Preventive vs. Curative Medicine: A Macroeconomic Analysis of Health Care over the Life Cycle*

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Abstract

This paper studies differences in health care usage and health outcomes between low- and high-income individuals. Using data from the Medical Expenditure Panel Survey (MEPS) I find that early in life the rich spend significantly more on health care, whereas from middle to very old age medical spending of the poor surpass that of the rich by 25%. In addition, low-income individuals are less likely to incur any medical expenditures in a given year, yet, when they do, their expenses are more likely to be extreme. To account for these facts, I develop and estimate a life-cycle model of two types of health capital: physical and preventive. Physical health capital determines survival probabilities, whereas preventive health capital governs the endogenous distribution of shocks to physical health capital, thereby controlling the life expectancy. Moreover, I incorporate important features of the U.S. health care system such as private health insurance, Medicaid, and Medicare. In the model, from the very early ages the rich spend more in preventive health to expand their life expectancy, which leads to milder health shocks (and lower curative medical expenditures) for them in old age compared to the poor. Public insurance—which is designed to insure large expenditures—amplifies these differences by hampering the incentives of the poor to invest in preventive health. I use the model to examine a counterfactual economy with universal health insurance in which 75% of preventive medical spending is reimbursed. My results suggest that policies encouraging the use of health care by the poor early in life produce significant welfare gains, even when fully accounting for the increase in taxes required to pay for them.

JEL codes: D52, D91, E21, E61, E65, H31, I12, I13, I14

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1 Introduction

How do low- and high-income individuals differ in their lifetime profiles of medical expenditures? How do their distributions of health care spending differ? Why do these differences exist? The answers to these questions are central to designing health care policies that aim to reduce disparities in health outcomes across income groups. In this paper, I first present novel empirical facts on differences in health care usage by income. I then develop a life-cycle model of health capital by distinguishing between preventive and curative medical expenditures. Importantly, my model allows individuals to endogenize the distribution of health shocks, thereby controlling their life expectancy.

Using data from the Medical Expenditure Panel Survey (MEPS) I document that low- and high-income individuals differ significantly in the age profile of their medical expenditures.[1] The ratio of average medical spending of low- to high-income individuals exhibits a hump-shaped pattern over the life cycle: Early in life, the rich spend more on health care than the poor, whereas from midway through life until very old age, the average medical spending of the poor exceeds that of the rich by around 25% in absolute (dollar) terms. This is particularly striking once income differences are taken into account.

In addition, I document that the distribution of healthcare expenditures for the poor has fatter tails compared to high-income individuals: the poor are less likely to incur any medical expenditures in a given year, yet, when they do, their spending is more likely to be extreme. Specifically, among the non-elderly, 24% of low-income individuals have zero medical spending in a given year, versus 10% of the rich. The average of the top 10% of the poor's medical expenditures, however, is substantially larger than that of the rich. Furthermore, the data shows that low-income individuals use less preventive care. Last,

[1] Throughout the paper the definition of health care expenditures includes all expenditures on health care goods and services except for over-the-counter drugs. The sources of payment for health care expenditures can be individuals (paying out-of-pocket costs), private insurance firms, the government (Medicaid, Medicare, etc.), and others.

their life expectancy is dramatically lower than that of high-income individuals.

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 endogenously the probability of surviving to the next period. This type of health capital depreciates because of health shocks, which, in turn, affect survival probability. Individuals can invest in physical health capital using "curative medicine" against shocks. 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 using "preventive medicine". To illustrate, a flu shot is a form of preventive medicine that basically affects an individual's probability of getting the influenza virus, whereas 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.[2]

In addition, I incorporate important features of the U.S. health care system into my model. Non-elderly individuals are offered private health insurance whose premium is determined endogenously by the zero profit condition of insurers. Children of low-income families and elderly are covered by Medicaid and Medicare, respectively. All insurance types reimburse medical expenditures up to a deductible and a co-payment. Moreover, in the case of severe health shocks, individuals are allowed to default. Therefore, overall, public insurance provides protection against low-probability high-cost shocks in later life better than frequent small preventive expenditures.

A novel feature of the model is to allow individuals to endogenize the distribution of health shocks through investment in preventive health capital, thereby controlling their life expectancy. In the the model there is a trade off between the amount of consumption per period and the expected life span. The rich spend more in preventive health to achieve a longer life expectancy. Therefore, as a cohort grows older, their health shocks are milder

[2] In the model "preventive care" refers to a broader concept than may be commonly understood. It includes all health care goods and services that can mitigate future health shocks.

compared to the poor, and, in turn, they incur smaller curative medical expenditures. This explains the increase in the ratio of the poor's medical expenditures to those of the rich. Furthermore, public insurance for the elderly largely subsidizes individuals' curative medical expenditures which allows the medical spending of the poor to exceed that of the rich from middle to very old age. This subsidy also hampers the incentives of low-income individuals to invest in preventive health, thereby amplifying disparities in health outcomes.

I estimate my model using both micro and macro data. I set some of the parameter values outside of the model. For the rest of the parameters (e.g., curative and preventive health production technologies, 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 using the available data. It is able to successfully explain the targeted features of the data 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. For this purpose, I contrast the benchmark economy against an economy with universal health care coverage in which all individuals are covered by private health insurance until retirement, whose premiums are financed through an additional flat income tax on individuals.[3] An immediate implication of this policy change is that low-income individuals 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 low-income individuals' gaining a longer life span. 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 in the benchmark economy. Around one-third of the welfare gains are due to the increase in expected life span. The rest comes from better opportunities

[3]According to the recent estimates, the PPAC act reduced the non-elderly uninsured rate from 17% to 10% (Soni et al. (2020)).

for insurance against health shocks.

In addition, under the PPAC Act of 2010 private insurance firms are required to provide some of the basic preventive care free of charge, including checkups, mammograms, etc. 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 individuals.[4] Under this new policy individuals invest more in preventive health capital, which results in an increase in the life expectancy of all income groups except for the top income quintile. However, total medical spending does not increase, because of the milder distribution of health shocks in the new economy. These results suggest that policies encouraging the use of health care by the poor early in life produce significant positive welfare gains, even when fully accounting for the increase in taxes and insurance premiums required to pay for them.

Related Literature There is a sizable literature that allow for heterogeneity in income and health shocks in their models. These studies usually view health shocks as health expenditure shocks (such as Palumbo (1999), Attanasio et al. (2008), and Jeske and Kitao (2009)). Most recently, De Nardi et al. (2017) develop a very rich life-cycle partial equilibrium model to study welfare costs of health shocks. They use the PSID data to argue that life-cycle health dynamics is exogenous and largely driven by ex-ante fixed heterogeneity, which is determined before age 20. In my paper, the distribution of health shocks is governed endogenously by preventive health capital. Because my model starts at birth, individuals already differ in their preventive health capital by age 20, thereby leading to heterogeneity in health dynamics henceforth. Other notable exceptions of the literature that endogenize the medical expenditure decisions of individuals over the life cycle are De Nardi et al. (2010), Halliday et al. (2009), Zhao (2009), and Prados (2012), , Ales et al. (2012)).

[4]I examine this policy change in the universal health care coverage economy discussed earlier.This policy change in an economy without universal health care coverage would lead many low-income individuals to drop out of the health insurance market due to the rise in health insurance premiums.

Furthermore, a large literature has studied a variety of economic issues related to decisions on prevention of illnesses (see Kenkel (2000) for a careful overview). These studies find that many preventive interventions add to medical costs not less than the amount they save, at the same time that they improve health (Russell (2007), Russell (1986)). In a recent paper White (2012) develops and estimates a structural model to study how investment in health through preventive care affects medical spending during retirement. He finds that even though preventive care improves longevity it does not reduce total demand for health care. These results are consistent with my empirical facts and quantitative model which both show that the total lifetime medical spending of the rich is not significantly lower than that of the poor.

My paper also contributes to the literature that study health care reforms using quantitative models (e.g., Cole et al. (2014)) Pashchenko and Porapakkarm (2013) study the welfare consequences of the ACA reform using a general equilibrium life-cycle model. They find that the reform decreases the number of uninsured by more than half and generates substantial welfare gains.

This paper also contributes to the literature that investigates the dynamic inefficiencies in insurance markets (e.g., Finkelstein et al. (2005) and Fang and Gavazza (2007)). For example, Fang and Gavazza (2007) study how the employment-based health insurance system in the U.S. leads to an inefficiently low level of health investment during working years. They find that every additional dollar of health expenditure during working years may lead to about 2.5 dollars of savings in retirement. My paper studies how public health insurance programs in old age can distort incentives to invest in health capital when young.

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

2 Empirical Facts

In this section, I present empirical facts on disparities in health care usage among people with different incomes. In particular, I document how medical spending differs by income groups over the life cycle and how the distribution of medical expenditures differs between low- and high-income individuals. First, I describe the data source and discuss my methodology to construct the income groups. Then, in Section 2.2, I present the empirical findings.

2.1 Data and Methodology

I used data from the MEPS that cover a period between 1996 and 2010. The MEPS surveys both families and all individuals starting from the birth. It is a representative sample of the civilian non-institutionalized population in the U.S. It provides detailed information about the usage and cost of health care. Its panel dimension is fairly short in that each individual is surveyed only for two consecutive years. There are 455,789 observations in my sample after sample selection (see Appendix A.1 for the details of the sample selection).

Medical expenditures are defined as spending on all health care services, including office- and hospital-based care, home health care, dental services, vision aids, and prescribed medicines, but not over-the-counter drugs. The sources of payment for medical expenditures can be individuals (paying out-of-pocket expenditures), federal or state government (through Medicaid and Medicare), private insurance firms, and other sources. But insurance premiums paid for private health insurance are not included. The expenditure data included in this survey were derived from both individuals and health care providers, which makes the data set more reliable than any other source for medical expenditure data.[5]

In my empirical analysis I group individuals based on their age and total family income. The measure of total income includes wages, business income, unemployment benefits, div-

[5]Selde et al. (2001) compare estimates of national medical expenditures from the MEPS and the National Health Accounts and find that much of the difference arises from differences in scope between the MEPS and the NHA—rather than from differences in estimates for comparably-defined expenditures.

idends, interest income, pensions, Social Security income, etc. I construct total family income by aggregating individual income over all family members. I then normalize total family income by family-type-specific federal poverty thresholds which take into account family composition (number of members and their ages).[6] I use this normalized family income in my analysis.

