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# Progressive Income-Contingent Student Loans

Yue Hua and George Kudrna

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# Progressive Income-Contingent Student Loans*

Yue Hua[†‡] George Kudrna[§]

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**Abstract**

Progressive income contingent loans (ICLs) for college students, where repayment rates increase with income, may provide additional insurance against income risks after graduation. We study how the progressiveness of ICLs affects life-cycle behaviors and welfare. We document stylized facts on education in Australia, where recent reforms made ICLs more progressive. We found correlations between reforms and enrollment rates. We estimate income dynamics and found that progressive ICLs provide more insurance in the first repaying years. Lastly, we build a heterogenous-agent life-cycle model and find that progressive ICLs induce higher education attainment and welfare than non-contingent loans or linear ICLs.

**Keywords:** Student loans, income-contingent repayment, income dynamics, heterogeneous-agent life-cycle model

**JEL Classification**: E24, D15, H52, I22, J24

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†School of Economics, University of New South Wales; email: yue.hua1@unsw.edu.au.

‡Corresponding author at: Level 4, UNSW Business School Building, Kensington, NSW 2052, Australia.

§CEPAR, UNSW Business School, UNSW Sydney and CAMA at ANU; email: g.kudrna@unsw.edu.au.

# 1 Introduction

Income contingent loans (ICLs) are an important policy tool for college education. They serve two purposes – both relaxing the borrowing constraint when students are still attending college and providing insurance against income risks in the repaying years after graduation. Neither is readily available in the private financial market, especially for students and recent graduates, who often have no collaterals.

The role of insurance played by ICLs became more prominent in the recent decades, with college education increasingly exhibiting high cost, high risks, but also high returns. In the past thirty years, tuition fees have quadrupled in the US; tripled in the UK and Australia. Dropout rates remain considerable at around 30%. Even after successfully graduating, graduates still face employment and earnings risks in the labor market. Despite all these costs and risks, college attendance continued to increase in developed countries, as college premium remains high at between 1.5 and 2.0. As a results, many college graduates and dropouts hold large amount of debt, which they struggle to pay back.

In recent decades, countries like the UK and the US have switched from non-contingent loans to ICLs. However, they are both linear ICLs, in the sense that repayment rates do not change with income level. In contrast, in Australia, where we base our study, student loans have been progressive since its introduction in 1989, with higher repayment rates (i.e. repayment amount as a percentage of income) associated with higher income levels.

We study how the progressiveness of ICLs affects educational choice and welfare. Borrowing the terminology from public finance, we consider an ICL to be more progressive when the repayment rates increases more with income level. The combination of income-contingency and a subsidized interest rate make ICLs redistributive in nature. High earners repay earlier, resulting in their repayment higher in present value terms. ICLs can be made more or less redistributive by allowing repayment rate to increase or decrease by income level.

While there is an abundance of literature studying the progressiveness of tax rates (Heathcote, Perri and Violante, 2010), ICL repayment rates differ from tax rate because, unlike taxable income, the amount of debt to be repaid is fixed. Unless borrowers never earn enough throughout their working life to finish repaying,[1] the total amount they need to repay only change by the accrued interest, regardless of how their income evolve over the repayment period.

We start by documenting reforms in the Australian ICL systems and their impact on educational attainment. We show that, with each reform, tuition fees have increased and repayment schedules have become more progressive. In our data sample, we also saw that enrollment rates respond to reforms, especially the reform in 2005.

We directly estimating the income processes faced by workers of different educational levels using panel survey data. As repayment is a function of income only, estimating the income process without solving the complete model is enough for us to simulate the random process of repayment over the life cycle.

Then, in order to study how education choices and, ultimately, welfare respond to policy change, we develop a Huggett (1996)-type heterogeneous-agent life-cycle model with (i) endogenous decisions on education, consumption and saving/borrowing; (ii) exogenous income process, student debt repayment, and parental transfer; and (iii) individual heterogeneity in schooling taste and income shocks. The setup is similar to Abbott, Gallipoli, Meghir and Violante (2019), except that we abstract from general equilibrium and endogenous parental linkages. Instead, we fully characterize the income dynamics and the income-contingent repayment regime, which is called for by our research question.

We estimate the model using longitudinal household survey data – 20 waves of HILDA 2001-2020 (Summerfield et al., 2021). We adopt a two-stage estimation process commonly used in literature (Gourinchas and Parker, 2002; De Nardi, French and Jones, 2016; Arellano, Blundell and Bonhomme, 2017). First, we estimate income process and policy parameters directly from observed data. Then, we use Simulated Method of Moments (SMM) to estimate deep, structural parameters such as psychic costs of schooling by solving the equilibrium repeatedly.

We test alternative income-contingent repayment designs on the estimated model. For example, we examine a policy counterfactual where we set the income threshold to zero, hence individuals with student debt repay the loan as long as he has non-zero income. We also simulate the results if the repayment plan in the US, where repayment does not depend

[1] In the case of Australia, this is estimated to be around 20% of the outstanding loans (Ey, 2017).

on income, and in the UK, where repayment rate is fixed, were carried out in Australia. Our results show that, compared to other policies, the current income contingent scheme used in Australia induces both higher educational attainment and higher welfare.

## 1.1 Related literature

Our paper falls within the growing literature that uses Huggett (1996)-style heterogeneous-agent, life-cycle models to study student loans. Ionescu (2009) and Lochner and Monge-Naranjo (2011) are among the first to study the US federal student loans (FSL), with the former focusing on default and the latter on human capital investment. Abbott, Gallipoli, Meghir and Violante (2019) uses a rich model to show that general equilibrium effects and crowding-out of parental transfer are key to evaluating loans and grants. Luo and Mongey (2019) focuses on job search and job-related amenities and finds that FSL borrowers choose higher-paying jobs with worse amenities. Hua (2023) endogenizes fertility and finds a negative impact of FSL on fertility among borrowers. Moschini, Raveendranathan and Xu (2022) considers over-optimism in college decisions, which causes FSL to reduce welfare. Kim and Kim (2023) decomposes the rise in student debts in the US from 1979.

We also complement the literature on ICL across countries and methodologies. In the US, where take-up rates of income-driven repayment (IDR) is low, Mueller and Yannelis (2022) finds in a field experiment that prefilling applications forms dramatically increases the take-up rate of IDR plan. Using a life-cycle OLG model, Matsuda and Mazur (2022) simulated the introduction of ICL in the US and found that it increased welfare in the US, with only mild costs from moral hazard while Hanushek, Leung and Yilmaz (2014) highlights the tradeoff between efficiency and inequality for loans and grants and finds ICL to be on the optimal frontier.

We contribute to this strand of literature in two ways. First, we focus on the role played by the shape of the repayment schedule, including the minimum repayment threshold and the progressiveness of the repayment rate. Second, we calibrate the model to match the Australian economy using microdata from the HILDA panel study.

While we do not theoretically solve for an optimal repayment schedule, our quantitative results complements the theory literature on dynamic optimal taxation. For example, Stantcheva (2017) shows that, in a model with risky human capital accumulation over the life cycle, income-contingent loans can achieve the optimum. Solving a Mirrlees (1971)-type economies, Findeisen and Sachs (2016) shows that optimal tax design resembles a non-progressive ICL while Farhi and Werning (2013) shows that it resembles an age-dependent tax. Paluszynski and Yu (2023) combines the optimal design of student loans with pensions. We numerically compare student loans with various contingency designs and show that ICLs are preferable to non-contingent counterfactuals, which is in line with theory results.

Our results also complement existing empirical studies on income-contingent loans, such as Higgins and Sinning (2013) on the case of Australia; Dearden, Fitzsimons, Goodman and Kaplan (2008) on the UK; Cox, Kreisman and Dynarski (2020) on the US. Chapman, Higgins and Stiglitz (2014) provides an overview of theory, practice, and analysis of income-contingent student loan designs across different countries.

# 2 Empirical background

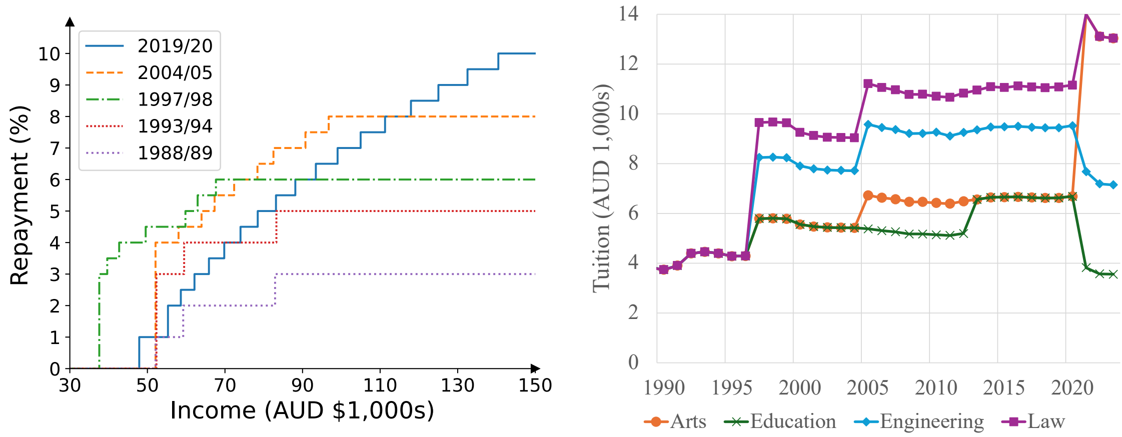
We focus our study on the case of Australia, which has a relatively long history of universal progressive ICL system, with multiple reforms in the past thirty years. Like many other developed countries in the recent decades, Australia has also gone through dramatic changes in both institutional background and labor market impacts of higher education.

## 2.1 HECS reforms

The income-contingent student loan scheme in Australia was established in 1989, known as the Higher Education Contribution Scheme (HECS). It is characterized by near-universal take-up rate, zero real interest rate, and repayment rates that vary with income.

Prior to 1989, higher education was free of charge in Australia, but the system became incompatible with increasing demand. The HECS system was established to let students bear some of the cost without having to pay upfront. All students studying bachelor degrees and above are automatically entered into ICL, with upfront payment (i.e. not taking the loans) remaining an option. The loans offer zero nominal interest rates, with outstanding debt indexed by the price level. After graduation, repayment is automatically collected by the Australian Tax Office during tax returns, according to a repayment schedule that is announced each year. We will focus our study on repayment schedules, both those carried out in reality and those hypothetical but of interest.

