Two-year Programs and College Financial Aid*

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Abstract

We evaluate recent policy proposals to make two-year programs tuition-free in a life cycle model featuring two-year (AA) and four-year (BA) programs. We document program tradeoffs, organized by accessibility and quality, which are then incorporated into the model. The AA program is easier to get into and cheaper, but has a lower consumption value, graduation likelihood, and labor market returns. We find that making the AA program tuition-free is a cost-effective way to increase the number of post-secondary graduates, but a spending-equivalent BA subsidy leads to more favorable outcomes in terms of output, skill of future generations, and welfare gains.

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1 Introduction

In the United States, two-year programs almost exclusively award Associate of Arts (AA) degrees and often serve a "transfer function" to four-year programs where graduates are predominantly awarded bachelor's (BA) degrees (Kane and Rouse, 1999; Lovenheim and Smith, 2023).[1] Several recent federal policy proposals have pushed to make two-year programs tuition-free at the national level, although these proposals have not yet been passed into law. Examples include the *America's College Promise Act of 2015* (U.S. Congress, 2015) and the *Free Community College* program in the Department of Education's 2024 fiscal year budget proposal (U.S. Department of Education, 2023). These proposed policies aim to increase the share of population with a postsecondary education degree in a cost-effective way. They also aim to provide postsecondary financial support to youth who are disadvantaged by their financial means or academic preparation for college. However, when subsidizing tuition for two-year programs as opposed to four-year programs, there is a tradeoff between subsidizing accessibility and subsidizing quality: compared to four-year programs, two-year programs are more accessible in that they are easier to get into and are cheaper, but are also of lower quality in terms of graduation likelihood, labor market returns, and the consumption value of on-campus experiences.

We contribute to the policy discussion in two ways. First, we document tradeoffs across the two programs and patterns in paths to highest postsecondary enrollment. Second, we build a quantitative life cycle model of postsecondary education that features both a two-year (AA) and four-year (BA) program and incorporates the tradeoffs we document empirically. We use our model to analyze a counterfactual experiment in which the AA program is made tuition-free, juxtaposed with a second experiment in which a spending-equivalent subsidy is given to BA program enrollees. Our main finding is that making AA programs tuition-free is a cost-effective way to increase the share of graduates with a postsecondary education degree in comparison to the spending-equivalent BA tuition subsidy. However, the BA subsidy leads to more favorable outcomes with respect to aggregate output, the skill distribution of future generations of young adults, and welfare gains.

In the first part of our paper, we present empirical evidence of the tradeoffs between AA and BA programs, as well as between AA-to-BA and straight-to-BA paths to BA enrollment. Our findings rely mostly on the 1997 National Longitudinal Surve of Youth (NLSY97) and the High School

[1] We use AA interchangeably with two-year and BA with four-year. BA refers to four-year bachelor's degrees generally, which are usually either bachelor's of science or bachelor's of arts. Besides Associate of Arts degrees, two-year institutions may also offer non-degree credentials such as short certificates or long certificates or diplomas, which we abstract from. Short certificates last less than one year, are often pursued mid-career, and are associated with small earnings gains (Lovenheim and Smith, 2023). Long certificates or diplomas, which can last between one and two years, are much less frequently awarded by two-year institutions compared to AA degrees (Jenkins, Fink, and Velasco, 2025).

Longitudinal Study of 2009 (HSLS:09), two nationally-representative panel datasets collected in the United States. The tradeoffs we document are divided into those related to accessibility and quality, described above. These tradeoffs are conceptualized and examined in similar forms in other studies using different datasets and methodologies—see for example Kane and Rouse (1995), Reynolds (2012), and Jenkins and Fink (2016). Our results articulate these tradeoffs and document supporting evidence in a way that is useful for our quantitative model's design and parameterization.

Next, we analyze the relationship between individual attributes and realized paths to highest postsecondary enrollment using the NLSY97. Our approach builds on work using the same dataset by Belley and Lochner (2007) to motivate our analysis of AA and BA programs in a model framework with borrowing constraints. Specifically, we broaden their definition of postsecondary enrollment to encompass enrollment by age 24, which facilitates our examination of AA to BA transfers. Working with this definition, we offer new findings on how demographic attributes predict postsecondary enrollment paths that include AA enrollment. In particular, we show that high school graduates and postsecondary enrollees with low parental income, low parental education, and low youth skill are more likely to enroll in AA programs. Similarly, among BA enrollees, these same attributes predict a higher likelihood of taking the AA-to-BA path. In supplementary exercises, we offer supporting evidence for these NLSY97 results using the HSLS:09.

Motivated by our empirical evidence, in the second part of our paper we build a life cycle model with both an AA and a BA program. The model features borrowing constraints, as well as key sources of postsecondary education financing such as Pell grants and other public and private grants, subsidized and unsubsidized student loans, parental transfers, and earnings from employment. In comparison to the BA program, the AA program is more accessible in terms of admissions, program duration (two instead of four years), annual tuition costs, and required effort. However, the AA program is also of lower quality in that it features a lower consumption value, lower continuation likelihood, and leads to lower returns on the labor market for graduates.[2] We also allow for transfers from the AA to the BA program. Consistent with our empirical findings, those who transfer experience a scarring effect in terms of BA graduation likelihood, labor market returns, and consumption value compared to direct enrollees in the BA program.[3]

[2]The admissions policy is modeled exogenously. The AA program follows an open admissions policy, consistent with the admissions policies for community colleges. In contrast, the BA program follows a selective admissions policy making it harder for those with lower skill to be admitted into the BA program. The selective admissions captures unmet admissions requirements, as well as capacity constraints and other frictions. For recent quantitative work on endogenous admissions, see Chade, Lewis, and Smith (2014), Fu (2014), Marto and Wittman (2024), and Hendricks, Koreshkova, and Leukhina (2024, 2025a,b).

[3]This scarring effect captures both the lower quality of instruction in AA programs and the potentially limited ability for AA enrollees to transfer to a high quality BA program.

We validate the model along three dimensions important to our main experiment. First, the calibrated model accounts for observed correlations of youth skill and parental income and education with AA, BA, and AA-to-BA enrollment from our NLSY97 regressions. Second, the model accounts for estimates of average tuition net of grants in both AA and BA programs. Third, the model generates an AA enrollment rate response to a AA subsidy that is consistent with the data from a quasi-natural experiment, reported in Denning (2017).

We analyze the aggregate and welfare implications of making the AA program tuition-free, and compare the results with a spending-equivalent subsidy given to those enrolled in the BA program. Specifically, we choose the BA subsidy so that the change government spending as a share of output is equal to the change generated by making the AA program tuition-free. The resulting BA tuition subsidy is significantly smaller than the AA tuition subsidy.[4] Before using the model to analyze the two experiments, we show that our model's prediction for the rise in public education grant spending which results from making the AA program tuition-free aligns quantitatively with the annual amount of $9 billion requested for the *Free Community College* proposal in the FY 2024 Congressional Justification by the U.S. Department of Education (2023).

In line with a goal of existing policy proposals, we find that making AA programs tuition-free is a cost-effective way to increase the share of the population with a postsecondary degree. The AA subsidy expansion leads to a large rise in AA enrollment driven by a "democratization effect" in which non-enrollees transition to AA enrollment, rather than a "diversion effect" in which those who would gone straight to BA enrollment now enroll in the AA program. The rise in AA enrollment also leads to a small rise in the mass of AA-to-BA transfers. As a result, the share of the population with a postsecondary degree increases by 2.37 percentage points. While the AA subsidy expansion significantly increases the AA enrollment rate, the BA subsidy expansion does not significantly increase the BA enrollment rate. Therefore, the BA subsidy expansion increases the share of the population with a postsecondary degree by only 0.66 percentage points.

While the AA tuition subsidy generates a significant increase in the share of postsecondary graduates, it also leads to fall in aggregate output. This is because, although the democratization effect dominates in regard to enrollment, the diversion effect dominates in regard to aggregate output. That is, those who would have enrolled in a BA and become a BA graduate now enroll in an AA and become an AA graduate, which is associated with a lower efficiency premium. In contrast, the BA tuition subsidy increases output by 0.39 percent. This is because the BA subsidy results in slightly more BA graduates, which (given the high-quality BA degree) leads to a rise in labor

[4]The smaller BA tuition subsidy results in the same increase in total government spending to output because more students enroll in a BA (extensive margin) and the cost per-enrollee in a BA program is higher as it lasts for longer and features a higher annual continuation likelihood (intensive margin).

efficiency units.

The BA tuition subsidy also leads to higher welfare gains for the average high school graduate than the AA tuition subsidy. This is because the benefits of subsidizing quality outweigh the benefits of subsidizing accessibility. For example, in partial equilibrium, the gains to the average high school graduate amount to 0.72 and 0.97 percent of lifetime consumption from the AA and BA subsidy expansion, respectively. General-equilibrium and inter-generational effects dampen the welfare gains from the AA tuition subsidy and amplify the gains from the BA tuition subsidy. When these effects are taken into account, the gains to the average high school graduate amount to 0.24 and 1.21 percent of lifetime consumption from the AA and BA subsidy expansion, respectively.

One of the goals of the proposals to make AA programs tuition-free is to provide postsecondary financial support to youth who are disadvantaged by their financial means or academic preparation for college. In partial equilibrium, we find that high school graduates with low parental income and low skill benefit more from the AA subsidy expansion than the BA subsidy expansion. However, once general-equilibrium effects are taken into account, the gains from the two subsidy expansions are almost the same with the gains from the BA subsidy expansion being slightly higher. Hence, our results emphasize the importance of general-equilibrium effects when evaluating an intended goal of the proposed policy.

Our structural analysis allows for distinct AA and BA programs, which allows us to evaluate AA-specific policies. This distinguishes us relative to most of the macroeconomic literature on postsecondary education financial aid, which focuses only on BA programs. Examples include Caucutt and Kumar (2003), Ionescu (2009), Chatterjee and Ionescu (2012), Krueger and Ludwig (2016), Ionescu and Simpson (2016), Abbott, Gallipoli, Meghir, and Violante (2019), Matsuda (2020, 2022), Colas, Findeisen, and Sachs (2021), Kim and Kim (2024), Luo and Mongey (2024), Krueger, Ludwig, and Popova (2025), Moschini, Raveendranathan, and Xu (2025), Vardishvili (2025), Wright (2025), and Moschini and Raveendranathan (2025).

Complementary to our analysis, a few recent structural studies in the macroeconomic literature on postsecondary education have incorporated representations of AA programs: Trachter (2015), Hendricks, Koreshkova, and Leukhina (2024, 2025a,b), and Park (2025). We differ from these papers in research focus and model attributes. Our research focus differs because we evaluate the implications of policy proposals to make AA programs tuition-free. As for model attributes, while our model overlaps with these papers in that the AA program is cheaper but leads to lower labor market returns, our model also incorporates important elements such as the option to transfer from the AA to the BA program, borrowing constraints, dropout risk, and general-equilibrium effects.

Specifically, Trachter (2015) models AA programs as a stepping stone to a BA in a framework with-

out borrowing constraints; the model is then applied to the U.S. economy in the 1970s where this assumption is a reasonable one. In Trachter (2015)'s model, high school graduates face uncertainty about their ability to accumulate human capital. This makes the cheaper AA program attractive due to its options to drop out of postsecondary education or to transfer up to a BA program once more information is known. Trachter (2015)'s main experiment is to quantify the contribution of each of these options to the total value of the AA program.

In a framework with endogenous college admissions and capacity constraints, Hendricks, Koreshkova, and Leukhina (2024, 2025a,b) approximate the AA program as a low-quality college. In their models, the AA increases human capital of an enrollee who will drop out after two years without a degree but does not give enrollees the option to transfer to a BA. For example, Hendricks, Koreshkova, and Leukhina (2025b) examine the effects of reallocating funds from low quality to high quality four-year colleges to increase capacity in selective four-year programs.

Park (2025) builds a model framework that includes an AA and BA program, as well as heterogeneous parental altruism; the last feature generates high variation in inter vivos transfers controlling for parental wealth. The model framework is stylized, in that it abstracts from dropout risk, the AA-to-BA transfer decision, and general-equilibrium effects. However, it is highly tractable, a useful attribute given the study's focus on the optimal design of need-based aid. Park (2025) finds that in the model young adults from affluent family backgrounds who do not receive significant transfers from their parents are more likely to attend the cheaper AA program. Hence, he argues that it is optimal to shift aid from the BA to the AA program.

This paper proceeds as follows. In Section 2 we present our main empirical findings from the NSLY97 and the HSLS:09. Section 3 presents our model framework, and Section 4 the model parameterization to the U.S. economy. Section 5 validates the model. Section 6 reports the results of our main experiment and Section 7 concludes.

2 Data

In this section we offer empirical evidence of tradeoffs faced by young adults choosing between AA and BA programs as well as AA-to-BA and straight-to-BA paths to BA enrollment. We then document the relationship between demographic attributes and paths to highest postsecondary enrollment in an environment where potential enrollees face these tradeoffs.

Our two main sources of data are the 1997 National Longitudinal Survey of Youth (Bureau of Labor Statistics, U.S. Department of Labor, 2019) and the public-use High School Longitudinal Survey of 2009 (National Center for Education Statistics, U.S. Department of Education, 2020),

supplemented by information on institutional structure from the literature and tabulations from the U.S. Department of Education. The NLSY97 and the HSLS:09 are both panel surveys are collected in the United States.

The NLSY97 follows a nationally representative sample of young adults from 1997 until 2019. The HSLS:09 follows a nationally representative sample of 9th graders from 2009 to 2016 (about three years after high school graduation for most sample members), with some information on postsecondary enrollees also collected for the 2017 academic year. The NLSY97 has a longer panel dimension, making it useful for measuring postsecondary enrollment, degree completion, and earnings later in life. On the other hand, the HSLS:09 features information on postsecondary application and acceptance outcomes, as well as financial aid receipt and pecuniary costs of college collected directly from postsecondary institutions, for a more recent cohort of young adults than the NLSY97.

Estimation samples Our main NLSY97 findings are computed using two cleaned estimation samples: the postsecondary outcomes sample and the earnings profile sample. We use the former to examine the relationship between education outcomes and demographic attributes, and the latter to examine the relationship between education attainment and earnings. Our NLSY97 analyses do not use survey weights.[5]

The postsecondary outcomes estimation sample is at the individual level and uses data on respondents who receive a high school diploma when they were 17, 18, 19, or 20 and who remain in the sample until they turn 30. We require that we observe the Armed Services Vocational Aptitute Battery (ASVAB) score, our preferred measure of skill, gender, race, Hispanic ethnicity, parental education, and parental income in 1997. Parental income is converted to 2013 dollars using the Consumer Price Index (CPI) from the Bureau of Labor Statistics, U.S. Department of Labor (2024). We also require that the variable reporting enrollment and graduation status from high school and two- or four-year college degree programs in each wave not imply contradictory information. These requirements leave us with 2,322 individual observations in the postsecondary outcomes estimation sample.

The earnings profile estimation sample is at the individual-year level, where the year refers to the year of the survey round's interview. This sample places the same restrictions on observations as the postsecondary outcomes sample, but with the following modifications. We replace the requirement of observing parental education and income with the requirement that we observe marital status, number of children, and the real wage, that the respondent not be enrolled in postsecondary

[5]Further details of how we identify our main estimation samples for the NLSY97 and HSLS:09 are available in Appendix A.1.

education, and that the respondent have completed high school and be aged 25 to 38 at the date of the survey round interview. In addition, we drop the requirement that we observe respondents until they are 30. We also require that the variable reporting enrollment and graduation status from high school and two- or four-year college degree programs in each wave not imply contradictory information. These requirements leave us with 4,261 individuals (26,038 individual-year observations) in the earnings profile estimation sample.

Our main HSLS:09 findings are computed using a cleaned sample in which we require that students earn a high school diploma in 2013. We also require that we observe honors-weighted high school GPA, race, gender, parental education, and parental income, which we convert to 2013 dollars using the CPI. High school GPA is our measure of skill in the HSLS:09 because there is no standardized test like the ASVAB of the NLSY97. In addition, we require that we have sufficient information to construct the respondent's highest postsecondary education attainment and that this information satisfy basic consistency conditions, as described further in Appendix A.2.1. This leaves us with a sample of 8,930 individuals, subsets of which additionally satisfy specific table requirements (e.g., being enrolled in postsecondary education or having a positive survey weight in the 2016 survey round). Our HSLS:09 analyses use survey weights.

Postsecondary education outcomes Using our NLSY97 postsecondary education outcomes estimation sample, we construct a set of indicator variables that record the path each respondent takes to their highest postsecondary enrollment after high school. Specifically, we flag whether the respondent enrolled in an AA or BA program after high school completion, measured at any survey round collected up to and including when the respondent is 24 years old; enrollment in any postsecondary education (PSE) after high school refers to enrolling in either type of program. Because we are interested in paths to the highest postsecondary enrollment by age 24, we separate AA enrollees into those who continue to a BA after AA enrollment and those who do not. This allows us to identify BA enrollees with a history of prior enrollment in an AA program ("AA to BA") and those who enroll directly in a BA ("straight to BA"). If the respondent enrolls first in a BA program after high school and, later, an AA program, then they are counted as a straight-to-BA enrollee and not counted as an AA enrollee. Analogous to how we define enrollment types, we define categories of degree attainment by flagging the highest degree received (AA or BA) and the path taken to that degree. If no postsecondary degree is completed, the respondent has a high school degree.[6]

[6]To be conceptually consistent with tracking the path-to-highest enrollment, we count BA-to-AA enrollees as straight-to-BA enrollees and not AA enrollees. Among the group of BA-to-AA enrollees earning a BA degree is more common than earning an AA, so our assignment choice also maximizes consistency between enrollment and degree attainment outcomes. However, our lens on the data implies that, among straight-to-BA enrollees, some may go on to earn an AA degree but not a BA degree. This would result in observations where the highest degree earned is an

In the NLSY97 earnings profile estimation sample, education attainment in each survey round's year records the highest postsecondary degree the respondent has at that point in time. For the construction of some indicator variables, the path to highest degree attainment at that point in time is also incorporated.

In the HSLS:09, postsecondary enrollment flags are constructed in an analogous fashion to the NLSY97, although the enrollment horizon is limited to three years after high school completion instead of by age 24. We are not able to construct analogous degree attainment flags in the HSLS:09 due to its shorter panel dimension.

In Section 2.1 we document the main tradeoff between AA and BA programs: AA programs are more accessible, but also lower in quality, compared to BA programs. In Section 2.2, we compare tradeoffs of taking the AA-to-BA or straight-to-BA path to BA enrollment. Section 2.3 documents postsecondary enrollment patterns of young adults who take the tradeoffs documented in Sections 2.1 and 2.2 as given.

2.1 Tradeoffs of AA versus BA programs

We organize the differences between AA and BA programs into differences in accessibility and quality. Regarding accessibility, besides being shorter in duration (usually two versus four years) AA programs are more accessible than BA programs in that they are easier to get into, they are cheaper per year, and they require lower effort. Regarding quality, AA programs are lower in quality than BA programs in that AA programs are associated with a lower completion likelihood than BA programs and AA degrees offer lower labor market returns than BA degrees. AA programs also offer a lower consumption value for enrollees, where consumption value is measured as in Jacob, McCall, and Stange (2018) using consumption amenity spending by AA versus BA institutions.

Accessibility Both four-year BA programs and two-year AA programs require aspiring enrollees to submit an application and be accepted in order to enroll. However, unlike four-year BA programs two-year AA programs often do not require standaradized test scores such as the SAT or ACT and have much less stringent standards for high school GPAs (Education USA, U.S. Department of State, 2025). In fact, 92 percent of two-year AA programs have no admission criteria and follow an "open enrollment" policy, while only 25 percent of four-year BA programs have no admission criteria (Lovenheim and Smith, 2023).[7]

AA but there is no record of AA enrollment because it did not occur on the path to the highest enrollment outcome. We drop the roughly 40 individuals for which this is the case from our estimation samples, a small fraction of all BA to AA enrollees.

