Income Inequality and Health Care Expenditures over the Life Cycle

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Abstract

This paper studies differences in the lifetime profile of health care usage between low- and high-income groups. Using data from the Medical Expenditure Panel Survey (MEPS) I find that early in life the rich spend significantly more on health care, whereas midway through life until very old age the medical spending of the poor dramatically exceeds that of the rich. In addition, the distribution of the poor's medical expenditures has fatter left and right tails. To account for these facts, I develop and estimate a life-cycle model of two distinct types of health capital: preventive and physical. Physical health capital determines survival probabilities, whereas preventive health capital governs the distribution of shocks to physical health capital, thereby controlling the expected lifetime. Moreover, I incorporate important features of the US health care system such as private health insurance, Medicaid, and Medicare. In the model, optimal expected lifetime is longer for the rich which can only be achieved by larger investment in preventive health capital. Therefore, as they age, their health shocks grow milder compared to the poor, and in turn they incur lower curative medical expenditures. Public insurance in old age amplifies this mechanism by hampering the incentives of the poor to invest in preventive health capital. I use the model to examine a counterfactual economy with universal health insurance in which 75% of the preventive medical spending is reimbursed on top of the existing coverage. My results suggest that policies encouraging the use of health care by the poor early in life have significant welfare gains, even when fully accounting for the increase in taxes required to pay for them.

1 Introduction

How do low- and high-income households differ in their lifetime profiles of medical expenditures? Why do they differ? The answers to these questions are central to designing and analyzing health care policies that target a reduction in the disparities in access to health care and health outcomes among income groups.[1] In this paper, I present empirical facts on lifetime profile of health care usage by income groups and study the differences among them using a life-cycle model of two distinct types of health capital, physical and preventive, which allows households to endogenize the distribution of health shocks, thereby controlling their expected lifetime.

Using data from the Medical Expenditure Panel Survey (MEPS) I document that low- and high-income households differ significantly in age profile of medical expenditures.[2,3] The average medical spending of low-income households relative to high-income ones exhibits a hump-shaped pattern over the lifetime and exceeds unity for a significant part of the life span.[4] Early in the life cycle, the rich spend more on health care in absolute (dollar) terms. Midway through life until very old age, the medical spending of the poor dramatically exceeds that of the rich.

In addition, the distribution of the poor's medical expenditures is more widely spread to the tails. A higher fraction of low-income individuals do not incur any health care spending in a given year than high-income households. Specifically, among the non-elderly, 24% of the poor have zero medical spending, versus 10% of the rich. However, the average of the top 10% medical expenditures of the poor is substantially larger than that of the rich. Furthermore, it is well known in the health economics literature that low-income households consume less preventive care in absolute terms. Last, the life expectancy of low-income households is dramatically lower than that of high-income households.

I develop a life-cycle model of health capital that can account for these facts. In my model there are two distinct types of health capital. First, "physical health capital" determines

[1]For example, low-income individuals in 1980 could expect to live about 25% fewer years than high-income people (Deaton and Paxson (1999)).

[2]Please note that throughout the paper the definition of health care expenditure includes all expenditures on health care goods and services except for over-the-counter drugs. Their source of payment can be out-of-pocket expenditures, private insurance firms, the government (Medicaid, Medicare, etc.) and others.

[3]Recently, Jung and Tran (2010b) also study the life-cycle profile of medical expenditures.

[4]The life span covers ages between 1 to 85 and older.

endogenously the probability of surviving to the next period and depreciates due to health shocks. Households can invest in physical health capital through expenditures on curative medicine. Second, "preventive health capital" governs the distribution of health shocks to physical health capital and depreciates at a constant rate. Individuals can invest in preventive health capital against depreciation using preventive medicine. For example, a flu shot is a preventive medicine that basically affects the probability of one's getting the influenza virus. On the other hand, getting the flu is a physical health shock that affects an individual's survival probability and depreciates physical health capital if it is not cured.

In addition, I incorporate important features of the US health care system into my model. Non-elderly individuals are offered private health insurance that covers medical expenditures of households up to a deductible and a co-payment. The premium of the health insurance depends only on age and is determined endogenously by the zero profit condition of the firm. Children of low-income families are covered by Medicaid and all of the elderly are provided insurance through Medicare, both of which reimburse medical expenditures up to a deductible and a co-payment. Moreover, in the case of severe health shocks, individuals are allowed to default. The government imposes the progressive US income tax schedule on households. The collected revenues are used to finance (i) the Social Security system, (ii) medical expenditures due to Medicaid and Medicare and default due to health shocks and (iii) other government expenditures. The residual budget surplus or deficit is distributed in a lump-sum fashion to households.

The model described here allows households to endogenize the distribution of health shocks through preventive health capital investment, thereby controlling their expected lifetime. The major trade-off in the model is between the amount of consumption per period and the length of expected lifetime. Optimal expected lifetime is longer for the rich which can only be achieved by larger investment in preventive health capital. Therefore, as the cohort grows older, low-income households draw larger health shocks compared to high-income households and in turn they incur higher curative medical expenditures. This explains the increase in medical expenditures of the poor relative to the rich. The reason why medical spending of the poor exceeds that of the rich midway through life until very old age is that public insurance in old age (such as Medicare and the default option) largely subsidizes the curative medical expenditures of the households. This also hampers the incentives of low-income households to invest in preventive health capital.

I estimate my model using both micro (the MEPS) and macro data. I set some of the parameter values outside of the model (e.g., income process, insurance coverage schemes etc.). For the rest of the parameters (e.g., curative and preventive health production technology parameters, distribution of health shocks, etc.) I use my model to choose their values. The model is stylized enough to allow me to identify its key parameters by the available data. The estimated model is able to successfully explain the targeted features of the data in the estimation (e.g., differences in the lifetime profiles of medical expenditures between the rich and the poor, mortality differential, etc.) as well as other (non-targeted) salient dimensions.

I then use my model to analyze the macroeconomic and distributional effects of expanding health insurance coverage, which is one of the main goals of the Patient Protection and Affordable Care (PPAC) Act of 2010.[5] For this purpose, I contrast the benchmark economy with a universal health care coverage economy in which all individuals are covered by private health insurance until retirement and whose premia are financed through an additional flat income tax on households.[6] An immediate implication of this policy change is that low-income households invest more in preventive and physical health capital, and in turn, they live longer by 1.25 years. Total medical spending increases slightly, from 9.84% of total income to 9.92%. This is due to a longer life span for low-income households. Moreover, I find that universal health care coverage is welfare improving: An unborn individual is willing to give up 1.5% of her lifetime consumption in order to live with universal health care coverage instead of the benchmark economy. Around one-third of the welfare gains are due to the increase in the expected lifetime. The rest is coming from better insurance opportunities against health shocks and redistribution in the economy.

In addition, under the PPAC Act of 2010 private insurance firms are required to provide basic preventive care free of charge, such as checkups, mammograms, colonoscopies, etc. However, patients are still required to cover co-payments for doctor visits and not all preventive care is free. Thus, I study the effect of this policy change by assuming that on top of the current private insurance scheme, firms pay 75% of the preventive medicine expenditures of households. I examine this policy change in the universal health care coverage economy discussed above.[7] Under this new policy households invest more in preventive

[5] This act is known as ObamaCare in the popular media.

[6] According to Congressional Budget Office estimates, about 95% of the non-elderly population is expected to have health insurance.

[7] This policy change in an economy without universal health care coverage would lead many of the low-income households to drop out of the health insurance market due to the rise in health insurance premia. But this is not what the PPAC Act of 2010 aims for.

health capital, which results in an increase in life expectancy of all income groups except for the top income quintile. However, total medical spending does not increase because of the decrease in the magnitude of health shocks. These results suggest that policies encouraging the use of health care by the poor early in life have significant positive welfare gains, even when fully accounting for the increase in taxes and insurance premia required to pay for them.

Related Literature There are several papers in the literature that allow for heterogeneity in income and health shocks among households (Palumbo (1999) and Jeske and Kitao (2009)). In their model, health shocks are basically health expenditure shocks. They implicitly assume that the amount of health expenditures due to a health shock is the optimal amount in order to have any chance of survival into the next period (Attanasio, Kitao, and Violante (2008)).

Some notable exceptions endogenize the medical expenditure decisions of households over the life cycle (De Nardi, French, and Jones (2009), Jung and Tran (2010a), Yogo (2007), Halliday, He, and Zhang (2009), Zhao (2009)). Recently, De Nardi, French, and Jones (2009) study the consumption and savings behavior of the very elderly who are subject to very large medical expenditure shocks. In their paper, out-of-pocket medical expenditures rise quickly with both age and permanent income. In one version of their model they allow households to choose medical spending optimally against an idiosyncratic "medical needs" shock. Since they restrict their analysis to the very elderly, they assume that medical expenditures do not affect survival probability. On the other hand, this paper models the survival probability as a function of health capital and studies the medical expenditure decisions of households since their birth.

In addition, Jung and Tran (2010a) develop a general equilibrium life-cycle model of health capital which plays two roles: agents derive utility from being healthy and health affects labor income. They use this model to study a counterfactual universal health insurance voucher policy. In their model, health shocks are exogenous and survival probability is the same for everyone in a cohort. Thus, they do not study the differences in life-cycle medical expenditure profiles between the rich and the poor.

My theoretical model sees health as a specific form of human capital. This concept is first introduced by Grossman (1972). In his seminal paper, he develops a health capital model in which health is a durable capital stock that produces an output of healthy time.

Grossman and Rand (1974) extend this model by distinguishing preventive and curative medicine to theoretically study the tradeoff between these two. In addition, Cropper (1977) explicitly introduces uncertainty into Grossman (1972) model by assuming sicknesses as exogenous random events.

This paper also contributes to a branch of the health economics literature that investigates the dynamic inefficiencies in insurance markets (Finkelstein, McGarry, and Sufi (2005), Fang and Gavazza (2007), Crocker and Moran (2003)). For example, Fang and Gavazza (2007) study how the employment-based health insurance system in the US leads to an inefficiently low level of individual health investment during working years in a theoretical model using the MEPS and the HRS data. They find that every additional dollar of health expenditure during working years may lead to about 2.5 dollars of savings in retirement. This paper also studies the dynamic inefficiency due to government-funded health insurance programs.

Furthermore, many researchers have studied a variety of economic issues in decisions of prevention of illnesses (see Kenkel (2000) for a careful overview). One of the findings of this literature is that many preventive interventions add to medical costs not less than they save, at the same time that they improve health (Russell (2007), Russell (1986)). This is consistent with my empirical facts that the total life time medical spending of the rich is not significantly lower than that of the poor.

The rest of the paper is organized as follows: In Section 2, I discuss the main data source and the empirical findings. Section 3 presents a stylized version of the full model to show the main mechanism at work. Then I introduce other features of the full model in Section 4. In Section 5, I discuss the estimation of the model and the model's fit to the data. Then I perform counterfactual policy experiments using the model in Section 6. Finally, I compare my findings to the literature in Section 7 and I conclude in Section 8.

2 Empirical Facts

In this section, I present empirical facts on health care expenditures over the life cycle. Particularly I document how medical spending differs by income groups over the life cycle. First, I discuss the data source and the methodology I employ to construct the income groups. Then in Section 2.2, I present the empirical findings.

2.1 Data and Methodology

I use the Medical Expenditure Panel Survey (MEPS) data that cover a period between 1996 and 2007. The MEPS surveys both families and individuals between ages 1 to 90.[8] It provides detailed information about usage and the cost of health care. Its panel dimension is fairly short in that an individual is surveyed only for two consecutive years. There are 359,826 observations in my sample after sample selection.[9]

Medical expenditure is defined to include all health care services such as office and hospital-based care, home health care, dental services, vision aids and prescribed medicines but not over-the-counter drugs. Moreover, the source of payment for medical expenditures can be households (out-of-pocket expenditures), federal or state government (Medicaid, Medicare), private insurance firms and other sources. But private insurance premiums are not included. The expenditure data included in this survey were derived from both households and the health care providers, which makes the data set a more reliable source for medical expenditure data than any other source.

My measure of total income includes wage, business, unemployment benefits, dividends, interest, pension, Social Security income, etc. I construct total family income by aggregating personal income over family members. Then I normalize total family income by family-type-specific federal poverty thresholds which take into account family composition (number of members and their ages).[10] I use this normalized family income to construct income groups (quintiles). I also group individuals into 9 age intervals, specifically, 0-14,15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85 and older. While constructing the income groups in a particular age interval, I restrict my sample to only those families that have a member within that particular age interval. Thus, a family may have been grouped into different income quintiles in different age bins, whereas an individual is assigned to only one income quintile.

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[8] Age data in the MEPS are capped with top code 90.

[9] The details of the sample selection are explained in Appendix A.1.

[10] I choose the federal poverty threshold as the household equivalence scale because it varies by number of members in the family and their ages. I do the normalization by using another commonly used scale, the square-root scale. The results are presented in Appendix A.2.

2.2 Empirical Facts on Medical Expenditures

The first empirical fact is the age profile of health care expenditures by income groups.[11] The blue line with crosses and the red line with circles on the left panel of Figure 1 show the age profiles of medical expenditures of bottom and top income quintiles, respectively.[12] For both income groups health care spending increases dramatically over the life cycle. However, there are significant differences in the dynamics of medical spending over the life cycle between income groups. To clarify this point, I plot the ratio of average medical expenditures of the poor to the rich over the life cycle. This is shown on the right panel of Figure 1 in the black solid line along with 95% bootstrap confidence intervals in the red dashed lines. As can be seen, the age profile of medical expenditures of the poor relative to the rich exhibits a pronounced hump-shape: Early on, the top income quintile group spends more on health care in absolute (dollar) terms. Midway through life until very old age, the medical spending of the bottom income quintile exceeds that of the top quintile. Between ages 50 to 70 health care expenditures of the poor are 25% higher than those of the rich in absolute levels. This is particularly striking once income differences are taken into account.[13] Finally, after age 80 high-income households consume health care services slightly more than low-income ones.[14]

The second empirical fact shows the differences in the extensive and intensive margins of health care spending between low- and high-income households. The left panel of Figure 2 plots the fraction of households that have not incurred any medical spending in a given year over the life cycle for the top and bottom income quintiles. First note that a significantly

[11]I use only the cross sectional aspect of the data to construct these profiles. However, please note that I use "age profile" and "lifetime profile" interchangeably throughout the paper.

