held a degree compared to over 30% in the 2002 and 2007 cohorts. Second, within each cohort, attainment continues to rise steadily after the traditional college ages. The 1967 cohort increased its degree share from roughly 15% at age 22 to more than 25% by age 40, while the 1997 cohort rose from just under 20% at age 22 to nearly 35% by the mid-30s. Third, recent cohorts not only achieve higher on-time completion but also show stronger late-life increases, suggesting a greater tendency to return to school.

Together with the NLSY79 and NLSY97 evidence, the CPS results confirm that delayed and intermittent degree attainment is not an artifact of data limitations. If anything, NLSY79's schooling-years proxy yields a conservative estimate of stopout and late completion. CPS evidence across multiple generations shows that the role of later-age college completion has only grown more pronounced in recent decades.

Figure B.1: College degree attainment by synthetic CPS cohorts, 1962–2016



Notes: Figure uses CPS ASEC data to construct synthetic cohorts by five-year intervals. Each cohort consists of individuals aged 20–25 in the indicated survey year (e.g., the 1962 cohort includes all individuals aged 20–25 in 1962). The share with at least a bachelor's degree is plotted as each cohort ages. Three patterns emerge: (i) each successive cohort attains higher college completion at all ages than the previous one; (ii) within-cohort attainment continues to rise well past age 25; and (iii) later-age completion is more pronounced in recent cohorts.

Appendix C Initial conditions

Table C.1 reports the distribution of individuals on the age 18 human capital and wealth conditions, which is directly imported into the optimization and simulation of the baseline model.

Appendix D Disutility of college parameter values

Table D.1 reports the numerical values for the college psychic cost/disutility of college parameters.

Table C.1: Distribution of individuals by initial conditions

	Wealth approximation cutoff																					
AFQT cutoff	$ 5,296	$ 10,593	$ 15,890	$ 21,187	$ 31,780	$ 42,374	$ 52,968	$ 63,561	$ 74,155	$ 84,748	$ 95,342	$ 105,935	$ 116,529	$ 127,122	$ 137,716	$ 148,309	$ 158,904	$ 169,496	$ 180,091	$ 190,683	$ 201,278	$ 211,880
0-5	0.0031	0.0039	0.0042	0.0059	0.0072	0.0037	0.0013	0.0013	0.0009	0.0013	0.0009	0.0007	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5-10	0.0037	0.0048	0.0074	0.0079	0.0107	0.0083	0.0053	0.0028	0.0031	0.0011	0.0009	0.0009	0.0002	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
10-15	0.0044	0.0057	0.0085	0.0066	0.0094	0.0061	0.0059	0.0042	0.0013	0.0042	0.0018	0.0011	0.0004	0.0000	0.0007	0.0002	0.0004	0.0002	0.0002	0.0000	0.0002	0.0000
15-20	0.0044	0.0053	0.0074	0.0068	0.0140	0.0085	0.0053	0.0079	0.0061	0.0050	0.0018	0.0024	0.0002	0.0007	0.0004	0.0004	0.0000	0.0007	0.0000	0.0000	0.0002	0.0000
20-25	0.0022	0.0044	0.0070	0.0077	0.0105	0.0079	0.0068	0.0035	0.0022	0.0028	0.0035	0.0015	0.0011	0.0007	0.0007	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000
25-30	0.0018	0.0033	0.0103	0.0074	0.0129	0.0081	0.0103	0.0088	0.0055	0.0028	0.0022	0.0007	0.0007	0.0009	0.0000	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000
30-35	0.0013	0.0020	0.0031	0.0037	0.0072	0.0077	0.0059	0.0059	0.0035	0.0018	0.0022	0.0013	0.0007	0.0007	0.0004	0.0000	0.0007	0.0002	0.0002	0.0000	0.0000	0.0000
35-40	0.0009	0.0039	0.0079	0.0057	0.0092	0.0085	0.0066	0.0057	0.0035	0.0026	0.0026	0.0013	0.0022	0.0009	0.0007	0.0004	0.0000	0.0007	0.0002	0.0002	0.0000	0.0000
40-45	0.0013	0.0039	0.0064	0.0044	0.0068	0.0083	0.0085	0.0031	0.0039	0.0037	0.0015	0.0022	0.0018	0.0013	0.0004	0.0009	0.0000	0.0009	0.0002	0.0000	0.0000	0.0000
45-50	0.0011	0.0020	0.0044	0.0055	0.0099	0.0046	0.0068	0.0042	0.0039	0.0033	0.0020	0.0015	0.0013	0.0015	0.0000	0.0002	0.0000	0.0000	0.0007	0.0004	0.0000	0.0002
50-55	0.0007	0.0009	0.0053	0.0046	0.0066	0.0046	0.0061	0.0055	0.0050	0.0044	0.0035	0.0015	0.0009	0.0015	0.0009	0.0004	0.0007	0.0002	0.0000	0.0000	0.0000	0.0000
55-60	0.0007	0.0009	0.0046	0.0048	0.0059	0.0042	0.0050	0.0039	0.0048	0.0031	0.0037	0.0018	0.0013	0.0007	0.0004	0.0002	0.0002	0.0004	0.0009	0.0002	0.0000	0.0000
60-65	0.0007	0.0007	0.0024	0.0024	0.0064	0.0053	0.0028	0.0039	0.0037	0.0026	0.0031	0.0033	0.0009	0.0002	0.0009	0.0004	0.0002	0.0000	0.0004	0.0000	0.0000	0.0000
65-70	0.0004	0.0015	0.0037	0.0031	0.0068	0.0050	0.0028	0.0061	0.0042	0.0037	0.0026	0.0022	0.0026	0.0007	0.0013	0.0007	0.0004	0.0002	0.0000	0.0000	0.0000	0.0000
70-75	0.0009	0.0013	0.0037	0.0031	0.0048	0.0031	0.0048	0.0035	0.0044	0.0048	0.0026	0.0024	0.0007	0.0011	0.0007	0.0007	0.0004	0.0002	0.0000	0.0002	0.0000	0.0000
75-80	0.0007	0.0018	0.0015	0.0015	0.0055	0.0044	0.0031	0.0037	0.0033	0.0028	0.0020	0.0009	0.0018	0.0011	0.0011	0.0004	0.0002	0.0007	0.0002	0.0000	0.0000	0.0000
80-85	0.0011	0.0018	0.0026	0.0022	0.0037	0.0048	0.0031	0.0053	0.0033	0.0024	0.0026	0.0011	0.0009	0.0020	0.0011	0.0002	0.0002	0.0015	0.0002	0.0000	0.0000	0.0000
85-90	0.0000	0.0002	0.0020	0.0018	0.0033	0.0022	0.0020	0.0042	0.0039	0.0031	0.0033	0.0015	0.0013	0.0011	0.0007	0.0000	0.0009	0.0013	0.0000	0.0002	0.0000	0.0000
90-95	0.0002	0.0011	0.0015	0.0009	0.0035	0.0042	0.0031	0.0028	0.0024	0.0028	0.0011	0.0013	0.0007	0.0011	0.0004	0.0007	0.0007	0.0009	0.0002	0.0000	0.0000	0.0000
95-100	0.0004	0.0011	0.0015	0.0011	0.0031	0.0011	0.0022	0.0033	0.0035	0.0022	0.0007	0.0018	0.0018	0.0018	0.0022	0.0007	0.0009	0.0011	0.0002	0.0004	0.0002	0.0004