I first group individuals into 9 age intervals: 1-14,15-24, 25-34, ... 75-84, and 85 and older. Then, within each age group I rank individuals based on their normalized family income and divide them into five age-specific income groups (quintiles). For example, let family f with normalized family income y have members, i_1 and i_2, in two different age groups a_1 and a_2, respectively. Then, I rank individual i_1 with other individuals in age group a_1 and i_2 within age group a_2 (which may lead i_1 and i_2 being in different quintiles). This allows me to rank individuals with their peers.

2.2 Empirical Facts on Medical Expenditures

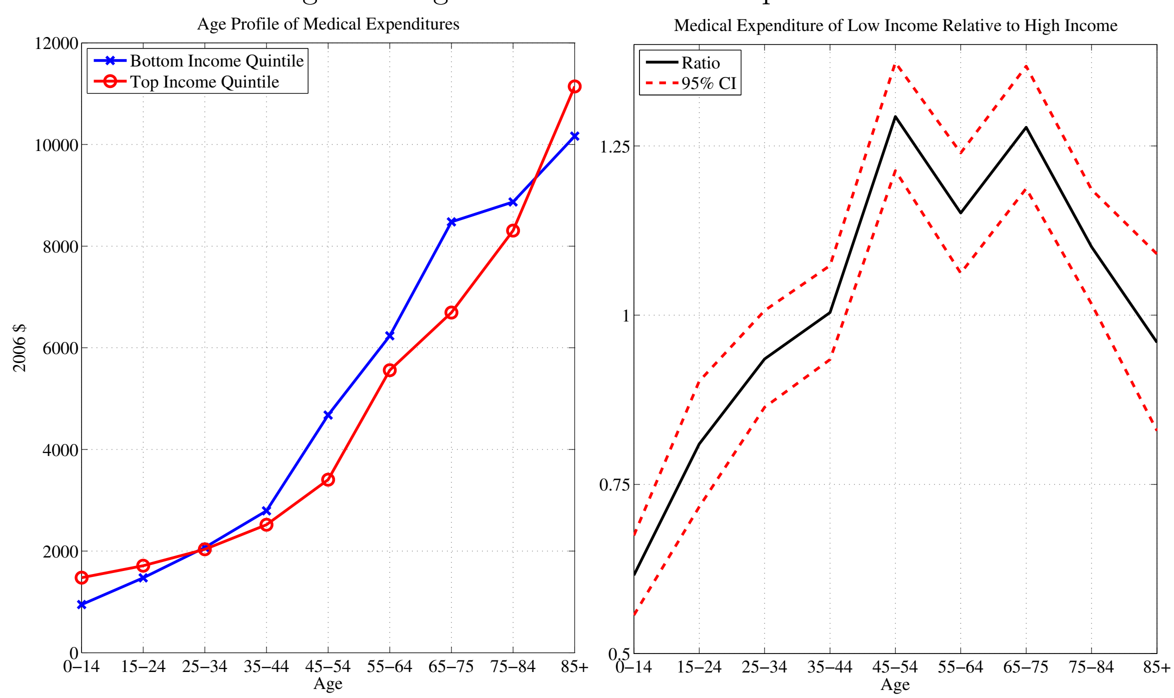
The first empirical fact that emerges from the data has to do with the age profile of health care expenditures (usage) by income groups.[7] The blue line with crosses and the red line with circles in the left panel of Figure 1 show the age profiles of the medical expenditures of the bottom and top income quintiles, respectively. For both income groups health care spending increases dramatically over the life cycle. However, there are significant differences in the increase of medical spending over the life cycle across income groups. To clarify this point, I plot the ratio of the average medical expenditures of the poor to those of the rich over the life cycle. This is shown in the right panel of Figure 1 as the black solid line, along with 95% bootstrap confidence intervals shown by the red dashed lines. As can be seen, the age profile of the medical expenditures of the poor relative to those of the rich exhibits a

[6]The results are robust to using the square-root scale as consumption equivalence scale (Figure 11).

[7]I use only the cross-sectional aspect of the data to construct these profiles. However, I use the terms "age profile" and "lifetime profile" interchangeably throughout the paper.

pronounced hump-shape.[8] Early on, the top income quintile spends more on health care in absolute (dollar) terms. From midway through life until very old age, the medical spending of the bottom income quintile exceeds that of the top quintile. Between ages 50 and 70 the 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.[9] Finally, after age 80 high-income individuals consume health care services slightly more than low-income individuals. These differences in health care usage are striking and are nothing like differences in non-medical consumption.[10]

Figure 1: Age Profile of Medical Expenditures



The second empirical fact has to do with the differences in the extensive and intensive margins of health care spending between low- and high-income individuals. The left panel of Figure 2 plots the fraction of individuals that have not incurred any medical spending

[8]These profiles are robust to controlling for year, gender, and race effects. They are also robust to controlling for reverse causality between medical expenditures and income (see Appendix A.2).

[9]There is at least a 4-fold difference in family income between the 20th and 80th percentiles.

[10]The ratio of the average non-medical consumption of the poor to that of the rich decreases over the life cycle because of the increasing inequality in consumption, and it never rises above 1.

in a given year over the life cycle for the top and bottom income quintiles. A significantly higher fraction of low-income individuals do not incur any medical expenditures in a year compared to the high-income group. For example, between ages 45 and 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 individuals. Moreover, the right panel of the same figure shows the average of very large medical expenditures, those in the top 10% of the medical expenditures distribution, 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 among low-income individuals incur more extreme expenditures. For example, between ages 45 and 54, the average of the top 10% medical expenditures is almost one and a half times higher for the poor compared to the rich. Combining these observations, I conclude that the medical expenditure distribution is more widely spread to the tails for the poor. In other words, low-income individuals are less likely to incur any medical expenditures in a given year, yet, when they do, the amounts are more likely to be extreme.

The third empirical fact regards preventive medicine usage by income groups. As it will be clear in the next section, I interpret "preventive care" a broader concept than may be commonly understood. My interpretation of preventive care includes all health care goods and services that can mitigate possible future health shocks not just regular physicals or cancer screenings. Keeping this in mind, in table 1 I document how frequently individuals use some of the standard forms of preventive care by income groups that indicate the disparities between low- and high-income individuals. In the MEPS, respondents are asked about the last time they used a particular preventive medicine. The respondents' answers to these questions are given 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. This table shows that high-income individuals consume preventive health care services and goods substantially more often than low-income individuals.[11]

Figure 2: Extensive and Intensive Margins of Medical Expenditures

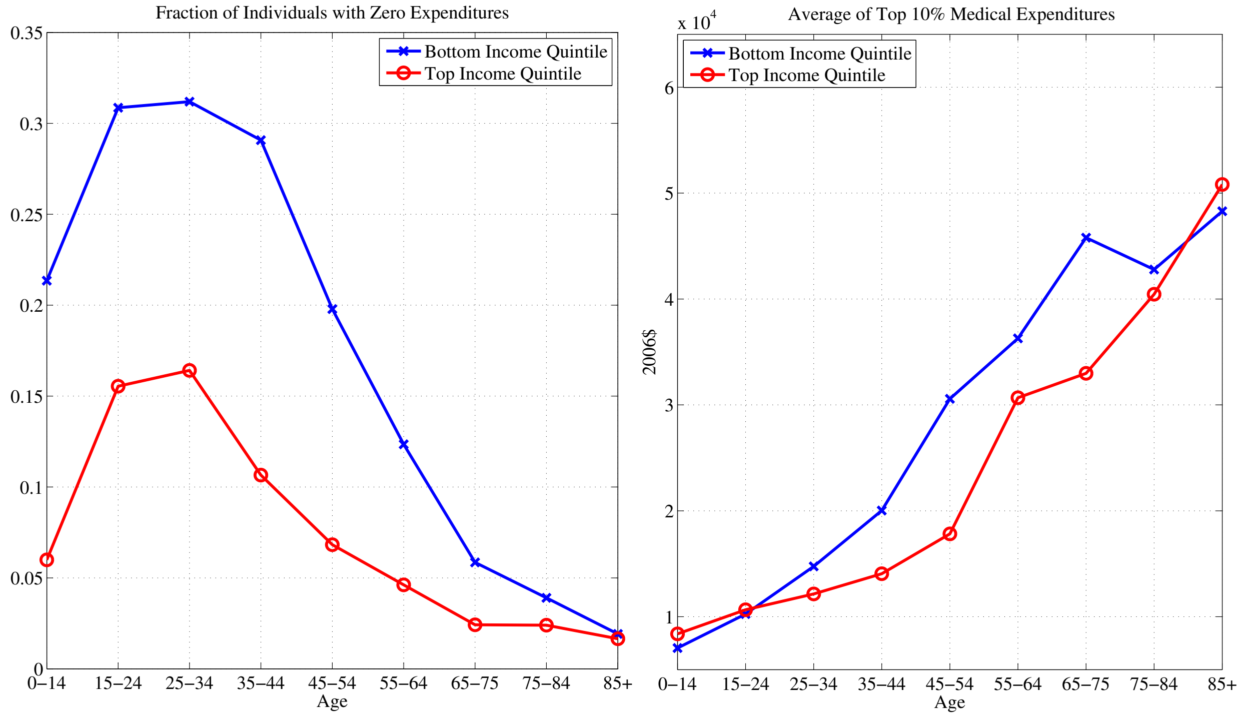


Table 1: Preventive Medicine Usage

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

Notes: This table reports the average number of years since respondents' last usage of some forms of preventive care by income groups. Thus, the smaller the figures in, the more frequently preventive care is used. The values in parentheses show the standard errors. Source: Author's calculations from the MEPS

Last, the large life expectancy gap between low- and high-income individuals is also well-known in the literature (Chetty et al. (2016); Pijoan-Mas and Rios-Rull (2013); Deaton and Paxson (1999); Attanasio and Emmerson (2003)). Using data from the Social Security

[11]There is more evidence in health economics literature that high-income individuals consume more preventive care (see Newacheck et al. (1996), Watson et al. (2001), Wilson and White (1977)). Also more examples of preventive care from the MEPS can be seen in Appendix A.3.

Agency (SSA) and the Survey of Income and Program Participation (SIPP) Cristia (2007) has found large differentials in mortality rates across individuals in different quintiles of the lifetime earnings distribution even after controlling for race, marital status, and education. Similarly, Lin et al. (2003) have found that at age 25, individuals from low-income families (with income less than $10,000 in 1980) expect to live almost 8 years less than high-income individuals (with income more than $25,000), which declines as a cohort gets older.

