Credit, Default, and Optimal Health Insurance

Jang, Youngsoo

Shanghai University of Finance and Economics - Institute for Advanced Research

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Youngsoo Jang†

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Abstract

How do defaults and bankruptcies affect optimal health insurance policy? I answer this question using a life-cycle model of health investment with the option to default on emergency room (ER) bills and financial debts. I calibrate the model for the U.S. economy and compare the optimal health insurance in the baseline economy with that in an economy with no option to default. With no option to default, the optimal health insurance is similar to the health insurance system in the baseline economy. In contrast, with the option to default, the optimal health insurance system (i) expands the eligibility of Medicaid to 22 percent of the working-age population, (ii) replaces 72 percent of employer-based health insurance with a private individual health insurance plus a progressive subsidy, and (iii) reforms the private individual health insurance market by improving coverage rates and preventing price discrimination against people with pre-existing conditions. This result implies that with the option to default, households rely on bankruptcies and defaults on ER bills as implicit health insurance. More redistributive healthcare reforms can improve welfare by reducing the dependence on this implicit health insurance and changing households' medical spending behavior to be more preventative.

JEL classification: E21, H51, I13, K35.

Keywords: Credit, Default, Bankruptcy, Optimal Health Insurance

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†Institute for Advanced Research, Shanghai University of Finance and Economics, No. 111 Wuchuan Road, Shanghai, China 200433. E-mail: jangys724@gmail.com

1 Introduction

This paper studies how defaults and bankruptcies affect optimal health insurance policy. Recently, a growing body of empirical studies has investigated the interactions between health-related events and household finance. Some studies find that healthcare reforms play a role in improving households financial outcomes, such as bankruptcy, delinquency, credit scores, and unpaid debts; others show that bankruptcy and emergency room act as implicit health insurance because households with a lower cost of bankruptcy are reluctant to buy health insurance by relying on these institutional features.[1] These empirical findings have been widely used to support the expansion of health insurance coverage against financial shocks due to health issues. However, there are relatively few structural approaches that examine how defaults and bankruptcies affect the design of optimal health insurance policy. In this paper, I fill this void by using a rich general equilibrium model to characterize the optimal health insurance policy according to whether the option to default is available.

The assessment of health insurance policies is related to several off-setting forces in welfare changes. On the one hand, health insurance improves welfare by mitigating health losses by providing more access to healthcare services due to a decrease in out-of-pocket medical expenses. Additionally, health insurance improves welfare because it reduces bankruptcies and defaults on medical bills by insuring financial risks from medical issues. On the other hand, expanding health insurance coverage can deteriorate welfare because more taxes must be levied in order to be financed. This increase in taxes increases the distortions of saving and labor supply, reducing the average income. General equilibrium effects even amplify this reduction in the average income by boosting the decrease in the aggregate supply of savings. Therefore, these trade-offs must be quantified to characterize optimal health insurance policies.

I undertake my quantitative analysis by building a model on the consumer bankruptcy framework used in Chatterjee, Corbae, Nakajima and Ríos-Rull (2007); Livshits, MacGee and Tertilt (2007) and the health capital framework of Grossman (1972, 2000, 2017). Asset markets are incomplete, and households have the option to default on their medical bills and financial debts. If a debtor defaults on his debt, the debt is eliminated, but his credit history is damaged. This default is recorded in his credit history, which hinders his borrowing in the future. The loan price differs across individual states, as it is determined by individual expected default probabilities. In the spirit of Grossman (1972, 2000, 2017), health capital is a component of individual utility and affects labor productivity and the mortality rate. Moreover, health shocks depreciate the stock of health capital, which results in reduced utility, labor productivity, and survival probability.

[1] Gross and Notowidigdo (2011); Mahoney (2015); Mazumder and Miller (2016); Hu et al. (2018); Miller et al. (2018); Dobkin et al. (2018) are included in this literature. The details will be covered in Related Literature again.

This model extends the standard health capital model in two directions. First, the model considers two types of health shocks: emergency and non-emergency. This setting is chosen to reflect the institutional features of the Emergency Medical Treatment and Labor Act (EMTALA), which is an important channel for defaults on medical bills, as Mahoney (2015) and Dobkin, Finkelstein, Kluender and Notowidigdo (2018) note in their empirical analyses.[2] Second, motivated by the study of Galama and Kapteyn (2011), health capital determines not the level of health but the distributions of these health shocks. Individuals who accumulate a higher level of health capital stock have a lower probability of emergency medical events and severe medical conditions, but all individuals cannot directly buy the optimal level of health. This setting helps to address two well-known criticisms for the model of Grossman (1972). First, the demand for medical and health service is negatively related to health status in the data, but the model of Grossman (1972) predicts that they are positively related, Second, the model of Grossman (1972) tends to exaggerate the degree of the responses of individual medical spending to maintain health over the life-cycle. This modeling strategy makes it possible to deal with these criticisms. Moreover, this set-up allows me to capture the additional preventative medical treatment effects of health insurance policies.

Using micro and macro data, I calibrate two types of models to the U.S. economy: a model with the option to default and a model with no option to default. They perform well in matching life-cycle and cross-sectional moments on income, health insurance, medical expenditures, medical conditions, and emergency room (ER) visits. These models account for salient life-cycle and cross-sectional dimensions of health insurance and health inequality. Furthermore, they reproduce the untargeted interrelationships among income, medical conditions, and ER visits.[3] These strong performances are largely achieved by the extended health capital framework. The model with the option to default is also good at capturing important life-cycle and cross-sectional dimensions of credit and bankruptcy.

To characterize optimal health insurance policies, this paper pays attention to three health insurance policy objects: the threshold of income eligibility for Medicaid, the subsidy rule for the purchase of private individual health insurance, and a reform of the private individual health insurance market that improves its coverage rates up to those of employer-based health insurance and prevents price discrimination against pre-exiting conditions. These policy components are parameterized into three parameters. This setting is so flexible that it can represent not only pre-existing healthcare systems around the world but also alternative healthcare reforms recently proposed in

[2]In the U.S., hospitals can assess the financial status of non-emergency patients before providing non-emergency medical treatment, but they cannot take this financial screening step before providing emergency medical treatments due to regulations in the EMTALA.

[3]Using data from the Medical Expenditure Panel Survey (MEPS), I find that the levels of health risks vary across income groups. Low-income households tend to have more severe medical conditions and to visit emergency rooms more frequently over the life-cycle.Appendix B describes the details of these empirical findings.

the U.S. Based on this flexibility, I characterize the optimal health insurance, which is summarized by a set of these three parameters maximizing a utilitarian welfare function that values the ex-ante lifetime utility of an agent born into the stationary equilibrium. In this setting, I seek the optimal health insurance with the option to default and that without the option to default.

I find that the option to default makes substantial differences in the features of these optimal health insurance policies. In the economy with no option to default, the optimal health insurance policy is close to the health insurance system in the baseline economy. The optimal health insurance policy with no option to default reduces the threshold of income eligibility for Medicaid from 7 percent to 5.5 percent of the average income. This policy provides a progressive subsidy for the purchase of private individual health insurance to households whose income is between 5.5 percent and 10.8 percent of the average income and implements no reform on the private individual health insurance market. In contrast, in the economy with the option to default, the optimal health insurance system is much more redistributive. This optimal health insurance policy provides Medicaid to households whose income is lower than 21.6 percent of the average income. The optimal health insurance offers a progressive subsidy to all households whose income is above the threshold of income eligibility for Medicaid. The optimal policy reforms the private individual health insurance market by improving coverage rates and preventing price discrimination against pre-existing conditions.

To understand the mechanism behind this result, I decompose the welfare changes into a component related to changes in consumption and a component related to changes in health. I find that in the economy with the option to default, changes in health are the main driving force behind the welfare improvement of the optimal health insurance policy, while these changes are not in the optimal policy with no option to default. This gap is driven by different responses of households' medical spending to each of the optimal health insurance policies. In the economy with the option to default, the optimal health insurance policy increases young and low-income households' medical spending, which decreases the overall level and dispersion of health risks and improves health. However, with no option to default, the optimal policy does not bring such large changes in households' medical spending, which leads to smaller changes in health than the optimal health insurance with the option to default does. This disparity is driven not by the difference between the two optimal health insurance policies but by heterogeneous responses of households' medical spending. The optimal health insurance policy for the economy with the option to default does not bring the same overall increases in medical spending over the life-cycle for the economy without the option to default.

This different response of households' medical spending implies that the option to default acts as implicit health insurance, as Mahoney (2015) emphasizes. In the economy with no option to default, households are more cautious in managing their health and spend on healthcare to be more preventative because bad health would otherwise come as a huge financial burden over the life-cycle. Thus, the optimal health insurance policy does not require a radical increase in the degree of redistributiveness for health insurance policies. However, with the option to default, young and low-income households can rely on the option to default to insure against health risks as well as financial risks. Thus, households with the option to default are less eager to manage their health than households without the option to default. The optimal health insurance policy reduces the dependence on this implicit health insurance by providing young and low-income households with more access to healthcare services because the policy decreases the effective prices of health insurance for them. This change increases overall levels of health capital stock for young and low-income households. Because health capital determines the distributions of health shocks, young and low-income households experience a reduction in overall levels of health shocks and improvements in health, thereby enhancing welfare. This finding implies that in economies where bankruptcies and defaults are easily accessible, more redistributive healthcare reforms can improve welfare by reducing the dependence on this implicit health insurance and changing households' medical spending behavior to be more preventative.

Related Literature: This paper belongs to the stream of the model-based quantitative macroeconomic literature that investigates the aggregate and distributional implications of health-related public policies.[4] Motivated by the seminal work of Grossman (1972), many of these studies address health as an investment goods that is affected by the behavior of investing efforts or resources. Among them, my work is the most closely related to three papers: Zhao (2014), Jung and Tran (2016), and Cole, Kim and Krueger (2018). Zhao (2014) studies the impacts of Social Security on aggregate health spending in an endogenous health capital model. He finds that Social Security increases aggregate health spending by reallocating resources to the old whose marginal propensity to spending on health is high. The study of Zhao (2014) has a similarity to my work in the sense that both studies investigate the effect of another type of public policy on health spending, while my work focuses not on the effects of Social Security but on the impacts of defaults and bankruptcies. Jung and Tran (2016) study the implications of the Affordable Care Act in a general equilibrium model with investment in health capital. Although, as my work does, they examine health insurance policies in a health investment model, the focus of my work is different because their model does not address the design of the optimal health insurance policy. Furthermore, they do not examine the effects of bankruptcies and defaults on healthcare spending. Cole, Kim and Krueger (2018) study the trade-off between the short-run benefits of generous health insurance policies and the long-run effects of health investment such as not smoking and exercising. The

[4] Suen et al. (2006); Hall and Jones (2007); Jeske and Kitao (2009); Attanasio, Kitao and Violante (2010); Ales, Hosseini and Jones (2012); Pashchenko and Porapakkarm (2013); Hansen, Hsu and Lee (2014); Yogo (2016); Nakajima and Tüzemen (2017); Zhao (2017); Feng and Zhao (2018) are broadly included in this literature.

modeling strategy they use for health risks is similar to that used in this work, as the distribution of health shocks depends on health status. In addition, their result for the optimal health insurance policy is similar to my work in the sense that providing full insurance is sub-optional. However, Cole, Kim and Krueger (2018) do not pay attention to risk-sharing against health risks through defaults and the accumulation of physical capital, which is formalized in my model.

This paper is in lined with the consumer bankruptcy literature based on quantitative models. In this model, defaults and bankruptcies are based on the modelling setting proposed in Chatterjee, Corbae, Nakajima and Ríos-Rull (2007) in the sense that the loan prices are characterized by individual states, medical expenses represent a primary driver of default, and ex-post defaults exist in general equilibrium. Livshits, MacGee and Tertilt (2007) is also closely related to this paper, as they examine the effects of bankruptcy policies on consumption smoothing across states and over the life-cycle. In both Chatterjee, Corbae, Nakajima and Ríos-Rull (2007) and Livshits, MacGee and Tertilt (2007), medical expenses are an important driving force of defaults, but neither study includes the details of health insurance policies that reshape the distribution of default risks from medical reasons across households. This paper extends these studies by employing the institutional details of health insurance policies with endogenous health into the consumer bankruptcy framework.

This study is linked to a growing stream of the empirical literature addressing the relationship between health-related events and household financial well-being.[5] Among these empirical studies, the most closely related paper is Mahoney (2015). He finds that ER and bankruptcy act as implicit health insurance because individuals with a lower financial cost of bankruptcy are more reluctant to purchase health insurance and make lower out-of-pocket medical payments conditional on the amount of care received. This study incorporates these institutional features in a structural model and finds that they are substantially important in designing the optimal health insurance policy because this implicit health insurance influences households' medical spending behavior.

The remainder of the paper proceeds as follows. Section 2 presents the model, defines the equilibrium, and explains the algorithm for the numerical solution. Section 3 describes the calibration strategy and the performance of the model. Section 4 presents reports the results of the policy analysis. Section 5 concludes this paper.

[5]These empirical studies estimate the effect of adverse health events and healthcare reforms on household financial consequences such as bankruptcy, delinquency, credit scores and unpaid debt. Gross and Notowidigdo (2011) empirically show that Medicaid expansions for children reduced the probability of bankruptcy. Mazumder and Miller (2016) find that the Massachusetts healthcare reform decreased bankruptcy, delinquency and the amount of debt, and it improved credit scores. Hu, Kaestner, Mazumder, Miller and Wong (2018) find that the Medicaid expansions under the Affordable Care Act (ACA) generally improved financial well-being for low-income households. Miller, Hu, Kaestner, Mazumder and Wong (2018) empirically show that the Medicaid expansions under the ACA reduced unpaid bills, medical bills, over-limit credit card spending, delinquencies and public records in Michigan. Dobkin, Finkelstein, Kluender and Notowidigdo (2018) show that hospital admissions reduced earnings, income, access to credit and consumer borrowing, and they increased out-of-pocket medical spending, unpaid medical bills and bankruptcy.

2 Model

2.1 Overview

Many components of this model are employed in the consumer bankruptcy literature (e.g., Chatterjee, Corbae, Nakajima and Ríos-Rull (2007); Livshits, MacGee and Tertilt (2007, 2010); Athreya (2008); Nakajima and Ríos-Rull (2014)) and health capital literature (e.g., Grossman (1972, 2000, 2017); Zhao (2014); Yogo (2016); Jung and Tran (2016)). The consumer bankruptcy framework provides a lens through which I can examine how bankruptcies and defaults interact with health insurance policies. Treating health as endogenous allows me to examine how healthcare reforms reshape the behavior of spending on healthcare over time and across states, which influences the evolution of health over the life-cycle. This relationship arises because compared to older people, for young people, spending on healthcare has more impacts on their health. Moreover, as empirical studies have shown, health affects labor productivity.[6] This relationship implies that considering endogenous health status is also important in analyzing how healthcare reforms influence earnings over the life-cycle.

The model has three distinctive features compared to the literature. First, I distinguish between emergency and non-emergency medical events to reflect institutional features related to the use of emergency rooms, which is an important channel for medical defaults in the U.S. According to the EMTALA, hospitals can assess the financial status of non-emergency patients before providing non-emergency medical treatment, but they cannot take this financial screening step before delivering emergency medical treatments. The cost is huge. Holmes and Madans (2013) show that unpaid debts in emergency departments represent 6% of total hospital costs. In addition, 55% of U.S. emergency care is uncompensated. This institutional feature is captured by separating health shocks into emergency health shocks and non-emergency health shocks.

Second, motivated by Galama and Kapteyn (2011), health capital affects the distribution of health shocks such that when a person has more health capital, he is less likely to experience severe or emergency medical events.Yet all households cannot directly buy the optimal level of health. This setting is helpful to address two criticisms for the model of Grossman (1972). First, the demand for medical and health service is negatively related to health in data, but the model of Grossman (1972) predicts that they are positively related, Second, the model of Grossman (1972) tends to exaggerate the degree of the responses of individual medical spending to maintain health over the life-cycle. As Galama and Kapteyn (2011) note, this modeling strategy allows me to address these criticisms. In addition, the additional preventative medical treatment effects of healthcare reforms must be captured, and interrelations among income, health risks and finan-

[6] Jones (2008) and Currie and Madrian (1999) review empirical evidence on the effect of health shocks on labor outcomes.

cial risks observed in micro data must be explained. Data show that levels of health risks vary across income groups. Low-income households tend to have more severe medical conditions and to visit emergency rooms more often. Data also demonstrate that those who have a record of filing for bankruptcies have lower levels of earnings and worse health status. Appendix B describes the details of these findings.

In the following sections, I describe the details of households, firms, financial intermediaries, hospitals and the government; then, I define the recursive general equilibrium of the model's stationary distribution.

2.2 Households

2.2.1 Household Environments

Demographics: The economy is populated by a continuum of households in J overlapping generations. This is a triennial model. They begin at age J_0 and work. They retire at age J_r, and the maximum survival age is $\bar{J}$. In each period, the survival rate is endogenously determined. The model has exogenous population growth rate n. There are 7 age groups, $j_g : 23-34, 35-46, 47-55, 56-64, 65-76, 77-91$ and $92-100$.

Preferences: Preferences are represented by an isoelastic utility function over an aggregate that is itself a constant elasticity of substitution (CES) function over consumption c and current health status h_c,

$$u(c, h_c) = \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \tag{1}$$

where λ_u is the weight on consumption, v is the elasticity of substitution between consumption c and health status h_c, and σ is the coefficient of relative risk aversion.

Labor Income: Working households at age j receive an idiosyncratic labor income y_j given by

$$\log(y_j) = \log(w) + \log(\bar{\omega_j}) + \phi_h \log(h_c) + \log(\eta) \tag{2}$$
$$\eta^{'} = \rho_\eta \eta + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon)$$

where w is the aggregate market wage, $\bar{\omega_j}$ is a deterministic age term, h_c is the current health status, ϕ_h is the elasticity of labor income y_j to health status h_c and η is an idiosyncratic productivity shock. η follows the above AR-1 process with a persistence of ρ_η and a persistent shock ϵ with a normal distribution.

Health Technology: In the model, health shocks interact with health capital. First, given health capital, I demonstrate how health shocks evolve. Next, I describe how health capital is intertemporally determined.

The model has two types of health shocks: emergency ϵ_e and non-emergency ϵ_n. These two shocks determine current health status h_c in the following way:

$$h_c = (1 - \epsilon_e)(1 - \epsilon_n)h \tag{3}$$

where h_c is the current health status, ϵ_e is an emergency health shock, ϵ_n is a non-emergency health shock, and h is the stock of health capital. Emergency health shocks ϵ_e and non-emergency health shocks ϵ_n depreciate health capital h, and the remaining health capital becomes the current health status h_c. Note that current health status h_c is different from the stock of health capital h.

Let us begin with emergency health shock ϵ_e. Households face emergency health shocks ϵ_e only when they experience an emergency medical event. The probability of emergency medical events is as follows:

$$X_{er} = \begin{cases} 1 & \text{with probability } \frac{(1-h+\kappa_e)}{A_{j_g}} \\ 0 & \text{with probability } 1 - \frac{(1-h+\kappa_e)}{A_{j_g}} \end{cases} \tag{4}$$

where X_{er} is a random variable of emergency medical events, and h is the stock of health capital. Regarding the probability function of emergency medical events, k_e is the scale parameter, and A_{j_g} is the age group effect parameter. k_e controls the average probability of emergency room events, and A_{j_g} influences the difference in probability across age groups. Households experience an emergency medical event $X_{er} = 1$ with probability $(1 - h + \kappa_e)/A_{j_g}$. This equation implies that health capital h determines the probability of emergency medical events.[7] When a household has more health capital, it is less likely to experience emergency medical events.

Conditional on an emergency medical event, $X_{er} = 1$, emergency health shocks ϵ_e evolve as follows:

$$\epsilon_e = \begin{cases} \epsilon_{se} & \text{with probability } p_{se} \text{ conditional on } X_{er} = 1 \\ \epsilon_{ne} & \text{with probability } 1 - p_{se} \text{ conditional on } X_{er} = 1 \end{cases} \tag{5}$$

where

$$0 < \epsilon_{ne} < \epsilon_{se} < 1 \quad \text{and} \quad 0 < m_e(\epsilon_{ne}) < m_e(\epsilon_{se})$$

[7] For example, let us assume that $A_{j_g} = 1$ and $k_e = 0$, and I compare two households: household A with $h = 0.5$ and household B with $h = 0.8$. Then, the probability of emergency medical events for household A is 0.5, while that for household B is 0.8.

where (ϵ_{ne}) ϵ_{se} is a (non-) severe emergency health shock, p_{se} is the probability of the realization of a severe emergency health shock ϵ_{se} and $(m_e(\epsilon_{ne}))$ $m_e(\epsilon_{se})$ is the medical cost of a (non-) severe emergency medical shock. A severe emergency health shock is larger than a non-severe emergency health shock. As examples of severe emergency health shocks, one might consider ER events such as car accidents and gunshot wounds. Non-severe emergency health shocks imply less serious ER events such as allergies or pink eye. These emergency health shocks incur emergency medical costs $m_e(\cdot)$. Note that emergency medical costs $m_e(\dot{)}$ are not a choice variable; rather they are a function of emergency health shock $\epsilon \in \{\epsilon_{ne}, \epsilon_{de}\}$. Severe emergency health shocks incur higher medical costs than non-emergency health shocks, $m_e(\epsilon_{ne}) < m_e(\epsilon_{se})$.[8]

Non-emergency health shock ϵ_n evolves as follows:

$$\epsilon_n \sim TN\left(\mu = 0, \sigma = \frac{((1/h) - 1 + \kappa_n)^{\alpha_n}}{B_{j_g}}, a = 0, b = 1\right) \tag{6}$$

where $TN(\mu, \sigma, a, b)$ is a truncated normal distribution on bounded interval $[a, b]$, for which the mean and standard deviation of its original normal distribution are μ and σ, respectively. Let us denote σ as the dispersion of the distribution of non-emergency health shocks. The dispersion σ is a function of health capital h with three parameters: κ_n, α_n and B_{j_g}. Regarding the dispersion of the distribution of non-emergency health shocks, κ_n is the scale parameter, α_n is the curvature parameter, and B_{j_g} is the age group effect parameter. k_n controls the overall size of non-emergency health shocks, α_n determines the extent to which differences in health capital affect the level of dispersion σ, and B_{j_g} influences the extent to which the level of dispersion σ differs across age groups.

Health capital determines the distribution of non-emergency health shocks through its dispersion σ. Figure 1 illustrates how health capital determines the distribution of non-emergency health shocks. The horizontal axis indicates the size of non-emergency health shocks, and the vertical axis indicates the value of the probability density function of non-emergency health shocks. Given values of parameters k_n, α_n and B_{j_g}, the dispersion of non-emergency health shocks, $\sigma = \frac{((1/h)-1+\kappa_n)^{\alpha_n}}{B_{j_g}}$, decreases with health capital h. Thus, the probability density function of non-emergency health shocks tends to be concentrated more around 0 if the level of health capital h is high, as the left-hand side graph in Figure 1 shows. This concentration means that those who accumulate a larger stock of health capital are less likely to confront a large non-emergency

[8] Households do not make a decision on the amounts of emergency medical costs, which are determined by the severity of emergency medical events. This setting may appear inconsistent with the data, for example, because either the rich or the poor spend more on emergency room healthcare conditional on visiting an emergency room. However, I find that, using data from the Medical Expenditure Panel Survey (MEPS), the amount charged for emergency room events is unrelated to income levels conditional on visiting an emergency room, which supports the choice of the emergency room setting. These results are presented in Appendix A.

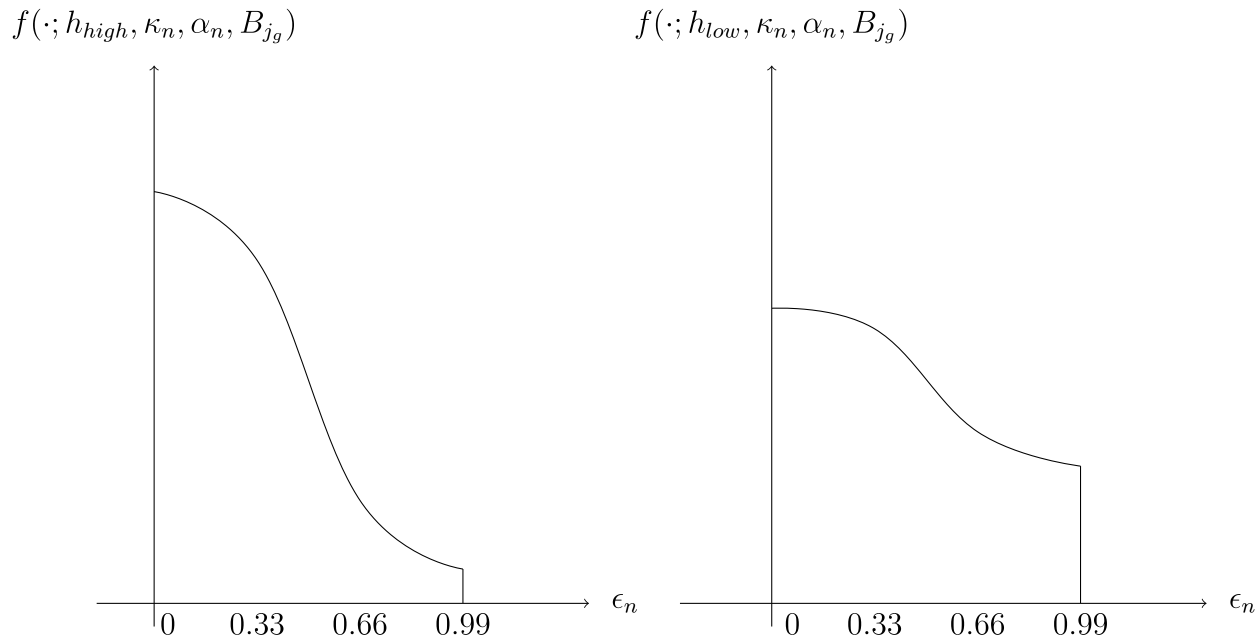


Figure 1: Distribution of Non-emergency Health Shocks across Levels of Health Capital $(h_{high} > h_{low})$

health shock. On the other hand, if a household has a low stock of health capital, the dispersion of the distribution of non-emergency health shocks is high, as the right-hand side graph in Figure 1 shows. This dispersion means that this agent is more likely to face a substantial non-emergency health shock.

To model health technology, I modify the health capital model of Grossman (1972, 2000, 2017). In the spirit of his work, health capital evolves as follows:

$$h^{'} = h_c + \psi_{j_g} m_n^{\varphi_{j_g}} = (1 - \epsilon_e)(1 - \epsilon_n)h + \psi_{j_g} m_n^{\varphi_{j_g}} \tag{7}$$

where $h^{'}$ is the stock of health capital in the next period, h_c is the current health status, ϵ_e represents emergency health shocks, ϵ_n represents non-emergency health shocks, h is the stock of health capital in the current period, ψ_{j_g} is the efficiency of non-emergency health technology for age group j_g, and φ_{j_g} is the curvature of the non-emergency medical expenditure function. Households invest in health capital through non-emergency medical expenditures m_n. Then, households' total medical expenditures m are given by

$$m = m_n + m_e(\epsilon) \tag{8}$$

where m_n and $m_e(\epsilon_e)$ are non-emergency and emergency medical expenditures, respectively.

This health technology differs in two key ways from that in other health capital models. First, the stock of health capital h is different from the current health status $h_c = (1 - \epsilon_n)(1 - \epsilon_e)$. Although the stock of health capital h determines the distributions of emergency and non-emergency health shocks, households cannot directly buy perfect health, as a full level of health capital does not guarantee no health shock. This phenomenon prevents rich and old households from always maintaining the best health status. Second, emergency and non-emergency medical expenditures differ in their features and roles. Non-emergency medical expenditure m_n is discretionary because it is a choice variable. However, emergency medical expenditures $m_e(\cdot)$ are non-discretionary as they are given by emergency health shocks ϵ_e. Moreover, only non-emergency medical expenditures m_n play a role in accumulating the stock of health capital in the next period, $h^{'}$. Emergency medical costs $m_e(\cdot)$ do not affect the accumulation of health capital. This choice reflects that the recovery after emergency medical treatments depends on non-emergency medical treatments. If a poor household faces an emergency health shock, it will receive emergency medical treatments regardless of whether it can pay due to the EMTALA. However, such patients may not obtain sufficient recovery treatments due to their tight budget constraints, as recovery treatments are included in non-emergency medical treatments. Thus, this insufficient recovery treatments induce a low level of health capital the low-income household has. Recall that health capital h determines two objects: the distribution of emergency medical events X_{er} and the distribution of non-emergency health shocks $TN(0, \sigma = \frac{((1/h)-1+\kappa_n)^{\alpha_n}}{B_{jg}}, 0, 1)$.

Survival Probability: A Household's survival probability is given by

$$\pi_{j+1|j}(h_c, j_g) = 1 - \Gamma_{j_g} \cdot \exp\left(-\nu h_c\right) \tag{9}$$

where $\pi_{j+1|j}(h^{'}, j_g)$ is the survival probability of living up to age $j+1$ conditional on surviving at age j in age group j_g with current health status h_c, Γ_{j_g} is the age group effect parameter of the survival probability, and ν is the curvature of the survival probability with respect to current health status h_c. The age group effect parameter of the survival probability Γ_{j_g} controls overall age effects up to death. Older age groups have a higher value of Γ_{j_g}. The curvature parameter of the survival probability ν captures differences in households' survival rate by current health status h_c.

Health Insurance: The health insurance plans in the benchmark model resemble those in the U.S.

For working-age households, the choice set of health insurance plans is given by

$$i \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0 \end{cases} \tag{10}$$

where i is health insurance status, NHI indicates no health insurance, MCD is Medicaid, IHI is private individual health insurance, EHI is employer-based health insurance, y is individual income, $\bar{y}$ is the income threshold for Medicaid eligibility, and ω is the offer of employer-based health insurance.

Medicaid MCD is available only for low-income working-age households. Thus, if a household's income is below the income threshold for Medicaid eligibility $\bar{y}$, it can take Medicaid. Otherwise, Medicaid MCD is not available as an insurance choice. Individual private health insurance IHI is available to every working-age household. Households do not have any requirement to buy it.