[7]Consistent with these differences, in Table A7 of Appendix A.2.2 we show that, comparing across skill, those with lower skill are more likely to apply to an AA program and and those with higher skill are more likely to apply

The lower pecuniary cost of AA programs versus BA programs holds true both before and after taking grant aid into account. As mentioned earlier, the HSLS:09 collects information on tuition and fees, as well as financial aid receipt, reported directly from postsecondary institutions for the first year of college enrollment. Restricting to survey respondents who enroll in the academic year immediately following high school completion (that is, in the fall of the 2013-2014 academic year), Table 1 reports the average sticker price in annual tuition and fees, as well as net tuition and fees after total grant aid is taken into account, among those enrolled in a two-year AA program and a four-year BA program. On an annual basis, the average AA enrollee pays much less than the average BA enrollee, and grant aid does not close this gap.

Table 1: Tuition and fees by postsecondary program type

Program type	Total	Net of grants
AA	3,942	869
BA	17,943	8,993
Observations	3,494	

Notes: The table reports tuition and fees, both total and net of grants, faced by AA enrollees and BA enrollees in the 2013-2014 academic year. Weights: PETS-SR longitudinal weights. Source: HSLS:09.

Next, we provide evidence consistent with lower or more flexible time requirements of AA programs: AA enrollees work more than BA enrollees. This is true even conditioning on parental income, which could affect the incentive to work while enrolled. Table 2 shows labor supply statistics for HSLS:09 sample members who enroll in an AA or BA program immediately after high school, broken down by parental income. Within each parental income tercile, AA enrollees work more hours on average. This is a result of both an extensive margin effect (AA enrollees are more likely to be working) and an intensive margin effect (AA enrollees work more hours conditional on working).

Quality We document lower AA completion likelihoods and labor market returns using the NLSY97. For each skill tercile and overall, Table 3 reports PSE completion rates for those who enroll in an AA or BA program by age 24. Specifically, the first three columns report mutually exclusive outcomes for AA enrollees: the share who earn an AA by age 30 but do not continue to a BA, the share who transfer to a BA program without earning an AA degree, and the share who both earn an AA and transfer to a BA. The fourth column reports the share of AA enrollees who either earn a degree or transfer to a BA, a broader (and, in our view, context-appropriate) definition of AA program "completion." In contrast to the first four columns, the fifth column focuses on BA

to a BA program. Furthermore, among applicants with low- and medium-high school GPAs, acceptance rates to postsecondary programs for the first academic year after high school completion are higher at AA programs than BA programs. The difference is especially stark in the lowest GPA tercile.

Table 2: Labor supply during first year of postsecondary enrollment

	AA enrollees			BA enrollees		
Parental income	**Hours**	**Share working**	**Hours | hrs>0**	**Hours**	**Share working**	**Hours | hrs>0**
1	16	0.593	27	11	0.526	21
2	18	0.683	27	10	0.508	20
3	19	0.718	26	7	0.382	19
Total	17	0.654	27	9	0.446	20
Observations	1,202			3,779		

Notes: Within each parental income tercile, the table reports average hours worked per week, labor force participation, and average hours worked per week conditional on working, for first-year enrollees in BA or AA programs in the fall of 2013. Weights: Second follow-up student longitudinal weights. Source: HSLS:09.

enrollees by age 24, and reports the share who go on to earn a BA degree by age 30 regardless of whether or not they took the AA-to-BA path to BA enrollment.

Table 3: Postsecondary completion rates among enrollees

	AA enrollees				BA enrollees
Skill	**AA degree only**	**AA to BA only**	**Both**	**Either**	**BA degree**
1	0.195	0.131	0.060	0.386	0.589
2	0.195	0.224	0.053	0.472	0.698
3	0.228	0.350	0.100	0.678	0.847
Total	0.204	0.223	0.068	0.495	0.769
Observations	677	677	677	677	1,288

Notes: The table reports postsecondary completion rates among AA and BA enrollees within each skill tercile and overall. Source: NLSY97.

Comparing across the first four columns reveals that the broader definition of completion for the AA program implies a significantly larger rate of completion than considering AA degree attainment as the only measure of completion. Comparing the fourth and fifth columns shows that, even controlling for skill and allowing for transferring to a BA to count as a successful completion, AA enrollees are less likely than BA enrollees to complete their program. This difference between completion rates of AA enrollees and BA enrollees would be even more stark if we did not include those who transfer from AA to BA without completing the AA (second column) in the broader definition of AA completion.

In Table 4, for each skill tercile we report median wages and sample counts by highest degree attained using the earnings profile estimation sample. Wages are converted to 2013 dollars using the CPI. The ratio of median wages for those with an AA or BA to those with only a high school degree yields a skill-specific measure of the wage premium associated with reaching each postsecondary degree attainment; these ratios are reported in the last two columns of the table. Within each skill tercile, the wage premium is lower for an AA than a BA.

Table 4: Wage premiums of highest degree attainment by skill tercile

	High school		AA		BA		Wage premium	
Skill	**Wage**	**Obs**	**Wage**	**Obs**	**Wage**	**Obs**	**AA**	**BA**
1	12.997	7,013	15.151	713	17.930	1,057	1.166	1.380
2	15.000	4,925	17.964	632	21.031	2,961	1.198	1.402
3	15.933	2,382	19.412	539	23.592	5,816	1.218	1.481

Notes: The table reports the median wage within each skill tercile by education attainment status for those not currently enrolled in postsecondary education and aged 25-38; the last two columns are the ratio of BA to HS and AA to HS median wages, that is the BA and AA wage premiums respectively. Observation counts are at the individual-year level. Source: NLSY97.

To provide indirect evidence of differences in consumption value across two- and four-year programs, we follow Jacob, McCall, and Stange (2018) and define spending on consumption amenities as equal to the sum of expenditures on student services and auxiliary enterprises. These categories include spending on items that make the university experience more enjoyable or improve quality of life for enrollees, such as student activities, student organizations, cultural events, residence halls, food services, intercollegiate athletics, and college unions. We compute spending on consumption amenities per full-time student for two- and four-year programs using the relevant institutional spending categories reported in nationally-representative National Center for Education Statistics (NCES) tabulations and converted to 2013 dollars using the CPI. Our estimates, with further explanation, are reported in Table A10 of Appendix A.3.2. Between 2013 and 2015, the average two-year program spent $2,120 on consumption amenities per full-time-equivalent student, while the average four-year program spent $6,471—roughly three times higher. We interpret this as evidence that, on average, the consumption value offered by a four-year BA program is higher than that of offered by a two-year AA program.[8]

2.2 Tradeoffs of AA-to-BA versus straight-to-BA

So far, we have highlighted key tradeoffs of enrolling in an AA versus a BA. We also examine the AA-to-BA path to BA enrollment and BA degree attainment. What are the tradeoffs of taking this route versus going straight to a BA? To fix ideas, in this section we articulate and examine several possible dimensions in which differences in outcomes might arise across enrollees who take either the AA-to-BA or straight-to-BA route. These differences are the total pecuniary cost of pursuing a BA degree, the likelihood of completing a BA degree conditional on BA enrollment, the labor market returns to the BA degree, and the consumption value of BA enrollment. In regard to the last

[8]Instructional spending, a separate category in these NCES tabulations, offers suggestive evidence for why four-year programs offer a higher wage premium and have higher completion rates than two-year programs. Specifically, as shown in Table A11 of Appendix A.3.2, instructional spending is twice as high for four-year programs.

point, previous studies have shown that social integration of transfer students is a point of concern for the students themselves and for college officials (Ellis, 2012; Inside Higher Ed, 2020). In what follows, we offer new evidence that speaks to the other differences.

To examine the impact of the AA-to-BA route on the total cost of pursuing a BA degree, using the NLSY97 we show in Table 5 both the average (with its standard error) and median years spent enrolled in a BA up to age 30, conditional on enrolling in a BA by age 24. The values are reported in separate rows for those who take the straight-to-BA route and those who take the AA-to-BA route. In addition, this breakdown is reported for all BA enrollees (first two columns) and for those who earn a BA by age 30 (last two columns).

Table 5: Years spent enrolled in BA up to age 30

	BA enrollees		**BA graduates**	
Path to BA enrollment	**Mean (SE)**	**Median**	**Mean (SE)**	**Median**
Straight to BA	4.28 (0.046)	4.00	4.59 (0.038)	4.00
AA to BA	2.94 (0.102)	3.00	3.17 (0.111)	3.00
Observations	1,288		990	

Notes: The table reports the mean (standard error) and median of years spent enrolled in a BA up to age 30. The statistic is reported separately for those who enroll straight in a BA and for those who take the AA to BA path. The "BA enrollees" columns condition on enrolling in a BA by age 24, and the "BA graduates" columns additionally condition on earning a BA by age 30. Source: NLSY97.

The first column indicates that taking the AA-to-BA route reduces years spent enrolled in a BA by at least one year on average, compared to going straight to a BA. The third column implies that this difference is not driven by BA dropouts: it is closer to 1.5 years on average among those who go on to earn the BA degree. The lower average duration of BA enrollment for AA-to-BA enrollees is also not driven by outliers: comparing median values in the second and fourth columns reveals a similar one-year difference. Together, the lower number of years spent enrolled in a BA and the lower annual cost of an AA documented in Table 1 indicate a lower overall cost of BA degree pursuit for AA-to-BA enrollees.

Among those who enroll in a BA by age 24, on average taking the AA-to-BA route is associated with a lower likelihood of progressing towards BA completion each year compared to going straight into BA enrollment. This pattern is shown in Table 6. The first two columns report the share who earn a BA by age 30, broken down by skill tercile, within each path to BA enrollment. These overall BA completion rates are increasing in skill for both paths to BA enrollment. However, those who take the AA to BA route arrive in their BA program with one or two academic years under their belt, unlike their straight-to-BA peers. To address this, we report annualized continuation rates in the last two columns. Consistent with the findings of Table 5, these annualized probabilities assume that those who take the AA-to-BA path need to successfully pass 3 years

enrolled in a BA to graduate, while those who take the straight-to-BA route need 4 years. Once annualized, the lower continuation probability is apparent for those in the AA-to-BA group.

Table 6: BA degree attainment rates by path to BA enrollment

	Overall share		Annualized probability	
Skill	**AA to BA**	**Straight to BA**	**AA to BA**	**Straight to BA**
1	0.625	0.573	0.855	0.870
2	0.706	0.696	0.890	0.913
3	0.765	0.857	0.915	0.962
Total	0.711	0.779	0.892	0.938
Observations	197	1,091	197	1,091

Notes: The table reports BA attainment rates by path to BA enrollment, within each skill tercile and in total (first and second columns) as well as the annualized continuation probability (third and fourth columns). The annualized probabilities assume AA-to-BA enrollees need 3 years of BA enrollment to graduate, while straight-to-BA enrollees need 4 years. Source: NLSY97.

We document the impact of paths to BA degree attainment on earnings by computing the wage premium of each path in the NLSY97. Table 7 reports the median wage and sample count within each skill tercile for those with only a high school degree, those with a BA degree who took the AA-to-BA route, and those with a BA degree who went straight to a BA. The last two columns report the BA wage premium for each path to BA degree attainment, computed as the ratio of median wages to those with only a high school degree. The BA wage premium is lower for those who took the AA-to-BA path in the top two skill terciles and the same in the bottom skill tercile. This indicates that, even controlling for skill and degree attainment, for many BA graduates taking the AA-to-BA route results in a lower wage premium.[9]

Table 7: Wage premiums of BA degree by skill tercile and path to BA enrollment

	High school		AA to BA		Straight to BA		Wage premium	
Skill	**Wage**	**Obs**	**Wage**	**Obs**	**Wage**	**Obs**	**AA to BA**	**Straight to BA**
1	12.997	7,013	17.930	389	17.933	668	1.380	1.380
2	15.000	4,925	20.333	798	21.284	2,163	1.356	1.419
3	15.933	2,382	22.499	843	23.759	4,973	1.412	1.491

Notes: The table tabulates the median wage within each skill tercile by highest degree attainment, specifically high school diploma, a BA having taken the AA-to-BA path to BA enrollment, and a BA having taken the straight-to-BA path to BA enrollment. The last two columns are the BA wage premiums for each skill bin, computed separately by path to BA enrollment. The sample is those not currently enrolled in postsecondary education who are aged 25-38. Observation counts are at the individual-year level. Source: NLSY97.

[9] In Appendix A.1.3, we show that the qualitative takeaway of an AA premium among those without a BA shown in Table 4 and an AA-to-BA penalty among those with a BA shown in Table 7 survives accounting for age effects and skill, along with other demographic attributes.

2.3 Paths to highest postsecondary enrollment

Postsecondary enrollment and demographic attributes How common are different paths to highest postsecondary enrollment, and what are the attributes of those who pursue various postsecondary education routes? Capitalizing on the more complete education profiles of the NLSY97, Table 8 reports postsecondary enrollment rates for each path to highest enrollment as well as demographic attributes for three groups: all high school graduates, AA enrollees, and BA enrollees. AA enrollees includes those who enroll in only an AA and those who go on to enroll in a BA; BA enrollees includes those who go straight to a BA and those who take the AA-to-BA route. For each group, the rows of Panel A of the table reports rates of postsecondary enrollment up to age 24, separated into three mutually exclusive paths to highest-program enrollment: enrolling in only an AA, only a BA (that is, no prior AA enrollment), or AA to BA. The last row of Panel A is the sum of the previous three, enrollment in any postsecondary education. Panel B reports demographic attributes: the average ASVAB score, real parental income in 1997, the share with at least one parent with a BA or higher in 1997, and the share who are female, black, or Hispanic.

The first column of Panel A of Table 8 reports enrollment statistics for the sample of all high school graduates. The most common path to highest-program enrollment by age 24 is only enrolling in a BA (47 percent), followed by only an AA (21 percent). At the same time, a quantitatively large share of high school graduates (8 percent) enroll in an AA and then a BA. Overall, more than 75 percent of high school graduates enroll in some form of PSE by age 24. Moving to the second column, within the sample of those who enroll in an AA by age 24 the majority (71 percent) enroll in only an AA, although a sizable share (29 percent) go on to enroll in a BA. The third column indicates that among those who enroll in a BA, 15 percent take the AA to BA route, while the remainder enroll directly in a BA program.

Comparing across columns in Panel B shows that there is sorting by several demographic attributes into AA and BA enrollment. In particular, compared to high school graduates, those who enroll in an AA by age 24 have lower average values for skill, parental income, and parental education, while those who enroll in a BA have higher average values. The share who are female is slightly higher among AA and BA enrollees, while the share who are black or Hispanic is slightly higher for AA enrollees, and slightly lower for BA enrollees, compared to all high school graduates.

Overall, these statistics suggest that both AA and BA programs are popular choices for high school graduates and that many high school graduates take the AA-to-BA path to BA enrollment, representing a sizable share of both AA and BA enrollees. Additionally, there is sorting by skill and demographic attributes into each postsecondary program type.

Table 8: Postsecondary enrollment rates and demographic attributes

			Enrolled by age 24	
Category	**Variable**	**All**	**AA**	**BA**
Panel A: Enrollment by age 24	Enroll AA only	0.21	0.71	0.00
	Enroll BA only	0.47	0.00	0.85
	AA to BA	0.08	0.29	0.15
	Enroll PSE	0.76	1.00	1.00
Panel B: Demographic characteristics	Skill (ASVAB)	54.68	47.64	67.95
	Real parental income	79,589	66,738	97,128
	At least one parent BA+	0.33	0.21	0.49
	Female	0.55	0.58	0.58
	Black	0.21	0.22	0.18
	Hispanic	0.16	0.21	0.12
	Observations	2,322	677	1,288

Notes: The table reports enrollment rates by path to highest postsecondary enrollment and demographic attributes for three groups: high school graduates, AA enrollees by age 24, and BA enrollees by age 24. Note that a sample member can enroll in both an AA and a BA by age 24. Source: NLSY97.

Postsecondary enrollment outcomes, parental income, and skill Among high school graduates, PSE program enrollment is related to skill, parental income, parental education, and other demographic attributes. However, these attributes have a joint distribution in the population, so that comparisons of means alone is not informative about the predictive power of each attribute for a given outcome holding other attributes fixed. In light of such concerns, Table 9 presents Average Marginal Effects (AMEs) for four probit regressions on various subsamples of high school graduates. In each regression, the dependent variable is an indicator for a specific postsecondary enrollment outcome and the controls are indicators for parental income terciles, skill terciles, having at least one parent with a BA or higher, and (although not shown in the main text) flags for being female, black, or Hispanic. Regression coefficients for all regressions in Table 9 are reported in Table A1 of Appendix A.1.1.

Model (1) regresses an indicator for enrolling in a BA program by age 24 on our set of controls for the sample of high school graduates. The results indicate that, on average and holding other attributes fixed, being in a lower parental income tercile or a lower skill tercile negatively predicts enrolling in a BA, while having at least one parent with a BA or higher positively predicts this outcome. These AMEs are statistically significant at the one percent level.

In model (2), we regress an indicator for enrolling in an AA program by age 24 on our set of controls for the sample of high school graduates. Being in a lower parental income or skill tercile positively predicts enrolling in an AA, while having at least one parent with a BA or higher negatively predicts this outcome. However, the AMEs for parental income are less statistically significant than in model (1): the first tercile is significant at the five percent level and the second tercile is significant at the ten percent level. Other AMEs are significant at the one percent level.

Table 9: Average Marginal Effects: Predicting postsecondary enrollment

	Dependent variable			
Control variable	**(1) Enroll BA**	**(2) Enroll AA**	**(3) Enroll AA**	**(4) AA to BA**
Flag: Parental income tercile 1	-0.146	0.061	0.146	0.075
	(0.0258)	(0.0260)	(0.0306)	(0.0295)
Flag: Parental income tercile 2	-0.071	0.044	0.075	0.058
	(0.0228)	(0.0234)	(0.0257)	(0.0228)
Flag: Skill tercile 1	-0.498	0.115	0.420	0.179
	(0.0258)	(0.0261)	(0.0331)	(0.0419)
Flag: Skill tercile 2	-0.225	0.113	0.179	0.049
	(0.0228)	(0.0228)	(0.0252)	(0.0223)
Flag: At least 1 parent BA+	0.224	-0.105	-0.188	-0.078
	(0.0221)	(0.0215)	(0.0242)	(0.0211)
Additional demographic flags	Y	Y	Y	Y
Sample	HS grads	HS grads	Enroll PSE	Enroll BA
Observations	2,322	2,322	1,768	1,288
pseudo- R^2	0.24	0.04	0.17	0.07

Notes: The table reports probit regression AMEs for regressions with the following dependent variables: (1) the likelihood of enrolling in a BA at some point up to age 24, conditional on completing high school (HS); (2) the likelihood of enrolling in an AA at some point up to age 24, conditional on completing high school; (3) the likelihood of enrolling in an AA conditional on enrolling in any PSE at some point up to age 24; (4) the likelihood of previously enrolling in an AA, conditional on enrolling in a BA at some point up to age 24. Standard errors in parentheses. Additional demographic flags included but not shown here are an indicator for being female, black, and Hispanic. Source: NLSY97.

Model (3) reports how parental income, skill, and parental education predict enrolling in an AA conditional on enrolling in any PSE. Being in a lower parental income tercile or a lower skill tercile positively predict enrolling in an AA among all PSE enrollees, while having at least one parent with a BA negatively predicts this outcome. These AMEs are statistically significant at the one percent level.

Model (4) reports how the same set of controls predict taking the AA-to-BA path among BA enrollees. Being in a lower parental income or skill tercile positively predicts taking this route, while having at least one highly educated parent negatively predicts it. These AMEs are statistically significant at the five percent level, except for the first skill tercile and parental education which are significant at the one percent level.