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

3 Intuition in a Stylized Framework

In this section I introduce a simple life-cycle model of health capital with public health insurance that features the distinction between physical and preventive health capital. Using this environment, I discuss the key mechanism that can account for the differences in the lifetime profiles of medical expenditures between low- and high-income individuals. Then, in Section 4 I enrich this framework by introducing empirically relevant features that are necessary for a sound quantitative analysis.

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 probability of survival to the next period. They can live up to a maximum age of T.

Preferences and Endowment I assume standard preferences over consumption that are additively separable over time with the current period utility function:

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

where c and σ denote consumption and the constant relative risk aversion coefficient, respectively. For a positive value of life, $\sigma < 1$ must be assumed. With this assumption, individuals 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. I also assume that individuals discount the future at a discount factor, β.

Individuals are born as one of two ex-ante types: rich or 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.[12] Physical health capital determines an individual's survival probability together with health shocks, whereas preventive health capital governs the distribution of health shocks. Preventive care includes all health care goods and services that can mitigate possible future severe and costly health shocks. To illustrate, the flu shot is a form of preventive medicine (an investment in preventive health capital) that basically affects an individual's probability of getting the influenza virus, whereas 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. Other examples of preventive medicine are the relatively cheap recommended diabetic services and the effective management of diabetes, which can avoid end-stage renal disease, a health shock that is highly morbid and very costly.

A newborn individual is born with 1 unit of physical health capital; i.e., $h_0 = 1$. Each period she is hit by a health shock, ω_t. Against these shocks she can invest in physical health capital by using 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 at age t, and A_t^c and θ_t^c denote the productivity

[12] Grossman and Rand (1974) are the first that distinguish between preventive and curative medicine to theoretically study the tradeoff between two.

and the curvature of the physical health production technology at age t, respectively. She can invest in physical health capital only up to the point of fully recovering from 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. Against depreciation she can invest in preventive health capital by using 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 the preventive health production technology, respectively. In each period she can invest in preventive health capital only up to the point of fully recovering the current depreciation; i.e., $m_{P,t} \leq (\delta_x x_t/A^p)^{1/\theta^p}$:[13]

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

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

[13] As in the case of physical health capital, this implies that depreciation in preventive health capital is irreversible in that if they are not recovered in the current period, they cannot be recovered in the future periods.

$$
log(\omega_t) \sim \begin{cases} \mathbb{N}(\mu_t^G, \sigma_t^2) & w/p \quad \pi(x_t) \\ \mathbb{N}(\mu_t^B, \sigma_t^2) & w/p \quad 1 - \pi(x_t) \end{cases} \tag{4}
$$

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 $s(h_t - \omega_t) = h_t - \omega_t$.[14]

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.[15] The government provides health insurance after age T_O which reimburses medical expenditures according to a coverage scheme with a deductible and co-payments:

$$
\chi(m) = \begin{cases} 0 & m \leq \iota \\ \varsigma(m - \iota) & m \geq \iota \end{cases} \tag{5}
$$

where m denotes the total medical expenditures of the individual, which is the sum of curative medical expenditures, $m_{C,t}$, and preventive medical expenditures, $m_{P,t}$. The individual does not receive reimbursement for her medical expenditures up to the deductible, ι. And for every dollar she spends above the level of the deductible she receives ς fraction of each

[14]I make an implicit assumption that current investment in physical health capital does not affect the current survival probability but the probability of survival in future periods. I need to make this assumption in order to identify physical health production technology parameters, which I will discuss further in Section 5.1.1. In the model with reasonable parametrization agents choose to recover from 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 would not change the results significantly.

[15]The natural borrowing limit in this economy is zero because of endogenous survival probability. In order to check the role of the borrowing constraint in deriving my results I have worked out a version of the model where agents are endowed with heterogeneous initial wealth and receive the same small income stream so that they would never need to borrow against future income. The results hold qualitatively and I conclude that the borrowing constraint does not play a crucial role in my results. Details are available upon request.

dollar spent as the remainder of the co-payment. To finance the health insurance scheme, the government imposes a lump sum tax on individuals which is denoted by τ^L. Then the budget constraint for an individual is as follows:

$$\begin{aligned} w^i + (1+r)a_t &= c_t + a_{t+1} + m_{C,t} + m_{P,t} + \tau^L \quad t \leq T_O \\ w^i + (1+r)a_t &= c_t + a_{t+1} + m_{C,t} + m_{P,t} - \chi(m_{C,t} + m_{P,t}) + \tau^L \quad t \geq T_O \end{aligned} \tag{6}$$

3.2 Mechanism

I am now ready to discuss the key mechanism that can account for the differences between low- and high-income individuals in their lifetime profiles of medical expenditures. I start by introducing how curative and preventive medical expenditures evolve over the lifetime for both types of individuals.[16]

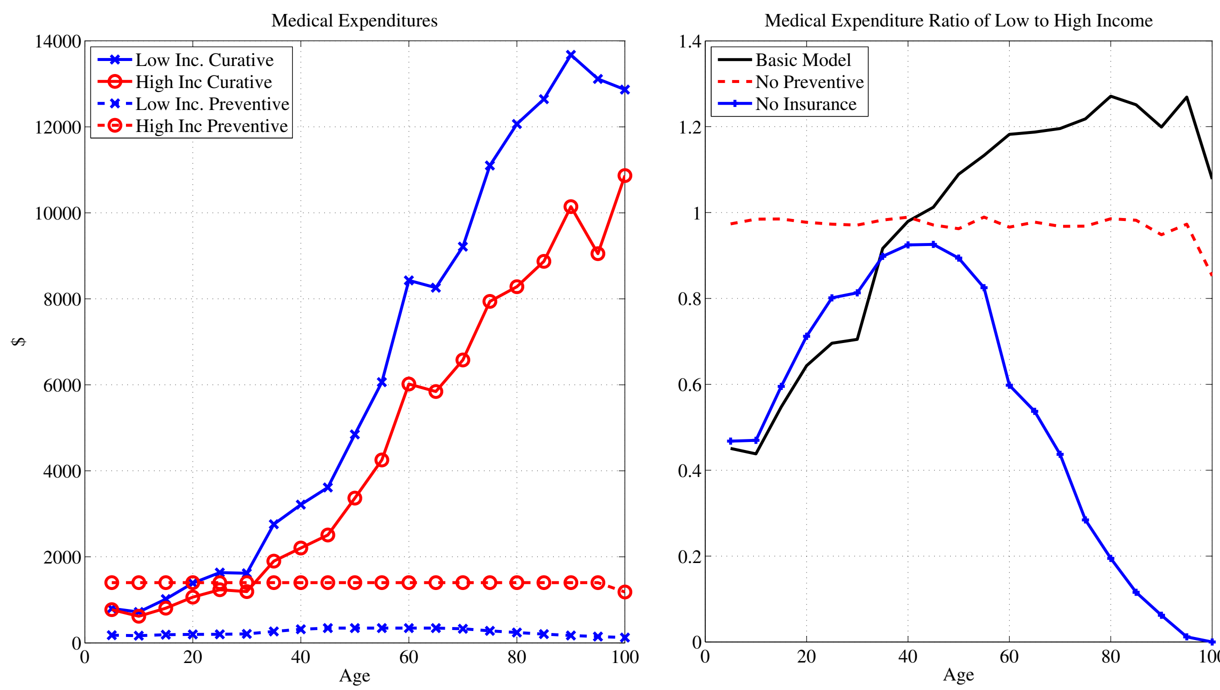
The left panel of Figure 3 shows the lifetime profiles of medical expenditures. Dashed and solid lines plot preventive and curative medical expenditures, respectively. And red circles and blue crosses represent high- and low-income individuals, respectively. Further, the solid black line in the right panel shows the ratio of the medical spending of low-income individuals to that of high-income individuals. Throughout the life cycle rich individuals spend substantially more on preventive medical expenditures than do poor individuals, 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 expected life span. Through the distribution of health shocks, life expectancy is mainly determined by the investment in preventive health capital.[17] The richer the

[16]Even the simplest version of the model is complicated enough not to allow me to derive any analytical results. For this reason, I solve the model computationally and simulate it using the parameter values discussed in Section 5.1.1. The emphasis in the present section is on the economic forces at work. Therefore, I relegate the details of the parameter values to that section.

[17]Because shocks are irreversible, the marginal benefit of curative medical expenditures is high enough that both low- and high-income agents choose to recover from health shocks fully for most of the life span.

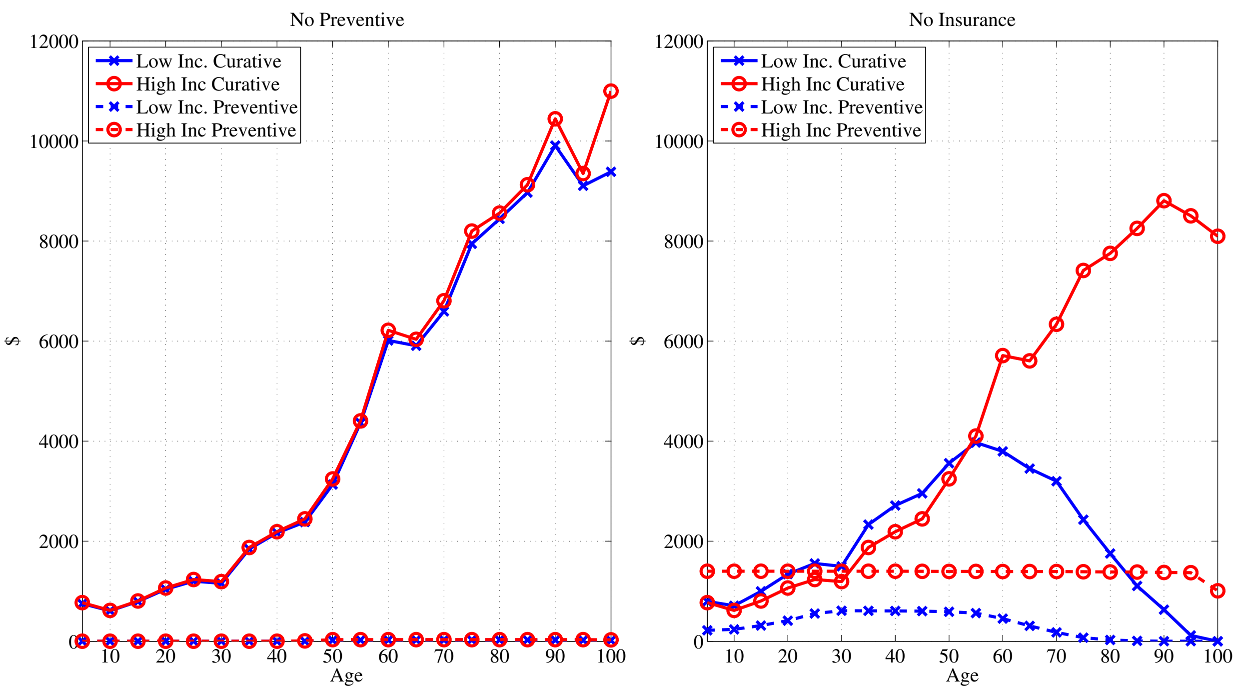
individual, the longer she can afford to live (as she can afford to consume more). Thus, high-income individuals invest in preventive health capital more than low-income individuals do. Therefore, as a cohort grows older, low-income persons draw greater health shocks compared to high-income individuals, and in turn they incur higher curative medical expenditures. This explains the increase in the ratio of the medical expenditures of low-income individuals to those of high-income individuals until very old age.