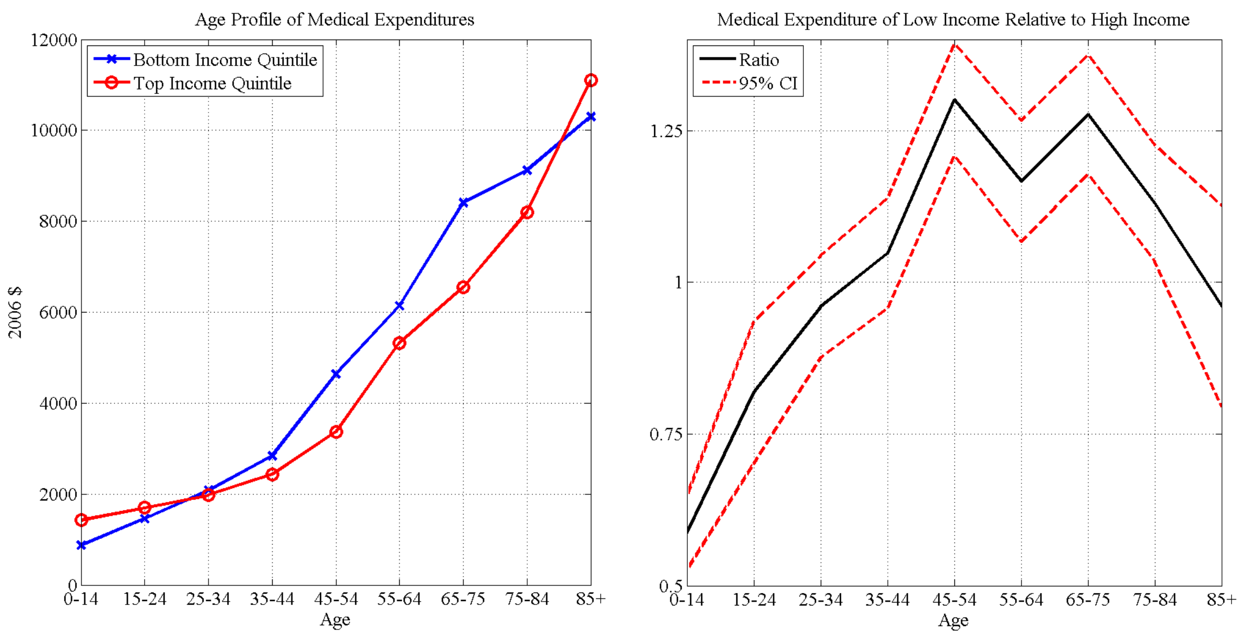
[12]I do not control for year, gender, and race effects. These profiles are robust to controlling for these observables. See Appendix A.2 for a version of this figure where year, gender and race effects are controlled for. Unfortunately, I cannot control for cohort and age effects simultaneously, since my sample covers only a 10-year time span, which does not allow me to observe different cohorts in an age bin. Cohort effects can change my empirical findings if they affect different income groups differently. Recently Jung and Tran (2010b) construct life-cycle profiles of medical expenditures in the MEPS by controlling time and cohort effects simultaneously. They use a seminonparametric partial linear model. They do not find much difference in time and cohort effects between low- and high-skill groups, which can be thought of as a proxy to income. This suggests that cohort effects do not affect my empirical findings.

[13]The ratio of 80th percentile income to 20th percentile is around 4.

[14]Please note that the non-medical consumption of the low-income group relative to the high-income would have decreased over the lifetime due to the increasing inequality in consumption and the ratio would have never risen above 1.

higher fraction of low-income households do not incur any medical expenditure compared to the high-income group. For example, between ages 45 to 54, 20% of the poor do not incur any medical spending in a year, whereas this number is only 7% for the rich. However, this difference is smaller for older households. Moreover, the right panel of the same figure shows the average of the 10% medical expenditures by income groups. For most of the life span, the right tail of the medical expenditure distribution is also fatter for the poor: The top spenders of low-income households incur more extreme expenditures. For example, between ages 45 to 54, the average of the top 10% medical expenditures of the poor is almost one and a half times higher than that of the rich. Combining these two solid observations, I conclude that the distribution of the poor's medical expenditures is more widely spread to the tails.[15]

Figure 1: Age Profile of Medical Expenditures

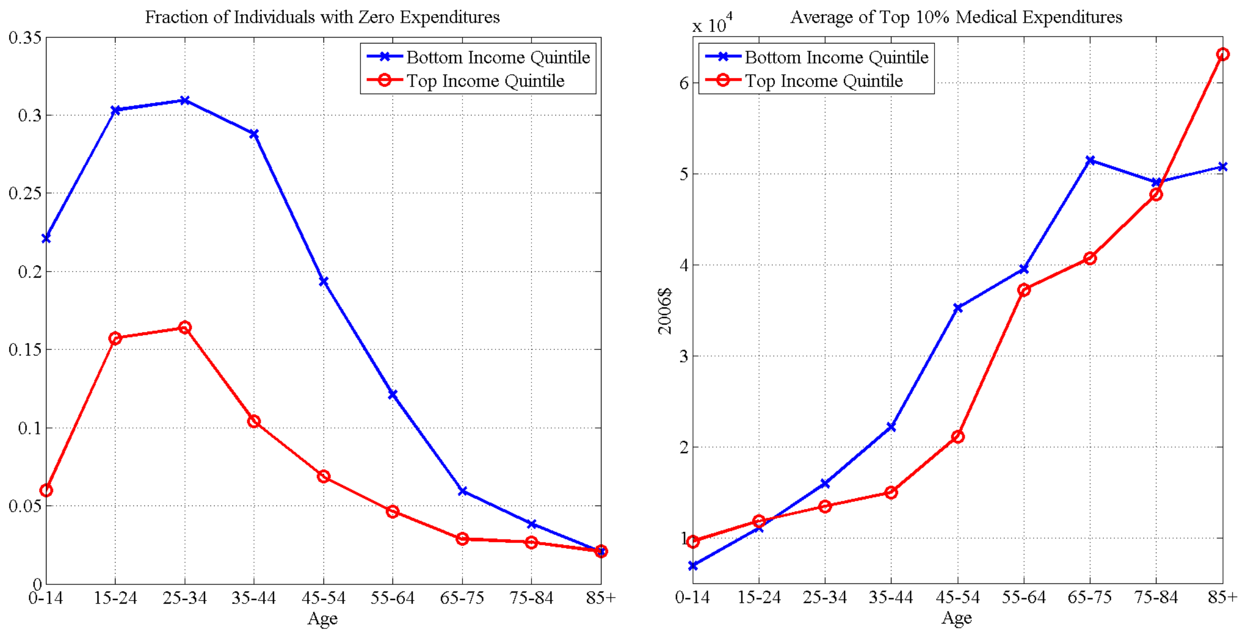


The third empirical fact regards preventive medicine usage by income groups. It is well known in the health economics literature that high-income households consume more preventive care (Newacheck, Hughes, and Stoddard (1996), Watson, Manski, and Macek (2001), Wilson and White (1977)). Using the MEPS data, I provide more evidence in support of this argument. Table 1 reports how frequently households use preventive care

[15]For non-medical goods, the right tail of the expenditure distribution is fatter for high-income households.

for a selected group of examples along with their standard errors in parenthesis.[16] In the MEPS, respondents are asked when was the last time they used a particular preventive medicine. The respondents' answers to these questions are in terms of the number of years since their last usage. Thus, the smaller the figures in Table 1, the more frequently preventive care is used. Note that high-income households consume preventive health care services and goods substantially more often than low-income households.

Figure 2: Extensive and Intensive Margins of Medical Expenditures



Last, another well-known empirical fact in the literature is that the life expectancy of low-income households is dramatically lower than that of high-income ones (Deaton and Paxson (1999), Attanasio and Emmerson (2003), De Nardi, French, and Jones (2009)). At age 25, individuals from low-income families (with family income less than $10,000 in 1980) expect to live almost 8 years shorter lives than those of high-income individuals (with family income more than $25,000 in 1980) (Lin, Rogot, Johnson, Sorlie, and Arias (2003)). Although this difference is smaller for older households, there is still a significant mortality differential between income groups.

[16]There are more examples of preventive care in Appendix A.3 that support the argument.

Table 1: Preventive Medicine Usage

Income Quintiles	Dentist	Cholesterol	Flu Shot	Prostate Test	Mammogram
Bottom Quintile	2.608	2.863	4.230	4.057	3.293
	(0.00984)	(0.0235)	(0.0215)	(0.0223)	(0.0149)
Top Quintile	1.689	2.207	3.733	2.814	2.433
	(0.00966)	(0.0180)	(0.0253)	(0.0223)	(0.0184)
Observations	254445	169552	176935	43337	72777

All of these empirical facts show substantial disparities in health care spending and health outcomes between low- and high-income households.

3 Intuition in a Stylized Framework

In this section I introduce a simple version of the more general model studied in Section 4, which features the distinction between physical and preventive health capital. Then I use this model to illustrate the key mechanisms at work in the model and how the model generates results consistent with the facts reported in Section 2.2. Then I discuss the other features of the full model in Section 4.

3.1 The Basic Model of Health Capital

The economy is populated by overlapping generations of a continuum of agents. The cohort size of newborns is normalized to 1. The agents are subject to health shocks that affect their survival probability to the next period. They can live up to a maximum age of T.

Preferences and Endowment I assume standard preferences over consumption:

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

where c and σ denote consumption and the constant relative risk aversion coefficient, respectively. For a positive value of life, $\sigma < 1$ needs to be assumed. With this form of preferences, households value both consumption and a longer lifetime over which consumption can be smoothed. Thus these preferences introduce a trade-off between more consumption per period and a longer lifetime, which will play a key role in my model.

Individuals are born as one of two ex-ante types: rich and poor, $i \in \{rich, poor\}$. Each period they are endowed with constant income, w^i, depending on their ex-ante type.

Health Technology The model features two distinct types of health capital: physical health capital and preventive health capital. Physical health capital determines the survival probability together with health shocks, whereas preventive health capital affects the distribution of health shocks. For example, the influenza vaccine (flu shot) is a preventive medicine (an investment in preventive health capital) that basically affects the probability of one's getting the influenza virus. On the other hand, getting the influenza virus is a physical health shock that affects an individual's survival probability and depreciates physical health capital if it is not cured.[17]

A newborn individual is born with 1 unit of physical health capital, i.e., $h_0 = 1$. Each period she is hit by a physical health shock, ω_t. She can invest in physical health capital according to a physical health production technology. Specifically, $Q_t^C = A_t^c m_{C,t}^{\theta_t^c}$, where $m_{C,t}$ denotes the curative medicine, and A_t^c and θ_t^c denote the productivity and the curvature of a physical health production technology at age t, respectively. She can invest in physical health capital only up to fully recovering the current health shock, i.e., $m_{C,t} \leq (\omega_t / A_t^c)^{1/\theta_t^c}$:

$$h_{t+1} = \begin{cases} h_t & if \quad A_t^c m_{C,t}^{\theta_t^c} \geq \omega_t \\ h_t - \omega_t + A_t^c m_{C,t}^{\theta_t^c} & otherwise \end{cases} \tag{2}$$

Similarly a newborn individual is also endowed with 1 unit of preventive health capital, i.e., $x_0 = 1$. Each period her preventive health capital depreciates at a constant rate of δ_x. She can invest in preventive health capital according to a preventive health production technology, $Q_t^P = A^p m_{P,t}^{\theta^p}$ where $m_{P,t}$ denotes the preventive medicine at age t, and A^p and θ^p denote the productivity and the curvature of a preventive health production technology, respectively. In a period she can invest in preventive health capital only up to fully

[17] In a more broad definition preventive care includes all health care goods and services that can mitigate future severe and costly health shocks. For example, relatively cheap recommended diabetic services and effective management of diabetes can avoid end-stage renal disease, which is highly morbid and very costly.

recovering the current depreciation in preventive health capital, i.e., $m_{P,t} \leq (\delta_x x_t / A^p)^{1/\theta^p}$:

$$x_{t+1} = \begin{cases} x_t & if \quad A^p m_{P,t}^{\theta p} \geq \delta_x x_t \\ x_t(1-\delta_x) + A^p m_{P,t}^{\theta p} & otherwise \end{cases} \tag{3}$$

The health shocks are assumed to be log-normally distributed with parameters μ_t^j , and σ_t^2 where j denotes the type of the distribution. In any period, the agent draws her health shock from one of the two types of distribution, which differ only in the mean, μ_t^j. Particularly, health shocks can be drawn from either the "good" distribution with mean μ_t^G (distribution of mild shocks) or the "bad" distribution with mean μ_t^B (distribution of severe shocks). The probability that one draws the health shock from the "good" distribution is a linear function of preventive health capital and is denoted by $\pi(x) = x$.

The probability of surviving to the next period is a linear function of current physical health capital net of the health shock and is given by $s(h_t - \omega_t) = h_t - \omega_t$[18].

Financial Market Structure Individuals receive a constant stream of income, w^i, depending on their ex-ante type ($i \in \{rich, poor\}$). They can accumulate assets, a, at a constant interest rate r. They are not allowed to borrow.[19] They allocate their total resource between consumption c, curative medicine m_c, preventive medicine m_p, and asset holdings for next period:

$$w^i + (1+r)a_t = c_t + m_{C,t} + m_{P,t} + a_{t+1} \tag{4}$$

Individuals are allowed to default in the case of severe health shocks if their resources

[18] I make an implicit assumption that current investment in physical health capital does not affect the current survival probability but future ones. I need to make this assumption to identify physical health production technology parameters, which I will discuss further in Section 5.1.2. A more realistic way to model survival probability is to make it depend also on curative medical expenditures as well as physical health capital and health shocks. With the current setup agents choose to recover the health shocks fully for most of the life span. This is due to the fact that shocks are irreversible in that if they are not cured in the current period, they cannot be cured in the future and they affect survival probabilities in all future periods. Thus, allowing the survival probability to depend on current curative medicine may not change the results significantly.

[19] The natural borrowing limit in this economy is zero borrowing. In order to check whether the borrowing constraint plays an important role in my results, I have worked out a version of the model where agents are endowed with heterogeneous initial wealth and receive the same small amount of income stream. See Appendix B for simulation results of this case. The results hold qualitatively and I conclude that borrowing constraints do not play a crucial role in my results.

are not enough to fully recover the shock (i.e., $\left(\frac{\omega}{A^p}\right)^{(1/\theta^p)} > w^i + (1+r)a - c_{min}$). Allowing them to have an option to default also captures the relatively free government programs such as Medicaid and Medicare or emergency room examinations. If an individual chooses to default the shock is fully recovered and her consumption level equals the consumption floor, c_{min} for one period. She spends her entire resource on curative medicine and therefore she can neither buy preventive medicine nor save for the next period. In future periods, she can accumulate asset and invest in preventive health capital.

Let I_t^D be a binary variable and equal to 1 if the household chooses to default, zero otherwise. Then, the Bellman equation for a type-i household (where $i \in \{rich, poor\}$) can be written as:

$$
\begin{aligned}
V_t^i(h_t, x_t, a_t) &= \mathbb{E}_{\omega_t}\left[\max_{\substack{I_t^D, a_{t+1},\\ m_{C,t}, m_{P,t}, c_t}} u(c_t) + \beta s(h_t - \omega_t) V_{t+1}^i(h_{t+1}, x_{t+1}, a_{t+1})\right] \\
s.t. &\quad (2) \ and \ (3) \\
I_t^D &\in \{0,1\} \\
(1 - I_t^D) w^i &= (1 - I_t^D)(-(1+r)a_t + c_t + a_{t+1} + m_{C,t} + m_{P,t})
\end{aligned}
$$

$$
\begin{aligned}
I_t^D m_{C,t} &= I_t^D (\omega_t / A_t^c)^{(1/\theta_t^c)} \\
I_t^D c_t &= I_t^D c_{min}, \ I_t^D a_{t+1} = 0, \ I_t^D m_{P,t} = 0 \\
log(\omega_t) &\sim \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}
\end{aligned}
$$

3.2 Mechanism

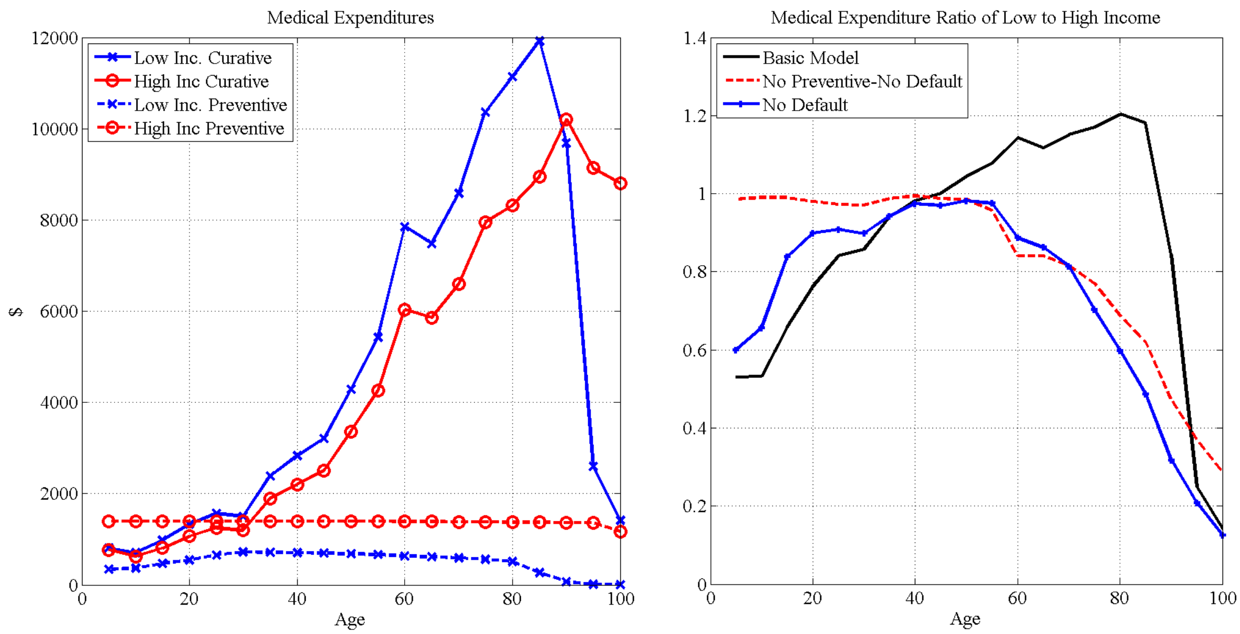
Even the simplest version of the model is complicated enough not to allow me to derive any analytical results. For this reason, to discuss the mechanism with key ingredients, I simulate the model using the parameter values discussed in Section 5.1.2. The emphasis in this section is on the economic forces at work. Therefore, I relegate the details of the parameter values to Section 5.1.2.