Employer-based health insurance EHI is available only to those who have an offer ω from their employers. Jeske and Kitao (2009) show that the offer rate of employer-based health insurance EHI tends to be higher in high-salary jobs. Thus, I assume that the offer of employer-based health insurance EHI is randomly determined, and the probability of an offer of employer-based health insurance increases with households' persistent component of idiosyncratic labor productivity shock η. Explicitly, the likelihood of an offer of employer-based health insurance EHI is given by $p(EHI|\eta)$, where η is the persistent component of the idiosyncratic shock to earnings. Following Jeske and Kitao (2009), the offer probability $p(EHI|\eta)$ increases with η.

The price of private health insurance is given by

$$p_{i'}(h_c, j_g) = \begin{cases} 0 & \text{if } i' = NHI \text{ or } i' = MCD \\ p_{IHI}(h_c, j_g) & \text{if } i' = IHI \\ p_{EHI} & \text{if } i' = EHI \end{cases} \tag{11}$$

where $p_{i'}(\cdot,\cdot)$ is a premium for health insurance i' for the next period, h_c is the current health status, and j_g is the age group. $p_{IHI}(h_c, j_g)$ is the health insurance premium of private individual health insurance IHI for an insured individual whose health status is h_c within age group j_g, and p_{EHI} is the premium for employer-based health insurance.

Individual private health insurance IHI and employer-based health insurance EHI differ in the price system. Individual health insurance has premiums $p_{IHI}(h_c, j_g)$, where h_c and j_g are the current health status and age group, respectively. This setting is based on the individual private health insurance market in the U.S. before the Affordable Care Act (ACA). Individual private health insurance providers are allowed to differentiate prices by considering customers' pre-existing conditions, age and smoking status. Contrary to the separating equilibrium of individual health insurance IHI, employer-based health insurance EHI has a single premium p_{EHI}. This price is independent of any individual state, which reflects that in the U.S., the providers of employer-based health insurance cannot discriminate against employees based on their pre-existing conditions due to the Health Insurance Portability and Accountability Act (HIPAA). In addition, a fraction $\psi_{EHI} \in (0, 1)$ of the premium p_{EHI} is covered by employers, so insurance holders pay $(1 - \psi_{EHI}) \cdot p_{EHI}$.

All health insurance plans provide coverage $q_i \cdot m$, and $(1 - q_i)m$ becomes an out-of-pocket medical expenditure for an insured household. For example, for Medicaid holders, Medicaid MCD covers $q_{MCD} \cdot m$, and $(1 - q_{MCD}) \cdot m$ represents their out-of-pocket medical expenditures.

Retired households use Medicare. Medicare is public health insurance for elderly households. I assume that all retired households use Medicare and do not access the private health insurance market.

Default: The model has two types of default based on the source of debt: financial default and non-financial default. Following Chatterjee, Corbae, Nakajima and Ríos-Rull (2007), Livshits, MacGee and Tertilt (2007) and Nakajima and Ríos-Rull (2014), financial default is modeled to capture the procedures and consequences of Chapter 7 bankruptcy.[9] Non-financial default is modeled to reflect the features of the EMTALA.

Households have either a good credit history or a bad credit history. Good credit history means that the credit record has no bankruptcy. Bad credit history implies that the household's credit record has a bankruptcy. The type of credit history determines the range of feasible actions of households in the financial markets.

Households with a good credit history can either save or borrow through unsecured debt. They can default on both financial and medical debts by filing for bankruptcy. In the period when filing for bankruptcy, these households can neither save nor dis-save. They have a bad credit history in the next period. If a household with a good credit history either has no debt or repays its unsecured debt, it preserves its good credit history in the next period.

Households with a bad credit history pay a cost for having a bad credit history that is as much as χ portion of their earnings for each period. Households with a bad credit history can save assets but cannot borrow from financial intermediaries. Because of the absence of financial debt, they do not engage in financial default. However, they can default on emergency medical expenses,

[9] Chapter 7 covers 70 percent of household bankruptcies. The other type of household bankruptcy is Chapter 13, which I do not address here.

as the EMTALA requires hospitals to provide emergency medical treatment to patients on credit regardless of patients' ability to pay the emergency medical costs. In the period when defaulting on emergency medical expenses, these households cannot save, and they preserve the bad credit history in the next period. Unless they default, with an exogenous probability λ, their bad credit history changes to a good credit history in the next period.

Tax System and Government Budget: Taxes are levied from two sources: payroll and income. On the one hand, Social Security and Medicare are financed through payroll tax. τ_{ss} is the payroll tax rate for Social Security, and τ_{med} is that for Medicare. On the other hand, income tax covers government expenditure G, Medicaid q_d and the subsidy for employer-based health insurance ψp_e. I choose the progressive tax function from Gouveia and Strauss (1994), which has been widely used in the macroeconomic policy literature. The income tax function $T(y)$ is given by

$$T(y) = a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y y \tag{12}$$

where y is taxable income. a_0 denotes the upper bound of the progressive tax as income y goes to infinity. a_1 determines the curvature of the progressive tax function, and a_2 is a scale parameter. To use Gouveia and Strauss's (1994) estimation result, I take their estimates in a_0 and a_1. a_2 is calibrated to match a target that is the fraction of total revenues financed by progressive income tax, which is 65 percent (OECD Revenue Statistics 2002). τ_y is chosen to balance the total government budget.

2.2.2 Dynamic Household Problems

Households experience two phases of the life-cycle: working and retirement. For each period, households have either good or bad credit history. Good credit history means that the household has a record for a bankruptcy filing in its recent credit history. Bad credit history implies that the household has no such record. Here, I focus on explaining the choice problem of working-age households with good credit history because their choice problem is so informative as to understand decisions all the other types of households can make. Appendix C describes all types of the dynamic household problems in recursive form.

Figure 2 shows the time-line of events for working-age households with a good credit history. Each period consists of two sub-periods. At the beginning of sub-period 1, assets a, health insurance status i and stock of health capital h are given from the previous period. Then, emergency health shocks ϵ_e, non-emergency health shocks ϵ_n, non-medical expenditure shocks ζ, uninsurable idiosyncratic shocks to the efficient units of labor η and an offer of employer-based health insurance ω are realized. These health shocks affect households' utility, labor productivity and mortality.

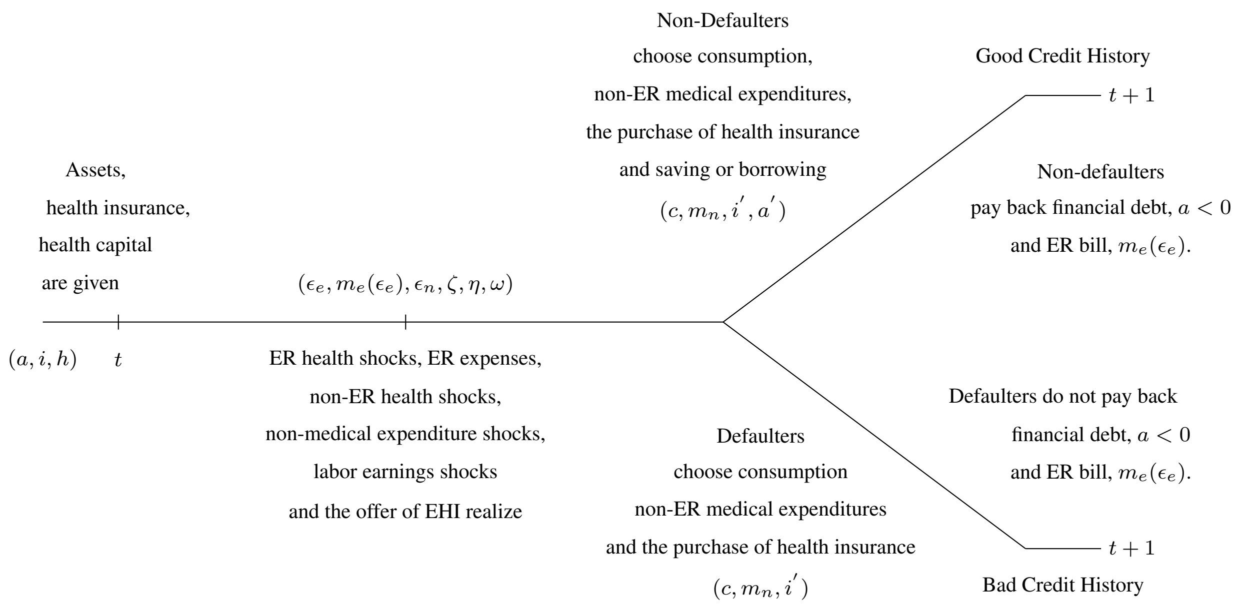


Figure 2: Time-line of Events for Working-age Households with a Good Credit History

Emergency health shocks ϵ_e incur specific sizes of non-discretionary medical costs $m_e(\epsilon_e)$.[10] Let $V_j^G(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$ denote the value of working-age households with a good credit history in sub-period 1. They solve

$$V_j^G(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega) = \max\{v_j^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \zeta, \omega), v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)\} \tag{13}$$

where $v_j^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ is the value of non-defaulting with good credit history and $v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ is the value of defaulting with a good credit history. The defaulting value, $v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$, does not depend on the current assets, a, and non-medical expenditure shocks, ζ, because all debts are eliminated with the default decision.

In sub-period 2, the available choices differ with default decision in sub-period 1. Non-

[10]This setting means that the amount of emergency medical costs is independent of households' income. This setting is supported by evidence in micro data. Using data from the MEPS, I find that, conditional on the use of emergency rooms, the amount of emergency room charges is unrelated to households' income. Further details are presented in Appendix A.

defaulting working-age households with a good credit history at age j in age group j_g solve

$$v_j^{G,N}(a,i,h,\epsilon_e,\epsilon_n,\zeta,\eta,\omega)=\max_{\{c,\,a',\,i',\,m_n\geq 0\}}\frac{\left[\left(\lambda_u c^{\frac{v-1}{v}}+(1-\lambda_u)h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+\beta\pi_{j+1|j}(h_c,j_g)\underset{\epsilon_e'|h',\epsilon_n'|h',\eta'|\eta,\omega'|\eta',\zeta'}{\mathbb{E}}\left[V_{j+1}^{G}(a',i',h',\epsilon_e',\epsilon_n',\zeta',\eta',\omega')\right] \tag{14}$$

such that

$$c+q(a',i',h';j,\eta)a'+p_{i'}(h_c,j_g)$$
$$\leq(1-\tau_{ss}-\tau_{med})\,w\bar{\omega}_j h_c^{\phi_h}\eta+a+\kappa$$
$$-(1-q_i^n)\,m_n-(1-q_i^e)\,m_e(\epsilon_e)-\zeta-T(y)$$

$$\zeta\sim U[0,\bar{\zeta}]$$
$$h'=h_c+\varphi_{j_g}m_n^{\psi_{j_g}}=(1-\epsilon_n)(1-\epsilon_e)h+\varphi_{j_g}m_n^{\psi_{j_g}}$$
$$y=w\omega_j h_c\eta+(\frac{1}{q^{rf}}-1)a\cdot\mathbb{1}_{a>0}$$

the feasible set of health insurance choice i follows (10) , and

the health insurance premium $p_{i'}(h_c,j_g)$ follows (11).

Non-defaulting working-age households with a good credit history make decisions on consumption c, saving or debt a', the purchase of health insurance for the next period i' and non-emergency medical expenditures m_n. They earn labor income $w\bar{\omega}_j h_c^{\phi_h}\eta$ and accidental bequest κ. They pay out-of-pocket medical costs, the amount of which differs based on insurance status. If a household purchased health insurance in the previous period, the insurance company covers a part of its medical expenditure, $q_i^n m_n+q_i^e m_e(\epsilon_e)$ where q_i^n (q_i^e) is the fraction of non-emergency (emergency) medical expenditure health insurance i covers.[11] The rest of the medical expense is the household's out-of-pocket medical expenditure, $(1-q_i^n)\,m_n+(1-q_i^e)\,m_e(\epsilon_e)$. If a household did not purchase health insurance in the previous period, the total medical expenditure is the same as the household's out-of-pocket medical expenditure, $q_i^n=q_i^e=0$. They also pay costs incurred by non-medical expenditure shocks, ζ, which follows a uniform distribution of $U[0,\bar{\zeta}]$. These households pay a progressive tax $T(\cdot)$ based on their income y. They preserve their good credit history to the next period.

[11]The fraction of medical expenses covered by health insurance differs between emergency and non-emergency treatments. According to the MEPS, the coverage rates of health insurances are larger for the case of emergency medical treatments. More details are described in Section 3 (calibration).

Health insurance plays both roles. First, health insurance decreases the marginal cost of investing in health capital by reducing the out-of-pocket medical expenses for non-emergency treatment. Second, health insurance partially insures the risk of emergency medical expense shocks. Since physical capital a can also play the same roles, how the relative price of health capital h to physical capital a changes is a key to determining the allocation of these two types of capital. Health insurance policies alter this relative price. If a health insurance policy subsidizes the purchase of health insurance to poor households, they face a lower relative price of health capital h to physical capital h than rich households and decide to increase their medical spending. This individual change in medical spending behavior results in a reallocation of health h and physical a capital over households.

Defaulting working-age households with a good credit history at age j in age group j_g solve

$$
\begin{aligned}
v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega) = & \max_{\{c,\, i',\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \\
& + \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e^{'}|h^{'}, \epsilon_n^{'}|h^{'}, \eta^{'}|\eta, \omega^{'}|\eta^{'}, \zeta^{'}} \left[V_{j+1}^{B}(0, i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \zeta', \eta^{'}, \omega^{'})\right] \qquad (15) \\
& \text{such that} \\
& c + p_{i'}(h_c, j_g) = (1 - \tau_{ss} - \tau_{med}) w \bar{\omega}_j h_c^{\phi_h} \eta - (1 - q_i^n) m_n - T(y) + \kappa \\
& h_c = (1-\epsilon_n)(1-\epsilon_e) h \\
& h^{'} = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}} \\
& \text{the feasible set of health insurance choice } i \text{ follows (10), and} \\
& \text{the health insurance premium } p_{i'}(h_c, j_g) \text{ follows (11).}
\end{aligned}
$$

Defaulting working-age households with a good credit history make decisions on consumption c, health insurance $i^{'}$ for the next period and non-emergency medical expenditures m_n, but they can neither save nor dis-save in this period, $a^{'} = 0$. As non-defaulting households do, the out-of-pocket medical expenses depend on their health insurance status. However, contrary to the case of non-defaulting households, these households do not repay emergency medical expenses ϵ_e because they have an exemption from them. They also have exemptions from the unsecured financial debt $a < 0$ and costs incurred by non-medical expenditure shocks ζ. The exemptions from those debts are given at the cost of their credit record. Their credit history will become bad in the next period.

A majority of the decision-making problems of working-age households with bad credit history are nearly identical to those of non-default households with good credit history. The problems they face in sub-period 1 are the same as the problems of working-age households with good credit history. In sub-period 2, as non-defaulters with good credit history do, non-defaulters with bad credit choose consumption c, health insurance for the next period $i^{'}$, and non-emergency medical expenditures m_n. They pay out-of-pocket medical costs as working households with good credit history do, $(1-q_i^n)\,m_n + (1-q_i^e)\,m_e(\epsilon_e)$. However, contrary to the case of non-defaulters with a good credit history, non-defaulters with a bad credit history are not allowed to borrow, $a \geq 0$, and pay a pecuniary cost of having a bad credit history equal to some fraction of their earnings, $\xi w \bar{\omega}_j h_c^{\phi_h} \eta$. In addition, their credit history is randomly determined in the next period. Defaulters with bad credit history pay a pecuniary cost of having a bad credit history equal to some fraction of their earnings, $\xi w \bar{\omega}_j h_c^{\phi_h} \eta$. They can neither save nor dis-save, $a^{'} = 0$, and they make decisions on consumption c, health insurance for the next period $i^{'}$ and non-emergency medical expenditures m_n. Defaulters with bad credit history also do not repay emergency medical costs ϵ_e and non-medical expenses ζ, so $(1-q_i^n)m_n$ becomes their out-of-pocket medical cost.[12] They maintain bad credit history in the next period.

It is worthwhile mentioning the difference between filing for bankruptcy and defaulting. The bankruptcy system of this model is to capture the features of the Chapter 7 Bankruptcy in the U.S. Since refilling bankruptcy is not allowed on average for ten years in the U.S., I assume that only those who have a good credit history can file for bankruptcy. However, this does not mean those who have a bad credit history cannot default on debts. Households with a bad credit history are allowed to default on non-financial debts such as ER bills and costs from divorce.

Retired households do not have any labor income but receive Social Security benefits. Borrowing is not allowed for them, $a^{'} \geq 0$. I assume that all retired households have Medicare and do not use any private health insurance. At the beginning of each period, retired households face non-medical expenditure shocks ζ, emergency health shocks ϵ_e, and non-emergency health shocks ϵ_n. They make decisions on consumption c, saving or debt $a^{'}$, and non-emergency medical expenditures m_n. They pay out-of-pocket medical costs, $(1-q_{med}^n)m_n + (1-q_{med}^e)m_e(\epsilon_e)$.

2.3 Firm

The economy has a representative firm. The firm maximizes its profit by solving the following problem:

$$\max_{K,N} \{zF(K,N) - wN - rK\} \tag{16}$$

where z is the total factor productivity (TFP), K is the aggregate capital stock, N is aggregate labor, and r is the capital rental rate.

[12] They do not have any debt via the financial sector, as those with bad credit cannot borrow regardless of their default decision.

2.4 Financial Intermediaries

There are competitive financial intermediaries, and loans are defined by each state. This system implies that with the law of large numbers, ex post-realized profits of lenders are zero for each type of loan. The lenders can observe the state of each borrower, and the price of loans is determined using good credit-status households' default probability and the risk-free interest rate.[13]

Specifically, the default probability of a household with a good credit history G, total debt $a^{'}$, insurance purchase status $i^{'}$, health capital for the next period $h^{'}$, current age j and current idiosyncratic earnings shock η in the next period is given by

$$d(a^{'}, i^{'}, h^{'}; j, \eta) = \sum_{\epsilon_n^{'}, \epsilon_e^{'}, \eta^{'}, \omega^{'}, \zeta^{'}} \pi_{\epsilon_e^{'}|h^{'}} \pi_{\epsilon_n^{'}|h^{'}} \pi_{\eta^{'}|\eta} \pi_{\omega^{'}|\eta^{'}} \pi_{\zeta^{'}} \mathbb{1}_{\{v^{G,N}(a^{'}, i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \omega^{'}, j+1) \leq v^{G,D}(i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \omega^{'}, j+1)\}} \tag{17}$$

where $\pi_{\epsilon_e^{'}|h^{'}}$ is the probability of an emergency health shock $\epsilon_e^{'}$ in the next period conditional on health capital $h^{'}$ for the next period, $\pi_{\epsilon_n^{'}|h^{'}}$ is the probability of a non-emergency health shock ϵ_n in the next period conditional on health capital $h^{'}$ for the next period, $\pi_{\eta^{'}|\eta}$ is the transitional probability of idiosyncratic shocks on earnings $\eta^{'}$ in the next period conditional on the current idiosyncratic shocks on earnings η, and $\pi_{\omega^{'}|\eta^{'}}$ is the probability of the offer of employer-based health insurance in the next period conditional on the idiosyncratic shock to earnings $\eta^{'}$ in the next period.

The zero-profit condition of the financial intermediaries that make a loan of amount $a^{'}$ to households with age j, current idiosyncratic labor productivity η, health capital $h^{'}$ for the next period, and health insurance $i^{'}$ for the next period is given by

$$(1 + r^{rf})\, q(a^{'}, i^{'}, h^{'}; j, \eta)\, a^{'} = (1 - d(a^{'}, i^{'}, h^{'}; j, \eta))\, a^{'} \tag{18}$$

where r^{rf} is the risk-free interest rate and $q(a^{'}, i^{'}, h^{'}; j, \eta)$ is the discount rate of the loan price.[14] Then, the discount rate of the loan price $q(a^{'}, i^{'}, h^{'}; j, \eta)$ is

$$q(a^{'}, i^{'}, h^{'}; j, \eta) = \frac{1 - d(a^{'}, i^{'}, h^{'}; j, \eta)}{1 + r^{rf}}. \tag{19}$$

[13] Note that households with a bad credit history cannot access the financial market.

[14] Financial intermediaries consider both households' health insurance $i^{'}$ and health capital $h^{'}$ for the next period to price loans. This assumption is necessary to solve the model, as no pooling equilibrium exists under symmetric information between lenders and borrowers. Solving default models under asymmetric information is beyond the scope of this paper.

2.5 Hospital

The economy has a representative agent hospital. For convenience, I denote household state s as $(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ and credit history as $v \in \{G, B\}$; the hospital earns the following revenue:

$$m_n(\mathbf{s}, j) + (1 - g_d(\mathbf{s}, j))\, m_e(\epsilon_e) + g_d(\mathbf{s}, j)\ \max(a, 0) \tag{20}$$

where $m_n(\mathbf{s}, j)$ is the decision rule for non-emergency medical expenditures for households of state s at age j. $m_e(\epsilon_e)$ is emergency medical expenses for emergency health shocks ϵ_e, and $g_d(\mathbf{s}, j)$ is the decision rule for defaulting for households of state s at age j. All households always pay non-emergency medical expenditures m_n, regardless of whether they default, as the hospital can assess patients' financial abilities before providing non-emergency medical treatment. However, the payment amount for emergency medical treatments $m_e(\epsilon_e)$ depends on individual default decisions. This is because the EMTALA requires hospitals to provide emergency medical treatment regardless of whether the patients can pay their emergency medical bills. Non-defaulters repay all of their emergency medical expenditures to the hospital, but defaulters provide their assets instead of paying emergency medical expenses. If the asset level of these individuals is below 0 (debt), the hospital receives no payment.

For each period t, hospital profits are given by

$$\sum_{j=J_0}^{\bar{J}} \int \{[m_n(\mathbf{s}, j) + (1 - g_d(\mathbf{s}, j))\, m_e(\epsilon_e) + g_d(\mathbf{s}, j)\ \max(a, 0)] - \frac{(m_n(\mathbf{s}, j) + m_e(\epsilon_e))}{\zeta}\} d\mu(\mathbf{s}, j) \tag{21}$$

where ζ is the mark-up of the hospital, and $\mu(\mathbf{s}, j)$ is the measure of households at age j of state s. Following Chatterjee, Corbae, Nakajima and Ríos-Rull (2007), mark-up ζ is adjusted to ensure zero profits in equilibrium.[15]

Note that the mark-up of the hospital ζ is an instrument through which I can evaluate the efficiency of healthcare policies in terms of healthcare providers, because the size of the hospital's mark-up ζ increases with unpaid medical debt.

2.6 Equilibrium

Appendix E defines a recursive competitive equilibrium.

[15]Note that the object of default is here only emergency medical expenditures, while that in Chatterjee, Corbae, Nakajima and Ríos-Rull (2007) is all medical expenditures.

2.7 Numerical Solution Algorithm

Here, I describe the key ideas of the numerical solution algorithm. Appendix G demonstrates each step of the algorithm with details.

Substantial computational burdens are involved in solving the model. The model has a large number of individual state variables, and loan prices depend on the state of individuals due to the endogenous default setting. Moreover, the model has many parameters that must be adjusted to match cross-sectional and life-cycle moments in the model with those in the data.

To solve the model, I apply an endogenous grid method to the variable of asset holdings $a^{'}$ for the next period and discretize the variables of health capital $h^{'}$ for the next period and health insurance $i^{'}$ for the next period because the variation of asset holdings $a^{'}$ is the largest among endogenous state variables. The endogenous grid method I use is an extension of Fella's (2014) method. Fella (2014) develops an endogenous grid method to solve models with discrete choices under an exogenous borrowing limit. One of the main contributions of Fella (2014) is an algorithm identifying concave regions over the solution set, to which Carroll's (2006) endogenous grid method is applicable. However, Fella's (2014) endogenous grid method is not directly applicable to models with default options, as these models do not have any predetermined feasible set of solutions. Based on the theoretical findings of Arellano (2008); Clausen and Strub (2017), I add a numerical procedure for finding the lower bound of feasible sets for the solution to Fella's (2014) algorithm that identifies concave regions over the solution sets, which allows me to use the endogenous grid method to solve this model.

Definition 2.7.1. For each $(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$, $a^{'}_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ is ***the risky borrowing limit*** if

$$\forall a^{'} \geq a^{'}_{rbl}(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta),$$
$$\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) a^{'}}{\partial a^{'}} = \frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)}{\partial a^{'}} a^{'} + q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) > 0.$$

I numerically compute the risky borrowing limit for each state and take it as the lower bound of feasible sets for solution $a^{'}$. To use the endogenous grid method, a first-order condition (FOC) is required. The following proposition guarantees the existence of an FOC and provides the form of the FOC, which is needed to use the endogenous grid method.

Proposition 2.7.1. *Given a pair of (ϵ_e, ϵ_n), for any $(\bar{i}^{'}, \bar{h}^{'}, j, \eta)$ and for any $a^{'} \geq a^{'}_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$,*
(i) the FOC of asset holdings $a^{'}$ exists, and
(ii) the FOC is as follows:

$$\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}} \frac{\partial u(c, (1-\epsilon_e)(1-\epsilon_n)\bar{h})}{\partial c} = \frac{\partial W^G(a^{'}, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)}{\partial a^{'}} \tag{22}$$

where W^G is the expected value of working-age households with a good history.

Proof. See Appendix D. □

For each of the grid points for asset holdings $a^{'}$ for the next period, endogenous grid methods computes the endogenously-driven current assets $a(a^{'})$ by using the FOC in Proposition 2.7.1. Note that since the endogenously-driven current assets $a(a^{'})$ is located on an endogenous grid of the current assets a, it is required to additionally compute the decision rule and values on the exogenous grid. The monotonicity of decision rules and value functions allows endogenous grid methods to use interpolations to compute those on the exogenous grid for the current assets a.

I modify this interpolation step as follows. For each of the grid points for asset holdings $a^{'}$ of which value is above zero, I use a linear interpolation as other endogenous grid methods do. However, for each of the grid points for asset holdings $a^{'}$ whose value is below zero, I use the grid search method to avoid potentially unstable solutions due to numerical errors in calculating the derivative of loan rate schedules $\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}}$. Although Proposition 2.7.1 proves that these loan rate schedules are differentiable, as Hatchondo, Martinez and Sapriza (2010) point out, the accuracy of solution is sensitive to how to compute the derivative of loan rate schedules $\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}}$. I use the grid search method only for asset holdings $a^{'}$ of which value is below zero. Despite the inclusion of this grid search method, this hybrid method substantially reduces computational time because the method does not search the whole range of the assets grid. This grid search is operated only between the risky borrowing limit and zero assets. Moreover, using the monotonicity, I can repeatedly narrow the range of the feasible set of solutions in grid search.

3 Calibration

I calibrate the model to capture cross-sectional and life-cycle features of the U.S. economy before the Affordable Care Act (ACA), because the period of the ACA is too brief to be considered as the steady state of the U.S. healthcare system. To reflect these features, I take information from multiple micro data sets. In particular, I use the MEPS to capture salient cross-sectional and life-cycle dimensions on the use of emergency rooms, medical conditions, and medical expenditures.[16]

To calibrate the model, I separate parameters into two groups. The first set of parameters is determined outside the model. I choose the values of these parameters from the macroeconomic

[16] The details of the data selection process are provided in Appendix A.

literature and policies. The other set of parameters requires solving the stationary distribution of the model to minimize the distance between moments generated by the model and their empirical counterparts. Table 1 shows the values of parameters resulting from the calibration, Table 2 summarizes the targeted aggregate moments and the corresponding moments generated by the model, and Figure 3 shows the targeted life-cycle moments and the corresponding model-generated moments.

Table 1: Benchmark Parameter Values

Parameter	Description	Internal	Value
Demographics			
J_0	Initial age	N	23
J_r	Retirement age	N	65
$\bar{J}$	Maximum length of life	N	100
π_n	Population growth rate (percent)	N	1.2%
Preferences			
λ_u	Weight on consumption	Y	0.601
v	Elasticity of substitution b.w c and h_c	Y	0.329
σ	Risk aversion	N	3 (De Nardi, French and Jones (2010))
β	Discount factor	Y	0.790
Labor Income			
$\bar{\omega}_j$	Deterministic life-cycle profile	N	{0.0905,-0.0016}*
ϕ_h	Elasticity of labor income to health status	N	0.594
ρ_η	Persistence of labor productivity shocks	Y	0.847
σ_ϵ	Standard deviation of persistent shocks	Y	0.556
Health Technology			
κ_e	Scale of ER health shocks	Y	0.310
A_{j_g}	Age group effect on ER health shocks	Y	{1, 1.338, 1.452, 1.591, 1.546, 1.687}
p_{se}	Probability of drastic ER health shocks	N	0.2
κ_n	Scale of non-ER health shocks	Y	0.019
α_n	Dispersion of non-ER health shocks	Y	0.543
B_{j_g}	Age group effect of non-ER health shock	Y	{1, 0.710, 0.458, 0.295, 0.180, 0.012}
ψ_{j_g}	Efficiency of health technology	Y	{0.465, 0.430, 0.497, 0.567, 0.533, 0.302}
φ_{j_g}	Curvature of health technology	Y	{0.314, 0.221, 0.259, 0.263, 0.393, 0.728}
Survival Probability			
Γ_{j_g}	Age group effect on survival rate	Y	{0.004, 0.01, 0.02, 0.026, 0.113, 0.221, 0.574}
ν	Elasticity of survival rate to health status	N	0.226 (Franks, Gold and Fiscella (2003))
Health Insurance			
$\bar{y}$	Income threshold for Medicaid eligibility	Y	0.043
(q^n_{MCD}, q^e_{MCD})	Medicaid coverage rates	N	(0.7,0.8)
(q^n_{IHI}, q^e_{IHI})	IHI coverage rates	N	(0.55,0.7)
(q^n_{EHI}, q^e_{EHI})	EHI coverage rates	N	(0.7,0.8)
(q^n_{med}, q^e_{med})	Medicare coverage rates	N	(0.55,0.75)

Table 1 continued from previous page

Parameter	Description	Internal	Value
p_{med}	Medicaid premium	N	0.021
$p(EHI\|\eta)$	EHI offer rate	N	Appendix H
ψ_{EHI}	Subsidy for EHI	N	0.8
ξ_{IHI}	Markup for IHI	Y	1
ξ_{EHI}	Markup for EHI	Y	1
Default			
ξ	Cost of having a bad credit history	Y	0.390
λ	1/Duration of having a bad credit history	N	0.333
$\bar{\zeta}$	Non-medical expense shocks $\zeta \sim U[0, \bar{\zeta}]$	Y	0.033
Tax and Government			
ss	Social Security benefit	N	0.256
τ_{ss}	Social Security tax	Y	0.082
τ_{med}	Medicare payroll tax	Y	0.051
G	Government spending/ GDP	N	0.18
a_0	Upper bound of the progressive tax fnc	N	0.258 (Gouveia and Strauss (1994))
a_1	Curvature of the progressive tax fnc	N	0.768 (Gouveia and Strauss (1994))
a_2	Scale of the progressive tax fnc	Y	1.257
τ_y	Proportional tax rate	Y	0.077
Firm			
z	Total factor productivity	Y	0.557
θ	Capital income share	N	0.36
δ	Depreciation rate	N	0.24
Hospital			
ζ	Mark-up of hospital	Y	1.040

The model period is triennial . One unit of output in the model is the U.S. GDP per capita in 2000 ($\$36, 245.5$).