Figure 3: Lifetime Profile of Medical Expenditures in the Basic Model



To make the role of preventive health capital clear, the left panel of Figure 4 shows the case where I shut down the preventive health capital channel by assuming that the "good" and the "bad" health shock distributions have the same mean (i.e., $\mu^G = \mu^B$). If there were only physical health capital and the health shocks of the rich and the poor grow the same, then the medical expenditures of low-income individuals would be very similar to those of high-income individuals. As a result, the ratio of the medical expenditures of the poor to those of the rich would exhibit a non-increasing profile over the life cycle (shown by the dashed red line in the right panel in Figure 3).

Figure 4: Lifetime Profile of Medical Expenditures: No Preventive Health and No Insurance



Public health insurance for the elderly affects medical expenditure decisions not only in old age but also early in life. It hampers the incentives of the poor to invest in preventive health capital early in life and allows them to incur medical expenditures higher than their resources in old age.[18] In the right panel of Figure 4 I present the simulation results of the case where there is no public insurance. As can be seen, the poor spend significantly more on preventive medicine early in life than in the case with public insurance. This leads to milder health shocks for the poor. Furthermore, without public insurance, the medical spending of the poor never exceeds that of the rich, as shown by the solid blue line with plus signs in the right panel of Figure 3.[19] While I modeled the public insurance as similar

[18]Even though insurance covers total health care expenditures (the sum of preventive and curative medical expenditures) the nonlinear (deductible-co-payment) coverage scheme leads to reimbursement of larger medical expenditures at a higher rate, which, in turn, provides less incentives to invest in preventive health capital compared to physical health capital as well.

[19]Indeed by the end of life cycle medical expenditures of the poor converge to zero. This is because shocks become too large that the survival probability converges to zero.

to Medicare in this simple model, emergency room examinations for low-income individuals and the provision of Medicaid for the medically needy would have similar implications.

4 Full Model

The simple model with two types of health capital and public insurance looks like a promising way to study the differences in the dynamics of medical expenditures by income. But it falls short of delivering a sound quantitative analysis, 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., the availability of private health insurance, Medicaid, etc.), all of which can play an important role in the evaluation of counterfactual health care policy.

In this section, I introduce a richer version of the basic framework presented in Section 3.1, extending the basic model while preserving its main structure. Specifically, the accumulation processes for the physical and preventive health capitals (h_t and x_t, respectively) are the same as those given by Equations (2) and (3). First, I discuss individuals' life-cycle problem—specifically, their preferences and the three different phases of life: childhood, working years, and retirement. Then, in Section 4.2, I introduce a private health insurance market and the Medicaid in addition to the Medicare. Last, I discuss the government's budget constraint in Section 4.3.

4.1 The Individual's Problem

4.1.1 Preferences

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

$$u(c, h) = b + \frac{c^{1-\sigma}}{1-\sigma} + \alpha \frac{h^{1-\gamma}}{1-\gamma} - e^{\psi} \tag{7}$$

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 (as 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 allows them to prolong the joy of being alive. Second, under these preferences the marginal utility of consumption falls rapidly relative to 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 choose a relative risk aversion coefficient, σ, greater than 1.

I also assume that individuals 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., the marginal utility of a fine meal is lower for diabetics) and other situations where they are substitutes (e.g., the marginal utility of hiring a maid is higher for a sick person). Thus, I choose the intermediate case and assume that health and consumption 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_{ADULT}. 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. I now 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 welfare 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 from the insurance firm for their medical expenditures according to health insurance coverage function $\chi^{PRV}(m)$, where m is total medical expenditures. If their income is lower than a certain poverty threshold, they are eligible for Medicaid, $\chi^{MCD}(m)$, which is a government-financed health insurance contract. The details of the private and 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.[20]

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_{ADULT} 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 deterioration in health status. Thus, workers experience a decrease in their earnings due to physical health shocks. In addition, the government taxes total income progressively at average tax rate $\tau(.)$.

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

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 U.S. poverty alone does not necessarily qualify an adult for Medicaid.[21] 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.[22]

Retirement Years: Individuals retire at age T_{RET} and start receiving constant pension payments from the government as a function of their last-period earnings, $\Phi(w^i_{T_{RET}})$. 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 from the government for their medical expenditures with respect to health insurance coverage function $\chi^{MCR}(m)$.

4.2 Health Insurance Plans

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

Individuals are not allowed to buy private health insurance after they observe the health shock in each period. They must make their decision before the health shock is realized. One way to interpret this condition is that private insurance firms can discriminate against

[21] Some of the groups eligible for Medicaid are individuals who qualify for Aid to Families with Dependent Children (AFDC), pregnant women with income lower than some certain poverty threshold, children under age 19, recipients of SSI, and recipients of foster care.

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

patients with pre-existing health conditions. Another way to interpret it is that shocks are observable by private insurance firms, and the price firms ask for after a shock is higher than the individual's willingness to pay due to operational costs.

All three types of insurance plans reimburse medical expenditures according to a deductible and co-payment coverage scheme, as introduced by equation 5. Each insurance type, $j \in \{PRV, MCD, MCR\}$ (private, Medicaid, and Medicare, respectively), has its own coverage scheme (ς^j, ι^j), which is determined exogenously.

Premiums for private insurance depend only on age so that everybody at 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. So there is cross-subsidization between the healthy and the unhealthy.[23] The private health insurance market consists of many small firms. Insurance premiums are determined competitively through firms' zero-profit condition. A firm's revenue in the age t sub-market is composed of insurance premiums 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.

Default Option: It is well known in the literature that health shocks are among the major reasons for bankruptcies (Himmelstein et al. (2009)). Therefore, I allow individuals in my model to default in the case of a severe health shock if they do not have sufficient resources to fully recover from the shock.[24] If an individual chooses to default she spends all of her resources on curative medicine up to the consumption floor, c_{min}, and the rest of the curative medical expense for fully recovering from her health shock is covered by the government.

[23] In reality there is also cross-subsidization between the young and the old which I abstract in my model.

[24] Default option also captures emergency room examinations for low-income individuals and the provision of Medicaid to persons who are medically needy (De Nardi et al. (2011)) during their adulthood.

Therefore she can neither buy preventive medicine nor save for the next period. In future periods, she can accumulate assets and invest in preventive health capital.

4.3 The Tax System and the Government Budget

The government imposes a progressive income tax, $\tau(.)$. The revenues collected 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) to finance the government expenditure, G, that does not yield any direct utility to consumers. The residual budget surplus or deficit, Tr, is distributed in a lump-sum fashion to individuals regardless of age.

4.4 The 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 $j \in \{PRV, MCD, MCR\}$. The dynamic program of a typical individual is given by:

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

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

Definition 1. A stationary competitive equilibrium of this economy for given insurance coverage schemes $\chi^j()$, tax rate function $\tau()$, and 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 function $\{V_t(z_t')\}_{t=1}^T$, 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 $\left\{p_t^{PRV}\right\}_{t=1}^{T_{RET}}$ the 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:
$$\int_{z_t'} I_t^{PRV}(z_t') p_t^{PRV} d\Lambda'(z_t') - (1+\Delta) \int_{z_t} m(z_t) d\Lambda(z_t) = 0 \ \forall t \tag{8}$$

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

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

$$\begin{aligned}
\sum_{t=T_{ADULT}+1}^{T}\int_{z_t}\tau(w+ra_t-p_t^{PRV}I_t^{PRV}(z_t'))d\Lambda(z_t) &= G+\sum_{t=1}^{T}\int_{z_t}Trd\Lambda(z_t)+ \\
\sum_t\int_{z_t}\chi^{MCD}(m_{C,t}(z_t)+m_{P,t}(z_t))I_t^{MCD}(z_t)d\Lambda(z_t) &+ \\
\sum_t\int_{z_t}\chi^{MCR}(m_{C,t}(z_t)+m_{P,t}(z_t))I_t^{MCR}(z_t)d\Lambda(z_t) &+ \\
\sum_t\int_{z_t}(m_{C,t}(z_t)+c_{min}-y_t-a_t)I_t^{D}(z_t)d\Lambda(z_t) &+ \sum_{t=T_{RET}+1}^{T}\int_{z_t}w_t(z_t)d\Lambda(z_t)
\end{aligned} \tag{9}$$

The first term in the government's budget is the total revenue collected through the tax on the total income earned by all adult agents. On the right-hand side, the government finances government expenditures, G, lump-sum transfers, Tr, Medicaid expenditures for eligible children, Medicare expenditures of all of the elderly, curative medicine expenditures due to default, and pension payments to retirees.

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 in fitting the salient features of the data.

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.).

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

CRRA Coefficient De Nardi et al. (2010) 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 ($\sigma = 2$).[25]

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

Income Process I calibrate the common deterministic age profile for income using the MEPS data.[26] For the stochastic component of the income process, three parameters are required. The first is the variance of individual-specific fixed effects, σ_α^2, which determines the cross-sectional variation in income among children and the variation in initial conditions in 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 speaking, does not allow me to estimate these parameters. Thus, I use the estimated values of these parameters from Storesletten et al. (2000), since they estimate an $AR(1)$ income process using household income data.[27]

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

[26] 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 $\Phi()$.