To summarize, having lower skill or poorer or less educated parents predicts a higher likelihood of enrolling in an AA program among both high school graduates and PSE enrollees, as well as a higher likelihood of taking the AA to BA route among BA enrollees. These same attributes negatively predict enrolling in a BA among all high school graduates.

In Table A5 of Appendix A.2.1, we estimate probit regressions analogous to those of Table 9 in the HSLS:09. The results are very similar to those of Table 9, although because of the HSLS:09's shorter panel dimension we do not observe medium-term education outcomes with the same ac-

curacy as the NLSY97 and this lowers the statistical significance of some of the predictors in the HSLS:09.

In the next section, we build a quantitative model of college enrollment with borrowing constraints in which consumers choose between AA and BA programs. The AA program offers the option to transfer to the BA program after successfully completing one or two years and incorporates attributes documented in Section 2.

3 Model

Based on our empirical findings, we build an overlapping generations model with an AA program and a BA program. These two programs differ in both accessibility and quality. Program features related to accessibility are admission likelihoods, program duration, tuition and fees, effort costs, and financial aid. Program features related to quality are consumption values, the exogenous components of continuation likelihoods, and labor market returns for graduates. Additionally, AA enrollees may have the option to transfer to the BA program but not vice versa. For those who transfer from AA to BA, the BA consumption value, continuation likelihoods, and labor market returns are distinct from those who directly enroll in a BA.

Section 3.1 provides an overview organized by agent type. Section 3.2 presents consumer value functions before and while enrolled in an AA or BA program because these value functions capture most of the novel elements of the model. Appendix B presents the value functions after the highest level of degree attainment, additional functional forms, equilibrium definition, and computational algorithm.

3.1 Overview

Time is discrete and runs forever; each period lasts one year. The economy contains a two-year postsecondary institution, a four-year postsecondary institution, heterogeneous overlapping generations of consumers, a government, and a final goods firm.

3.1.1 Two- and four-year postsecondary education institutions

The two-year institution offers an AA program, while the four-year institution offers a BA program. The differences between the two programs can be organized into features related to accessibility and quality.

Program features related to accessibility The AA program follows an open admissions policy allowing any high school graduate to enroll. In contrast, the BA program follows selective ad-

missions, which is incorporated through a straight-to-BA enrollment option shock, $q(s)$, that is specific to skill s. Only high school graduates who receive the favorable straight-to-BA enrollment option shock may enroll directly in the BA program. Others can transfer to the BA program if they enroll in and successfully complete the first or second academic year in the AA program. The straight-to-BA enrollment option shock captures admissions requirements, discussed in Section 2.1, as well as frictions and capacity constraints in BA programs (especially selective ones) that result in the lower skill being less likely to be admitted directly into a BA program.

Apart from program duration and admissions policies, the two postsecondary institution types also feature distinct tuition and fees, $\kappa(d_e)$, and effort cost, $\lambda(d_e)$. The argument $d_e \in \{N, A, B\}$ records the postsecondary program enrollment status, where the elements of the set denote nonenrollment, AA enrollment, and BA enrollment, respectively. When $d_e = N$, the values for the corresponding variables are set to zero.

The extent of financial aid also varies between the two programs. The college room and board expenditure amount, $\bar{c}(d_e)$, is program-specific and is used only to determine the cost of attendance, $\kappa(d_e) + \bar{c}(d_e)$, which then determines an upper bound for Pell grants and subsidized student loans in equations (4) and (5), discussed below. Additionally, grants from private sources and public sources other than Pell, $\theta^{pr}(s, d_e)$ and $\theta^{other}(s, d_e)$, respectively, are program and skill specific. While Pell grants, described in Section 3.1.3, are need-based, these other grants incorporate a merit-based component.

Program features related to quality Enrollment is associated with consumption value given by CV^A and $CV^B\left(j^A\right)$ for the AA and BA program, respectively. In $CV^B(\cdot)$, the argument j^A records the number of years of AA completion for BA enrollees, which allows the model to feature scarring effects for AA-to-BA enrollees in comparison to straight-to-BA enrollees. The exogenous component of continuation likelihoods is program- and skill-specific. The exogenous probabilities of continuing each academic year are given by $p^A(s)$ and $p^B\left(s, j^A\right)$ for the AA and BA program, respectively.

The path to highest degree attainment indexes labor market returns for graduates via the deterministic component of life cycle earnings, $\epsilon\left(j, e^B, e^A, s\right)$, where j denotes age. After the highest level of postsecondary degree is permanently determined, the history of postsecondary education is recorded with the indicator variables e^B and e^A.

The indicator variable e^B records BA completion status. Completing the BA leads to a skill-specific BA wage premium. Additionally, BA completion status indexes the persistence, $\rho_\eta\left(e^B\right)$, innovation variance, $\sigma^2_\eta\left(e^B\right)$, and the initial draw variance, $\sigma^2_{\eta_0}\left(e^B\right)$, which are the parameters for the AR(1) process for earnings, and also the wage rate, $w(e^B)$, and Social Security transfers,

$ss\left(e^B, e^A, s\right)$. The function for Social Security transfers is presented in equation (20) of Appendix B.2.

The indicator variable e^A is an AA flag that reflects distinct attributes for those with and without a BA. For consumers without a BA degree, AA completion leads to a AA-specific wage premium. For consumers with a BA degree, a history of having transferred to the BA from the AA program leads to a scarring effect on wages. This effect is the same for those who transfer after one or two years in the AA program. Consequently, the AA flag indexes the deterministic component of life cycle earnings, $\epsilon\left(j, e^B, e^A, s\right)$ and Social Security transfers, $ss\left(e^B, e^A, s\right)$.

3.1.2 Consumers

This section presents the consumers' preferences and an overview of their life cycle.

Preferences The consumer's flow utility function over consumption and leisure is given by, $U\left(c, \ell, j, d_e\right)$, in which the inputs are household consumption, c, hours worked, ℓ, adult age, j, which also records AA academic year when $j \in \{1, 2\}$ and BA academic year when $j \in \{1, 2, 3, 4\}$, and postsecondary education enrollment status, d_e. The utility function is given by

$$U\left(c, \ell, j, d_e\right) = \frac{\left[\left(\frac{c}{\zeta_j}\right)^{\upsilon}\left(1 - \ell - \lambda\left(d_e\right)\right)^{1-\upsilon}\right]^{1-\sigma}}{1-\sigma} \tag{1}$$

where ζ_j is an adult equivalence parameter that determines child consumption, υ is consumption share, and σ determines the relative risk aversion.

In addition to the objects that affect flow utility in equation (1), a consumer enrolled in a postsecondary program experiences the consumption value gains described above in Section 3.1.1, which they weigh using the idiosyncratic weight for the consumption value of college, γ. Furthermore, a consumer who is delinquent on student loans experiences a stigma cost captured by a utility penalty, ξ_D.

Life cycle overview Consumers start making decisions when they turn 18 at model age $j = 1$. Adults survive each period with probability ψ_j and live for a maximum of J periods.

When a consumer enters the economy as an adult, they are indexed by skill endowment, s, stochastic idiosyncratic earnings productivity, η, initial net assets, a, Expected Family Contribution, f, and weight for the consumption value of college, γ. The skill endowment of a new adult is drawn once from a distribution that depends on whether or not their parent has a BA. The stochastic component of earnings follows a log AR(1) process that depends on BA completion status. Net assets at the

start of adulthood are determined by a one-time inter vivos transfer from the consumer's parent, and are recorded with $a \geq 0$. The Expected Family Contribution (EFC) depends on the income of each high school graduate's parents and its calculation is explained in Section 3.1.3. The weight for the consumption value of college is drawn from a log-normal distribution with a zero mean and variance, σ_γ^2.

Consumers are subject to borrowing constraints, and make the postsecondary education enrollment decision after the realization of the straight-to-BA enrollment option shock. Expenses while enrolled in the AA or BA program can be financed with federal student loans, inter vivos transfers from parents, earnings while in college, Pell grants, other public grants, and private grants. Federal student loans are the only form of debt in the model and are recorded with $a < 0$.

Repayment of federal student loans begins when a consumer is no longer enrolled in any postsecondary education. Subsidized federal student loans have interest assessed starting at this point, whereas interest accrues on unsubsidized federal loans during enrollment as well. In repayment, consumers choose between making a full payment, $d_f = 0$, and delinquency, $d_f = 1$. A full payment implies that the consumer must make a payment of at least $\rho_R(j, a)$, whereas delinquency leads to a partial payment, $\rho_D(j, a, y)$, due to garnishment of disposable income above the amount $\bar{y}$ at a rate τ_g; additional costs of delinquency are a collection fee that is proportional to the missed payment, ϕ, and the stigma cost, ξ_D. The payment functions are provided in Appendix B.2.

Upon paying off student loans, consumers solve a standard consumption-savings problem, which is affected by the presence of a child from age j_f until age $j_f + j_a$. At the beginning of age $j_f + j_a$, the family draws the child's skill endowment, s_c. The altruistic parent then makes an inter vivos asset transfer to their child that takes into account the child's skill.

Consumers retire at age j_r and subsequently receive Social Security transfers until they die. Assets of the deceased are redistributed as age-dependent accidental bequests, Tr_j.

The consumer's income depends on their age, the other idiosyncratic states such as BA completion status, AA flag, skill, AR(1) productivity, and net assets as well as hours worked. For ease of exposition, we summarize the consumer's pretax income using $y(\cdot)$ given by

$$\begin{aligned} y\left(j, e^B, e^A, s, \eta, a, \ell\right) =& w\left(e^B\right) \epsilon\left(j, e^B, e^A, s\right) \eta \ell \mathbb{I}_{j<j_r} + ss\left(e^B, e^A, s\right) \mathbb{I}_{j \geq j_r} + \\ & r\left[a \mathbb{I}_{a>0} \mathbb{I}_{j>1} + Tr_j\right]. \end{aligned} \tag{2}$$

3.1.3 Government

The government provides grants for college education (Pell grants and the other public grants), runs the federal student loan program, funds Social Security, and finances a required government consumption set as an exogenous fraction g of gross domestic product (GDP). Government spending is financed with tax revenue collected from a flat consumption tax, τ_c, and a progressive income tax and transfer function, $T(y)$, which is levied on pretax income, y. The income tax and transfer function follows the specification of Heathcote, Storesletten, and Violante (2017), and is given by

$$T(y) = y - \tau_l y^{1-\tau_p}, \tag{3}$$

where τ_p governs the tax progressivity and the level parameter τ_l is used to balance the government budget constraint in every period as shown in equation (22) of Appendix B.2.

Pell grants The Pell grant function assigns an amount that is based on the EFC, f, and the cost of attendance, $\kappa(d_e) + \bar{c}(d_e)$. Specifically, the Pell grant has a maximum value of θ_{max}^{Pell}, and is decreasing in the EFC, with a value given by the function

$$\theta^{Pell}(f, d_e) = \max\left[\min\left[\kappa(d_e) + \bar{c}(d_e) - f, \theta_{max}^{Pell} - f\right], 0\right]. \tag{4}$$

Federal student loans The federal student loan program is characterized by a college-year specific student loan limit for subsidized and unsubsidized loans, $\bar{A}(j)$, a college-year specific student loan limit for subsidized loans, $\bar{A}_s(j)$, and a student loan interest rate, $r_{SL} = r + \tau_{SL}$, where r is the risk-free interest rate on savings and τ_{SL} is an add-on set by the government. The subsidized loan function is given by

$$a_s(f, j, d_e, a') = -\mathbb{I}_{a'<0} \min\left[-a', \bar{A}_s(j), j \max\left[\kappa(d_e) + \bar{c}(d_e) - f - \theta^{Pell}(f, d_e), 0\right]\right]. \tag{5}$$

This function computes the amount of federal loans taken out by the student that are treated as subsidized. The function implies that, subject to the limit $\bar{A}_s(j)$, either the cost of attendance net of the EFC and Pell grant or the total amount of student debt (whichever is smaller) can be treated as a subsidized loan.

Expected Family Contribution The EFC, f, is an input into the Pell grant and subsidized loan functions in equations (4) and (5) and is determined as follows. If the consumer has parental income below the automatic zero EFC income threshold, $y_{f=0}$, the EFC is set to zero. Otherwise, parental income is used to determine adjusted available income, $y_{ad}(y)$, which is then used to calculate the EFC using a progressive step function, $G(y)$.

The adjusted available income function is given by

$$y_{ad}(y) = y - T(y) - y_{PA}, \tag{6}$$

where y_{PA} denotes the income protection allowance.

The progressive EFC step function is given by

$$G(y) = \begin{cases} \max\left[\tau_{f,1} y_{ad}(y), 0\right] & \text{if } \; y_{ad}(y) \leq Y_{f,1} \\ \tau_{f,1} Y_{f,1} + \tau_{f,2}\left[y_{ad}(y) - Y_{f,1}\right] & \text{if } \; Y_{f,1} < y_{ad}(y) \leq Y_{f,2} \\ ... & \\ \tau_{f,1} Y_{f,1} + ... + \tau_{f,6}\left[y_{ad}(y) - Y_{f,5}\right] & \text{if } \; Y_{f,5} < y_{ad}(y), \end{cases} \tag{7}$$

where y is parental income, the set $\{Y_{f,i}\}_{i=1}^{5}$ determines the intervals of the step function, and $\tau_{f,1} < \tau_{f,2} < ... < \tau_{f,6}$ are the marginal rates within the intervals. The progressive EFC step function and the adjusted available income function jointly imply that, among those who do not qualify for an automatic zero EFC, individuals with a lower disposable parental income will be assigned a lower EFC.

3.1.4 Final goods firm

Output is produced by a final goods firm using a Cobb-Douglas production function that combines aggregate capital and aggregate labor. In turn, aggregate labor is a constant elasticity of substitution aggregator of efficiency units of labor without a BA degree and efficiency units of labor with a BA degree with elasticity of substitution $1/(1-\iota)$ and share parameter ν. Specifically, the final goods production function is given by

$$Y = K^{\alpha}\left[Z\left[\nu L_{(e^B=0)}^{\iota} + (1-\nu) L_{(e^B=1)}^{\iota}\right]^{1/\iota}\right]^{1-\alpha}, \tag{8}$$

where K is aggregate capital, Z is aggregate labor productivity, $L_{(e^B=0)}$ is efficiency units of labor without a BA, $L_{(e^B=1)}$ is the efficiency units of labor with a BA, and α is the capital share. The capital stock depreciates at rate δ.

3.2 Consumer value functions before and while enrolled in college

Given their type, (s, η, a, f, γ), the lifetime expected value to an 18-year-old (that is, $j = 1$ in the model) is given by

$$V^0(s,\eta,a,f,\gamma) = (1-q(s)) \max\left[V\left(j,e^B,e^A,s,\eta,a\right), V^A(j,s,\eta,a,f,\gamma)\right] + \quad (9)$$
$$q(s) \max\left[V\left(j,e^B,e^A,s,\eta,a\right), V^A(j,s,\eta,a,f,\gamma), V^B\left(j,s,\eta,a,f,\gamma,j^A\right)\right],$$

where $j = 1$, $e^B = 0$, $e^A = 0$, and $j^A = 0$. In the equation, $V\left(j,e^B,e^A,s,\eta,a\right)$ is the value of not attending college, $V^A(j,s,\eta,a,f,\gamma)$ is the value of enrollment in the AA program, and $V^B\left(j,s,\eta,a,f,\gamma,j^A\right)$ is the value of enrollment in the BA program. For the value of not attending college, see equation (12) of Appendix B.1.

The value of enrollment in the AA program at age $j = 1$ is given by

$$V^A(j,s,\eta,a,f,\gamma) = \max_{c\geq 0, \ell\in\mathscr{L}, a'\geq -\bar{A}(j)} U(c,\ell,j,d_e) + \gamma C V^A + \quad (10)$$
$$\beta\psi_j E_{\eta'|e^B,\eta}\Big[p^A(s)\max\left[V\left(j+1,e^B,e^A,s,\eta',a'\right), V^A(j+1,s,\eta',a',f,\gamma), V^B(j+1,s,\eta',a',f,\gamma,j_a)\right]$$
$$+\left(1-p^A(s)\right)V\left(j+1,e^B,e^A,s,\eta',a'\right)\Big]$$

s.t.

$$(1+\tau_c)c + a' + \tilde{\kappa}(d_e) = \tilde{y}\left(j,e^B,e^A,s,\eta,a,\ell\right) + a + Tr_j + r_{SL}\left(\mathbb{I}_{a<0}a - a_s(f,j,a',d_e)\right),$$

where $j = 1$, $d_e = A$, $e^B = 0$, $e^A = 0$, and $j_a = 1$. In the equation, $\mathscr{L}$ is the set of feasible work hours, β is the discount factor, a' is the stock of assets or federal student loans in the next period, $\tilde{\kappa}(d_e,s,f) = \kappa(d_e) - \theta^{Pell}(f,d_e) - \theta^{other}(s,d_e) - \theta^{pr}(s,d_e)$ summarizes tuition and fees net of all grants, and $\tilde{y} = y - T(y)$ summarizes disposable income. The continuation value reflects that, if the consumer passes to the second year of the AA program, they may choose to drop out, continue the AA program, or transfer to the second year of the BA program.

At age $j = 2$, the value of enrollment in the AA program is the same as in equation (10) except for the fact that, if the consumer graduates from the AA program, there is no endogenous dropout decision and the consumer chooses between entering the labor market as an AA graduate and transferring to the third year of a BA.

The value of enrollment in the BA program at ages $j \in \{1,2,3\}$ is given by

$$V^B\left(j,s,\eta,a,f,\gamma,j^A\right) = \max_{c\geq 0,\ell\in\mathscr{L},a'\geq -\bar{A}(j)} U\left(c,\ell,j,d_e\right) + \gamma C V^B\left(j^A\right) + \tag{11}$$

$$\beta\psi_j E_{\eta'|e^B,\eta}\Bigg[p^B\left(s,j^A\right)\max\left[V\left(j+1,e^B,e^{A'}\left(j^A\right),s,\eta',a'\right),V^B\left(j+1,s,\eta',a',f,\gamma,j^A\right)\right]$$

$$+\left(1-p^B\left(s,j^A\right)\right)V\left(j+1,e^B,e^{A'}\left(j^A\right),s,\eta',a'\right)\Bigg]$$

s.t.

$$(1+\tau_c)\,c + a' + \tilde{\kappa}\left(d_e\right) = \tilde{y}\left(j,e^B,e^A,s,\eta,a,\ell\right) + a + Tr_j + r_{SL}\left(\mathbb{I}_{a<0}a - a_s\left(f,j,a',d_e\right)\right)$$

$$e^{A'}\left(j^A\right) = \begin{cases} 0 & \text{if } \ j^A \in \{0,1\} \\ 1 & \text{if } \ j^A = 2, \end{cases}$$

where $d_e = B$, $e^B = 0$, and $e^A = 0$. In the equation, $e^{A'}\left(j^A\right)$ is an AA flag function for those exiting college. In equation (11), those exiting college enter the labor market as a BA dropout. For these individuals, the function records whether or not the individual enters the labor market with an AA degree.

At age $j = 4$, the value of enrollment in the BA program is the same as in equation (11) with modifications to the continuation value and the AA flag function, $e^{A'}\left(j^A\right)$, for those exiting college. Specifically, in the continuation value there is no dropout decision, and if the consumer completes the BA program, then their state variable is modified to reflect the BA degree. The AA flag function in equation (11) is modified to reflect whether or not BA graduates have a history of prior AA enrollment, which then affects their labor market returns through $\epsilon\left(j,e^B,e^A,s\right)$. However, the function is unchanged for dropouts.

