The Distributional Effects of Student Debt Forgiveness in General Equilibrium: the Role of Housing

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Abstract

This paper studies the redistributional effect of student loan forgiveness by developing a general equilibrium overlapping generations model with both college education and housing choices. After making a college decision in their early 20s, agents face a discrete housing choice each period as well as the standard consumption-saving decision. Using this framework, I examine the response to a one-time student loan forgiveness. I find that general equilibrium plays an important role in amplifying the regressive aspect of the program. As the government finances the policy by raising tax rates, all individuals but the beneficiaries inevitably face welfare loss. Homeowners are partly compensated by the housing market forces. The program increases housing demand by its recipients as they are more likely to buy houses earlier than they would have otherwise. The net result is an increase in housing prices, which partially mitigates the welfare costs of the program for existing homeowners. The worst impacted group is poor high school graduates, who are particularly hurt more by general equilibrium effects through both capital and labor markets.

Keywords Student Loans, General Equilibrium, Housing, Redistribution, Wealth.

JEL classification C61, C63, C68, E21, E65, G51, H31

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1 Introduction

"Public expenditures are made for the primary benefit of the middle classes, and financed with taxes which are borne in considerable part by the poor and rich" - Director's Law-

In August 2022, the Biden-Harris Administration officially announced student loan forgiveness which reduces the size of federal student loans by up to $10,000 for any household whose annual income is less than $125,000. President Biden believes that a post-high school education serves as a ladder to a middle-class life but the rising cost of education deprives the poor of such opportunity.[1] In fact, the recent rise in student loans has attracted much attention from both economists and policymakers.[2] Average education debt (in 2021 dollars) in the United States has rapidly increased above inflation from $23,562 in 2007 to $37,148 in 2020 (Figure 1). Compared to per capita GDP, average student debt is still rising and now accounts for the second largest portion, around 10%, of household debt. Growing debt burdens have led to increased calls for loan forgiveness and, more recently, policies forgiving debt for some borrowers. Additionally, a strand of literature has recently documented that decisions on college education are closely related to those on home purchases.[3] Despite the increasing concerns regarding the costs of higher education and its relation to housing decisions later in life, there exists little quantitative work which exclusively considers the interactions between college and housing decisions.

My goal is to explore the redistributional effect of student loan forgiveness. To begin with, all individuals incur welfare losses as the government finances the policy by raising future tax rates. However, the magnitude differs across individuals. The general equilibrium effects on the housing market play an important role. A one-time capped loan forgiveness benefits existing homeowners.[4] The beneficiaries with existing debt (partly) forgiven can afford to purchase houses earlier and raise the demand for housing. Given the inelastic supply

[1] https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/24/fact-sheet-president-biden-announces-student-loan-relief-for-borrowers-who-need-it-most/

[2] See Looney and Yannelis (2015) and Folch and Mazzone (2022) for concerns addressed by economists. In the political realm, although the Biden-Harris administration is the first to officially announce massive loan forgiveness, the history of loan forgiveness can be dated back to the College Cost Reduction and Access Act of 2007, the last year of President George W. Bush's presidency.

[3] See Bleemer et al. (2014) and Bleemer et al. (2021). After the Great Recession, some surveys revealed that young college graduates consider student debts as the main impediment to other large purchases such as housing and vehicle (Stone et al., 2012; Shadad, 2014). However, some papers including Houle and Berger (2015), Letkiewicz and Heckman (2018), and Scott III and Bloom (2021), using survey data sets such as PSID, SCF, and NLSY97, found little evidence that student debt is the primary cause of delaying large purchases. Only recently, a few papers have started documenting the significant correlation between the size of student debt and college graduates' homeownership rates using administrative data sets (Mezza et al., 2020; Bleemer et al., 2021).

[4] Capped loan forgiveness is a deduction of existing debt up to a certain amount. According to the official announcement, all college graduates with outstanding federal student loans will have the debt forgiven for up to $10,000. This number will be doubled for Pell Grant beneficiaries.

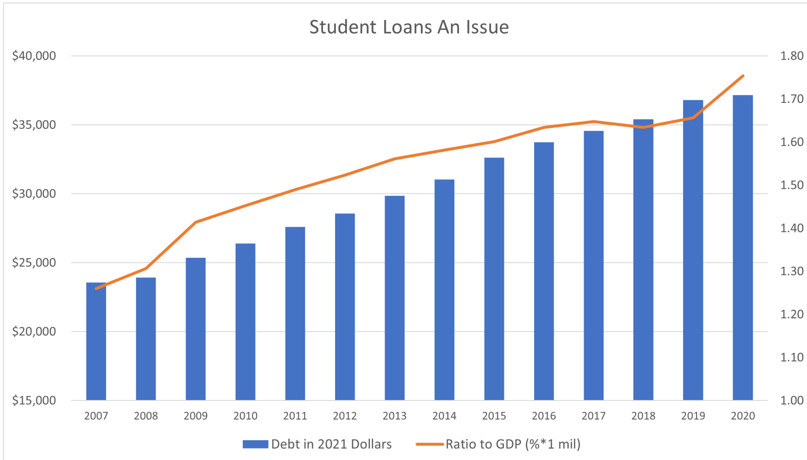

Figure 1: Rising Student Debt

of housing, the rise in the demand leads to the rise in house prices and homeowners are partly compensated for welfare losses due to higher tax rates. My model predicts that the house prices rise by 0.32% above the steady state value.

In addition, general equilibrium effects in both capital and labor markets worsen the welfare losses of the poor. Student loan forgiveness crowds out private investment and capital because the government borrows from the private sector for financing. Furthermore, some individuals change their college decisions as the policy makes higher education more attractive.[5] The effective labor force in the economy increases as more people choose to go to college.[6] Consequently, the aggregate capital-to-labor ratio decreases significantly on impact. The poor suffer welfare losses due to its large deviation from the stationary economy. First, assets become more important than the individual labor productivity as interest rates rise and wages fall. Second, the resulting fluctuation of aggregate variables is critical to the poor as they cannot smooth their consumption.[7] My model predicts that the annualized interest rate rises by 0.45%p and that the annual wage falls by 0.3% compared to the steady state values.

To assess the policy, I first build a general equilibrium overlapping generations model with both higher education and housing. An individual enters the model when he/she reaches

[5]The policy was first discussed during the presidential race in 2019. Based on the official announcement of the Biden-Harris Administration in August 2022, the policy will be effective no later than March 2023. Matriculations take place every year and the discussion of the policy may have changed the college decisions of some populations.

[6]Due to higher aggregate education level, people earn more income and save more but this increase of the aggregate capital is second-order. The decrease in the aggregate capital due to government financing and the increase of the aggregate labor due to the policy still are dominant.

[7]This result depends on the high elasticity of substitution between skilled and unskilled labor. Although the conventional value would be 1.5, Bils et al. (2022) argued the value can be high as nearly 4.

working age.[8] Individuals are exposed to uninsurable income risks. Based on their starting wealth, labor productivity, and the opportunity cost of college education, the entering individual makes a college decision by comparing the benefit of an enhanced future income stream and the cost of tuition fees. This benefit is larger for higher-productivity agents as the effect of a college education is multiplicative. In each period thereafter, an agent makes a consumption-saving decision along with a discrete housing choice based on their wealth, labor productivity, education level, homeownership state, and any mortgage. A housing transaction requires both a downpayment and a debt-to-income restriction to be satisfied. That is, both the current asset position and income level determine the availability of home purchases.