Since being established in 1989, the Australian ICL system has gone through three major reforms – in 1997, 2004, and 2019[2] – which at the same time increased tuition fee and made the repayment schedule more progressive.




(a) Repayment schedule across reforms

(b) Tuition fee by discipline

*Notes:* (a) Data from Australian Taxation Office (2022). Income is adjusted for inflation and in units of thousands of 2022 Australian dollars. The years selected in this figure are those immediately after a reform. (b) Statistics taken from the ABC news article "From free university to $15,000 a year for an arts degree". Tuition fee is defined as the government-mandated minimum annual student contribution and deflated to 2020 dollars. Universities can charge up to 30% higher than the minimum.

Figure 1a illustrates the major changes in the repayment schedules from 1989 until 2022. At the beginning, the repayment schedule is a simple, three-tiered schedule, ranging from 1% to 3% of income, not too different from a linear ICL. The range of variation in repayment rates increased over the past three decades. The largest change occurred in the most recent reform in 2019, shown in the solid blue line in Figure 1a, where the range of variation increased from 4 ppts to 9 ppts. Yet it would be difficult to know the impact of this reform, since many students who are affected haven't graduated. Our structural approach can provide guidance on the long-run impact of this reform.

[2]Appendix B provides more detailed information about each reform relevant to this paper. Higgins (2019) provides a policymakers' narrative of the 1997 and 2005 reforms.

Tuition fees increased during all four reforms and remained stable between each reform, as shown in Figure 1b. Tuition doubled in 1997 and increased by about 20% in both 2005 and 2021. As it takes three years to complete a bachelor's degree in Australia, the typical amount of student debt for a bachelor graduate is between \$20,000 to \$50,000 Australian dollars in 2020. At the same time, total education expenditure per student has remained stable at around \$25,000 Australian dollars since 2000[3]. This means the private share of education has increased, at least if we do not consider the discounting associated with ICL repayment.

## 2.2 Outcomes

The size of the higher education sector in Australia ballooned into significance starting from the 1980s. Using both repeated cross-sections from the census (Australian Bureau of Statistics, 2016) and panel data from HILDA (Watson and Wooden, 2012), we find large increases in college education attainment. In 1981, only 5% of Australians aged 25-34 hold a bachelor's degree. Today, more than 30% do.

Figure 2 shows the increase in educational attainment in Australians aged 25-34 from 1981 to 2016. There is a large increase in the share of population with post-secondary education, matched by the decrease in those with less than 12 years of education. The shares of younger population holding certificates and bachelor degrees both expanded notably, whereas the shares for other levels of post-secondary education either only slight increased or remained stable.

Although there are many education levels officially recognized in Australia, as seen in Figure 2, we categorize individuals into four groups based on their eligibility for ICLs and the difference in their income processes during entering the labor market. The four groups are Below Year 12, Year 12, Vocational Education, and Higher Education.

It is common in Australia for high school students to leave school at Year 10 or 11, at around the age of 16, if they do not intend to go to college. Even in 2020, more than 10% of individuals leave college before Year 12.[4] Their earnings are also notably lower than those with twelve years of education or above, as shown in Figure 3. Therefore, we consider them

[3] Figure 13 in the Appendix shows the time trend using OCED data.

[4] See Figure 11 in the Appendix.

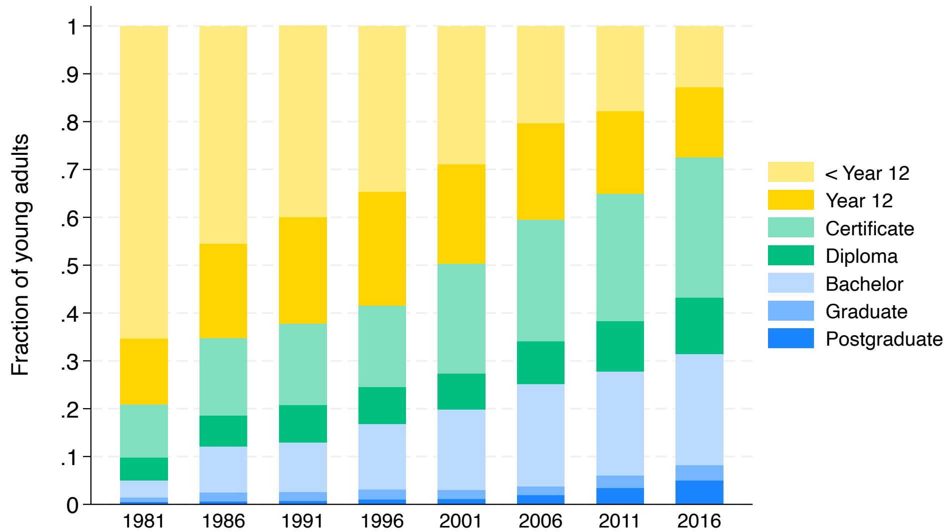



Figure 2: Educational attainment in Australia, 1981-2016

*Notes:* Data from Census of Population and Housing 1981-2016, 1% sample. Non-citizens or individuals born outside of Australia are excluded. Young adults include individuals aged 25-34.

as a separate education group and model the decision of staying through Year 12 explicitly in our life-cycle model in Section 4.

The vocational education sector in Australia is sizable. About 10% of adults aged 25-34 hold a vocational degree that takes two or more years to complete, such as a diploma or a Certificate III or IV. Before the reform in 2005, they were not eligible for ICLs. In the 2005 reform, it was announced that vocational students are included in the ICL scheme starting 2007.

College dropout rates remain stable since 2005. While less than half of all bachelor students at Australian universities graduate in four years, more than 70% manage to do so in nine. Appendix B shows the trend in completion rates from 2005 to 2019. Enrollment has increased since the 2000s while college premium has remained stable.

In order to understand how the repayment schedule translates into actual repayment, we need to study the income dynamics that graduates face after leaving college. We do so by estimating the income process and analyzing how repayment schedule affect repayment dynamics in the next section.

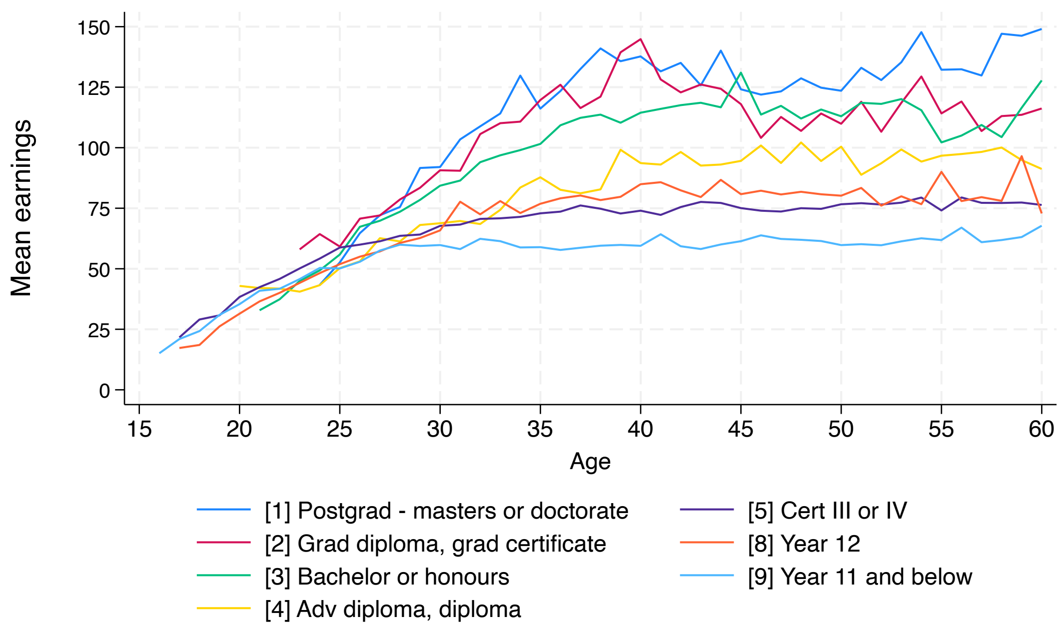



Figure 3: Age-earnings profile for different education level

*Notes:* Sample here include all male full-time workers in HILDA Waves 1-20. The unit used is thousands of Australian dollar in 2012. Education category is based on highest level completed. We drop estimates where there are less than 10 observations in an age-education cell.

# 3 Income dynamics

We assume the earning process depends only on experience and education. Specifically, the log earnings for individual $i$ of tenure $t \geq 1$ and education $e$ follows the stochastic process below:

$$y^e_{i,t} = \bar{y}^e_t \exp(\nu_{i,t}) \tag{1}$$

$$\nu_{i,t} = \rho^e \nu_{i,t-1} + \epsilon_{i,t} \tag{2}$$

$$\epsilon_{i,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma^e_\epsilon) \tag{3}$$

where $\bar{y}^e_a$ is the common age- and education-specific earnings profiles and $\nu_{i,a}$ is an AR(1) process, with persistence $\rho^e \in (0,1)$[5] and normally-distributed innovations $\epsilon_{i,t}$.

The initial distribution of earnings when workers first enter the labor market, i.e. $t = 0$, is the following:

$$\nu_{i,0} = \eta \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma^e_\eta) \tag{4}$$

We use the HILDA panel survey data, which includes 30,000 individual-year observations of earnings between years 2000 to 2020 after data cleaning.[6] Table 1 shows the summary statistics of our sample for selected years. It can be seen that the share of key characteristics, including marital status, education, and occupation, remain stable over the time period, with the exception of aging population and increasing education attainment.

We first estimate the common age-earnings profile $\bar{y}^e_t$ described in equation (1) using fractional polynomials separately for four education types.[7] Figure 4 compares the fitted profile and the data average for each age-education cell. We choose fractional polynomials over the more commonly used quadratic polynomials because of their flexibility to fit both the sharp earnings increase at the beginning of the career and the slow decline at the end.