[27] Recall that I used total family income in my empirical analysis in constructing income quintiles.

Last, I estimate the decrease in labor earnings due to deterioration in physical health status (ζ) using the MEPS data. Using the (very short) panel dimension of the survey, I control for the fixed effects and estimate the effect of health status on labor earnings.[28]

Social Security Benefits and Tax Schedule In a realistic model of the retirement system, a pension would be a function of lifetime average earnings, but using this in my model would require me to incorporate average earnings as an additional continuous state variable individual's problem. Instead, in my model the retirement pension is a function of predicted average lifetime earnings. I first regress average lifetime earnings on the last period's earnings and use the coefficients to predict an individual's average lifetime earnings, denoted by $\hat{y}_{LT}(w_{T_{RET}})$ (see Karahan and Ozkan (2013) for details). Like Guvenen et al. (2013) 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 $b = 35.46\%$.

I also use the progressive tax schedule estimated by Guvenen et al. (2013) for the US economy.

Consumption Floor and Poverty Threshold Hubbard et al. (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, in a recent paper De Nardi et al. (2010) estimate the effective consumption floor in a setting with uncertain out-of-pocket medical expenditures for the elderly and find it to be much smaller (\$2700 in 1998). I follow an intermediate path between these two papers and set the consumption floor at \$5000 per year.

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

Since the unit of interest in my model is an individual, I set the poverty threshold equal to the federal poverty threshold for a single adult in 2006, which is \$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 individual herself, how much of it is paid by the private insurance firm, how much of it is paid through Medicaid or Medicare, and how much of it is paid by other sources. Then, using this information, I estimate equation 5 for private insurance holders and Medicare holders. The details of the estimation are 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 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 and 20 years and their income is lower than 100% of the poverty threshold, then they are eligible for Medicaid.[29]

5.1.1 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.

In the following paragraphs, I discuss further which moments help me 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 as to why this is the case. This approach

[29] Health Care Financing Administration (2000) explains the Medicaid eligibility criteria in detail.

should be convincing, since it provides an understanding of how the moments are sufficient to pin down the parameters.[30]

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.[31] The value of being alive, b, is identified from the average life expectancy in the population (75 years), particularly, life expectancy of the poor. The larger b is, the longer the life expectancy low-income individuals aim for.

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)). I then use these weights to estimate α and β:

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

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, and 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: The means of the "good" and "bad" distributions of log health shocks (μ_t^G, μ_t^B) and the common standard deviation of the distributions, σ_t^2. I assume that the difference between the means of the "good" and "bad" distributions is constant for each age t; i.e., $\mu_t^B = \mu_t^G + \bar{\mu}$. So,

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

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

there are two parameters in each t, the means and the variances of the "good" distributions (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 probability of survival to $t+1$. First, I normalize the distribution of health shocks such that the 99.999th percentile of the distribution equals 1 (which is the worst shock, implying death with certainty). Then, the average conditional survival probability in each t along with this normalization can pin down the distribution of shocks. Last, I use differences in the lifetime profile of medical expenditures between low- and high-income individuals to identify the difference in means of the distributions, $\bar{\mu}$, along with preventive health capital technology parameters, (A^p, θ^p)[32].

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 elasticity, θ_t^c, parameters of the physical health production function. Let's suppose that we can observe the curative medical expenditure distribution in the data[33] and that individuals choose to fully cure health shocks.[34] Then there is a one-to-one relationship between the distribution of shocks and the distribution of curative medical expenditures in the data through the physical health production function:

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

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

[33]We don't observe curative and preventive medical expenditures separately in the data. Thus I use my model to differentiate between these two types of medical expenditures. I'll discuss how I identify the distribution of preventive medicine expenditures in the next paragraph.

[34]Indeed, model simulations imply that for reasonable parameter values individuals choose to fully recover from health shocks throughout their lifetime except in very old age (older than 90).

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: the constant depreciation rate δ_x, and the productivity and curvature parameters of preventive health production function (A^p, θ^p) (notice that they do not depend on age). The difference between the means of the "good" and the "bad" distributions of health shocks $(\bar{\mu})$ and the depreciation in preventive health capital (δ_x) cannot be identified jointly. Thus, I assume that $\delta_x = 7.5\%$.

The ratio of the medical consumption of low income individuals to that of high income individuals over the life cycle (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 poor's medical expenditures to those of the rich through a rise in the differences between their 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, the medical expenditures of low-income individuals are substantially lower than those of high-income individuals. Thus, there must be enough differences in the model between low- and high-income groups in preventive medicine usage to match the counterpart in the data.

5.2 Model Performance

In this section, I examine the fit of the model to the data. First I discuss the performance of the model in matching the targeted moments in the estimation. Then I discuss an informal validation 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, 18, and 19 (Appendix B).[35]

5.2.1 Fit of the Model to the Targeted Moments

The left panel of Figure 5 plots the average medical expenditures of individuals (the dashed red line), which are computed using 10000 simulated life-cycle paths for individuals starting with the same initial condition, and the data counterpart (the solid blue line). The right panel shows the simulated ratio of the medical expenditures of low-income individuals to those of high-income individuals and its data counterpart. Average medical expenditures over the life cycle (along with the variances) and the increase in the 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, particularly the dramatic increase in health care expenditures and the hump-shaped ratio of the expenditures of the poor to those of the rich.

Figure 6 shows the age profile of conditional survival probability implied by the model and its data counterpart, which is targeted in the estimation. Except in 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 individuals. 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 corresponding values in the data. Notice that the model is able to endogenously generate a decreasing life expectancy differential between low- and high-income individuals, albeit not as large a difference as that observed in the data. At age 25, there is a difference of almost 8 years in the life expectancies of the rich and the poor in the data, whereas the model generates only 5 years.

[35] I estimate the model using the method of simulated moments. For each set of parameters the code takes a few hours to solve the model.

Figure 5: Medical Expenditures over the Lifetime

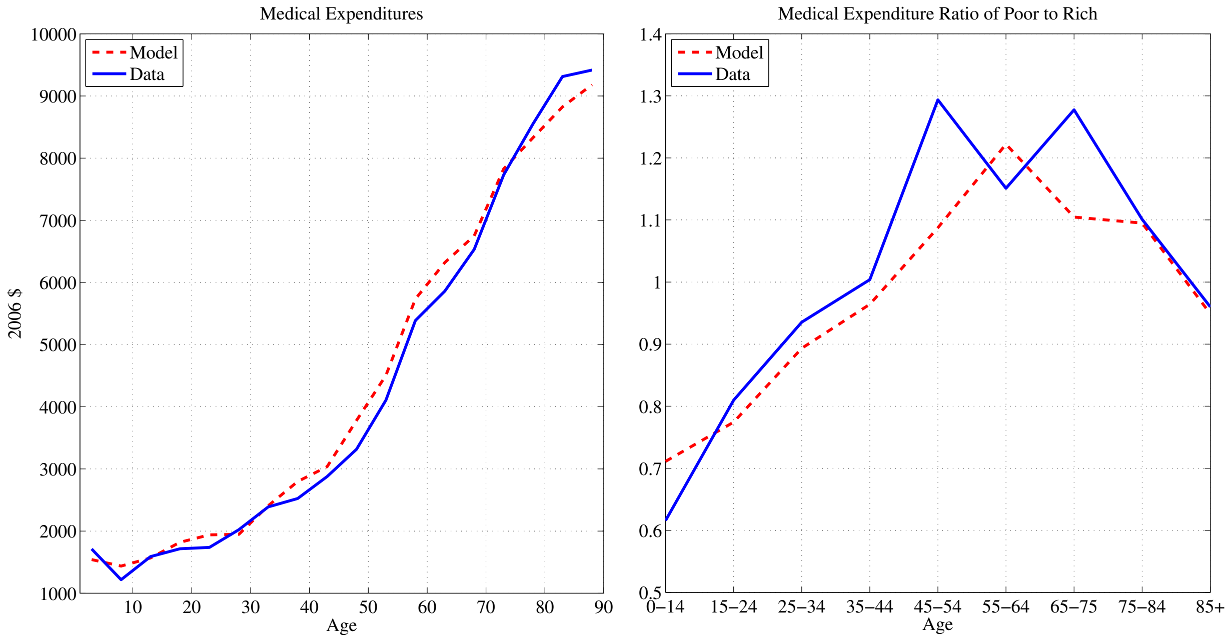
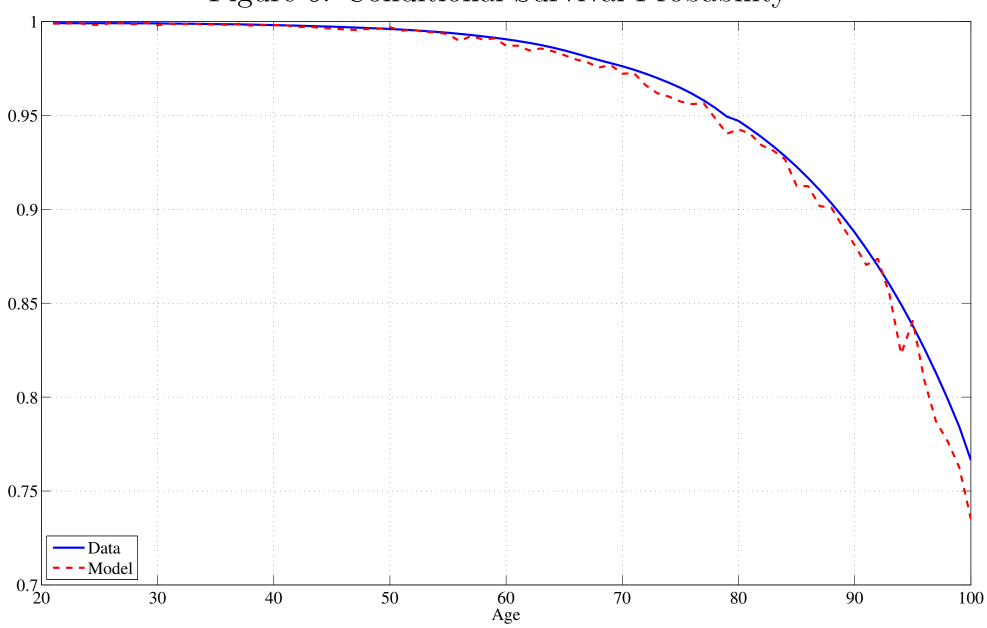


Figure 6: Conditional Survival Probability



5.2.2 An Informal Validation Discussion

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

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

Note: Life expectancy data is taken from Lin et al. (2003)

In my estimation I target only the increase in the ratio of the medical expenditures of low-income individuals to those of high income individuals but not the decrease at the end of the life cycle (see the right panel of Figure 5). The model can capture this decrease fairly well. First, a selection effect plays an important role at the end of life. As a cohort of individuals grows older, it becomes increasingly composed of the rich; therefore the difference between the rich and the poor decreases (Shorrocks (1975)). Second, the return on health capital investment is lower for low-income individuals since they expect to live shorter lives. This reduces the medical spending of the poor relative to the rich.

