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Health, Health Insurance, and Inequality

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Abstract

This paper identifies a *"health premium"* of insurance coverage that the insured is more likely to stay healthy or recover from unhealthy status. We introduce this feature into the prototypical macro-health model and estimate the baseline economy by matching the observed joint distribution of health insurance purchase, health status and income over the life cycle. Quantitative analysis reveals that an individual's insurance status has substantial and persistent impact on health, which will be reinforced by and subsequently amplify the feedback effect of health on labor earnings and income inequality. Providing *"Universal Health Coverage"* would narrow health and life expectancy gaps, with a mixed effect on income distribution in absence of any additional redistribution of income or wealth.

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JEL classification: E21, E60, G51, I14, O15.

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1 Introduction

As the only OECD country without universal health insurance, the U.S. had over 44 million citizens without coverage in 2013, just before the major coverage provisions of the Affordable Care Act (ACA) were implemented. Despite the ACA's expansion of comprehensive health insurance to millions of Americans, the rate of uninsured individuals remained at 10.2% in 2021. Staying uninsured can have detrimental effect on one's health due to the lack of primary preventive care and screening service, and the inaccessibility to medical service once sick. Such effect has persistent impact on individual's health over life cycle as being unhealthy will face less favorable price in the insurance market and hence more likely to stay uninsured and unhealthy henceforth. Furthermore, such effect will be reinforced by the impact of bad health on individual's productivity and earning ability.

This paper studies the persistent effect of health insurance coverage on health disparity and income inequality over the life cycle. Using data from the Medical Expenditure Panel Survey (MEPS), we identify a *"health premium"* of insurance coverage that the insured is more likely to remain healthy or recover from illness. To consistently estimate the health premium, we develop an empirical triangular model with an instrumental variable (IV), and employ a recently developed semi-parametric estimator. We then introduce this feature into the prototypical macro-health model. Quantitative analysis reveals that an individual's insurance status has a significant and persistent impact on health over the life cycle, which is reinforced by and subsequently amplifies the feedback effect of health on labor earnings and income inequality. Providing *"Universal Health Coverage"* (UHC) would narrow health and life expectancy gaps, with a mixed effect on income distribution in absence of any additional redistribution of income or wealth.

We begin by documenting stylized facts on the interdependence between health and income. We gather data on individual income, health status, medical spending, and health insurance coverage from MEPS. In our data, unhealthy individuals report substantially lower income, and face higher medical expenditure compared to healthy individuals across all ages. Concurrently, low-income workers are less likely to be insured, primarily due to affordability constraints or a reduced likelihood of receiving employer-sponsored health insurance (EHI) offers in their workplace. Furthermore, insurance coverage affects individual health as the insured has better access to primary prevention and screening services; has a regular source of health care; and is more likely to have healthy behavior through wellness program under insurance coverage. These facts indicate substantial impact of income on individual health through endogenous insurance choice. To tackle the endogeneity of health insurance choice and potential reverse causality, we implement an instrumental variable (IV) approach. Specifically, we use the group averages of EHI offer rates within the same occupation and age group as an IV for an individual's insurance status. We find that health insurance coverage carries a significant "health premium" for the working age population. For instance, conditional on being healthy, an insured 40 year old is 9 percentage points more likely to remain healthy next year compared to an uninsured counterpart. There is a even larger difference in the probability of transiting from unhealthy to healthy between the insured and the uninsured.

Guided by these empirical regularities, we develop a life cycle model to study the interaction between health disparity and income inequality. Our framework departs from standard heterogeneous agent models with incomplete markets, idiosyncratic health expenditure shocks and income risk. We extend these models along the following three dimensions. First, we consider the impact of health on productivity and labor earnings. Second, individual income affects health and mortality risk through endogenous insurance choice. Third, we enrich the modeling of the health insurance market by considering implicit health insurance, including consumption floor and medical bankruptcy. This last aspect is crucial for understanding individual health insurance choice, especially for low income households. Together with the first two factors, they are essential for reproducing the joint distribution of health and income.