The left panel of Figure 3 shows the lifetime profile of medical expenditures. Dashed and solid lines plot preventive and curative medical expenditures, respectively. And red circles and blue crosses represent high- and low-income households, respectively. Moreover, the solid black line on the right panel shows the ratio of medical spending of low-income households to high-income ones. Throughout the lifetime rich households spend substantially more on preventive medical expenditures than do poor households, whereas the curative medical spending of the poor exceeds that of the rich until very old age.

The major trade-off in the model is between the amount of consumption per period and the length of lifetime. Through the magnitude of the health shocks, expected lifetime is mainly determined by the investment in preventive health capital. The richer the household, the longer it can afford to live (since it can afford to consume more). Thus, high-income households invest in preventive health capital more than low-income households do. Therefore, as the cohort grows older, low-income households draw larger health shocks compared to high-income households and in turn incur higher curative medical expenditures. This explains the increase in the medical expenditures of low-income households relative to those of high-income until very old age. The option to default in the case of severe health shocks amplifies this mechanism by hampering the incentives of low-income households to invest in preventive health capital and allowing them to incur medical expenditures higher than their resources. By means of this option to default, the medical spending of the poor exceeds that of the rich midway through life until very old age.

As for the very elderly, the return on health capital investment is low for them, since they face large health shocks and expect to live shorter lives. The return is even lower for poor households, since the level of their preventive health capital is low compared to that of rich which leads to shorter lives for the poor. This is the major reason for the sharp decrease in the ratio of medical spending of the poor to the rich for the very elderly. In addition, selection effect also plays a role. Among the very elderly the low-income households are mostly the lucky ones who have drawn smaller shocks during their lives so they could accumulate relatively more assets; therefore the difference between the rich and the poor is less significant for older households. Moreover the lucky elderly poor could also invest in preventive health capital more, thereby making the mean of health shocks relatively smaller for them.

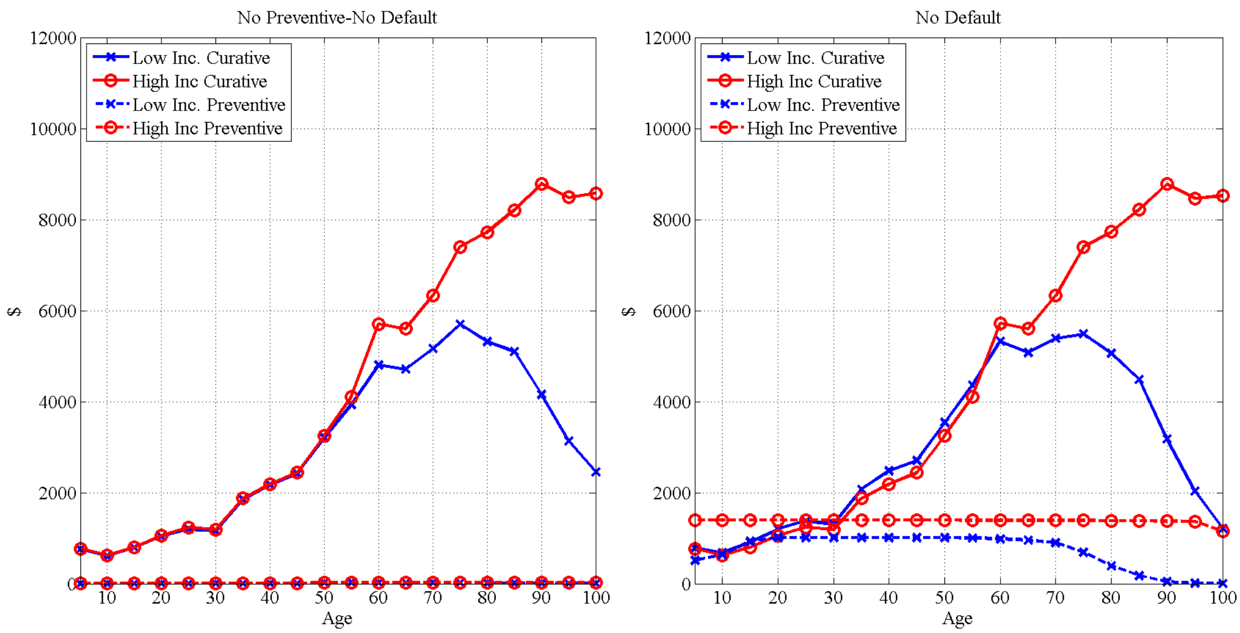
Figure 3: Lifetime Profile of Medical Expenditures



The major ingredients of the model are two distinct types of health capital and the option to default. To investigate their role in the mechanism, I first shut down both the preventive health capital channel and the option to default. I assume that the "good" and the "bad" health shock distributions have the same mean (i.e., $\mu^G = \mu^B$) and restrict agents so that they are not able to default. The dashed red line on the right panel in Figure 3 plots the ratio of medical expenditures of low- to high-income households in the case of no preventive health capital. If there were only physical health capital, then medical expenditures of the poor relative to the rich would exhibit a non-increasing profile over the life cycle. The left panel of Figure 4 shows the lifetime profile of medical expenditures. Early in life both low- and high-income households optimally choose the corner solution, which is to fully recover the health shocks.[20] As an individual grows older, the health shocks get larger. Then both the return on health capital investment decreases and the cost of fully recovering the shocks increase. As a result, the poor invest in health capital less than the amount needed to fully recover the shocks, whereas for the rich the corner solution is still optimal for them until very old age.

[20]This is why the ratio of medical expenditures is around 1 for the major part of the life cycle in Figure 3.

Figure 4: Lifetime Profile of Medical Expenditures



Now I turn to the role of the option to default. For this purpose I restrict agents so that they are not able to default but I allow for two distinct types of health capital. The solid blue line with plus signs on the right panel of Figure 3 shows the expenditures of the poor relative those of the rich for this case. As seen in the figure, the concavity of the relative expenditure profile is more pronounced when agents are allowed to default. Without the option to default, on average the health care spending of low-income households would never exceed that of high-income households. The right panel of Figure 4 plots the lifetime profile of curative and preventive medical expenditures for low- and high-income households in the case of no default. If default is not allowed the poor spend significantly more on preventive medicine over the life cycle compared to the case with the option to default. Thus, I conclude that the option to default amplifies the mechanism by hampering the incentives of the poor to invest in preventive health capital and allowing them to incur medical expenditures higher than their resources.

4 Full Model

The simple model of two distinct types of health capital looks promising to study the differences in dynamics of medical expenditure between low- and high-income households.

But it falls short of being a model to be used for policy evaluation, since it lacks major features of the labor market (i.e., idiosyncratic labor market risk, etc.) and the U.S. health care system (i.e., availability of private health insurance, Medicaid, Medicare, etc.), which can play an important role in the evaluation of counterfactual health care policy.[21] For this purpose we need a full-blown model that takes into account these features.

In this section, I introduce a richer version of the basic framework presented in Section 3.1. Namely, I extend the basic model by preserving its main structure. Specifically, the accumulation process for the physical and preventive health capitals (h_t and x_t, respectively) are the same as those given by Equations (2) and (3). Moreover, households are still allowed to default in the case of "severe" health shocks.

First, I discuss the household's life-cycle problem, specifically, the preferences and the three different phases of life: childhood, working years, and retirement. Then in Section 4.2, I introduce health insurance plans and a private health insurance market. Last I discuss the government's budget constraint in Section 4.3.

4.1 Household's Problem

4.1.1 Preferences

Households' preferences over being alive, consumption, and physical health are ordered according to (à la Hall and Jones (2007)):

$$u(c,h) \quad = \quad b + \frac{c^{1-\sigma}}{1-\sigma} + \alpha \frac{h^{1-\gamma}}{1-\gamma} \tag{5}$$

where b, c, and h denote the value of being alive, consumption, and physical health capital, respectively. Although the general mechanism would work under homothetic preferences (which is shown in the basic model in Section 3.1), there are a few advantages to using this type of preferences: First, it allows me to incorporate the value of life explicitly so that agents prefer to live longer not just because they prefer to smooth their consumption over a longer period but also because an additional year of life gives them the joy of being alive. Second, under these preferences the marginal utility of consumption falls rapidly relative to

[21] Indeed due to the lack of insurance, this model implies a very sharp decline in the ratio of medical expenditures of low to high income for old households.

the joy of being alive, which implies larger differences in the valuation of life between low- and high-income agents than under homothetic preferences. This feature of the preferences comes in handy in the quantitative analysis. Last, these preferences allow me to a choose relative risk aversion coefficient, σ, greater than 1.

I also assume that households enjoy the quality of their lives, where α and γ represent quality-of-life parameters. There are situations where health and consumption are complements (e.g., marginal utility of a fine meal is lower for diabetics) and other situations where they are substitutes (e.g., marginal utility of hiring a maid is higher for a sick person). Thus, I choose the intermediate case and assume that they are separable (Hall and Jones (2007), Yogo (2007)).

4.1.2 Three Phases of the Life Cycle

Individuals live through three phases of the life cycle, each of which has unique features. They are born into families of different income levels and stay with their parents until age T_{CHILD}. Then they join the labor force and earn an idiosyncratic labor income until age T_{RET}. Finally, they retire and receive a retirement pension from the government proportional to their last period's labor income. Throughout their lifetime, they are subject to an endogenous death probability, and by the end of age T, everyone dies with certainty. Now, I discuss the three phases of the life cycle in detail.

Childhood Years: Individuals are born into families that are heterogeneous in family income. Throughout childhood they receive a constant stream of income, w^i, from their parents. I do not model the parent-child interaction explicitly (which would unnecessarily complicate the model further). Rather, I assume that, each period, parents spend the same constant amount of money on behalf of and for the enjoyment of their children.

Parents are offered a private health insurance contract for their children. If they choose to buy insurance, they pay a premium of p_t^{PRV} and they receive reimbursement for their medical expenditures according to health insurance coverage function $\chi^{PRV}(m)$ from the insurance firm, where m is total medical expenditures. If their income is lower than some level of poverty threshold, they are eligible for Medicaid, $\chi^{MCD}(m)$, which is a government-financed health insurance contract. The details of the private and the Medicaid health insurance contracts will be discussed in Section 4.2. I assume that there is no cost of enrolling in Medicaid; thus, once they are eligible, parents choose to enroll their children in this program.[22]

Parents are not allowed to accumulate assets for their children throughout this phase. They can buy consumption, c_t, curative medicine, $m_{C,t}$, preventive medicine $m_{P,t}$ and private health insurance with their income.

Working Years: After age T_{CHILD} individuals join the labor force. They inelastically supply labor hours in return for idiosyncratic labor income, w_t^i, which follows an $AR(1)$ process. In addition, an individual's physical health status in the current period, $h_t - \omega_t$, affects her labor productivity proportionally. Specifically, her labor earnings at age t are $w_t^i(1 - (1 - (h_t^i - \omega_t^i))\zeta)$, where ζ determines the decrease in earnings due to health status. Thus, workers experience a decrease in their earnings due to physical health shocks. Moreover, the government taxes total income progressively with average tax rate $\tau(.)$.

Individuals in their working years are also offered private health insurance. They can buy insurance by paying an age-specific insurance premium, p_t^{PRV}. In the US poverty alone does not necessarily qualify an adult for Medicaid.[23] Thus I assume that adults are not eligible for Medicaid. Since more than 85% of private insurance is provided through employers (Mills (2000)), I assume that the health insurance premium is tax deductible.

Financial markets are incomplete in that adults (both workers and retirees) can only accumulate a risk-free asset, a_t, at a constant interest rate r against idiosyncratic labor market risk and idiosyncratic health risk, although they are not allowed to borrow.[24]

Retirement Years: Individuals retire at age T_{RET} and as long as they are alive, they receive constant pension payments from the government as a function of their last period earnings, $\Phi(w_{T_{RET}}^i)$. They die by the end of age T with certainty.

All of the elderly are covered by Medicare, which is a government-financed health insurance contract. Namely, they receive reimbursement for their medical expenditures with respect to health insurance coverage function $\chi^{MCR}(m)$ from the government.

[22] It is well known in the literature that although they are eligible, some people do not enroll in Medicaid. I abstract from this feature in my model.

[23] Some of the eligibility groups for Medicaid are AFDC-eligible individuals (Aid to Families with Dependent Children), pregnant women with income lower than threshold, children under age 19, recipients of SSI, recipients of foster care. Thus, poverty alone does not necessarily qualify an individual for Medicaid. As a result, I assume that adults are not eligible for Medicaid.

[24] Since survival probability is endogenous, natural borrowing limit is zero borrowing limit.

4.2 Health Insurance Plans

Individuals are offered different health insurance contracts during different phases of their lifetime. During childhood and working years they are offered private health insurance. If they are poor during childhood, they are covered by Medicaid. And all of the elderly are covered by Medicare.

Individuals are not allowed to buy private health insurance after they observe the health shock. They need to make their decision before the health shock is realized. One way to interpret this condition is that private insurance firms can discriminate against patients with pre-existing health conditions. Another way to interpret it is that shocks are observable by the private insurance firm, and the price firms ask for is higher than the individual is willing to pay due to operational costs.

All three types of insurance plans involve both deductibles and co-payments. The coverage function of a health insurance plan $j \in \{PRV, MCD, MCR\}$ (private, Medicaid, and Medicare plans, respectively) is as follows:

$$\chi^j(m) = \begin{cases} 0 & m \leq \iota^j \\ \varsigma^j(m-\iota) & m \geq \iota^j \end{cases} \tag{6}$$

where m denotes total medical expenditures of the individual including curative medical expenditures $m_{C,t}$ and preventive medical expenditures $m_{P,t}$. Namely, an individual who is covered by the health insurance plan j does not receive reimbursement for her medical expenditures up to deductible ι^j. And for every dollar she spends above the level of the deductible ι^j, she receives ς^j fraction of each dollar spent as the remainder of co-payment. These reimbursement schemes are determined exogenously.

Insurance premiums depend only on age so that everybody in age t pays the same insurance premium p_t^{PRV} regardless of their physical health capital h_t^i, preventive health capital x_t^i, income w_t^i, and asset holdings a_t^i. The private health insurance market consists of many small firms. Insurance premiums are determined competitively through firms' zero-profit condition. The firm's revenue in the age t sub-market is composed of insurance premia collected from customers. The costs of the firm include both the financial losses due to medical expenditures and operational costs (overhead costs), which are proportional to financial losses, specifically Δ fraction of financial losses. Since there is free entry to every sub-market t, in equilibrium, revenues pay out costs in each sub-market.