Next, we estimate the AR(1) process of the residual earnings $\nu_{i,t}$ using GMM. We

[5] We tested for the hypothesis of $\rho^e = 1$, i.e. the income process is a random walk, and found it rejected for all four education groups.

[6] We provide details of our data cleaning process in Appendix C.1.

[7] We provide details on the regression in Appendix C.2.

| | 2001 | 2010 | 2020 |
|---|---|---|---|
| *Demographics* | | | |
| Age | 35.9 | 39.7 | 43.3 |
| % Married | 78.7 | 79.7 | 82.1 |
| Family size | 3.3 | 3.1 | 3.4 |
| *Education* | | | |
| % Bachelor and above | 24.9 | 28.8 | 32.8 |
| % Below Year 12 | 20.5 | 16.8 | 10.5 |
| *Location* | | | |
| % Major city | 60.5 | 61.0 | 58.5 |
| % All city | 84.9 | 85.6 | 80.2 |
| *Occupation* | | | |
| % Managers | 17.4 | 19.6 | 24.9 |
| % Professionals | 23.5 | 24.4 | 24.3 |
| % White collar | 53.4 | 55.5 | 58.4 |
| Observations | 1190 | 1766 | 1331 |

Table 1: Summary statistics for selected years

*Notes:* Marriage includes both legal marriage and de facto relationships. Family size is defined as the number of individuals, including both children and adults. White-collar occupation includes (i) managers, (ii) professionals, (iii) clerical and administrative workers, and (iv) sales workers.

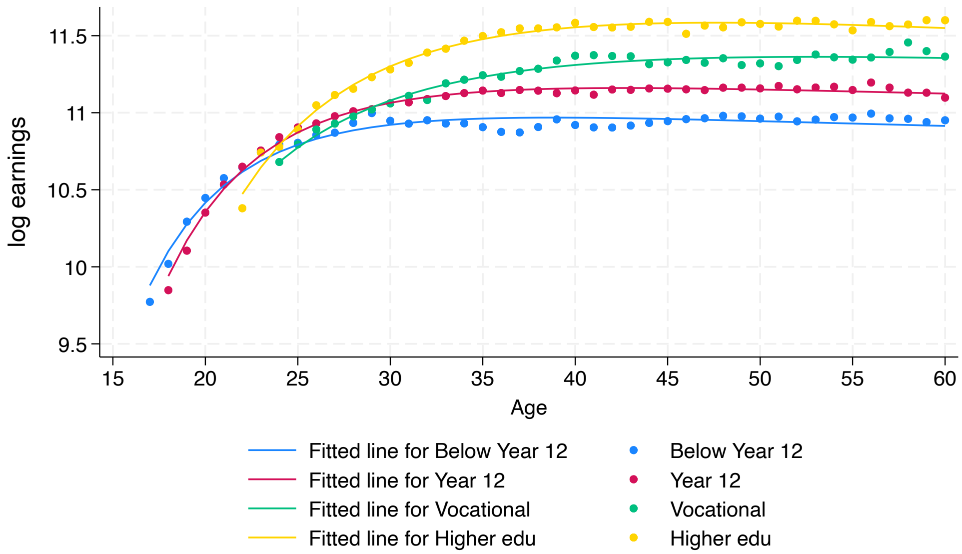



Figure 4: Fit for age-earnings profile by education

*Notes:* Data from HILDA Waves 1-20, all male full-time workers aged 25-55. We use fractional polynomial fit. We include controls for marital status, region, and cohort.

choose GMM over log-likelihood estimation for two reasons. Firstly, it is less reliant on the assumption of log normality, which has been shown be inconsistent with empirical results regarding income dyanmics (Guvenen, Kaplan, Song and Weidner, 2022). Secondly, it allow us to better match qualitative features of earnings volatility, such as the initial dispersion and whether variances increase over age. We believe these qualitative features to be crucial when studying the role of insurance with income-contingent repayment.

We target three moments: the variance of earnings for workers with less than five years of experience; the variance of earnings for workers with 25 to 35 years of experience; and the covariance between current earnings and earnings in the previous year. We summarize the targeted moments in Table 2.

Since we have the same number of moments and parameters, we are able to match the targeted moments exactly. Table 3 summarizes the estimated parameters for the AR(1) process. Figure 5 compares the simulated standard deviations of earnings in the AR(1) process and the standard deviations directly measured in the data.

The estimated earnings processes exhibit high persistence across all education levels.

| | Var, tenure 0-5 | Var, tenure 25-35 | Cov |
|---|---|---|---|
| HS dropout | 0.20 | 0.20 | 0.18 |
| HS graduate | 0.20 | 0.19 | 0.18 |
| VET | 0.19 | 0.27 | 0.22 |
| Higher ed | 0.20 | 0.24 | 0.23 |

Table 2: Targeted moments in GMM estimation

| | Initial disperson $\sigma_\eta$ | AR(1) shock $\sigma_\epsilon$ | Persistence $\rho$ |
|---|---|---|---|
| HS dropout | 0.44 | 0.19 | 0.91 |
| HS graduate | 0.45 | 0.15 | 0.94 |
| VET | 0.36 | 0.28 | 0.84 |
| Higher ed | 0.45 | 0.04 | 0.99 |

Table 3: Estimated AR(1) parameters

Yet the patterns of earnings volatility differ across education. For those with post-secondary education, either vocational or higher education, volatility increases with age. For those without post-secondary education, either high school dropouts or high school graduates, volatility is either decreasing or near-constant.

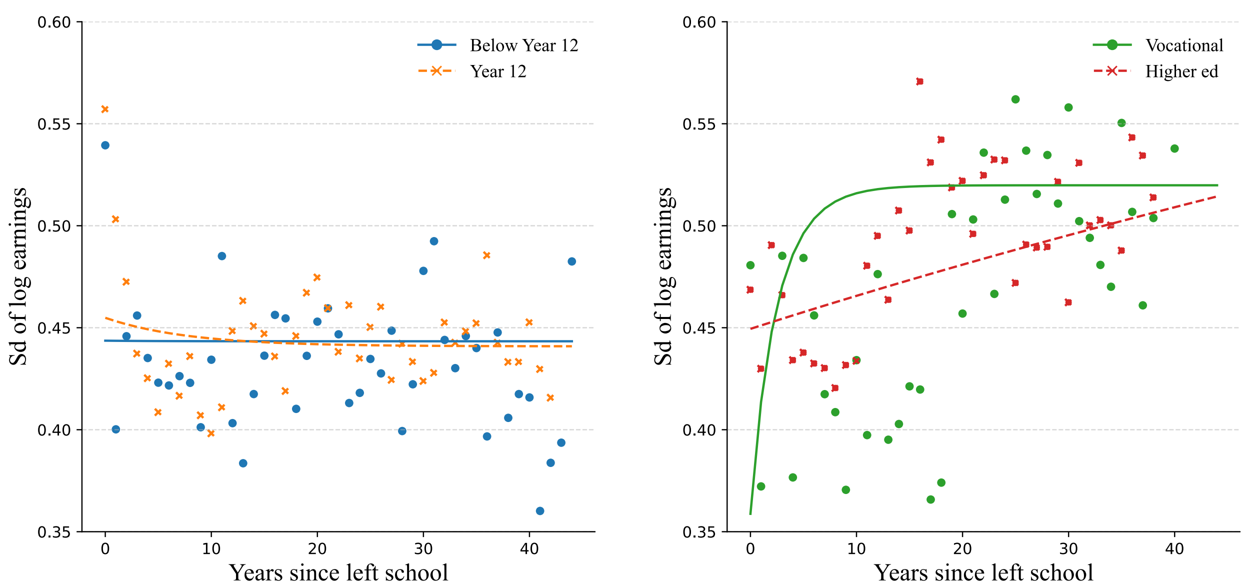



Figure 5: Variances generated by AR(1) by age and education

# 4 Life-cycle model

In order to understand how different ICL scheme affects consumption, educational decision, and welfare, we'll go beyond estimating the income risks and construct a life-cycle model where heterogeneous agents make decisions on education, consumption, and borrowing in the presence of risks and credit constraint.

## 4.1 Overview of the life cycle

We model individuals from the age of 16, when they begin to make schooling decisions, and 65, the retirement age in Australia[8]. We model each time period to be one year and divide the entire time frame into two stages – student stage and worker stage. We provide a brief summary of each stage here, with full details to follow in Sections 4.1.1 and 4.1.2.

**Student.** At age 16, a student receives parental transfer, realizes learning ability shock, and makes a two-stage education decision. First, she chooses whether or not to finish high school. If she chooses not to finish, she becomes a *high school dropout* type ($hd$) and enters the worker stage immediately. If she decides to finish high school, then she makes second education choice at age 18, between three education levels – *high school gradautes* ($hg$), *vocational education* ($ve$), and *higher education* ($he$).

We assume that only students in vocational and higher education are eligible for student loans.[9] We also abstract from voluntary up-front payment and repayment, which accounts for less than 10% of all eligible students, for tractability reason. In our model, all vocational and higher education students take up ICLs, which they gradually repay over the worker stage.

**Worker.** A student enters the worker stage immediately after graduation. Depending on education, the work stage starts from 16 to 22 and ends stochastically with the arrival of children as workers become parents. Workers receive exogenous stochastic earnings, pay off debt, and make consumption-savings decision. They do not make decisions on entering or

[8]Individuals can start to draw age pension at the age of 65 since 2017. The age limit gradually increases to 67 in 2014.

[9]This is true since 2007, where vocational students became eligible for ICLs as part of the 2005 reform. Before 2007, only higher education students are eligible for ICLs.

exiting the labor market or choose hours of work.

We do not endogenize labor supply in this paper. We believe modeling it credibly would be an endeavor beyond the scope of this paper. Predicting labor supply response requires an accurate estimation of labor supply elasticity and possibly accounting for the difference between males and females. To our knowledge, there is still no consensus on such an estimate for the Australian economy. We comfort ourselves by the fact that zero is within the range of existing estimates more often than not (Dandie and Mercante, 2007), and that previous studies report the effects of moral hazard in the context student loans are generally small (Matsuda and Mazur, 2022; Chatterjee and Ionescu, 2012).

We describe the choices, shocks, and value functions of the student and the worker stage below. Throughout the section, we will adopt the double subscript that's standard when describing life-cycle models. For instance, we will use $x_{j,t}$ to denote a variable $x$ associated with an individual who is aged $j$ at time $t$. To stay concise, we may omit the age or the time subscript when there is no danger of confusion.