Demographics: The model period is triennial. Households enter the economy at age 23 and retire at age 65. Since the mortality rate is endogenous, life spans differ across households. Their maximum length of life is 100 years. These values correspond to $J_r = 15$ and $\bar{J} = 26$. The chosen population growth rate π_n is 1.2 percent, which is consistent with the annual population growth rate in the U.S.

Preferences: Preferences are represented by a power utility function over a CES aggregator over consumption and health status. λ_u is the weight of non-medical consumption on the CES aggregator in the utility function. λ_u is chosen to match the ratio of the total medical expenditures to output of 0.163 in the National Health Expenditure Accounts (NHEA). υ is the elasticity of substitution between non-medical consumption and current health status, which is chosen to target the correlation between non-medical consumption and medical expenditures, which is 0.153 in the PSID. The

Table 2: Targeted Aggregate Moments

Moment	Empirical value	Model value
Risk-free interest rate (percent)	4	4
AVG of bankruptcy rates (percent)	1	1.1
Fraction of bankruptcy Filers with Medical Bills	0.62	0.64
Total medical expenditures/GDP	0.163	0.163
CV of medical expenditures	2.67	2.57
Corr b.w. consumption and medical expenditures	0.153	0.149
Autocorrelation of earnings shocks	0.952	0.953
STD of log earnings	1.29	1.25
Fraction of ER users aged b.w. 23 and 34	0.125	0.128
AVG of health shocks b.w. ages of 23 and 34	0.116	0.124
Individual health insurance take-up ratio	0.11	0.095
Employer-based health insurance take-up ratio	0.685	0.650
Working-age households' Medicaid take-up ratio	0.044	0.044

The model period is triennial . I transform triennial moments into annual moments. One unit of output in the model is the U.S. GDP per capita in 2000 $(\$36,432.5)$.

value of v is 0.329, which implies that the marginal utility of non-medical consumption increases with health status. This result is consistent with the empirical finding of Finkelstein, Luttmer and Notowidigdo (2013). σ is the coefficient of relative risk aversion, which is chosen by following De Nardi, French and Jones (2010). β is the discount factor of households. It is chosen to match an equilibrium risk-free interest rate of 4 percent.

Labor Income: To obtain the deterministic life-cycle profile of earnings $\bar{\omega_j}$, I take the following steps. First, in the MEPS, I choose the Physical Component Score (PCS) as the counterpart of health status in the model.[17] I normalize the PCS by dividing all of the observations by the highest score in the sample. Second, exploiting the panel structure of the MEPS data, I regress the difference in log labor income on differences in age squared, education, sex and the PCS.[18] I choose the summation of the age and age-squared terms as the deterministic life-cycle profiles of earnings $\bar{\omega_j}$. ϕ_h is set based on the estimate of the coefficient of the PCS. ρ_η is chosen to match the autocorrelation of the idiosyncratic component $\phi_h \log(h_c) + \log(\eta)$ with the autocorrelation of earnings shocks without the health component of 0.957 in Storesletten, Telmer and Yaron (2004). σ_ϵ is chosen such that the model generates a standard deviation of 1.29 for the log earnings in the Survey of Consumer Finance (SCF) (Díaz-Giménez, Glover and Ríos-Rull (2011)).

[17]The PCS is a continuous health measure between 0 and 100 that indicates individual physical condition.

[18]This setting absorbs individual fixed effects. Further, one might be concerned about endogeneity issues due to reverse causality from labor income to health, but empirical studies including Currie and Madrian (1999) and Deaton (2003) show that it is difficult to find a direct effect of labor income on health.

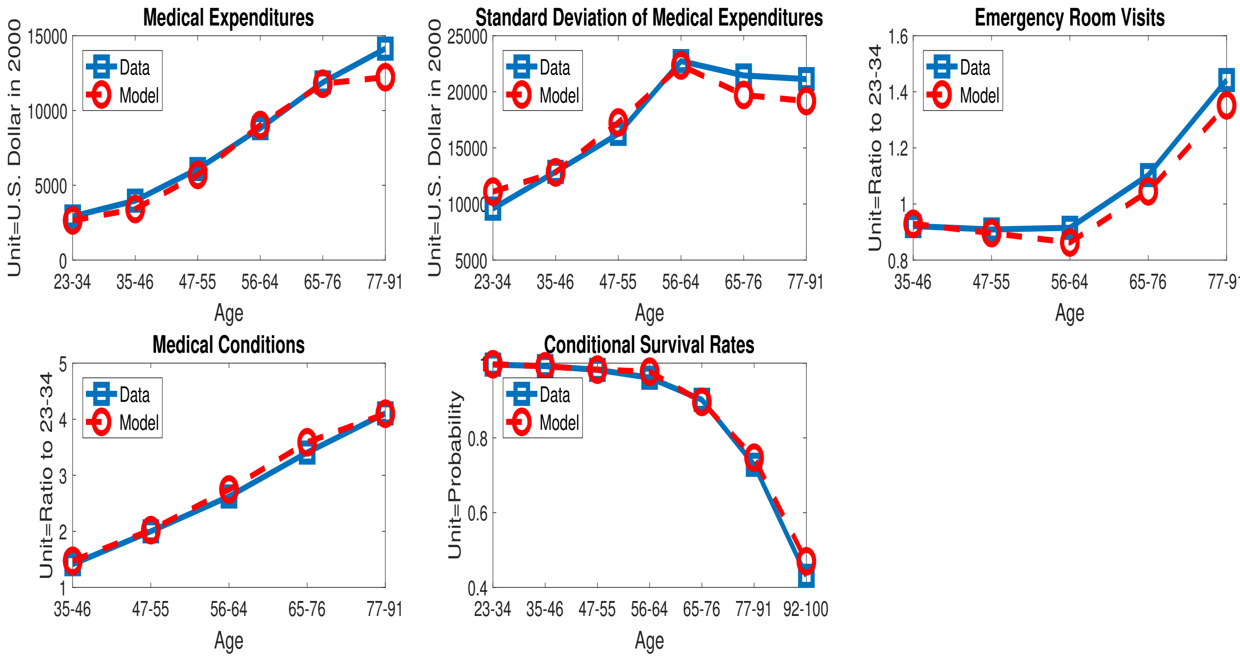


Figure 3: Targeted Life-cycle Moments

Health Technology: I choose the scale parameter of the function for emergency health shocks κ_e to target the average fraction of emergency room users aged between 23 and 34, which is 0.125 in the MEPS. A_g governs differences in emergency room visits by age group. It is chosen to match the ratio of the fraction of emergency room visits for each age group to that of households aged between 23 and 34. The upper-right panel of Figure 3 shows that these ratios observed in data are close to those generated by the model. p_{se} is the probability of an extreme emergency medical event conditional on the occurrence of an emergency medical event. I model these extreme emergency medical events as emergency events that incur the top 20 percent of emergency medical expenses. κ_n is chosen to target the average health shocks of households aged between 23 and 34, which is 0.125 in the MEPS. α_n determines the degree of differences in health shocks across levels of health capital. It is selected to target the coefficient of variation of medical expenditures of 2.67 in the MEPS. B_{j_g} is set to match the ratio of the average of medical conditions transformed by health shocks for each age group to that of households aged between 23 and 34. The lower-left panel of Figure 3 shows that the model generates a similar age profile of medical conditions. ψ_{j_g} is set to match the average of medical expenditures for each age group. φ_{j_g} is chosen to target the standard deviation of medical expenditures for each age group. The upper-left and upper-middle panels of Figure 3 show that the life-cycle profiles of the mean and standard deviation for medical expenditures in the data are close to those generated by the model.

Survival Probability: Γ_{j_g} controls the disparities in survival rates across age groups. Γ_{j_g} is chosen to target the average survival rate for each age group, which is calculated based on Bell and Miller (2005). ν governs the predictability of the PCS for the survival rate. I choose ν based on the estimate of Franks, Gold and Fiscella (2003). They use a somewhat different type of health measure from the MEPS. Whereas the MEPS uses the SF-12 as its PCS, Franks, Gold and Fiscella (2003) choose the SF-5 as their PCS. Although the types of PCS differ, Østhus, Preljevic, Sandvik, Leivestad, Nordhus, Dammen and Os (2012); Lacson, Xu, Lin, Dean, Lazarus and Hakim (2010); Rumsfeld, MaWhinney, McCarthy Jr, Shroyer, VillaNueva, O'brien, Moritz, Henderson, Grover, Sethi et al. (1999) find that different types of PCS are highly correlated. Based on their finding, I use the estimate of Franks, Gold and Fiscella (2003) by transforming their five-year result to a three-year value and rescaling the 0-100 scale into the relative scale of the model. Recall that, in the model, health status is represented by a health status relative to the healthiest in the economy.

Health Insurance: The income threshold for Medicaid eligibility $\bar{y}$ is chosen to match the percentage of Medicaid takers among working-age households, which is 4.4 percent in the MEPS. Health insurance coverage rates, q^e_{MCD}, q^e_{IHI}, q^e_{EHI} and q^e_{med}, (q^n_{MCD}, q^n_{IHI}, q^n_{EHI} and q^n_{med}), are chosen to match the fraction of (non-) emergency out-of-pocket medical expenditures among the total medical expenditures for each type of health insurance. The Medicare premium p_{med} is set to 2.11 percent of GDP per capita, which is based on the finding in Jeske and Kitao (2009). The offer rates of employer-based health insurance $p(EHI|\eta)$ are set to target the offer rates across earnings levels in the MEPS. Appendix H demonstrates the details. For each age group j_g, I calculate the conditional offer rates given a level of earnings in the data. Then, I map the offer rate in the data onto the stationary distribution of earnings shocks in the model and calculate the conditional offer rate $p(EHI|\eta)$. The subsidy for employer-based health insurance ψ_{EHI} is chosen such that employer-based health insurance takers pay 20 percent of the premium. ξ_{IHI} and ξ_{EHI} are set to the take-up ratios of individual private health insurance and employer-based health insurance, respectively.

Default: The cost of bad credit history ξ is chosen to match the average Chapter 7 bankruptcy rate in Livshits, MacGee and Tertilt (2007). λ is chosen to match the average duration of exclusion, which is 10 years for Chapter 7 bankruptcy filing.

Tax and Government: ss is chosen to match a replacement rate of 40 percent. Social Security tax τ_{ss} is chosen to balance the government budget for Social Security. τ_{med} is set to balance the government budget for Medicare. Non-medical government spending is set at 18 percent of U.S. GDP. a_0 and a_1 are taken from Gouveia and Strauss (1994). As in Jeske and Kitao (2009) and Pashchenko and Porapakkarm (2013), the scale parameter of the income tax function a_2 is chosen to match the fraction of tax revenue financed by progressive income taxation of 65 percent, which is the average value of the OECD member countries. The proportional income tax τ_y is chosen to balance the government budget constraint.

Firm: TFP z is chosen to normalize output to 1. θ is chosen to reproduce the empirical finding that the share of capital income is 0.36. Annual depreciation rate δ is 8 percent.

Hospital: Hospital mark-up ζ is chosen to represent the zero profit condition of the hospital.

3.1 Model Performance

Before conducting a series of counterfactual experiments for the three healthcare reforms, I demonstrate the performance of the model by assessing the consistency of the untargeted results of the model with their empirical counterparts.

Life-cycle Dimensions: Figure 4 depicts the life-cycle profiles of average consumption, earnings and assets. The shape of the consumption profile is concave and relatively flatter than the other two profiles. Earnings profiles increase until the mid-40s and decline until retirement. After retirement, households receive Social Security benefits. Households save assets until their retirements and spend them afterward. The shape of the three profiles resembles that of their empirical counterparts, which are documented in Heathcote, Perri and Violante (2010) and Díaz-Giménez, Glover and Ríos-Rull (2011).

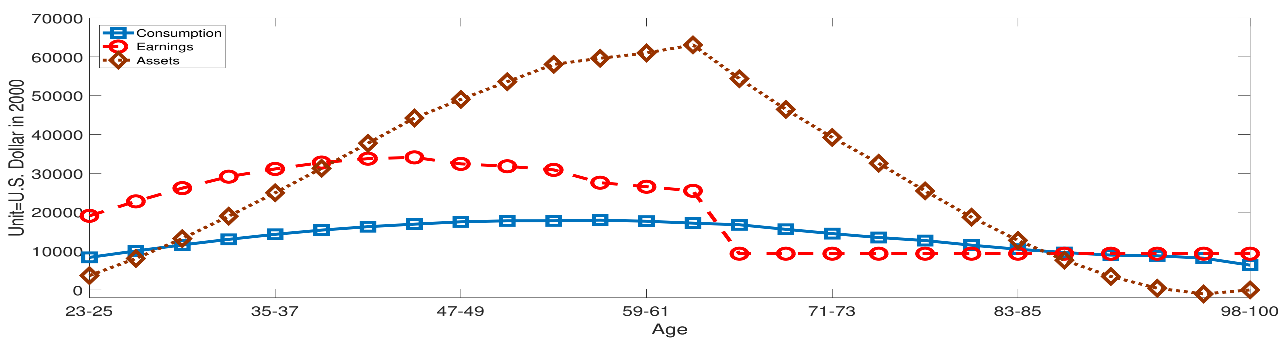


Figure 4: Age Profiles of Consumption, Earnings and Assets

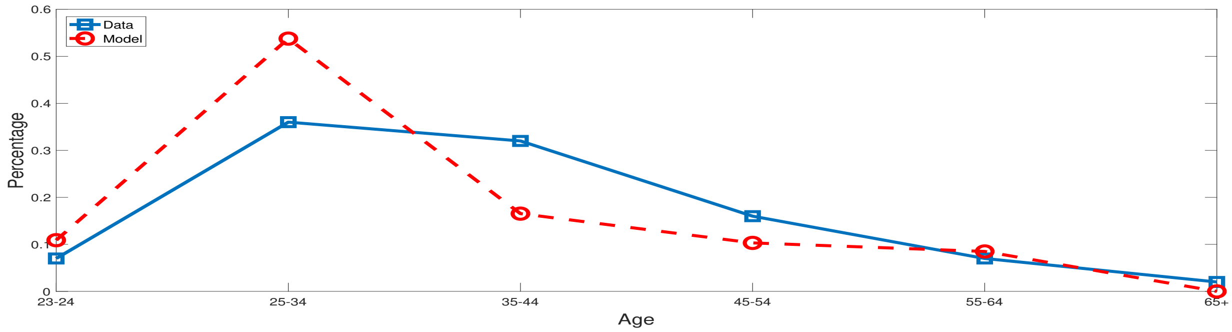


Figure 5: Age Profiles of Bankruptcy Filings (Source: Sullivan, Warren and Westbrook (2001))

Figure 5 displays the profiles of the fraction of bankruptcy filings over the life-cycle. In the data, the life-cycle profile of bankruptcy filings is hump-shaped, and bankruptcy filers aged between 25 and 44 consist of more than half of the total bankruptcy filers. The model broadly reproduces these features well, meaning that it successfully reflects how default risks evolve over the life-cycle.

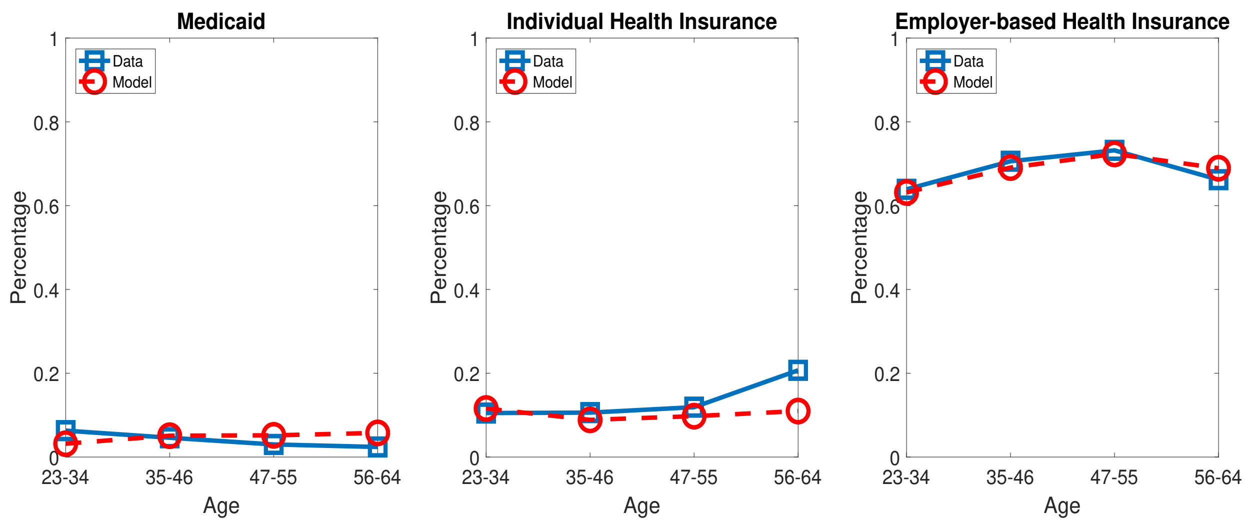


Figure 6: Age Profiles of Insurance Take-up Ratios

Figure 6 shows the age profiles of take-up ratios for health insurance. These take-up ratios in the model are broadly similar to those in the data. Before the expansion of Medicaid under the ACA, only a small portion of working-age households used Medicaid, as it was available only to low-income households. The model generates this feature well. Regarding individual health insurance, the model reproduces the life-cycle profile for those aged between 23 and 55 well. However, the model does not match the empirical rise in its take-up ratio for those aged between 56 and 64 because the model cannot capture early retirement. In the data, those who take early retirement tend to purchase individual health insurance until they reach the Medicare eligibility age. Since all households in the model are required to retire at age 65, the model fails to reproduce this. The model succeeds in generating the hump-shaped age profiles in employer-based health insurance in the data, which implies that the model, overall, reflects life-cycle features of health insurance behaviors well .

Table 3: Untargeted Cross-sectional Moments

Moment	Empirical Value	Model Value
Debt - earnings Ratio	0.084	0.074
Correlation b.w. Income and ER Visits	-0.09	-0.14
Correlation b.w. Income and Medical Conditions	-0.15	-0.27

The model period is triennial . I transform the triennial moments into annual moments.

Cross-sectional Dimensions: Table 3 shows cross-sectional moments that are not explicitly targeted. The empirical values of these moments are obtained from previous studies and the data. Empirical values for the debt to earnings ratio is from Livshits, MacGee and Tertilt (2007). The debt to earnings ratio is 8.4 percent in the data, which is 7.4 percent in the model. The model also generate reasonable values on health-related cross-sectional moments. The empirical values of these health-related moments below are from the MEPS. The model generates negative values of the correlation between income and emergency room visits and of the correlation between income and medical conditions quantified to health shocks. Note that the negative correlation values can be reproduced owing to the model's setting for the distribution of health shocks: the likelihood of emergency and non-emergency health shocks negatively depends on health capital.

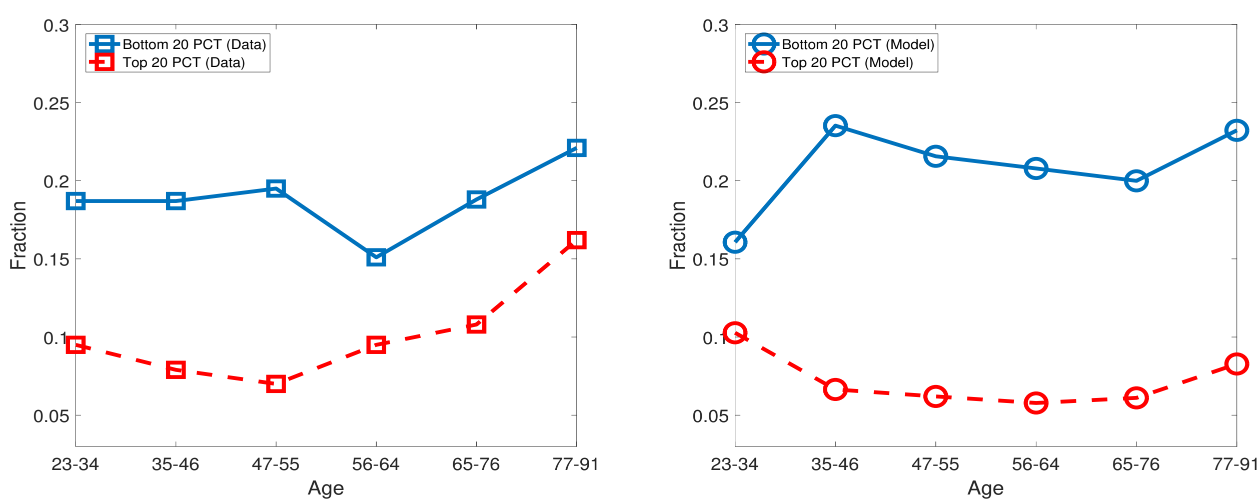


Figure 7: Bottom and Top End of the Emergency Room Usage Distribution

Figure 7 implies that the model endogenously captures the features of emergency room usage of low-income individuals and high-income individuals. The left panel of Figure 7 shows that, in the data, low-income individuals visit emergency rooms more frequently over the life-cycle, which is well-replicated in the model. Note that the fraction differs across income levels, as the distribution of emergency health shocks depends on health capital. If the distribution depended only on age, there would be no difference in visits to emergency rooms across income groups.

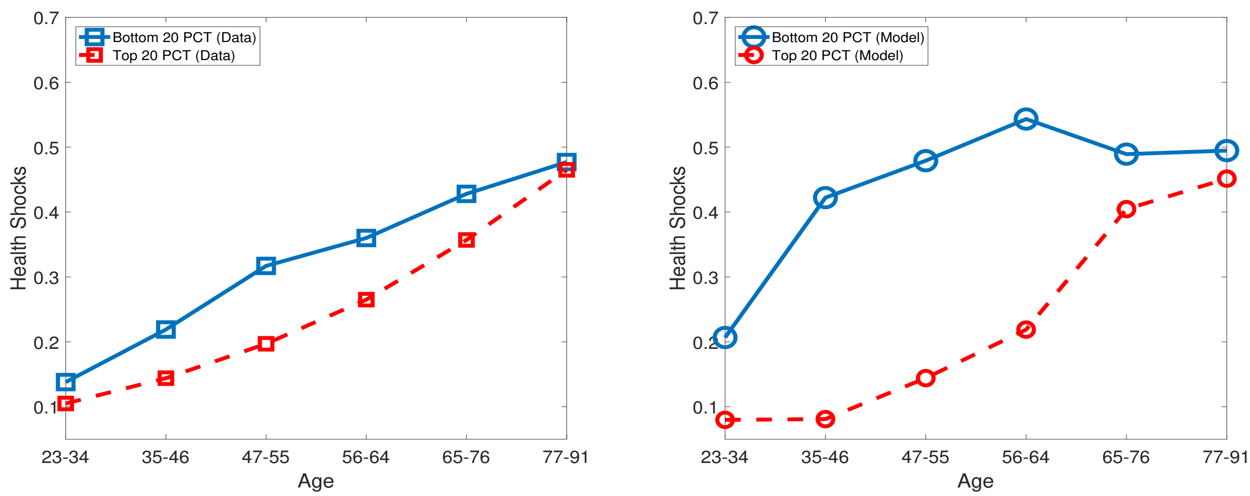


Figure 8: Bottom and Top End of the Medical Conditions Distribution

Figure 8 compares the age profiles of medical conditions between individuals in the top 20 percent of income and those in the bottom 20 percent. It implies that the model captures the distributional features of medical conditions across income groups. The left panel of Figure 8 implies that low-income individuals tend to suffer from more severe health shocks than high-income individuals, which is presented in the model's result. These successes of the model make it possible to capture asymmetric financial risks across income groups, as health risks are linked to financial risks via emergency and non-emergency medical expenses.

4 Results

4.1 Health Insurance Policy and Social Welfare Function

All health insurance policies in this study address the reforms of two types of health insurance for non-retirees: Medicaid (public health insurance for non-retirees) and private individual health insurance (IHI). The ideal target is to characterize a complete set of healthcare reforms that maximizes social welfare. However, healthcare reforms in the U.S. include a large number of policy components that affect a wide range of agents.[19] I put my focus mainly on policy components related to households. In addition, in all policy experiments going forward, I preserve the system of employ-based health insurance in the baseline economy because healthcare reforms proposed in the U.S. have mainly addressed policies of Medicaid and IHI.

Specifically, my goal is to find the optimal design of three objects: (i) the eligibility rule of Medicaid, (ii) the subsidy rule for the purchase of IHI, and (iii) the reform of the IHI market on its pricing rule, p_{IHI}, and coverage rates, (q^e_{IHI}, q^n_{IHI}). Ideally, one would impose no restrictions on the objects the government can select. Unfortunately, optimizing such unrestricted objects is computationally unfeasible. Therefore, first, I represent (i) the eligibility rule for Medicaid and (ii) the subsidy rule for the purchase of IHI in one function with a two-parameter family. The subsidy function of Medicaid and IHI is given by

$$\Phi(y, i; \bar{M}, a_p) = \begin{cases} 1 & \text{if } y \leq \bar{M} \text{ \& } i = MCD \\ -\frac{1}{a_p} \cdot y + \frac{1}{a_p} \cdot \bar{M} + 1 & \text{if } \bar{M} < y \leq \bar{M} + a_p \text{ \& } i = IHI \\ 0 & \text{otherwise} \end{cases} \tag{23}$$

where $\Phi(y, i; \bar{M}, a_p)$ is the proportion of subsidy on the premium of health insurance i given to households whose income is y. $\bar{M}$ is the income threshold for Medicaid eligibility, and a_p is the income threshold of the subsidy for the purchase of IHI. For example, if a household earns income lower than the income eligibility of Medicaid M, this household can use Medicaid. If a household is between $\bar{M}$ and $\bar{M} + a_p$, this household is not eligible for Medicaid, but it can receive a subsidy for the purchase of IHI as much as a fraction $-1/a_p \cdot y + 1/a_p \cdot \bar{M} + 1$ of the health insurance premium. Note that when a_p increases, the subsidy covers more households with larger benefits.

I define the IHI market reform as follows:

$$\mathbf{\Pi}(b_p) = (p_{IHI}, q^n_{IHI}, q^e_{IHI}) = \begin{cases} (p_{IHI}(h_c, j_g), 0.55, 0.7) & \text{if } b_p = 0 \\ (p_{IHI}(j_g), 0.70, 0.8) & \text{if } b_p = 1 \end{cases} \tag{24}$$

where $\mathbf{\Pi}(b_p)$ is a vector of the pricing rule for IHI p_{IHI}, the coverage rate for non-medical expenses q^n_{IHI}, and that of emergency medical expenses q^e_{IHI} conditional on a reform of b_p. $b_p = 0$ implies no reform in the IHI market. Thus, the premium of IHI depends on the current health status h_c as well as age group j_g, and its coverage rates (q^n_{IHI}, q^E_{IHI}) are lower than those of Medicaid and employer-based health insurance. $b_p = 1$ implies that the premium depends only on age group j_g and that the coverage rates, (q^e_{IHI}, q^n_{IHI}), improve to be the same as the EHI and Medicaid's

[19] For example, policies in the Affordable Care Act reach the health insurance industry, household, firm and government sectors.

coverage rate.

The above setting is so flexible that the functions allow me to replicate not only pre-existing healthcare systems around the world but also alternative healthcare reforms recently proposed in the U.S. For example, if $\bar{M}$ is larger than the income of a household whose income is the highest, this policy implies a universal healthcare system (single-payer healthcare system). Additionally, by choosing $b_p = 1$ and adjusting $\bar{M}$ and a_p properly, it is possible to mimic the Medicaid expansion and the progressive subsidies for the purchase of individual health insurance of the ACA. Furthermore, if one chooses $b_p = 0$ and establishes lower values of $\bar{M}$ and a_p than those of the ACA, he can mimic the policies of the American Health Care Act. The parameterization of healthcare reform permits us to avoid restricting the scope of this study to specific reforms. Rather, this flexibility makes it possible to explore more general features of health insurance policies, which allows the characterization of optimal health insurance policies.

Healthcare reforms can be represented by three parameters $(\bar{M}, a_p, b_p)$. An issue is that different healthcare reforms require different levels of tax revenues because the reforms are funded by taxes. I adjust a_0 of the income tax function , $a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y\, y$, to balance the government budget while preserving the values of a_1, a_2 and τ_y in the baseline economy. Recall that a_0 determines the upper bound of the progressive tax as income y goes to infinity. Therefore, the higher a_0, the more progressive the tax system. As noted in Pashchenko and Porapakkarm (2013), this setting takes into account that more redistributive healthcare reforms require more progressive income taxes.

The government maximizes a social welfare function (SWF). The SWF values the ex-ante lifetime utility of an agent born into the stationary equilibrium implied by the chosen healthcare reform. The government solves

$$\max_{\bar{M}\geq 0, a_p \geq 0, b_p \in \{0,1\}} SWF(\bar{M}, a_p, b_p) \tag{25}$$

such that

$$SWF(\bar{M}, a_p, b_p) = \int V^G_{j=23}(\mathbf{s}_0; \bar{M}, a_p, b_p)\mu(d\mathbf{s}_0, j = 23; \bar{M}, a_p, b_p)$$

$$\mathbf{s}_0 = (a = 0, i = i_0, h = h_0, \epsilon_e, \epsilon_n, \eta, \zeta, \omega)$$

(23) and (24).

where $V^G_{j=23}(\cdot; \bar{M}, a_p, b_p)$ is the value of households at age 23 associated with $(\bar{M}, a_p, b_p)$, $\mu(\cdot; j = 23; \bar{M}, a_p, b_p)$ is the distribution over households at age 23 associated with $(\bar{M}, a_p, b_p)$. Recall that all newborn households start with zero assets and the maximum level of health capital stock. The initial distribution of health insurance status is obtained from the MEPS by computing the joint distribution between earnings and health insurance status at age 23. I interpret that the level of earnings in the MEPS reflects the level of labor productivity η. I assume that $(\epsilon_e, \epsilon_n, \eta, \zeta, \omega)$ are on their stationary distributions at age 23.