4 Parameterization

This section presents the externally estimated parameters related to the AA and BA program and all internally calibrated parameters in Sections 4.1 and 4.2, respectively. The remaining externally estimated parameters are presented in Appendix C. Note that, because the model is calibrated so that GDP per capita for those 18 and over is one in the initial equilibrium, we can conveniently normalize several target moments by GDP per capita for those 18 and over in the data. As such, in several rows within Tables 10 and 11 in this section and Table C1 of Appendix C, we note that an external parameter or target moment is normalized. The value of the denominator is computed by combining information on GDP from the Bureau of Economic Analysis (BEA) from BEA Table 1.1.5 with population levels from the US Census Bureau (Census Bureau of the United States,

2020) for 2013-2015.

4.1 Externally estimated parameters related to the AA and BA program

Table 10 reports the externally estimated parameters related to the AA and BA program organized into Panels A and B based on features related to accessibility and quality, respectively.

In Panel A, annual tuition and fees, $\kappa\left(d_e\right)$, is set to 0.057 and 0.258 for the AA and BA programs, respectively, using information from the HSLS:09. These estimates are drawn from Table 1 and then normalized by GDP per capita for those 18 and over in 2013. Analogously, the college room and board amount, $\bar{c}\left(d_e\right)$, is set to 0.091 and 0.142 using data from NCES Table 330.10 (2019). Note that the college room and board amounts are only used to determine an upper bound for need-based aid (Pell grants and subsidized loans) in equations (4) and (5). These values imply that the AA program is much cheaper than the BA program in terms of tuition and fees, but AA enrollees face a lower upper bound for need-based aid because of the lower estimated amount for college room and board.

In Panel B, the deterministic component of the life cycle earnings process, $\epsilon\left(j, e^B, e^A, s\right)$, is assumed to have the functional form given by

$$\epsilon\left(j, e^B, e^A, s\right) = \exp\left(\beta_1^{age}\left(e^B\right) j + \beta_2^{age}\left(e^B\right) j^2 + \beta_3^{age}\left(e^B\right) j^3 + \beta^s\left(e^B, s\right) + \beta^A\left(e^B\right) e^A\right),$$

where $\beta_1^{age}\left(e^B\right)$, $\beta_2^{age}\left(e^B\right)$, and $\beta_3^{age}\left(e^B\right)$ are coefficients for the age-specific third-order polynomial, $\beta^s\left(e^B, s\right)$ is a skill tercile shifter, and $\beta^A\left(e^B\right)$ is an AA shifter. All coefficients and shifters are specific to BA completion status, e^B. The remaining parameters in Panel B govern the stochastic component of the earnings process, which follows a log AR(1) process with persistence, $\rho\left(e^B\right)$, and an innovation term drawn from a Normal distribution with variance, $\sigma_\eta^2\left(e^B\right)$. When individuals enter the economy as a young adult without a BA, they make their initial AR(1) productivity draw from a log-normal distribution with zero mean and variance, $\sigma_{\eta_0}^2\left(e^B = 0\right)$.

All of these parameters are estimated using data from both the NLSY97 and PSID (Survey Research Center, Institute for Social Research, 2021), with full estimation details are provided in Appendix A.1.3.

Figure 1 provides a visual illustration of the deterministic component of the life cycle earnings process. Panel 1a depicts the efficiency units by BA completion status for a high-skill individual without the AA flag. Among those without a BA, these are individuals without an AA degree and among those with a BA, these are individuals who had directly enrolled in the BA. The panel implies a large BA efficiency premium, especially at the middle to later stages of the life cycle.

Table 10: Externally estimated parameters related to the AA and BA program

Parameter	Description	Data source	Value	
Panel A: Program parameters related to accessibility			$d_e = A$	$d_e = B$
$\kappa(d_e)$	Annual tuition, normalized	HSLS:09	0.057	0.258
$\bar{c}(d_e)$	College room and board, normalized	NCES	0.091	0.142
Panel B: Program parameters related to quality: earnings process			$e^B = 0$	$e^B = 1$
$\beta_1^{age}(e^B)$	Coefficients of age-specific polynomial	PSID and NLSY97	0.0958	0.188
$\beta_2^{age}(e^B)$			-0.00151	-0.00330
$\beta_3^{age}(e^B)$			0.0000069	0.0000188
$\beta^s(e^B, s)$	Skill tercile shifters by s		(-0.156,-0.0581,0)	(-0.218,-0.0782,0)
$\beta^A(e^B)$	AA shifter		0.131	-0.0638
$\rho_\eta(e^B)$	AR(1) persistence		0.927870	0.922504
$\sigma_\eta^2(e^B)$	AR(1) innovation variance		0.037087	0.042391
$\sigma_{\eta_0}^2(e^B)$	AR(1) initial draw variance		0.058800	0.142481

Notes: The table presents the externally estimated parameters related to the AA and BA program. In the table, "n/a" refers to the case in which the initial draw variance is not applicable when $e^B = 1$ because all young adults enter the economy without a BA, that is $e^B = 0$. The remaining externally estimated parameters are presented in Table C1 of Appendix C.

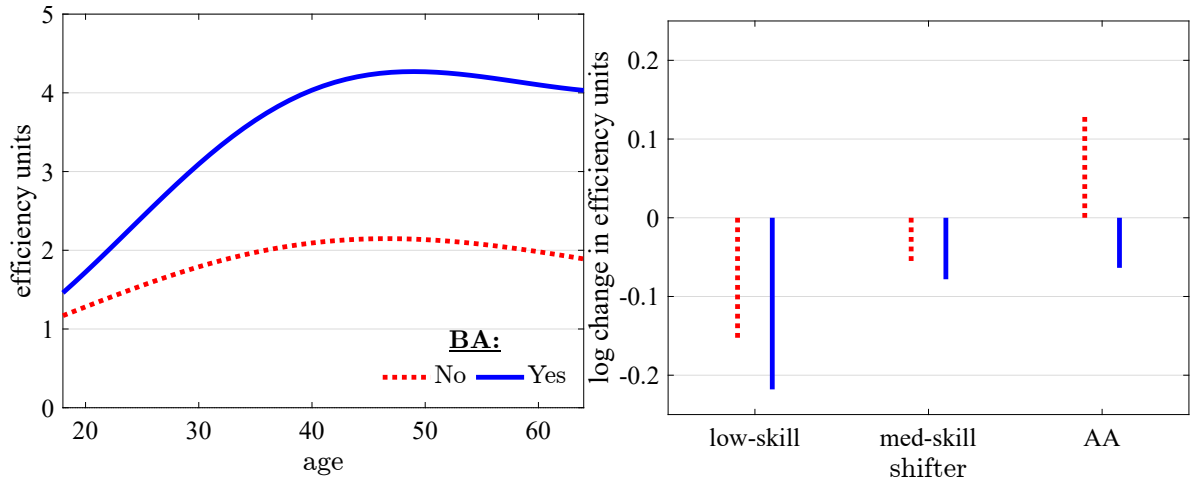
Panel 1b of Figure 1 depicts the skill tercile and AA shifters by BA completion status. A comparison across skill shifters within a BA completion status implies that lower skill is associated with a larger drop in efficiency units. A comparison across BA completion status within a skill tercile implies a smaller BA efficiency premium for those with lower skill. Lastly, among those without a BA, the AA shifter implies a roughly 13 percent increase in efficiency units for an AA degree, and among those with a BA, the AA shifter implies a roughly 6 percent decrease in efficiency units for a history of an AA-to-BA transfer.[10]

4.2 Internally calibrated parameters

Table 11 reports the internally calibrated parameters organized into Panels A through D based on parameter type. Although parameters and moments are grouped using the most significant one-to-one relationship between each parameter and target moment, and are discussed accordingly, the parameters are calibrated jointly and each parameter can affect all target moments.

Panel A reports AA and BA parameters related to accessibility. The straight-to-BA enrollment option shock, $q(s)$, is parameterized to target AA enrollment rates by skill for those from the top parental income tercile, estimated using the NLSY97 and reported in Table A2 of Appendix A.1.2. Additional details on the estimation of the empirical moments including sample selection criteria

[10] In Appendix C.2, we show that the model accounts for the empirical pattern that the AA wage premium is lower than the BA wage premium within each skill tercile. We also show that the model accounts for the the lower BA wage premium for the many BA graduates taking the AA-to-BA route in comparison to straight-to-BA enrollees.



(a) High-skill and no AA flag

(b) Skill tercile and AA shifters

Figure 1: Deterministic component of life cycle productivty

Notes: The figure depicts by BA completion status, the deterministic component of life cycle earnings productivity for a high-skill individual without an AA flag, $\epsilon\left(j, e^B, e^A = 0, s = 3\right)$, and the skill tercile and AA shifters, $\beta^s\left(e^B, s\right)$ and $\beta^A\left(e^B\right)$, in Panels 1a and 1b, respectively. Values are drawn from Panel B of Table 10. Data source: PSID and NLSY97.

are provided in Appendix A.1. Focusing on enrollment rates of individuals from high-income families minimizes the role of borrowing constraints in the AA enrollment target moment. The calibrated values imply that those with lower skill are academically disadvantaged in that they are less likely to receive the option to directly enroll in a BA.

The remaining parameters of Panel A are governed by target moments from the HSLS:09. Additional details on the estimation of the empirical moments including sample selection criteria are provided in Appendix A.2. Each of the rows draw from Tables 2 of Section 2.1 and Table A8 of Appendix A.2.3. The program-specific college effort cost, $\lambda(d_e)$, is set to match the average weekly hours worked as a fraction of 40 hours (full-time work) for first-year students while in an AA and BA program, respectively. The calibrated effort cost for the AA program is smaller than that for the BA program. The next four rows of the panel contain the parameters representing program-and-skill-specific grants and scholarships from public sources other than Pell grants, $\theta^{other}(s, d_e)$, and private sources, $\theta^{pr}(s, d_e)$. These parameters are set to match the program-and-skill-specific ratios of public grants net of Pell to tuition and fees, and of private grants to tuition and fees.

Panel B reports AA and BA parameters related to quality. All target moments in this panel are based on the NLSY97 and are drawn from Tables 3 and 6 of Section 2 and Table A2 of Appendix A.1.2. The consumption value offered by the AA program, CV^A, is calibrated to match the AA

enrollment rate. For the BA program, the consumption value for direct enrollees, $CV^B\left(j^A=0\right)$, is calibrated to match the total BA enrollment rate while the consumption value for AA to BA transfers, $CV^B\left(j^A\in\{1,2\}\right)$, is calibrated to match the transfer to BA rate of AA enrollees. The AA program features the lowest consumption value. Within the BA program, those who enroll directly experience a higher consumption value than those who transfer from the AA program. The ranking of these calibrated values are consistent with the discussion on consumption amenity spending from Section 2.

The remaining rows of Panel B contain parameters related to the exogenous likelihood of continuation in each program. The skill-specific annual probability of being allowed to continue the AA program, $p^A\left(s\right)$, is calibrated to target the skill-specific AA graduation or transfer to BA rates for AA enrollees. Similarly, the skill-specific annual probability of being allowed to continue the BA program for those who directly enroll in the BA program, $p^B\left(s,j^A=0\right)$, is calibrated to target skill-specific BA graduation rates for straight-to-BA enrollees. Lastly, the analogous BA continuation probability for AA-to-BA enrollees, $p^B\left(s,j^A\in\{1,2\}\right)$, is calibrated to target skill-specific BA attainment rates for AA enrollees. The calibrated values of $p^A\left(s\right)$ are less than $p^B\left(s,j^A\right)$ for all skill levels, reflecting the lower quality of the AA program. Additionally, the calibrated values of $p^B\left(s,j^A\right)$ are slightly lower when $j^A\in\{1,2\}$ than when $j^A=0$ for all skill levels. These results imply that, in the model, the annual likelihood of being allowed to continue a BA is lower for AA-to-BA enrollees in comparison to straight-to-BA enrollees. This captures a scarring effect for AA-to-BA enrollees in terms of their continuation likelihood once they enroll in a BA, consistent with qualitative findings of Table 6.

Panel C reports preference parameters. The variance of the log-normal distribution for the weight on the consumption value of college, σ_γ^2, is calibrated to account for an estimate of the responsiveness of the enrollment rate from a quasi-natural experiment in which prospective students are given a \$1,000 subsidy to attend college (AA or BA programs). Based on the preferred estimate of Deming and Dynarski (2009), the calibration targets a PSE enrollment rate response of 4.00 percentage points. In the model, the enrollment rate response is computed in a partial equilibrium in which the distribution of 18-year-olds and general equilibrium prices, taxes, and transfers are held fixed at their initial steady state values. Targeting the enrollment response using the variance of the weight on the consumption value of college places quantitative discipline on the results from the subsidy expansion experiments in Section 6. This is because those who place a high weight on the consumption value of college are more likely to have selected into PSE enrollment in the status quo equilibrium while the remaining pool of nonenrollees are not as likely to value enrollment in a PSE.

Returning to Panel C, the discount factor, β, is calibrated to target a capital-to-output ratio of 3,

Table 11: Internally calibrated parameters

Parameter			Target moment		
Symbol	**Description**	**Value**	**Description**	**Data value**	**Model value**
Panel A: AA and BA parameters related to accessibility					
$q(s)$	Straight-to-BA enroll. opt. shock	(0.526,0.751,0.854)	AA enrollment | High income	*(0.414,0.257,0.151)*	*(0.422,0.258,0.151)*
$\lambda(d_e)$	Effort cost: $d_e \in \{A, B\}$	(0.495,0.555)	Average hours / Full time hours	*(0.425,0.225)*	*(0.431,0.224)*
$\theta^{other}(s, A)$	Public grants net Pell | AA	(0.000,0.002,0.004)	Public grants net Pell to tuition | AA	*(0.000,0.040,0.080)*	*(0.000 0.040 0.080)*
$\theta^{pr}(s, A)$	Private grants | AA	(0.014,0.013,0.011)	Private grants to tuition | AA	*(0.257,0.239,0.195)*	*(0.257 0.239 0.195)*
$\theta^{other}(s, B)$	Public grants net Pell | BA	(0.046,0.053,0.071)	Public grants net Pell to tuition | BA	*(0.199,0.228,0.305)*	*(0.199,0.228,0.305)*
$\theta^{pr}(s, B)$	Private grants | BA	(0.031,0.032,0.037)	Private grants to tuition | BA	*(0.132,0.138,0.158)*	*(0.132,0.138,0.158)*
Panel B: AA and BA parameters related to quality					
CV^A	Cons. val. AA	6.344	AA enrollment	*0.292*	*0.295*
$CV^B\left(j^A = 0\right)$	Cons. val. BA | Straight-to-BA	11.798	Total BA enrollment	*0.555*	*0.569*
$CV^B\left(j^A \in \{1, 2\}\right)$	Cons. val. BA | AA-to-BA	8.654	Transfer rate to BA | AA	*0.290*	*0.283*
$p^A(s)$	AA cont. prob.	(0.569,0.631,0.786)	Grad. or transfer to BA | AA enrollee	*(0.386,0.472,0.678)*	*(0.382,0.467,0.676)*
$p^B\left(s, j^A = 0\right)$	BA cont. prob. | Straight-to-BA	(0.885,0.919,0.963)	BA grad. rate | Straight-to-BA enrollee	*(0.573,0.696,0.857)*	*(0.580,0.698,0.857)*
$p^B\left(s, j^A \in \{1, 2\}\right)$	BA cont. prob. | AA-to-BA	(0.823,0.881,0.923)	BA attainment rate | AA enrollee	*(0.120,0.195,0.344)*	*(0.114,0.183,0.337)*
Panel C: Preferences					
σ^2_γ	Var. cons. value weight	0.560	Enrollment response | $1,000 subsidy	*0.040*	*0.031*
β	Discount factor	0.987	Capital-to-output ratio	*3.000*	*3.000*
β_c	Parent altruism toward child	0.051	Average transfer, normalized	*0.583*	*0.570*
υ	Cons. share utility	0.406	Average worker is full time	*0.333*	*0.333*
ξ_D	Federal delinquency cost	0.052	Federal delinquency rate | BA	*0.088*	*0.087*
Panel D: Production technology and Social Security					
Z	Aggregate labor productivity	1.360	GDP per capita 18+	*1.000*	*0.999*
ν	No BA labor share	0.525	BA wage premium | Middle skill	*1.402*	*1.404*
χ	SS replacement rate	0.186	SS expenditure, fraction of GDP	*0.047*	*0.047*

Notes: The table presents the internally calibrated parameters and the associated target moments.

consistent with Jones (2016). The degree of parental altruism, β_c, is set so that the model matches average parent-to-child 6-year total transfers during the period from age 18 to 23 in the NLSY97, reported in Table A4 of Appendix A.1.4. The consumption share in the utility function, υ, is calibrated so that the average non-retiree works full time, ft, which is parameterized in Panel A of Table C1 in the Appendix. The parameter governing the costs of being delinquent on student loans, ξ_D, targets the average cohort delinquency rate for BA programs for 2013-2015 reported by the Federal Student Aid (FSA) report FSA (2021b) (e.g., a delay in payment of 270 days or more).

Panel D reports production technology and Social Security parameters. Aggregate labor productivity, Z, is set so that GDP per capita for the population aged 18 and over is one in the model. The parameter that determines the labor share for labor without a BA, ν, is set so that the model matches the BA wage premium for the middle skill tercile, drawn from Table 4. The Social Security replacement rate, χ, targets the average ratio of total Social Security expenditure to GDP, estimated using 2013-2015 data from BEA Table 1.1.5 and BEA Table 2.1.

To summarize, our model specification and parameterization together imply that the AA program is more accessible than the BA program. Any high school graduate can enroll in the AA program

(by assumption), whereas the BA program is more selective in admissions, especially for the lower skill. Additionally, the AA program is cheaper because it lasts for two years instead of four years, the annual tuition is lower, and the required effort is lower, which allows individuals to earn more from employment. However, the AA program is of lower quality than the BA program in that it features a lower consumption value, a lower continuation likelihood, and leads to a lower wage premium for graduates. Individuals who are successful in the AA program are allowed to transfer to the BA program, but they experience a scarring effect in terms of the BA consumption value, continuation likelihoods, and labor market returns.

5 Model Validation

In this section, we validate the model by showing that it accounts for several key empirical patterns.

Our parameterized model incorporates salient features of AA and BA programs related to accessibility and quality discussed in Sections 2.1 and 2.2. This parameterized model also accounts for patterns of sorting into AA and BA enrollment discussed in Section 2.3. Table 12 reports AMEs from four probit regressions that predict the likelihood of BA enrollment (taking any path to this outcome) among high school graduates, AA enrollment among high school graduates, AA enrollment among PSE enrollees, and AA to BA enrollment among high school graduates who ever enroll in a BA, respectively. In all four regressions, the controls in both the data and the model include indicators for parental income terciles, skill terciles, and parental education; additional controls included in the data regression (but not reported here) are flags for being female, black, or Hispanic. The empirical estimates are drawn from Table 9.

In all four regressions, the model's baseline equilibrium produces AMEs with signs that are consistent with those in the data. In particular, the model reproduces the empirical pattern that those with lower skill or poorer or less educated parents are less likely to enroll in a BA among all high school graduates, but more likely to enroll in an AA program among both high school graduates and PSE enrollees, as well as more likely to take the AA-to-BA route among BA enrollees. Furthermore, the model's AMEs quantitatively align well with those in the data for most of the controls.

In one of our main experiments in Section 6, we analyze the implications of making the AA program tuition-free. For the credibility of results from this experiment, it is important that our model's baseline successfully reproduces the average net tuition observed in the data.[11] As such, Table 13 reports program-specific average annual net tuition and fees after total grant aid is taken

[11] While we incorporated the rich college financial aid system in the US into our model and parameterized it to match program-specific sticker prices for tuition, we did not target average net tuition. Net tuition incorporates grant aid, which is a function of student attributes such as parental income and youth skill.