### 4.1.1 Student stage

In the student stage, the individual receives parental transfers and psychic costs of schooling. She then makes two educational decisions sequentially – first, whether to complete high school and, second, whether to start work immediately, pursue vocational education, or pursue higher education. This two-stage setup is common in literature studying educational policy using life-cycle models such as Fuchs-Schündeln, Krueger, Ludwig and Popova (2022) and Abbott, Gallipoli, Meghir and Violante (2019). It also captures the idea that attending college requires a fixed cost in the form of additional studying years.

At age 16, a student receives parental transfer $b_t$ and a pair of taste shocks for education levels, $\epsilon_1 = (\epsilon_{1,1}, \epsilon_{1,2})$. Equipped by these two state variables, she then chooses between dropping out and finishing high school. Her value function can be written as:

$$V^S_{16,t}(b_t, \epsilon_1) = \max \Big\{ \underbrace{\mathbb{E}_y \Big[ \tilde{V}^W_{16,t}(hd, b_t, y_{16,t}, d_{16,t} = 0) \Big] + \epsilon_{1,1}}_{\text{drop out}}, \underbrace{\tilde{V}^S_{16,t}(b_t) + \epsilon_{1,2}}_{\text{finish HS}} \Big\}, \tag{5}$$

$$\epsilon_{1,k} \sim EV(-\gamma, \delta_1) \text{ for } k \in \{1, 2\}. \tag{6}$$

The high school student makes the discrete decision by maximizing the sum of choice-specific lifetime-utilities and taste shocks $\epsilon$, which follow an extreme value distribution with location $-\gamma$, the Euler-Mascheroni constant, and scale $\delta_1$, which will be calibrated.

The first term of equation (5) shows the lifetime value for leaving high school at age 16. The student then becomes a worker with type $hd$ (i.e. high school dropout) and solves the worker's problem. We will defer characterizing the worker's problem to Section 4.1.2.

The second term of equation (5) shows the lifetime value for finishing high school, $\tilde{V}^S_{16,t}$. We now further characterize $\tilde{V}^S_{16,t}$. The student pays an annual psychic cost $\psi$ for each year she remains in school. She chooses how much to consume ($c_t$) and save ($a_{t+1}$). As a high school student, she cannot borrow at this stage, as shown by inequality (10). Her optimization problem conditional on finishing high school is

$$\tilde{V}^S_{16,t}(b_t) = \max_{c,a} \left[u(c_{16,t}) - \psi\right] + \beta \left[u(c_{17,t+1}) - \psi\right] + \beta^2 V^S_{18,t+1}(a_{18,t+2}), \tag{7}$$

subj. to

$$c_{16,t} + a_{17,t+1} = b_t, \tag{8}$$

$$c_{17,t+1} + a_{18,t+2} = (1+r)a_{17,t+1}, \tag{9}$$

$$a_{17,t+1}, a_{18,t+2} \geq 0. \tag{10}$$

If the student chooses to finish high school, she makes a second choice at age 18 between one of three education levels – high school graduate ($hg$), vocational education ($ve$), and higher education ($he$) – by solving a similar discrete choice problem to equation (5), shown in equation (11).

$$\begin{aligned} V^S_{18,t}(a_{18,t}) = \max \Big\{ & \underbrace{\mathbb{E}_y \left[\tilde{V}^W_{18,t}(hg, a_{18,t}, y_{18,t}, d_{18,t} = 0)\right]}_{\text{HS graduate}} + \epsilon_{2,1}, \\ & \underbrace{\tilde{V}^S_{18,t}(ve, a_{18,t}) + \epsilon_{2,2}}_{\text{vocational}}, \underbrace{\tilde{V}^S_{18,t}(he, a_{18,t}) + \epsilon_{2,3}}_{\text{higher edu}} \Big\}, \end{aligned} \tag{11}$$

$$\epsilon_{2,k} \sim EV(-\gamma, \delta_2) \text{ for } k \in \{1, 2, 3\}. \tag{12}$$

If the student chooses to become a high school graduate, she enters the labor market immediately as a type-$hg$ worker (i.e. high school graduate) and solves the worker's problem, as shown in the first term in (11).

If the student chooses vocational education, she receives capital income $ra_{j,t}$ from last period, accumulates student debt $d_{j+1,t+1}$, and chooses how much to consume $c_{j,t}$. She cannot borrow privately, as shown by impsing borrowing constraint (16). Her optimization problem at age 18 is

$$\begin{aligned}\tilde{V}^S_{18,t}(ve, a_{18,t}, \psi) = \max_{c_{\alpha,\tau}} \left[u(c_{18,t}) - \psi\right] + \beta \left[u(c_{19,t+1}) - \psi\right] \\ + \beta^2 \mathbb{E}_{y_{20,t+2}} \left[V^W_{20,t+1}(ve, a_{20,t+2}, y_{20,t+2}, d_{20,t+2})\right],\end{aligned} \tag{13}$$

subject to budget constraint (14), debt accumulation (15), and borrowing constraint (16).

$$c_{j,\tau} + a_{j+1,\tau+1} = (1+r)a_{j,\tau} \tag{14}$$

$$d_{j,\tau+1} = d_{j,\tau} + \phi^{ve}, d_{18,t} = 0 \tag{15}$$

$$a_{j+1,\tau+1} \geq 0. \tag{16}$$

for $(j, \tau) \in \{(18, t), (19, t+1)\}$.

If she chooses higher education, her optimization problem at age 18 is

$$\begin{aligned}\tilde{V}^S_{18,t}(he, a_{18,t}, \psi) = \max_{c_{\alpha,\tau}} \sum_{(\alpha,\tau)=(18,t)}^{(21,t+3)} \beta^{\tau-t} \left[u(c_{\alpha,\tau}) - \psi\right] \\ + \beta^4 \mathbb{E}_{y_{22,t+4}} \left[V^W_{22,t+2}(he, a_{22,t+4}, y_{22,t+4}, d_{22,t+4})\right],\end{aligned} \tag{17}$$

subj. to

$$c_{j,\tau} + a_{j+1,\tau+1} = (1+r)a_{j,\tau} \tag{18}$$

$$d_{j,\tau+1} = d_{j,\tau} + \phi^{he}, d_{18,t} = 0 \tag{19}$$

$$a_{j+1,\tau+1} \geq 0 \tag{20}$$

for $(j, \tau) \in \{(18, t), (19, t+1), (20, t+2), (21, t+3)\}$.

### 4.1.2 Worker stage

From the age she leaves school until the age of retirement, a worker receives stochastic earnings net of student debt repayment and chooses how much to consume and save.

A worker at age $j$ with education $e$, asset position $a_{j,t}$, and debt $d_{j,t}$ solves the consumption-savings problem specified by equations (21)-(24). Otherwise, she remains in the work stage next period. In equation (23), her student loan debt is automatically deducted by repayment rate $\tau(y_{j,t})$ multiplied by her earnings $y_{j,t}$, where $\tau$ is determined by the income-contingent repayment rules. The worker can borrow up to an exogenous borrowing limit $L$, which will later be calibrated.

$$V^W_{j,t}(e, a_{j,t}, y_{j,t}, d_{j,t}) = \max_{c_{j,t}} u(c_{j,t}) + \beta \mathbb{E}_y \left[ V^W_{j+1,t+1}(e, a_{j+1,t+1}, y_{j+1,t+1}, d_{j+1,t+1}) | y_{j,t} \right], \tag{21}$$

subj. to

$$a_{j+1,t+1} + c_{j,t} + (d_{j,t} - d_{j+1,t+1}) = (1+r)a_{j,t} + y_{j,t} \tag{22}$$

$$d_{j,t} - d_{j+1,t+1} = \min\{d_{j,t}, \tau(y_{j,t})y_{j,t}\} \tag{23}$$

$$a_{j+1,t+1} \geq -L. \tag{24}$$

At age 65, the worker retires. Any of her remaining student loan debt is written off, as stipulated by the Australian student loan system. We do not model pension or retirement explicitly. Instead, we adopt a warm glow utility function to be the terminal lifetime value at the retirement age of 65, following the literature on retirement and bequest (De Nardi, 2004). The optimization problem faced by a worker aged 64, i.e. one period before retirement, is therefore characterized as follows.

$$V^W_{64,t}(e, a_{64,t}, y_{64,t}, d_{64,t}) = \max_{c_{64,t}} u(c_{64,t}) + g(a_{65,t+1}), \tag{25}$$

subj. to

$$a_{65,t+1} + c_{64,t} + \min\{d_{64,t}, \tau(y_{64,t})y_{64,t}\} = (1+r)a_{64,t} + y_{64,t} \tag{26}$$

$$a_{65,t+1} \geq -L. \tag{27}$$

The warm glow utility function $g$ is increasing and concave in the terminal asset position

$a_{65,t+1}$.

## 4.2 Government

We do not attempt to balance government budget through changing tax rate. Instead, we calculate the total and per capita cost of running the student loan program.

The government issues new loans for individuals at student stage and receives repayment after they graduate and receive income higher than the minimum repayment threshold. It generates revenue from workers' repayment of student loans and uses it to issue new loans. The budget deficit at time $t$ can be written as

$$\underbrace{\sum_{j=18}^{22} \int_{\chi} d_{j,t} d\varphi_{j,t}^{S}}_{\text{new issuance}} - \underbrace{\sum_{j=20}^{\bar{a}} \int_{\chi} (d_{j,t} - d_{j+1,t+1}) d\varphi_{j,t}^{W}}_{\text{repayment}}. \tag{28}$$

## 4.3 Equilibrium

For this paper, we focus on partial equilibrium, where prices, earning profiles in this case, are exogenously determined. We do not let earnings respond to policy change for two reasons. First, not having to calculate market-clearing earnings numerically allow us to model government policies and individual decisions in richer detail. Second, Australia is a relatively small and open economy, thus earnings are likely to be affected by the global labor market. With some abuse of notation to ensure conciseness, we formally define the concept of equilibrium in Definition 4.1.