I quantify welfare changes from the baseline economy by computing the consumption equivalent variation **CEV** in the following way:

$$\sum_{j=1}^{J} \int_{\mathbf{s}} \beta^{j-1} \pi_{j+1|j}(h_{c,0}(\mathbf{s}, j)) u((1 + \mathbf{CEV}) c_0(\mathbf{s}, j), h_{c,0}(\mathbf{s}, j)) \mu_0(d\mathbf{s}, j) \tag{26}$$
$$= \sum_{j=1}^{J} \int_{\mathbf{s}} \beta^{j-1} \pi_{j+1|j}(h_{c,1}(\mathbf{s}, j)) u(c_1(\mathbf{s}, j), h_{c,1}(\mathbf{s}, j)) \mu_1(d\mathbf{s}, j)$$

where β is the discount rate, and $\pi_{j+1|j}(h_c)$ is the rate of surviving up to age $j + 1$ conditional survival up to age j with a current health status h_c. The subscripts of these variables indicate the economy concerned. A subscript of 0 means that the variables refer to the baseline economy and that of 1 implies that the variables refer to an economy relative to the baseline economy.

4.2 Optimal Health Insurance Policy

Table 4: Optimal Policies and Welfare Changes

Variable	Baseline	Optimal
Health Insurance System $(\bar{M}, a_p, b_p)$	$(0.04, 0, 0)$	$(0.216, 10.42, 1)$
Welfare Changes (CEV)	–	+6.48%

Table 4 shows the optimal health insurance system and its welfare change. The optimal health insurance system is given by a threshold of the eligible income for Medicaid $\bar{M} = 0.216$, a progressive parameter of the subsidy for the purchase of IHI $a_p = 10.42$, and the indicator of the IHI market reform $b_p = 1$. These imply that the threshold of eligible income for Medicaid is 21.6 percent (approximately \$7,870) of the average income in the Baseline model (\$36,432.5), the subsidies for the purchase of IHI are given up to households whose income is between 21.6 percent (approximately \$7,870) and 1,042 percent (approximately \$379,627) of the average income in the baseline model (\$36,432.5). Thus, all working-age populations will be eligible either for Medicaid or for the subsidy for the purchase of the IHI. However, this does not mean that everyone receives the same amount of benefits. When household's income decreases by \$1,000 in the interval above $\bar{M} = 0.216$, the subsidy increases by 2.24 (1/10.42) percent of the health insurance premium. The optimal health insurance policy implements the reform of the IHI market in (24). The optimal health insurance policy improves welfare by 6.48 percent.

4.2.1 Inspection of the Optimal Health Insurance Policy

Table 5: Health-Related Outcomes

Moment	Baseline	Optimal	$b_p = 0$	Low $\bar{M}$	High $\bar{M}$	Low a_p	High a_p
Health Insurance System							
$\bar{M}$ (Medicaid Eligibility)	0.04	0.216	0.344	0.04	0.4	0.216	0.216
a_p (Threshold for the IHI Subsidy)	0	10.42	0	10.42	10.42	0.2	50
b_p (IHI Reform)	0	1	0	1	1	1	1
Health Insurance							
Total Insurance Take-up Ratio	79%	97.9%	97.2%	97.9%	97.8%	95.9%	97.9%
Medicaid Take-up Ratio	4.4%	21.7%	36.6%	3.3%	37%	23.9%	21.7$
IHI Take-up Ratio	9.5%	57.7%	8.1%	79.2%	11.5%	13.3%	65.5%
IHI Premium/AVG Income**	6.3%	8.8%	6.6%	7.86%	10%	7.9%	9.8%
EHI Take-up Ratio	65.1%	18.5%	52.5%	15.4%	17.7%	58.7%	10.8%
EHI Premium/AVG Income**	9%	5 %	5.9%	9%	3.6%	7%	2.4%
Medical Expenditure							
AVG Medical Exp.*	5898	6085	6004	6044	5996	5939	6037
CV of Medical Exp.	2.57	2.49	2.5	2.49	2.49	2.51	2.49
Health Measure							
AVG Health	0.672	0.704	0.702	0.705	0.705	0.701	0.705
STD of Log Health	0.867	0.806	0.811	0.822	0.807	0.812	0.806
AVG Health Shocks	0.352	0.340	0.341	0.340	0.340	0.341	0.340
AVG Prob of ER Visits	0.130	0.119	0.120	0.120	0.119	0.119	0.120
Life Expectancy	74.9	75.02	75.01	75.02	75.02	75.01	75.02
Corr(Income, Health Measure)							
Corr(Income, Health Shocks)	-0.27	-0.229	-0.232	-0.228	-0.229	-0.233	-0.228
Corr(Income, ER Visits)	-0.14	-0.120	-0.121	-0.120	-0.120	-0.122	-0.120

The model period is triennial . I transform the triennial moments into annual moments.
* Unit=U.S. dollar in 2000.
** The average income in the baseline economy.

Health-related Outcomes: Table 5 shows the health-related outcomes in economies with five types of health insurance policies. The first and second columns represent results in the baseline economy and the economy with the optimal health insurance policy, respectively. There are three more columns to explore the implications of three policy parameters, $(\bar{M}, a_p, b_p)$. $b_p = 0$ represents the results of an economy where the eligibility rule for Medicaid $\bar{M}$ and the rule of the subsidy for the purchase of the IHI a_p are the optimal while not reforming the IHI market. Low (High) $\bar{M}$ represents the results for an economy of which $\bar{M}$ is lower (higher) than that in the economy with the optimal health insurance policy. Low (High) a_p demonstrates results in an economy of which a_p is lower (higher) than that in the economy with the optimal health insurance policy.

'Health Insurance System' in 'Optimal' in Table 5 shows that the optimal health insurance policy expands health insurance coverage while changing the composition of health insurance. These changes are driven by the expansion of Medicaid eligibility and the provision of the subsidy for the purchase of IHI. The take-up ratio of health insurance increases by 19 percentage points. The take-up ratios of Medicaid and IHI increase by 17.3 percentage points and 48.2 percentage points, respectively. However, these policies crowd out EHI by 46.6 percentage points. The premium of IHI increases because the IHI market reform, b_p, requires improving the coverage rates of the IHI, (q^n_{IHI}, q^e_{IHI}). The optimal health insurance policy reduces EHI's premium because the expansions of the IHI and Medicaid give rise to a less risky pool of EHI.

'Medical Expenditure' in 'Optimal' in Table 5 demonstrates that these changes in health insurance increase the average medical expenditure and decrease the inequality of medical spending. The expansions of Medicaid and IHI allow low-income households to have more access to health-care services by progressively reducing the effective prices of health insurance. This change causes low-income households to increase medical spending, which increases the average level of medical expenditure and decreases differences in medical spending between low- and high-income households. Furthermore, the optimal health insurance policy changes the timing of medical spending over the life-cycle. 'Optimal' in Table 6 shows that the optimal health insurance policy increases the average medical spending during the working-age period, while decreasing it for retired households. The optimal health insurance policy allows young households to have more access to health-care services by lowering the effective prices of health insurance for them. This change makes the slope of the life-cycle profile of medical spending flatter, which reduces inequality in medical spending across age groups.

Table 6: Average Medical Expenditure by Age Group

Age	Baseline $[0.04, 0, 0]$	Optimal $[0.216, 10.24, 1]$		$b_p = 0$ $[0.344, 0, 0]$		Low $\bar{M}$ $[0.04, 10.42, 1]$		High $\bar{M}$ $[0.4, 10.42, 1]$		Low a_p $[0.216, 0.2, 1]$		High a_p $[0.216, 50, 1]$	
23-34	2,578	2,754	(+6.83)	2,730	(+5.9)	2,752	(+6.75)	2,754	(+6,83)	2,737	(+6.17)	2,752	(+6.75)
35-46	3,730	3,896	(+4.45)	3,838	(+2.9)	3,898	(+4.5)	3,897	(+4.48)	3,845	(+3.08)	3,897	(+4.48)
47-55	5,756	5,986	(+4)	5,892	(+2.36)	5,994	(+4.13)	5,990	(+4.07)	5,901	(+2.52)	5,995	(+4.15)
56-64	8,596	9,136	(+6.28)	8,835	(+2.78)	9,161	(+6.57)	9,135	(+6.27)	8,841	(+2.85)	9,160	(+6.56)
65-76	11,592	11,571	(-0.18)	11,511	(-0.7)	11,642	(+0.43)	11,512	(-0.69)	11,559	(-0.28)	11,598	(+0.05)
77-100	8,739	8,653	(-0.98)	8,665	(-0.85)	8,741	(+0.02)	8,564	(-2)	8,703	(-0.41)	8,653	(-0.98)

Unit=U.S. dollar in 2000.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
The parentheses () indicate % change from the baseline economy.

'Health Measure' in 'Optimal' in Table 5 shows that these changes in medical spending give rise to improvements in overall health and reduced health inequality. As mentioned previously, the optimal policy increases medical spending for young and low-income households. These changes improve their health, and thereby reduce inequality in health. The optimal health increases the average health status by 4.7 percent and decreases the standard deviation of the log of health status by 7.3 percent. The average level of health shocks declines by 3.5 percent, and the average probability of visiting emergency rooms decreases by 8.9 percent. The average life expectancy increases by 0.12 years, and the correlations between income and adverse health measures such as health shocks and ER visits decline. 'Optimal' in Table 7 shows that the optimal policy improves overall health for working-age households. The left graph of Figure 9 shows that the optimal health insurance policy decreases inequality in health over the life-cycle, and this reduction is larger for working-age households. Note that this enhanced health is a key driving force behind the welfare improvement of the optimal health insurance policy.

Table 7: Average Health Status by Age Group

Age	Baseline [0.04, 0, 0]	Optimal [0.216, 10.24, 1]	$b_p = 0$ [0.344, 0, 0]	Low $\bar{M}$ [0.04, 10.42, 1]	High $\bar{M}$ [0.4, 10.42, 1]	Low a_p [0.216, 0.2, 1]	High a_p [0.216, 50, 1]
23-34	0.864	0.875 (+1.27)	0.874 (+1.16)	0.875 (+1.27)	0.875 (+1.27)	0.874 (+1.16)	0.875 (+1.27)
35-46	0.759	0.805 (+6.06)	0.803 (+5.8)	0.805 (+6.06)	0.805 (+6.06)	0.803 (+5.8)	0.805 (+6.06)
47-55	0.671	0.725 (+8.05)	0.721 (+7.45)	0.725 (+8.05)	0.725 (+8.05)	0.721 (+7.45)	0.725 (+8.05)
56-64	0.577	0.624 (+8.15)	0.619 (+7.28)	0.624 (+8.15)	0.624 (+8.15)	0.617 (+6.93)	0.624 (+8.15)
65-76	0.436	0.458 (+5.05)	0.454 (+4.13)	0.458 (+5.05)	0.458 (+5.05)	0.452 (+3.67)	0.458 (+5.05)
77-100	0.184	0.185 (+0.54)	0.185 (+0.54)	0.186 (+1.09)	0.184 (0)	0.185 (+0.54)	0.185 (+0.54)

Unit=U.S. dollar in 2000.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
The parentheses () indicate % change from the baseline economy.

'Health Insurance' in the last five columns in Table 5 shows that the composition of health insurance varies substantially across health insurance policies. '$b_p = 0$' implies that without the reform of the IHI market, the optimal policy increases the take-up ratio of Medicaid by 32.2 percentage points while crowding out EHI by 12.6 percentage points. The premium of EHI falls because expanding Medicaid causes the composition of the pool of EHI to be less risky. 'Low $\bar{M}$' and 'High $\bar{M}$' show that the income threshold of eligibility for Medicaid $\bar{M}$ determines the take-up ratio of Medicaid. The premium of EHI in 'Low $\bar{M}$' is higher than that in 'High $\bar{M}$' because the expansion of Medicaid absorbs riskier households and makes the pool of EHI less risky. 'Low a_p' and 'High a_p' show that the income threshold of the subsidy for the purchase of IHI a_p decides the composition between IHI and EHI. In these two economies, there is little difference in the take-up ratio of Medicaid, whereas the take-up ratios of EHI and IHI substantially differ. As a_p increases, IHI premium increases, and that of EHI decreases because IHI pool becomes riskier.

$b_p = 0$ of Table 5 shows that whether to reform the IHI market has crucial impacts on the optimal composition of health insurance. In this economy, preserving the EHI market is optimal. This result is related to properties of EHI. As Jeske and Kitao (2009) noted, in terms of welfare, EHI is costly because it has a number of regressive policy components. The EHI tends to be offered to high-income individuals and give tax deductions to high-income individuals. However, EHI is good for welfare because this health insurance maintains a large pool of the risk-sharing channel. Without the reform of the IHI market, IHI cannot replace the risk-sharing channel of EHI. Therefore, not subsidizing the IHI market is optimal. Rather, insuring risks in health through public health insurance - that is, Medicaid - is better for welfare when the IHI reform is not implemented.

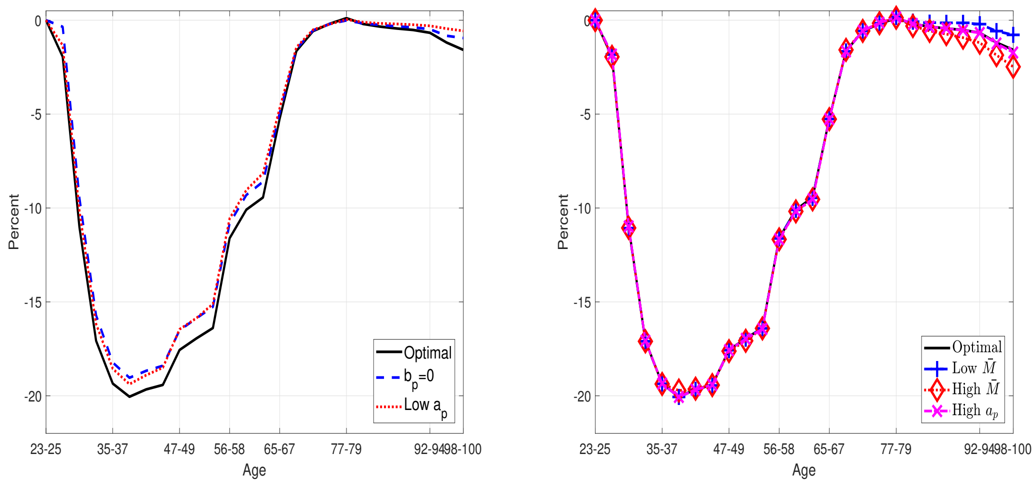


Figure 9: Change in the STD of the Log Health Status from the Baseline Economy

Although Medicaid crowds out EHI, the magnitude is relatively small because EHI still plays a substantial role in sharing health risks.

The last four columns of Table 5 show that when the reform of the IHI market is implemented, the total take-up ratio of health insurance is a key determinant of health outcomes. Although 'Optimal', 'Low $\bar{M}$', 'High $\bar{M}$', and 'High a_p' substantially differ in their composition of health insurance, there is little difference in their health outcomes in 'Health Measure' because those economies implement the reform of the IHI market, which improves the coverage rates of IHI up to those of Medicaid and EHI. Because the pricing rules are different across health insurance types, outcomes related to health insurance are heterogeneous across economies. However, the effects of those health insurance types on health outcomes are similar across those economies because their total take-up ratios of health insurance are similar and the coverage rates of IHI are the same as those of Medicaid and EHI. Table 7 shows that medical spending behavior over the life-cycle is similar across those four economies. Table 8 and the right panel of Figure 9 imply that those four economies generate similar life-cycle patterns for health status and inequality in health.

Macroeconomic Outcomes: Table 8 implies that macroeconomic variables closely interact with health insurance policies. Compared to the baseline economy, all these health insurance policies cause the same directions of changes in macroeconomic variables. Output and consumption increase, while the ratio of capital to output and inequality in consumption decrease. These changes imply that these health insurance policies cause households to save less and consume more than the case of the baseline economy. Two forces cause this reduction in savings. First, to finance these healthcare reforms, taxes must be levied on incomes. This rise in income taxes reduces the after-tax return on savings, which causes individuals to save less. Second, these policies reduce precautionary savings by improving health, which reduces the overall levels of health shocks, as shown in Table 5. The increase in output is caused by an increase in the average efficiency units of labor. Those health insurance policies improve overall health status, leading to an increase in overall levels of labor productivity. These changes bring about more income while reducing savings, thereby leading to an increase in average consumption.

Table 8: Macroeconomic Outcomes

Moment	Baseline $[0.04, 0, 0]$	Optimal $[0.216, 10.24, 1]$	$b_p = 0$ $[0.344, 0, 0]$	Low $\bar{M}$ $[0.04, 10.42, 1]$	High $\bar{M}$ $[0.4, 10.42, 1]$	Low a_p $[0.216, 0.2, 1]$	High a_p $[0.216, 50, 1]$
Output	1*	1.012 (+1.2)	1.011 (+1.1)	1.011 (+1.1)	1.012 (+1.2)	1.013 (+1.3)	1.009 (+0.9)
Capital/Output	2.96	2.924 (-1.22)	2.93 (-1.01)	2.92 (-1.35)	2.93 (-1.04)	2.94 (-0.68)	2.91 (-1.69)
AVG of Cons	0.362	0.369 (+1.93)	0.366 (+1.1)	0.371 (+2.49)	0.368 (+1.66)	0.367 (+1.38)	0.369 (+1.93)
STD of Log Cons	0.875	0.821 (-6.17)	0.822 (-6.06)	0.822 (-6.06)	0.819 (-6.4)	0.826 (-5.6)	0.821 (-6.17)
Units of Eff Labor	2.331	2.377 (+1.97)	2.373 (+1.8)	2.377 (+1.97)	2.377 (+1.97)	2.373 (+1.8)	2.377 (+1.97)
STD of Log Earns	1.253	1.215 (-3.03)	1.217 (-2.87)	1.215 (-3.03)	1.215 (-3.03)	1.217 (-2.87)	1.215 (-3.03)
Gini COEF of Earns	0.589	0.580 (-1.53)	0.580 (-1.53)	0.580 (-1.53)	0.580 (-1.53)	0.581 (-1.36)	0.580 (-1.53)
AVG Tax Rate	22%	23.5% (+6.86)	23% (+4.73)	23.4% (+8.05)	23.8% (+8.05)	22.8% (+3.77)	23.9% (+8.41)

* I normalize the output value in the benchmark model to 1.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
The parentheses () indicate % change from the baseline economy.

Figure 10 shows how the policy parameters, $(\bar{M}, a_p, b_p)$, affect the levels of consumption over the life-cycle. Compared to the baseline economy, all of these health insurance policies generate two qualitatively similar changes in the consumption profiles. First, these health insurance policies reduce older households' consumption because the elderly have to pay more taxes to finance these health insurance policies and because benefits from those policies are given only to working-age households. Second, these policies increase consumption for working-age households. As noted in Table 8, improvements in health following those policies lead to an increase in earnings.

The magnitude of changes in consumption depends on the values of policy parameters, $(\bar{M}, a_p, b_p)$. The right panel of Figure 10 suggests that the reform of the IHI market plays a quantitatively important role in increasing consumption for working-age households. As Table 5 shows, without the reform of the IHI market, the insurance take-up ratio is less than that in the case of optimal health insurance. Thus, the optimal policy with no reform in the IHI market improves health less than the optimal health insurance policy with the reform of the IHI market. Because health affects earnings, the policy without the reform of the IHI generates less income for working-age households than the optimal health insurance policy, which results in the difference in consumption for working-age households. The economy with the policy without the reform of the IHI market has higher levels of consumption for retired households than that with the optimal policy because taxes are lower in the economy with no reform of the IHI market.

The middle panel of Figure 10 implies that how these redistributive health insurance policies

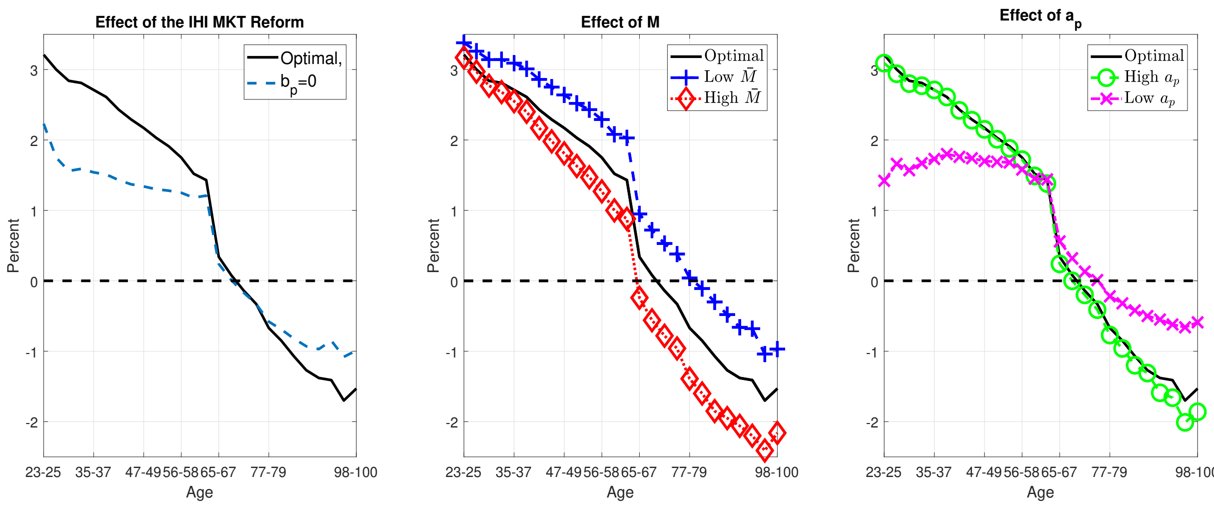


Figure 10: Changes of the AVG Consumption from the Baseline Economy

affect the levels of consumption over the life-cycle. Recall that, as Table 5 shows, the total take-up ratios of health insurance are almost the same across these economies, and thereby their health-related outcomes are very similar. However, they have a substantial difference in the composition of health insurance. Compared to the case of 'High $\bar{M}$', households in the case of 'Low $\bar{M}$' are more likely to use IHI with the subsidy for its purchase and less likely to use Medicaid. Because this subsidy covers a part of the IHI premium, burdens from taxes are less heavy in the economy with 'Low $\bar{M}$' than in that with 'High $\bar{M}$'. This difference in the way of financing health insurance creates this gap in consumption between 'Low $\bar{M}$' and 'High $\bar{M}$'.

The right panel of Figure 10 shows the above two implications at the same time. Similar to the case of '$b_p = 0$', the economy with 'Low a_p' has a lower take-up ratio of health insurance and a lower level of the average health status than the economy with the optimal health insurance policy. This deters labor income for working-age households from increasing to the level in the economy with the optimal policy, which leads to the difference in consumption. The economy with 'High a_p' puts more resources on health than the economy with the optimal health insurance. As Table 5 shows, this additional input has little impact on health while increasing the average income taxes. Thus, compared to the economy with the optimal health insurance policy, there is little difference in the levels of consumption for working-age households, whereas overall levels of consumption for old households are lower in the case of 'High a_p due to heavier taxes.

Figure 11 shows how the policy components, $(\bar{M}, a_p, b_p)$ have impacts on consumption inequality over the life-cycle. The left and right panels of Figure 11 imply that consumption inequality is positively related to health inequality. Table 5 shows that, compared to the economy with the optimal health insurance policy, the economy with '$b_p = 0$' and that with 'Low a_p' have higher levels of the standard deviation of the log of health. This means that their earnings inequality is

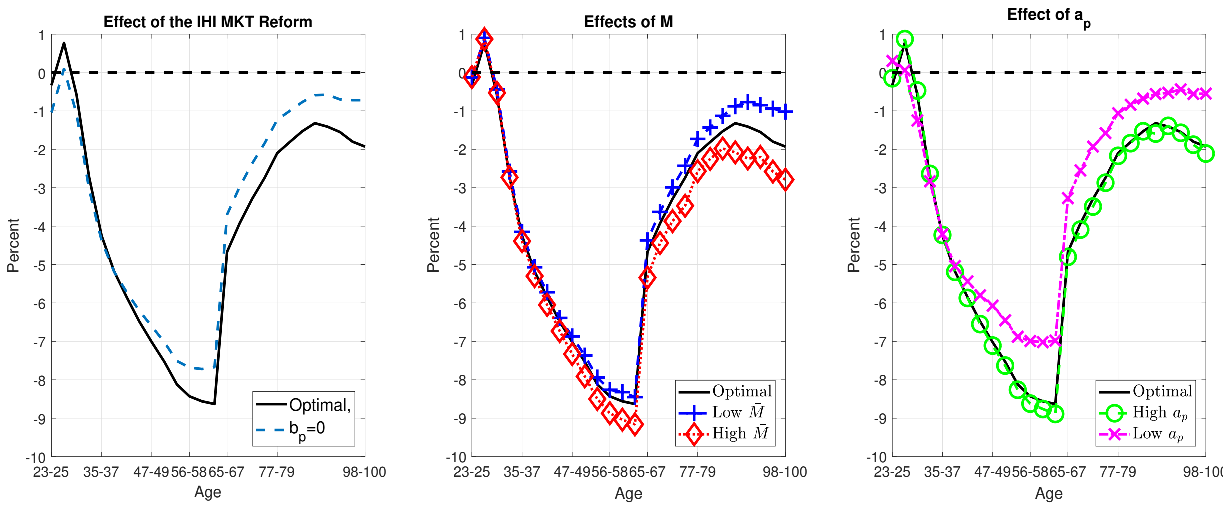


Figure 11: Changes in the STD of the Log of Consumption from the Baseline Economy

also higher, which is linked to higher inequality in consumption. The middle panel of Figure 11 shows how these redistributive health insurance policies affect consumption inequality. Compared to the case of 'Low $\bar{M}$,households in the economy with 'High $\bar{M}$' are less likely to pay a part of IHI premium and more likely to use Medicaid with no premium. Thus, low-income households in the economy with 'High $\bar{M}$' can afford to allocate more income to consumption, which leads to lower inequality in consumption.

Financial Consequences: Table 9 reports the financial consequences of these health insurance policies. All healthcare reforms decrease overall bankruptcies, bankruptcies with medical bills, and defaults on emergency medical bills. The magnitude of these reductions is positively related to the total take-up ratio of health insurance. As mentioned previously, these healthcare reforms allow households to increase medical spending in the early phases of the life-cycle and low-income households to increase their spending on healthcare. This medical spending smoothing increases overall health capital and decreases health inequality. These changes in the evolution of health mitigate the correlation between income and health risks, as the distribution of health risks depends on the level of health capital. This phenomenon implies that these healthcare reforms lead young and low-income individuals to face less severe medical conditions and reduce their frequency of emergency room visits, thereby reducing overall levels of financial risks for these groups of households. This reduction in financial risks decreases defaults on ER bills and bankruptcies. These healthcare reforms decrease hospitals' mark-up because the amount of unpaid medical bills declines.

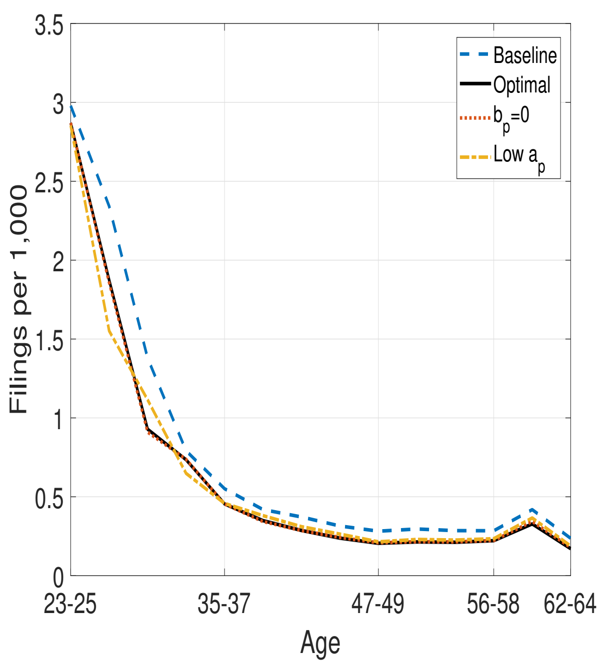
Table 9 shows that all these health insurance policies decrease overall debt because these policies decrease the demand for debts from medical reasons. These health insurance policies increase the risk-free interest rate because of general equilibrium effects. As mentioned previously, more

Table 9: Financial Outcomes

Moment	Baseline $[0.04, 0, 0]$	Optimal $[0.216, 10.24, 1]$	$b_p = 0$ $[0.344, 0, 0]$	Low $\bar{M}$ $[0.04, 10.42, 1]$	High $\bar{M}$ $[0.4, 10.42, 1]$	Low a_p $[0.216, 0.2, 1]$	High a_p $[0.216, 50, 1]$
AVG B.K. Rate	1.09%	0.91% (-16.5)	0.91% (-16.5)	0.9% (-17.4)	0.9% (-17.4)	0.9% (-17.4)	0.9% (-17.4)
% of B.K. with Med Bills	64%	56.9% (-11.1)	56.9% (-11.9)	56.4 (-11.9)	56.4% (-11.9)	57.4% (-10.3)	56.4% (-11.9)
Default Rate on ER Exp.	3.2%	2.01% (-37.2)	2.01% (-37.2)	1.99% (-37.8)	1.98% (-38.1)	2.03% (-36.6)	1.99% (-37.8)
Hospital's Mark-up	1.04	1.026 (-1.35)	1.026 (-1.35)	1.025 (-1.44)	1.026 (-1.35)	1026 (-1.35)	1.025 (-1.44)
Risk-free Int. Rate	4%	4.14% (+3.5)	4.12% (+3)	4.17% (+4.3)	4.14% (+3.5)	4.08% (+2)	4.19% (+4.8)
AVG BOR. Int. Rate	17.9%	18.7% (+4.5)	17.9% (0)	18.7% (+4.5)	18.6% (+3.9)	16.2% (-9.5)	18.8% (+5)
AVG Default Premium	13.9%	14.6% (+5)	13.8% (-0.7)	14.6 (+5)	14.5% (+4.3)	12.1% (-13)	14.6% (+5)
AVG Debt*	1,669	1,415 (-15.2)	1,431 (-14.3)	1397 (-16.3)	1,392 (-16.6)	1,430 (-14.3)	1394 (-16.5)

The model period is triennial . I transform the triennial moments into annual moments.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
The parentheses () indicate % change from the baseline economy.
* Unit=U.S. dollar in 2000.

income taxes are levied to finance these health insurance policies, which decreases the after-tax return on savings. This change decreases the aggregate supply of savings, which increases the risk-free interest rate. The direction of changes in the average borrowing interest rate is not universal because the above two offsetting forces determine this rate. The reduced demand for debts plays a role in raising the average borrowing interest rate, while the decrease in the aggregate supply of savings pushes up the average borrowing interest rate. The relative magnitude of these two forces determines the average borrowing interest rate at equilibrium.