Table 12: Average Marginal Effects: predicting PSE enrollment outcomes in data and model

	Dependent variable							
	Data				Model			
Control variable	**(1) Enr. BA**	**(2) Enr. AA**	**(3) Enr. AA**	**(4) AA to BA**	**(1) Enr. BA**	**(2) Enr. AA**	**(3) Enr. AA**	**(4) AA to BA**
Parental income tercile 1	-0.15	0.06	0.15	0.07	-0.33	0.10	0.23	0.16
Parental income tercile 2	-0.07	0.04	0.07	0.06	-0.26	0.03	0.15	0.09
Skill tercile 1	-0.50	0.12	0.42	0.18	-0.36	0.20	0.37	0.22
Skill tercile 2	-0.23	0.11	0.18	0.05	-0.16	0.12	0.16	0.08
At least one parent BA+	0.22	-0.10	-0.19	-0.08	0.10	-0.01	-0.06	-0.04
Sample	HS grads	HS grads	Enroll PSE	Enroll BA	HS grads	HS grads	Enroll PSE	Enroll BA

Notes: The table reports probit regression AMEs with the following dependent variables: (1) the likelihood of enrolling in a BA at some point up to age 24, conditional on completing high school; (2) the likelihood of enrolling in an AA at some point up to age 24, conditional on completing high school; (3) the likelihood of enrolling in an AA conditional on enrolling in any PSE at some point up to age 24; (4) the likelihood of previously enrolling in an AA, conditional on enrolling in a BA at some point up to age 24. The control variables are flags for parental income tercile 1, parental income tercile 2, skill tercile 1, skill tercile 2, and at least one parent with a BA or higher. Controls included in the data regression but not reported here are indicators for the sample member being female, black, and Hispanic. Data source: NLSY97.

into account for first-year enrollees. The empirical estimates are drawn from Table 1 and then normalized by GDP per capita for those 18 and over. The model does well producing estimates close to those observed in the data.

Table 13: AA and BA net tuition in data and model

Program	**Data**	**Model**
AA	0.012	0.014
BA	0.129	0.135

Notes: The table reports the average net tuition and fees after total grant aid is taken into account for first-year enrollees in AA and BA programs, respectively. The estimates are normalized by GDP per capita for those 18 and over. Data source: HSLS:09.

Lastly, the implications from making the AA program tuition-free critically depend on the AA enrollment rate response from that policy. In Table 14, we report the rise in the AA enrollment rate following a $1,000 subsidy for enrollment in the AA program. The empirical estimate is from Denning (2017), based on a quasi-natural experiment of tuition discounts for community colleges in Texas. The model enrollment response compares reasonably well with the data.

6 Main Experiment: Subsidizing AA or BA Programs

This section presents the results from our two main counterfactual experiments. First, we examine the aggregate and welfare implications of making the AA program tuition-free. Second, we

Table 14: Change in AA enrollment rate given $1,000 AA subsidy in data and model

Quasi-natural experiment	Data	Model
$1,000 AA subsidy	5.1	4.3

Notes: The table presents estimates for the change in the AA enrollment rate given a $1,000 subsidy for enrollment in the AA program. In the model, the change in the AA enrollment rate is computed in a partial equilibrium in which the distribution of 18-year-olds and general equilibrium prices, taxes, and transfers are held fixed at their initial steady state values. Data source: Denning (2017).

examine the implications of a spending-equivalent subsidy expansion for the BA program.

In Section 6.1, we describe the two counterfactual experiments and then compare the model's prediction for the fiscal cost of making the AA program tuition-free to a budget-proposal estimate from the U.S. Department of Education. In Section 6.2, we analyze the aggregate implications of the two subsidy expansions across steady states in general equilibrium. In Section 6.3, we report the resulting welfare changes across steady states in both partial and general equilibrium.

6.1 Experiment description

Let $\bar{\theta}^A(s)$ denote the subsidy for a consumer with skill s in the experiment in which the AA program is made tuition-free ("AA subsidy expansion"). In this experiment, the Pell grant function for the AA program is modified to be

$$\theta^{Pell}(f, A) = \bar{\theta}^A(s) + \max\left[\min\left[\kappa(A) + \bar{c}(A) - f, \theta^{Pell}_{max} - f\right], 0\right],$$

where $\bar{\theta}^A(s) = \kappa(A) - \theta^{other}(s, A) - \theta^{pr}(s, A)$. The Pell grant function for the BA program is the same as in the initial equilibrium. The AA subsidy expansion ensures that any individual enrolled in the AA program does not pay tuition. Furthermore, the Pell grant that an individual was already eligible for in the initial equilibrium is unaffected. This specific modeling of the policy is consistent with the proposed *Free Community College program*, which was presented as a "first-dollar program." A first-dollar program refers to financial aid that is applied to college costs before other sources of aid, such as Pell grants, which can instead be used to cover expenses beyond tuition and fees such as room and board (U.S. Department of Education, 2023).[12]

In the experiment in which a spending-equivalent subsidy is provided for the BA program ("BA subsidy expansion"), the Pell grant function for the BA program is modified to be

$$\theta^{Pell}(f, B) = \bar{\theta}^B(s) + \max\left[\min\left[\kappa(B) + \bar{c}(B) - f, \theta^{Pell}_{max} - f\right], 0\right],$$

[12]To maintain the first-dollar nature of the policy, for the subsidized student loan function in equation (5), we use the Pell grant function without the $\bar{\theta}^A(s)$ or $\bar{\theta}^B(s)$ terms even after the policy changes.

where $\bar{\theta}^B(s) = M^B\bar{\theta}^A(s)$ and M^B is a scalar. The Pell grant function for the AA program is the same as in the initial equilibrium. The scalar M^B is calibrated so that the resulting increase in the ratio of total government spending to output is the same across steady states in general equilibrium in both experiments.[13]

Table 15 reports the resulting changes in fiscal aggregates and the associated skill-specific subsidies from the two experiments in Panels A and B, respectively. As indicated by Panel A, in both experiments, the ratio of total government spending to output increases by 0.053 percentage points. We also note that our chosen spending-equivalence criterion results in essentially the same increase in public education grant and federal student loan spending to output, making the two experiments even more comparable.

Table 15: Changes in fiscal aggregates after subsidy expansions and associated subsidies

		Subsidy expansion	
Category		**AA**	**BA**
Panel A: Changes in fiscal aggregates	Public education grants	0.039	0.045
Units: percentage of output	Federal student loans	0.009	0.005
	Government consumption	0	0
	Social Security	0.005	0.004
	Total government spending	0.053	*0.053*
Panel B: Annual per-enrollee subsidy by skill	$\bar{\theta}^A(s)$ and $\bar{\theta}^B(s)$	(0.042,0.041,0.041)	(0.012,0.012,0.012)
Units: see table notes	In 2013 dollars	(2949,2861,2877)	(853,828,833)

Notes: The table reports general-equilibrium changes in fiscal aggregates across steady states after each subsidy expansion (Panel A) and the associated skill-specific AA or BA subsidies (Panel B). The subsidy units are per enrollee per year, and are reported both as parameter values and in 2013 dollars. The total government spending change in the second column is in italics because it is targeted in the calibration.

Panel B of Table 15 indicates that the annual per-enrollee subsidy for the AA program is approximately \$3,000, whereas the spending-equivalent subsidy for the BA program is approximately \$800. The BA tuition subsidy is significantly smaller than the AA tuition subsidy because of an extensive margin effect (more individuals enroll in a BA program) and an intensive margin effect (the BA program lasts for four years instead of two years and features a higher annual continuation probability).

Table 16 compares the predicted annual increase in public education grants in the AA subsidy expansion with an estimate from the U.S. Department of Education (ED) based on the FY 2024 Congressional Justification (U.S. Department of Education, 2023). The ten-year ED budget request of \$90 billion for the *Free Community College* proposal is converted to an annual estimate of \$9 billion and then reported as a percentage of GDP in 2023 from BEA Table 1.1.5. The model

[13]Total government spending in our model is the sum of public education grants, federal student loan program expenditure, government consumption, and Social Security expenditure. Expressions for these variables are provided in equation (22) of Appendix B.2.

estimate aligns reasonably well with the ED estimate.

Table 16: Annual increase in total public education grants

Units	Department of Education	AA subsidy expansion
Percentage of initial output	0.032	0.039

Notes: The table compares the estimated cost of the *Free Community College* proposal from the U.S. Department of Education (ED) with the annual increase in public education grant spending from the model experiment in which the AA program is made tuition-free. Both statistics are reported as a percentage of initial output. The details of the ED estimate are provided in the main text.

6.2 Aggregate implications

Table 17 reports aggregate changes across steady states in general equilibrium following the AA and BA subsidy expansions. The aggregates are organized into Panels A through D based on statistic type.

Panel A reports changes in education statistics. The subsidy expansion for the AA program leads to a large increase in PSE enrollment, the result of a large increase in AA enrollment. Only a small share of students substitute from the BA to the AA program, which mitigates the rise in PSE enrollment to a small extent. These changes in the enrollment rates imply that the democratization effect in which non-enrollees transition to AA enrollment dominates the diversion effect in which those who would have enrolled in the BA program now enroll in the AA program.[14] A byproduct of increased AA enrollment is an increase in transfers to a BA. As a result of these enrollment changes, the population share of PSE graduates increases by 2.37 percentage points. Hence, the AA subsidy expansion is consistent with subsidizing accessibility and successfully achieves the proposed policy goal of increasing the share of PSE graduates.

In contrast to the AA subsidy expansion, the BA subsidy expansion leads to a smaller rise in PSE enrollment because the spending-equivalent BA tuition subsidy is smaller than the analogous AA tuition subsidy (see Table 15). The second two rows indicate that the BA subsidy expansion increases straight to BA enrollment primarily due to students substituting out of the AA program. We also see that more high school graduates transfer from the AA to the BA program. As a result of these enrollment changes, the population share of PSE graduates increases by 0.66 percentage points because the share of BA graduates outweighs the fall in the share of AA graduates. This outcome is consistent with subsidizing quality.

[14]The patterns of enrollment changes from the AA subsidy expansion in our model are qualitatively consistent with the findings of Mountjoy (2022), although we change a different cost margin in our analysis. Specifically, Mountjoy (2022) develops a novel instrumental variable approach and applies it to a reduced-form decomposition of two-year enrollment changes after a decrease in distance to an AA program. He finds that the democratization effect is larger than the diversion effect.

Table 17: Steady state changes after subsidy expansions in general equilibrium

			Subsidy expansion	
Category	**Variable**	**Description**	**AA**	**BA**
Panel A: Education statistics	Enrollment rate:	PSE	6.17	0.30
Units: percentage point change		AA	8.23	-1.20
		Straight to BA	-2.06	1.50
		AA to BA	0.92	0.22
	Educational attainment:	PSE	2.37	0.66
		AA	2.93	-0.59
		BA	-0.55	1.26
Panel B: Macroeconomic aggregates	Output		-0.15	0.39
Units: percentage change	Consumption		-0.13	0.40
	Labor efficiency units:	Aggregate	-0.12	0.46
		No BA	1.51	-2.25
		BA	-1.43	2.65
	Capital		-0.18	0.27
Panel C: Prices, income tax rate, transfers	Risk-free rate		0.01	0.02
Units: percentage point/percentage change	Wage rate:	No BA	-0.43	0.62
		BA	0.31	-0.61
	Income tax rate:	At baseline mean income	0.05	0.01
	Accidental bequests		-0.18	0.48
	Social Security by skill:	No AA or BA	(-0.17,-0.19,-0.15)	(0.53,0.57,0.53)
		AA only	(-0.26,-0.17,-0.34)	(0.45,0.62,0.53)
		BA | Straight to BA	(0.13,0.18,0.21)	(-0.16,-0.26,-0.22)
		BA | AA to BA	(0.21,0.12,0.13)	(-0.12,-0.24,-0.23)
Panel D: Averages of initial characteristics	Net assets		-1.30	-1.26
Units: percentage or percentage point change	EFC		-0.11	0.73
	Share with:	Low skill	0.16	-0.37
		Medium skill	0.02	-0.06
		High skill	-0.19	0.42

Notes: The table reports general-equilibrium changes from the initial baseline equilibrium to the final steady state in the AA and BA subsidy expansions. Panels A, B, C, and D report changes in education statistics, macroeconomic aggregates, prices, income tax rate, and transfers, and averages of initial characteristics, respectively.

Panel B reports changes in macroeconomic aggregates. In the AA subsidy expansion, both aggregate output and consumption decrease, whereas in the BA subsidy expansion, the same aggregates increase. These contrasting outcomes are observed due to how the two subsidies differentially affect the quality of PSE graduates. The AA subsidy expansion leads to many more PSE graduates as shown in Panel A, but it also leads to a fall in the aggregate labor efficiency units, as indicated by Panel B. The latter is due to the diversion effect in which those who would have enrolled in a BA and become a BA graduate now enroll in an AA and become an AA graduate, which is associated with a lower efficiency premium (see Figure 1a). That is, while the democratization effect dominates in regard to enrollment, the diversion effect dominates in regard to aggregate output. In contrast, although the BA tuition subsidy leads to a smaller increase in the share of PSE graduates, the quality of the graduates are higher, which results in an increase in the aggregate labor efficiency units. The sign of the change in the capital stock in the two experiments reflect the sign of the change in aggregate labor efficiency units.

Panel C reports changes in prices, the income tax rate, and transfers. In both experiments, the change in the interest rate is small. In the AA subsidy expansion, the increase in the labor without

a BA leads to a fall in the wage rate for those without a BA and vice versa; furthermore, as the economy becomes poorer, accidental bequests decrease. For the same variables, the mechanisms are analogous with the BA subsidy expansion but they move in the opposite direction. The income tax rate increases slightly more in the AA subsidy expansion, whereas in the BA subsidy expansion the income tax rate barely increases. This outcome suggests that the BA subsidy expansion almost pays for itself in the long run. Lastly, changes in Social Security transfers reflect the directional changes in the wage rates.

Panel D reports changes in the averages and shares of initial characteristics of high school graduates whose distribution can change across equilibria, specifically net assets, EFC, and skill. Changes in AR(1) productivity and the weight for the consumption value of college are not reported. The qualitative changes in net assets are the same in both experiments: the tuition subsidy crowds out inter vivos transfers from parents so that initial net assets fall. The AA subsidy expansion leads to a fall in the average EFC as the economy becomes poorer and the analogous effect is observed in the opposite direction for the BA subsidy. The AA subsidy expansion leads to fewer parents with a BA degree, resulting in fewer children with high skill. In contrast, the BA subsidy leads to more parents with a BA degree, resulting in more children with high skill. This again captures a better quality outcome of this subsidy expansion.

6.3 Welfare implications

To measure welfare changes from the AA and BA subsidy expansions we use lifetime consumption equivalent variation, the most commonly used measure of welfare in the macroeconomic literature on postsecondary education, and supplement it with an alternative measure, one-time equivalent transfers. Lifetime consumption equivalent variation is computed as the percentage change in consumption in every age and state of a consumer in the initial steady state equilibrium that makes the consumer indifferent between the initial and final steady state.[15] The one-time equivalent transfer measure is a one-time transfer in the initial steady state that makes a consumer indifferent between the initial and final steady state. The one-time transfers are reported as a percentage of GDP per capita for those 18 and over in the initial steady state. The details of welfare computation are provided in Appendix B.4.

Table 18 reports the welfare changes for the average high school graduate from the AA and BA subsidy expansions, in partial and general equilibrium. The welfare changes are in units of percent changes in lifetime consumption. For the partial equilibrium welfare changes, the prices, tax rate,

[15] Due to the presence of utility shifters such as the consumption value of college and the stigma cost of student loan delinquency, there does not exist an analytical solution for the consumption equivalent variation, and thus it is computed numerically.

accidental bequests, and Social Security transfers are held fixed at their initial steady state values. In the first two rows with the distribution label "Fixed", the distribution of high school graduates in the initial equilibrium is used to compute both the initial and final steady state values for welfare. In the third row with the distribution label "Endogenous", the distribution of high school graduates in the initial equilibrium is used to calculate the initial steady state value and the distribution of high school graduates in the final equilibrium is used to calculate the final steady state value for welfare.

The main takeaway from the table is that the spending-equivalent BA subsidy is more valuable to the average high school graduate than the AA subsidy: the lifetime consumption gains from the spending-equivalent BA subsidy expansion range from 0.97 to 1.21 percent, while the gains from the AA subsidy expansion range from 0.24 to 0.72 percent. This is because although the AA program is more accessible, the BA program is higher in quality.

Table 18: Welfare changes in lifetime consumption for the average high school graduate

		Subsidy expansion	
Equilibrium	**Distribution Ω^0**	**AA**	**BA**
Partial	Fixed	0.72	0.97
General	Fixed	0.52	1.17
General	Endogenous	0.24	1.21

Notes: The table reports partial- and general-equilibrium welfare changes for the average high school graduate from the AA and BA subsidy expansions. The welfare changes are reported as the percentage change in lifetime consumption. The "Distribution Ω^0" labels are described in the main text.

Table 18 also highlights the importance of general equilibrium and intergenerational effects for the welfare gains. A comparison of the first two rows indicates that general-equilibrium effects, that is, changes in prices, taxes, accidental bequests, and Social Security transfers, act to dampen the welfare gains from the AA subsidy and to amplify the gains from the BA subsidy. In the AA subsidy expansion, the cost of the fall in the wage rate for those without a BA outweighs the benefit of the rise in the wage rate for those with a BA. This is because a lower wage rate for those without a BA weakens insurance for idiosyncratic states associated with lower lifetime income (e.g., those with lower skill or parental income are less likely to obtain a BA, which is associated with a lower lifetime income). The opposite effect on insurance results in amplified general equilibrium gains for the BA subsidy expansion.

A comparison of the last two rows indicates that in net intergenerational effects also act to dampen the welfare gains from the AA subsidy and to amplify the gains from the BA subsidy. In the AA subsidy expansion, the average high school graduate is worse off because they face a drop in inter vivos transfers from their parents and are more likely to draw a lower skill level. The latter effect

is driven by fewer parents having a BA. In the BA subsidy expansion, while the same effect is observed for the inter vivos transfers, this effect is outweighed by the increased likelihood for high school graduates to be of higher skill, as more parents have a BA.

Table 19 reports the welfare changes for high school graduates by skill and parental income terciles from the AA and BA subsidy expansions in partial and general equilibrium. The welfare changes are reported as lifetime consumption changes in Panel A and as one-time transfers in Panel B. In both partial and general equilibrium, the within-group average is computed using the distribution of high school graduates in the initial equilibrium for both the initial and final steady state welfare values in order to maintain comparability within a given income-skill type.

A comparison across subsidy expansions within the same income-skill type implies that, for high school graduates with low skill and low parental income, the AA subsidy expansion is more effective at increasing welfare than the spending-equivalent BA subsidy expansion in partial equilibrium. However, that is not the case in general equilibrium. This reversal in the ordering of gains is observed due to the opposite effects the policies have on the wage rates, discussed above. Overall, these results suggest that policy proposals to help disadvantaged youth by making AA programs tuition-free will not be as beneficial once general-equilibrium effects are taken into account.