**Definition 4.1.** An equilibrium is a sequence of tuples $\mathbf{E} = \{(\Psi_{j,t}^{e}, \varphi_{j,t}^{S}, \varphi_{j,t}^{W}, \xi_{j,t}^{S}, \xi_{j,t}^{W})\}_{j,t}$, which consists of:

(i) a Markov process $\Psi_{j,t}^{e}$ for earnings $\{y_{j,t}^{e}\}$ for education $e$, age $j$, and time $t$;

(ii) aggregate distribution functions $\{\varphi_{j,t}^{S}(\cdot)\}$ and $\{\varphi_{j,t}^{W}(\cdot)\}$ over exogenous and endogenous states $\chi_{j,t}^{S} = (a_{j,t}, \psi)$ and $\chi_{j,t}^{W} = (e, a_{j,t}, y_{j,t}, d_{j,t})$ for student and worker stage, respectively;

(iii) individual decision rules at student stage $\xi^S_{j,t}(\chi^S_{j,t}) = (e, c_{j,t}, a_{j+1,t+1})$ and worker stage $\xi^W_{j,t}(\chi^W_{j,t}) = (c_{j,t}, a_{j+1,t+1})$; and

(iv) initial conditions $\{(y^e_{j,t=0}, \varphi^S_{j,t=0}, \varphi^W_{j,t=0}, \xi^S_{j,t=0}, \xi^W_{j,t=0})\}_{j,t=0}$

such that the following conditions are satisfied:

(i) *(Optimality).* $\xi^S_{j,t}$ maximizes equations (5) - (20) and $\xi^W_{j,t}$ maximizes equations (21) - (24);

(ii) *(Aggregation).*

$$\int \varphi^S_{j,t} \mathrm{d}\chi^S_{j,t} + \int \varphi^W_{j,t} \mathrm{d}\chi^W_{j,t} = 1, \forall j, t \tag{29}$$

(iii) *(Laws of motion).*

$$\varphi^S_{j+1,t+1}(a_{j+1,t+1}, \psi) = \int \varphi^S_{j,t} \cdot \mathbb{1}_{a_{j+1,t+1} \in \xi^S_{j,t}} \mathrm{d}\chi^S_{j,t} \tag{30}$$

and

$$\begin{aligned} &\varphi^W_{j+1,t+1}(e, a_{j+1,t+1}, y_{j+1,t+1}, d_{j+1,t+1}) \\ &\qquad = \int\int \varphi^W_{j,t} \cdot \mathbb{1}_{a_{j+1,t+1} \in \xi^W_{j,t}} \cdot \mathbb{1}_{d_{j+1,t+1} = d_{j,t} - \min\{d_{j,t}, \tau(y_{j,t}) y_{j,t}\}} \mathrm{d}\chi^W_{j,t} \mathrm{d}\Psi^e_{j,t} \end{aligned} \tag{31}$$

**Definition 4.2.** A steady-state equilibrium is an equilibrium in which $(\Psi^e_{j,s}, \varphi^S_{j,s}, \varphi^W_{j,s}, \xi^S_{j,s}, \xi^W_{j,s}) = (\Psi^e_{j,t}, \varphi^S_{j,t}, \varphi^W_{j,t}, \xi^S_{j,t}, \xi^W_{j,t}), \forall s, t$.

# 5 Model Parametrization

In this section, we describe in details how to choose functional forms, external parameters, and internal parameters, so that the model matches the Australian economy.

## 5.1 Functional forms

**Preferences.** We assume the individuals have CRRA utility over consumption. Specifically,

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \tag{32}$$

We take the parameter of risk aversion $\sigma$ to be 2, which is commonly used in life-cycle models (Lochner and Monge-Naranjo, 2016; Abbott, Gallipoli, Meghir and Violante, 2019). It is also in line with previous empirical studies that estimated $\sigma$ to be anywhere from 1 to 10. A higher $\sigma$ means the individual is more risk-averse and thus have more incentive to accumulate precautionary saving. Our parameterization allows for a moderate role for precautionary savings.

We assume the same functional form for the warm glow terminal value as in (De Nardi, 2004). In particular, the value associated with having asset $a$ at age 65 is

$$g(a) = g_1 \left(1 + \frac{a}{g_2}\right)^{1-\sigma} \tag{33}$$

Both $g_1$ and $g_2$ are positive values to be calibrated to match the mean and standard deviation of asset distribution around age 65.

**Income-contingent repayment.** The repayment rate of student loan debt is a increasing, concave function of income level starting from a minimum income threshold. Specifically, I use the following functional form,

$$\tau(y_t) = \min\{0.1, \max\{0, -0.33 + 0.08 \log(y)\}\}. \tag{34}$$

It is a smoothed function of the actual repayment schedule since the 2019-20 reform. It matches very well with the actual tax schedule because the steps in the actual schedule are also linear in log income. We compare the actual and model repayment schedule in Figure 6.

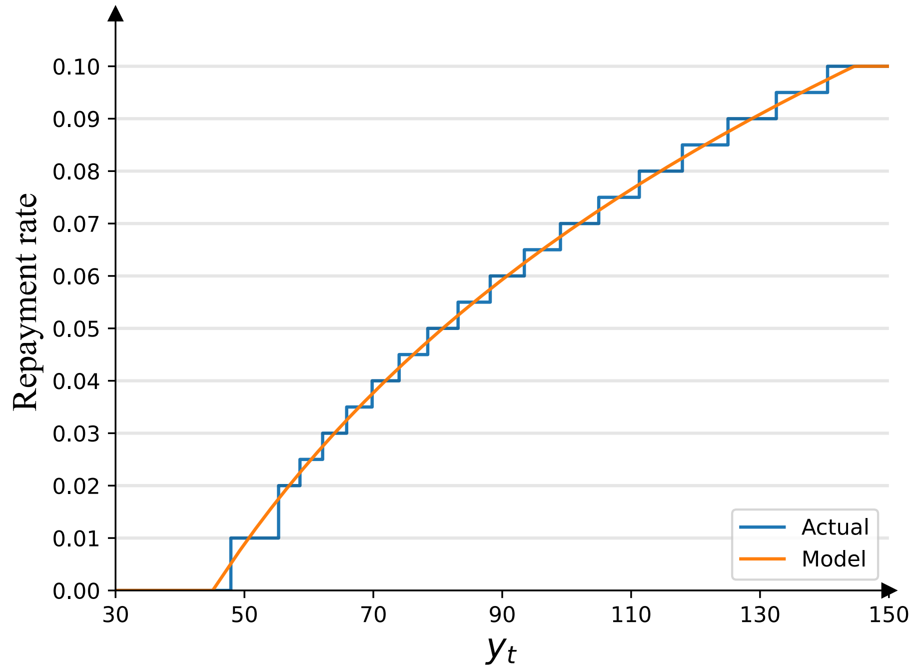



Figure 6: Debt repayment rate schedule

*Notes:* The line marked as "actual " is the repayment scheme for the 2019-20 financial year.

## 5.2 Parameters estimated externally

We choose the CRRA parameter to be 2, which is standard in literature related to household consumption and saving (Lochner and Monge-Naranjo, 2016; Abbott, Gallipoli, Meghir and Violante, 2019). We choose the deposit interest rate to be 4%, an average value for commercial banks in Australia in recent years. We take the household discount rate to be $\beta = 1/(1+r)$, so households are neither more patient or impatient than banks. We take the fees for vocational and higher education, $\phi^{ve}$ and $\phi^{he}$ to be the typical values of a 2-year diploma and a 4-year Bachelor's program, respectively. Table 4 summarizes all parameters chosen or estimated externally.

| *Parameter* | *Value* | *Description* |
|---|---|---|
| $\sigma$ | 2 | Intertemporal elasticity of substitution = 0.5 |
| $r$ | 4% | Average deposit rate |
| $\beta$ | 0.96 | Imposing $\beta(1+r)=1$ |
| $\phi^{ve}$ | 15 | Average fee for a two-year vocational diploma |
| $\phi^{he}$ | 36 | Average fee for a three-year bachelor's degree |
| $\omega^S$ | 35 | Annual transfer to students |
| $\omega^W$ | 18.2 | Annual transfer to workers |
| $L$ | 10 | Borrowing constraint for adults |
| $T^r$ | 65 | Retirement age |

Table 4: Parameters estimated externally

Notes: Table 4 lists all parameters chosen or estimated without solving the model. The unit used for all monetary values are $1,000s of Australian dollars in 2012.

# 6 Policy analysis

Using the estimated model, we now compare the benchmark policy to two other counterfactual policies – the first where we lower the minimum repayment income to 0 so that borrowers repay immediately after starting to work, and the second where repay is a fixed amount that does not depend on income level.

1. **Benchmark.** The repayment schedule described shown in Figure 6.

2. **Stringent.** Moving the threshold of starting to repay from $50,000 to $0. Namely, the new repayment rate schedule is:

$$\tau^{\mathrm{ST}}(y) = \min\left\{10\%, \max\left\{0, -0.33 + 0.08\log\left[y + \exp(0.33/0.08)\right]\right\}\right\}. \tag{35}$$

3. **Mortgage-style (US).** Fixed *amount* of repayment over 15 years. The corresponding repayment rate schedule is:

$$\tau^{\mathrm{US}}(y) = \frac{\phi^k}{15} \cdot \frac{1}{y} \tag{36}$$

where $\phi^k$ is the cost associated with education level $k$. We also assume the borrower repay all income when her income is smaller than the monthly repayment required. We do not model default, which occurs to around 10% of student borrowers in the US.

4. **Flat-rate (UK).** Fixed *rate* of repayment at 9% of the part of income that exceeds a minimum threshold of 51,100 Australian dollars, and 0 otherwise.

$$\tau^{\mathrm{UK}}(y) = \begin{cases} 0 \text{ if } y < 51.1 \\ 9\% \cdot \frac{y-51.1}{y} \text{ if } y \geq 51.1 \end{cases} \tag{37}$$

Figure 7 compares the three repayment schemes.