4.3 The Tax System and the Government Budget

The government imposes a progressive income tax, $\tau(.)$. The collected revenues are used for three main purposes: (i) to finance the Social Security system, (ii) to finance the medical expenditures due to Medicaid, Medicare and default and (iii) finally, to finance the government expenditure, G, that does not yield any direct utility to consumers (because of either corruption or waste).[25] The residual budget surplus or deficit, Tr, is distributed in a lump-sum fashion to all households regardless of age.

4.4 Individual's Dynamic Program

Let I^D be an indicator that is equal to 1 if the agent chooses to default and 0 otherwise. Similarly, $I^j$is an indicator that is equal to 1 if the agent is covered by type-j health insurance and 0 otherwise, where $j \in \{private, Medicaid, Medicare\}$. The dynamic program of a typical individual is given by:

$$
\begin{aligned}
V_t(h_t, x_t, a_t, w_t) &= \mathbb{E}_{\omega_t}\left[\max_{\substack{I_t^{PRV}, I_t^D, a_{t+1}, \\ m_{C,t}, m_{P,t}, c_t}} \left\{u(c_t, h_t - \omega_t) + \beta s(h_t - \omega_t)\mathbb{E}_{w_{t+1}}\left[V_{t+1}(h_{t+1}, x_{t+1}, a_{t+1}, w_{t+1})\right]\right\}\right] \\
\text{s.t} &\quad (2)\ and\ (3) \\
I_t^{MCR} &= \begin{cases} 1 & if \quad t \leq T_{CHILD}\ and\ w_t \leq \underline{\mathrm{w}} \\ 0 & otherwise \end{cases} \\
I_t^{MCD} &= \begin{cases} 1 & if \quad t > T_{RET} \\ 0 & otherwise \end{cases} \\
\sum_j I_t^j &\leq 1 \\
y_t &= \begin{cases} w_t - p_t^{PRV} I_t^{PRV} & t \leq T_{CHILD} \\ (1 - \tau(w_t + ra_t - p_t^{PRV} I_t^{PRV}))(w_t + ra_t - p_t^{PRV} I_t^{PRV}) & t > T_{CHILD} \end{cases} \\
(1 - I_t^D) y_t &= (1 - I_t^D)(-a_t + a_{t+1} + c_t + m_{C,t} + m_{P,t} - \sum_j I_t^j \chi^j (m_{C,t} + m_{P,t}))
\end{aligned}
$$

[25] Another way to think about government expenditures is that households enjoy government spending separately from their utility from consumption and health.

$$
\begin{aligned}
I_t^D m_{C,t} &= I_t^D (\omega_t / A_t^c)^{(1/\theta_t^c)} \\
I_t^D c_t &= I_t^D c_{min},\ I_t^D a_{t+1} = 0,\ I_t^D m_{P,t} = 0 \\
a_{t+1} &= 0 \qquad \forall t \leq T_{CHILD} \\
w_t &= \begin{cases} \bar{w} & t \leq T_{CHILD} \\ \rho w_{t-1} + \eta_t,\ \eta_t \sim N(0, \sigma_\eta^2) & T_{CHILD} < t \leq T_{RET} \\ \Phi(w_{T_{RET}}) & t > T_{RET} \end{cases} \\
log(\omega_t) &\sim \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}
\end{aligned}
$$

Definition 1. A stationary competitive equilibrium of this economy for given insurance coverage schemes $\chi^j()$, average tax rate function $\tau()$, and risk-free interest rate r is a set of decision rules, $\left\{I_t^{PRV}(z_t'),\, I_t^D(z_t),\, a_{t+1}(z_t),\, m_{C,t}(z_t),\, m_{P,t}(z_t),\, c_t(z_t)\right\}_{t=1}^T$; value functions $\{V_t(z_t')\}_{t=1}^T$, where $z_t' = (h_t, x_t, a_t, w_t)$ and $z_t = (h_t, x_t, a_t, w_t, \omega_t)$; age-dependent prices for private health insurance plans $\left\{p_t^{PRV}\right\}_{t=1}^{T_{RET}}$ and measures $\{\Lambda_t(z_t)\}_{t=1}^T$, $\left\{\Lambda_t'(z_t')\right\}_{t=1}^T$such that:

1. Given insurance coverage schemes $\chi^j()$, average tax rate function $\tau()$, risk-free interest rate r, and age-dependent prices for private health insurance plans $\left\{p_t^{PRV}\right\}_{t=1}^{T_{RET}}$ decision rules and the value function solve the individual's problem.

2. The age-dependent private health insurance plan price satisfies firms' zero-profit condition:

$$\int_{z_t'} I_t^{PRV}(z_t') p_t^{PRV} d\Lambda'(z_t') - (1+\Delta) \int_{z_t} m(z_t) d\Lambda(z_t) = 0 \ \ \forall t \tag{7}$$

3. $\{\Lambda_t(z_t)\}_{t=1}^T$,$\left\{\Lambda_t'(z_t')\right\}_{t=1}^T$ are generated by individuals' optimal choices.

4. The government budget balances as discussed in Section 4.3:

$$\begin{aligned}
\sum_{t=T_{CHILD}+1}^{T}\int_{z_t}(w+ra_t-p_t^{PRV}I_t^{PRV}(z_t')-y_t)d\Lambda(z_t) &= G+\sum_{t=1}^{T}\int_{z_t}Trd\Lambda(z_t)+ \\
\sum_t\int_{z_t}\chi^{MCD}(m_{C,t}(z_t)+m_{P,t}(z_t))I_t^{MCD}(z_t)d\Lambda(z_t) &+ \\
\sum_t\int_{z_t}\chi^{MCR}(m_{C,t}(z_t)+m_{P,t}(z_t))I_t^{MCR}(z_t)d\Lambda(z_t) &+ \\
\sum_t\int_{z_t}(m_{C,t}(z_t)+c_{min}-y_t-a_t)I_t^{D}(z_t)d\Lambda(z_t) &+ \sum_{t=T_{RET}+1}^{T}\int_{z_t}w_t(z_t)d\Lambda(z_t)
\end{aligned} \tag{8}$$

The first term in the government's budget is the total tax revenue from total income collected from all adult agents. On the right-hand side, government finances government expenditures, G, lump-sum transfers, Tr, Medicaid expenditures integrated over eligible children, Medicare expenditures integrated over all elderly, curative medicine expenditures due to default, and last the pension payments, which depend on a worker's last period income.

5 Quantitative Analysis

In this section, I begin by discussing the parameter choices for the model. Then in Section 5.2, I present simulation results and their counterparts in the data to evaluate the model's performance such as the lifetime profile of medical expenditures by income, mortality differences, conditional survival probability over the life cycle, etc.

5.1 Estimation

My basic estimation strategy is to fix some parameters exogenously outside of the model (e.g., labor income process, insurance coverage schemes, etc.) and to choose the remaining parameters using the model and a set of moments from the MEPS (e.g., distribution of health shocks, physical and preventive health production technology parameters, etc.).

5.1.1 Externally Calibrated Parameters

Table 16 shows the parameters that are fixed exogenously together with their values.

Demographics The model period is one year. Households enter the labor market at age 21 ($T_{CHILD} = 20$). Moreover, workers retire at age 65 ($T_{RET} = 65$) and die with certainty at age 110 ($T = 110$).

CRRA coefficient De Nardi, French, and Jones (2009) estimate the constant relative risk aversion coefficient in a structural model with uncertain medical expenditures. I follow them and set the constant relative risk aversion coefficient $\sigma = 3$, which is higher than is usually assumed in the literature ($\sigma = 2$).[26]

Interest rate I assume that interest rate, r is determined exogenously by world factors in an open-economy equilibrium and I set $r = 2.5\%$.

Income Process I calibrate the common deterministic age profile for income using the MEPS data.[27] For the stochastic component of the income process, three parameters are required. These are the variance of individual-specific fixed effects, σ_α^2 which determine the cross-sectional variation in income among children and the variation in initial conditions in the beginning of the labor market. The other two parameters are the persistence, ρ, and the variance, σ_η^2, of persistent shocks. The MEPS has a very short panel dimension that practically does not allow me to estimate these parameters.[28] Thus, I use the estimated values of these parameters from Storesletten, Telmer, and Yaron (2000), since they estimate an $AR(1)$ income process using household income data.[29]

Last, I estimate the decrease in labor earnings due to physical health status (ζ) using the MEPS data. Using the (fairly short) panel dimension of the survey, I control for the fixed effects and estimate the effect of health status on labor earnings.[30]

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[26] I do a robustness check with $\sigma = 2$, and all the results hold qualitatively.

[27] I use the normalized family income to calibrate the deterministic component. There is little change in average (normalized) family income throughout childhood. Thus, I assume that children receive a constant (but idiosyncratic) stream of income. During adulthood, labor income increases by 60% up to age 45 and then decreases by 25% by the age of retirement. This hump-shaped profile is in line with other estimates in the literature. Income during retirement is determined by the government pension function $\Phi()$.

[28] In the MEPS, respondents are surveyed for only two consecutive years.

[29] They also include a transitory component but due to computational issues, in my model and calibration I abstract from transitory income shocks.

[30] Health status is measured by the subjective evaluation of the respondent. The details are reported in Appendix A.4

Social Security Benefits In a realistic model of the retirement system, a pension would be a function of lifetime average earnings, but this would require me to incorporate average earnings as an additional continuous state variable to the problem of the household.[31] Instead, in my model the retirement pension is a function of predicted average lifetime earnings. I first regress average lifetime earnings on last period's earnings and use the coefficients to predict an individual's average lifetime earnings, denoted by $\hat{y}_{LT}(w_{T_{RET}})$ (Karahan and Ozkan (2009)). Following Guvenen, Kuruscu, and Ozkan (2009) I use the following pension schedule:

$$\Phi(\hat{y}_{LT}(w_{T_{RET}})) = a \times AE + b \times \hat{y}_{LT}(w_{T_{RET}})$$

where AE is the average earnings in the population. I set $a = 16.8\%$ and $b = 35.46\%$.

Consumption Floor and Poverty Threshold Hubbard, Skinner, and Zeldes (1994) estimate the statutory consumption floor for a representative adult considering SSI benefits, housing subsidies and food stamps and find it to be \$7000 (in 1984). However, De Nardi, French, and Jones (2009) recently estimate the effective consumption floor in an uncertain out-of-pocket medical expenditures setting for the elderly and find it to be much smaller (\$2700 in 1998). Thus I follow an intermediate path between these two papers and set the consumption floor to be \$5000 per year.

Since the unit of interest in my model is an individual, I set the poverty threshold to be equal to the federal poverty threshold for a single adult in 2006, which is equal to \$10488.

Insurance Coverage Schemes I use the MEPS data to estimate the insurance coverage schemes, $\chi^j(m)$. In the MEPS, in addition to total medical expenditures, variables that itemize expenditures according to the major source of payment categories are also available. Thus, I can identify how much of the total expenditure is paid by the household itself, how much of it is paid by the private insurance firm, and how much of it is paid through Medicaid or Medicare, etc. Then using this information, I estimate equation 6 for private insurance holders and Medicare holders. The details of the estimation is presented in Appendix A.5.

I assume that the Medicaid coverage scheme is the same as the private coverage function. Because in the data Medicaid holders incur medical expenditures mostly in the case of

[31] I refrain from doing so, since this would complicate the model without adding any further insight for my purposes.

severe health shocks, I cannot identify the coverage function for small values of medical expenditures. Moreover, in many states Medicaid is provided through private insurance companies, which makes my assumption reasonable. If individuals are younger than 6 years and their income is lower than 133% of the poverty threshold, or if they are between 7-20 years and their income is lower than 100% of the poverty threshold, then they are eligible for Medicaid.[32]

5.1.2 Estimated Parameters

My approach for estimating the remaining parameters is to use my model to match moments in the data that are sufficient to identify all the parameters.

Now, I discuss further which moments help to pin down which parameters. I informally argue that each of the parameters has a significant effect on a subset of the moments and give some intuition for why this is the case. This approach should be convincing, since it provides an understanding of how the moments are sufficient to pin down the parameters (Kaplan (2010)).[33]

Preference Parameters The discount factor β is identified from the wealth to income ratio in the economy. I choose β to match an aggregate wealth to income ratio of 3.[34] The value of being alive, b, is identified from average life expectancy in the population (75 years), particularly, life expectancy of the poor.

To identify the remaining preference parameters, (α, γ), which determine the utility from quality of health, I follow Hall and Jones (2007) and draw upon the literature on quality-adjusted life years (QALYs). This literature compares the flow utility level of a person with a particular disease with that of a person in perfect health and estimates QALY weights by age (Cutler and Richardson (1997)). Then I use these weights to estimate α and β:

$$\frac{u(\bar{c}_{20}, \bar{h}_{20})}{0.94} = \frac{u(\bar{c}_{65}, \bar{h}_{65})}{0.73} = \frac{u(\bar{c}_{85}, \bar{h}_{85})}{0.62}$$

[32] Please see details in Health Care Financing Administration (2000).

[33] Note that I use "pin down" and "identify" interchangeably throughout this section.

[34] I define aggregate wealth as the sum of asset holdings and aggregate income as the sum of labor earnings (excluding retirement pension).

where $\bar{c}_t$ and $\bar{h}_t$ denote the average consumption and average physical health capital net of health shocks at age t and 0.94, 0.73, 0.62 are the QALY weights at age 20, 65 and 85 respectively.

Distribution of Health Shocks I normalize the initial level of physical health capital to 1. At each age t there are three parameters for the distribution of the log of health shocks: Means of "good" and "bad" health shock distribution, (μ_t^G, μ_t^B), and the common standard deviation of the distributions, σ_t^2. I assume that the difference between means of the "good" and the "bad" distributions is constant for each age t, i.e., $\mu_t^B = \mu_t^G + \bar{\mu}$. So, there are two parameters in each t, (μ_t^G, σ_t^2), and a common $\bar{\mu}$. Recall that the survival probability is a function of both the current physical health capital h_t and the health shock ω_t. Thus, the distribution of health shocks at age t affects the conditional survival probability to $t+1$. First, I normalize the distribution of health shocks such that the 99.9th percentile of the distribution equals 1 (which is the worst shock, implying death with certainty). Then, the aggregate conditional survival probability in each t can pin down the distribution of shocks along with this normalization. Last, I use differences in the lifetime profile of medical expenditures between low- and high-income households to identify the difference in means of the distributions, $\bar{\mu}$, along with preventive health capital technology parameters, (A^p, θ^p)[35].

Physical Health Production Technology I use the distribution of medical expenditures within 5-year age bins in the data to identify the productivity, A_t^c, and the elasticity, θ_t^c, parameters of the physical health production function. First, let's suppose that we can observe the curative medical expenditure distribution in the data[36] and households choose to fully cure the health shocks[37]. Then there is a one-to-one relationship between the distribution of shocks and the distribution of curative medical expenditures in the data through

[35]Recall from Section 3.2 that if $\bar{\mu} = 0$ then medical expenditures of the poor relative to the rich exhibit a non-increasing profile over the life cycle.

[36]In order to identify the curative medical expenditure distribution in the data we need to identify the preventive medical expenditure distribution, and vice-versa. I'll discuss how we identify the distribution of preventive medicine expenditures using my model in the next paragraph.