We estimate parameter values using micro data from the MEPS and the Panel Study of Income Dynamics (PSID) through innovative econometric techniques that are designed to address the endogeneity of health insurance choice and the simultaneity bias arising from the interaction between health and income. Our baseline economy reproduces the observed health insurance choice as well as the joint distribution of income and health over the life cycle. In our model, higher income households are substantially more likely to obtain insurance coverage and stay healthy, with elasticity similar to that of the data.

We simulate our model to quantify the impact of health insurance coverage on generating persistent difference in income and health over the life cycle. Numerical analysis indicates that a worker who has health insurance coverage initially is more likely to remain healthy by up to 10 years, compared to an otherwise identical worker without insurance. Such effects would reinforce the impact of health on earning ability, and further widen the income gap. Hence, providing health insurance can be an effective policy in reducing health disparity and income inequality.

Building on this, our baseline model serves as a laboratory for a counterfactual policy analysis to assess the welfare implications of UHC, a strategy widely adopted by most OECD countries. This policy, particularly relevant in the context of health-income dynamics, is expected to notably improve health outcomes for low-income individuals who otherwise lack access to health insurance. As a result, it promises to reduce disparities in health and life expectancy—a contrast to canonical models that do not account for the endogenous evolution of health.

In addition, UHC introduces a substantial "level effect", by nurturing a healthier and more productive population, which in turn broadens the tax base. This expansion of the tax base serves to mitigate the fiscal distortions required to fund such policy, marking a significant improvement over the predictions of traditional models. However, the policy's impact on income distribution is complex. Enhanced health leads to increased productivity and labor earnings, particularly benefiting low-income workers and potentially reducing income inequality. Conversely, improved health outcomes and extended lifespans, especially among the poor due to better insurance coverage, could inadvertently exacerbate income inequality. This effect arises by boosting the relative share of low-income individuals in the population, provided there are no additional measures for income or wealth redistribution.

1.1 Related literature

Much of the economic literature on the determinants of health starts with Grossman (1972), in which health is modeled as an investment good whose evolution can be actively managed by investing effort or other resources. A recent quantitative literature embeds this idea into dynamic models with heterogeneous agents and incomplete market to study the macroeconomic and distributional implications of health, health insurance, and health care policies, see for instance Feng (2010), Jung and Tran (2016), Hong et al. (2017), Prados (2017), and Cole et al. (2019). We depart from these papers by specifying a particular channel in which health insurance can influence the evolution of health. It is generally challenging to estimate the health production function due to a lack of concrete health metrics, imperfect observability of some contributing factors, and the difficulty in estimating the relative price of medical service. Our study focuses on evaluating the impact of health insurance choice on the evolution of a binary health status, and is thereby amenable to parameterization and estimation. We identify the causal effect of health insurance on health outcomes using econometric techniques outside our model. Our work hence contributes to the recent macro-health researches that endogenize health process by exploring specific mechanisms and rich micro-level data, see for instance Ozkan (2014), Pelgrin and St-Amour (2016), Fonseca et al. (2020), Mahler and Yum (2022), and Greenwood et al. (2022). Nevertheless our results should be interpreted as a conservative lower bound of the impact of income on health, as we omit other factors that affect the evolution of health and are correlated with income.

Our paper complements a strand of literature that studies health and inequality. de Nardi et al. (2023) study the pecuniary and non-pecuniary costs of exogenous bad health shocks, and finds that exogenous health heterogeneity is important in accounting for lifetime inequality. Hosseini et al. (2019) study the impact of health inequality on lifetime earnings inequality. In these papers, individual's health follows some exogenous path subject to uncertain shocks. They focus on the impact of health on health expenditure and labor productivity. Our study adds to this literature by allowing for an endogenous health process: Individuals can invest in their health by purchasing health insurance. This allows us to study the policy implications of health insurance. In this regard, our paper contributes to a broad literature that studies macroeconomic aspects of health policies, including French and Jones (2004), Hall and Jones (2007), Jeske and Kitao (2009), Bruegemann and Manovskii (2010), Pashchenko and Porapakkarm (2013), Hansen et al. (2014), Braun et al. (2017), and others.