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 ratio of the medical expenditures of the poor to those of the rich for the averages of the bottom 50% and the top 10% of expenditures, respectively.[36] The model is capable of generating differences between the rich and the poor for the top and the bottom of the expenditure distribution.

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

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

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

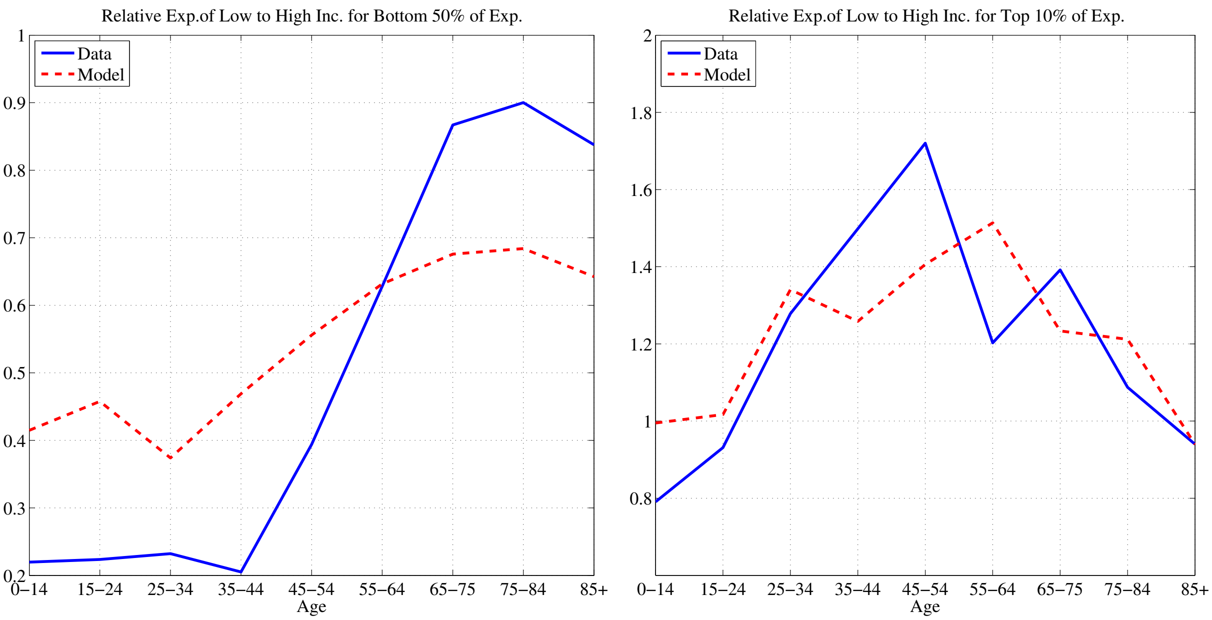


Table 3 shows three selected statistics in the data and their model counterparts. First, the model results suggest that 85% of the population under age 65 is covered by private insurance, whereas in the data this number is only 73%. This is due to the lack of public insurance channels for adults between ages 21 and 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 a rate of Medicaid coverage of 23% for children under age 20, whereas in the data this number is 22%. Last, out of total medical expenditures the share of Medicaid and Medicare in the data is 29% and the model counterpart is 26%, which allows me to conclude that the model is fairly successful in fitting the data.

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%

Data source: Author's calculations from the MEPS and the model simulations.

6 Policy Analysis

The model is quite successful in matching the salient features of the data. This encourages me to use the model as a laboratory to study the macroeconomic and distributional effects of PPAC Act of 2010.

6.1 Policy I: Universal Health Care Coverage

One of the main provisions of the PPAC Act of 2010 is to expand health insurance coverage by expanding Medicaid eligibility, subsidizing private health insurance for low-income individuals, providing incentives for employers to provide health benefits, and imposing tax penalties on individuals who do not obtain health insurance. These provisions are financed by a variety of taxes, fees, and cost-saving measures. According to Congressional Budget Office estimates, about 95% of the non-elderly population is expected to have health insurance when the legislation takes full effect.[37]

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 premiums of

[37] The 5% of the non-elderly population that will lack health insurance will consist of low-income individuals 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.

all non-elderly individuals.[38] The cost of this provision is offset by a proportional income tax that keeps government expenditures net of transfers the same as before the policy change. In particular, the government budget constraint (equation 9) 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 (in the column labeled "Bench.") and their steady-state values after the policy change (in the 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 individuals, they invest more in both preventive and physical health capital; therefore, on average, they live longer by 1.25 years (see Table 5).[39]

Table 4: Policy Analysis

	Bench.	Policy I	Policy II
Change in Average Tax Rate	-	+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%
Change in Welfare	-	1.5%	2.5%

The increase in preventive expenditures and curative expenditures due to a longer life span exceeds the savings in curative expenditures due to milder health shocks. As a result,

[38]Similarly, one can think of this policy as providing vouchers from the government to non-elderly individuals so they purchase private health insurance. The value of an individual's voucher is exactly equal to the health insurance premium she would be paying (Jung and Tran (2010a)).

[39]The model predicts a higher mortality differential between the rich and the poor in the U.S. compared to other developed countries where universal health insurance is provided. Delavande and Rohwedder (2008) estimate the socioeconomic mortality differential in the U.S and in ten European countries using subjective survival probabilities. They find a significantly larger mortality differential between the lowest and highest wealth terciles in the U.S. than in European countries. The difference in the probability of surviving to age 75 between the top and bottom wealth terciles is 14% in the U.S., whereas in European countries it is only 8%.

aggregate health care expenditures increase slightly, from 9.84% of aggregate income to 9.92%.[40] However, because of the longer life span per capita health care expenditures increase even less, from \$4750 to only \$4755. Similarly, due to the longer life span Medicare expenditures rise slightly, from 2.48% of aggregate income to 2.495%. Furthermore, the share of preventive care expenditures does not change significantly (it rises from 21.5% to only 21.7%).

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.

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

In addition I compute the change in the welfare of society due to universal health care coverage, which is basically a redistributive policy. On the one hand, it increases the welfare of the poor by providing them health insurance at the relatively low cost of an increase in taxes. On the other hand, it reduces the welfare of the rich through higher tax rates. In order to quantitatively evaluate the net increase in social welfare, I compute the fraction of lifetime consumption that an unborn individual would be willing to give up in order to live

[40] 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 individuals accumulate less capital because of the distortion caused by better insurance opportunities against health shocks and the redistribution in the new economy. To be more precise, total income decreases very slightly, by 0.2%.

in an economy with universal health care coverage instead of in the benchmark economy. Let $(1-\phi)$ be this fraction; then ϕ solves the following equation:

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

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

An unborn individual (who does not know what family she will born into) would be willing to give up 1.5% of her lifetime consumption in order to live with universal health care coverage instead of in the benchmark economy. Around one-third of the welfare gains are due to the increase in the lifetime expectancy of the bottom first and second income quintiles. The rest comes from better opportunities for insurance against health shocks.

As expected, welfare gains are not evenly distributed and not even every newborn 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). People who are born into median-income households gain most from this policy; they are willing to give up 2.1% of their lifetime consumption in order to live under the new policy. The welfare of newborns of very rich families (in the top 2%) worsens since they expect to cover most of the cost of universal health care coverage over their life time without gaining much in insurance $(1-\phi=-0.88\%)$. Surprisingly, the welfare gains for children of low-income households are very small $(1-\phi=0.6\%)$. This is because curative medicine expenditures constitute the majority of their health care expenditures and the option of default in case of a severe health shock is not as costly for them as it is for middle-income individuals. Thus additional insurance against health shocks from a universal health coverage policy is not as valuable to them as it is to a child of a middle-income household.

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. Therefore it is not surprising that this policy is welfare improving since it is redistributive in nature, transferring income from the rich to the poor. On the other hand, this way of financing universal health care coverage is based on an assumption designed to simplify the complicated changes in the law. In reality the tax burden on high-income individuals 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, including childhood immunizations, checkups, mammograms, colonoscopies, cervical screenings, and treatment for high blood pressure.[41] 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 individuals' preventive medicine expenditures. I examine this policy change in the universal health care coverage setting discussed in the

[41]Some of the other free preventive care goods and services 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.

previous section.[42]

The results of this policy change are reported in Tables 4 and 5 under the heading labeled "Policy II." An immediate implication of the new policy is an increase in insurance premiums due to higher coverage of preventive medicine costs by firms. As a result, the government raises the flat tax from 3.1% to 4.06% to finance the rise in premiums. Under this new policy, individuals spend more on preventive care, which results in significant increase in the 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 the top income quintile (see the bottom row of Table 5).[43]

Surprisingly, even though individuals spend more on preventive care, and they live longer on average, aggregate medical spending does not change (it remains 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 because of the greater investment in preventive health capital. As a result, total Medicare spending decreases by 0.075% of total income, from 2.495% to 2.42%, and per capita health care expenditures decrease slightly, from $4755 to $4738.

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 in 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 the 2.5% gain).

Again welfare gains are highest for the newborn children of median individuals. However,

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

[43] Individuals in the top income quintile have already reached the maximum level of preventive health capital investment before the policy change.

under the "free preventive medicine" policy, not just the newborn children of families in the top 2% of the income distribution but also the children of the bottom 2% are worse off compared to an economy with only universal health insurance (see the last row of Table 6). This is because even under the "free preventive medicine" policy, the poor do not increase their spending on preventive health care to a level high enough that the subsidy they get for their preventive medicine expenditures offsets the increase in taxes that is 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 thorough analysis would compute transitional dynamics after the policy change, but that is computationally infeasible at this point. However, one can speculate about the transition of the economy from the old steady state to the new one. After the policy change we would expect aggregate medical costs to increase in the short term, since the 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 it would only imply an increase in tax rates for them.