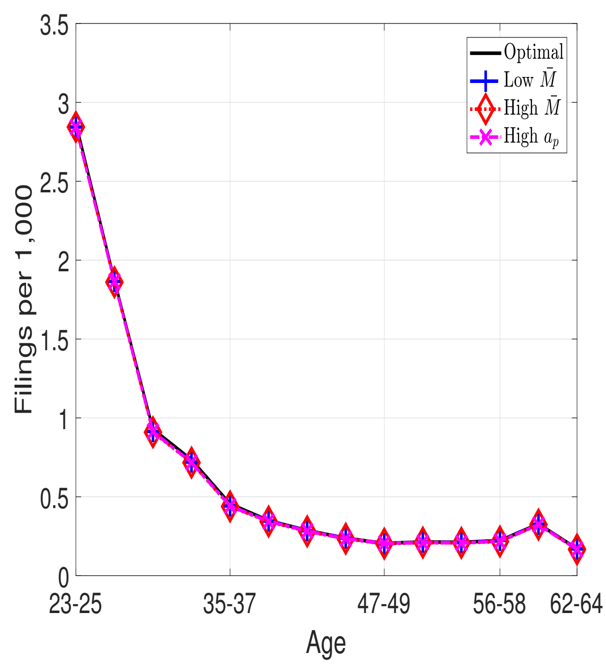


Figure 12: Bankruptcies over the Life-cycle

Figure 12 implies that the total take-up ratio is a key determinant of bankruptcy. The left panel of Figure 12 compares economies whose take-up ratio of health insurance is different. Recall that the take-up ratio of health insurance is the lowest in the baseline economy. As the take-up ratio increases, bankruptcies decline over the life-cycle. The right panel of Figure 12 compares economies whose take-up ratios are very close to one another. There is little difference across those economies, which implies that the take-up ratio of health insurance is the key determinant of bankruptcy. Figure 13 shows that the take-up ratio of health insurance is also the key determinant of defaults on ER bills. The right panel of Figure 13 compares economies in which the take-up ratios are different. The baseline economy generates the highest profiles of defaults on ER bills, while the other economies, whose take-up ratios are lower, show much lower levels of defaults on ER bills. The right panel of Figure 13 suggests that when there is little difference in the take-up ratios, defaults on ER bills are also very similar over the life-cycle.

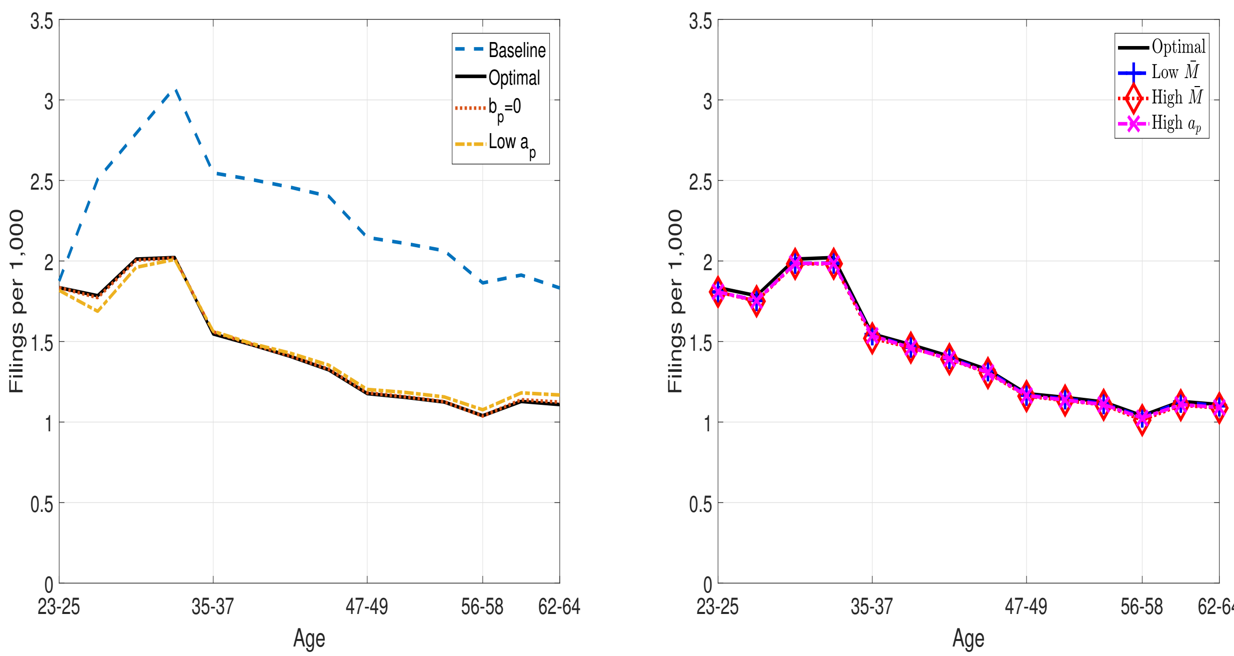


Figure 13: Defaults on ER Bills over the Life-cycle

4.2.2 Decomposition of the Welfare Change for the Optimal Health Insurance Policy

Welfare is determined by the level and distribution of consumption and health status because they are the components of the utility function. Due to the monotonicity and concavity of the utility function, the social welfare function (25) rises when the levels of consumption and health increase and inequalities in consumption and health decrease. The aggregate outcomes and life-cycle profiles may not be enough to understand welfare implications because the optimal health insurance policy might alter the level and distribution of consumption and health in predicting different directions of welfare changes. For example, Figure 11 indicates that this policy reduces inequality in consumption within cohort, but Figure 10 implies that consumption inequality across generations can increase due to the decrease in consumption among retired households. Thus, following Conesa et al. (2009), I decompose the CEV into four components: a component stemming from the change in the level of consumption, that from the change in the distribution of consumption, that from the change in the level of health, and that from the change in the distribution of health.[20]

Table 10 shows that changes in health are the main deriving forces behind the welfare improvement of the optimal health insurance policy. In particular, reduced health inequality plays the largest role in improving welfare. Although both changes in the level and distribution of health improve welfare, the contribution of the change in the distribution is more than seven times larger than that in the level. Although the change in consumption improves welfare, the impact is much

[20] Conesa et al. (2009) decompose welfare changes into these four components by using a feature of the utility function in their study: the utility function is homothetic with respect to consumption. Note that the utility function in this study is homothetic not with respect to consumption but with respect to both consumption and health. To decompose welfare changes, I modify the procedure in Conesa et al. (2009) as follows.

Regarding total change in welfare, I numerically compute CEV in (26). Let CEV_c^0 and CEV_h^0 be defined as

$$V((1+CEV_c^0)c_0,(1+CEV_c^0)h_0) = V(c_1,h_0)$$
$$V((1+CEV_h^0)c_0,(1+CEV_h^0)h_0) = V(c_0,h_1).$$

Because the utility function is not homothetic with respect to consumption, the summation of CEV_c^0 and CEV_h^0 is not equal to CEV. I rescale them by defining CEV_c and CEV_h as follows:

$$CEV_c = \frac{CEV_c^0}{CEV_c^0 + CEV_h^0} \times CEV$$
$$CEV_h = \frac{CEV_h^0}{CEV_c^0 + CEV_h^0} \times CEV.$$

I further decompose CEV_c^0 into a level effect CEV_{cl}^0 and a distributional effect CEV_{cd}^0 as follows:

$$V((1+CEV_{cl}^0)c_0,(1+CEV_{cl}^0)h_0) = V(\hat{c}_0,h_0)$$
$$V((1+CEV_{cd}^0)\hat{c}_0,(1+CEV_{cd}^0)h_0) = V(c_1,h_0)$$

where $\hat{c}_0 = \frac{C_1}{C_0}c_0$ is the consumption allocation by rescaling the allocation c_0 with the change in aggregate consumption $\frac{C_1}{C_0}$. Note that $CEV_c^0 \approx CEV_{cl}^0 + CEV_{cd}^0$, but this does not hold to CEV_c. I define CEV_{cl} and CEV_{cd} as follows:

$$CEV_{cl} = \frac{CEV_{cl}^0}{CEV_c^0 + CEV_h^0} \times CEV$$
$$CEV_{cd} = \frac{CEV_{cd}^0}{CEV_c^0 + CEV_h^0} \times CEV.$$

I take the same decomposition as that for health.

Table 10: Decomposition of Welfare Change

Total Change		+6.48
Consumption	Total	+1.37
	Level	+1.97
	Distribution	-0.60
Health	Total	+5.11
	Level	+0.60
	Distribution	+4.51

Unit = % change from the baseline economy

smaller than that of health. As seen in Table 8 and Figure 10, the increase in the consumption level improves welfare. However, the change in the distribution of consumption plays a role in reducing welfare, which implies that the effect of the decrease in the level of consumption for old households dominates the reduced consumption inequality within the cohort. This phenomenon implies that reallocating health across households is the largest driving force behind the welfare improvement of the optimal policy.

4.3 Comparison with an Economy with No Option to Default

I investigate the effects of the option to default on the optimal health insurance policy. To do so, I take the following steps. First, following the literature, I turn off the option to default by imposing a huge penalty on defaulting. Specifically, I restrict defaulting households to use only 1 percent of their income.[21] In this setting, households default only when their not-defaulting budget set is the empty set. Second, I re-calibrate the model with the same targets as in the baseline economy with the option to default. Finally, I find the optimal health insurance policy with no option to default and compare this policy with the optimal health insurance policy in the economy with the option to default. Note that in this economy, there is no borrowing because the level of the natural borrowing limit is zero.

4.3.1 Re-calibration

Table 11 shows the parameter values of the economy with no option to default. Because I re-calibrate only internally determined parameters, the values of parameters that are determined outside the model are the same as those in the case with the option to default. The values of the calibrated parameters differ between the economy with the option to default and that with no option to default, which reflects how the option to default makes a difference in households' behavior.

[21] One might consider not allowing the option to default mechanically without any penalty. This setting is not feasible because the monotonicity of the expected value function does not hold around the default region.

Table 11: Parameter Values of the Economy with No Option to Default

Parameter	Description	Internal	Value
Demographics			
J_0	Initial age	N	23
J_r	Retirement age	N	65
$\bar{J}$	Maximum length of life	N	100
π_n	Population growth rate (percent)	N	1.2%
Preferences			
λ_u	Weight on consumption	Y	0.487
υ	Elasticity of substitution b.w c and h_c	Y	0.382
σ	Risk aversion	N	3 (De Nardi, French and Jones (2010))
β	Discount factor	Y	0.719
Labor Income			
$\bar{\omega_j}$	Deterministic life-cycle profile	N	{0.0905,-0.0016}*
ϕ_h	Elasticity of labor income to health status	N	0.594
ρ_η	Persistence of labor productivity shocks	Y	0.847
σ_ϵ	Standard deviation of persistent shocks	Y	0.556
Health Technology			
κ_e	Scale of ER health shocks	Y	0.293
A_{j_g}	Age group effect on ER health shocks	Y	{1, 1.410, 1.481, 1.623, 1.603, 1.791}
p_{se}	Probability of drastic ER health shocks	N	0.2
κ_n	Scale of non-ER health shocks	Y	0.019
α_n	Dispersion of non-ER health shocks	Y	0.542
B_{j_g}	Age group effect of non-ER health shock	Y	{1, 0.690, 0.468, 0.296, 0.161, 0.013}
ψ_{j_g}	Efficiency of health technology	Y	{0.453, 0.422, 0.487, 0.577, 0.533, 0.201}
φ_{j_g}	Curvature of health technology	Y	{0.326, 0.221, 0.260, 0.258, 0.392, 0.668}
Survival Probability			
Γ_{j_g}	Age group effect on survival rate	Y	{0.004, 0.01, 0.016, 0.029, 0.113, 0.192, 0.554}
ν	Elasticity of survival rate to health status	N	0.226 (Franks, Gold and Fiscella (2003))
Health Insurance			
$\bar{y}$	Income threshold for Medicaid eligibility	Y	0.070
(q^n_{MCD}, q^e_{MCD})	Medicaid coverage rates	N	(0.7,0.8)
(q^n_{IHI}, q^e_{IHI})	IHI coverage rates	N	(0.55,0.7)
(q^n_{EHI}, q^e_{EHI})	EHI coverage rates	N	(0.7,0.8)
(q^n_{med}, q^e_{med})	Medicare coverage rates	N	(0.55,0.75)
p_{med}	Medicaid premium	N	0.021
$p(EHI\|\eta)$	EHI offer rate	Y	$0.9 \times p(EHI\|\eta)$ of the Baseline
ψ_{EHI}	Subsidy for EHI	N	0.8
ξ_{IHI}	Markup for IHI	Y	2.80
ξ_{EHI}	Markup for EHI	Y	1
Default			
$\bar{\zeta}$	Non-medical expense shocks $\zeta \sim U[0, \bar{\zeta}]$	N	0.033

Table 11 continued from previous page

Parameter	Description	Internal	Value
Tax and Government			
ss	Social Security benefit	N	0.256
τ_{ss}	Social Security tax	Y	0.084
τ_{med}	Medicare payroll tax	Y	0.046
G	Government spending/ GDP	N	0.18
a_0	Upper bound of the progressive tax fnc	N	0.258 (Gouveia and Strauss (1994))
a_1	Curvature of the progressive tax fnc	N	0.768 (Gouveia and Strauss (1994))
a_2	Scale of the progressive tax fnc	Y	1.312
τ_y	Proportional tax rate	Y	0.097
Firm			
z	Total factor productivity	N	0.557 (Baseline)
θ	Capital income share	N	0.36
δ	Depreciation rate	N	0.24
Hospital			
ζ	Mark-up of hospital	Y	1.001

In the economy with no option to default, the value of the substitution elasticity between consumption and health, ν, is larger than that in the baseline economy. This difference implies that households with no option to default are more likely to substitute non-medical spending into medical spending. Additionally, the value of β in the economy with no option to default is smaller than that with the option to default. Because households with no option to default must insure all health risks only through savings, they tend to save more than households with the option to default.[22] Recall that in the economy with the option to default, the offer rate of the EHI, $p(EHI|\eta)$, is computed from the data. However, with no option to default, its scale is adjusted to 0.9. Without any adjustment, the take-up ratio is approximately 75 percent in the model because all households that receive the offer use EHI to insure health risks. To match this moment in the model with its empirical counterpart, I calibrate the scale of the offer rate of the EHI. The mark-up of the hospital, ζ, is much lower in the economy without the option to default because strategic defaults are not allowed.

Table 12 reports the targeted aggregate moments in the economies with and without the option to default. Overall moments are close across the data, in the economy with the option to default, and in the economy without the option to default. Note that the average bankruptcy rate is not a target in the economy without the option to default because any voluntary defaults are not allowed. Because strategic default is not allowed in the economy without the option to default, the fraction of bankruptcy filers with medical bills is also not targeted. Those two moments have positive values in

[22] Recall that in this economy, there is no sustainable borrowing constraint because the natural borrowing limit is zero.

Table 12: Targeted Aggregate Moments in the Economies with and without the Option to Default

Moment	Target	w/ OPT DEF	w/o OPT DEF
Risk-free interest rate (percent)	4	4	4
AVG of bankruptcy rate (percent)	1	1.1	0.06*
Fraction of bankruptcy Filers with Medical Bills	0.62	0.64	1*
Total medical expenditures/GDP	0.163	0.163	0.165
CV of medical expenditures	2.67	2.57	2.53
Corr b.w. consumption and medical expenditures	0.153	0.153	0.153
Autocorrelation of earnings shocks	0.952	0.953	0.953
STD of log earnings	1.29	1.25	1.26
Fraction of ER users aged b.w. 23 and 34	0.125	0.128	0.124
AVG of health shocks b.w. ages of 23 and 34	0.116	0.124	0.124
Individual health insurance take-up ratio	0.11	0.095	0.104
Employer-based health insurance take-up ratio	0.685	0.650	0.654
Working-age households' Medicaid take-up ratio	0.044	0.044	0.043

The model period is triennial . I transform triennial moments into annual moments.
* : They are not targeted because there is no option to default.

the economy without the option to default because there exist extreme cases where non-defaulting households cannot have a positive consumption due to emergency bills and non-medical expense shocks. Figure 14 displays the targeted life-cycle moments in the economies with and without the option to default. Overall moments are close across the data, the economy with the option to default and the economy with no option to default.

4.3.2 Comparison of the Optimal Health Insurance Policies with and without the Option to Default

Table 13 implies that the option to default makes substantial differences in the features of optimal health insurance policies. With no option to default, the optimal health insurance policy is very close to the health insurance system in the baseline economy. When households cannot choose to default, the income threshold for Medicaid eligibility is 0.07 in the baseline economy, while it is 0.055 in the economy with the optimal policy. The optimal health insurance policy with no option to default increases the income threshold of the subsidy for the purchase of the IHI by 0.053 without reforming the IHI market. As a result, the composition of health insurance is very similar between the baseline economy and the economy with no option to default plus the optimal health insurance. When the option to default is not available, the average and the dispersion of medical expenditures are almost the same across the baseline economy and the economy with the optimal policy. However, in the economy with the option to default, the optimal policy decreases inequality

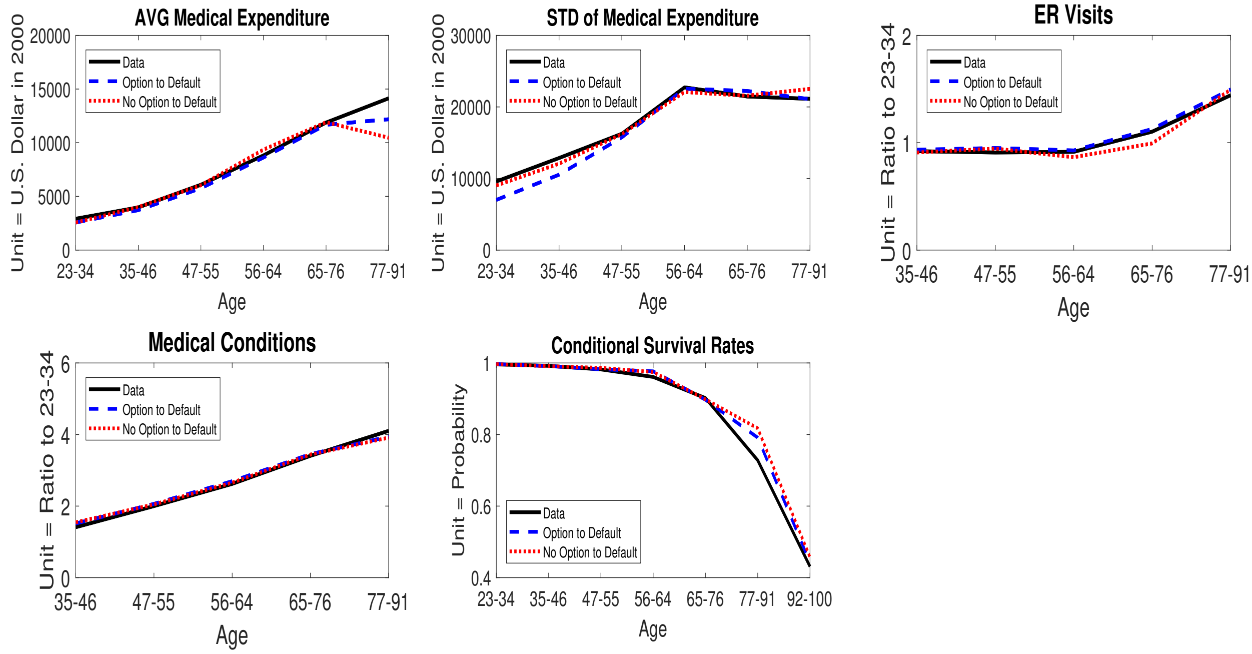


Figure 14: Targeted Life-cycle Moments in the Economies with and without the Option to Default

in medical spending more substantially.

Table 13: Optimal Health Insurance in the Economies with and without the Option to Default

Variable	Baseline	w/ OPT DEF	w/o OPT DEF
Optimal Health Insurance $(\bar{M}, a_p, b_p)$	–	$(0.216, 10.42, 1)$	$(0.055, 0.053, 0)$
Total Insurance Take-up Ratio	80.2%	97.9%	80.8%
Medicaid Take-up Ratio	4.3%	21.7%	2.4%
IHI Take-up Ratio	10.4%	57.5%	12.5%
EHI Take-up Ratio	65.4%	18.5%	65.9%
Total Medical Expenditure/GDP	0.1671	0.1670	0.1669
CV of Medical Expenditure	2.53	2.49	2.52

Table 14 implies that each of the optimal health insurance policies has different driving forces behind its welfare improvements through the status of the option to default. In the economy with the option to default, changes in health are the main driving force behind improvements in welfare, while without the option to default, changes in consumption take this role. With the option to default, changes in health account for improvements in welfare by 5.11 percent, but with no option to default, these changes increase welfare by 0.73 percent. This gap is largely attributable to the difference in distributional changes in health. When the option to default is allowed, changes in the distribution of health lead to improvements in welfare by 4.51 percent. However, with no option to default, changes in the distribution of health under the optimal policy play a minor role in welfare changes, which improves welfare by 0.73 percent. Furthermore, changes in consumption play a role in increasing welfare in both economies, but the source is different. In the economy with the option to default, changes in the distribution of consumption reduce welfare, but in the economy with no option to default, welfare gain stems from changes in both the level and distribution of consumption.

Table 14: Decomposition of Welfare Changes by the Option to Default

		w/ OPT DEF	w/o OPT DEF
Total Change		+6.48	+2.14
Consumption	Total	+1.37	+1.41
	Level	+1.97	+0.53
	Distribution	-0.60	+0.88
Health	Total	+5.11	+0.73
	Level	+0.60	0
	Distribution	+4.51	+0.73

Unit = Percentage change from each of the baseline economies.

To understand the mechanisms behind the difference in these welfare changes, Table 15 compares changes in aggregate variables from each of the baseline economies. Table 15 implies that whether the option to default is allowed brings about substantial differences in the effect of these optimal health insurance policies on changes in health. The average health increases by 4.54 percent in the economy with the option to default, while it increases by 0.9 percent in the economy without the option to default. Furthermore, with the option to default, the optimal policy reduces the standard deviation of the log of health by 7.28 percent, but the optimal policy without the option to default decreases it by 1.92 percent. These changes imply that different impacts of each of the optimal health insurance policies cause the different welfare implications in Table 14.

This difference in health causes differences in aggregate outcomes. In the economy with the option to default, the optimal health insurance policy increases output despite the reduced ratio of capital to output because improved health enhances overall labor productivity. Although the optimal policy with no option to default increases output, this is driven not only by improved health but also by an increase in capital. The optimal policy increases capital because its reduced threshold of income eligibility for Medicaid increases the precautionary motive for savings for medical reasons. The standard deviation of the log of earnings decreases more in the optimal policy with the option to default because the decrease in health inequality is larger in this case.

In both economies, each of the optimal health insurance policies increases the average level of consumption, which contributes to improvements in welfare. One might be concerned that the direction of changes in the inequality of consumption is inconsistent with welfare changes in Table 14. However, as mentioned previously, welfare changes from the distributional change in

Table 15: Changes of the Aggregate Variables from Each of the Baseline Economies

Moment	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
Output	+1.2	+1	-13.3
Capital/Output	-1.22	+1.22	-36.2
AVG of Cons	+1.93	+0.52	-19.59
STD of Log Cons	-6.17	+1.91	-12.93
AVG of Health	+4.54	+0.9	-1.77
STD of Log Health	-7.28	-1.92	-0.76
Units of Eff Labor	+1.97	+0.32	-0.34
STD of Log Earns	-3.03	-0.34	-0.76
AVG Tax Rate	+6.86	+0.38	+18.31

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

consumption are relevant not only to the dispersion within age groups but also to the curvature of the consumption life-cycle The details will be addressed again with the life-cycle profiles of consumption.

'Non-optimal w/o OPT DEF' shows that the optimal policy in the economy with the option to default cannot bring improvements in health if the option to default is not allowed. Rather, this policy deteriorates overall health status. This policy decreases the average income by reducing the aggregate stock of capital. This reduced capital is caused by a decrease in the after-tax return on savings to finance this health insurance policy without improvements in health. This reduction in income decreases consumption and medical spending, thereby causing worse health outcomes.

Table 16: Changes in the Average Medical Expenditure from Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	+6.83	+1.01	-1.63
35-46	+4.45	+0.02	-1.49
47-55	+4	+0.78	-6.97
56-64	+6.28	+1.82	-16.15
65-76	-0.18	+0.89	-21.68
77-100	-0.98	+0.58	-25.14

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

Table 16 implies that in the economy with the option to default, the optional health insurance policy increases medical spending for working-age households more than the optimal policy in the economy with no option to default does. In addition, Table 17 shows that in the economy with the option to default, the optimal health insurance policy reduces inequality in medical spending within age groups more than the optimal policy in the economy without the option to default does. 'Non-optimal w/o OPT DEF' shows that in the economy without the option to default, the optimal health insurance policy in the economy with the option to default cannot bring such changes in medical spending for working-age households. Rather, this policy reduces medical spending because of the reduction in the average income due to a decrease in capital from more taxes and general equilibrium effects.

Table 17: Changes in the Coefficient of Variation for Medical Expenditures from Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	-3.78	-0.3	-2.54
35-46	-4	+0.04	-10.16
47-55	-3.5	-0.19	-6.79
56-64	-4.15	-0.97	+1.84
65-76	-0.87	-0.6	+4.73
77-100	-1.34	-1.13	+1.15

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

These differences in medical spending behavior mean that when the option to default is available, young and low-income households substantially rely on defaults and bankruptcies as implicit health insurance. Thus, providing a more redistributive healthcare reform decreases the dependence on this implicit health insurance by leading young and low-income households to increase their spending on healthcare services. However, when the option to default is not available, even in the baseline economy, these households look after their health more carefully through medical spending because health risks would otherwise come as huge financial burdens over the life-cycle. Therefore, the optimal health insurance requires less redistributive healthcare reform than the optimal policy in the case with the option to default.

Table 18 and Table 19 show that these differences in medical spending behavior cause different evolutions in health over the life-cycle. Table 18 shows that when the option to default is available, the optional health insurance policy improves health more than the optimal policy in the case

Table 18: Changes in the Average Health Status for Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	+1.27	-0.03	-2.28
35-46	+6.06	+1.37	-1.02
47-55	+8.05	+1.68	+1
56-64	+8.15	+1.78	-0.08
65-76	+5.05	+1.1	-7.14
77-100	+0.54	+0.49	-11

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

without the option to default. In particular, with the option to default, the increase in medical spending for working-age periods drives substantial improvements in health for retired households. When the option to default is not available, the magnitude of improvements in health is weaker over the life-cycle. Table 19 shows that each of the optimal health insurance policies reduces health inequality over the life-cycle, but the magnitude is larger in the economy with the optimal. As Table 17 presents, this gap is driven by the magnitude of the reduced inequality in medical expenditure. The final columns of Table 18 and Table 19 show that when the optimal health insurance with the option to default is implemented in the economy without the option to default, this policy fails to improve health and reduce inequality in health because this policy does not change households' medical spending behavior to be preventative if the option to default is not available.

Table 20 shows that each of the optimal health insurance policies leads to increases in the levels of consumption over the life-cycle, and the magnitude is larger in the economy with the option to default. Improvements in health increase overall levels of labor income because this enhanced health increases the average labor productivity. This increase in labor income increases overall levels of consumption over the life-cycle, and the magnitude of this force is larger in the optimal policy with the option to default. The last column shows that when the optimal health insurance with the option to default is implemented in the economy with no option to default, overall consumption falls because of the reduction in the average income due to a drop in capital from more taxes and general equilibrium effects.

Table 21 demonstrates that the optimal health insurance policy with the option to default reduces inequality in consumption for overall age groups, while the optimal policy with no option to default increases inequality in consumption for working-age households. This gap arises because

Table 19: Changes in the STD of the LOG of Health from Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	-7.51	+0.94	+9.49
35-46	-19.62	-3.01	-3.43
47-55	-16.97	-5.04	-8.79
56-64	-10.38	-4.4	-6.14
65-76	-1.91	-0.3	+0.71
77-100	-0.6	+0.03	-8.06

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

Table 20: Changes in the Average Consumption from Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	+2.97	-1.13	-7.92
35-46	+2.51	+0.34	-19.34
47-55	+2.04	+1.31	-21.34
56-64	+1.57	+1.64	-22.83
65-76	-0.01	+0.75	-18.35
77-100	-1.24	-0.2	-12.19

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

the threshold of income eligibility for Medicaid is much higher in the optimal policy with the option to default. With the option to default, the optimal policy expands Medicaid up to working-age households whose income is 21.6 percent of the average income, but without the option to default, the optimal policy reduces the thresholds to working-age households whose income is 5.3 percent of the average income. The reduction in the threshold level increases consumption inequality because it reduces disposable income for low-income households. Inequality in consumption by the elderly increases in both economies because all these old households have to pay more taxes. The last column implies that its dispersion of consumption falls because of its more progressive income tax.

Note that welfare related to changes in the distribution of consumption is affected not only by

Table 21: Changes in the STD of the Log of Consumption from Each of the Baseline Economies

Age	Optimal w/ OPT DEF $[0.216, 10.24, 1]$	Optimal w/o OPT DEF $[0.055, 0.053, 0]$	Non-optimal w/o OPT DEF $[0.216, 10.24, 1]$
23-34	-0.72	+0.24	-7.29
35-46	-5.44	+5.78	-14.45
47-55	-7.56	+5.17	-11.46
56-64	-8.54	-1.18	-2.28
65-76	-3.66	-0.97	-5.82
77-100	-1.68	-0.32	-7.5

'Optimal w/ OPT DEF' represents the results of the optimal health insurance policy in the economy with the option to default. 'Optimal w/o OPT DEF' demonstrates the results of the optimal policy in the economy without the option to default. 'Non-optimal w/o OPT DEF' displays the results for the economy without the option to default while implementing the optimal health insurance policy for the economy with the option to default.
The square brackets [] indicate the health insurance policy $[\bar{M}, a_p, b_p]$.
Unit = Percentage change from each of the baseline economies.

consumption inequality within cohorts but also by the curvature of the life-cycle profile of consumption. If the average levels of consumption for young and old households increase, welfare improves not only through changes in the level of consumption but also through those in the distribution of consumption. This phenomenon occurs because these changes make the life-cycle profile of consumption flatter. This mechanism helps to understand the relationship between changes in consumption and welfare implications. In the economy with the option to default, although the optimal policy reduces consumption inequality within all age groups, it decreases the average consumption for old households, which makes the profile more curved. Hence, this policy improves welfare due to the level of consumption but has a small welfare loss from the distribution of consumption. In the case without the option to default, whereas the optimal policy increases consumption inequality within working-age cohorts, this policy increases the average consumption for households aged between 65 and 76, and the magnitude of the decrease in the consumption among households aged between 77 and 100 is mild. This policy improves welfare from changes in the distribution of consumption, which means that in this case, the effects of the changes in the life-cycle profile of consumption dominate those of changes in the inequality of consumption within cohorts in welfare changes.