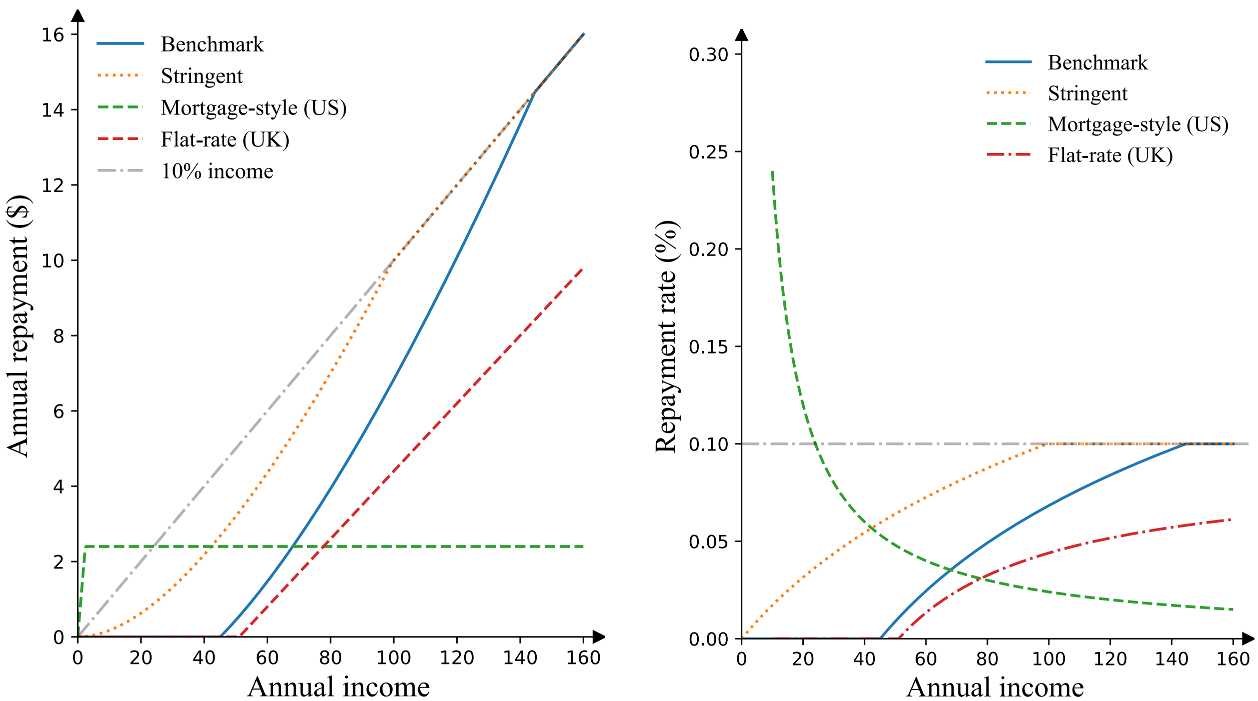



Figure 7: Repayment amounts and rates under three policies

*Notes:* We use $1,000s of Australian dollars in 2012 as the unit for the horizontal axes in both panels and the vertical axis in panel (a). We use percentage of income as the unit for the vertical axis in panel (b). Under the non-contingent repayment scheme, we assume repayment cannot exceed income.

## 6.1 Debt repayment

We first study the changes in repayments over the years.

Figure 8 shows how borrowers repay debt over the life cycle under the benchmark and two counterfactual policies. By construction, mortgage-style repayment requires 15 years to fully repay for every borrowers. For the benchmark and the stringent repayment policies, the average time required for fully repaying is less, but a fraction of borrowers who experience negative income shocks take longer than 15 years to fully repay. Under the benchmark policy, about 10% individuals never fully repay their debt, similar to the level reported in the data (Ey, 2017).

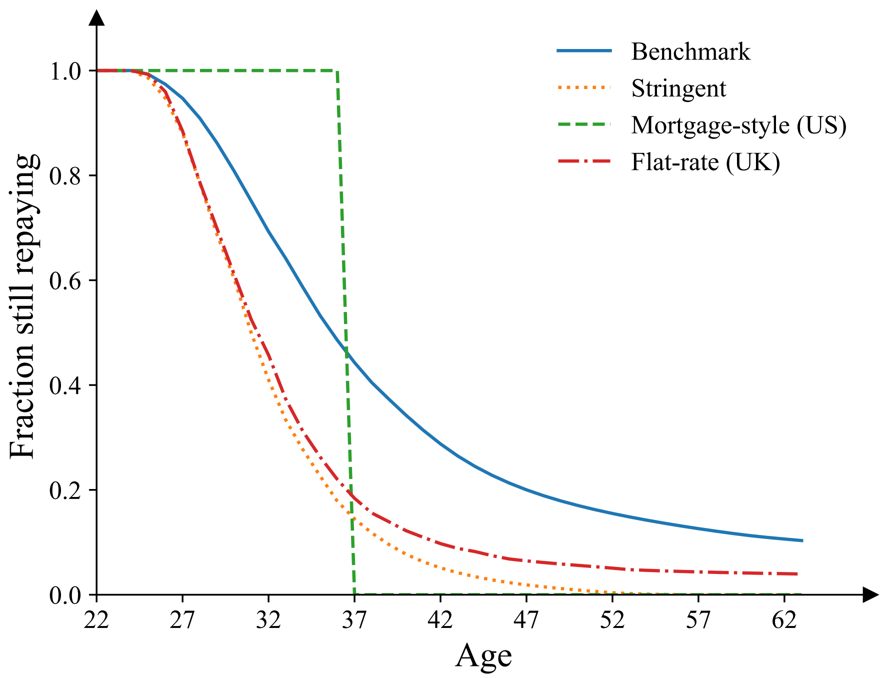



Figure 8: Fraction of borrowers that haven't fully repaid under three different policies

Table 5 summarizes the results regarding debt repayment under three different policies. The benchmark policy performs generally better than the non-contingent alternative, both allowing borrowers to finish repaying sooner and the repayment also take up a smaller fraction of income on average.

## 6.2 Consumption & welfare

Figure 9 shows the model-generated consumption profiles for four educational groups. The consumption profiles exhibit the hump-shaped pattern typical in life cycle models, as was

Table 5: Repayment statistics under three policies

| **Outcomes** | **Policy** | | |
|---|---|---|---|
| | Benchmark | Stringent | Mortgage-style (US) |
| *Years until start* | | | |
| mean | 1.19 | 0 | 0 |
| std | 1.85 | - | - |
| P10 | 0 | - | - |
| P90 | 4 | - | - |
| *Years until finish* | | | |
| mean | 11.45 | 8.08 | 15 |
| std | 6.43 | 3.62 | - |
| P10 | 5 | 4 | - |
| P90 | 20 | 13 | - |
| *Annual repayment* | | | |
| mean ($1,000s) | 1.85 | 3.95 | 2.60 |
| std ($1,000s) | 3.00 | 3.21 | 0.33 |
| mean (% of income) | 2.15 | 6.17 | 5.82 |
| std (% of income) | 2.52 | 2.11 | 3.14 |

discussed in the seminal paper by Gourinchas and Parker (2002). All post-secondary education provides increase in consumption, and thus welfare, over the entire life cycle. Higher education provides the most significant gain.

We compare the change in consumption under the counterfactual policies in Figure 10. The patterns of consumption change is similar under all three counterfactual policies. Compared to the current benchmark, average consumption is lower under all three counterfactual policies before age 30. On the other hand, between age 35 and 50, the counterfactual policies provide higher average consumption.

This difference in the life-cycle profile of consumption highlights better insurance provided by the current progressive repayment rates, compared to other policies. In the first decade after graduation, individuals face high uncertainties but have low savings to smooth consumption. The progressiveness of repayment rate mitigates this problem.

The higher average consumption under counterfactual policies also cautions us against studying only the short-run effects of student loan repayment. The US and UK plans provide

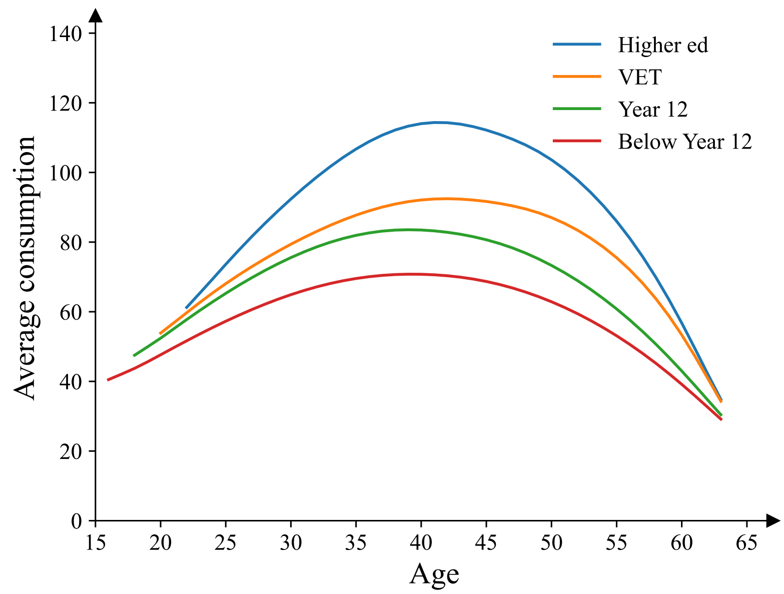



Figure 9: Consumption profiles for four education groups

Notes: Figure 9 shows consumption profiles generated by the model described in Section **??**. The unit of y axis is thousands of Australian dollars in 2012.

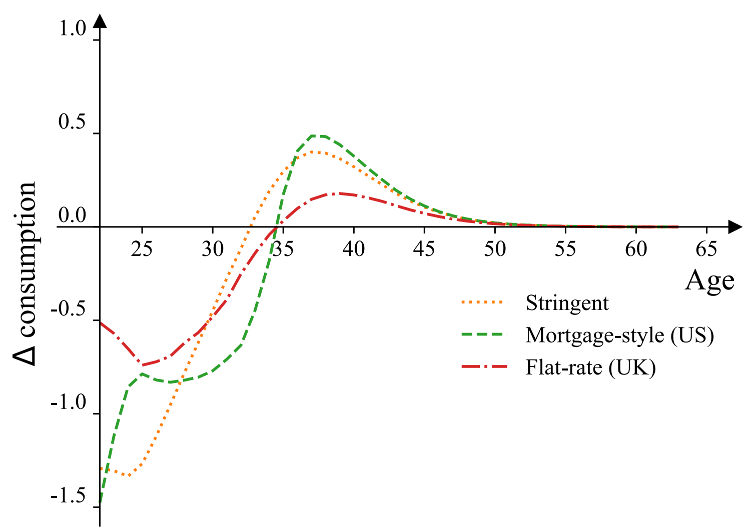



Figure 10: Consumption difference under counterfactual policies against benchmark

Notes: The unit of y axis is thousands of Australian dollars in 2012.

higher consumption ten years or more after graduation, when most, if not all, borrowers have finished repaying. Policy analysis only focusing on a few years after graduation will overstate the benefit of the benchmark policy compared to other alternatives.