Table 19: Welfare changes after subsidy expansions by skill and parental income terciles

			Subsidy expansion					
			AA by skill			**BA by skill**		
Category	**Equilibrium**	**Income**	Low	Med	High	Low	Med	High
Panel A: Lifetime consumption	Partial	1	1.38	1.09	0.84	0.60	0.85	1.33
Units: percentage		2	0.96	0.72	0.55	0.50	1.06	1.32
		3	0.56	0.28	0.16	0.65	0.97	1.06
	General	1	1.03	0.77	0.60	1.04	1.23	1.57
		2	0.60	0.46	0.41	0.95	1.36	1.40
		3	0.35	0.20	0.19	0.89	0.98	0.89
Panel B: One-time transfer	Partial	1	3.80	2.97	2.04	1.72	2.28	3.27
Units: percentage of initial GDP per capita 18+		2	3.40	1.97	1.52	1.79	2.92	3.74
		3	2.60	1.23	0.71	3.04	4.29	4.74
	General	1	2.87	2.08	1.44	2.91	3.34	3.87
		2	2.16	1.23	1.15	3.37	3.77	3.98
		3	1.63	0.90	0.84	4.12	4.31	3.99

Notes: The table reports partial- and general-equilibrium welfare changes for high school graduates by skill and parental income terciles from the AA and BA subsidy expansions. In Panel A, welfare changes are reported as the type-specific percentage change in lifetime consumption. In Panel B, welfare changes are reported as one-time transfers.

For a comparison across parental income and skill types within the same experiment, we use the one-time equivalent transfers in Panel B instead of the lifetime consumption changes in Panel A. This is because the lifetime consumption change is computed for the specific income-skill type

given their type-specific consumption in the initial steady state, which makes the welfare measure conceptually difficult to compare across types. Overall, the welfare comparison across types within the same experiment emphasizes the stark heterogeneity in gains by parental income and skill.

The rows of Panel B indicate that, controlling for skill, those with low parental income benefit more from the AA subsidy expansion in comparison to their peers with high income in both partial and general equilibrium. The opposite is true for the BA subsidy expansion. This difference arises because those with low income especially value the low pecuniary and low effort cost of the AA program, and thus the AA subsidy expansion, while those with high income especially value the high consumption value of the BA program, and thus the BA subsidy expansion.

The columns of Panel B indicate that, controlling for parental income, those with low skill benefit more from the AA subsidy expansion in comparison to their peers with high skill in both partial and general equilibrium. Again, the opposite is generally true for the BA subsidy. This is because those with low skill are less likely to receive the straight-to-BA enrollment option while those with high skill expect high returns to BA enrollment, both in terms of continuation likelihood and earnings conditional on graduation.

7 Conclusion

Several recent policy proposals have sought to make AA programs tuition-free at the national level. However, the existing structural macroeconomic literature on postsecondary financial aid has focused predominantly on BA programs. In this paper, we document tradeoffs between AA and BA programs related to accessibility and quality, as well as patterns of AA, BA, and AA-to-BA enrollment. Next, we build a quantitative model with an AA and BA program which reflects the key tradeoffs. We then use our framework to analyze the impact of making two-year programs tuition-free, and compare it with an alternative spending-equivalent BA subsidy.

Our results show that making the AA program tuition-free is a cost-effective way to increase the share of postsecondary graduates, consistent with one of the goals of this proposed policy. However, the spending-equivalent BA tuition subsidy leads to higher output, skill levels of future generations, and welfare gains. General-equilibrium and inter-generational effects are important for the welfare gains from the two policies we consider. Specifically, general-equilibrium effects act so that, while high school graduates who are disadvantaged by their financial means and academic background benefit more from the AA subsidy expansion in partial equilibrium, in general equilibrium the BA subsidy expansion is slightly more beneficial. Hence, our results highlight the importance of general-equilibrium effects when evaluating whether the proposed policy achieves another goal: supporting disadvantaged youth.

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Online Appendix for: "Two-year Programs and College Financial Aid"

by Emily G. Moschini and Gajendran Raveendranathan

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A Data Appendix

A.1 The 1997 National Longitudinal Survey of Youth

We use our NLSY97 postsecondary outcome estimation sample for results regarding postsecondary enrollment patterns and related model parameterization moments in the main text (Bureau of Labor Statistics, U.S. Department of Labor, 2019). We also use the NLSY97 in our estimation of the life cycle earnings process, which is estimated using the earnings profile estimation sample, and in our estimation of inter vivos transfers, which is based on a third sample with modifications to the earnings profile estimation sample described below. Following Abbott, Gallipoli, Meghir, and Violante (2019), in our NLSY97 analyses we do not use survey weights. When we convert nominal dollar values to real values, we have converted to 2013 dollars using the Consumer Price Index or CPI (Bureau of Labor Statistics, U.S. Department of Labor, 2024). Our three estimation sample cleaning procedures are described next, along with descriptions of how several key variables are constructed.

Estimation samples Our postsecondary outcomes estimation sample is at the individual level, and consists of respondents who we observe up to age 30 and who complete high school at the age of 17, 18, 19, or 20.[16] We also require that we observe the ASVAB score, parental income in 1997, parental education, gender, race, and Hispanic ethnicity for each respondent and that the variable reporting enrollment and graduation status from high school and two- or four-year college degree programs in each wave not imply contradictory information. Regarding dropping observations with inconsistent enrollment/graduation status, we drop observations where there is a record of achieving some college by age 30 (i.e., up to and including age 30) but no record of whether it was enrollment in a two-year or a four-year program, where there is missing education information at age 30, where the first enrollment after high school is a four-year program but the highest program completed is a two-year program, and where the respondent reports being a two-year program graduate by age 30 but there is no record of two-year program enrollment by age 24, or where they report being a four-year program graduate by age 30 but there is no record of four-year program enrollment by age 24. This leaves us with a total of 2,322 individuals.

Throughout our analyses using the postsecondary outcomes estimation sample, we interpret two-year program as synonymous with an AA and four-year program as synonymous with a BA. When

[16] In our NLSY97 analyses, for variables where we condition on an outcome occurring up to and including age 24 or 30 we account for the fact that the NLSY97 switched to collecting data every other year instead of every year after 2011 in the following way. Given the age of the respondent in 1997, we identify the year in which they are 24 or 30. If that year is not an interview year, then we use enrollment or graduation status reported when they are 25 or 31, respectively.

we define AA or BA enrollment, we refer to being enrolled in a two-year or four-year program, respectively, at some point by age 24. When we define graduation rates for AA or BA programs, we refer to being a graduate of a two-year or four-year program, respectively, by age 30. We define someone who takes the AA-to-BA enrollment path as someone who we observe being enrolled in a two-year program before being enrolled in a four-year program; we do not require that the respondent graduate from the two-year program before starting the four-year program in this definition. When we assign observations to terciles of skill (i.e., the ASVAB score) and parental income in 1997, we do so using the distribution of valid observations for skill or parental income among survey respondents who completed high school at the ages of 17, 18, 19, or 20 and who have a valid ASVAB score, but do not impose other requirements on the sample.

The earnings profile estimation sample reshapes the data to be at the individual-year level, where the year is the year of the interview. Observations in this sample are selected the same way as the postsecondary outcomes estimation sample with two changes. First, we replace the requirement that we observe parental income and parental education with a requirement that we observe marital status and number of children and that, in a given year, the individual be a high school graduate who is not enrolled in postsecondary education. We also replace the requirement that we observe the respondent until age 30 with the requirement that the respondent is aged from 25 to 38. Second, we restrict attention to observations where there is a valid value for the hourly wage at the respondent's main job. Next, we convert hourly wage to real hourly wage using the CPI, and drop observations where annualized real wage growth across consecutive survey waves is larger than 4 or smaller than -2, or where real wages are above 400 dollars or below 1 dollar. We also drop observations with inconsistent postsecondary enrollment/degree attainment status in the following sense: where the first enrollment after high school is a four-year program but the highest program completed is a two-year program, where the respondent reports being a two-year program graduate by age 30 but there is no record of two-year program enrollment by age 24, and where they report being a four-year program graduate by age 30 but there is no record of four-year program enrollment by age 24. This yields 4,261 individuals (26,038 individual-year observations) in the earnings profile estimation sample.

When we estimate the earnings profile using the earnings profile estimation sample, we separately estimate age profiles, skill shifters, and the marginal impact of the AA attribute for those with a four-year degree (with a BA) and those without (without a BA). Among those without a BA, the AA attribute is set to one if the respondent has a two-year degree and zero otherwise. Among those with a BA, the AA attribute is set to one if the respondent has a history of AA-to-BA enrollment and zero otherwise.

For the inter vivos transfers estimation sample, we use the same sample selection criteria as the

earnings profile estimation sample, with three changes. First, the inter vivos sample also includes observations who are currently enrolled in school. Second, we change the age restriction so that we keep only high school graduates aged 18 to 23 in the survey rounds from 1997 to 2003, who are counted as independents in the NLSY97, and for whom we observe parental income in 1997. Third, we do not require consistency in education records. This yields 3,333 individuals (9,913 individual-year observations) in the inter vivos transfer sample.

A.1.1 Predicting PSE enrollment outcomes: regression coefficients

Table A1 reports probit regression coefficients for the AMEs reported in Table 9 of the main text.

Table A1: Regression Coefficients: Predicting PSE enrollment outcomes

	Dependent variable			
Control variable	**(1) Enroll BA**	**(2) Enroll AA**	**(3) Enroll AA**	**(4) AA to BA**
Flag: Parental income tercile 1	-0.473	0.186	0.445	0.338
	(0.0812)	(0.0790)	(0.0908)	(0.1258)
Flag: Parental income tercile 2	-0.233	0.136	0.236	0.269
	(0.0745)	(0.0724)	(0.0802)	(0.1053)
Flag: Skill tercile 1	-1.482	0.355	1.204	0.684
	(0.0850)	(0.0794)	(0.0996)	(0.1395)
Flag: Skill tercile 2	-0.691	0.347	0.540	0.232
	(0.0718)	(0.0704)	(0.0764)	(0.1023)
Flag: At least 1 parent BA+	0.718	-0.327	-0.575	-0.355
	(0.0708)	(0.0693)	(0.0747)	(0.0975)
Flag: Female	0.267	0.054	-0.079	0.062
	(0.0596)	(0.0567)	(0.0664)	(0.0902)
Flag: Black	0.504	-0.152	-0.509	-0.425
	(0.0836)	(0.0784)	(0.0968)	(0.1348)
Flag: Hispanic	0.094	0.110	0.000	-0.004
	(0.0859)	(0.0808)	(0.0989)	(0.1369)
Constant	0.565	-0.803	-0.595	-1.193
	(0.0792)	(0.0786)	(0.0861)	(0.1136)
Sample	HS grads	HS grads	Enroll PSE	Enroll BA
Observations	2,322	2,322	1,768	1,288
pseudo- R^2	0.24	0.04	0.17	0.07

Notes: The table reports probit regression coefficients for regressions with the following dependent variables: (1) the likelihood of enrolling in a BA at some point by age 24, conditional on completing high school; (2) the likelihood of enrolling in an AA at some point by age 24, conditional on completing high school; (3) the likelihood of enrolling in an AA conditional on enrolling in any PSE at some point by age 24; (4) the likelihood of previously enrolling in an AA, conditional on enrolling in a BA at some point by age 24. Standard errors in parentheses. Source: NLSY97.

A.1.2 Target moments for internally calibrated parameters

The first three columns of Table A2 reports various education-related rates used in the internal calibration of the model, by skill tercile and overall. In the table's first column we report the AA enrollment rate by skill tercile for those with parents in the top parental income tercile. The second and third columns report AA and BA enrollment rates by skill tercile, respectively, among high school graduates. The fourth column reports rates of BA attainment by age 30 for each tercile,

conditional on enrolling in an AA by age 24.

Table A2: Internal calibration targets: moments by skill tercile from the NLSY97

	Enrollment type			
Skill	**AA | Rich**	**AA**	**BA**	**BA degree | AA enr**
1	0.414	0.365	0.230	0.120
2	0.257	0.337	0.548	0.195
3	0.151	0.199	0.808	0.344
Total	0.217	0.292	0.555	0.207
Observations	799	2,322	2,322	677

Notes: The table reports rates within each skill tercile of AA enrollment rates by age 24 for those for those with parents in the top parental income tercile as well as AA and BA enrollment rates by age 24 and BA degree attainment by age 30 conditional on enrolling in an AA by age 24. Source: NLSY97.

Table A3 reports another set of calibration targets, the distribution across skill terciles for children from families with low and high parental education.

Table A3: Child skill distribution by parental education

	At least one parent BA+	
Skill	**No**	**Yes**
1	0.393	0.100
2	0.329	0.285
3	0.278	0.615
Observations	1,554	768

Notes: The table reports the conditional distribution of child skill across terciles within each parental education grouping among high school graduates. Source: NLSY97.

A.1.3 Life cycle earnings profile estimation

To estimate the parameters of the earnings profile we follow Abbott, Gallipoli, Meghir, and Violante (2019) and Moschini, Raveendranathan, and Xu (2025) and use the Panel Study of Income Dynamics or PSID (Survey Research Center, Institute for Social Research, 2021), in combination with the NLSY97, earnings profile estimation sample described at the start of this section. We use both the PSID and NLSY97 because the longer panel dimension of the PSID allows us to observe more ages than the NLSY97 and to estimate a more complete life cycle age profile, while variables in the NLSY97 allow us to incorporate the joint effects of skill, AA and BA enrollment, and AA-to-BA enrollment on labor earnings. We estimate the stochastic component of the earnings process on the residuals from the NLSY97 skill-shifter estimation, which uses age-free wages cleaned by applying the age profiles estimated using the PSID.

Modulo the CPI base year used to compute real dollar values, the PSID sample is created using the same procedure as Moschini and Raveendranathan (2025). The age-profile estimation using

the PSID implements a Heckman correction for labor force participation that has two stages; in the second stage, the PSID estimation sample contains 4,966 individuals for the no-BA group (73,190 individual-year observations) and 3,574 individuals (52,881 individual-year observations) in the BA group. The NLSY97 earnings profile estimation sample has 2,705 individuals in the no-BA group (16,204 individual-year observations) and 1,705 individuals (9,834 individual-year observations) in the BA group. Note that a single individual can appear in both education groups over the course of their working life.

Panel B in Table 10 of Section 4 reports the life cycle earnings process parameter values estimated in the PSID and NLSY97.

A.1.4 Inter vivos transfers

We estimate average inter vivos transfers to college-aged children from their parents in the NLSY97, reported in Table A4, using the inter vivos estimation sample described at the start of this section.

We compute yearly nominal transfers from parents to their child as follows. We account for the implicit transfer from parents to their children who live with them and do not pay rent by flagging those living with their parents and paying no rent, and then imputing the average monthly rent using rent paid by sample members with the same family income tercile, college enrollment status, and interview year who are not living with their parents. Next, we annualize rent and add it to yearly net income received from parents. Net income received from parents sums across both the mother and father if both parents are not present. Finally, we add any yearly allowances received.

The transfer ratio reported in the first row of Table A4 is computed as follows. Within each year, we multiply the quantity by six and divide by that year's nominal GDP per capita for those over 18. The result is a unitless ratio of implied total transfers received to per capita income for each individual while they are young adults of college age. We then average this ratio across individuals and years to compute the transfer ratio while sample members are young adults of college age. GDP per capita for those 18 and over in each year is computed as described in Section 4. Table A4 also reports the average real values of the components of transfers, where dollars are converted using the CPI.

A.2 The High School Longitudinal Study of 2009

The High School Longitudinal Study of 2009 (HSLS:09) is a panel survey conducted by the United States Department of Education that is representative of 9th graders in the US in 2009 (National Center for Education Statistics, U.S. Department of Education, 2020). The panel collects information in the base year of 2009 (BY), in a first follow-up in 2011 (F1), an update in the summer

Table A4: Inter-vivos transfers: average transfers + sample summary statistics

Variable	Mean
Transfer ratio	0.583
Transfers	6,415
Transfers not allowance	644
Allowance	190
Imputed rent	6,491
Obs	9,913
Individuals	3,333

Notes: The table reports statistics related to inter vivos transfers in the NLSY97. Sample: independents aged 18-23 from 1997 to 2003. Dollars are in real values. Observations are at individual-year level. Source: NLSY97.

of 2013 (2013 Update), in a second follow-up in 2016 (F2), and via postsecondary transcripts and student records (PETS-SR). The BY and F1 rounds of data collection implement several questionnaires to sample members, their parents, and school administrators. In the 2013 Update either the student or the parent (on behalf of the student) completes a questionnaire; in F2, only the student completes a questionnaire. PETS-SR contains information on grants and tuition and fees collected directly from postsecondary institutions and administrative records.

Our HSLS:09 estimation sample requires that students earn a high school diploma in 2013 and have valid observations for honors-weighted high school GPA, race, gender, parental education, and parental income. GPA is our measure of skill in the HSLS:09 because there is no standardized test like the ASVAB of the NLSY97. A valid parental income observation means we can see discretized parent income at least once before high school completion; if we observe it twice, we use the average real value after assigning a dollar value to each income bin, as described in the discussion surrounding Table A9 of Appendix A.3.1. Real dollar values are converted to 2013 dollars using the CPI. We also require that the respondent live with at least one parent at some point in the first two waves of data collection. In addition, we require that we have sufficient information to construct the respondent's postsecondary education outcome and that this outcome satisfy basic consistency conditions.

A.2.1 Predicting postsecondary enrollment outcomes

Table A5 reports Average Marginal Effects (AMEs) from a set of probit regressions similar to that of Table 9 of the main text, which are run on the NLSY97 postsecondary outcomes sample. Coefficients for Table A5 are presented in Table A6.

Using the sample of high school graduates, model (1) regresses an indicator for BA enrollment within 3 years of high school completion on indicators for parental income tercile, skill tercile, parental educational attainment, and (although their AMEs are not reported) demographic flags

for being female, black, or Hispanic. Those with poorer parents or lower skill are less likely to enroll in a BA, while those with at least one parent with a BA or higher are more likely to enroll in a BA. Model (2) predicts AA enrollment within 3 years of high school completion on the same set of controls and using the same sample as model (1). Lower parental income or skill positively predicts AA enrollment, while at least one highly educated parent negatively predicts it; everything is significant at the one percent level except for the first tercile of parental income which is significant at the five percent level. In models (3) and (4), we use the same controls to predict enrolling in an AA among PSE enrollees and taking the AA-to-BA route among BA enrollees, respectively. Poorer parents and lower skill positively predict AA enrollment among PSE enrollees and AA-to-BA enrollment among BA enrollees, while parental education negatively predicts those outcomes. In model (3), the AMEs are significant at the one percent level. In model (4), significance changes for parental income and parental education: the second parental income tercile and parental education are significant at the five percent level, while the first parental income tercile is not significant even at the ten percent level. The shorter panel dimension of the HSLS:09 compared to the NLSY97 affords a relatively narrow temporal window to observe AA-to-BA transfers, which may play a role in the lower significance of the AMEs in model (4).

Table A5: Average Marginal Effects: Predicting PSE enrollment outcomes

	Dependent variable			
Control variable	**(1) Enroll BA**	**(2) Enroll AA**	**(3) Enroll AA**	**(4) AA to BA**
Parental income tercile 1	-0.202	0.059	0.152	0.029
	(0.0261)	(0.0245)	(0.0304)	(0.0207)
Parental income tercile 2	-0.117	0.068	0.101	0.034
	(0.0216)	(0.0209)	(0.0240)	(0.0135)
Skill tercile 1	-0.534	0.152	0.439	0.125
	(0.0223)	(0.0278)	(0.0329)	(0.0329)
Skill tercile 2	-0.252	0.136	0.192	0.051
	(0.0205)	(0.0208)	(0.0223)	(0.0147)
Flag: At least 1 parent BA+	0.170	-0.041	-0.119	-0.034
	(0.0196)	(0.0174)	(0.0225)	(0.0164)
Additional demographic flags	Y	Y	Y	Y
Sample	HS grads	HS grads	Enroll PSE	Enroll BA
Observations	6,996	6,996	5,352	4,164

Notes: The table reports probit regression AMEs for: (1) the likelihood of enrolling in an BA at some point up to 3 years after high school completion; (2) the likelihood of enrolling in a AA at some point up to 3 years after high school completion; (3) the likelihood of enrolling in an AA at some point up to 3 years after high school completion, conditional on enrolling in any PSE; and (4) the likelihood of taking the AA to BA path at some point up to 3 years after high school completion, conditional on enrolling in a BA. Standard errors in parentheses. Additional demographic flags included but not shown here are an indicator for being female, black, and Hispanic. Weights are Second follow-up student longitudinal weights. Source: HSLS:09.