Notes: This table reports the distribution of individuals across initial conditions. Rows correspond to AFQT cutoffs (human capital bins), and columns correspond to wealth approximation cutoffs (in U.S. dollars). Entries are shares of the total population.

Table D.1: College psychic cost parameters by age group

Panel A: Ages 19–25							
Age	19	20	21	22	23	24	25
Continuous schooling	4.00	2.42	1.36	2.20	16.74	-4.11	3.82
New enrollment	–	8.47	6.90	7.08	25.45	79.36	14.56
Completing BA	–	–	–	-3.15	2.94	6.09	6.93
Panel B: Ages 26–32							
Age	26	27	28	29	30	31	32
Continuous schooling	3.56	1.92	5.01	5.99	6.62	6.87	7.58
New enrollment	12.86	9.16	9.24	9.10	9.29	9.89	10.16
Completing BA	7.38	7.68	8.08	8.46	8.84	9.12	9.65
Panel C: Ages 33–39							
Age	33	34	35	36	37	38	39
Continuous schooling	7.96	9.37	10.35	22.49	29.84	20.93	18.85
New enrollment	9.96	10.46	10.70	11.19	11.79	12.28	12.59
Completing BA	25.63	38.45	85.54	43.38	11.80	12.39	12.54
Panel D: Ages 40–46							
Age	40	41	42	43	44	45	46
Continuous schooling	19.74	23.63	28.33	31.44	19.80	14.39	22.89
New enrollment	13.39	13.36	13.89	14.11	14.21	15.06	15.87
Completing BA	13.00	13.38	14.04	14.17	15.64	14.81	15.62
Panel E: Ages 47–53							
Age	47	48	49	50	51	52	53
Continuous schooling	27.98	32.73	32.69	39.78	49.27	61.72	65.48
New enrollment	15.41	16.31	16.37	19.53	18.08	31.81	18.71
Completing BA	16.60	16.65	17.07	17.01	17.76	17.75	18.79
Panel F: Ages 54–60							
Age	54	55	56	57	58	59	60
Continuous schooling	66.40	55.93	36.45	15.53	19.67	21.74	18.08
New enrollment	34.04	19.19	55.90	19.74	19.91	106.04	67.75
Completing BA	18.65	24.19	19.47	26.11	19.63	20.84	26.49
Panel G: Ages 61–65							
Age	61	62	63	64	65		
Continuous schooling	18.74	22.69	29.25	28.00	21.68		
New enrollment	71.58	78.35	71.30	73.66	132.39		
Completing BA	28.46	31.67	36.65	41.25	93.07		

Notes: This table reports the calibrated parameter values for $dis(e, age, yr)$. For each age, values are differentiated by enrollment status and proximity to degree completion. *Continuous schooling* refers to disutility if an individual is currently enrolled in college and more than 1.5 years away from completing a bachelor's degree. *New enrollment* refers to disutility if an individual is not currently enrolled but is more than 1.5 years away from completing a bachelor's degree. *Completing BA* refers to disutility if an individual is within one year of completing a bachelor's degree, regardless of current enrollment status.

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