The distinctive feature of the model is that it clears the housing market as well as assets, labor, and goods markets. That is, housing price, interest rate, and wage are determined endogenously. This allows me to analyze the general equilibrium effects of government policies. Another notable feature is that agents' problems induce a non-convexity as housing is a discrete choice. I utilize the generalized endogenous grid method (GEGM) from Fella (2014) to exploit the fast speed of the endogenous grid method (EGM) of Carroll (2006) and solve for the non-concave value functions.

Starting from the stationary equilibrium, I examine the economic response following a one-time capped student loan forgiveness. Up to \$10,000 is eliminated from existing student loans for college graduates with positive debt. The government finances the policy by raising future tax rates. The policy is redistributive. Aggregate consumption-equivalent-welfare (CEW) falls by 0.2%. While all agents suffer welfare losses from the rise in tax rates, welfare gains/losses vary significantly across different types of households by homeownership and wealth; the loss is compensated partly for homeowners by an equilibrium rise in house prices and the welfare losses are the greatest for those near the borrowing constraint.

The model is particularly successful in demonstrating two features. First, agents who already made college decisions tend to buy houses earlier when debt is partly forgiven. The change of behavior effectively raises the demand for housing and the house price as well. In particular, my model predicts that \$10,000 forgiveness will result in a 5.29%p increase in the four-year-later homeownership rate for the benficiaries. Second, agents who are about to make college decisions consider higher education and homeownership as substitutes. The cost of college education significantly falls as it is the first-order impact of the policy. On the other hand, the change in house prices and the resulting service flow from housing is second order. Agents, at the margin, choose college education over homeownership following debt forgiveness.

Although the two effects are countervailing in terms of the demand for housing, the change in college decisions shows a delayed and a more prolonged response. While college graduates whose existing debt has been forgiven purchase houses upon the arrival of the forgiveness,

[8] For simplicity, the model does not consider childhood.

agents whose college decisions have been affected make different housing decisions in subsequent periods. In sum, house prices rise sharply with the arrival of the forgiveness, decline as the college-decision-affected generations pay off their student debt, and fluctuate back to the steady state value. Also, as more agents choose to go to college, effective aggregate labor in the economy expands. A permanent type of an individual is education level, the change of which has a life-long reverberation compared to one-time forgiveness of the already-existing debt. The economy is subject to, once again, a new fluctuation when the cohort affected by the policy dies. That is, the reverberation of the substitutability effect influences the economy throughout a longer period.

This paper is organized as follows. Section 2 summarizes the literature, Section 3 provides an overview of the model, Section 4 explains the computation methods and technical issues, Section 5 calibrates the model to the data, Section 6 presents the main results of the model, Section 7 concludes with takeaways, and Section 8 lists future works.

2 Related Literature

This paper relates to the strand of literature that aims at assessing political influence on income, wealth inequality, and thereby welfare. Benabou (1996) explored the tradeoff between growth cost and benefit of government-driven redistribution. Fernandez and Rogerson (1996) analyzed policies that affect spending on public education in a multi-community model. Particularly, appropriately financed policies to enhance public education in (relatively) poor communities play a large welfare-enhancing role. Guerrieri et al. (2017) documented that geographical segregation accounted for 28% of the rise in income inequality since the 1980s. Durlauf and Seshadri (2018) provided empirical evidence that rising income inequality for the OECD countries can be explained by less intergenerational mobility and, thus, socioeconomic segregation.

More specifically, there is a considerable number of papers analyzing financial aid in higher education and its effectiveness on the educational choice of individuals. The seminal paper would be Abbott et al. (2019). Meghir et al. developed a comprehensive model, compared different financial aid policies, explored the role of parental transfer in assessing the policies, and concluded that the current ability-based grant is superior to other measures. Gordon and Hedlund (2016) documented the recent trend of rising tuition fees and college premiums. Lucca et al. (2019) shed light on the role of expanding credit supply on education choices.

On the other hand, another strand of literature developed a general equilibrium model of housing. The seminal paper, Favilukis et al. (2017) studied the impact of financial constraint on housing boom using the general equilibrium analysis. They incorporated a realistic wealth distribution driven by bequest heterogeneity in preferences which is also in my model abridgedly. Campbell and Hercowitz (2005), Eggertsson and Krugman (2012), Kiyotaki et al.

(2011), Rognlie et al. (2018), Greenwald and Guren (2021) all provided tractable macro housing model with general equilibrium effects of housing prices.

As this paper incorporates both the education choices to housing decisions, one key component that it relies on is the relationship between housing and college decisions. After the Great Recession, Stone et al. (2012) and Shadad (2014) surveyed a wide range of respondents and found that young college graduates recognize student debts as a leading impediment to other large purchases, such as houses and cars. However, subsequent papers were cautious in fully supporting the argument. Among them, Houle and Berger (2015), using the National Longitudinal Survey of Youth 1997, cited debtor-to-non-debtor comparison as being the dominant factor deriving the association of student debt and homeownership which is modest in size. Only recently, a few papers confirmed the widely held belief using the administrative data set. Mezza et al. (2020) reported that \$1,000 increase in student loan debt lowers the homeownership rate by 1.8 percentage points for public 4-year college-goers during their mid-20s. Also, Bleemer et al. (2021) found out that \$5,707 increase in student debt could account for a 3.84 percentage point out of the 7.74 percentage point decrease in the four-year-later homeownership rate.

To my best knowledge, the closest papers are Folch and Mazzone (2022) and Catherine and Yannelis (2020). Folch and Mazzone (2022) developed a partial equilibrium model to argue that higher education and homeownership are considered substitutes.[9] This feature is also shown in my model. Catherine and Yannelis (2020) also evaluated the loan forgiveness and concluded the policy may be regressive but in a different context. They utilized the SCF data to find that poor college graduates tend to not pay off all their debt and argued that the policy would endow less than the face value of the remaining debt for the poor.

3 Model

In this section, I build a quantitative model to study the effect of student loan forgiveness. Time runs forever. A unit measure of each generation appears in my model after working age. An agent is heterogeneous in wealth (k), labor productivity (l), and the opportunity cost of college education ($\bar{c}$). An individual makes a college decision once entering the economy. Each generation lives for 6 periods. An agent may choose to buy or sell a house whenever possible. The diagram for this timeline appears in Figure 2.

[9]There, higher education refers to beyond undergraduate level, such as Masters or Ph.D. level.

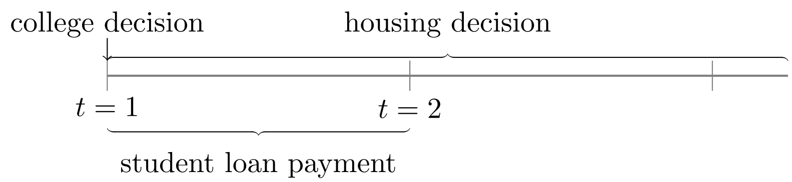

Figure 2: Timeline

3.1 Environment

Preferences. Utility before working age is not considered. Each agent maximizes expected lifetime CRRA utility over composite consumption (x) which consists of both non-durable consumption (c) and service flow from housing (s). That is,

$$u(c, s) = \frac{x^{1-\sigma}}{1-\sigma} \tag{1}$$

where $x = c^{\zeta} s^{1-\zeta}$ and σ is the relative risk aversion parameter. ζ is the weight on non-durable consumption compared to the service flow. The homeownership state is binary, either renting or owning homes, $s \in \{s_r, s_o\}$, $s_r < s_o$.