Table A6: Regression coefficients: Predicting PSE enrollment outcomes

	Dependent variable			
Control variable	**(1) Enroll BA**	**(2) Enroll AA**	**(3) Enroll AA**	**(4) AA to BA**
Parental income tercile 1	-0.712	0.216	0.534	0.213
	(0.0893)	(0.0881)	(0.1027)	(0.1435)
Parental income tercile 2	-0.425	0.246	0.371	0.244
	(0.0781)	(0.0753)	(0.0870)	(0.0913)
Skill tercile 1	-1.673	0.556	1.361	0.722
	(0.0751)	(0.0938)	(0.0968)	(0.1442)
Skill tercile 2	-0.843	0.506	0.685	0.374
	(0.0670)	(0.0737)	(0.0741)	(0.0998)
Flag: At least 1 parent BA+	0.596	-0.146	-0.419	-0.237
	(0.0664)	(0.0630)	(0.0748)	(0.1066)
Flag: Female	0.055	0.039	0.019	-0.005
	(0.0558)	(0.0578)	(0.0658)	(0.1008)
Flag: Black	0.324	-0.004	-0.212	-0.098
	(0.1144)	(0.1225)	(0.1350)	(0.2315)
Flag: Hispanic	0.040	0.092	0.077	0.079
	(0.0987)	(0.1048)	(0.1161)	(0.1302)
Constant	0.995	-1.233	-1.098	-1.613
	(0.0879)	(0.0857)	(0.1001)	(0.1360)
Sample	HS grads	HS grads	Enroll PSE	Enroll BA
Observations	6,996	6,996	5,352	4,164

Notes: The table reports probit regression coefficients for the probit regressions of Table A5. Standard errors in parentheses. Weights are second follow up student longitudinal weights. Source: HSLS:09.

A.2.2 Postsecondary application and acceptance rates

Table A7 reports application and acceptance rates for the subset of high school graduates for whom valid values for this set of variables are reported in the 2013 Update wave of the HSLS:09. These moments reflect application and acceptance outcomes in the fall of the 2013-2014 academic year. Specifically, the first two columns report the share of high school graduates with valid values who apply to an AA program and who are accepted to an AA program conditional on applying. The third and fourth columns report the same information for BA programs.

Table A7: Postsecondary application and acceptance rates by skill tercile

	AA		**BA**	
Skill	**Applied**	**Accepted | applied**	**Applied**	**Accepted | applied**
1	0.466	0.893	0.264	0.739
2	0.328	0.936	0.592	0.916
3	0.120	0.917	0.892	0.986
Total	0.300	0.911	0.591	0.928
Observations	5,956			

Notes: The table reports statistics related to application and acceptance in AA or BA PSE programs in the 2013-2014 academic year. Rates are reported within each skill tercile and for all high school graduates with valid application and acceptance info in the 2013 Update wave. The sample count is reflects the number of high school graduate observations that satisfy this criterion. Weights: Second follow-up student longitudinal weights. Source: HSLS:09.

A.2.3 Target moments for internally calibrated parameters

Table A8 reports moments used as targets in the internal calibration of the model framework, specifically grants received as a share of tuition and fees by skill tercile for BA and AA enrollees in their first academic year (2013-2014). Note that our method of apportioning total grants to public versus private grants with a 70-30 breakdown, as estimated in Krueger and Ludwig (2016), means that when we subtract Pell subsidy rates from public subsidy rates to get the "Public grants net Pell" the number is negative for the lowest skill bin. We have bounded the residual public grants after netting out Pell at zero for the lowest skill bin.

Table A8: Grants subsidy rate by skill tercile

	First-year AA enrollees		First-year BA enrollees	
Skill	**Pub Grants net Pell/TF**	**Prv Grants/TF**	**Pub Grants net Pell/TF**	**Prv Grants/TF**
1	0.000	0.257	0.199	0.132
2	0.040	0.239	0.228	0.138
3	0.080	0.195	0.305	0.158
Observations	844		2,652	

Notes: The table reports average grant subsidy rates for public grants net of Pell grants and for private grates broken within each skill tercile, among 2013-2014 academic year AA and BA enrollees. Weights: PETS-SR longitudinal weights. Source: HSLS:09.

A.3 Other sources

A.3.1 CPS ASEC

We use the Current Population Survey's Annual Socioeconomic Supplement (CPS ASEC) in 2009 and 2012 to compute within-bin average incomes that we impute to income bins in the BY and F1 waves of the HSLS:09 to assign parental income a real dollar value. Table A9 reports these dollar values for each income bin. Income bin thresholds are drawn from the HSLS:09. These moments are computed for total income at the tax unit level. For the 2008 income values, the sample is observations with a child between 13 and 14 and adults between 35 and 70 in 2009. For the 2011 income values, the sample is households with a child between 16 and 17 and adults between 35 and 70 in 2012. The ages of the child in these sample selection criteria reflect the ages of sample members in the BY and F1 waves of the HSLS:09. Income values are in 2013 dollars.

A.3.2 NCES Tabulations

Spending on consumption amenities We use NCES tabulations of average institutional spending on various spending categories to compute the average number of dollars per student spent on consumption amenities at two-year programs and four-year programs. Following Jacob, Mc-

Table A9: CPS ASEC median income by income bin

Income bin	Income (2008)	Income (2011)
1	9,226	8,716
2	27,055	25,921
3	48,700	46,126
4	70,290	67,302
5	90,956	87,072
6	112,081	107,315
7	133,797	128,426
8	156,393	150,346
9	177,592	170,268
10	198,426	190,085
11	220,406	210,460
12	240,993	232,075
13	425,959	320,444
Observations	89,925	87,475

Notes: The table reports the within-bin median income used to impute dollar values to the HSLS:09 family income variable. These imputation moments from the CPS ASEC are in real dollars, rounded to the nearest dollar and converted using the CPI. Source: 2009 and 2012 CPS ASEC.

Call, and Stange (2018) we measure spending on consumption amenities as the sum of spending on student services and auxiliary enterprises. In NCES tabulations, within two- or four-year programs, average spending on student services and auxiliary enterprises are reported separately for institutional "classifications," i.e. public, private not-for-profit, and private for-profit. Specifically, average spending on student services and auxiliary enterprises by public and private not-for-profit institutions in academic years 2013, 2014, and 2015 are found in NCES Table 334.10 (2024) and NCES Table 334.30 (2024), respectively. Private for-profit institutions have student services and auxiliary enterprise spending reported separately for the 2014 and 2015 academic years in NCES Table 334.60 (2015b) and NCES Table 334.60 (2018), respectively. For the 2013 academic year, NCES Table 334.60 (2015a) instead reports spending on student services combined with academic and institutional support. To address the fact that student services is not reported separately for the 2013 academic year, we multiply spending on student services plus academic and institutional support by the ratio of spending on student services to the sum of student services, academic support, and institutional support in 2014 and 2015 from NCES Table 334.60 (2015b) and NCES Table 334.60 (2018) to find an imputed value for spending on student services in 2013. Dollars are converted to 2013 using the CPI.

We aggregate across institutional classifications in each academic year by taking a weighted sum, where weights are shares of enrollment totals in public, private not-for-profit, and private for-profit institutions among two- and four-year programs reported in NCES Table 303.25 (2023). Table A10 reports the components of each academic year's mean as well as the total mean across academic years. For each program type, the mean across years is reported in Section 2.1 in the main text.

Table A10: Spending on consumption amenities by program type

		Spending				Enrollment share		
Program type	**Year**	**Average**	**Public**	**Private NFP**	**Private FP**	**Public**	**Private NFP**	**Private FP**
Two-year (AA)	2013	2,092	2,029	3,325	2,619	0.950	0.010	0.050
	2014	2,068	2,058	4,509	2,821	0.950	0.000	0.040
	2015	2,200	2,183	4,947	3,146	0.950	0.000	0.040
	mean	2,120						
Four-year (BA)	2013	6,244	5,629	8,626	3,317	0.600	0.290	0.110
	2014	6,611	5,809	8,908	4,839	0.610	0.290	0.100
	2015	6,560	5,919	9,087	3,488	0.610	0.290	0.090
	mean	6,471						

Notes: For the 2013, 2014, and 2015 academic year, the table reports the weighted average of spending on consumption amenities using enrollment shares as weights. The 'mean' row is the average across academic years. The table also reports the components of the weighted average, specifically the total spending on consumption amenities and the enrollment share for postsecondary institutions who are public, private not-for-profit, and private for-profit. Spending is in 2013 dollars. Sources: NCES tabulations cited in text.

Spending on instruction To measure spending on instruction, for public and private not-for-profit institutional classifications we use the same sources as Table A10. However, for instructional spending there is no need to impute for the 2013 value because it is reported as a distinct category in NCES Table 334.60 (2015a). Table A11 reports average spending on instruction for two-year and four-year programs, average spending within each institutional classification, and enrollment share weights. On average during the 2013-2015 time period, spending on instruction is more than twice as high among four-year institutions compared to two-year institutions.

Table A11: Spending on instruction by program type

		Spending				Enrollment share		
Program type	**Year**	**Average**	**Public**	**Private NFP**	**Private FP**	**Public**	**Private NFP**	**Private FP**
Two-year (AA)	2013	5,689	5,640	8,370	4,954	0.950	0.010	0.050
	2014	5,683	5,765	9,391	5,148	0.950	0.000	0.040
	2015	5,966	6,065	7,667	5,095	0.950	0.000	0.040
	mean	5,779						
Four-year (BA)	2013	11,637	10,957	16,125	3,518	0.600	0.290	0.110
	2014	12,167	11,226	16,552	5,186	0.610	0.290	0.100
	2015	12,247	11,498	16,848	3,854	0.610	0.290	0.090
	mean	12,017						

Notes: For the 2013, 2014, and 2015 academic year, the table reports the weighted average of spending on consumption amenities using enrollment shares as weights. The 'mean' row is the average across academic years. The table also reports the components of the weighted average, specifically the total spending on instruction and the enrollment share for postsecondary institutions who are public, private not-for-profit, and private for-profit. Spending is in 2013 dollars. Sources: NCES tabulations cited in text.

B Model Appendix

B.1 Consumer value functions after highest degree attainment

This section presents the value functions after the highest level of degree attainment is permanently determined.

Consumers are required to begin student loan payments the year after they are no longer enrolled in college, regardless of whether or not they completed college. The idiosyncratic state of a consumer when $j \neq j_f + j_a$ is given by the tuple $\left(j, e^B, e^A, s, \eta, a\right)$. The consumer's value function is given by

$$V\left(j, e^B, e^A, s, \eta, a\right) = \max_{d_f \in \{0,1\}} \left(1 - d_f\right) V^R\left(j, e^B, e^A, s, \eta, a\right) + d_f V^D\left(j, e^B, e^A, s, \eta, a\right), \quad (12)$$

where d_f, $V^R\left(\cdot\right)$, and $V^D\left(\cdot\right)$ denote the student loan delinquency decision, the value of repayment, and the value of delinquency, respectively. The value of repayment for $j \neq j_f + j_a$ is given by

$$V^R\left(j, e^B, e^A, s, \eta, a\right) = \max_{c \geq 0, \ell \in \mathscr{L}, a'} U\left(c, \ell, j, d_e\right) + \beta \psi_j E_{\eta' | e^B, \eta} V\left(j+1, e^B, e^A, s, \eta', a'\right) \quad (13)$$

s.t.

$$\left(1 + \tau_c\right) c + a' = \tilde{y}\left(j, e^B, e^A, s, \eta, a, \ell\right) + a + Tr_j + \mathbb{I}_{\{a<0\}} r_{SL} a$$

$$a' \geq \min\left[\left(1 + r_{SL}\right) a + \rho_R\left(j, a\right), 0\right],$$

where $d_e = 0$. The constraint on a' is the loan repayment constraint, which requires that if the consumer has outstanding federal loans, then the consumer must repay at least $\rho_R\left(j, a\right)$ of the outstanding principal plus interest.

Alternatively, these consumers can choose delinquency. The value function for $j \neq j_f + j_a$ is given by

$$V^D\left(j, e^B, e^A, s, \eta, a\right) = \max_{c \geq 0, \ell \in \mathscr{L}} U\left(c, \ell, j, d_e\right) - \xi_D + \beta \psi_j E_{\eta' | e^B, \eta} V\left(j+1, e^B, e^A, s, \eta', a'\right)$$

s.t. (14)

$$\left(1 + \tau_c\right) c = \tilde{y}\left(j, e^B, e^A, s, \eta, a, \ell\right) + Tr_j - \rho_D\left(j, a, y\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)$$

$$a' = \left(1 + r_{SL}\right) a + \rho_D\left(j, a, y\left(j, e^B, e^A, s, \eta, a, \ell\right)\right) - \phi_D\left[\rho_R\left(j, a\right) - \rho_D\left(j, a, y\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)\right],$$

where $d_e = 0$. In the case of delinquency, consumers are not allowed to save, and additionally have their wage garnished to make a partial payment $\rho_D\left(j, a, y\right)$. Therefore, they consume whatever remains from their disposable income, plus accidental bequests, after making the partial payment.

The parameter ϕ_D is the fraction of the missed payment, the difference between full payment and partial payment, that is charged as a collection fee. The outstanding principal plus interest is then augmented by the missed payment plus the collection fee net of any partial payment. During delinquency the consumer also faces a stigma cost, ξ_D.

When $j = j_f + j_a$, in addition to the choices described above, the parent chooses an inter vivos transfer to their child, who will become an independent agent in that period. At the start of age $j_f + j_a$, the parent draws their child's skill type and then chooses whether or not to be delinquent on any student debt payments; the EFC of the child, f, is determined based on parental income. The value function before the draw of child skill type is given by

$$V\left(j, e^B, e^A, s, \eta, a\right) = \sum_{s_c} \pi_{s_c}\left(s_c | e^B\right) \left[\max_{d_f \in \{0,1\}} \left(1 - d_f\right) V^R\left(j, e^B, e^A, s, \eta, a, s_c\right) + d_f V^D\left(j, e^B, e^A, s, \eta, a, s_c\right) \right], \tag{15}$$

where $\pi_{s_c}\left(s_c | e^B\right)$ is the probability over child skill, which depends on whether the parent has a BA. The value of repayment for $j = j_f + j_a$ is given by

$$V^R\left(j, e^B, e^A, s, \eta, a, s_c\right) = \max_{c \geq 0, \ell \in \mathscr{L}, a', a_c \geq 0} U\left(c, \ell, j, d_e\right) + \beta \psi_j E_{\eta' | e^B, \eta} V\left(j+1, e^B, e^A, s, \eta', a'\right) + \beta_c E_{\eta_c | e_c^B} E_{\gamma_c} V^0\left(s_c, \eta_c, a_c, \mathbb{I}_{\hat{y} > y_{f=0}} G\left(\hat{y}\right), \gamma_c\right) \tag{16}$$

s.t.

$$\left(1 + \tau_c\right) c + a' + a_c = \tilde{y}\left(j, e^B, e^A, s, \eta, a, \ell\right) + a + Tr_j + r_{SL} a \mathbb{I}_{a<0}$$

$$a' \geq \min\left[\left(1 + r_{SL}\right) a + \rho_R\left(j, a\right), 0\right]$$

$$\hat{y} = y\left(j, e^B, e^A, s, \eta, a, \ell = ft\right),$$

where $d_e = 0$ and $e_c^B = 0$. In the equation, a_c is the inter vivos transfer to the child, $V^0\left(\cdot\right)$ is the child's value function, β_c disciplines the intensity of parental altruism toward the child, and $\hat{y}$ is income at full time work hours, $\ell = ft$. When computing the EFC, parental income assuming full time work hours is used to avoid moral-hazard incentives with respect to hours worked; otherwise, the parent may have an incentive to work fewer hours to lower the EFC so that the child qualifies for more need-based aid.[17]

When $j = j_f + j_a$ and the consumer chooses delinquency, we assume for simplicity that those consumers cannot make an inter vivos transfer to their child. Therefore, the value functions for

[17] In reality this moral hazard incentive is most likely not large, because the EFC is updated for every academic year of college. For the purposes of tractability, in our model the EFC is determined in the year that the child leaves the household and stays constant thereafter.

delinquency are the same as in equation (14), with the difference that the parent has a term reflecting altruistic utility toward their child in their objective function.

B.2 Additional functional forms and equilibrium definition

This section presents functional forms not provided in the main text in Section 3.1 and the equilibrium definition.

Full payment function. Federal student loan repayment leads to a full payment given by the function

$$\rho_R(j,a) = \begin{cases} -\left[\dfrac{r_{SL}}{1-(1+r_{SL})^{-(T_{SL}+1-j)}}\mathbb{I}_{j\leq T_{SL}} + (1+r_{SL})\,\mathbb{I}_{j>T_{SL}}\right] a & \text{if } a<0 \\ 0 & \text{otherwise} \end{cases} \tag{17}$$

If there is an outstanding balance and j is still within T_{SL} periods of repayment, then the loan is amortized with an interest rate of r_{SL}. If j is not within T_{SL} periods of repayment, then the outstanding principal plus interest is due. If there is no outstanding loan balance, the payment amount is zero.

Partial payment function. Federal student loan delinquency leads to a partial payment given by the function

$$\rho_D(j,a,y) = \min\left[\tau_g \max\left[y - T(y) - \bar{y}, 0\right], \rho_R(j,a)\right] \tag{18}$$

To present the function for Social Security transfers and then define the equilibrium, we must first discuss notation. Let $\vec{\omega}$ denote the idiosyncratic state of a consumer. This state depends on age and enrollment status in the following way:

$$\vec{\omega} = \begin{cases} (s,\eta,a,f,\gamma) & \text{for 18-year-olds, before realization of } q(s) \\ (s,\eta,a,f,\gamma,Q) & \text{for 18-year-olds, after realization of } q(s) \\ (j,s,\eta,a,f,\gamma) & \text{for consumers in an AA} \\ \left(j,s,\eta,a,f,\gamma,j^A\right) & \text{for consumers in a BA} \\ \left(j,e^B,e^A,s,\eta,a\right) & \text{for consumers not enrolled in an AA or BA, if } j \neq j_f + j_a \\ \left(j,e^B,e^A,s,\eta,a,s_c\right) & \text{if } j = j_f + j_a, \end{cases} \tag{19}$$

where $Q \in \{0,1\}$ is an indicator for whether an individual received the option to directly enroll in a BA program.

Let $\Omega^0(\cdot)$, $\Omega^A(\cdot)$, $\Omega^B(\cdot)$, and $\Omega(\cdot)$ denote the distributions of 18-year-olds before the realization of the straight-to-BA enrollment option shock, AA enrollees, BA enrollees, and consumers not enrolled in an AA or BA, respectively. Furthermore, let $d_d^A(\vec{\omega})$ and $d_d^B(\vec{\omega})$ denote the dropout decisions that solve the endogenous discrete dropout problems in the continuation values of equations (10) and (11), respectively.