[37]Indeed model simulations imply that for reasonable parameter values households choose to fully recover the health shocks throughout their lifetime except for very old age (older than 90). This is due to the fact that shocks are irreversible in that if they are not cured in the current period, they cannot be cured in the future and they decrease the survival probability in all future periods.

the physical health production function:

$$\begin{aligned} \omega_t &= A_t^c m_{C,t}^{\theta_t^c} \\ \log \omega_t &= \log A_t^c + \theta_t^c \log m_{C,t} \\ \log m_{C,t} &= \frac{\log \omega_t - \log A_t^c}{\theta_t^c} \end{aligned}$$

Thus, the mean and variance of the distribution of medical expenditure shocks identify the parameters (A_t^c, θ_t^c).

Preventive Health Production Technology I normalize the initial level of preventive health capital to 1. There are three parameters of preventive health production technology: constant depreciation rate δ_x, productivity and curvature parameters of preventive health production function, (A^p, θ^p) (notice that they do not depend on age). The difference in means of the "good" and the "bad" distribution of health shocks ($\bar{\mu}$) and depreciation in preventive health capital (δ_x) cannot be identified jointly. Thus, I assume that $\delta_x = 7.5\%$.

The age profile of medical consumption of low income relative to high income (see the right panel of Figure 1) identifies the preventive health production function parameters (A^p, θ^p). Namely, as can be seen in Figure 3, the model generates an increase in the ratio of medical expenditures of the poor to the rich through the rise in differences in curative medical expenditures. Thus, preventive medical expenditures should be small enough that the increase in differences in $m_{C,t}$ can surpass the differences in $m_{P,t}$. Moreover, early in life, medical expenditures of low-income households are substantially lower than those of high-incomes ones. Thus, there has to be enough differences in preventive medicine usage in the model between low- and high-income groups to match the counterpart in the data.

5.2 Model's Performance

In this section, I examine the fit of the model to the data. First I discuss the performance of the model in fitting the targeted moments in the estimation. Then I present an informal over-identification test of the model by showing the model's performance in fitting the moments that are not targeted in the estimation. The estimated parameter values for the model are shown in Tables 17, 19, and 18.[38]

[38] I estimate the model using the method of simulated moments. For each set of parameters the code takes 1 hour to solve the model. Thus, at this point I am unable to report the standard errors of the parameters.

5.2.1 Fit of the Model to the Targeted Moments

The left panel of Figure 5 plots the average medical expenditures of households (dashed red line), which are computed using 10000 simulated life-cycle paths for individuals starting with the same initial condition, and the data counterpart (solid blue line). And the right panel shows the medical expenditures of low-income households relative to high-income ones and its data counterpart. Average medical expenditures over the life cycle (along with the variances) and the increase in relative expenditures of low- to high-income individuals are used as target moments in my estimation. The model is able to account for the key medical expenditure profiles over the life cycle: The dramatic increase in health care expenditures and the hump-shaped expenditures of the poor relative to the rich.

Figure 5: Medical Expenditures over the Lifetime

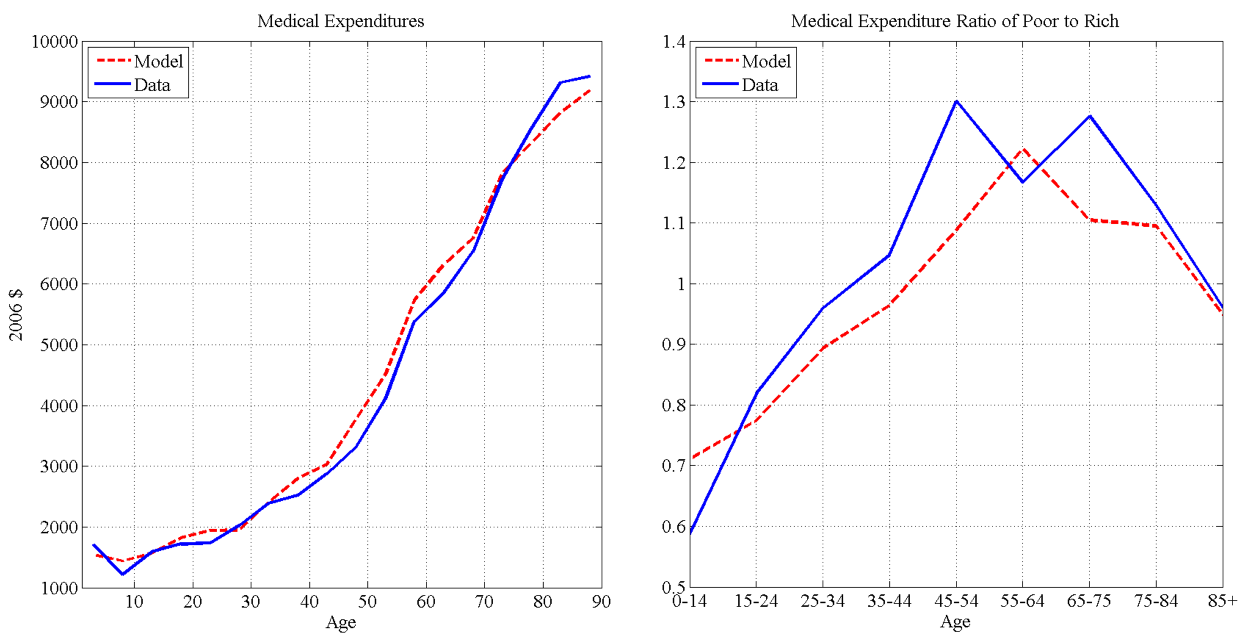


Figure 6 shows the age profile of conditional survival probability implied by the model and its data counterpart, which is used in the estimation. Except for very old age, the model is able to endogenously generate an age profile of conditional survival probability that is very close to the data. Next, I turn to mortality differences between low- and high-income households. For this purpose I compute the life expectancies of both income groups at ages 25, 45 and 65. The results are shown in Table 2 along with their values in the data. Notice that the model is able to endogenously generate a decreasing life expectancy differential between low- and high-income households, albeit not as large a difference as that observed in the data. At age 25, there is almost 8 years difference in life expectancies of the rich and the poor, whereas the model generates only 5 years.

Figure 6: Conditional Survival Probability

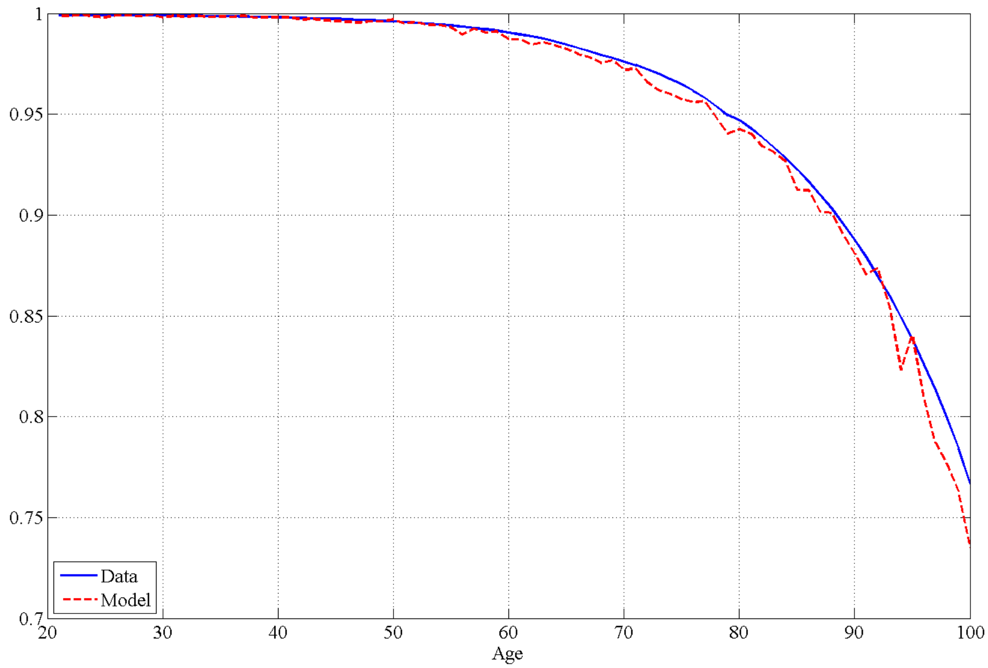


Table 2: Life Expectancy Differential

	Low Income		High Income	
Life Expectancy	Data	Model	Data	Model
Age 25	45.0	48.5	52.9	53.8
Age 45	27.0	30.4	33.9	35.1
Age 65	13.8	15.1	17.1	18.1

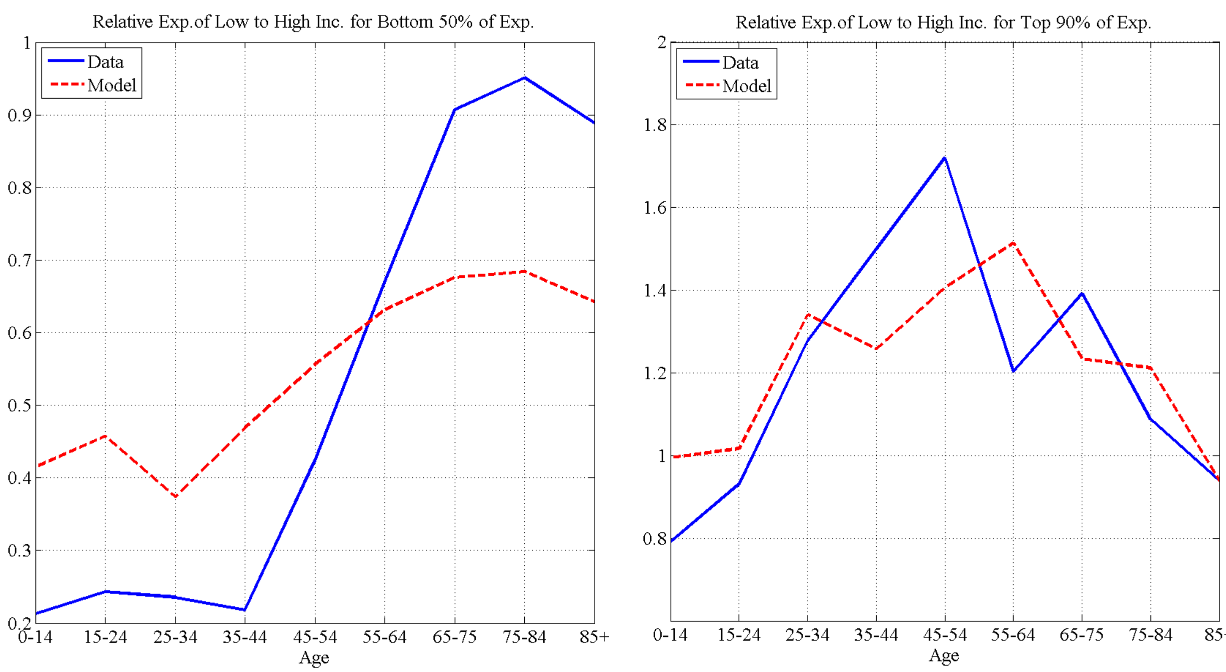
5.2.2 An Informal Over-Identification Discussion

So far, I have presented the fit of the model in matching moments used in the estimation. Now, I present an informal over-identification test of the model by showing the model's performance in fitting the moments that are not targeted in the estimation.

In my estimation I target only the increase in the ratio of medical expenditures of low to high income but not the decrease in the end of the life cycle (see the right panel of Figure

5). The model can capture this decrease fairly well. First, the return on health capital investment is lower for low-income households since they expect to live shorter lives. This reduces medical spending of the poor relative to the rich. Second, selection effect plays a role in the end of the life. As a cohort of individuals grows older, it becomes increasingly composed of the rich; therefore the difference between rich and poor decreases (Shorrocks (1975)). Moreover, the low-income households that could survive until very old age are mostly the lucky ones who are hit by relatively small shocks during their lives. Thus, they could invest more in preventive health capital and therefore, the mean of health shocks they face are relatively smaller.

Figure 7: Bottom and Top End of the Medical Expenditure Distribution



In addition, I decompose the differences in the lifetime profile of medical expenditures between the rich and the poor by investigating the bottom and the top of the spending distribution separately. The left and the right panels of Figure 7 show the average of the bottom 50th and the top 10th percent medical expenditures of the poor relative to those of the rich, respectively.[39] The model is capable of generating differences between the rich

[39] In the data, the bottom 10th percentile of the medical expenditures is zero for both rich and poor. Thus, I choose to investigate the bottom 50th percentile.

and the poor for the top and the bottom of the expenditure distribution. Namely, the average spending of the rich exceeds that of the poor in the bottom of the distribution and this difference is smaller for older ages. On the other hand, in the top of the expenditure distribution low-income households incur more extreme expenditures for most of the life span and the ratio of the spending of the poor to the rich follows a hump-shaped.

Table 3: Aggregate Statistics

	Data	Model
Private Insurance Coverage under age 65	73%	85%
Medicaid Coverage under age 20	22%	23%
Share of Medicaid and Medicare	29%	26%

Table 3 shows three selected statistics in the data and their model counterparts. First, the model results suggest that 85% of the population under age 65 is covered by private insurance, whereas in the data this number is only 73%. This is due to the lack of public insurance channels for individuals between ages 21 to 65 in the model. Thus, the only option for adults is to buy private insurance, which leads to higher ratios of private insurance coverage in the adult population. Second, the model implies an 23% Medicaid coverage for children under age 20, whereas in the data this number is 22%. Lastly, out of total medical expenditures the share of Medicaid and Medicare in the data is 29% and its model counterpart is 26%, which allows me to conclude that the model is fairly successful in fitting the data.[40]

6 Policy Analysis

I now use the model to study counterfactual policy experiments.

6.1 Policy I: Universal Health Care Coverage

One of the main provisions of the Patient Protection and Affordable Care (PPAC) Act of 2010 is to expand health insurance coverage by expanding Medicaid eligibility, subsidizing low-income households to obtain private health insurance, providing incentives for employers

[40]In the data total public spending constitutes 45% of all health care expenditures.

to provide health benefits, and imposing tax penalties for individuals who do not obtain health insurance. These provisions are financed by a variety of taxes, fees, and cost-saving measures. According to the Congressional Budget Office estimates, about 95% of the non-elderly population is expected to have health insurance.[41]

I use my model to evaluate the macroeconomic implications of expanding insurance coverage to the whole population (universal health care coverage). I model the actual policy reform by assuming that the government pays for the private health insurance premia of all non-elderly individuals.[42] The cost of this provision is offset by a proportional income tax that keeps the government expenditures net of transfers the same as before the policy change. In particular, the government budget constraint (equation 8) is satisfied by increasing tax rates ($\tau(.)$) proportionally to income to keep government expenditures (G) constant. This exercise should be viewed as a first step to understanding the impact of the recent reform on the health care system.

Table 4 shows some selected aggregate statistics for the benchmark model (column labeled "Bench.") and their steady-state values after the policy change (column labeled "Policy I"). In order to finance the universal health care coverage policy, the government imposes an additional 3.1% flat tax on income. Since the new policy provides access to health insurance for low-income households, they invest in both preventive and physical health capital more; therefore on average, they live longer by 1.25 years (see Table 5).

Table 4: Policy Analysis

	Bench.	Policy I	Policy II
Average Tax Rate	+0%	+3.1%	+4.06%
Health Spending % of Income	9.84%	9.92%	9.92%
Health Spending/Capita	$4750	$4755	$4738
Medicare Expenditures	2.48%	2.495%	2.42%
Preventive Spending % of Total Spending	21.5%	21.7%	38.5%
Welfare	0%	1.5%	2.5%

The increase in preventive expenditures and curative expenditures due to a longer life

[41] The 5% of the non-elderly population who will lack health insurance will consist of low-income households who are eligible for Medicaid, but do not enroll in it and young single adults who prefer to pay a penalty instead of buying health insurance.