Income. Individuals earn both labor and asset income. An individual supplies labor inelastically and earns stochastic labor income. Labor productivity evolves exogenously according to a Markov process. Education level then has a multiplicative effect on labor productivity. In sum, labor earnings become

$$\tilde{w}_t(l_t; e) = w l_t e. \tag{2}$$

Notice that l_t together with $e \in \{e_C, e_H\}$ features the efficiency unit of labor. w is the market wage. The labor income alone is taxed at the rate, τ.

Next, individuals save in liquid assets (a). Asset income is the interest payment of the assets (ra). Borrowing on liquid assets is not allowed.

Student Debt. Agents make irreversible college decisions after they enter the economy. Higher education is not time-consuming. Any college entrant immediately graduates and begins working as a college graduate. All students borrow from a (competitive) financial firm to pay the tuition fees (d_0) and the amount is refinanced at graduation. The borrowing rate is the same as the market saving rate. The equation for fixed student loan repayment (P_τ) over the first two periods looks as follows:

$$\left(1 + \frac{1}{1+r}\right) P_\tau = d_0. \tag{3}$$

The left-hand side of the equation is the present value at $t = 1$ of the repayments. Recall that r is the market rate for saving in liquid assets. The student borrower is indifferent between paying the full amount at $t = 1$ and borrowing to pay for the tuition fees.

Mortgage. Housing is identical, the unit is one, and is indivisible. An agent owns at most one house only for residential purposes. Transactions regarding houses are feasible at any period. Particularly, an agent could buy a house so long as 1) he/she pays for the down payment and 2) the debt-to-income ratio is below the restriction level. In addition, selling is possible at any time as cash transfer always exceeds the remaining mortgage balance. The transaction cost (κP_0) of selling is imposed on the selling side for simplicity.

The borrowing rate is again the same as the saving rate such that the three-period repayment plan is actuarially fair. An agent pays the down payment as well as the first-period mortgage repayment (at t). During the next two periods ($t+1, t+2$), the agent continues repaying the mortgage. The equation for fixed repayment of mortgage (P_λ) looks as follows:

$$\lambda P_0 + \big(1 + \frac{1}{1+r} + (\frac{1}{1+r})^2\big) P_\lambda = P_0. \tag{4}$$

P_0 is the market house price and λ is the down payment rate. The left-hand side of the equation is the present value of all payments whereas the right-hand side is the price of the house. The equation boils down to the following:

$$P_\lambda = \frac{r(1+r)^2}{(1+r)^3 - 1}(1-\lambda)P_0.$$

Any remaining mortgage carries over following a law of motion below.

$$m' = (m - P_\lambda)(1+r). \tag{5}$$

m is the mortgage balance at the beginning of the period. The prime notation denotes the next period. Once the repayment is deducted from the mortgage in the current period, the balance will grow at the borrowing rate which becomes the mortgage balance for the next period.

3.2 Household Problem

An agent enters each period with five state variables: savings in liquid assets (a) , the realized individual labor productivity (l) , mortgage carry-over (m), homeownership state (h), and education parameter (e). A value function at t looks as follows:

$$V_t(a, l, m, h; e).$$

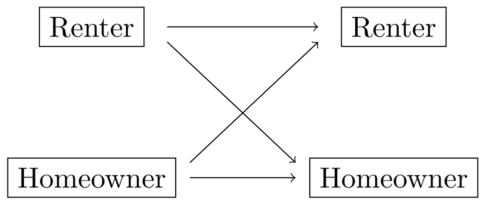

Figure 3: Endogenous Decision on Homeownership

$h \in \{h_r, h_o\}$ is binary where h_r is renter and h_o is homeowner. The education parameter is also binary, $e \in \{e_C, e_H\}$, $e_C > e_H > 0$. The education parameter is separated by a semicolon to illustrate that it is a permanent component.

3.2.1 College Decision

Any generation entering the economy faces a college decision. Higher education is not time-consuming but instead incurs output cost ($\bar{c}$). An agent will go to college if and only if

$$V_1(a - \bar{c}, l, m, h_r; e_C) > V_1(a, l, m, h_r; e_H) \tag{6}$$

The left-hand side of the equation is the value when attending college and the right-hand side is the value when not attending college. Notice that all agents are born with no house, i.e. $h = h_r$.

3.2.2 Housing Decision

At the beginning of each period, an agent faces a discrete choice, whether to become a renter or a homeowner. Given the state variables, he/she compares the value of being a renter, V^r, and that of being a homeowner, V^o. That is,

$$V_t(a, l, m, h; e) = \max\Big\{V_t^r(a, l, m, h; e), V_t^o(a, l, m, h; e)\Big\}. \tag{7}$$

Below I define four (2 × 2) different household problems based on both 1) the state of homeownership when entering the period and 2) the choice of homeownership during the period.

1. *A renter becomes a renter again ($h = h_r, h' = h_r$)*

   Should an agent remains as a renter, the value is

$$V_t^r(a, l, m, h_r; e) = \max_{c, a'}\Big\{u(c, s_r) + \beta E\big[V_{t+1}(a', l', m', h_r; e)|l\big]\Big\} \tag{8}$$

subject to

$$\begin{aligned} c + a' + \bar{S} &= (1+r)a + (1-\tau)\tilde{w}(l,e) + T + \Pi, \\ m = & m' = 0 \\ a' &\geq 0, \\ c &> 0. \end{aligned}$$

Given that this agent continues to be a renter, she optimizes the value by adjusting the current period's non-durable consumption (c) and the saving (a') for the next period. The current period utility consists of two components, non-durable consumption (c) and amenities from renting ($s = s_r$). In addition, the agent discounts and takes expectation of the future value of starting as a renter in the next period based on the realized labor productivity she observes.

The left-hand side of the budget constraint is the total spending. c is the non-durable consumption and a' is the saving in liquid assets. $\bar{S}$ is the repayment of tuition fees if existent. Formally,

$$\bar{S} = \begin{cases} P_\tau \text{ iff } e = e_C \text{ and } t = 1, 2 \\ 0 \quad \text{otherwise} \end{cases}$$

where $P_\tau = \frac{d_0}{(1+\frac{1}{1+r})}$ from equation 3.

The right-hand side of the budget constraint characterizes the cash-on-hand. The first term is the carry-over of assets from the previous period. The second term is labor income minus taxation. The third term is a lump-sum transfer from the government. Lastly, Π is, the redistribution from the deceased who die with houses in the prevcious period. Some agents choose not to sell their houses at the last period because they favor more the service flow from homeownership compared to the cash transfer from selling. To close the economy, such houses are retrieved by the government and the revenue associated with it will be distributed among all households the following period. This term will be later formally stated when introducing the government.