These results point to avoidable health conditions due to lower investment in preventive health capital by poor individuals in the US. According to Nolte and McKee (2007), the U.S. health care system is particularly bad at prevention: the U.S. ranked last in forestalling preventable deaths with timely and effective care among 19 peer countries. In addition, according to the National Healthcare Disparities Report (2003), in the U.S. avoidable health conditions are a particularly pervasive issue for individuals of lower socioeconomic status. For example, poor individuals 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. Further, 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).

In a recent study, Kolstad and Kowalski (2012) investigate the impact of the health care reform law 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, the Massachusetts reform allows them to examine the impact of an expansion to near-universal health insurance coverage for the country using the state population as a test case. 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 empirical results are in line with my quantitative findings.

7 Conclusion

In this paper, I have studied disparities in health outcomes and health care usage across income groups. Using data from the MEPS, I have found that early in life high-income individuals spend more on health care, whereas from midway through life until old age the average medical spending of the poor exceeds that of the rich in absolute terms. Furthermore, low-income individuals are less likely to incur any medical expenditures in a given year, yet, when they do incur medical expenditures, the amounts are more likely to be extreme.

I used an estimated structural life-cycle model of health capital with endogenous distribution of health shocks to explain these facts. Early in life high-income individuals spend more on preventive care than low-income individuals do. In turn, as a cohort grows older, the health shocks of the rich grow milder compared to those of the poor. Public insurance against health shocks in old age (through Medicare, Medicaid, or the option to default on medical expenditures) amplifies this mechanism by hampering the incentives of the poor to spend on preventive care. Furthermore, it allows the poor to incur medical expenditures in amounts larger than their resources and larger than the medical spending of the rich. My results from counterfactual policy experiments suggest that policies encouraging the use of health care by the poor early in life produce significant welfare gains, even when fully accounting for the increase in taxes required to pay for them.

The PPAC Act of 2010 is one of the most important health care reforms in our recent history. It will surely have large effects on not only people's access to health care but also their health care usage behavior, which, in turn, will affect the dynamics of health shocks. Thus, in order to study this health care policy a structural model that endogenizes the dynamics of health shocks is needed. In this paper, I have focused on preventive medical care as a key determinant of the timing and size of health shocks. Yet, it is well known in the medical literature that there are several other factors affecting an individual's health, such as lifestyle choices, dietary behavior, or genes. This paper is a stepping stone in modeling the determinants of the distribution of health shocks and further research is warranted.

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APPENDICES FOR ONLINE PUBLICATION

A Data Appendix

A.1 Data Cleaning

I merge MEPS waves between 1996 and 2010, which provides 455,789 observations (after dropping reporting units that did not complete the survey). First, I construct a family unit as a group of individuals who share the same dwelling unit ID (duid), and yearly family ID (famidyr) in the same year.[44] I drop families whose reference person is younger than 18 years (172 observations) or the oldest member is younger than 18 years (946 observations). 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). I convert income using CPI and medical expenditures using MPI to 2006 dollars.

Table 7: Number of Observations by Gender

sex		Freq.	Percent	Cum.
Female	|	238,065	52.23	52.23
Male	|	217,724	47.77	100
Total	|	455,789	100.00	

[44]The MEPS has its own family units and provides family size for them. For 13755 individuals the family size of the MEPS is inconsistent with the number I found, but I continue to use my own definition of family unit for these individuals.

Table 8: Number of Observations by Year

year	Freq.	Percent	Cum.
1996	21,407	4.7	4.7
1997	32,705	7.18	11.87
1998	22,857	5.01	16.89
1999	23,783	5.22	22.1
2000	24,339	5.34	27.44
2001	32,524	7.14	34.58
2002	37,773	8.29	42.87
2003	32,885	7.21	50.08
2004	33,043	7.25	57.33
2005	32,632	7.16	64.49
2006	32,769	7.19	71.68
2007	29,876	6.55	78.24
2008	32,046	7.03	85.27
2009	35,596	7.81	93.08
2010	31,554	6.92	100
Total	455,789	100	

Table 9: Number of Observations by Race

racey	Freq.	Percent	Cum.
White	348,304	76.42	76.42
Black	76,061	16.69	93.11
Indian/Alaskan	4,785	1.05	94.16
Asian	20,705	4.54	98.7
Other	5,934	1.3	100
Total	455,789	100	

Table 10: Summary Statistics

Variable	Obs	Weight	Mean	Stdev	Min	Max
Real total income	455789	4.1956e+09	24383.85	30784.83	-101129.9	680559.4
Real total consumpt.	455789	4.1956e+09	3170.694	9880.732	0	1088442
Real total income	455789		19974.51	27741.7	-101129.9	680559.4
Real total consumpt.	455789		2884.238	9351.652	0	1088442
Real family income	455789	4.1956e+09	65655.72	51581.04	1005.079	770137.6
Real Family Consumption	455789	4.1956e+09	8078.804	15838.33	0	1092570

A.2 Medical Expenditures

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

Figure 8 and 9 show age profile of medical expenditures by income for males and females only, respectively.

Figure 8: Age Profile of Medical Expenditures by Income for Males

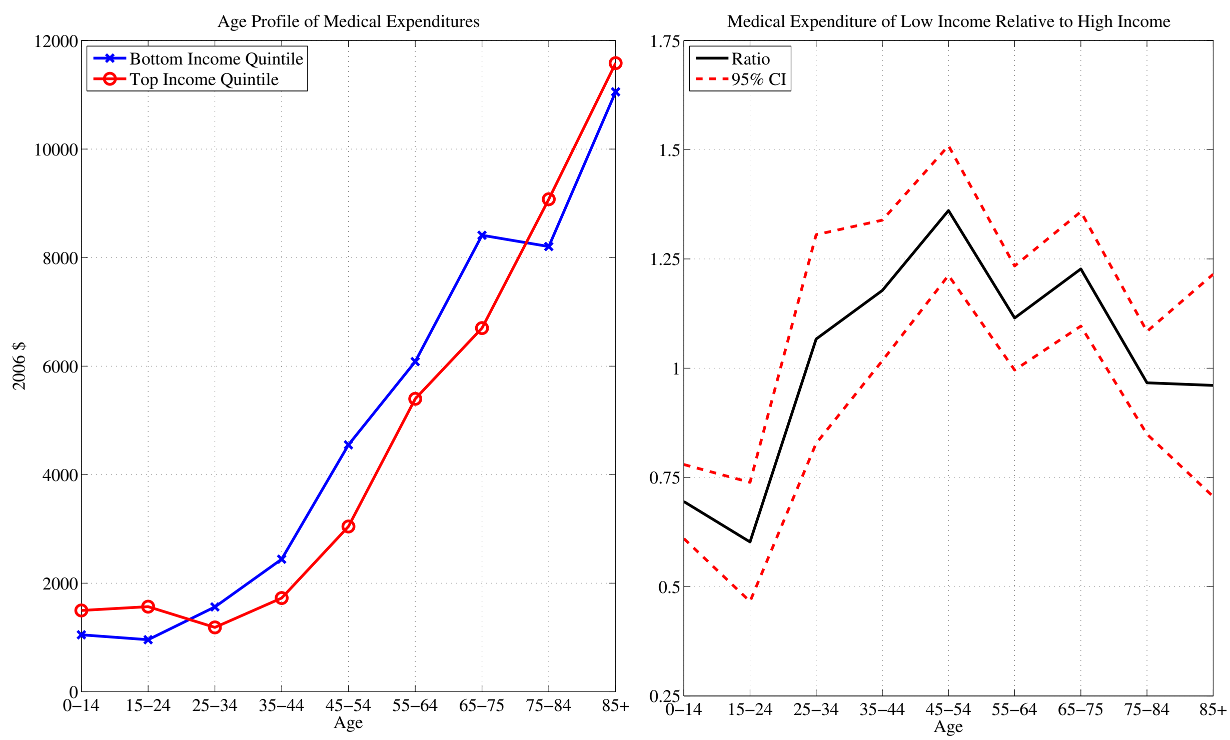
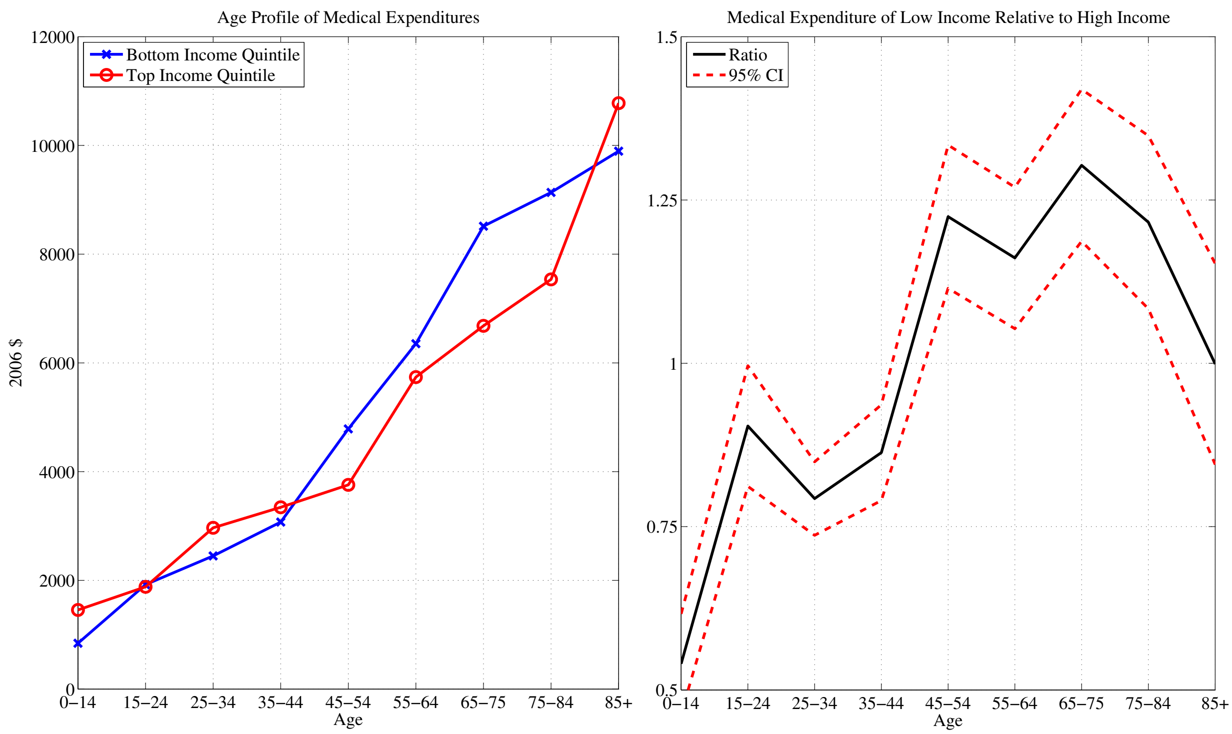


Figure 9: Age Profile of Medical Expenditures by Income for Females



To control for year, gender, and race effects, I run a tobit regression of total medical expenditures on year, gender and race dummies along with body mass index dummies and a smoking dummy.[45] Remember that the MEPS has a panel dimension of two years. In my tobit regression I only use the second year's medical expenditures for each individual.[46]

To control for reverse causality between income and medical expenditures (health), I condition individuals on their previous year's normalized family income. So, top and bottom

[45]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. In a recent study Jung and Tran (2010b) construct life-cycle profiles of medical expenditures in the MEPS after controlling for time and cohort effects simultaneously by using 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 for income groups. This suggests that cohort effects would not affect my empirical findings.