5 Conclusion

This paper examines how defaults and bankruptcies affect optimal health insurance. I build a life-cycle general equilibrium model in which agents have the option to default on their emergency medical bills and financial debts. They decide to invest in health capital and occasionally face emergency room events. Using micro and macro data, I calibrate the model based on the U.S.

economy and use the model for the optimal health insurance policy. Then, I compare the optimal health insurance policy with the option to default to the optimal policy without the option to default.

I find that the availability of the option to default makes substantial differences in the features of the optimal health insurance. With no option to default, the optimal health insurance policy is almost the same as the health insurance system in the baseline economy. When the option to default is not available, households take care of their health more carefully through medical spending because health risks would otherwise become huge financial burdens over the life-cycles. However, when the option to default is available, the optimal health insurance is much more redistributive than the health insurance system in the baseline economy, which means that households with the option to default rely on defaults and bankruptcies as implicit health insurance. Therefore, implementing more redistributive health insurance policies can improve welfare by reducing the dependence on this implicit health insurance and changing households' medical spending behavior to be more preventative.

Regarding future research, it is important to understand the effects of other financial institutional features on healthcare reforms. In particular, housing plays an important role in households' borrowing and saving behavior. Examining how housing policies interact with optimal health insurance needs to be studied, given the importance of housing in households' financial activities. In addition, elaborating the insurance choice behavior of the elderly is essential. Here, health insurance policies are for working-age individuals, so those for the elderly are simplified. Given the considerable effect of long-term care on aggregate savings, as shown in Kopecky and Koreshkova (2014), studying how long-term care risks and health insurance interact with financial risks is a meaningful task. Such analyses are deferred to future work.

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Online Appendix

Appendix A Charges from ER Events across Income Levels

Table 22: Charges from ER Events by Income Groups

Income	Average Charges of ER Events*
0-20 pct	2443.56
20-40 pct	2436.46
40-60 pct	2249.54
60-80 pct	2307.37
80-100 pct	2325.41

Source: author's calculation based on the MEPS 2000-2011
* Unit = U.S. Dollar in 2000

Table 23: Charges from ER Events by Age and Income Groups

	Average Charges for ER Events*					
Income	Age 23 - 34	Age 35 - 46	Age 47 - 55	Age 56 -64	Age 65 - 76	Age 77 - 91
0-20 pct	1992.87	2222.93	2549.63	3025.09	2616.33	3154.18
20-40 pct	2094.95	2066.45	2752.9	2820.07	2902.95	2657.69
40-60 pct	2030.77	2129.41	2603.14	2625.31	2112.71	2197.29
60-80 pct	2023.42	2244.27	2394.9	2582.79	2348.57	2607.37
80-100 pct	2209.8	2051.07	2577.25	2464.83	2687.7	2284.63

Source: author's calculation based on the MEPS
* Unit = U.S. Dollar in 2000

Table 24: Regression Result of the Log of ER Charges

	Only Income	Age and Income
log income	0.122 (0.144)	0.12(0.144)
age		0.005778 (0.004)

I run an OLS regression of the log of ER charges on the log of income and age.
The parentheses indicate p-values.

Table 22 shows that differences in the average charges from ER events are small across income levels. The maximum gap is smaller than 200 dollars. Table 23 also confirms that the result is still robust after controlling age groups. There is no monotonic relationship between income and the amount of charges for ER events across age groups. Lastly, Table 24 indicates that the correlation between the log of charges for the ER and the log of income is not statistically significant at the 10 percent level.

Appendix B Findings on Emergency Room Visits, Medical Conditions, and Bankruptcy

Table 25: Correlation Between Health Risks and Income

Moment	Value
Corr b.w. Medical Conditions and Income	-0.146^{*}
Corr b.w. Fraction of ER Visits and Income	-0.078^{*}

[*]: statistically significant at the 5 level.

Table 25 shows that both medical conditions quantified by health shocks and the fraction of emergency room visits are negatively correlated with income.[23] The correlation between medical conditions and income is -0.146, and the correlation of the fraction of emergency room visits and income is -0.078. This indicates that the level of health risks differs across income levels. Low-income individuals are more exposed to health shocks than high-income individuals, and the poor are more exposed to emergency medical events, which is an important channel for default on emergency medical bills through the EMTALA.

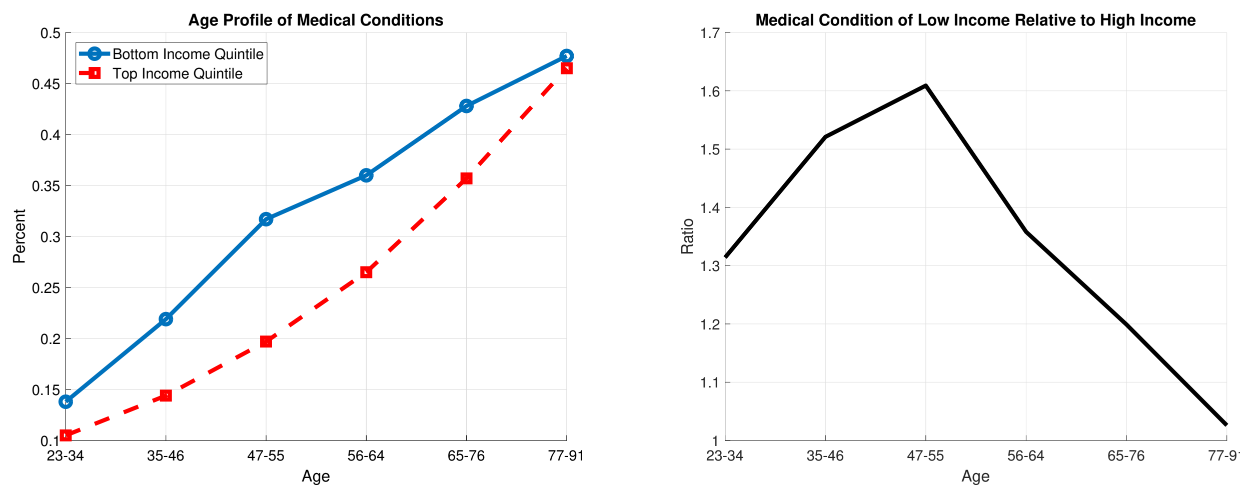


Figure 15: Age Profile of Medical Conditions

Figure 15 indicates the life cycle profile of medical conditions quantified by health shocks between high-income individuals and low-income individuals. Differences in medical conditions across income groups are shown over the whole phase of life-cycle. The gap in medical conditions increases until age 55 and declines around retirement periods and the difference gets diminished

[23] Appendix F presents how medical conditions in the Medical Expenditure and Panel Survey (MEPS) are quantified in details.

and keeps declining until later life. The gap rapidly rises until age 55, and decreases around retirement periods and getting smaller in later life. The gap is large when households within an age group are revealed by more different healthcare circumstances. For example, old households have small differences, as their healthcare circumstance might be more similar than young households due to Medicare.

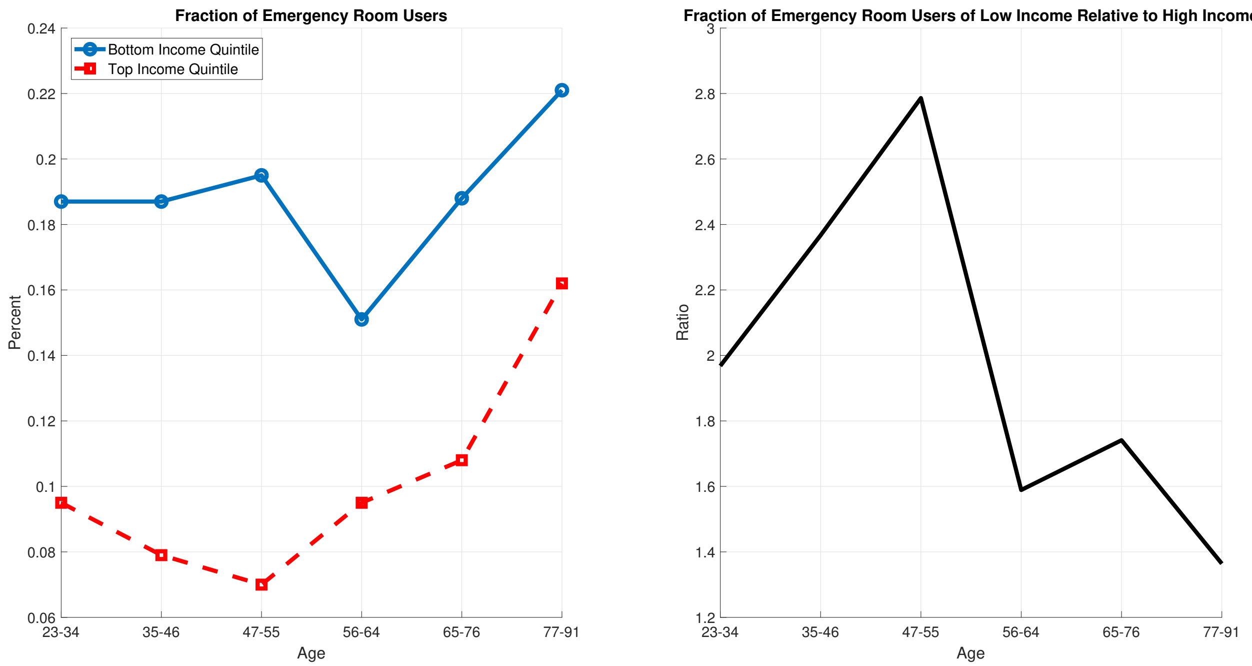


Figure 16: Age Profile of the Fraction of Emergency Room Visits

Figure 16 shows that the fraction of visiting emergency rooms between the top 20 percent income individuals and the bottom 20 percent income individuals over the life cycle. Differences in emergency room visits across income groups appear over the whole phase of life-cycle. These gaps become disproportionately larger during working-age periods. This implies that during working-age periods, low-income individuals are more substantially exposed to emergency medical events, which may lead low-income individuals medical defaults through the EMTALA. Given that old households have more similar health-related circumstances due to Medicare, the gap is larger when households within an age group have more differences in their health-related circumstances.

Table 26: Average Health Status by Bankruptcy Filing

	Health Status (PSID)		Health Status (SCF)	
	$23 \leq Age \leq 100$	$23 \leq Age \leq 64$	$23 \leq Age \leq 100$	$23 \leq Age \leq 64$
B.K. in 2 yrs	2.62	2.6	2.27	2.26
None	2.32	2.2	1.96	2.05

In the PSID, Excellent=1, Very good=2, Good=3, Fair=4, Poor=5.
In the SCF, Excellent=1, Good=2, Fair=3, Poor=4.
Source: Author's calculation based on the PSID in 1996 and the SCF in 2001.

Table 26 implies that those who have filed for bankruptcy in 2 years tend to have worse health status than those who did not file for bankruptcy. This findings is confirmed in both the PSID and the SCF.[24] This difference is still robust in working-age samples.

Table 27: Average Earnings by Bankruptcy Filing

	Earnings (PSID)	Earnings (SCF)
B.K. in 2 yrs	23643.3	32073.1
None	35130.6	53861.9

All samples are aged between 23 and 64.
In the PSID, Unit is U.S. dollar in 1995.
In the SCF, Unit is U.S. dollar in 2000.
Source: Author's calculation based on the PSID in 1996 and the SCF in 2001.

Table 27 shows that those who have filed for bankruptcy in 2 years have lower earnings than those who have no record related to bankruptcy filings. This is consistent with previous findings in the empirical literature. This results is observed in both the PSID and the SCF.

To sum up, first, the level of health risks vary across income groups. Low-income individuals are more exposed to health risks. In particular, the poor visit emergency rooms more frequently, which is an important trigger of default on emergency medical bills via the EMTALA. Second, those who have a record of filing for bankruptcies tend to have worse health status and low earnings. These findings imply interrelations among income, health risks and financial risks.

[24] A lower number means a better health status, although it is hard to interpreter the meaning of differences in numbers, as these numbers just indicate the ordering of health statuses.

Appendix C Household Dynamic Problems

The households' optimal decision problems can be represented recursively. I begin with the problems of working-age households. They start working at the initial age J_0 and continue working until age $J_r - 1$. The state of working-age households is $(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$ and $\upsilon \in \{G, B\}$, where a is their level of assets, i is health insurance, h is the stock of health capital, ϵ_e is emergency health shock, ϵ_n is non-emergency health shock, ζ is non-medical expense shocks, η is idiosyncratic shock on labor productivity and ω is the current offer status for employer-based health insurance. υ is the current credit history, where G and B mean good and bad credit history, respectively.

At the beginning of sub-period 1, emergency health shocks ϵ_e, non-emergency health shocks ϵ_n, non-medical expense shocks ζ, idiosyncratic shocks on earnings η, and the employer-based health insurance offer ω are realized. Next, individuals decide whether to default. Let $V_j^G(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$ ($V_j^B(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$) denote the value function of age $j < J_r$ agent with a good (bad) credit history in sub-period 1. They solve

$$V_j^G(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega) = \max \{v_j^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega), v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)\} \tag{27}$$

$$V_j^B(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega) = \max \{v_j^{B,N}(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega), v_j^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)\} \tag{28}$$

where $v_j^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$ ($v_j^{B,N}(a, i, h, \epsilon_e, \epsilon_n, \zeta, \eta, \omega)$) is the value of non-defaulting with a good credit (bad credit) history and $v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ ($v_j^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$) is the value of defaulting with a good credit (bad credit) history. The values of defaulting, $v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ and $v_j^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$, do not depend on the current assets a, as all assets and debts are eliminated with the default decision, $a = 0$.

Non-defaulters with a good credit history at age $j < J_r$ in age group j_g solve

$$v_j^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \zeta, \omega) = \max_{\{c,\, a',\, i',\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \underset{\epsilon_e'|h', \epsilon_n'|h', \eta'|\eta, \omega'|\eta', \zeta'}{\mathbb{E}} \left[V_{j+1}^{G}(a', i', h', \epsilon_e', \epsilon_n', \eta', \zeta', \omega')\right] \tag{29}$$

such that

$$c + q(a', i', h'; j, \eta) a' + p_{i'}(h_c, j_g)$$
$$\leq (1 - \tau_{ss} - \tau_{med}) w \bar{\omega}_j h_c^{\phi_h} \eta + a$$
$$- (1 - q_i^n)\, m_n + (1 - q_i^e)\, m_e(\epsilon_e) - \zeta - T(y) + \kappa$$

$$\zeta \sim U[0, \bar{\zeta}]$$
$$h_c = (1 - \epsilon_n)(1 - \epsilon_e) h$$
$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1 - \epsilon_n)(1 - \epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$i \in \{NHI, MCD, IHI, EHI\}$$
$$i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \;\&\; \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \;\&\; \omega = 0. \end{cases}$$
$$y = w \omega_j h_c^{\phi_h} \eta + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}$$

where c is consumption, a' is asset holdings in the next period, i' is the purchase of health insurance for the next period, m_n is non-emergency medical expenditure, h_c is the current health status and β is the discount rate. $\pi_{j+1|j}(h_c, j_g)$ is the rate of surviving up to age $j+1$ condition on surviving up to age j with the current status of health h_c in age group j_g. $\mathbb{E}_{\epsilon_e'|h', \epsilon_n'|h', \eta'|\eta, \omega'|\eta', \zeta'}$ is an expectation that is taken to non-medical expense shocks ζ', (non-) emergency health shocks (ϵ_n') ϵ_e', idiosyncratic shocks on labor productivity η' and the offer probability of employer-based health insurance ω', conditional on the current idiosyncratic labor productivity η and health capital h' for the next period. $q(a', i', h'; j, \eta)$ is the discount rate of loan for households with future endogenous state, (a', i', h'), conditional on the current idiosyncratic labor productivity, η and age j, and $p_{i'}(h_c, j_g)$ is the premium of health insurance i' for the next period given the current health status h_c and age group j_g. τ_{ss} and τ_{med} are payroll taxes for Social Security and Medicare, respectively. w is the market equilibrium wage, $\bar{\omega}_j$ is age-deterministic labor productivity, ϕ_c is the elasticity of earnings with respect to current health status h_c, and η is idiosyncratic shock on labor productivity. q_i^n and q_i^e are the coverage rate of health insurance i for non-emergency and emergency medical expense, respectively. $m_e(\epsilon_e)$ is emergency medical expense, $T(\cdot)$ is income tax, y is total income, and κ is accidental bequest. NHI means no health insurance, MCD is Medicaid, IHI is private individual health insurance, EHI is employer-based health insurance, $\bar{y}$ is the threshold for Medicaid eligibility, ω is the current offer status for employer-based health insurance, q^{rf} is the discount rate of the risk-free bond, and $\mathbb{1}_{a>0}$ is the indicator function for savings. Thus, $(\frac{1}{q^{rf}} - 1)a$ means capital income.

Note that the expectation is taken to emergency and non-emergency health shocks conditional on health capital $h^{'}$ for the next period, $\epsilon_e^{'}|h^{'}$ and $\epsilon_n^{'}|h^{'}$, as the distributions of these health shocks are determined by health capital $h^{'}$. In addition, the probability of the offer for employer-based health insurance is conditional on idiosyncratic shocks on earnings $\eta^{'}$ in the next period, as the offer rate $\omega^{'}$ increases with labor productivity level $\eta^{'}$.

Non-defaulters with a good credit history have an endowment from their labor income $w\bar{\omega}_j h_c^{\phi_h}\eta$, their current assets a and accidental bequest κ. Then, these households access financial intermediary to either borrow $(a^{'} < 0)$ at prices that reflect their default risk or save $(a^{'} > 0)$ at the risk-free interest rate. Afterward, they make decisions on consumption c, the purchase of health insurance $i^{'}$ and non-emergency medical expenditures m_n. In turn, non-defaulters with a good credit history pay a health insurance premium $p_{i'}(h_c, j_g)$, an out-of-pocket medical expenditures $(1 - q_i)(m_n + m_e(\epsilon_e))$, payroll taxes for Social Security and Medicaid $(\tau_{ss} + \tau_{med})w\bar{\omega}_j h_c^{\phi_h}\eta$ and income tax $T(y)$ for income $y = w\omega_j h_c^{\phi_h}\eta + (\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}$. They preserve the good credit history until the next period.

Defaulting households with a good credit history at age $j < J_r$ in age group j_g solve

$$v_j^{G,D}(i,h,\epsilon_e,\epsilon_n,\eta,\omega) = \max_{\{c,\, i',\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h', \epsilon_n'|h', \eta'|\eta, \omega'|\eta', \zeta'} \left[V_{j+1}^{B}(0, i', h', \epsilon_e', \epsilon_n', \zeta', \eta', \omega')\right] \quad (30)$$

such that

$$c + p_{i'}(h_c, j_g) = (1-\tau_{ss}-\tau_{med}) w \bar{\omega}_j h_c^{\phi_h} \eta - (1-q_i^n) m_n - T(y) + \kappa$$

$$\zeta \sim U[0, \bar{\zeta}]$$
$$h_c = (1-\epsilon_n)(1-\epsilon_e)h$$
$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$i \in \{NHI, MCD, IHI, EHI\}$$
$$i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0. \end{cases}$$
$$y = w\omega_j h_c^{\phi_h} \eta + \left(\frac{1}{q^{rf}} - 1\right) a \cdot \mathbb{1}_{a>0}.$$

On their budget constraint, debts from the financial intermediaries a, and emergency medical expenditures $m_e(\epsilon_e)$ and non-medical expense shocks ζ do not appear, as these individuals default on these two types of unsecured debts. Defaulters can determine the level of consumption c, the purchase of health insurance for the next period i', and non-emergency medical expenditure m_n, while they can neither save nor dissave in this period. In turn, they pay a health insurance premium $p_{i'}(h_c, j_g)$, an out-of-pocket medical expenditures $(1-q_i)m_n$, payroll taxes for Social Security and Medicaid $(\tau_{ss}+\tau_{med})w\bar{\omega}_j h_c^{\phi_h}\eta$, and income tax $T(y)$ for their labor income $y = w\omega_j h_c^{\phi_h}\eta$.

Non-defaulters with a bad credit history at age $j < J_r$ in age group j_g solve

$$
\begin{aligned}
v_j^{B,N}(a,i,h,\epsilon_e,\epsilon_n,\eta,\zeta,\omega) = & \max_{\{c,\, a'\geq 0,\, i',m_n\geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \quad (31)\\
& + \beta\pi_{j+1|j}(h_c,j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h',\epsilon_n'|h',\eta'|\eta,\omega'|\eta',\zeta'} \Big[\lambda V_{j+1}^G(a',i',h',\epsilon_e',\epsilon_n',\zeta',\eta',\omega') \\
& + (1-\lambda)V_{j+1}^B(a',i',h',\epsilon_e',\epsilon_n',\zeta',\eta',\omega')\Big] \\
& \text{such that} \\
& c + q^{rf}a' + p_{i'}(h_c,j_g) \\
& \leq (1-\tau_{ss}-\tau_{med})(1-\chi)w\bar{\omega}_j h_c^{\phi_h}\eta + a + \kappa \\
& - (1-q_i^n)\, m_n + (1-q_i^e)\, m_e(\epsilon_e) - \zeta - T(y) \\
& \\
& \zeta \sim U[0,\bar{\zeta}] \\
& h_c = (1-\epsilon_n)(1-\epsilon_e)h \\
& h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{j_g}} \\
& i \in \{NHI, MCD, IHI, EHI\} \\
& i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \;\&\; \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \;\&\; \omega = 0. \end{cases} \\
& y = w\omega_j h_c^{\phi_h}\eta + (\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}
\end{aligned}
$$

where λ is the probability of recovering their credit history to be good, and χ is a proportion of earnings that is paid for the pecuniary cost of staying with a bad credit history. Although the problem of non-defaulters with bad credit is similar to that of non-defaulters with good credit, there are three differences between two problems. First, non-defaulters with bad credit are not allowed to borrow but they can save, $a' \geq 0$. Second, they need to pay the pecuniary cost of having a bad credit history as much as a fraction χ of earnings, $\chi w\bar{\omega}_j h_c^{\phi_h}\eta$. Lastly, the status of its credit history in the next period is not deterministic. With a probability of λ, the status of credit history for non-defaulters with a bad credit history changes to be good, and they stay with a bad credit history with a probability of $1-\lambda$. This process reflects the exclusion penalty in Chapter 7 Bankruptcy of 10 years in the U.S.

Defaulters with a bad credit history at age $j < J_r$ in age group j_g solve

$$
\begin{aligned}
v_j^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega) = \max_{\{c,\, i',\, m_n \geq 0\}} & \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \\
& + \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e^{'}|h^{'}, \epsilon_n^{'}|h^{'}, \eta^{'}|\eta, \omega^{'}|\eta^{'}, \zeta^{'}} \left[V_{j+1}^{B}(0, i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \omega^{'})\right] \qquad (32)
\end{aligned}
$$

such that

$$
\begin{aligned}
& c + p_{i'}(h_c, j_g) = (1 - \tau_{ss} - \tau_{med})(1-\chi) w \bar{\omega}_j h_c^{\phi_h} \eta - (1 - q_i) m_n - T(y) + \kappa \\
& \\
& \zeta \sim U[0, \bar{\zeta}] \\
& h_c = (1-\epsilon_n)(1-\epsilon_e) h \\
& h^{'} = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}} \\
& i \in \{NHI, MCD, IHI, EHI\} \\
& i^{'} \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0. \end{cases} \\
& y = w \omega_j h_c^{\phi_h} \eta + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}.
\end{aligned}
$$

The problem of defaulters with a bad credit history has two differences compared to the case of households with a good credit history. First, defaulters with a bad credit history have to pay the pecuniary cost of staying bad credit as much as a fraction χ of their earnings, $\chi w \bar{\omega}_j h_c^{\phi_h} \eta$. Second, they default only on emergency medical expenses and non-medical expense shocks. For defaulters with bad credit, their previous status is either non-defaulter with bad credit or defaulters with good credit. In both statuses, individuals could not make any financial loan in the previous period.

Retired households at age $J_r \leq j \leq \bar{J}$ in age group j_g solve

$$V_j^r(a, h, \epsilon_e, \epsilon_n, \zeta) = \max_{\{c,\, a' \geq 0,\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \tag{33}$$

$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h', \epsilon_n'|h', \zeta'} \left[V_{j+1}^r(a', h', \epsilon_e', \epsilon_n', \zeta')\right]$$

such that

$$\zeta \sim U[0, \bar{\zeta}]$$

$$c + q^{rf} a' + p_{med} \leq ss + a + \kappa - (1 - q_{med}^n)\, m_n - (1 - q_{med}^e)\, m_e(\epsilon_e) - \zeta - T(y)$$

$$h_c = (1-\epsilon_n)(1-\epsilon_e)h$$

$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{j_g}}$$

$$y = ss + (\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}$$

where ss is Social Security benefit, p_{med} is the Medicare premium, and (q_{med}^e) q_{med}^n is the coverage rate of Medicare for (non-) emergency medical expenses. For simplicity, retired households cannot borrow, but they can save. I assume that retired households do not access private health insurance markets. Retired households do not have labor income, but receive Social Security benefit, ss, in each period. Thus, they pay income tax based on Social Security benefit ss and capital income $(\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}$. Retired households do not pay payroll taxes, as they do have labor income.

Appendix D Proof of proposition 2.7.1

Clausen and Strub (2017) introduce an envelope theorem to prove that First Order Conditions are necessary conditions for the global solution. They show that the envelop theorem is applicable to default models where idiosyncratic shocks on earnings are iid. I extend their application to solve this model, which has persistent idiosyncratic shocks on earnings. To use their envelope theorem, it is necessary to introduce the following definition.

Definition D.0.1. I say that $F : C \to \mathbb{R}$ is **differentiably sandwiched** between the lower and upper support functions $L, U : C \to \mathbb{R}$ at $\bar{c} \in C$ if

1. L is a differentiable lower support function of F at $\bar{c}$,i.e L is differentiable, $L(c) \leq F(c)$ for all $c \in C$, and $L(\bar{c}) = F(\bar{c})$.
2. U is a differentiable upper support function of F at $\bar{c}$,i.e U is differentiable, $U(c) \geq F(c)$ for all $c \in C$, and $U(\bar{c}) = F(\bar{c})$.

Let us begin with the FOC (17): For any $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$

$$\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}} \frac{\partial u(c, (1-\epsilon_e)(1-\epsilon_n)\bar{h})}{\partial c} = \frac{\partial W^G(a^{'}, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)}{\partial a^{'}}.$$

Lemma 2 (Maximum Lemma) and Lemma 3 (Reverse Calculus) in Clausen and Strub (2017) tell me that if each constituent function (q, u, W^G) of the FOC (17) has a differential lower support function at a point $a^{'}$, $q \times u$ and W^G are differentiable at $a^{'}$ and the FOC (17) is a necessary condition for the global solution.

Formally, **the proof of proposition 2.7.1** is as follows:

Proof. $u(\cdot, (1-\epsilon_e)(1-\epsilon_n)\bar{h})$ has trivially a differentiable lower support function, as itself is differentiable by the assumption. By lemma D.1 and lemma D.2, the discount rate of loan $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ and the expected value function $W^G(\cdot, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)$ have a differentiable lower support function, respectively. That implies that each $u(\cdot, (1-\epsilon_e)(1-\epsilon_n)\bar{h})$, $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ and $W^G(\cdot, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)$ has a differentiable lower support function. Lemma 3 (Reverse Calculus) in Clausen and Strub (2017) implies that the FOC (17) exists and holds. □

Lemma D.1. *Let a state $(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be given. Let $a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be the risk borrowing limit (credit limit) of $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$. For all $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$, the discount rate of loan $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ has a differentiable lower support function.*

Proof. Case1: For any $a \geq 0$, $q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) = \frac{1}{1+r^{rf}}$, and there by $\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}} = 0$. Thus, $q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ itself is a differentiable lower support function.

Case2: For any $a_{rbl}(\bar{i}', \bar{h}'; j, \eta) < a' < 0$, $q(a', \bar{i}', \bar{h}'; j, \eta) = \frac{1-d(a', \bar{i}', \bar{h}'; j, \eta)}{1+r^{rf}}$. It implies that finding a lower differentiable support function of $q(a', \bar{i}', \bar{h}'; j, \eta)$ is equivalent to doing a upper differentiable support function of

$d(a', \bar{i}', \bar{h}'; j, \eta) = \sum_{\epsilon_n', \epsilon_e', \eta', \omega'} \pi_{\epsilon_e'|h'} \pi_{\epsilon_n'|h'} \pi_{\eta'|\eta} \pi_{\omega'|\eta'} \mathbb{1}_{\{v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \leq v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}}$

, where $\mathbf{s}_1' = (\bar{i}', \bar{h}', \epsilon_e', \epsilon_n', \omega')$. Let us transform $\pi_{\eta'|\eta}$ to a continuous PDF $f(\eta'|\eta)$. Given state $\mathbf{s}_1'$, let us denote $\delta(a', \eta; \mathbf{s_1'}) = \pi_{\epsilon_e'|\mathbf{h}'} \pi_{\epsilon_n'|\mathbf{h}'} \int \mathbb{1}_{\{\mathbf{v^{G,N}(a', s_1', \eta', j+1) \leq v^{G,D}(s_1', \eta', j+1)}\}} \pi_{\omega'|\eta'} \mathbf{f}(\eta'|\eta) \mathbf{d}\eta'$. Since $a' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$, $\{\eta' : v^{G,N}(a', \mathbf{s_1}, \eta', j+1) \leq v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}$ is non-empty. Theorem 3 (The Maximal Default Set Is a Closed Interval) and Theorem 4 (Maximal Default Set Expands with Indebtedness) in Chatterjee et al. (2007) imply that for any $a' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$ and for each state $(\mathbf{s}_1', \eta', j+1)$, there are two points $\eta_1'(a'; \mathbf{s}_1', j+1)$ and $\eta_2'(a'; \mathbf{s}_1', j+1)$ such that (i) $\{\eta' : v^{G,N}(a', \mathbf{s_1}, \eta', j+1) \leq v^{G,D}(\mathbf{s_1'}, \eta', j+1)\} = [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]$ and (ii) for any $a' < a''$, $[\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)] \subset [\eta_1'(a''; \mathbf{s}_1', j+1), \eta_2'(a''; \mathbf{s}_1', j+1)]$. The first property means

$\int_{\{\eta': v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \leq v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta' = \int_{\eta' \in [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$

, and the second property implies that $\eta_1'(a'; \mathbf{s}_1', j+1)$ increases with a' and $\eta_2'(a'; \mathbf{s}_1', j+1)$ decreases with a'.