[42] Similarly, one can think of this policy as non-elderly individuals receive vouchers from government to purchase private health insurance. The value of the voucher exactly equals to the health insurance premium she would be paying for Jung and Tran (2010a).

span exceeds the savings in curative expenditures due to milder health shocks. As a result, aggregate health care expenditures increase slightly, from 9.84% of aggregate income to 9.92%.[43] However, due to a longer life span per capita health care expenditures increase even less, only from \$4750 to \$4755. Similarly, due to the longer life span Medicare expenditures rise slightly, from 2.48% of aggregate income to 2.495%. Furthermore, share of preventive care expenditures does not change significantly (it rises only from 21.5% to 21.7%).

Including low-income households into insurance pool has ambiguous effects on insurance premia. On the one hand, the poor spend less on preventive medicine compared to the rich, in turn lower health insurance premia. On the other hand, they are subject to larger health shocks, thereby rising insurance premia. As a result, health insurance premia of individuals younger than 30 years old decrease by 2.5%. However government pays 1.5% more for households older than 30 compared to the benchmark case.

Table 5: Life Expectancy at Birth for Income Quintiles

	Q1	Q2	Q3	Q4	Q5
Benchmark	71.95	75.2	76.3	76.5	76.8
Policy I	73.2	75.3	76.3	76.5	76.8
Policy II	74.65	75.9	76.5	76.6	76.8

Note: Q1 through Q5 denote lifetime income quintiles from lowest to highest, respectively.

In addition I compute the change in welfare of the society due to universal health care coverage. On the one hand, it increases the welfare of the poor by providing them health insurance at a relatively low cost. On the other hand, it reduces the welfare of the rich due to higher tax rates. In order to evaluate the net effect of universal health care coverage on social welfare quantitatively, I compute the fraction of lifetime consumption that an unborn individual would be willing to give up in order to live in an economy with universal health care coverage instead of the benchmark economy. Namely, let $(1-\phi)$ be this fraction, then ϕ solves the following equation:

$$\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^B-\omega_t)u(c_t^B,h_t^B-\omega_t)=\mathbb{E}\sum_{t=1}^{T}\beta^{t-1}s(h_t^P-\omega_t)u(\phi c_t^P,h_t^P-\omega_t)$$

[43]The change in total income is negligible. This is because the slight increase in labor earnings due to better health outcomes is offset by a decrease in asset income. Under the new policy households accumulate less capital because of the distortion by better insurance opportunities against health shocks and redistribution in the economy due to the income transfer from the rich to the poor. To be more precise, total income decrease very slightly by 0.2%.

where $\{c_t^B, h_t^B\}$, $\{c_t^P, h_t^P\}$ denote the optimal consumption and physical health capital in the benchmark economy and in the economy with universal health care coverage.

Social welfare is improved under the new health care policy so that an unborn individual would be willing to give up 1.5% of her lifetime consumption in order to live with universal health care coverage instead of the benchmark economy. Around one-third of the welfare gains are due to the increase in the expected lifetime of the bottom first and second income quintile groups. The rest is coming from better insurance opportunities against health shocks.

As expected, welfare gains are not evenly distributed and not even every new born child is better off under the new policy. Welfare gains follow a hump-shaped pattern over the parental income of newborn children (see Table 6). Children of median-income households are gaining most from this policy; they are willing to give up 2.1% of their lifetime consumption in order to live under this new policy . The welfare of newborn babies of very rich families (top 2 percentile group) worsens since they expect to cover most of the cost of universal health care coverage without gaining much insurance ($1 - \phi = -0.88\%$). Surprisingly, children of low-income households' welfare gains are very small ($1 - \phi = 0.6\%$). This is because that curative medicine expenditures constitute the most part of their health care expenditures and the option of default in case of a severe health shock is not too costly for them. Thus additional insurance against health shocks from universal health coverage policy is not very valueable to them.

Please note that in my model labor supply is inelastic; thus, higher tax rates do not lead to a distortion in labor supply, which would reduce the welfare gains. Thus it is not suprising that this policy is welfare improving since it is redistributive in nature that it transfers income from the rich to the poor in the economy. On the other hand, this way of financing universal health care coverage is an assumption to simplify the complicated changes in the law. In reality the tax burden on high-income households will be small compared to this hypothetical exercise, since only a small part of the population will need a subsidy to buy insurance. However, one should still be careful in interpreting the welfare gains in this counterfactual policy experiment.

Table 6: Welfare Gains, $1 - \phi$

	Bottom 2%	Median	Top 2%
Policy I w.r.t Benchmark	0.6%	2.1%	-0.88%
Policy II w.r.t Benchmark	0.35%	3.13%	-1.2%
Policy II w.r.t Policy I	-0.24%	1.105%	-0.29%

Note: This table shows the welfare gains in terms of percentage of lifetime consumption.

6.2 Policy II: Free Preventive Medicine

Under the PPAC Act of 2010 private insurance firms are required to provide basic preventive care free of charge such as childhood immunizations and checkups, mammograms, colonoscopies, cervical screenings, and treatment for high blood pressure.[44] However, patients are still required to pay co-payments for doctor visits and not all preventive care is free. Thus, I study the effect of this policy change by assuming that on top of the current private insurance scheme, firms pay 75% of households' preventive medicine expenditures. I examine this policy change in a universal health care coverage setting discussed in the previous section.[45]

The results of this policy change are reported in Tables 4 and 5 under the column labeled "Policy II". An immediate implication of the new policy is an increase in insurance premia due to higher preventive medicine costs covered by firms. As a result, the government raises flat taxes from 3.1% to 4.06% to finance the rise in premia. Under this new policy, individuals spend more on preventive care which results in an significant increase in share of preventive care expenditures from 21.7% of total medical spending to 38.5%. This also leads to an improvement in life expectancy for all income groups except for the top income quintile (see the bottom row of Table 5).[46]

[44]Some of the other free preventive care items are diabetes and cholesterol tests; counseling on such topics as quitting smoking, losing weight, eating healthfully, treating depression, and reducing alcohol use; routine vaccinations against diseases such as measles, polio, or meningitis; flu and pneumonia shots; counseling, screening, and vaccines to ensure healthy pregnancies; regular well-baby and well-child visits, from birth to age 21, etc.

[45]If I impose the "free preventive care" restriction on health insurance firms in the benchmark case (in which the government does not provide private health insurance to all individuals), many of the low-income households drop out of the health insurance market due to the rise in health insurance premia. But this is not what the PPAC Act of 2010 aims for. Thus, I study this policy change in a universal health care coverage setting.

[46]Top income quintile households have already reached maximum of preventive health capital investment before the policy change.

Surprisingly, even though households spend more on preventive care, and they live longer on average, aggregate medical spending does not change (remains the same at 9.92% of total income) compared to the universal health insurance coverage economy (Policy I). This is due to the milder distribution of health shocks in the new economy by means of larger investment in preventive health capital. As a result, total Medicare spending decreases by 0.075% of total income, from 2.495% to 2.42% of total income and per capita health care expenditures decrease slightly from $4755 to $4738 in the new economy.

I also compute the welfare change for this counterfactual policy experiment: an unborn individual would be willing to give up 2.5% of her lifetime consumption in order to live under this new policy instead of the benchmark economy, which implies a 1% welfare gain compared to the universal health care coverage economy. In this case most of the welfare gain is due to the increase in life expectancy (around 60% of 2.5% gain).

Again welfare gains are highest for new born children of median households. However, under the "free preventive medicine" policy not only new born children of top 2% households but also children of bottom 2% families are worse off compared to an only universal health insurance coverage economy (see last row of Table 6). This is because even under the "free preventive medicine" policy, the poor do not increase spending on preventive health care to a level that the subsidy they get for their preventive medicine expenditures could offset the increase in taxes that are required to pay for this policy.

Please also note that I am simply comparing two steady-state economies, before and after the policy change. A more thourough analysis would be to compute transitional dynamics after the policy change which is computationally infeasible at this point. However, one can speculate about the transition of the economy from old steady state to the new one. After the policy change we should expect aggregate medical costs to increase in the short term since elderly would not be affected by the new policy but only the young who would react to this policy by increasing their spending on preventive care without experiencing an immediate substantial decline in curative medicine expenditures. Thus, from a political economy point of view, the elderly would not support this policy change since this would only imply an increase in tax rates for them.

These results suggest that policies encouraging the use of health care by the poor early in life have significant positive welfare gains, even when fully accounting for the increase in taxes and insurance premia required to pay for them.

7 Comparison of Results to the Literature

In this section I compare the implications of the model introduced in Section 4 to the findings of other studies in the literature.

First, the model presented in this paper points to avoidable health conditions due to lower investment in preventive health capital for poor households. According to Nolte and McKee (2007), the US health care system is particularly bad in prevention: the US ranked last in preventable deaths with timely and effective care among 19 peer countries. Note that the US is the only country without universal health coverage among rich countries and the lack of health insurance is the most important factor for inadequate access to health care services (Docteur and Oxley (2003)). In addition according to National Healthcare Disparities Report (2003), in the US avoidable health conditions are a particularly pervasive issue for lower socioeconomic individuals. For example, poor households with diabetes are less likely to receive recommended diabetic services in the early stages of the disease and, as a result, are more likely to be hospitalized for diabetes and its complications. Or low-income patients have higher rates of avoidable hospital admissions (i.e., hospitalizations for health conditions that, in the presence of comprehensive primary care, rarely require hospitalization).

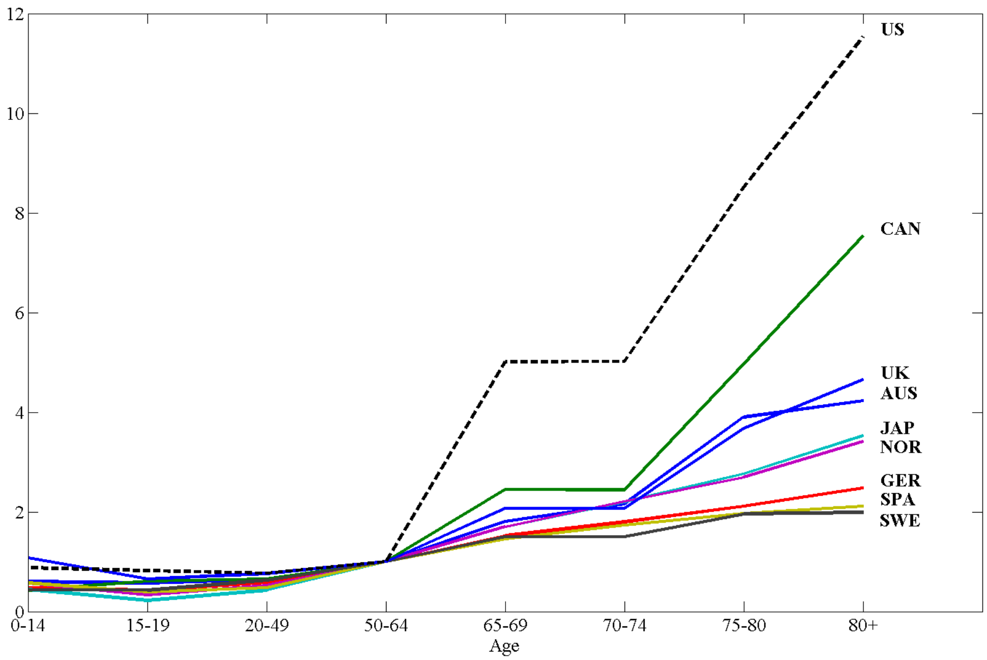
Second, the model implies a steeper growth in medical expenditures over the life cycle for the US compared to other rich countries where there is relatively better access to health care for the poor. Figure 8 shows the age profile of the average medical expenditures relative to that of the 50-64 age group for nine rich OECD countries (Australia, Canada, Germany, Japan, Norway, Spain, Sweden, U.K., and U.S.) (Hagist and Kotlikoff (2005)). In all countries medical expenditures increase over the life cycle. However, in the U.S. the increase in health care spending is dramatically more rapid. This is consistent with the prediction of the model.

Third, the model predicts a higher mortality differential between the rich and the poor for the U.S. compared to other rich countries. Delavande and Rohwedder (2008) estimate the socioeconomic mortality differential in the U.S and in ten European countries using subjective survival probabilities.[47] They find a significantly larger mortality differential between the lowest and highest wealth tercile groups in the US compared to European

[47]The subjective expectation of survival has been shown to be predictive of the actual. For a more detailed discussion of the methodology, see Delavande and Rohwedder (2008).

countries. The difference in probability of surviving to age 75 between the top and the bottom wealth tercile is 14%, whereas in European countries it is only 8%.

Figure 8: Medical Expenditures over the Life Cycle in OECD Countries



Source: Hagist and Kotlikoff (2005) Table 2.

Recently, Kolstad and Kowalski (2010) investigate the impact of health care reform passed in the state of Massachusetts in April 2006 on hospital usage and preventive care. The key provision of this reform is an individual mandate to obtain health insurance, which is also key in the PPAC Act of 2010. Thus, Massachusetts reform allows them to examine the impact of expansion to near-universal health insurance coverage for the country using the state population. They find evidence that hospitalizations for preventable conditions were reduced. They also study the costs at the hospital level and find that growth in health care spending did not increase after the reform in Massachusetts relative to other states. These are in line with my findings in Section 6.1.

8 Conclusion

One of the goals of the PPAC Act of 2010 is to reduce the disparities in health outcomes between low- and high-income groups. Then the differences in the lifetime profiles of medical expenditures between the rich and the poor become an important determinant in designing and analyzing health care policies. This paper studies the differences in lifetime profiles of health care usage among income groups.

Using data from the MEPS I document new empirical facts on health care expenditure by income. First low- and high-income households differ significantly in age profiles of medical expenditure. Particularly, the average medical spending of low-income households relative to high-income households exhibits a hump-shaped pattern over the lifetime and is above 1 for a significant part of the life span. Second, a higher share of low income households do not incur any health care expenditure in a given year than high income households. Yet their medical spending is more extreme.

I develop and estimate a life-cycle model of health capital that can account for these facts. The main feature of my model is to distinguish between "physical health capital", which determines the probability of surviving to the next period, and "preventive health capital", which affects the mean of shocks to physical health capital. Moreover, I carefully incorporate important features of the U.S. health care system into my model such as private health insurance, Medicaid and Medicare.

I estimate my model using both micro (MEPS) and macro data. Then I use my model to analyze the macroeconomic effects of a counterfactual universal health coverage policy. For this purpose I simply assume that all individuals are covered by private health insurance and this is financed through a flat income tax on households. I find that in the new steady state, medical expenditures slightly increase, and the life expectancy of the poor increases by 1.25 years.

In addition, the PPAC Act of 2010 forces private insurance firms to provide basic preventive care free of charge. However, patients will still need to pay co-payments for doctor visits and not all preventive care is free. Therefore, I study the effect of this policy change by assuming that on top of the existing private insurance scheme, firms pay 75% of households' preventive medicine expenditures in an economy with universal health care coverage. My results suggest that the life expectancy of all individuals increases except for the top income quintile group. However, total medical spending does not increase.

In this paper the emphasis is on the demand side of the health insurance market. An interesting future work would be to extend the model discussed in this paper to a more general case in which individuals are offered several types of private insurance coverage schemes that differ in their co-payments and deductibles. Furthermore these coverage schemes are determined endogenously along with their prices. It would be interesting to study how would the recent health care reform affect the private health insurance market in this setup.

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APPENDICES

A Data Appendix

A.1 Data Cleaning

I merge MEPS waves between 1996-2007, which provides 367,363 observations (after dropping reporting units that did not complete the survey). First, I construct family units as a group of individual who share the same dwelling unit id (duid), yearly family id (famidyr) in the same year.[48] I drop families whose reference person is younger than 18 years (172 observations dropped) or the oldest member is younger than 18 years (946 observations dropped). I construct family income as the sum of family members' total income. I drop families whose income is lower than 10% of the poverty threshold (6449 observations are dropped). I convert income to 2006 dollars using CPI and medical expenditures using MPI.