2. *A renter buys a house ($h = h_r, h' = h_o$)*

The agent can also buy a house. The value of buying a house is

$$V_t^o(a, l, m, h_r; e) = \max_{c,a'} \left\{ u(c, s_o) + \beta E\big[V_{t+1}(a', l', m', h_o; e)|l\big] \right\} \tag{9}$$

subject to

$$c + a' + (\lambda P_0 + P_\lambda) + \bar{S} = (1+r)a + (1-\tau)\tilde{w}(l,e) + T + \Pi$$

$$
\begin{aligned}
\psi &> \frac{\bar{S} + \lambda P_0 + P_\lambda}{(1-\tau)\tilde{w}} \text{ (DTI condition)} \\
m' &= ((1-\lambda)P_0 - P_\lambda)(1+r) \\
a' &\geq 0 \\
c &> 0.
\end{aligned}
$$

The agent still makes the consumption-saving decision. The transaction of a housing purchase is not time-consuming and she will enjoy the increased amenities ($s = s_o$) from the homeownership in the current period. Also, she takes expectation of future value as a homeowner in the next period given her labor productivity realization.

What changes in the budget constraint is the payment for both the down payment and the mortgage repayment. From equation 4, the mortgage debt repayment is $P_\lambda = \frac{r(1+r)^3(1-\lambda)P_0}{(1+r)^3-1}$. Next, the mortgage, after the payment, grows at the borrowing rate (r).

3. *A homeowner remains homeowner ($h = h_o, h' = h_o$)*

Should the agent continues to be a homeowner, the value is

$$
V_t^o(a, l, m, h_o; e) = \max_{c,a'} \left\{ u(c, s_o) + \beta E\big[V_{t+1}(a', l', m', h_o; e)|l\big] \right\} \tag{10}
$$

subject to

$$
\begin{aligned}
c + a' + P_\lambda + \bar{S} &= (1+r)a + (1-\tau)\tilde{w}(l, e) + T + \Pi, \\
P_\lambda &= \begin{cases} \frac{r(1+r)^2}{(1+r)^3-1}(1-\lambda)P_0 & \text{if } m > 0, \\ 0 & \text{if } m = 0, \end{cases} \\
m' &= \begin{cases} (1+r_d)(m - P_\lambda) & \text{if } m > 0, \\ 0 & \text{otherwise.} \end{cases}
\end{aligned}
$$

The agent maximizes the sum of current-period utility and the discounted expectation of future value as a homeowner, with the corresponding saving and mortgage. The homeowner will repay only if the remaining mortgage debt exists. Recall that the repayment is fixed and the mortgage balance reaches zero three periods after since the home purchase.

4. *A homeowner sell her house($h = h_o, h' = h_r$)*

Should the agent sells her house and become a renter, the value is

$$
V_t^r(a, l, m, h_o; e) = \max_{c,a'} \left\{ u(c, s_r) + \beta E\big[V_{t+1}(a', l', m', h_r; e)|l\big] \right\} \tag{11}
$$

subject to

$$c + a' + \bar{S} = (1+r)a + (1-\tau)\tilde{w}(l,e) + T + \Pi + \big[(1-\kappa)P_0 - m\big].$$

What is different in the above problem is the cash transfer, $[(1-\kappa)P_0 - m]$, from selling the house. The transaction cost is imposed on the selling side. After paying the transaction cost, the agent first pays off any outstanding mortgage, if existent. The model parametrization does not allow default as an agent is always able to afford the outstanding mortgage if selling the house.

3.3 Firm Problem

3.3.1 Production Firm

The firm has a constant return to scale production technology. That is,

$$Y = AK^{\alpha}L^{1-\alpha}. \tag{12}$$

A is the total factor of productivity, K is the capital, and L is the labor. The prices are determined competitively. That is,

$$[r] : \frac{\partial}{\partial K}\big[Y - rK - \delta K\big] = 0, \tag{13}$$

$$[w] : \frac{\partial}{\partial L}\big[Y - wL\big] = 0. \tag{14}$$

r is the rate of return on capital, δ is the capital depreciation rate, and w is the wage.

3.3.2 Financial Firm

A competitive financial firm operates in the loanable funds market. Households supply loanable funds by saving in liquid assets. On the other hand, the demand comprises two sectors: households and firms. First, households borrow to finance either 1) tuition fees or 2) housing purchases. Next, the production firm borrows to use the loans to buy physical capital. Perfect competition ensures the borrowing rate is identical to the saving rate.

3.4 Government

The government levies a proportionate tax (τ) on labor earnings only. The tax revenue is used to finance government expenditure, G, and lump-sum transfer, T. Government expenditure has no welfare-enhancing role. The government budget is

$$G + T = \tau\bar{Y} \tag{15}$$

where $\bar{Y}$ denotes the aggregate labor earnings.

The government has another role in redistribution. If an agent dies with homeownership, the housing unit is retrieved by the government and sold to a new buyer. The revenue generated by this activity is equally distributed among all households. The transaction cost is deducted. In sum,

$$\Pi = \int_{\{t=6,h'=h_o\}} [(1-\kappa)P_0 - m] d\mu. \tag{16}$$

3.5 Stationary Equilibrium

A steady-state recursive equilibrium is a collection of value functions, $V_t(a, l, e, h, m)$; policy functions, $c(*), a'(*), h(*)$, and $e(a, l, \bar{c})$; measure of households, $\mu(a, l, e, h, m, age)$; the aggregate capital, K; the aggregate labor, L; the house price, P_0; the interest rate, r; and the wage, w; such that

1. Given the set of prices, $\{r, w, P_0\}$, and Π, households solve for equations 8, 9, 10, and 11. This engenders a stationary distribution $\mu(a, l, e, h, m, t)$.

2. $\{r, w\}$ is competitively determined using equations 13 and 14.

3. $\{P_0\}$ clears the housing market.

$$\begin{aligned} S_h = & \int_{\{h=h_r,h'=h_o\}} d\mu(a, l, e, h, m, t) + \int_{\{h=h_o,h'=h_o\}} d\mu(a, l, e, h, m, t) \\ & - \int_{\{h=h_o,h'=h_r\}} d\mu(a, l, e, h, m, t) - \int_{\{t=6,h'=h_o\}} d\mu(a, l, e, h, m, t) \end{aligned}$$

   where S_h is the fixed supply of housing. The first term on the right-hand side is the total number of agents purchasing a home. The second term is the number of agents who continue as a homeowner. The third term is the number of those who sell houses. The last term is the number of agents who die with homeownership.

4. The asset market clears.

$$\begin{aligned} K = & \int a' d\mu(a, l, e, h, m, t) - \int m' d\mu(a, l, e, h, m, t) \\ & - \int d_0 d\mu(a, l, e, h, m, t) + \int P_\tau d\mu(a, l, e, h, m, t) \end{aligned}$$

   The aggregate capital the production firm utilizes is equal to the aggregate saving minus the net amount of loans to households. The second term on the right-hand side is the net loans from home purchases whereas the third and the fourth terms, together, are the net loans from tuition fees.

5. The labor market clears.

$$L = \int led\mu(a, l, e, h, m, t)$$

6. The goods market clears.

$$C + [K' - (1-\delta)K] + G + T + T_h = Y$$

   where C is the aggregate consumption, K is the aggregate capital, G is the government expenditure, T is the lump-sum transfer, T_h is the aggregate transaction cost, and Y is the aggregate output.