Since $\int_{\eta' \in [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$

$= \int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta' - \int_{-\infty}^{\eta_1'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$, if there is an upper differentiable support of $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ and an lower differentiable support of

$\int_{-\infty}^{\eta_1'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$, $\delta(a', \eta; \mathbf{s_1'}) = \int_{\eta' \in [\eta_1'(\mathbf{a}'; \mathbf{s_1'}, \mathbf{j+1}), \eta_2'(\mathbf{a}'; \mathbf{s_1'}, \mathbf{j+1})]} \pi_{\omega'|\eta'} \mathbf{f}(\eta'|\eta) \mathbf{d}\eta'$ has a differentiable lower support. Without loss of generality, I will prove the existence of a differentiable upper support of

$\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$.

Claim: $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ has an upper differentiable support.

Proof of the claim: Finding an upper support function of $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ is equivalent to searching for an upper support function of $\eta_2'(a'; \mathbf{s}_1', j+1)$. I am going to use the implicit function theorem to find an upper differentiable support. Take any $\hat{a}' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$ and $\eta' \in (\eta_1'(\hat{a}'; \mathbf{s}_1', j+1), \eta_2'(\hat{a}'; \mathbf{s}_1', j+1))$. Pick any $\epsilon_1 < \eta_2'(\hat{a}'; \mathbf{s}_1', j+1) - \eta_1'(\hat{a}'; \mathbf{s}_1', j+1)$. Consider a case that for a realized value $(a', \eta') \in B((\hat{a}', \eta_2'(a'; \mathbf{s}_1', j+1)), \epsilon)$, a household anticipates state $(a', \eta') = (a', \eta_2'(a'; \mathbf{s}_1', j+1))$. In other words, the household correctly recognizes a' but incorrectly acknowledges η'. Then, in the period after the next period, the decision rule for asset holdings is $a'' = g_a(a', \eta_2'(a'; \mathbf{s}_1', j+1)$. Define this borrower's net value function $L(a', \eta'; \hat{a}')$ on

$B((a^{'}, \eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)), \epsilon)$ in the following way:

$$
\begin{aligned}
L(a^{'}, \eta^{'}; \hat{a}^{'}) = u\Big(w\bar{\omega}_j h_c \eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) \\
-T(y^{'}) + \kappa^{'} - q(g_a(a^{'}, \eta_2^{'}(a^{'}i^{''}, h^{''}; \eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1), j+1) g_a(a^{'}i^{''}, h^{''}, \eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1), j+1) - p_{i^{''}}, h_c^{'}\Big) \\
-u\Big(w\bar{\omega}_j h_c \eta^{'} - (1-q_i)m_n^{'} - T(y^{'}) + \kappa^{'} - p_{i^{''}}, h_c^{'}\Big) \\
+\beta \pi_{j+2|j+1}(h_c^{'}, j_g) \underset{\epsilon_e^{''}|h^{''}, \epsilon_n^{''}|h^{''}, \eta^{''}|\eta_2^{'}(a^{'}i^{''}, h^{''}), \omega^{''}|\eta^{''}}{\mathbb{E}} \Bigg[\Big[V^G(g_a(a^{'}, \eta_2^{'}(a^{'}i^{''}, h^{''}), \eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)), i^{''}, h^{''}, \epsilon_e^{''}, \epsilon_n^{''}, \eta^{''}, \omega^{''}, j+2)\Big] \\
-\Big[V^B(0, \eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)), i^{''}, h^{''}, \epsilon_e^{''}, \epsilon_n^{''}, \eta^{''}, \omega^{''}, j+2)\Big]\Bigg]
\end{aligned} \tag{34}
$$

Note that the value function is continuous and differentiable on $B\left((\hat{a}^{'}, \eta_2^{'}(\hat{a}^{'}; \mathbf{s}_1^{'}, j+1)), \epsilon\right)$, as the utility function u is differentiable. Also, this value function is an implicit function for $a^{'}$ and $\eta^{'}$, and $L(\hat{a}^{'}, \eta_2^{'}(\hat{a}^{'}; \mathbf{s}_1^{'}, j+1)); \hat{a}^{'}) = 0$. The value function is differentiable with respect to $\eta^{'}$ and its value is non-zero (positive). Thus, the implicit function theorem implies that there is an open neighborhood U of $\hat{a}^{'}$ and an open neighborhood V of $\eta_2^{'}(\hat{a}^{'}; \mathbf{s}_1^{'}, j+1))$ such that $\bar{\eta}^{'} = \bar{\eta}^{'}(a^{'}, \hat{a}^{'})$ satisfies

$$L(a^{'}, \bar{\eta}^{'}(a^{'}, \hat{a}^{'}); \hat{a}^{'}) = 0$$

, where $\bar{\eta}^{'} \in V$ and $a^{'} \in U$. Since this household overvalues repaying debt, $\bar{\eta}^{'}(\cdot, \hat{a}^{'})$ is an upper support of $\eta_2^{'}(\cdot; \mathbf{s}_1^{'}, j+1)$ at $\hat{a}^{'}$. Furthermore, the implicit function theorem implies that $\bar{\eta}^{'}(\cdot, \hat{a}^{'})$ is differentiable on U. Thus, $\bar{\eta}^{'}(\cdot, \hat{a}^{'})$ is an upper differentiable support function of $\eta_2^{'}(\cdot; \mathbf{s}_1^{'}, j+1)$ at $\hat{a}^{'}$. Since the statement holds for all $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$, $\eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)$ has an upper differentiable upper support for all $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$. Therefore, the claim is proven. Q.E.D.

Since $\int_{-\infty}^{\eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)} \pi_{\omega^{'}|\eta^{'}} f(\eta^{'}|\eta) d\eta^{'}$ has an upper differentiable support function,
$d(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) = \sum_{\epsilon_n^{'}, \epsilon_e^{'}, \eta^{'}, \omega^{'}} \pi_{\epsilon_e^{'}|h^{'}} \pi_{\epsilon_n^{'}|h^{'}} \int_{-\infty}^{\eta_2^{'}(a^{'}; \mathbf{s}_1^{'}, j+1)} \pi_{\omega^{'}|\eta^{'}} f(\eta^{'}|\eta) d\eta^{'}$ has an upper differentiable support function. □

Lemma D.2. *Let a state $(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be given. Let $a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be the risk borrowing limit (credit limit) of $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$. For all $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$, the expected value function $W^G(\cdot, \bar{i}^{'}, \bar{h}^{'}; \eta, j+1)$ has a differentiable lower support function.*

Proof. To ease notation, let us denote $\mathbf{s}_1^{'} = (\bar{i}^{'}, \bar{h}^{'}, \epsilon_e, \epsilon_n, \eta^{'}, \omega^{'})$
(i) Case 1: $\bar{a}^{'} > 0$.
In this case, the discount rate of loan becomes q^{rf}. I can use the standard technique of Benveniste and Scheinkman's theorem. Consider a case that for a realized value $(a^{'}, \eta^{'})$, a household takes $a^{''} = g_a(\bar{a}^{'}, \mathbf{s}_1^{'}, j+1)$ for all $a^{'}$ and $\eta^{'}$. Let us define this agent's net value function $L(a^{'}, \eta^{'}; \bar{a}^{'})$ in

the following way:

$$L^0(a^{'},\eta^{'};\bar{a}^{'},\mathbf{s}_1^{'}) = u\Big(w\bar{\omega}_j h_c\eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) - T(y^{'}) + \kappa^{'} - q^{rf} g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1) - p_{i^{''}}, h_c^{'}\Big) \tag{35}$$

$$+\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^G(g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big]$$

Since there is no debt, the agent does not default. Thus, $L^0(\bar{a}^{'},\eta^{'};\bar{a}^{'}) = V^G(\bar{a}^{'},\mathbf{s}_1^{'}) = v^{G,N}(\bar{a}^{'},\mathbf{s}_1^{'})$ and $L(a^{'},\eta^{'};\bar{a}^{'}) \le V^G(a^{'},\mathbf{s}_1^{'})$ for all $a^{'} \ge 0$. Moreover, $L(a^{'},\eta^{'};\bar{a}^{'})$ is differentiable at $\bar{a^{'}}$. Therefore, $L(\cdot,\eta^{'};\bar{a}^{'})$ is a lower differentiable support function of $V^G(\bar{a}^{'},\mathbf{s}_1^{'})$.
(ii) Case2: $a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta) < \bar{a}^{'} < 0$.
Let us consider a case for realized value $(a^{'},\eta^{'})$, a household takes $a^{''} = g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1)$ for all $a^{'}$ and $\eta^{'}$. Let us define this agent's net value function $L^1(a^{'},\eta^{'};\bar{a}^{'})$ in the following way:

$$\begin{aligned} L^1(a^{'},\eta^{'};\bar{a}^{'},\mathbf{s}_1^{'}) = \max\Big\{ & u\Big(w\bar{\omega}_j h_c\eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) \\ & -T(y^{'}) + \kappa^{'} - q - q(g_a(a^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''};\eta^{'},j+1)g_a(a^{'},\mathbf{s}_1^{'},j+1) - p_{i^{''}}, h_c^{'}\Big) \\ & +\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^G(g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big], \\ & u\Big(w\bar{\omega}_j h_c\eta^{'} - (1-q_i)m_n^{'} - T(y^{'}) + \kappa^{'} - p_{i^{''}}, h_c^{'}\Big) \\ & +\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^B(0,i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big] \Big\} \end{aligned} \tag{36}$$

$L^1(\bar{a}^{'},\eta^{'};\bar{a}^{'}) = V^G(\bar{a}^{'},\mathbf{s}_1^{'})$ and $L^1(a^{'},\eta^{'};\bar{a}^{'}) \le V^G(a^{'},\mathbf{s}_1^{'})$ for all $a^{'} \ge 0$. Moreover, $L(a^{'},\eta^{'};\bar{a}^{'})$ is differentiable with respect to $a^{'}$. Therefore, $L^1(\cdot,\eta^{'};\bar{a}^{'})$ is a lower differentiable support function of $V^G(\bar{a}^{'},\mathbf{s}_1^{'})$.

□

Appendix E Recursive Equilibrium

I define a measure space to describe equilibrium. To ease notation, I denote $\mathbf{S} = \mathbf{A} \times \mathbf{I} \times \mathbf{H} \times \mathbf{ER} \times \mathbf{NER} \times \mathbf{E} \times \mathbf{O} \times \Upsilon$ as the state space of households, where $\mathbf{A}$ is the space of households' assets a, $\mathbf{I}$ is the space of households' health insurance i, $\mathbf{H}$ is the space of households' health capital h, $\mathbf{ER}$ is the space of emergency health shocks ϵ_e, $\mathbf{NER}$ is the space of non-emergency health shocks ϵ_n, $\mathbf{O}$ is the space of the offer of employer-based health insurance ω and Υ is the space of credit history $\upsilon \in \{G, B\}$. In addition, let $\mathbb{B}(\mathbf{S})$ denote the Borel σ-algebra on $\mathbf{S}$. In addition, I denote $\mathbf{J} = \{J_0, \cdots, J_r, \cdots, \bar{J}\}$ as the space of households' age. Then, for each age j, a probability measure $\mu(\cdot, j)$ is defined on the Borel σ-algebra $\mathbb{B}(\mathbf{S})$ such that $\mu(\cdot, j) : \mathbb{B}(\mathbf{S}) \longrightarrow [0, 1]$. $\mu(B, j)$ represents the measure of age j households whose state lies in $B \in \mathbb{B}(\mathbf{S})$ as a proportion of all age j. The households' distribution at age j in age group j_g evolves as follows: For all $B \in \mathbb{B}(\mathbf{S})$,

$$\mu(B, j+1) = \int_{\left\{\mathbf{s} | \left(g_a(\mathbf{s},j), g_i(\mathbf{s},j), g_h(\mathbf{s},j), \epsilon_e', \epsilon_n', \eta', \omega', \upsilon'\right) \in B\right\}} \left[\Gamma_{\upsilon}^{\upsilon'} \; \pi_{j+1|j}(h_c, j_g) \; \pi_{\epsilon_e'|g_h(\mathbf{s},j)} \; \pi_{\epsilon_n'|g_h(\mathbf{s},j)} \; \pi_{\eta'|\eta} \; \pi_{\omega'|\eta'}\right] \; \mu(d\mathbf{s}, j) \tag{37}$$

where $\mathbf{s} = (a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, \upsilon) \in \mathbf{S}$ is the individual state. $g_a(\cdot, j)$ is the policy function for assets at age j, $g_i(\cdot, j)$ is the policy function for health insurance at age j, and $g_h(\cdot, j)$ is the policy function for health investment at age j. In addition, $\Gamma_{\upsilon}^{\upsilon'}$ is the transitional probability of credit history υ' in the next period conditional on the current status of credit history υ, $\pi_{j+1|j}(h_c, j_g)$ is the rate of surviving up to age $j+1$ conditional on surviving up to age j with the current health status h_c in age group j_g and $\pi_{\epsilon_e'|g_h(\mathbf{s},j)}$ ($\pi_{\epsilon_n'|g_h(\mathbf{s},j)}$) is the transition probability for ϵ_e' (ϵ_n') conditional on $g_h(\mathbf{s}, j)$. $\pi_{\eta'|\eta}$ is the transitional probability of idiosyncratic labor productivity for the next period η' conditional on η and $\pi_{\omega'|\eta'}$ is the probability of receiving an employer-based health insurance offer ω' for the next period conditional on η'.

Definition E.0.1 (***Recursive Competitive Equilibrium***)**.** Given an distribution of newborn agents $B_0 \in \mathbf{S}$, a social Security benefit ss, a Medicare coverage rate q_{med}, a Medicare premium p_{med}, a subsidy rule for employer-based health insurance ψ_{EHI}, mark-ups of health private insurances ν_{IHI} and ν_{EHI}, an income threshold for Medicaid eligibility $\bar{y}$, health insurance coverage rates $\{q_{MDC}, q_{IHI}, q_{EHI}\}$, private individual health insurance pricing rules $\{p_{IHI}(\cdot, j_g)\}_{j_g=1}^{4}$, subsidies for private individual health insurances $\psi_{EHI}(\cdot, \cdot)$, a tax policy, $\{T(\cdot), \tau_{ss}, \tau_{med}\}$,
a recursive competitive equilibrium is
a set of prices $\left\{w, r^{rf}, r, q^{rf}, \{q(\cdot, \cdot, \cdot, j, \cdot)\}_{j=J_0}^{J_r-1}, \{p(\cdot, j_g)\}_{j_g=1}^{4}, p_{med}\right\}$
, a set of the mark-up of hospital $\{\zeta\}$
, a set of decision rules for households $\left\{\{g_d(\cdot, j), g_a(\cdot, j), g_i(\cdot, j), g_h(\cdot, j)\}_{j=J_0}^{\bar{J}}\right\}$
, a set of default probability function $\left\{d(\cdot, \cdot, \cdot; j, \cdot)\}_{j=J_0}^{\bar{J}}\right\}$

, a set of values $\Big\{ \{V^G(\cdot,j), v^{G,N}(\cdot,j), v^{G,D}(\cdot,j), V^B(\cdot,j), v^{B,N}(\cdot,j), v^{B,D}(\cdot,j)\}_{j=J_0}^{J_r-1},$
$\{v^{G,r}(\cdot,j), v^{B,r}(\cdot,j)\}_{j=J_r}^{\bar{J}} \Big\}$
and distributions of households $\{\mu(\cdot,j)\}_{j=J_0}^{\bar{J}}$ such that

(i) Given prices, the policies above, the decision rules $g_d(\mathbf{s},j), g_a(\mathbf{s},j), g_i(\mathbf{s},j)$ and $g_h(\mathbf{s},j)$ solve the household problems in Appendix C and $V^G(\cdot,j), v^{G,N}(\cdot,j), v^{G,D}(\cdot,j), V^B(\cdot,j)$, $v^{B,N}(\cdot,j), v^{B,D}(\cdot,j), v^{G,r}(\cdot,j)$ and $v^{B,r}(\cdot,j)$ are the associated value functions.

(ii) Firm is competitive pricing:

$$w = \frac{\partial zF(K,N)}{\partial N}, \quad r = \frac{\partial zF(K,N)}{\partial K}$$

, where K is the quantity of aggregate capital, and $N$is the quantity of aggregate labor.

(iii) Loan prices and default probabilities are consistent, whereby lenders earn zero expected profits on each loan of size $a^{'}$ for households with age j that have health insurance $i^{'}$ for the next period, health capital $h^{'}$ for the next period and the current idiosyncratic shock on earnings η:

$$\begin{aligned} q(a^{'},i^{'},h^{'};j,\eta) &= \frac{(1-d(a^{'},i^{'},h^{'};j,\eta))}{1+r^{rf}} \\ d(a^{'},i^{'},h^{'};j,\eta) &= \sum_{\epsilon_n^{'},\epsilon_e^{'},\eta^{'},\omega^{'}} \pi_{\epsilon_e^{'}|h^{'}}\pi_{\epsilon_n^{'}|h^{'}}\pi_{\eta^{'}|\eta}\pi_{\omega^{'}|\eta^{'}}\mathbb{1}_{\{v^{G,N}(\mathbf{s}_n^{'},j+1)\,\leq\, v^{G,D}(\mathbf{s}_d^{'},j+1)\}} \end{aligned}$$

, where $s_n^{'} = (a^{'},i^{'},h^{'},\epsilon_e^{'},\epsilon_n^{'},\eta^{'},\omega^{'},j+1)$ and $s_d^{'} = (i^{'},h^{'},\epsilon_e^{'},\epsilon_n^{'},\eta^{'},\omega^{'},j+1)$.

(iv) The hospital has zero profit:

$$\sum_{j=J_0}^{\bar{J}} \int \Bigg\{ [m_n(\mathbf{s},j) + (1-g_d(\mathbf{s},j))m_e(\epsilon_e) + g_d(\mathbf{s},j)\max(a,0)] \\ - \frac{(m_n(\mathbf{s},j)+m_e(\epsilon_e))}{\zeta} \Bigg\} \mu(d\mathbf{s},j) = 0.$$

(v) The bond market and the capital market are clear:

$$
\begin{aligned}
r^{rf} &= r - \delta \\
q^{rf} &= \frac{1}{1 + r^{rf}} \\
K &= \sum_{j=J_0}^{\bar{J}} \Bigg[\int \Big(q(g_a(\mathbf{s}, j), g_i(\mathbf{s}, j), g_h(\mathbf{s}, j); j, \eta) g_a(\mathbf{s}, j) \\
&\quad + (p(g_i, h_c, j_g) \cdot \mathbb{1}_{\{g_i(\mathbf{s},j) \in \{IHI, EHI\}\}} \Big) \mu(d\mathbf{s}, j) \Bigg].
\end{aligned}
$$

(vi) The labor market is clear:

$$
N = \sum_{j=J_0}^{J_r - 1} \left[\bar{\omega}_j \int \left((1 - \epsilon_e)(1 - \epsilon_n) h \eta \right) \mu(d\mathbf{s}, j) \right].
$$

(vii) The goods market is clear:

$$
\underbrace{\sum_{j=J_0}^{\bar{J}} \left[\int \left(c(\mathbf{s}, j) + \frac{m_n(\mathbf{s}, j) + m_e(\epsilon_e)}{\zeta} \right) \mu(d\mathbf{s}, j) \right]}_{\text{Aggregate Non-medical Consumption + Aggregate Medical Expenditures}} + \underbrace{K - (1-\delta)K}_{\text{Aggregate Investment}}
$$

$$
+ \underbrace{G}_{\text{Government Spending Irrelevant to Health Insurance}}
$$

$$
+ \sum_{j=J_0}^{J_{r-1}} \Bigg[\int \Big\{ \underbrace{\left(\psi_{IHI}(p_{IHI}(h_c, j_g), y(\mathbf{s}, j)) \cdot \mathbb{1}_{\{g_i(\mathbf{s},j)=IHI\}} \right)}_{\text{Government Subsidy for Private Individual Health Insurance IHI}}
$$

$$
+ \underbrace{\left(\psi_{EHI} \cdot p_{EHI} \cdot \mathbb{1}_{\{g_i(\mathbf{s},j)=EHI\}} \right) \Big\}}_{\text{Government Subsidy for Employer-Based Health Insurance EHI}} \quad \mu(d\mathbf{s}, j) \Bigg]
$$

$$
= \underbrace{zF(K, N)}_{\text{Total Output}}
$$

$$
\underbrace{- \chi w \sum_{j=J_0}^{J_r-1} \left[\bar{\omega}_j \int \left((1-\epsilon_e)(1-\epsilon_n) h_c g_d(\mathbf{s}, j) \right) \mu(d\mathbf{s}, j) \right]}_{\text{Deadweight Loss from Default}}
$$

$$
\underbrace{- \sum_{j=J_0}^{J_r-1} \left[\int \left(\nu_{g_i} p_{g_i}(h_c, j_g) \mathbb{1}_{\{g_i(\mathbf{s},j) \in \{IHI, EHI\}\}} \right) \mu(d\mathbf{s}, j) \right]}_{\text{Deadweight Loss due to the Mark-up of Private Health Insurance Markets}}.
$$

(viii) The insurance markets are clear:

For each age group j_g and each health group h_g, the premium of the private individual health insurance $p_{IHI}(h_g, j_g)$ satisfies

$$
\underbrace{(1 + \nu_{IHI})}_{\text{Mark-up of IHI}} \underbrace{\sum_{j \in J_g} \int q_{IHI} \cdot \mathbb{1}_{\{\{i=IHI\} \cap \{h \in h_g\}\}} \cdot (m_n(\mathbf{s}, j) + m_e(\epsilon_{e,t})) \mu(d\mathbf{s}, j)}_{\text{Total Medical Expenditure Covered by IHI}}
$$

$$
= (1 + r^{rf}) \, p_{IHI}(h_g, j_g) \underbrace{\sum_{j \in J_g} \int \mathbb{1}_{\{\{g_i(\mathbf{s},j)=IHI\} \cap \{h \in h_g\}\}} \mu(d\mathbf{s}, j)}_{\text{Total Demand for IHI}}.
$$

The premium of the employer-based health Insurance p_{EHI} satisfies

$$\underbrace{(1+\nu_{EHI})}_{\text{Mark-up of EHI}} \underbrace{\sum_{j=J_0}^{J_r-1} \int q_{EHI} \cdot \mathbb{1}_{\{i=EHI\}}(m_n(\mathbf{s},j) + m_e(\epsilon_e))\mu(d\mathbf{s},j)}_{\text{Total Medical Expenditure Covered by EHI}}$$

$$= (1+r^{rf}) \cdot p_{EHI} \cdot \underbrace{\sum_{j=J_0}^{J_r-1} \int \mathbb{1}_{\{g_i(\mathbf{s},j)=EHI\}}\mu(d\mathbf{s},j)}_{\text{Total Demand for EHI}}.$$

(ix) Social Security (ss) and Medicare are financed by their own objective payroll taxes τ_{ss} and τ_{med}. The government budget constraint is balanced:

$$\underbrace{\sum_{j=J_r}^{\bar{J}} \int (ss)\mu(d\mathbf{s},j)}_{\text{Total Social Security Benefit}} = \underbrace{\sum_{j=J_0}^{J_r-1} \int \tau_{ss}\, w\bar{\omega}_j h_c \eta \mu(d\mathbf{s},j)}_{\text{Revenue from Social Security Tax}}$$

$$\sum_{j=J_r}^{\bar{J}} \int \left(\underbrace{q_{med}(m_n(\mathbf{s},j) + m_e(\epsilon_{e,t}))}_{\text{Medical Expenses Covered by Medicare}} - \underbrace{p_{med}}_{\text{Medicare Premium}} \right) \mu(d\mathbf{s},j) = \underbrace{\sum_{j=J_0}^{J_r-1} \int \tau_{med}\, w\bar{\omega}_j h_c \eta \mu(d\mathbf{s},j)}_{\text{Revenue from Medicare Tax}}$$

$$\underbrace{G}_{\text{Government Spending}} + \sum_{j=J_0}^{J_{r-1}} \Bigg[\int \Big\{ \underbrace{\big(\psi_{IHI}(p_{IHI}(h_c,j_g), y(\mathbf{s},j)) \cdot \mathbb{1}_{\{g_i(\mathbf{s},j)=IHI\}}\big)}_{\text{Subsidy for IHI}}$$

$$+ \underbrace{\big(\psi_{EHI} \cdot p_{EHI} \cdot \mathbb{1}_{\{g_i(\mathbf{s},j)=EHI\}}\big)}_{\text{Subsidy for EHI}} \Big\} \mu(d\mathbf{s},j) \Bigg] = \underbrace{\sum_{j=0}^{J} \int T(y)\mu(d\mathbf{s},j)}_{\text{Revenue from Income Tax}}.$$

(x) Distributions are consistent with individual behavior.

For all $j \leq \bar{J} - 1$ and for all $B \in \mathbb{B}(\mathbf{S})$,

$$\mu(B, j+1) = \int_{\left\{\mathbf{s} | \left(g_a(\mathbf{s},j), g_i(\mathbf{s},j), g_h(\mathbf{s},j), \epsilon_e', \epsilon_n', \eta', \omega', \upsilon'\right) \in B\right\}} \left[\Gamma_{\upsilon}^{\upsilon'}\ \pi_{j+1|j}(h_c, j_g)\ \pi_{\epsilon_e'|g_h(\mathbf{s},j)}\ \pi_{\epsilon_n'|g_h(\mathbf{s},j)}\ \pi_{\eta'|\eta}\ \pi_{\omega'|\eta'} \right]\ \mu(d\mathbf{s},j)$$

, where $\mathbf{s} = (a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, \upsilon) \in \mathbf{S}$ is the individual state.

(xi) Accidental bequests κ are evenly distributed to all of the households:

$$\kappa = \sum_{j=J_0}^{\bar{J}-1} \left(\int [(1 - \pi_{j+1|j}(h_c, j_g))(a(1 + r^{rf})) \cdot \mathbb{1}_{\{a>0\}}] \mu(d\mathbf{s}, j) \right).$$

Appendix F Data Details

F.1 Data Cleansing

I choose the MEPS waves from 2000 to 2011. Among various data files in MEPS, by using individual id (DUPERSID), I merger three types of data files: MEPS Panel Longitudinal files, Medical Condition files, and Emergency Room visits files. To clean this data set, I take the following steps. First, I identify household units with the Health Insurance Eligibility Unit (HIEU). Second, I define household heads who have the highest labor income within a HIEU. I eliminate households in which the heads are non-respondents for key variables such as demographic features, educational information, medical expenditures, health insurance, health status, and medical conditions. Second, among working age (23-64) head households, I drop families that have no labor income. Third, I use the MEPS longitudinal weight in MEPS Panel Longitudinal file for each individual. Since each survey of MEPS Panel Longitudinal files covers 2 consequent years, I stack individuals in the 10 different panels into one data set. To use the longitudinal weight with my stacked data set, I follow the way in Jeske and Kitao (2009). As they did, I rescale the longitudinal weight in each survey to make the sum of the weight equal to the number of HIEUs. In this way, I address the issues of different size of samples across surveys and reflect the longitudinal weight in each survey. Lastly, I convert all nominal values into the value of U.S. dollar in 2000 with the CPI. The number of observations in each panel is as follows.

Year	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
Numbers	5218	10187	7484	7577	7548	7294
Year	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	
Numbers	7721	5835	8611	7988	7020	

Table 28: MEPS Panel Sample Size

F.2 Variable Definitions

Household Unit(MEPS Panel Longitudinal files, Medical Condition files, and Emergency Room visits files): To define households, I use the Health Insurance Eligibility Units (HIEU) in the MEPS. To capture behaviors related to health insurance, the HIEU is a more proper id than dwelling unit. Since the HIEU is different from dwelling unit, even within a dwelling unit, multiple HIEUs can exist. A HIEU includes spouses, unmarried natural or adoptive children of age 18 or under and children under 24 who are full-time students.

Head(MEPS Panel Longitudinal files): The MEPS does not formally define heads in households. I define head by choosing the highest earner within a HIEU.

Household Income (MEPS Panel Longitudinal files): The MEPS records individual total income (TTLPY1X and TTPLY2X). Household income is the summation of all house members' total income.

Medical Expenditures (MEPS Panel Longitudinal files): The MEPS provides information on individual total medical expenditures (TOTEXPY1 and TOTEXPY2). However, this variable includes medical expenditures paid for by Veteran's Affairs (TOTVAY1 and TOTVAY2), Workman's Compensation (TOTWCPY1 and TOTWCPY2) and other sources (TOTOSRY1 and TOTOSRY2) that are not covered in this study, I redefine the total medical expenditure variable by subtracting these three variables from the original total medical expenditure variable.

Insurance Status(MEPS Panel Longitudinal files): For working age head households, I categorize four type of health insurance status: uninsured, Medicaid, individual health insurance, and employer-based health insurance. The MEPS records whether each respondent has a health insurance, whether the insurance is provided by the government or private sectors (INSCOVY1 and ISCOVY2), and whether to use Medicaid (MCDEVY1 and MCDEVY2). Using this variable, I define the uninsured and Medicaid users. The MEPS also records employer-based health insurance holders (HELD1X, HELD2X, HELD3X, HELD4X, HELD5X) for five subsequent survey periods. I define employer-based health insurance holders who have experience in holding employer-based health insurance within a year. I define individual health insurance holders as those who do not have employer-based health insurance (HELD1X, HELD2X, HELD3X, HELD4X, HELD5X) but have a private health insurance (INSCOVY1 and INSCOVY2).

Employer-Based Health Insurance Offer rate (MEPS Panel Longitudinal files): The MEPS provides information as to whether respondents' employer offers health insurance (OFFER1X, OFFER2X, OFFER3X, OFFER4X, OFFER5X).