Table 7: Number of Observations by Year

year	Freq.	Percent	Cum.
1996	21,771	6.05	6.05
1997	33,040	9.18	15.23
1998	23,111	6.42	21.66
1999	23,981	6.66	28.32
2000	24,517	6.81	35.13
2001	32,775	9.11	44.24
2002	38,074	10.58	54.82
2003	33,162	9.22	64.04
2004	33,322	9.26	73.3
2005	32,901	9.14	82.44
2006	33,074	9.19	91.64
2007	30,098	8.36	100
Total	359,826	100	

[48] The MEPS has its own family unit and provides family size for them. For 13755 individuals family size of the MEPS is inconsistent with the number I found, although I kept these individuals with my own definition of family unit.

Table 8: Number of Observations by Race

Race	Freq.	Percent	Cum.
White	281,482	78.23	78.23
Black	56,808	15.79	94.01
Indian/Alaskan	3,769	1.05	95.06
Asian	13,957	3.88	98.94
Other	3,810	1.06	100
Total	359,826	100	

Table 9: Number of Observations by Gender

Gender	Freq.	Percent	Cum.
Female	188,206	52.3	52.3
Male	171,620	47.7	100
Total	359,826	100	

Table 10: Summary Statistics

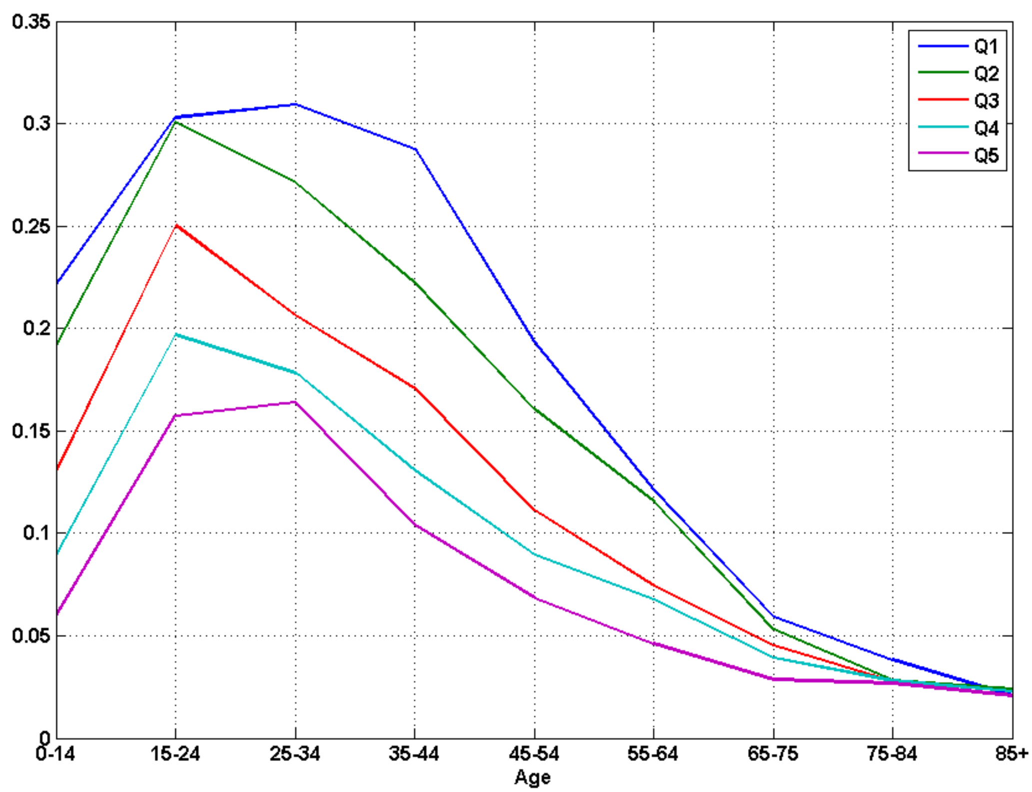
Variable	Obs	Weight	Mean	Stdev	Min	Max
Real total income	359826	3.3342e+09	24767.18	31187.2	-102255	684888.4
Real total consumpt.	359826	3.3342e+09	3090.97	9916.78	0	1088773
Real total income	359826		20475.88	28304	-102255	684888.4
Real total consumpt.	359826		2880.324	9370	0	1088773
Real family income	359826	3.3297e+09	66855.3	52166	990.85	775036
Real Family Consumption	359826	3.3297e+09	7895.97	15787	0	1092902

A.2 Medical Expenditures

The measure of medical expenditures I use in my analysis is total medical expenditure that can be financed by the household, and/or government, and/or private insurance company, and/or other sources (hospital's funds, or non-profit organizations). In addition it includes office- and hospital-based care, home health care, dental services, vision aids, and prescribed medicines, etc.

I first clean year, gender and race effects from the medical expenditures and control for random effects. For this purpose since medical expenditures are very skewed to the left with a fat right tail, I take the natural logarithm of them. But there are many observations with zero medical expenditures (see Figure 9). For zero-expenditure observations I proceed in 2 different ways: First, I clean year, gender and race effects omitting zero-expenditure observations (Model I). Second, I added $1 to the medical expenditures and use the whole sample (Model II).[49]

Figure 9: Fraction of Individuals with Zero Expenditures by Income Quintile



[49]In this case the distribution of residuals is not Gaussian.

Table 11: Regression Results

VARIABLES	(Model I) logtotexp	(Model II) logtotexp_all
Male	-0.346***	-0.928***
	(0.00847)	(0.0138)
White	0.240***	0.321***
	(0.0399)	(0.0663)
Black	-0.198***	-0.714***
	(0.0413)	(0.0686)
Indian/Alaskan	0.0190	-0.347***
	(0.0608)	(0.102)
Asian	-0.292***	-0.680***
	(0.0445)	(0.0748)
yeardum1	-0.229***	-0.0773***
	(0.0182)	(0.0285)
yeardum2	-0.263***	-0.210***
	(0.0168)	(0.0265)
yeardum3	-0.249***	-0.240***
	(0.0179)	(0.0282)
yeardum4	-0.235***	-0.202***
	(0.0176)	(0.0275)
yeardum5	-0.156***	-0.174***
	(0.0176)	(0.0277)
yeardum6	-0.0213	0.0713***
	(0.0162)	(0.0255)
yeardum7	0.000443	0.0780***
	(0.0157)	(0.0248)
yeardum8	0.0174	0.118***
	(0.0162)	(0.0253)
yeardum9	0.00331	0.0276
	(0.0162)	(0.0254)
yeardum10	0.0486***	0.0679***
	(0.0157)	(0.0246)
yeardum11	0.0567***	0.0690***
	(0.0140)	(0.0217)
Constant	6.969***	6.235***
	(0.0410)	(0.0679)
Observations	290,965	359,826
Number of myid	174,981	199,484

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 10: Age Profile of Medical Expenditures by Income (Model I)

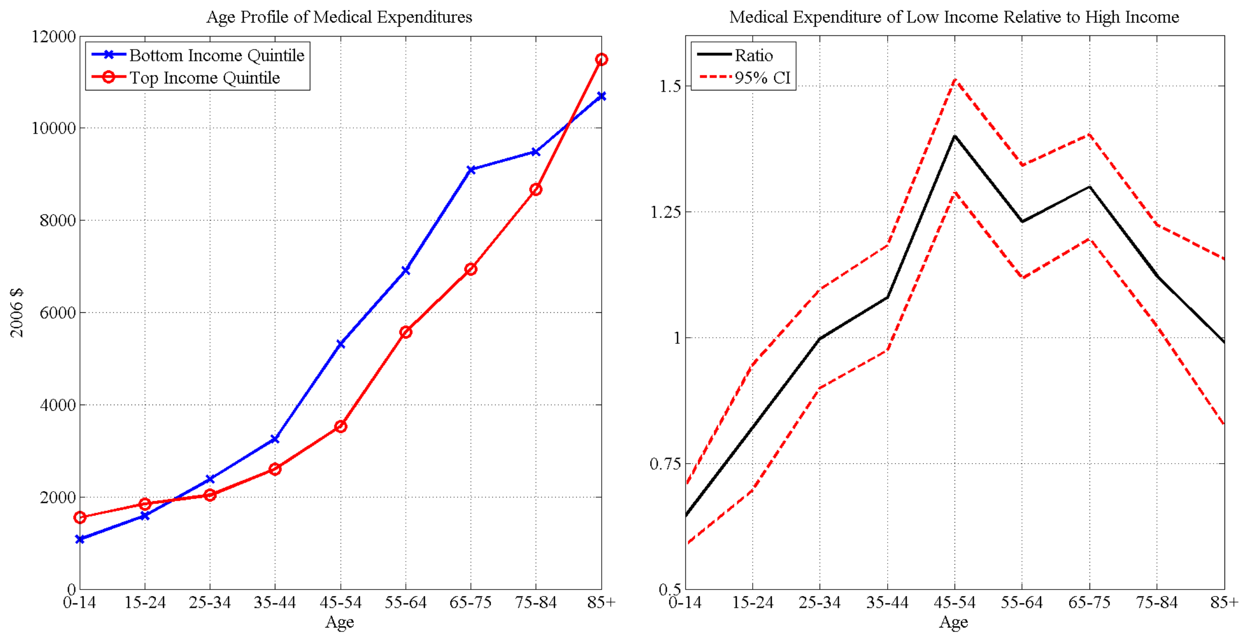
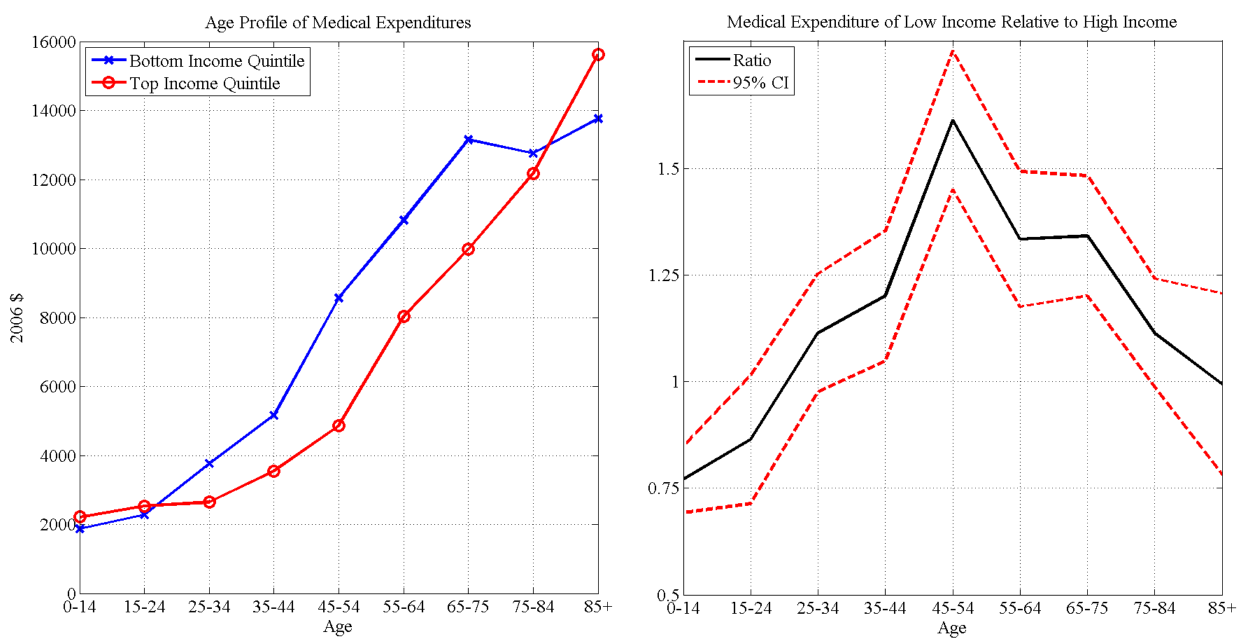
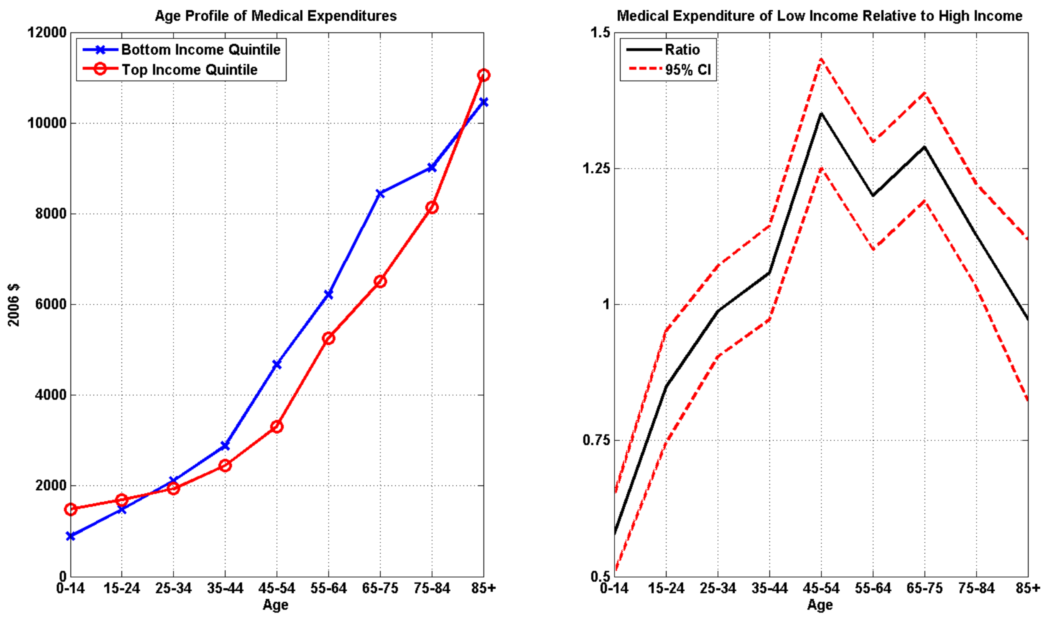


Figure 11: Age Profile of Medical Expenditures by Income (Model II)



I also normalize family income with the square-root equivalence scale. Figure 12 shows the age profile of medical expenditures for this case.

Figure 12: Age Profile of Medical Expenditures by Income (Square-Root Scale)



A.3 Preventive Medicine Usage

In the MEPS respondents are asked how often they use a particular preventive medicine. In particular, they are asked "Time since your last..." and their answers are categorized into "within past year," "within past two years,"... etc.[50]

Table 12 shows the average durations between two consecutive usages of preventive care by income group where Q1, Q2, .. Q5 denote the income quintiles from lowest to highest, respectively.

[50]In the case of regular dentist checks the question is "How often do you get..." and the possible answers are "twice a year," "once a year," "once in two years," etc.

Table 12: Preventive Medicine Usage

	Dentist	Blood Pressure	Cholesterol	Flu Shot	Regular Check up	Pap Test	Prostate Test	Breast Exam	Mamogram
Q1	2.608	1.573	2.863	4.23	2.302	2.306	4.057	2.205	3.293
	(0.00984)	(0.0106)	(0.0235)	(0.0215)	(0.0216)	(0.0176)	(0.0223)	(0.0177)	(0.0149)
Q2	2.356	1.497	2.716	4.151	2.191	2.179	7.781	2.009	3.011
	(0.0102)	(0.00905)	(0.0206)	(0.0200)	(0.0175)	(0.0165)	(0.0215)	(0.0165)	(0.0173)
Q3	2.102	1.397	2.538	4.004	2.029	2.02	3.414	1.85	2.722
	(0.00967)	(0.00827)	(0.0208)	(0.0223)	(0.0151)	(0.0170)	(0.0200)	(0.0158)	(0.0182)
Q4	1.883	1.332	2.377	3.927	1.923	1.908	3.14	1.727	2.552
	(0.00953)	(0.00784)	(0.0191)	(0.0216)	(0.0159)	(0.0160)	(0.0253)	(0.0155)	(0.0183)
Q5	1.689	1.286	2.207	3.733	1.816	1.799	2.814	1.611	2.433
	(0.00966)	(0.00615)	(0.0180)	(0.0253)	(0.0137)	(0.0166)	(0.0223)	(0.0130)	(0.0184)
Obs.	254445	175515	169552	176935	175222	92743	43337	93046	72777

A.4 Effect of Health Status on Income

The MEPS has a panel dimension for two consecutive years, which allows me to identify the effect of health status on labor earnings. I impose more restrictions on top of the sample I use for medical expenditure analysis. I restrict my sample to those between ages 18 and 65 who work at least 10 hours per week. Moreover, my sample excludes workers whose hourly wage is less than $2.75. I also control for year (yeardum), highest educational degree (hidegdum), and race (racedum) dummies.