7. The government budget balances by equations 15 and 16, and

8. The measure of households is invariant.

3.6 Perfect Foresight Transitional Dynamics

This section describes student loan forgiveness in the model. A one-time loan forgiveness arrives at $t_e = 1$. All agents are informed of the arrival at the beginning of $t_e = 1$ and make decisions accordingly. Particularly, two generations may be the direct beneficiaries of the policy. The first is those who made college decisions in the previous period and came to $t_e = 1$ as Age 2. This generation's college decision would not be affected and the policy merely removes (partly) the existing debt. The second is those who are entering the economy at $t_e = 1$ as Age 1. The policy would impact some of this generation in college decisions. Considering the time interval between the discussion of the policy and the actual effectiveness, one should expect that some high school students would change their college decisions having forgiveness in mind[10]. The loan forgiveness takes place only once and does not arouse any moral hazard concern. The amount is capped. That is, up to \$10,000 will be deducted from the existing debt.

The government has a separate balance sheet for the policy that is different from the balanced budget condition in the stationary equilibrium. First, the government borrows from financial firms to implement student loan forgiveness. Then, the government raises the tax rate by the same amount in $t_e = 1, 2, 3, ..., 6$ to repay the expense. The increment in tax rates is the same for all periods. Additionally, the borrowing rate is the same as the saving rate. In sum, the present value of the expenditure must be equal to the present value of the excess revenue from the increased tax rates.

[10] The policy was first described by President Biden himself during the presidential race in late 2020. Although he did not address the policy until early 2022, President Biden officially announced the loan forgiveness in August. It will be effective in early 2023.

However, the tax revenue in each period may be different as the aggregate variables fluctuate with the loan forgiveness as well. Recall that the government runs a balanced budget in the stationary equilibrium. That is,

$$G + T = \tau \hat{Y}$$

where G is the government expenditure that has no welfare-enhancing role, T is the lump-sum transfer, and the right-hand side is the total government revenue. The value of G and T are fixed. Any excess revenue due to higher tax rates will be paid to the financial firm.

Tuitions and mortgages are refinanced as interest rates fluctuate. The repayment of either tuition fee or mortgage is defined to equate the present value of repayment and the price that needs to be paid. In the perfect foresight transitional dynamics, the stream of interest rates is common knowledge. The repayment accommodates the change in interest rates. Formally,

$$\left(1 + \frac{1}{1 + r_{t_e}}\right) P_\tau = d_0$$

determines the repayment of tuition fees when a college decision is made at t_e and

$$\lambda P_0 + \left(1 + \frac{1}{1 + r_{t_e}} + \frac{1}{(1 + r_{t_e})(1 + r_{t_e+1})}\right) P_\lambda = P_0$$

determines the repayment of a mortgage when a home purchasing decision is made at t_e.

4 Computation

There are two difficulties with the computation. First, the number of state variables makes it computationally heavy. Next, the value function is not strictly concave as agents face discrete (housing) decisions each period. Fella (2014) introduced the generalized endogenous grid method (GEGM) to benefit from the fast speed of the endogenous grid method (See Carroll (2006)) and accommodate non-concavity as well. I computed the value functions using the GEGM. Below is the computational strategy.

4.1 Stationary Equilibrium

Two objects should be cleared by the guess and verify procedure. One is the lump-sum transfer. The lump-sum transfer consists of two components: the standard lump-sum transfer and the transfer from agents dying with a house. Although the former is fixed, the latter is dependent on the distribution and choices of the agents. The guess on the value of the lump-sum transfer should match the the lump-sum transfer resulting from the steady state distribution. The other object is the aggregate capital-to-labor ratio. The constant-return-to-scale firm production ensures that both interest rate and wage are determined from the capital-to-labor ratio. The supply of aggregate capital and labor should be equal to the demand for them.

4.2 Perfect Foresight Transitional Dynamics

Four transitional paths exist: Aggregate capital-to-labor ratio, lump-sum transfer, housing price, and tax rate. The economy converges back to the steady state eventually as the loan forgiveness takes place only once. The implementation is the standard perfect foresight simulation; 1) Iterate backward on value functions of each generation given the transitional paths and 2) compute the evolution of distribution according to the value functions. Four transitional paths of variables exist; they are aggregate capital-to-labor ratio, house prices, tax rate increment, and lump-sum transfer.

5 Parameters

The model frequency is ten-year. However, for ease of exposition, this section presents annual values. Five parameters are chosen internally: tuition fees (d_0), housing price (P_0), distribution of output cost ($\bar{c}$), lump-sum transfer (T), and service flow from homeownership. Exogenous parameters are first introduced. Then, the values of the internal parameters are introduced with calibration target moments, namely college graduation rate, homeownership rate, and the ratio of lump-sum transfer to government revenue.

5.1 Exogenous Parameters

Preferences. The risk aversion parameter, σ, is 2. The annual discount rate, β, is 0.96. The weight on non-durable consumption, ζ, is 0.539.[11]

Labor Income. Labor income consists of three components: market wage (w), individual labor productivity (l_t), and education (e). Market wage is an equilibrium object. The labor productivity follows an AR(1) process in logs. That is,

$$\log(l_{t+1}) = \rho \log(l_t) + \epsilon \tag{17}$$

where $\epsilon \sim N(0, \sigma_\epsilon^2)$. The values of ρ and σ_ϵ are chosen to be 0.973 and 0.17, respectively, following Heathcote et al. (2010). They also estimated the income ratio between skilled and unskilled labor. Although they documented that college premium has risen significantly since

[11] Folch and Mazzone (2022) obtained this value by running the SMM (Nelder-Mead Algorithm).

1970, the premium has remained rather stable after 2010. Their estimation yields 1.9. This paper sets $e_C = 1.6$ and $e_H = 1$.[12]

Housing Transaction. The down payment rate is 20%, which is standard. First homeowners usually face smaller down payment rates because of the relevant policies. However, the housing transaction is not restricted to first homeownership in the model so this paper uses the standard rate. Transaction cost is 7.2% of the housing price.[13]

Tax. The proportionate labor income tax rate is 35% following Folch and Mazzone (2021).

Parameters	Model	Reference	Description	Citation
Preference				
β	0.96		annual discount factor	
σ	2		CRRA coefficient	
ζ	0.539	0.539	weight on non-durable consumption	Folch and Mazzone
Labor				
ρ	0.97	0.973	persistence of labor productivity AR (1)	Heathcote et al.
σ_ϵ	0.17	0.17	transitory component of AR(1)	Heathcote et al.
e_c	1.6	1.9	education parameter	Heathcote et al.
Housing				
λ	0.2		down payment rate	
κ	0.072		selling cost rate	
Tax				
τ	0.35	0.35	proportionate tax rate	Folch and Mazzone

Table 1: Exogenous Parameters

5.2 Calibration

Three moments are targeted: college graduation rate, homeownership rate, and the ratio of lump-sum transfer to tax revenue. First, according to the 2019 survey[14], the college graduation rate out of the whole population is 47.5%. To be precise, the college graduation rate should be larger since the high school graduation rate is only 90%. However, this paper dichotomizes the population into two: one with higher education and the other without. Therefore, calibration targets the number 47.5%. Second, the homeownership rate has fluctuated with the business cycle since the Great Recession. The rate has ranged between 61.5% and 65% until early 2020.