Medical Conditions (Medical Condition files): The Medical Condition Files in the MEPS keep track of individual medical condition records with various measures. I choose Clinical Classification Code for identifying individual medical conditions (CCCODEX).

Health Shocks (Medical Condition files and morbidity measures from the WHO): In order to quantify these individual medical conditions, I use a measure from the World Health Organization (WHO). The WHO provides two types of measures to quantify the burden of diseases: mortality measures (years of life lost to illness (YLL) and morbidity measures (years lived with disability (YLD)). I use the adjusted morbidity measure in the study of Prados (2017). Table 29 is the morbidity measures in Prados (2017).

Condition	Disab. Wgt.	Condition	Disab. Wgt.
Tuberculosis	0.23	Aortic, peripheral, and visceral artery aneurysms	0.29
Bacterial infection, unspecified site	0.04	Aortic and peripheral arterial embolism	0.29
Mycoses	0.00	Other circulatory disease	0.13
Hiv infection	0.57	Phlebitis, thrombophlebitis and thromboembolism	0.13
Hepatitis	0.08	Pneumonia (except that caused by tuberculosis or sexual	0.04
Viral infection	0.01	Influenza	0.01
Other infections, including parasitic	0.02	Acute and chronic tonsillitis	0.00
Sexually transmitted infections (not HIV or hepatitis)	0.07	Acute bronchitis	0.00
Cancer of head and neck	0.20	Other upper respiratory infections	0.00
Cancer of stomach	0.33	Chronic obstructive pulmonary diseas	0.23
Cancer of colon	0.22	Asthma	0.23
Cancer of rectum and anus	0.22	Pleurisy, pneumothorax, pulmonary collapse	0.23
Cancer of liver and intrahepatic bile duct	0.20	Respiratory failure, insufficiency, arrest	0.23
Cancer of pancreas	0.20	Lung disease due to external agents	0.04
Cancer of bronchus, lung	0.43	Other lower respiratory disease	0.04
Cancer of bone and connective tissue	0.06	Other upper respiratory disease	0.00
Melanomas of skin	0.06	Intestinal infection	0.02
Other non-epithelial cancer of skin	0.06	Gastroduodenal ulcer (except hemorrhage)	0.02
Cancer of breast	0.27	Gastritis and duodenitis	0.02
Cancer of uterus	0.10	Appendicitis and other appendiceal conditions	0.46
Cancer of cervix	0.08	Regional enteritis and ulcerative collitis	0.02
Cancer of ovary	0.10	Intestinal obstruction without hernia	0.02
Cancer of other female genital organs	0.10	Diverticulosis and diverticulitis	0.20
Cancer of prostate	0.34	Peritonitis and intestinal abscess	0.20
Cancer of testis	0.09	Nephritis, nephrosis, renal sclerosis	0.09
Cancer of bladder	0.09	Acute and unspecified renal failure	0.09
Cancer of kidney and renal pelvis	0.09	Chronic renal failure	0.10
Cancer of brain and nervous system	0.09	Urinary tract infections	0.01
Cancer of thyroid	0.09	Hyperplasia of prostate	0.04
Hodgkin's disease	0.06	Inflammatory diseases of female pelvic organs	0.33
Non-hodgkin's lymphoma	0.31	Endometriosis	0.10
Leukemias	0.09	Prolapse of female genital organs	0.10
Cancer, other and unspecified primary	0.09	Ovarian cyst	0.10
Secondary malignancies	0.75	Female infertility	0.11
Malignant neoplasm without specification of site	0.09	Ectopic pregnancy	0.55
Neoplasms of unspecified nature or uncertain behavior	0.09	Skin and subcutaneous tissue infection	0.07
Maintenance chemotherapy, radiotherapy	0.09	Other inflammatory condition of skin	0.07
Benign neoplasm of uterus	0.09	Chronic ulcer of skin	0.07
Other and unspecified benign neoplasm	0.09	Other skin disorders	0.07
Diabetes mellitus without complication	0.20	Rheumatoid arthritis and related disease	0.53
Diabetes mellitus with complications	0.20	Osteoarthritis	0.19
Nutritional deficiencies	0.03	Spondylosis, intervertebral disc dis	0.06
Gout and other crystal arthropathies	0.13	Joint disorders and dislocations, trauma related	0.07
Deficiency and other anemia	0.05	Fracture of neck of femur (hip)	0.19
Sickle cell anemia	0.05	Spinal cord injury	0.73
Meningitis (except that caused by tuberculosis or std)	0.31	Skull and face fractures	0.43
Parkinson's disease	0.68	Fracture of upper limb	0.19
Multiple sclerosis	0.53	Fracture of lower limb	0.19
Paralysis	0.57	Other fractures	0.19
Epilepsy, convulsions	0.11	Sprains and strains	0.06
Headache, including migraine	0.03	Intracranial injury	0.36
Cataract	0.10	Crushing injury or internal injury	0.22
Retinal detachments, defects, vascular occlusion and reti	0.10	Open wounds of head, neck, and trunk	0.17
Glaucoma	0.10	Open wounds of extremities	0.17
Blindness and vision defects	0.10	Superficial injury, contusion	0.17
Otitis media and related conditions	0.02	Burns	0.16
Other ear and sense organ disorders	0.07	Poisoning by other medications and d	0.17
Other nervous system disorders	0.50	Poisoning by nonmedicinal substances	0.17
Heart valve disorders	0.13	Other injuries and conditions due to	0.17
Peri-, endo-, and myocarditis, cardiomyopathy	0.32	Nausea and vomiting	0.00
Essential hypertension	0.25	Abdominal pain	0.00
Hypertension with complications and secondary hyperte	0.25	Malaise and fatigue	0.00
Acute myocardial infarction	0.15	Allergic reactions	0.00
Coronary atherosclerosis and other heart disease	0.29	Adjustment disorder	0.02
Pulmonary heart disease	0.13	Anxiety disorder	0.17
Other and ill-defined heart disease	0.13	Attention-deficit, conduct, and disruptive behavior disor	0.17
Conduction disorders	0.13	Delirium, dementia, and amnestic and other cognitive di	0.71
Cardiac dysrhythmias	0.13	Developmental disorders	0.02
Cardiac arrest and ventricular fibri	0.15	Impulse control disorders	0.13
Congestive heart failure, nonhyperte	0.15	Mood disorders	0.23
Acute cerebrovascular disease	0.61	Personality disorders	0.66
Occlusion or stenosis of precerebral arteries	0.61	Schizophrenia and other psychotic disorders	0.66
Other and ill-defined cerebrovascular disease	0.61	Alcohol-related disorders	0.55
Transient cerebral ischemia	0.61	Substance-related disorders	0.55
Late effects of cerebrovascular dise	0.61	Suicide and intentional self-inflict	0.23
Peripheral and visceral atherosclero	0.29		

Table 29: Disability Weights (Source:Prados (2017))

For calculating health shocks from medical conditions, I follow the method in Prados (2017). Let's assume that a household has D kinds of medical conditions. Denote d_i as the WHO index for medical condition i, where $i = 1, \dots, D$. For this household, its health shock ϵ_h is represented by

$$(1 - \epsilon_h) = \prod_{i=1}^{D} (1 - d_i). \tag{38}$$

This measure well represents the features of medical condition in the sense that it reflects not only multiple medical conditions but also differences in their severity.

Emergency Room Usages and Charges (Emergency Room Visits files): Emergency Room Visits files in the MEPS record respondents who visit emergency rooms. These files records the Clinical Classification Code as to why respondents visit emergency rooms (ERCCC1X, ERCCC2X, ERCCC3x) and as to how much hospitals charge from emergency medical events to patients (ERTC00X).

Appendix G Computation Details

There are computational burdens in this problem, because not only the dimension of individual state is large, but also the value functions of the model are involved with many non-concave and non-smooth factors: the choice of default, health insurance, medical cost, progressive subsidy and tax policies.

To solve the model with these complexities, I extend the endogenous grid method of Fella (2014). He provides an algorithm to handle non-concavities on the value functions with an exogenous borrowing constraint. I generalize the method for default problems in which borrowing constraints differ across individuals.

Whereas there are several types of value functions in the model, the computational issues are mainly related to four types of value functions: the value function of non-defaulting households with a good (bad) credit history $v^{G,N}$ ($v^{B,N}$), the value function of retired households with a good (bad) credit history $v^{G,r}$ ($v^{B,r}$). [25] The value function with a bad credit history and two retired households' value functions are solved with the algorithm of Fella (2014), because these problems have an exogenous borrowing constrain with discrete choice, which is consistent with the setting of Fella (2014). My endogenous grid method is for solving the value function of non-defaulting with a good credit history $v^{G,N}$ in which loan prices differ across individuals states.[26]

In the following subsections, first, I demonstrate how to solve the value of non-defaulting households with a good credit history $v^{G,N}$ with my endogenous grid method.[27] Then, I show how to solve the other value functions with the endogenous grid method of Fella (2014).

G.1 Notation and Discretization of States

Before getting into details, let us begin with notations to explain the algorithm. To ease notation, I denote $\mathrm{s}_{-a} = (i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ and $\mathrm{s}_p^{'} = (i^{'}, h^{'}, \eta, j)$. Then, $V^G(a, \mathrm{s}_{-a}) = V^G(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ and $q(a^{'}, \mathrm{s}_p^{'}) = q(a^{'}, i^{'}, h^{'}; j, \eta)$. I also denote $W^G(a^{'}, s_p^{'}, h_c) = W^G(a^{'}, i^{'}, h^{'}, \eta, j, h_c)$ as the expected value function of working households with good credit conditional on η, h_c, age j and age group j_g, $\pi_{j+1|j}(h_c, j_g)\, \mathbb{E}_{\epsilon_e^{'}|h^{'}, \epsilon_n^{'}|h^{'}, \eta^{'}|\eta, \omega^{'}|\eta^{'}} \left[V^G(a^{'}, \mathrm{s}_{-a}^{'})\right]$. $G_{a^{'}} = \{a_1^{'}, \cdots, a_{N_{a^{'}}}^{'}\}$ and $G_O = \{O_1, \cdots, O_{N_O}\}$ are the grid of asset holdings $a^{'}$ and cash on hand O, respectively.

In the model, households need to make choices on three individual state variables: assets a, health insurance i, and health capital h. I discretize two endogenous states: health insurance i and

[25] The value function of filing for default is not involved with any continuous choice variable.

[26] Jang and Lee (2018) extend this endogenous grid method to solve infinite horizon models with default risk and aggregate uncertainty

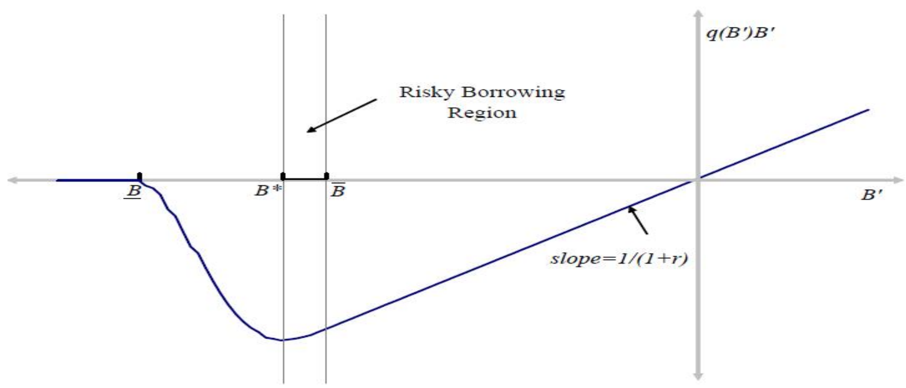
[27] The steps I use here are also described in Jang and Lee (2018). They extend this endogenous grid method to solve an infinite horizon model with default risk and aggregate uncertainty.

health capital h. I apply the endogenous grid method to assets a by taking this variable as continuous. This way is efficient because the variation of assets is the largest among the endogenous state variables. When solving the problems, I regard the choice of health insurance $\bar{i}'$ and health capital for the next period $\bar{h}'$ as given states, and apply the endogenous grid method to asset holdings a' in the next period.

G.2 Calculating the Risky Borrowing Limit (Credit Limit) $(v^{G,N})$

I set up the feasible sets of the solution based on the work in Arellano (2008) and Clausen and Strub (2017). They investigate the property of the risky borrowing limits (credit limits). They show that the size of loan $q(a')a'$ increases with a' for any optimal debt contract. If the size of loan $q(a')a'$ decreases in a', households can increase their consumption by increasing debts, which is not an optimal debt contract. Arellano (2008) (Clausen and Strub (2017)) defines the risky borrowing limit (credit limit) to be the lower bound of the set for optimal contract. For example, in Figure 17, B^* is the risky borrowing limit.

Figure 17: Risky Borrowing Limit (Arellano (2008))



For each state $s_p' = (\bar{i}', \bar{h}', j, \eta)$, I calculate the risky borrowing limit $a_{rbl}'(s_p')$ such that

$$\forall a' \geq a_{rbl}(s_p'), \frac{\partial q(a', s_p')a'}{\partial a'} = \frac{\partial q(a', s_p')}{\partial a'}a' + q(a', s_p') > 0. \tag{39}$$

I compute the numerical derivative of the discount rate of loan prices $q(a', s_p')$ over the grid of asset holdings $G_{a'}$ in the following way:

$$D_{a'}q(a_k', s_p') = \begin{cases} \frac{q(a_{k+1}', s_p') - q(a_k', s_p')}{a_{k+1}' - a_k'}, & \text{for } k < N_{a'} \\ \frac{q(a_k', s_p') - q(a_{k-1}', s_p')}{a_k' - a_{k-1}'}, & \text{for } k = N_{a'}. \end{cases} \tag{40}$$

I calculate the risky borrowing limit $a_{rbl}(\cdot)$ for each state $s_p^{'}$ and fix them as the lower bound of the feasible set for the solution of asset holdings $a^{'}$. For each state $s_p^{'}$, I denote $G_{a^{'}}^{rbl(s_p^{'})}$ as the collection of all of the grid points for asset holdings $a_k^{'}$ above the risky borrowing limit $a_{rbl}(s_p^{'})$, which means for all $a_k^{'} \in G_{a^{'}}^{rbl(s_p^{'})}$, $a_k^{'} > a_{rbl}(s_p^{'})$.

G.3 Identifying (Non-) Concave Regions

Note that the FOC (17) is not sufficient but necessary, because of non-concavities on the expected value function $W^G(a^{'}, s_p^{'})$ with respect to $a^{'}$. If the concave regions can be identified, the FOC (17) is a sufficient and necessary condition for an optimal choice of asset holdings $a^{'}$ on the concave region. I use the algorithm of Fella (2014) to divide the domain of the expected value functions $G_{a^{'}}^{rbl(s_p^{'})}$ into the concave and non-concave regions.

For each state $s_p^{'}$, the concave region is identified by two threshold grid points $\bar{a}^{'}(s_p^{'})$ and $\underline{a}^{'}(s_p^{'})$ that satisfy the following condition: for any $a_i^{'} \in G_{a^{'}}^{rbl(s_p^{'})}$ and $a_j^{'} \in G_{a^{'}}^{rbl(s_p^{'})}$ with $\bar{a}^{'}(s_p^{'}) < a_i^{'} < a_j^{'}$ ($a_i^{'} < a_j^{'} < \underline{a}^{'}(s_p^{'})$), $D_{a^{'}}W^G(a_i^{'}, s_p^{'}, h_c) > D_{a^{'}}W^G(a_j^{'}, s_p^{'}, h_c)$.[28] This condition implies that for all grid points of which values are greater than $\bar{a}^{'}(s_p^{'})$ (less than $\underline{a}^{'}(s_p^{'})$), the derivative of the expected value function $D_{a^{'}}(\cdot, s_p^{'})$ strictly decreases with asset holdings $a^{'}$.

For each state $s_p^{'}$, I take the following steps to find the thresholds $\bar{a}^{'}(s_p^{'})$ and $\underline{a}^{'}(s_p^{'})$. First, I check the discontinuous points of the derivative of the expected value function $D_{a^{'}}W^G(a^{'}, s_p^{'}, h_c)$. I compute the derivative of the expected value function $D_{a^{'}}W^G(a^{'}, s_p^{'}, h_c)$ in the same way as the derivative of the discount rate of loan price (40). Second, among the discontinuous points, I find the minimum value, which is $v_{max}(s_p^{'})$. Third, I search for the maximum $a_i^{'} \in G_{a^{'}}^{rbl(\mathbf{s}_p^{'})}$ satisfying $D_{a^{'}}W^G(a^{'}, s_p^{'}, h_c) \leq v_{max}(s_p^{'})$. The maximum is defined as $\bar{a}^{'}(s_p^{'})$. Fourth, among the discontinuous points, I find the maximum value, which is $v_{min}(s_p^{'})$. Then, I search for the minimum $a_i^{'} \in G_{a^{'}}^{rbl(\mathbf{s}_p^{'})}$ satisfying $D_{a^{'}}W^G(a^{'}, s_p^{'}, h_c) \geq v_{min}(s_p^{'})$.The minimum is defined as $\underline{a}^{'}(s_p^{'})$.

G.4 Computing the Endogenous Grid for the Cash on Hand

$$\frac{\partial q(a_k^{'}, \mathbf{s}_\mathbf{p}^{'})\mathbf{a}_\mathbf{k}^{'}}{\partial a^{'}} \frac{\partial u(c, h_c)}{\partial c} = \frac{\partial W^G(a_k^{'}, \mathbf{s}_\mathbf{p}^{'}, \mathbf{h}_\mathbf{c})}{\partial a^{'}}. \tag{41}$$

First, for each state $\mathbf{s}_p^{'}$ and h_c, and for each grid point $a_k^{'} \in G_{a^{'}}^{rbl(s_p^{'})}$, I retrieve the endogenously-driven consumption $c(a_k^{'}, \mathbf{s}_p^{'}, h_c)$ from the FOC (41). Since the utility function has a CES aggregator, the endogenously-driven consumption $c(a_k^{'}, \mathbf{s}_p^{'}, h_c)$ cannot be computed analytically. I use

[28]For each $s_p^{'}$, the thresholds are the same across h_c because the survival rate $\pi_{j+1|j}(h_c, j_g)$ is a constant number.

the bisection method to compute the endogenously-driven consumption $c(a_k^{'}, \mathrm{s}_p^{'}, h_c)$. Second, I compute the endogenously-determined cash on hand $O(a_k^{'}, \mathrm{s}_p^{'}, h_c) = c(a_k^{'}, \mathrm{s}_p^{'}, h_c) + q(a_k^{'}, \mathbf{s_p^{'}})\mathbf{a_k^{'}}$. Lastly, I store the pairs of $((a_k^{'}, \mathrm{s}_p^{'}, h_c), O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$.

G.5 Storing the Value Function over the Endogenous Grid for Cash on Hand

For each state $\mathrm{s}_p^{'}$ and h_c, and for each grid point $a_k \in G_{a^{'}}^{rbl(s_p^{'})}$, I compute the value function of non-defaulters with good credit $v^{G,N}$ over the endogenous grid for cash on hand $O(a_k^{'}, \mathrm{s}_p^{'}, h_c)$ in the following way:

$$\tilde{v}^{G,N}(O(a_k^{'}, \mathrm{s}_p^{'}, h_c), \mathrm{s}_p^{'}, h_c) = u(O(a_k^{'}, \mathrm{s}_p^{'}, h_c) - q(a_k^{'}, \mathbf{s_p^{'}})\mathbf{a_k^{'}}, \mathbf{h_c}) + \mathbf{W^G}(\mathbf{a_k^{'}}, \mathbf{s_p^{'}}, \mathbf{h_c}). \tag{42}$$

Note that (i) (42) is irrelevant to any max operator and (ii) the value function $v^{G,N}(O(a_k^{'}, \mathrm{s}_p^{'}), \mathrm{s}_p^{'})$ is valued on the endogenous grid, not on the exogenous grid. I store the computed value $v^{G,N}$ over the endogenous grid for cash on hand $O(a_k^{'}, \mathrm{s}_p^{'})$.

G.6 Identifying the Global Solution on the Endogenous Grid for Cash on Hand

Using information about the identification of (non-) concave regions on asset holdings $a^{'}$ in G.3, I identify the global solutions on the pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$.

Specifically, I take the following steps. First, for each state $(\mathrm{s}_p^{'}, h_c)$, I identify $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ as the pairs of the global solution if $a_k^{'} \geq \bar{a}^{'}(\mathrm{s}_p^{'})$ or $a_k^{'} \in [a_{rbl}(\mathrm{s}_p^{'}), \underline{a}^{'}(\mathrm{s}_p^{'})]$. Note that the FOC (17) is sufficient and necessary here, as these pairs are on the concave region of the global solution. I save these pairs.

Second, for each state $(\mathrm{s}_p^{'}, h_c)$ and each $a_k^{'} \in (\underline{a}^{'}(\mathrm{s}_p^{'}), \bar{a}^{'}(\mathrm{s}_p^{'}))$, I check whether the pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ implies the global solution in the following way:

$$a_g^{'} = \underset{\{a_j^{'} \in (\underline{a}^{'}(\mathrm{s}_p^{'}), \bar{a}^{'}(\mathrm{s}_p^{'}))\}}{\operatorname{argmax}} u(O(a_k^{'}, \mathrm{s}_p^{'}, h_c) - q(a_j^{'}, \mathrm{s}_p^{'})a_j^{'}, h_c) + W^G(a_j^{'}, \mathrm{s}_p^{'}, h_c). \tag{43}$$

If $a_g^{'} = a_k^{'}$, then I identify the pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ as an global solution. Otherwise, I discard the pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$.

G.7 Interpolating the Value Function on the Endogenous Grid for Assets

Given the saved pairs of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ and $(i, h, \epsilon_e, \epsilon_n)$, I compute the corresponding current assets a. Due to the non-linear progressive tax and insurance subsidies, for each pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ and for each $(i, h, \epsilon_e, \epsilon_n)$, I find the corresponding assets a by using the Newton-Raphson method. Then I obtain the pairs of $(a(a_k^{'}\mathbf{s}^{'}, \mathbf{h_c}, \mathbf{i}, \mathbf{h}, \epsilon_\mathbf{e}, \epsilon_\mathbf{n}), \mathbf{a^k})$. Note that these pairs correspond to global solutions, as the saved pairs of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ implies the global solutions.

G.8 Interpolating the Value Function on the Endogenous Grid for Assets

Given the saved pairs of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ and $(i, h, \epsilon_e, \epsilon_n)$, I compute the corresponding current assets a. Due to the non-linear progressive tax and insurance subsidies, for each pair of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ and for each $(i, h, \epsilon_e, \epsilon_n)$, I find the corresponding assets a by using the Newton-Raphson method. Then, for each state, $(\mathrm{s}_p^{'}, i, h, \epsilon_e, \epsilon_n)$, I obtain the pairs of $(a(a_k^{'}, \mathrm{s}_p^{'}, i, h, \epsilon_e, \epsilon_n), a^{'})$. Note that these pairs correspond to global solutions, as the saved pairs of $(a_k^{'}, O(a_k^{'}, \mathrm{s}_p^{'}, h_c))$ implies the global solutions.

G.9 Evaluating the Value Function over the Exogenous Grid for the Current Assets

Since the value function $\tilde{v}^{G,N}$ and decision rule $g^{G,N}$ preserve the monotonicity with the current asset a, it is possible to interpolate the value on the exogenous grid for assets G_a. For each state $(\mathrm{s}_p^{'}, i, h, \epsilon_e, \epsilon_n)$, using a linear interpolation, I find a_0 such that $a_0 = a(a^{'} = 0, \mathrm{s}_p^{'}, i, h, \epsilon_e, \epsilon_n)$.

If the value of grid $a_i \in G_a$ is above a_0, I use a linear interpolation to compute the value function of $\tilde{v}^{G,N}$ and $g^{G,N}$ on the exogenous grid of the current assets G_a. If $a_i \in G_a$ is lower than a_0, I use the grid search method.

G.10 Optimize the discrete choices

Until this step, the choice of health insurance $i^{'}$ and health capital $h^{'}$ are given statuses. Optimize these two choices by searching the grid for each variable. The number of grid points for these variables is relatively smaller than that of grid points on asset a. Therefore, the computation is not so costly in this procedure. Formally, solve the following problems:

$$v^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max_{\{i^{'}, h^{'}\}} \tilde{v}^{G,N}(a, i^{'}, h^{'}, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$$

G.11 Interpolating the Value Function on the Grid for Assets

Given a state $\mathrm{s}_p^{'}$ and $(i, h, \epsilon_e, \epsilon_n)$, since the level of assets a has a monotonic relation with cash on hand O, it is possible to interpolate the value function $\tilde{v}^{G,N}$ and decision rule $g^{G,N}$ over the exogenous grid of cash on hand G_O into the grid for assets G_a. Due to the non-linear progressive tax and insurance subsidies, for each state $\mathrm{s}_p^{'}$ and $(i, h, \epsilon_e, \epsilon_n)$, and for each grid point of the cash on hand $O_k \in G_O$, I find the corresponding assets a by using the Newton-Raphson method.

Next, using a linear interpolation, for each state $\mathrm{s}_p^{'}$ and $(i, h, \epsilon_e, \epsilon_n)$, I evaluate the value function $\tilde{v}^{G,N}$ and decision rule $g^{G,N}$ on the grid for the current assets G_a.

G.12 Optimize the discrete choices

Until this step, the choice of health insurance $i^{'}$ and health capital $h^{'}$ are given statuses. Optimize these two choices by searching the grid for each variable. The number of grid points for these variables is relatively smaller than that of grid points on asset a. Therefore, the computation is not so costly in this procedure. Formally, solve the following problems:

$$v^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max_{\{i^{'}, h^{'}\}} \tilde{v}^{G,N}(a, i^{'}, h^{'}, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$$

G.13 Solving the Other Values

I use the grid search method to solve defaulting values $v^{G,D}$ and $v^{B,D}$, because they do not an intertemporal choice on assets and the number of grid points over health insurance i and health status h is relatively small.

For values of retired households $v^{G,r}$ and $v^{B,r}$ and values of non-defaulting households with a bad credit history $v^{B,N}$, I apply the endogenous grid method of Fella (2014). It is almost the same as the previous steps other than G.2, as there is no unsecured debt in these problems. The lower bounds of feasible solution set are given by zero assets ($v^{B,N}$, $v^{B,r}$) or the natural borrowing limit ($v^{G,r}$). Precisely, with the predetermined borrowing limits, I take the steps of Section G.1 and Section G.3- Section G.11.

G.14 Updating the Expected Value Functions and Loan Price Schedules for age $j-1$

First, I update the value functions $V^G(\mathbf{s})$ and $V^B(\mathbf{s})$.

$$V^G(\mathbf{s}) = \max\{v^{G,N}(\mathbf{s}), v^{G,D}(\mathbf{s}_{-\mathbf{a}})\}$$
$$V^B(\mathbf{s}) = \max\{v^{G,N}(\mathbf{s}), v^{G,D}(\mathbf{s}_{-\mathbf{a}})\} \tag{44}$$

Second, I update the expected value functions $W^G(\mathbf{s}_p^{'}, h_c)$ and $W^B(\mathbf{s}_p^{'}, h_c)$ for age $j-1$ and age group j_g.

$$W^G(a^{'}, i^{'}, h^{'}, \eta, j, h_c) = \pi_{j|j-1}(h_c, j_g) \sum_{\epsilon_n^{'}, \epsilon_e^{'}, \eta^{'}, \omega^{'}} \pi_{\epsilon_e^{'}|h^{'}} \pi_{\epsilon_n^{'}|h^{'}} \pi_{\eta^{'}|\eta} \pi_{\omega^{'}|\eta^{'}} V^G(a^{'}, i^{'}, h^{'}, \eta_e^{'}, \eta_n^{'}, \eta^{'}, \omega^{'}, j)$$
$$W^B(a^{'}, i^{'}, h^{'}, \eta, j, h_c) = \pi_{j|j-1}(h_c, j_g) \sum_{\epsilon_n^{'}, \epsilon_e^{'}, \eta^{'}, \omega^{'}} \pi_{\epsilon_e^{'}|h^{'}} \pi_{\epsilon_n^{'}|h^{'}} \pi_{\eta^{'}|\eta} \pi_{\omega^{'}|\eta^{'}} V^B(a^{'}, i^{'}, h^{'}, \eta_e^{'}, \eta_n^{'}, \eta^{'}, \omega^{'}, j) \tag{45}$$

Lastly, the loan price function $q(a^{'}, i^{'}, h^{'};, j-1, \eta)$ is updated in the following way:

$$d(a^{'}, i^{'}, h^{'}; j-1, \eta) = \sum_{\epsilon_n^{'}, \epsilon_e^{'}, \eta^{'}, \omega^{'}} \pi_{\epsilon_e^{'}|h^{'}} \pi_{\epsilon_n^{'}|h^{'}} \pi_{\eta^{'}|\eta} \pi_{\omega^{'}|\eta^{'}} \mathbb{1}_{\{v^{G,N}(a^{'}, i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \omega^{'}, j) \leq v^{G,D}(i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \omega^{'}, j)\}}$$
$$q(a^{'}, i^{'}, h^{'}; j-1, \eta) = \frac{1 - d(a^{'}, i^{'}, h^{'}; j, \eta)}{1 + r^{rf}}$$

where $d(a^{'}, i^{'}, h^{'}; j-1, \eta)$ is the expected default probability with state $(a^{'}, i^{'}, h^{'}; j-1, \eta)$.

I repeatedly take these steps (G.1 - G.10) until the initial age.

Appendix H Offer Rate of Employer-Based Health Insurance

Table 30: Offer Rate of Employer-Based Health Insurance

	Age			
Earnings PCT	23-34	35-46	47-55	56-64
0-2.9	0.413	0.365	0.368	0.399
2.9-6.6	0.449	0.487	0.428	0.43
6.6-12.3	0.322	0.386	0.4	0.376
12.3-20.5	0.352	0.437	0.514	0.494
20.5-31.1	0.376	0.597	0.669	0.633
31.1-43.5	0.511	0.744	0.793	0.747
43.5-56.5	0.673	0.834	0.845	0.789
56.5-68.9	0.791	0.89	0.878	0.82
68.9-79.5	0.846	0.91	0.899	0.847
79.5-87.7	0.884	0.912	0.902	0.855
87.7-93.4	0.916	0.918	0.9	0.859
93.4-97.1	0.912	0.887	0.876	0.813
97.1-100	0.884	0.912	0.913	0.854

Source: author's calculation based on the MEPS 2000-2011

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