[46]Tobit regression does not allow me to control for fixed effects. In an earlier version of this paper, I estimated the year, gender, and race effects by controlling for random effects, which resulted in similar profiles.

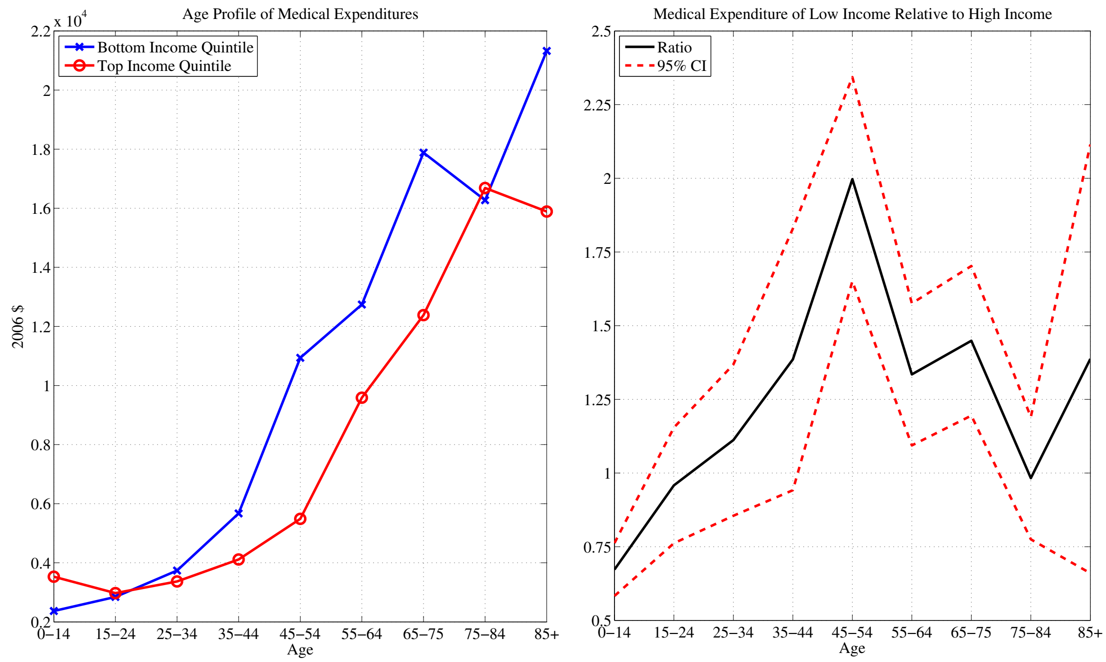
income quintiles in Figure 10 are according to family income in year $t-1$, while the y-axis shows medical expenditures in year t.

Table 11: Tobit Regression Results

VARIABLES	log(total exp)
male	-1.120***
	(0.0207)
Black	-1.177***
	(0.0316)
Indian/Alaskan/Aleut/Eskimo	-0.755***
	(0.118)
Asian/Pacific Islander	-0.977***
	(0.0546)
Other	-0.117
	(0.0790)
2001	0.0198
	(0.0535)
2002	0.0465
	(0.0455)
2003	0.155***
	(0.0489)
2004	0.0101
	(0.0497)
2005	0.205***
	(0.0498)
2006	0.0170
	(0.0501)
2007	0.128***
	(0.0492)
2008	-0.134**
	(0.0534)
2009	0.0237
	(0.0496)
2010	0.0348
	(0.0497)
bmi < 18.5	-0.250***
	(0.0367)
25<=bmi <30	0.440***
	(0.0254)
bmi>30	0.891***
	(0.0275)
smoking	-0.515***
	(0.0335)
Constant	6.133***
	(0.0392)
Observations	149,681

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 10: Age Profile of Medical Expenditures by Income



* Bootstrap means and confidence intervals are reported.

I also normalize family income with the square-root equivalence scale. Figure 11 shows the age profile of medical expenditures for this case.

Figure 11: Age Profile of Medical Expenditures by Income (Square-Root Scale)

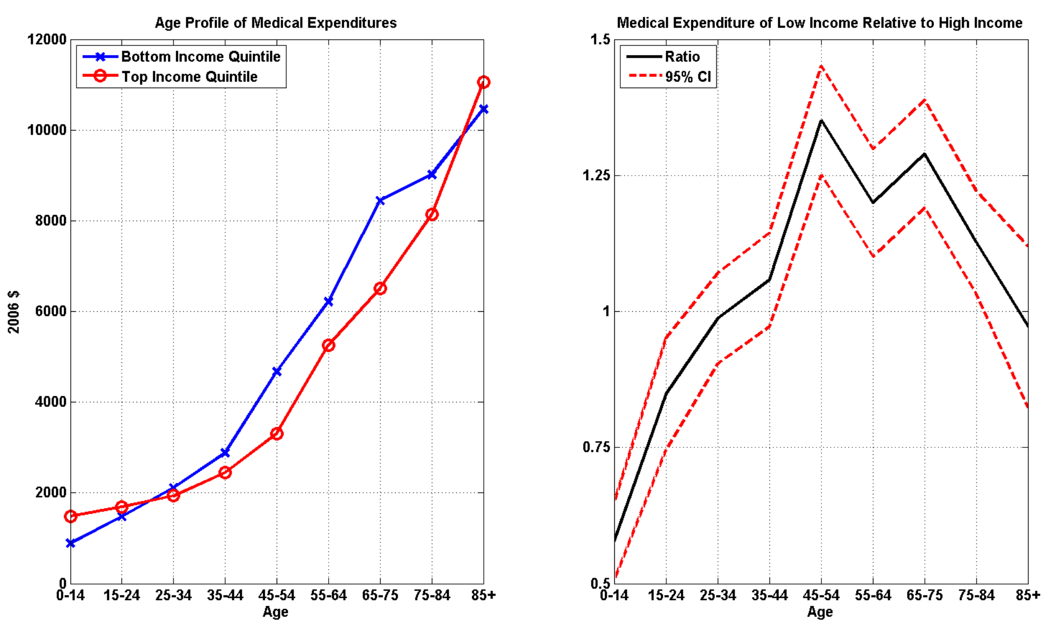
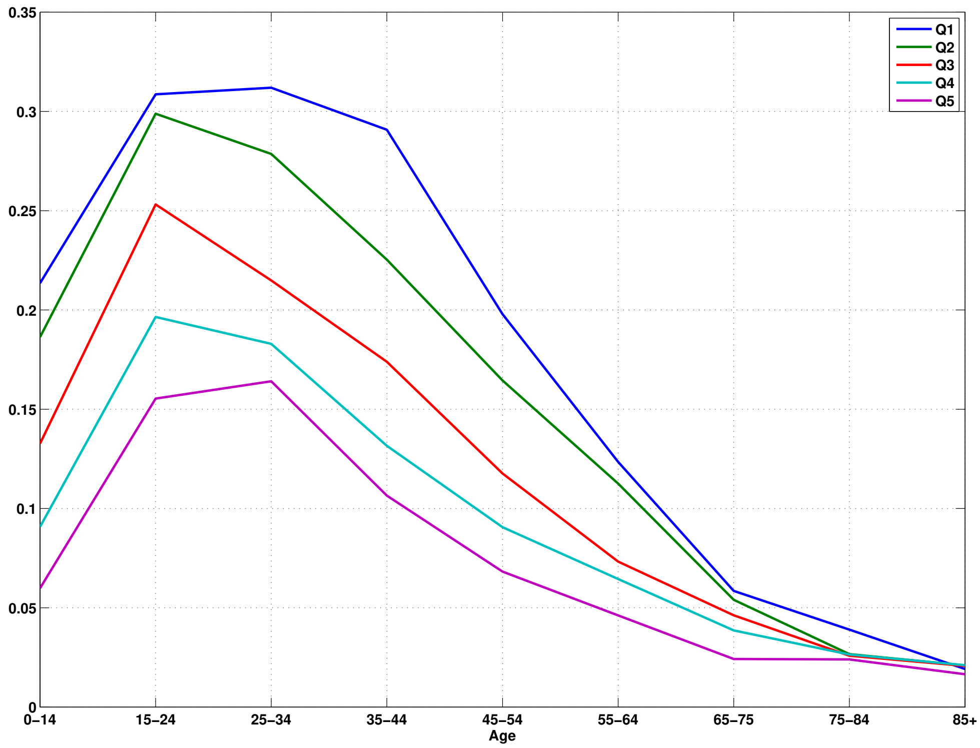


Figure 12: Fraction of Individuals with Zero Expenditures by Income Quintile



A.3 Preventive Medicine Usage

In the MEPS respondents are asked how often they use particular forms of preventive medicine. In particular, they are asked for the "Time since your last..." with the response options "within past year," "within past two years,"... etc.[47]

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.

[47] In the case of regular dentist checkups 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 of 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 the 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.

In my sample the range of health status is 1 to 5. So between the workers with the best and worst health status, 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 and 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.[48] I assume the following functional form for the insurance coverage, which features both a deductible and co-payments:

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

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

[48] I assume that Medicaid holders are covered by private insurance.

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
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

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.[49]

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.

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

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

B 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