[12] Heathcote et al. (2010) documented that the college premium has risen significantly since 1970. After the publication, they updated the estimation value for college premium and the number remained stable around 1.9. This paper, however, uses a different number which is a ratio between the median labor income of a college graduate and that of a high school graduate in 2019, before Covid-19.

[13] Lee (WP) provided the details for the cost of changing houses. Briefly, a strand of literature has documented the housing transaction cost to be in the range between 7% and 10% (Delcoure et al., 2002; Smith et al., 1988; Martin, 2003).

[14] This is survey data from ThinkImpact (2022)

This paper targets 65.5% which is the 2022 homeownership rate[15]. Third, Hubmer et al. (2021) documented that about 60% of the government revenue is spent on redistribution in the form of lump-sum transfer. Particularly, the model has two components of lump-sum transfer; the first is the standard lump-sum transfer and the second is redistribution from the dying agents with houses. The sum targets the value, of 60%.

Target	**Model**	**Description**	Information
47.5%	40.0%	college graduation rate	ThinkImpact (2019)
65.5%	56.3%	homeownership rate	BankRate (2022)
60%	48%	lump-sum transfer to tax revenue	Hubmer et al.

Table 2: Targeting Moments

Five parameters are chosen internally to match the above three moments: tuition fees, housing price, output cost distribution, lump-sum transfer, and service flow from housing. Values of tuition fees (d_0) and housing prices (P_0) are constant in the stationary equilibrium. Output cost follows an uniform distribution for simplicity (i.e., $\bar{c} \sim U[0, c_h]$). The nature of lump-sum transfer has been introduced in Section 5.2. Lastly, the state of homeownership is binary such that only two values exist for the service flow from housing. The service flow from housing for a renter, s_1, is normalized to 1. That for a homeowner is s_2. In sum, (d_0, P_0, c_h, T, s_2) is a vector of variables that are chosen internally to target the moments.

Parameters	**Model**	**Description**
d_0	7.8	tuition fees
P_0	10.0	house price
$\bar{c}$	$[0, 1.2]$	range of output cost
T	1.2	lump-sum transfer
s_2	1.5	addn'l service flow

Table 3: Internal Parameters

5.3 Equilibrium Objects

There are three equilibrium objects: aggregate capital-to-labor ratio (K/L), housing price (P_0), and transfer from the deceased ($\bar{T}$). In the stationary equilibrium, the aggregate capital-to-labor ratio is 3.765. The annualized interest rate is 6.33% and the ten-year wage is 10.38. Next, the housing price is 10.0. Considering the education parameter (e) is 1.6, the housing price is equivalent to the approximately seven-year wage of a median income earner. Lastly, the transfer from the deceased is 1.04. Together with the conventional lump-sum transfer, the sum is 2.24 which is about 48% of the total government tax revenue.

[15]The number is based on the survey data from Schnabel (2022)

Variables	Value	Description
K/L	3.765	capital-to-labor ratio
r	6.33%	annualized interest rate
w	10.38	10-year wage
P_0	10.0	house price
$\bar{T}$	1.04	transfer from the deceased

Table 4: Equilibrium Objects

6 Main Results

This section examines transitional dynamics using perfect foresight following a student loan forgiveness. First, student loan forgiveness is discussed and designed in the model. Second, the dynamics of aggregate variables are demonstrated. Third, the model successfully replicates two empirical findings of the previous literature; the first is the willingness to buy a first home after paying off student debt and the second is the substitution between higher education and homeownership. Fourth, the section closes by examining the role of the wealth position in welfare gain/loss. In short, the poor loses and the rich does not.

6.1 Policy Design

Any college graduates who have not paid off all of their student debt are eligible for forgiveness. However, considering the nature of the loan forgiveness, one would not merely assume it is deducting existing loans. In fact, the newly entering generation could change its college decision due to the policy. At large, two types are directly affected by the policy. First is those who have already made the college decision and are in the phase of repaying the student debt. The second is those who are about to make college decisions. Formally, the policy arrives at $t_e = 1$ and all agents in the economy react to it at the beginning of $t_e = 1$. That is, the implementation is anticipated. On the impact day, $t_e = 1$, college graduates of the age-2 generation who had made college decisions in the previous period are left with debt. Some portion of the debt will be forgiven due to the policy. In addition, any agent of the age-1 generation, on the impact day, expects that he/she would benefit from the program if attending college.

The loan forgiveness in the model is a capped forgiveness which removes up to \$10,000 of the remaining debt. The beneficiaries are supported by raising lump-sum transfers.[16] Financing of loan forgiveness has a separate balance sheet which is irrelevant to the government

[16] Per capita student loan exceeded a little more than \$38,000 in 2022. The official announcement stated that up to \$10,000 will be deducted from any remaining student debt balance if the beneficiary has an annual income less than \$125,000. The amount of forgiveness doubles for Pell Grant beneficiaries. In the model, total tuition fee is 7.8 which is approximately the five-year-income of a median labor-income earner. Unilaterally, a maximum 2.0 of student loan forgiveness is given to all college graduates with positive student debt.

balanced budget in the stationary equilibrium. The government first borrows from the financial firm to pay for the forgiveness. Then, the government repays by raising tax rates in the first six periods, $t_e = 1, 2, 3, ..., 6$, which is the longevity of a generation. Any excess revenue after spending on the government expenditure (G) and the normal lump-sum transfer (T) will be paid to the financial firm. The present value of the cost of implementation matches the present value of the excess revenue generated by the tax increment.

6.2 Movement of Aggregate Variables

The movement of aggregate capital-to-labor ratio contains much essential information (the upper-left panel of Figure 4). Note that aggregate capital only refers to the capital used by the production firm. The graph plots the percentage deviation from the steady state value over time. The ratio plummets at the beginning because the government borrows a large amount of money from the financial firm. Less capital is available for production. Following the impact day, two factors increase the ratio. First, the government repays for what it spent on the policy. Second, households save more in preparation for higher tax rates in the future. The economy then fluctuates back to the steady state. Market interest rate and wage (upper-right and lower-left panel of Figure 4) are isomorphic to the capital-to-labor ratio movement where the interest rate is in inverse and the wage in proportionate relation.

The lower-right panel of Figure 4 plots each newly entering generation's college graduation rate. For example, age-1 generation at $t_e = 1$ has approximately an 80% college graduation rate.[17] Recall that this generation is the direct beneficiary of the policy. What is interesting is, for $t_e = 3$ and 4, the college graduation rate is below the steady state level, which is 40%. These generations suffer from both low wages and higher taxes. The tuition fees remain the same but the market wage is lower than the steady state value in $t_e = 3, 4, 5$, and 6. A lower market wage decreases the incentive to have higher education.[18] A higher tax rate works similarly as disposable income decreases.

[17] This is an extreme change. The steady state college graduation rate is 40% and it almost doubles due to the policy. This value is sensitive to two parameters: the opportunity cost of college education and the initial distribution of wealth and labor productivity. First, there are five grid points for output cost. A finer grid should make the effect less extreme. Second, this paper assumes a curtailed normal distribution in regard to the initial wealth position. Also, the initial labor productivity is independent of the initial wealth position. A sparser distribution of wealth, which is shown in the Survey of Consumer Finances (SCF), and the positive correlation between wealth and labor productivity would lead to a more realistic college graduation rate. This is left for future work.