Social Security transfer function. Social Security transfers are set equal to a fraction χ of the average labor earnings for the 30 years before retirement (conditional on education, AA completion years, skill), plus the average unconditional labor earnings for the 30 years before retirement, divided by two. The transfer function is given by

$$ss\left(e^B, e^A, s\right) = \frac{\chi}{2}\left[\frac{\int w\left(e^B\right)\eta\epsilon\left(j, e^B, e^A, s\right)\ell(\vec{\omega})\,\Omega_t\left(\vec{\omega}|j_r - 30 \leq j < j_r, e^B, e^A, s\right)d\vec{\omega}}{\int \Omega_t\left(\vec{\omega}|j_r - 30 \leq j < j_r, e^B, e^A, s\right)d\vec{\omega}} + \right. \tag{20}$$
$$\left.\frac{\int w\left(e^B\right)\eta\epsilon\left(j, e^B, e^A, s\right)\ell(\vec{\omega})\,\Omega_t\left(\vec{\omega}|j_r - 30 \leq j < j_r\right)d\vec{\omega}}{\int \Omega_t\left(\vec{\omega}|j_r - 30 \leq j < j_r\right)d\vec{\omega}}\right].$$

Although we compute the transition path in our analysis, thus far we have omitted time subscripts for the ease of exposition. For the definition of equilibrium, we include a time subscript, t, to indicate which variables may change along a transition path.

Equilibrium definition. Given an initial level of capital stock K_0 and initial distributions over idiosyncratic states $\{\Omega_0^0(\vec{\omega}), \Omega_0^A(\vec{\omega}), \Omega_0^B(\vec{\omega}), \Omega_0(\vec{\omega})\}$, a competitive equilibrium consists sequences of household value functions $\{V_t^0(\vec{\omega}), V_t^B(\vec{\omega}), V_t^A(\vec{\omega}), V_t(\vec{\omega}), V_t^R(\vec{\omega}), V_t^D(\vec{\omega})\}$, household college entrance and dropout policy functions $\{d_{e,t}(\vec{\omega}), d_{d,t}^A(\vec{\omega}), d_{d,t}^B(\vec{\omega})\}$, household consumption, hours worked, and next period asset policy functions $\{c_t(\vec{\omega}), \ell_t(\vec{\omega}), a_t'(\vec{\omega})\}$, household delinquency policy functions $\{d_{f,t}(\vec{\omega})\}$, household inter vivos transfer policy function $\{a_{c,t}(\vec{\omega})\}$, production plans $\{Y_t, K_t, L_{(t,e^B)}\}$, tax policies $\{\tau_{l,t}\}$, prices $\{r_t, w_t\left(e^B\right)\}$, Social Security transfers $\{ss_t\left(e^B, e^A, s\right)\}$, accidental bequests $\{Tr_{t,j}\}$, and distributions $\{\Omega_t^0(\vec{\omega}), \Omega_t^A(\vec{\omega}), \Omega_t^B(\vec{\omega}), \Omega_t(\vec{\omega})\}$ such that:

(i) Given prices, transfers, and policies, the value functions and household policy functions solve the consumer problems in equations (9)-(16);
(ii) Given prices and the production technology, the firm's factor input choices solve its profit maximization problem;
(iii) Social Security transfers satisfy equation (20);
(iv) Accidental bequests are transferred to households between ages 50 and 60 $(33 \leq j \leq 43)$ after

deducting expenditure on private education subsidies[18]

$$Tr_{t+1,j} = \frac{\int (1-\psi_j)\, a_t'(\vec{\omega})\, \Omega_t(\vec{\omega})\, d\vec{\omega}}{\sum_{j=33}^{43} N_{t+1,j}} - \frac{\int \theta^{pr}(s,A)\, \Omega_{t+1}^{A}(\vec{\omega})\, d\vec{\omega}}{\sum_{j=33}^{43} N_{t+1,j}} - \frac{\int \theta^{pr}(s,B)\, \Omega_{t+1}^{B}(\vec{\omega})\, d\vec{\omega}}{\sum_{j=33}^{43} N_{t+1,j}}, \tag{21}$$

where $N_{t,j}$ denotes the mass of population of age j at time t;

(v) The parameter τ_l in the income tax and transfer function $T\left(y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)$ balances the government's budget constraint by solving:

$$\begin{aligned} G_t + E_t + D_t + SS_t = & \int \left[\tau_c c_t(\vec{\omega}) + T\left(y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)\right] \Omega_t^A(\vec{\omega})\, d\vec{\omega} + \\ & \int \left[\tau_c c_t(\vec{\omega}) + T\left(y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)\right] \Omega_t^B(\vec{\omega})\, d\vec{\omega} + \\ & \int \left[\tau_c c_t(\vec{\omega}) + T\left(y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right)\right] \Omega_t(\vec{\omega})\, d\vec{\omega}, \end{aligned} \tag{22}$$

where G_t, E_t, D_t, and SS_t are government consumption, total public education grants, federal student loan program expenditure, and Social Security expenditure, and are computed as follows:

$$\begin{aligned} G_t =& gY_t \\ E_t =& \int \left[\theta^{Pell}(f,A) + \theta^{other}(s,A)\right] \Omega_t^A(\vec{\omega})\, d\vec{\omega} + \int \left[\theta^{Pell}(f,B) + \theta^{other}(s,B)\right] \Omega_t^B(\vec{\omega})\, d\vec{\omega} \\ D_t =& \int \left[\min[a,0] - \min\left[a_t'(\vec{\omega}),0\right] + r_{SL}\left(\mathbb{I}_{a<0} a - a_s(j,a',f)\right)\right] \Omega_t^A(\vec{\omega})\, d\vec{\omega} + \\ & \int \left[\min[a,0] - \min\left[a_t'(\vec{\omega}),0\right] + r_{SL}\left(\mathbb{I}_{a<0} a - a_s(j,a',f)\right)\right] \Omega_t^B(\vec{\omega})\, d\vec{\omega} + \\ & \int \Bigg[\left(1 - d_{f,t}(\vec{\omega})\right) \left[\min[a,0]\left(1 + r_{SL}\right) - \min\left[a_t'(\vec{\omega}),0\right]\right] + \\ & d_{f,t}(\vec{\omega}) \big[-\rho_D\left(j, a, y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right) + \\ & \phi \max\left[\rho_R(j,a) - \rho_D\left(j, a y_t\left(j, e^B, e^A, s, \eta, a, \ell\right)\right), 0\right] \big] \Bigg] \Omega_t(\vec{\omega})\, d\vec{\omega} \\ SS_t =& \int \mathbb{I}_{j \geq j_r} ss_t\left(e^B, e^A, s\right) \Omega_t(\vec{\omega})\, d\vec{\omega}. \end{aligned}$$

(vi) Labor, capital, and goods markets clear in every period t; and

(vii) $\Omega_{t+1} = \Pi_t(\Omega_t)$, where Π_t is the law of motion that is consistent with consumer household

[18] In our baseline calibration and in all of the counterfactual exercises, accidental bequests are always positive because the assets of those who die exceed the expenditure on private subsidies to education costs. If they did not exceed private subsidies, then bequests would be negative, which is equivalent to a lump-sum tax.

policy functions and the exogenous processes for population, labor productivities, skill, and the probabilities of being allowed to continue college.

Note that in the stationary equilibrium, the equilibrium distribution will be stationary, all aggregates, prices, taxes, and transfers will be constant, and all value functions and policy functions will be time invariant.

B.3 Computational algorithm

This section presents the computational algorithm to solve for the stationary equilibrium. The algorithm for the transition path is analogous except that the value functions, policy functions, prices, taxes, transfers, and distributions are indexed by a time subscript.

1. Guess interest rate, r, wage rates, $w\left(e^B\right)$, the level parameter for the income tax rate, τ_l, Social Security transfers, $ss\left(e^B, e^A, s\right)$, and accidental bequests, Tr_j
2. Use backward induction to solve the consumer problems when $j = j_f + j_a + 1, \ldots, J$ (equations (12)-(14))
3. Guess value function before college, $V^0\left(s, \eta, a, f, \gamma\right)$ (equation (9))
4. Use backward induction to solve consumer problem when $j = 1, \ldots, j_f + j_a$ (equations (9)-(16). In solving the consumer problem at $j = j_f + j_a$, use $V^0\left(s, \eta, a, f, \gamma\right)$ for the altruism term.
5. Use new value before the realization of the straight-to-BA enrollment option shock to update $V^0\left(s, \eta, a, f, \gamma\right)$; repeat 4.-5. until convergence
6. Guess initial distribution of 18-year-old consumers Ω^0
7. Solve for distributions of $\{\Omega^A, \Omega^B, \Omega\}$
8. Use distribution of Ω for $j = j_f + j_a$, exogenous processes for child skill and productivity, and the policy function for the inter vivos transfers to compute new estimates for distribution of initial 18-year-old consumers
9. Update Ω^0 and repeat 7.-9. until convergence
10. Given the stationary distributions of $\{\Omega^A, \Omega^B, \Omega\}$, solve for new guesses:
    - Compute interest and wage rates from the firm's first order conditions
    - Compute the level parameter for the income tax rate using the government budget constraint (equation (22))
    - Compute Social Security transfers and accidental bequests (equations (20) and (21))
11. Update guesses in 1., and repeat steps 2.-11. until convergence

B.4 Welfare computation

To measure welfare changes for the average high school graduate, we use lifetime consumption equivalent variation supplemented with a second measure, one-time equivalent transfers.

The lifetime consumption equivalent variation, Δ_c, is computed numerically using the following equation

$$\int \tilde{V}^0_{\text{initial}}\left(s,\eta,a,f,\gamma;\Delta_c\right)\Omega^0_{\text{initial}}\left(\vec{\omega}\right)d\vec{\omega} = \int V^0_{\text{final}}\left(s,\eta,a,f,\gamma\right)\Omega^0_{\text{initial}}\left(\vec{\omega}\right)d\vec{\omega}, \tag{23}$$

where "initial" and "final" refer to the initial and final stationary equilibrium, respectively. In the equation, $\tilde{V}^0_{\text{initial}}\left(s,\eta,a,f,\gamma;\Delta_c\right)$ denotes the resulting value function when the consumption in every age and state of the given individual's life is scaled by $(1+\Delta_c)$ in $V^0_{\text{initial}}\left(s,\eta,a,f,\gamma;\Delta_c\right)$. Note that the consumption of the children after they move out is not scaled by $(1+\Delta_c)$.

When measuring welfare allowing the distribution of high school graduates to change in the final steady state, we use the distribution Ω^0_{final} instead of $\Omega^0_{\text{initial}}$ for the right-hand side of the equation.

The one-time equivalent transfer, Δ_a, is computed using the following equation

$$\int V^0_{\text{initial}}\left(s,\eta,a+\Delta_a,f,\gamma\right)\Omega^0_{\text{initial}}\left(\vec{\omega}\right)d\vec{\omega} = \int V^0_{\text{final}}\left(s,\eta,a,f,\gamma\right)\Omega^0_{\text{final}}\left(\vec{\omega}\right)d\vec{\omega}. \tag{24}$$

For the breakdowns by skill and parental income, the calculations are analogous, with modified requirements on the type space.

C Parameterization Appendix

C.1 Remaining externally estimated parameters

Table C1 reports the remaining externally estimated parameters that are not reported in Table 10. These parameters are organized into Panels A through E based on type. In several rows in Table C1, an external parameter is normalized by GDP per capita for those 18 and over and is flagged accordingly. GDP per capita for those 18 and over is computed the same way as for Tables 10 and 11, as described at the start of Section 4.

Panel A reports parameters related to demographics and hours, which we set by assumption unless stated otherwise. The fertility period, j_f, is set to 13 so that consumers have a child when they turn 30; the age adulthood begins, j_a, is set to 18; j_r is chosen so that the retirement age is 65; and, finally, J sets maximum life span to 100 years. For $j < j_f + j_a$, we set survival probabilities ψ_j

to one to rule out children without parents; ages $j \geq j_f + j_a$ use estimates from the 2010 Social Security Administration Life Tables presented in Bell and Miller (2020). The probabilities over child skill conditional on whether or not the parent has a BA, $\pi_{s_c}(s_c|e^B)$, are based on NLSY97 estimates and are drawn from Table A3 of Appendix A.1.2. We set full time hours, ft, to 1/3, which is equivalent to 8 hours of work per day, five days a week. The set of hours a consumer could work, $\mathscr{L}$, consists of full time hours scaled by 0, 0.75, 1.00, 1.25, and 1.50.

Table C1: Externally estimated parameters

Parameter	Description	Data target	Value
Panel A: Demographics and hours			
j_f	Child bearing age	30 years	13
j_a	Years for child to move out	18 years	18
j_r	Retirement age	65 years	48
J	Maximum life span	100 years	83
ψ_j	Survival probability	2010 SSA Life Tables	-
$\pi_{s_c}(s_c\|e^B=0)$	Probability over child skill	NLSY97	$(0.393, 0.329, 0.278)$
$\pi_{s_c}(s_c\|e^B=1)$	Probability over child skill		$(0.100, 0.285, 0.615)$
ft	Full time hours	8 hours per day	$1/3$
$\mathscr{L}$	Set of feasible work hours	Percent of full time hours	$(0, 0.75, 1, 1.25, 1.5)ft$
Panel B: Preferences and production technology			
σ	Risk aversion	Risk aversion $\upsilon = 2$, Chetty (2006)	$\frac{1}{\upsilon} + 1$
ζ_j	Adult equivalence scale	OECD modified scale	$1 + 0.3\mathbb{I}_{j_f \leq j < j_f + j_a}$
α	Capital share	Kydland and Prescott (1982)	0.360
δ	Depreciation rate	Krueger and Ludwig (2016)	0.076
ι	Elasticity of substitution	Bils, Kaymak, and Wu (2024)	0.750
Panel C: Pell grants and federal student loans			
θ^{Pell}_{max}	Pell maximum, normalized	Statutory	0.081
$\bar{A}(j)$	Subsidized and unsubsidized loan limit, normalized		(0.077,0.167,0.271,0.376)
$\bar{A}_s(j)$	Subsidized loan limit, normalized		(0.049,0.111,0.188,0.264)
τ_{SL}	Interest rate add-on		0.021
T_{SL}	Maximum years to repay		14
τ_g	Federal SL garnishment rate		0.150
$\bar{y}$	Garnishment-exempt income, normalized		0.151
ϕ_D	Student loan collection fee	Luo and Mongey (2024)	0.185
Panel D: EFC			
$y_{f=0}$	Automatic zero EFC income threshold, normalized	Statutory	0.345
$Y_{f,i}$	EFC step formula intervals, normalized		(0.220,0.276,0.332,0.388,0.444)
$\tau_{f,i}$	EFC step formula marginal rates		(0.220,0.250,0.290,0.340,0.400,0.470)
y_{PA}	Income protection allowance, normalized		0.306
Panel E: Government spending and tax policy			
g	Government consumption	BEA	0.146
τ_p	Income tax progressivity	CBO	0.177
τ_c	Consumption tax rate	OECD	0.044

Notes: The table presents the externally estimated parameters that are not presented in Table 10 of Section 4.1.

Panel B reports parameters that govern preferences and the goods production technology. The parameter that governs the relative risk aversion, σ, is set to $1/\upsilon + 1$ so that relative risk aversion is equal to 2 based on Chetty (2006). The adult equivalence scale, ζ, is set to 0.3 following the Organization for Economic Co-operation and Development (OECD) modified scale. The capital share parameter, α, is set to 0.36 following Kydland and Prescott (1982). The depreciation rate of capital, δ, is set to 0.076, as in Krueger and Ludwig (2016). The parameter that dictates the

elasticity of substitution between labor without and with a BA, ι, is set to 0.75, which implies an elasticity of substitution of 4. As our subsidy expansion experiments focus on a steady state to steady state comparison, we use this estimate, which Bils, Kaymak, and Wu (2024) argue is a lower bound for the long-run elasticity of labor substitution across schooling groups.

Panel C reports parameters related to Pell grants and federal student loans. Statutory values are used for all parameters except for the student loan collection fee. The maximum Pell amount, θ_{max}^{Pell}, is set to 0.081 based on Office of Postsecondary Education, Federal Student Aid (2013). The college-year specific loan limits for any federal student loans, $\bar{A}(j)$, and for subsidized student loans, $\bar{A}_s(j)$, are set using the yearly limits reported by the Congressional Research Service (CRS) in Smole (2019). The values imply that individuals can borrow more in the third and fourth years in comparison to the first two years resulting in a lower average annual loan limit for AA programs compared to BA programs. The interest rate add-on, τ_{SL}, is set to 0.021 as reported by the Chief Operating Officer for Federal Student Aid (FSA) in Chief Operating Officer for FSA (2021). The repayment period for student loans, T_{SL}, is set to 14. This value implies that for a BA enrollee who graduates the maximum repayment period is 10 years, which is equal to the period for the Standard Repayment Plan (10 years) outlined in Smole (2019). The garnishment rate in the event of student loan delinquency, τ_g, is set following the rate established by the 2005 Deficit Reduction Act (109th Congress of the United States of America, 2006). The income exempt from garnishment in delinquency, $\bar{y}$, is set to 0.152 based on our calculations using results from Yannelis (2020). The last parameter in this panel, the student loan collection fee, ϕ_D, is set to 0.185 following Luo and Mongey (2024).

Panel D reports parameters related to the EFC, which are based on statutory values. These parameters are drawn from Tables A3 and A6 of the EFC formula guide for 2013-2014 prepared by the Federal Student Aid Office, U.S. Department of Education (2014). The income threshold below which applicants are assigned an automatic zero EFC, $y_{f=0,}$ is set to 0.345. The parameters that determine the intervals and the marginal rates of the EFC step function, $\{Y_{f,i}\}_{i=1}^{5}$ and $\{\tau_{f,i}\}_{i=1}^{6}$, are reported in the next two rows of the panel. For the income protection allowance reported in the last row, y_{PA}, we use the allowance for a household with three members including the student and one student in college to set the parameter to 0.306.

Panel E reports parameters related to government spending and tax policy. Government consumption as a share of GDP, g, is set to 0.147 using estimates of the numerator and denominator from BEA Table 1.1.5 and BEA Table 3.1. The income tax progressivity, τ_p, and consumption tax rate, τ_c, are set to 0.177 and 0.044, respectively. These values are estimated in Moschini and Raveendranathan (2025) using data from the Congressional Budget Office (CBO) and OECD.

C.2 Skill-specific wage premiums in data and model

Table C2 reports the AA and BA wage premium by skill tercile. The empirical estimates are drawn from Table 4. In both the model and the data, the AA and BA wage premium is computed as the median hourly earnings of individuals with an AA or BA degree divided by the median hourly earnings of those with only a high school degree, for workers aged 25 to 38, within a given skill tercile. The age range is chosen to match the available NLSY97 sample used for the empirical estimates. The model captures the empirical pattern that the AA wage premium is lower than the BA wage premium within each skill tercile.

Table C2: AA and BA wage premium by skill tercile in data and model

	Data		**Model**	
Skill	**AA**	**BA**	**AA**	**BA**
Low	1.17	1.38	1.14	1.39
Medium	1.20	*1.40*	1.11	*1.40*
High	1.22	1.48	1.11	1.43

Notes: The table reports the AA and BA wage premium by skill tercile. For the BA premium, the middle row estimates are reported in italics because they are targeted in the calibration. Data source: NLSY97.

Table C3 reports the BA wage premium for those who transfer from the AA to the BA program and for those who enroll directly in the BA program within each skill tercile. The empirical estimates are drawn from Table 7. In both the data and the model, the BA wage premium for each path to BA degree attainment is computed as the median hourly earnings of individuals with a BA degree given their path divided by the median hourly earnings of those with only a high school degree, for workers aged 25 to 38, within a given skill tercile. Again, the age range is chosen to match the available NLSY97 sample used for the empirical estimates. The model accounts for the lower BA wage premium for the many BA graduates taking the AA-to-BA route in comparison to straight-to-BA enrollees.

Table C3: BA wage premium for AA to BA and straight to BA in data and model

	Data		**Model**	
Skill	**AA to BA**	**Straight to BA**	**AA to BA**	**Straight to BA**
Low	1.38	1.38	1.30	1.39
Medium	1.36	1.42	1.36	1.45
High	1.41	1.49	1.39	1.43

Notes: The table reports the BA wage premium by skill tercile and path to BA degree attainment. Data source: NLSY97.