Because of the insurance channel, the benchmark policy is able to provide higher welfare than counterfactual policies. In Table 6, we can see that, using consumption equivalence scale, the benchmark policy provides a welfare gain of between \$50 and \$100 Australian dollars per year throughout the individual's lifespan. This is a small but still significant increase.

| | Benchmark | Counterfactual $\Delta$ | | |
|---|---|---|---|---|
| | | Stringent | US | UK |
| | (1) | (2) | (3) | (4) |
| Edu attainment (%) | | | | |
| Below Year 12 | 14.61 | +0.39 | +0.25 | +0.28 |
| Year 12 | 40.72 | +5.16 | +3.18 | +3.60 |
| VET | 14.92 | -1.75 | -2.81 | -3.16 |
| Higher ed | 29.76 | -3.81 | -0.62 | -0.72 |
| Welfare | | | | |
| \$1,000/yr | 69.99 | -0.09 | -0.05 | -0.05 |
| p.p. | - | -0.12 | -0.07 | -0.07 |

Table 6: Educational & welfare under three policies

Notes: Column 1 shows the model-generated percentage of each education group. Columns 2-4 show the change in percentage points from the benchmark policy to the respective counterfactual policy. Welfare is calculated at the beginning of age 16, before the individual makes education choice.

## 6.3 Education decision

Since the benchmark student loan repayment schedule produces higher welfare, it is natural that more individuals choose to pursue post-secondary education after graduating from high school. Due to the two-stage education choice described in Section 4.1.1, more individuals also choose to complete high-school education, in anticipation of better welfare if they go on to pursue post-secondary education.

As is shown in Table 6, the share of individuals with fewer than 12 years of education is slight lower under the benchmark policy. The bigger differences come from the share of individuals pursue either vocational or higher education – the stringent counterfactual policy induces 3.8 percentage points lower rate in higher education, whereas the US and UK equivalent policies induces 2.5 and 3.2 percentage points low rate in vocational education, respectively.

# 7 Conclusions

In this paper, we study how the current income-contingent repayment design for student loans in Australia affects the flow of debt repayments, welfare as measured by consumption, and educational attainment. Our research question is motivated both by the cross-country differences in the income-repayment schedule and multiple reforms in Australia that changed the schedule over time. We document the details of the reform and institutional background for Australian student loans.

We adopt a structural approach, using a heterogenous-agent life-cycle model. We account for individual differences in schooling tastes and income shocks as well as allow individuals to choose education, consumption, saving and borrowing. We model income-contingent repayment as an exogenous function of the stochastic income

We mainly use the HILDA longitudinal survey to estimate our model. Since risk-smoothing is the most important mechanism for income-contingent repayment, we carefully estimate the age- and education-specific stochastic process for income using HILDA. We then use moments of the schooling distribution we measured from both HILDA and census data to jointly estimate the remaining parameters for the structural model.

We then compare the current policy in Australia with several counterfactual policies, such as lowering the minimum income threshold, using fixed amount or fixed rate of repayments. We found that, on average, the current benchmark induces slower repayment, higher welfare, and higher educational attainment, than the alternatives. This is due to the Australian policy provides better insurance in the first ten years after graduation.

There are several mechanisms that we haven't considered in this paper. Firstly, we do not consider general equilibrium effect of change in college premium, even though it is reasonable to expect college premium be affected by supply of college graduates. We do not consider this to be of first-order importance because comparing different repayment plans generally do not provide large enough change in college rate to significantly affect college premium.

Secondly, we do not take into account the change in labor supply under different policies. We expect the effect of moral hazard, that is, a more progressive income contingency discourages labor supply, to have some effects, but will not significantly change our results. Modeling labor supply rigorously, particularly the labor supply of women, places high demand on both data quality and model structure, which is beyond the scope of this paper.

Lastly, our model does not allow parent-child interaction to respond to policy change. This is mainly due to the lack of parent-child linked information in HILDA data but may be improved upon after we explore alternative data sources in Australia.

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Table 7: Glossary of variables

| | |
|---|---|
| $a_{j,t}$ | Asset position indexed by age and time |
| $b_t$ | Parental transfer received at age 16 |
| $c_{j,t}$ | Consumption indexed by age and time |
| $d_{j,t}$ | Remaining student debt indexed by age and time |
| $y_{j,t}$ | Earnings indexed by age and time |
| $g$ | Warm glow terminal utility function |
| $g_1, g_2$ | Parameters governing function $g$ |
| $r$ | Real interest rate |
| $\delta_1, \delta_2$ | Sd of taste shock - education |
| $\epsilon_1, \epsilon_2$ | Taste shock - education |
| $\gamma$ | Euler-Mascheroni constant |
| $\varphi$ | Aggregate distribution |
| $\chi$ | Generic vector of state variables |
| $\psi$ | Psychic utility cost of education |
| $\phi^{ve}, \phi^{he}$ | monetary cost of education |

# A Glossary

See Table 7 for a list of all variables used in the life-cycle model.

# B Additional empirical findings

**Education attainment.** Figure 11 shows similar trends in educational composition as Figure 2 using the annual HILDA dataset from 2001 to 2020 (Waves 1-20) to that in Figure 2. The left panel contains all individuals in working age (aged 25-60), whereas the right shows those aged between 25 and 34, same as in Figure 2. The composition shown in the right panel is consistent with that in Figure 2, using census data. With annual instead of five-year data, we can see that the increase in educational attainment for young workers is faster in 2001-2005 than the rest of the time period.

**Completion rates.** Figure 12 shows the 4-year, 6-year, and 9-year completion rates for bachelor students in Australian universities. Although there is a slight decline in the completion rates, the levels remain relatively stable over the 14-year period observed.

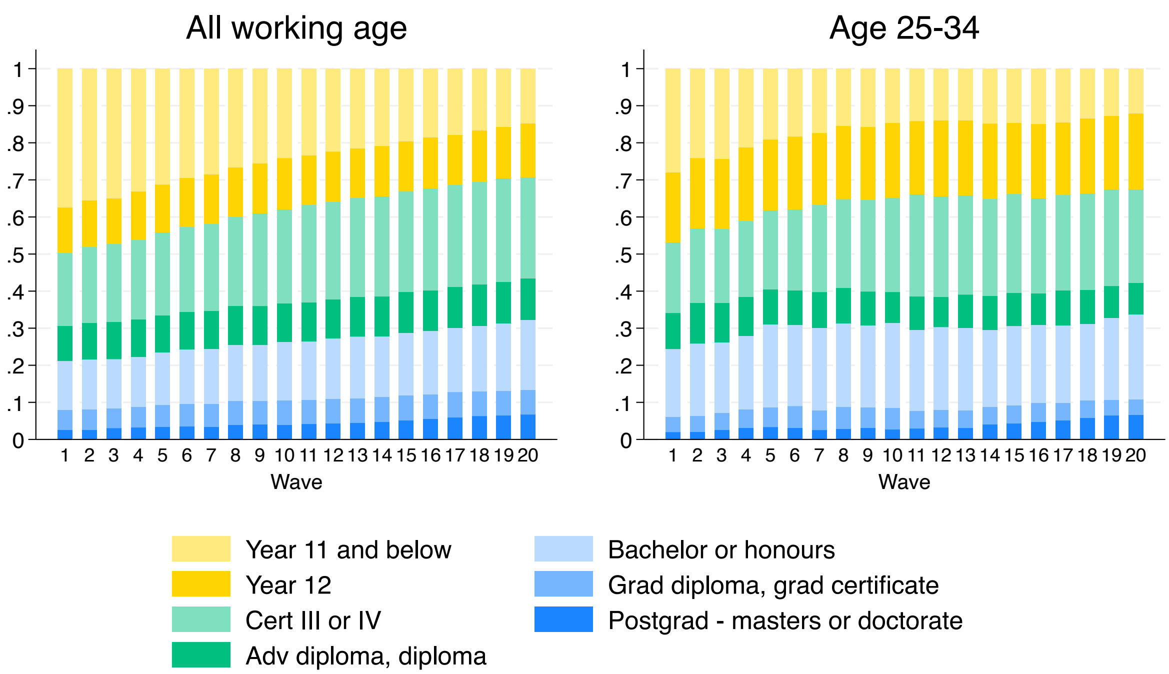


Figure 11: Trends in educational attainment using HILDA Wave 1-20

*Notes:* Sample from HILDA. We include all individuals born in Australia. We use cross-sectional individual weights for each wave. High school dropout is defined as those who completed year 11 or below; high school graduate as completed year 12; vocational as completed certificate or diploma; higher education as completed bachelor and above.