[18] This effect will be larger if skilled and unskilled labor are aggregated by the CES aggregator instead of linearly. For simplicity, the model assumes perfect substitutability of skilled and unskilled labor. Bils et al. (?) recently documented that the elasticity of substitution can be as high as 4 which is significantly higher than the conventional value of 1.2.

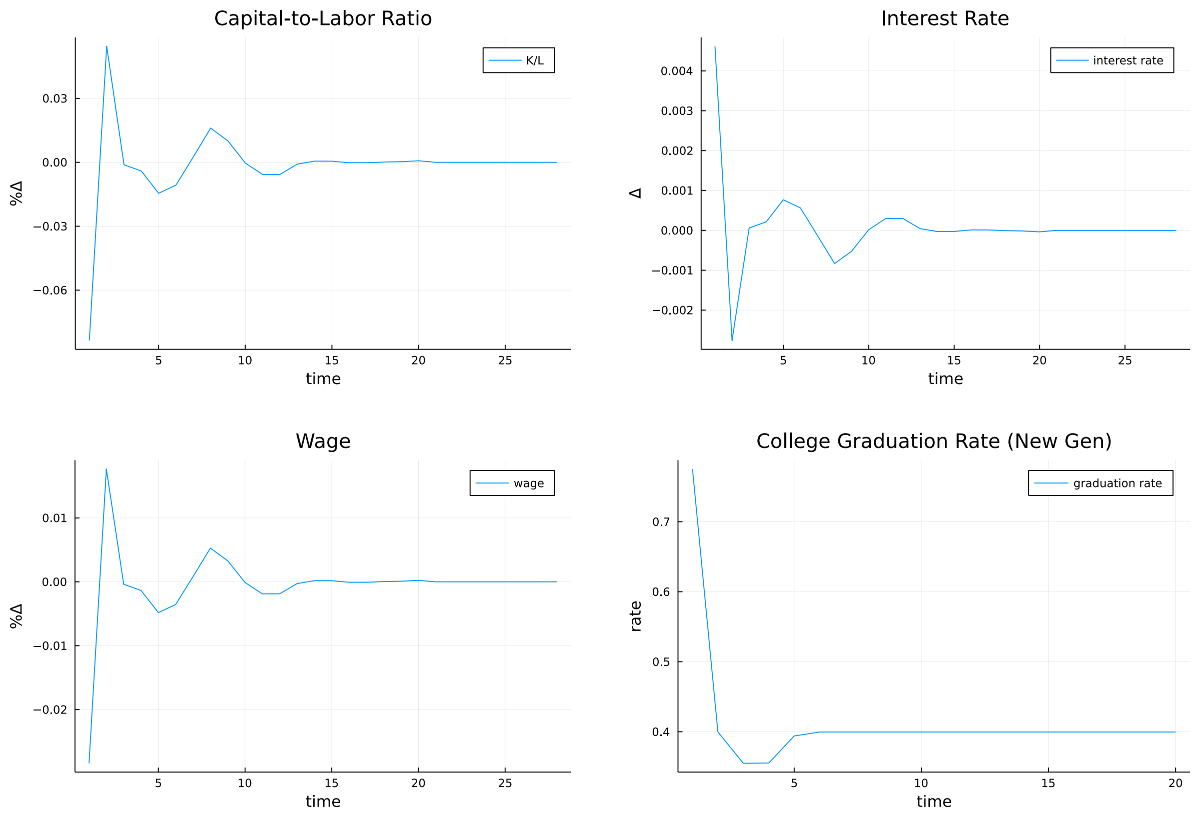

Figure 4: Aggregate Variables

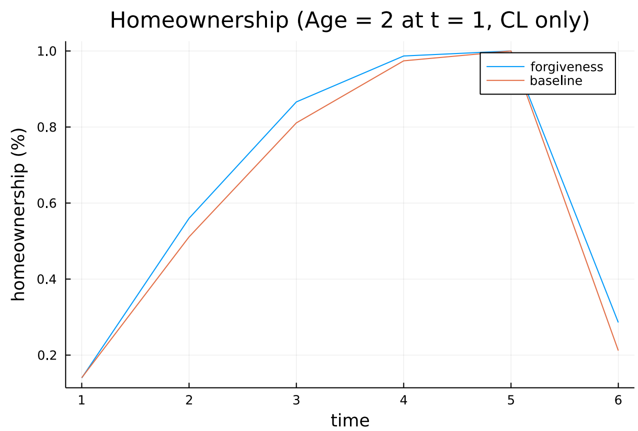

Figure 5: Earlier Homeownership Due to Forgiveness

6.3 Corroborating the Previous Literature

This section explores a couple of the findings documented by previous literature and demonstrates how this model successfully incorporates those empirical findings.

6.3.1 Rising Student Debt and Later Homeownership

Bleemer et al. (2021) documented that rising tuition fees lead to later homeownership after graduation.[19] Using exclusive administrative data, they estimated that per capita student loan increased by \$5,707 from 2003 to 2011 and that the four-year-later homeownership rate for the same sample decreased by 7.74 percentage point. They also concluded that 3.84 percentage point out of 7.74 percentage point could be explained by the rise in student debt.

If rising student debt leads to later homeownership, reducing existing student debt may raise the demand for housing. For this particular experiment, I exclusively look at the homeownership life-cycle of the age-2 college graduates on the impact day (Figure 5). This generation starts from the same homeownership rate at age 1 as it was in the stationary equilibrium. The generation responds immediately on the impact day and the homeownership rate significantly rises. A linear calculation, using numbers from Bleemer et al., yields that a \$10,000 forgiveness will result in a 6.73 percentage point increase in four-year-later homeownership rate. My model predicts a 5.29 percentage point increase.

6.3.2 Substitution of Higher Education and Homeownership

Higher education is a long-term investment at the cost of current consumption and earlier homeownership (Folch and Mazzone, 2022). The substitutability of higher education and

[19] To be more precise, the study explores the relationship between rising tuition fees and the fall in later homeownership. Bleemer et al. used student debt as an instrumental variable to show the correlation.

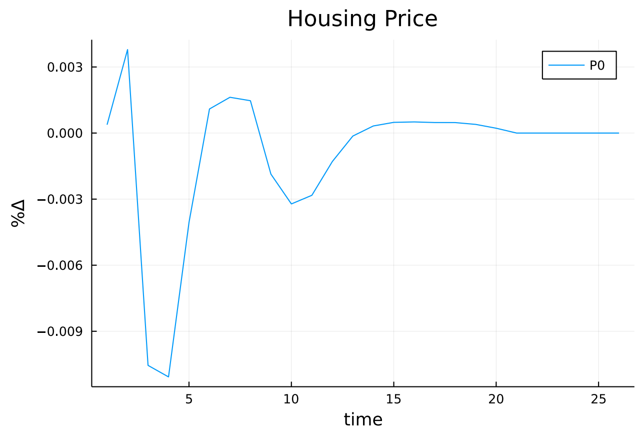

Figure 6: Rising Demand vs. Substitution Effect

earlier homeownership is present in the model. Particularly, for the age-1 generation on the impact day, college education becomes more attractive given the policy. Agents at the margin switch from earlier homeownership to higher education. However, the fall in housing demand is only maximized after 2 periods when the agent accumulates enough wealth to purchase houses. Figure 6 demonstrates the tension between rising housing demand and substitutability. In the beginning phase, the housing price rises as the deduction of the existing debt leads to higher housing demand. This effect dominates the substitutability effect. However, the housing price falls sharply because many agents chose higher education over homeownership.[20]