Table 13: Effect of Health Status on Income

VARIABLES	logearn
health	-0.111***
	(0.00337)
yeardum1	-0.331***
	(0.0106)
yeardum2	-0.285***
	(0.0108)
yeardum3	-0.219***
	(0.0106)
yeardum4	-0.163***
	(0.0103)
yeardum5	-0.141***
	(0.00958)
yeardum6	-0.115***
	(0.00935)
yeardum7	-0.115***
	(0.00971)
yeardum8	-0.0884***
	(0.00958)
yeardum9	-0.0538***
	(0.00918)
yeardum10	-0.0303***
	(0.00816)
age	0.295***
	(0.00761)
age2	-0.00578***
	(0.000193)
age3	3.66e-05***
	(1.57e-06)
male	0.201***
	(0.00549)
hidegdum2	0.169***
	(0.0151)
hidegdum3	0.390***
	(0.00840)
hidegdum4	0.809***
	(0.00996)
hidegdum5	0.967***
	(0.0128)
hidegdum6	1.104***
	(0.0196)
hidegdum7	0.564***
	(0.0119)
racedum1	0.114***
	(0.0319)
racedum2	-0.0103
	(0.0325)
racedum3	-0.0474
	(0.0428)
racedum4	0.0869**
	(0.0342)
Constant	5.162***
	(0.1000)
Observations	133,008
Number of myid	80,764

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In my sample the range of health status is between 1 to 5. So between best and worst health status workers, earnings change around 40%.

A.5 Estimation of Insurance Coverage Functions

In the MEPS both the total amount of expenditures and out-of-pocket expenditures are given. Moreover, in any given period information on whether the individual is insured, if she is insured, the type of insurance (e.g., private, Medicaid, Medicare, etc.) is provided. Using this information I estimate insurance coverage functions for private insurance holders and Medicare holders.[51] I assume the following functional form for the insurance coverage, which features both a deductible and a co-payment:

$$\chi(x) = \begin{cases} 0 & x \leq \iota \\ \varsigma(x - \iota) & x \geq \iota \end{cases}$$

where ι and ς determine deductibles and co-payment rates.

For the estimation of the private insurance coverage function I exclude anyone who is not covered by private insurance for the whole year, or who is covered by any other type of insurance at any point in that particular year.[52]

Table 14: Private Insurance Coverage

ς	0.955***
	(0.000415)
ι	0.0237***
	(0.000130)
Observations	139,300

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

For the estimation of the Medicare coverage function I exclude anyone who is not covered by Medicare for the whole year or who is covered by any other type of insurance at any point in that particular year.

[51] For Medicaid holders I assume that they are covered by private insurance.

[52] The amount of the deductible ι is in terms of average earnings, which is $30450.

Table 15: Medicare Coverage

ς	0.949***
	(0.00175)
ι	0.0575***
	(0.000941)
Observations	12,670
R-squared	1.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

B The Basic Model with Initial Wealth

In this section I present the simulation results for the basic model introduced in Section 3.1 with heterogeneity in initial wealth instead of heterogeneity in period income. The purpose of this exercise is to show that the borrowing constraint does not play a major role in medical expenditure profile of low-income households. The model is the same as the original one except households differ in their initial holdings of wealth at birth and receive a minimal constant stream of income per period (equal to the consumption floor). In addition, households are not allowed to default since their assets constitute the major portion of their lifetime wealth.

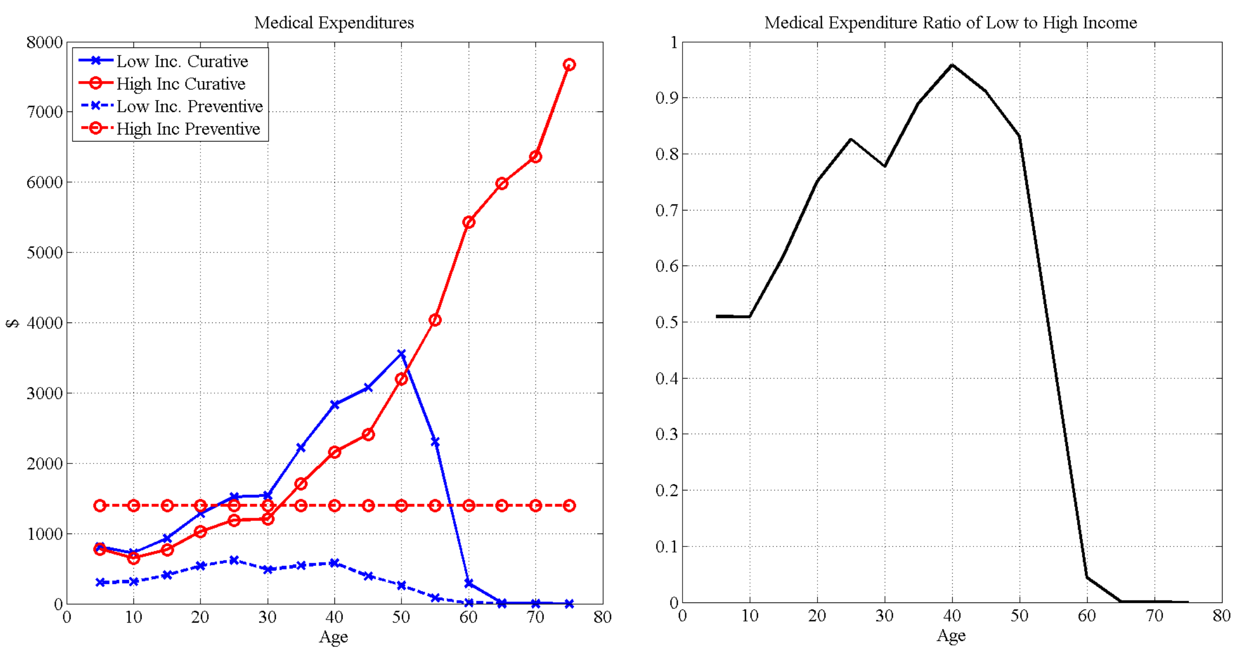
Then, the Bellman equation for a type-i household (where $i \in \{rich, poor\}$) can be written as:

$$
\begin{aligned}
V_t^i(h_t, x_t, a_t^i) &= \mathbb{E}_{\omega_t} \max_{I_t^D, c_t, m_{C,t}, m_{P,t} a_{t+1}} u(c_t) + \beta s(h_t - \omega_t) V_{t+1}^i(h_{t+1}, x_{t+1}, a_{t+1}^i) \\
w + (1+r)a_t^i &= c_t + m_{C,t} + m_{P,t} + a_{t+1}^i \\
h_{t+1} &= \begin{cases} h_t & if \quad A_t^c m_{C,t}^{\theta_t^c} \geq \omega_t \\ h_t - \omega_t + A_t^c m_{C,t}^{\theta_t^c} & otherwise \end{cases} \\
x_{t+1} &= \begin{cases} x_t & if \quad A^p m_{P,t}^{\theta p} \geq \delta_x x_t \\ x_t(1-\delta_x) + A^p m_{P,t}^{\theta p} & otherwise \end{cases} \\
log(\omega_t) &\sim \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases}
\end{aligned}
$$

where $a_0 \in \{a^{rich}, a^{poor}\}$and $w = c_{min}$.

Figure 13 shows the simulation results for this economy. Please note that the preventive medical expenditure behavior of low-income households is similar to the case where households receive a heterogeneous income per period.

Figure 13: Lifetime Profile of Medical Expenditures



C Estimation Results

Table 16: Fixed Parameters

Param	Explanation	Value
Demographics		
T	Life time	110 years
T_{CHILD}	Childhood	20 years
T_{RET}	Retirement Age	65
Income Process		
σ_α^2	Variance of Fixed effects	0.24
σ_η^2	Variance of Shocks	0.02
ρ	Persistence of Shocks	0.98
ζ	Decrease in earnings due to health shocks	40%
Private Insurance Plan/Medicaid		
ι	Deductible	722$
ς	Copayment	4.5%
Medicare		
ι	Deductible	1697$
ς	Copayment	5%
Miscellaneous		
r	Interest rate	2.5%
σ	CRRA coefficient	3
c_{min}	Consumption Floor	5000$
$\underline{\text{w}}$	Poverty Threshold	10488$

Table 17: Preference Parameters

Param	Explanation	Value
β	Discounting Factor	0.98
b	Value of being alive	6.75
α	Quality of life parameter	0.20
γ	Quality of life parameter	1.15

Table 18: Preventive Health Capital Parameters

Param.	Explanation	Value
δ_x	Preventive health depreciation	7.5%
A^p	Preventive health function productivity	0.28
θ^C	Preventive health function curvature	0.40

Table 19: Physical Health Parameters

Age	A^c	θ^c	μ	σ^2	Age	A^c	θ^c	μ	σ^2
1	0.15466	1.208109	-7.66545	1.703434	56	0.035172	0.869485	-5.86903	1.304228
2	0.15466	1.208109	-7.66545	1.703434	57	0.037824	0.850597	-5.74153	1.275895
3	0.15466	1.208109	-7.66545	1.703434	58	0.040687	0.831646	-5.61361	1.247469
4	0.15466	1.208109	-7.66545	1.703434	59	0.043669	0.813274	-5.4896	1.219912
5	0.15466	1.208109	-7.66545	1.703434	60	0.046839	0.795076	-5.36676	1.192614
6	0.225088	1.498756	-8.83517	1.96337	61	0.051328	0.803658	-5.24387	1.165304
7	0.225088	1.498756	-8.83517	1.96337	62	0.054971	0.785102	-5.12279	1.138398
8	0.225088	1.498756	-8.83517	1.96337	63	0.059163	0.765211	-4.993	1.109557
9	0.225088	1.498756	-8.83517	1.96337	64	0.063836	0.744638	-4.85877	1.079726
10	0.225088	1.498756	-8.83517	1.96337	65	0.06887	0.724096	-4.72473	1.04994
11	0.105945	1.372986	-8.83517	1.96337	66	0.070566	0.723387	-4.58989	1.019976
12	0.105945	1.372986	-8.83517	1.96337	67	0.075886	0.703553	-4.46405	0.99201
13	0.105945	1.372986	-8.83517	1.96337	68	0.080979	0.685828	-4.35158	0.967018
14	0.105945	1.372986	-8.83517	1.96337	69	0.085679	0.670435	-4.25391	0.945313
15	0.105945	1.372986	-8.83517	1.96337	70	0.090209	0.656379	-4.16473	0.925495
16	0.06723	1.363452	-8.83517	1.96337	71	0.085053	0.641626	-4.07111	0.904692
17	0.06723	1.363452	-8.83517	1.96337	72	0.090303	0.626031	-3.97217	0.882703
18	0.06723	1.363452	-8.83517	1.96337	73	0.095857	0.610493	-3.87358	0.860795
19	0.06723	1.363452	-8.83517	1.96337	74	0.101654	0.595205	-3.77657	0.839239
20	0.06723	1.363452	-8.83517	1.96337	75	0.107929	0.57961	-3.67762	0.817249
21	0.048962	1.340757	-9.05011	2.011136	76	0.109543	0.575596	-3.57445	0.794323
22	0.050157	1.330047	-8.97782	1.995071	77	0.117075	0.558288	-3.46697	0.770438
23	0.051328	1.31979	-8.90858	1.979684	78	0.125372	0.540467	-3.3563	0.745844
24	0.051518	1.318142	-8.89746	1.977212	79	0.134476	0.52222	-3.24299	0.720664
25	0.051224	1.320684	-8.91462	1.981027	80	0.13901	0.51359	-3.18939	0.708754
26	0.049118	1.313087	-8.92243	1.982762	81	0.144714	0.510161	-3.09923	0.688717
27	0.048987	1.314248	-8.93032	1.984515	82	0.153016	0.495438	-3.00978	0.668841
28	0.04949	1.309793	-8.90004	1.977788	83	0.161723	0.480831	-2.92105	0.649122
29	0.050613	1.300018	-8.83362	1.963028	84	0.170853	0.466338	-2.833	0.629556
30	0.052019	1.288079	-8.7525	1.944999	85	0.18042	0.451958	-2.74564	0.610143
31	0.03136	1.263582	-8.6429	1.920644	86	0.18157	0.413203	-2.65896	0.590881
32	0.032479	1.250788	-8.55539	1.901198	87	0.19187	0.399839	-2.57296	0.57177
33	0.033865	1.235537	-8.45107	1.878016	88	0.202667	0.386581	-2.48765	0.552811
34	0.035219	1.221228	-8.3532	1.856266	89	0.213976	0.37343	-2.40302	0.534005
35	0.036544	1.207752	-8.26102	1.835783	90	0.225815	0.360388	-2.31909	0.515354
36	0.030922	1.201206	-8.16219	1.813821	91	0.240758	0.368044	-2.23587	0.49686
37	0.032322	1.18591	-8.05826	1.790724	92	0.253748	0.354462	-2.15336	0.478524
38	0.033838	1.17007	-7.95063	1.766806	93	0.267315	0.341	-2.07157	0.460349
39	0.035604	1.152485	-7.83113	1.740252	94	0.281476	0.327657	-1.99052	0.442338
40	0.037395	1.135527	-7.71591	1.714646	95	0.296248	0.314438	-1.91021	0.424491
41	0.033983	1.117985	-7.59671	1.688157	96	0.302394	0.301342	-1.83065	0.406811
42	0.035874	1.100082	-7.47506	1.661124	97	0.318369	0.288371	-1.75185	0.389301
43	0.037776	1.083001	-7.35899	1.635331	98	0.33502	0.275527	-1.67382	0.371961
44	0.039635	1.06712	-7.25108	1.611352	99	0.352363	0.26281	-1.59657	0.354794
45	0.041563	1.051418	-7.14438	1.587641	100	0.372671	0.248692	-1.5108	0.335734
46	0.03328	1.048629	-7.03106	1.562457	101	0.363518	0.248692	-1.5108	0.335734
47	0.035193	1.031402	-6.91555	1.536789	102	0.363518	0.248692	-1.5108	0.335734
48	0.037154	1.014695	-6.80353	1.511895	103	0.363518	0.248692	-1.5108	0.335734
49	0.039081	0.999114	-6.69906	1.48868	104	0.363518	0.248692	-1.5108	0.335734
50	0.041253	0.982445	-6.5873	1.463843	105	0.363518	0.248692	-1.5108	0.335734
51	0.035327	0.978946	-6.47573	1.439051	106	0.35406	0.248692	-1.5108	0.335734
52	0.037538	0.961175	-6.35818	1.412928	107	0.35406	0.248692	-1.5108	0.335734
53	0.039907	0.943254	-6.23963	1.386584	108	0.35406	0.248692	-1.5108	0.335734
54	0.04249	0.924888	-6.11813	1.359585	109	0.35406	0.248692	-1.5108	0.335734
55	0.045278	0.906278	-5.99503	1.332228	110	0.35406	0.248692	-1.5108	0.335734