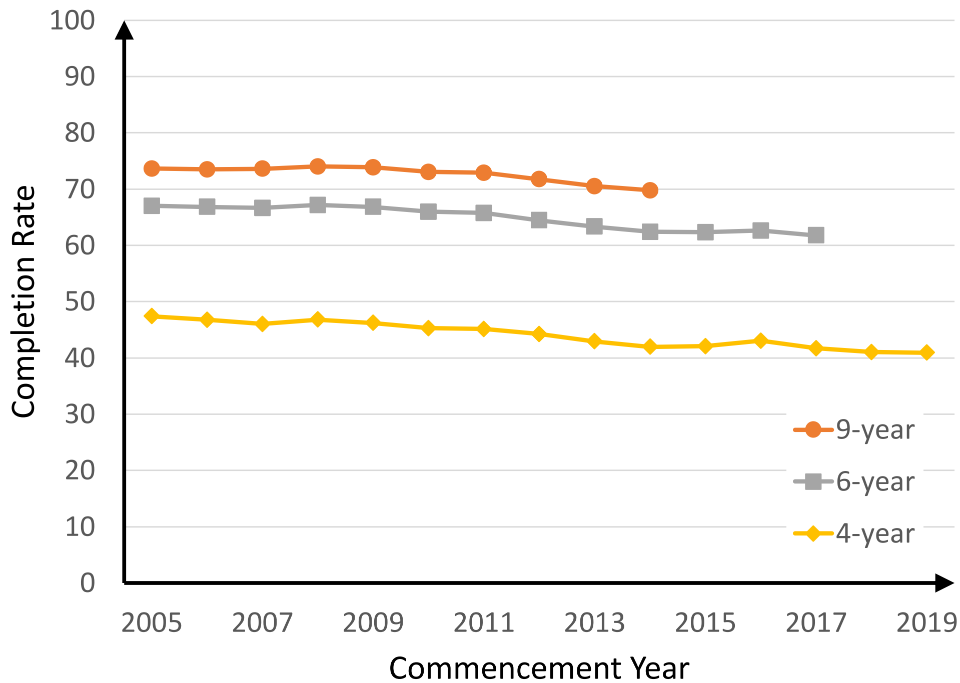


Figure 12: Trends in completion rates

*Notes:* Statistics from "Completion Rates of Higher Education Students - Cohort Analysis, 2005-2022" published by the Australian Department of Education. Sample includes all domestic students studying in institutions designated as universities by the DoE. Completion rates differ the length of time periods observed, i.e. the 4-year completion rate in 2019 represents the percentage of students graduating by 2023.

**Total educational expenditure.** Using OECD data, we can observe total expenditure as US dollars per student per year from 2000 to 2020. We convert US dollars to Australian dollars in 2020 using market exchange rate and CPI in Australia. Figure 13 shows the trend in expenditure of college since 2005. Total expenditure remains stable at around $25,000 dollars, with a slight decrease before 2012 and a slight increase after 2012.

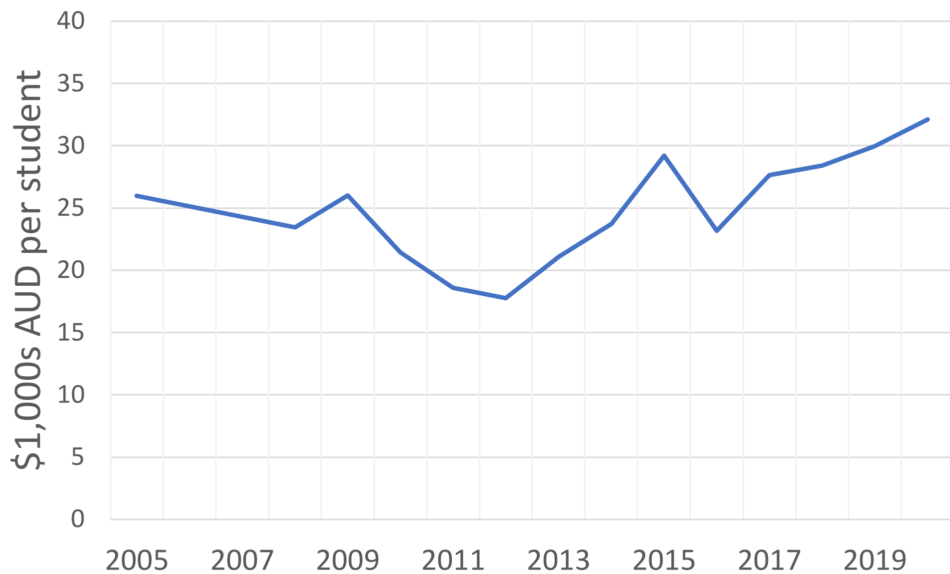


Figure 13: Total expenditure on tertiary education

*Notes:* Data from OECD, Education at a glance. Author's own conversion from US dollars

**HECS reforms.** Since its establishment in 1989, the HECS system has experienced three major reforms – in 1997, 2003, and 2019.

In 1997, the newly elected administration announced a HECS reform with three main features. Firstly, student contribution level was increased by about 40%. Secondly, contribution level changed from a uniform price into three levels by course of study, with subjects such as humanities and education being the lowest and those such as law and medicine being the highest. Lastly, income thresholds for repayment were reduced. Chapman (2006) studied the 1997 reform and found no adverse effects for students of any background despite the large changes.

The Higher Education Support Act (HESA) in 2003 introduced several changes to HECS. First, the uniform student contribution level is replaced by a range, where each school can set their own level. Secondly, the income threshold for repayment is increased. Thirdly, HECS is incorporated into the new Higher Education Loan Program (HELP), which also includes graduate-level studies and professional training. Nelson (2003) provided a summary of changes included in HESA 2003.

After the 2003 reform, higher education institutions were able to set their own fees up to 30% higher than the pre-reform level. The ceiling set by the government is binding for at least some universities. Most notably, Go8, the group of the eight top universities of Australia, all charge fees either equal to, or close to the upper bound.

In May 2017, Australian government announced a more progressive repayment schedule with a higher minimum repayment threshold and a higher top repayment rate. The proposed thresholds and rates did not start until 2019-20. The minimum repayment threshold for 2019-20 moved to $45,881, and the thresholds will be indexed in the years after 2019-20.

# C Estimating income dynamics

## C.1 Data cleaning

To estimate the parameters of the income process, we use the HILDA survey data from 2000 to 2020. We select all male respondents born in Australia. We keep only full-time workers aged between 25 and 55, as we do not wish to account for the wage loss from health shocks which commonly occurs after age 55.

Consistent with the rest of the paper, we divide individuals into four education groups – (1) Individuals with bachelor degrees or above (*Higher Education*); (2) individuals with vocational degrees that take at least one year to finish, such as Diploma and Certificate II or IV, but no higher education degrees (*Vocational Education* or *VET*); (3) individuals with 12 years of schooling who do not belong to the first two groups (*Year 12*); and (4) individuals with less than 12 years of schooling (*Less Than Year 12*). Higher education or vocational education dropouts will therefore be classified as *Year 12*. We have checked empirically that their earnings profiles are similar to those who never enrolled in post-secondary education.

For our measure of earnings, we use financial year gross wages and salary (variable name "wsfes"), which measures earnings before tax. We deflate earnings using CPI to 2020 dollars.

We drop observations with earnings below \$7,500 or above \$750,000, as well as those with abnormal growth (i.e. log difference bigger than 4 or smaller than -2 between two consecutive years).

## C.2 Estimating age-earnings profiles

When estimating the age-earnings profiles $\bar{y}_t^e$, we run the following regression:

$$y_{t,i}^e = f(t|e) + X_{i,t} + \nu_{i,t} \tag{38}$$

where $y_{t,i}^e$ is the log earnings of individual $i$ with education group $e$ at time $t$. $f(t|e)$ is a fractional polynomial with two terms, each with powers between -2 and 2. $X_{i,t}$ include control variables including marital status, cohort group, and geographical region. We do not control for individual fixed effects because we want to measure the initial dispersion in residual earnings $\epsilon_{i,t}$. $\nu_{i,t}$ is the residual term which we will use to estimate the AR(1) process in the next section.

We control for cohort effects because previous studies such as Meghir and Pistaferri (2004) found significant time effect in the US between 1980 and 2000. In order to examine the presence of cohort- and time-effect, we decompose the age-earnings profile by birth cohort and calendar year in Figure 14. For college workers, the age-earnings profile only slightly increases over cohort. As a result, the profiles controlling for cohort and controlling for time are similar with each other, and with the profile generated by the pooled sample. On the other hand, the non-college profiles increases significantly over time. The cross-sectional profile, depicted by the red dashed line, is much flatter than the longitudinal profile, depicted by the blue solid line.

## C.3 Estimating AR(1) process

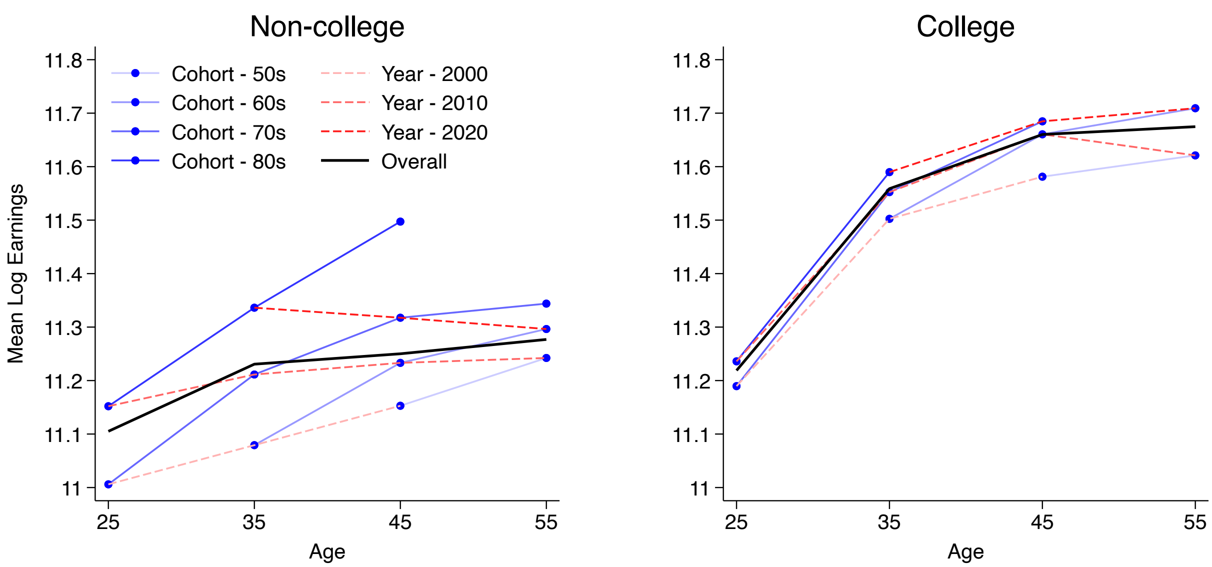


Figure 14: Log earnings by age, cohort, and time

*Notes:* Data from HILDA Waves 1-20, all male full-time workers aged 25-55. Each dot represents a within-group mean for a cohort-age group. The blue solid lines connect all dots for the same cohort group. The red dashed lines connect all dots with the same average calendar year of observation. The "overall" line represents within-group average not controlling for time or cohort. "College" includes individuals with at least a 2-year diploma degree.