6.4 The Importance of Wealth Position

Student loan forgiveness inevitably leads to large fluctuations in the economy. The general equilibrium effect impairs the welfare of the poor as consumption smoothing is difficult due to financial friction. Also, the tax rate is higher and disposable income decreases. Figure 7 depicts the consumption-equivalent welfare gain/loss of an age-2 generation on the impact day. Specifically, the left panel is the welfare gain/loss of a median-income college graduate who made college decisions before the policy but receives the benefit. The right panel is the welfare change of a median-income high school graduate. Notice that this generation is not affected by the distributional change (college decision) due to the policy. The x-axis is wealth distribution in quintiles. While all college graduates benefit from the program, the magnitude is significantly higher for the bottom quintile. On the other hand, the bottom quintile of high school graduates suffers the most due to the policy. Although all high school graduates do not benefit from loan forgiveness and bear high tax rates, the welfare loss is large relative to

[20] The substitutability effect at $t_e = 3, 4$ is very large. This happens because the model frequency is ten years. The whole generation, i.e. ten generations in an annual model, changes its college decision due to the policy when, in reality, it can be at most two generations that change.

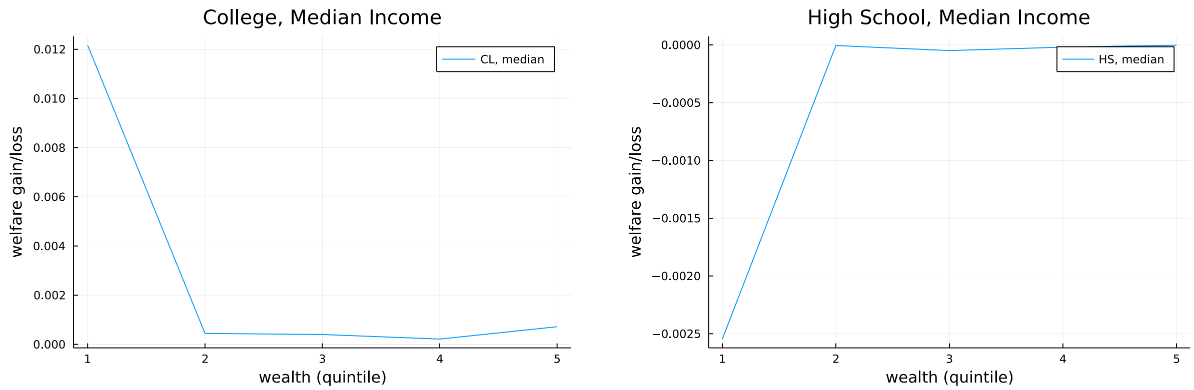

Figure 7: Welfare Gain/Loss in Wealth Distribution (Age 2, Impact Day)

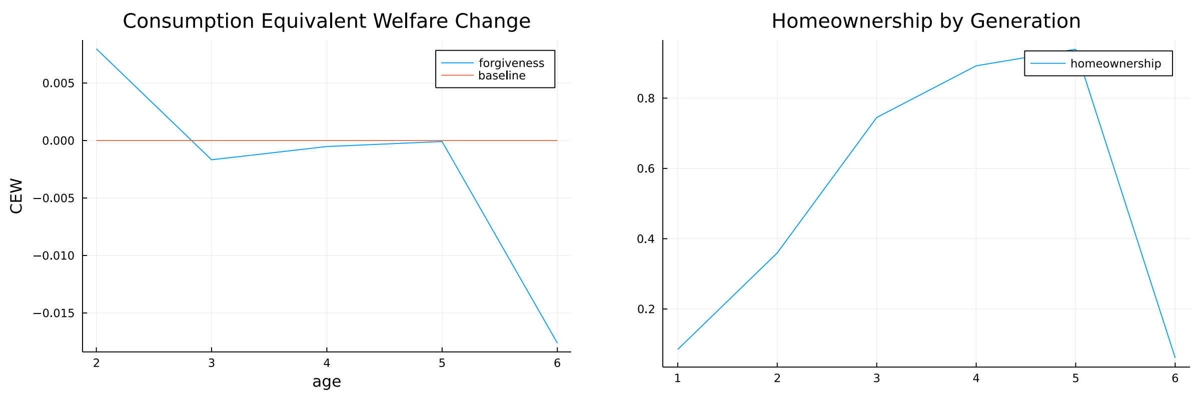

Figure 8: Compensation through Housing Market

other wealth positions. The graph is robust to different labor productivities and this effect is not restricted to mere median-income agents.

The left panel of Figure 8 is the welfare gain of different generations on the impact day. The right panel is the life-cycle homeownership rate in the stationary economy. Combined with the fact that ages 3, 4, and 5 are essentially homeowners, the sharp rise in housing prices (Figure 6) partly offsets the welfare loss due to the policy. The homeowners are relatively rich class. While aggregate fluctuations impair the welfare of the poor class, relatively richer homeowners do not lose because of the general equilibrium effect through the housing market.

7 Concluding Remarks

This paper incorporated housing decision as well as college decision and focused on the interaction between the two. In assessing the redistribution of student loan forgiveness, the housing market plays an important role. Particularly, due to loan forgiveness, homeowners do not lose welfare as much as they would in a model without the housing market. While it is true that some populations benefit by attending college due to the policy, poor high school graduates lose not only because they are not the beneficiary but also because they are vulnerable to the fluctuations of the aggregate variables. In sum, student loan forgiveness is a redistribution that disfavors the poor class.

Next, the model is capable of replicating two features documented in the previous literature. First, only recently, papers have started documenting the significant relationship between student loan and first homeownership. Although common belief has indicated that the repayment of student loans affects the college graduates' housing decision, the effect seemed insignificant in survey data. However, more recent studies using administrative data have significantly confirmed the belief. The correlation between student debt and housing demand is shown in the model. In addition, the model incorporates the substitution of higher education and earlier homeownership. College education is a long-term human capital investment that enhances the future income stream at the cost of current consumption. This behavior is also confirmed in the model.

8 Extensions

This section lists three of the possible future works that enrich the paper.

8.1 Decomposition of General Equilibrium Effects

The role of the housing market in homeowners losing less welfare become clearer when a counterpart model, with no fluctuating housing prices, is run. In addition to fixing the housing price, the model can also eliminate fluctuating relative prices, r and w, to measure the loss of the poor due to aggregate fluctuations.

8.2 CES Aggregator of Skilled and Unskilled Labor

Although a more recent study indicates higher elasticity of skilled and unskilled labor (Bils et al. (WP)), the value conventionally lies at more or less 1.2. Here, the original model is subjected to the introduction of the CES aggregator when aggregating labor and different values are tested for the elasticity. This would change some of the results quantitatively.

8.3 60-period Model with the Simulated Method Moments (SMM)

A sixty-period model is expected to yield a more realistic set of parameters when the SMM is run. The need for an annualized version is imperative because it affects the design of the policy. In the six-period model, college decisions are dhanged in ten-year generations, which is to some extent extreme. The sixty-year model would begin with the initial distribution that is similar to the distribution of wealth for age under 23 in the Survey of Consumer Finances data.

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