Our key mechanism that health insurance causally affects health resonates findings in a large empirical health literature, such as Currie and Gruber (1996), Doyle (2005), Card et al. (2009), and Finkelstein et al. (2012), among others. We differ from them by focusing on its macroeconomic implications on health and income inequality.[1] Our paper is also related to the empirical micro literature studying why so many Americans are uninsured, see, for instance, Cutler and Reber (1998), Card and Shore-Sheppard (2004), Herring (2005), Gruber (2008), and Mahoney (2015), among others. Guided by these works, we build our macro model to include most empirically relevant channels that matter to insurance choice. Taking into account the general equilibrium impacts allows us to understand the importance of these channels at the aggregate level.

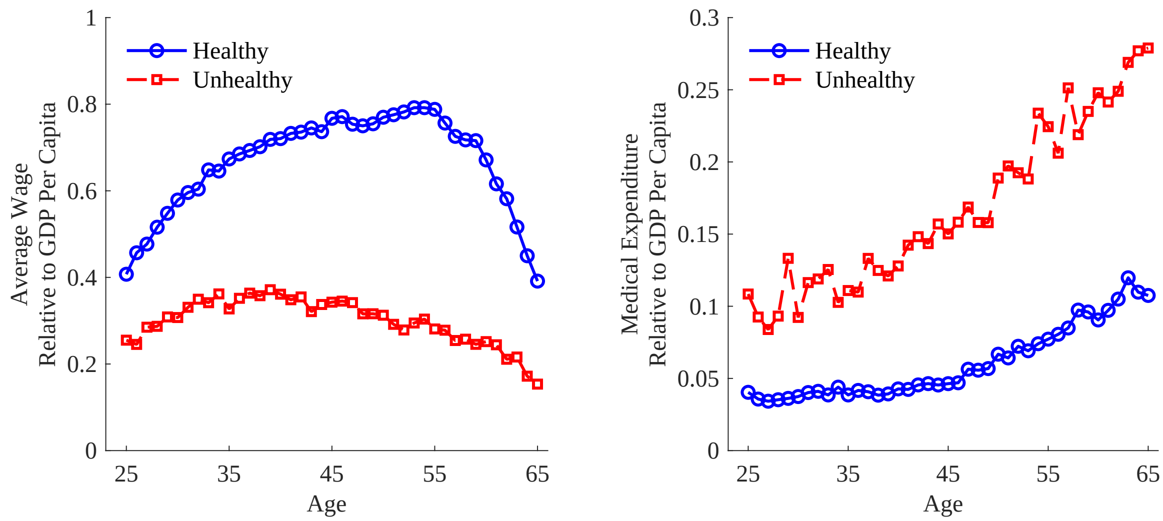
The rest of the paper proceeds as follows. Section 2 describes our identification strategy for estimating the health premium of insurance coverage. Section 3 develops a dynamic equilibrium model. Section 4 details how we estimate the model. Section 5 evaluates the fit and performance of our baseline economy. Section 6 explores the persistence effect of health insurance through the lens of our model, and Section 7 discusses the macroeconomic implications of implementing universal health insurance coverage program. Section 8 concludes the paper.

2 The Effects of Health Insurance on Health

In this section, we identify the crucial role of health insurance in determining the evolution of individual health using data from the Medical Expenditure Panel Survey (MEPS). In the MEPS data, health status is recorded as "excellent", "very good", "good", "fair", and "poor". In line with the literature, we classify an individual as "healthy" if her health status is "excellent", "very good", "good", and as "unhealthy" otherwise. Insurance status can take one of the following five states: no insurance coverage, covered by a private insurance plan, by EHI, by Medicaid, or by Medicare.

[1]Our instrumental variable approach also allows us to identify the effect for individuals of all ages, as we explained in Section 2.2, while their approaches typically apply to a small and special group of individuals, such as those at age of 65 in Card et al. (2009).

Figure 1: Income and Medical Expenditure by Health



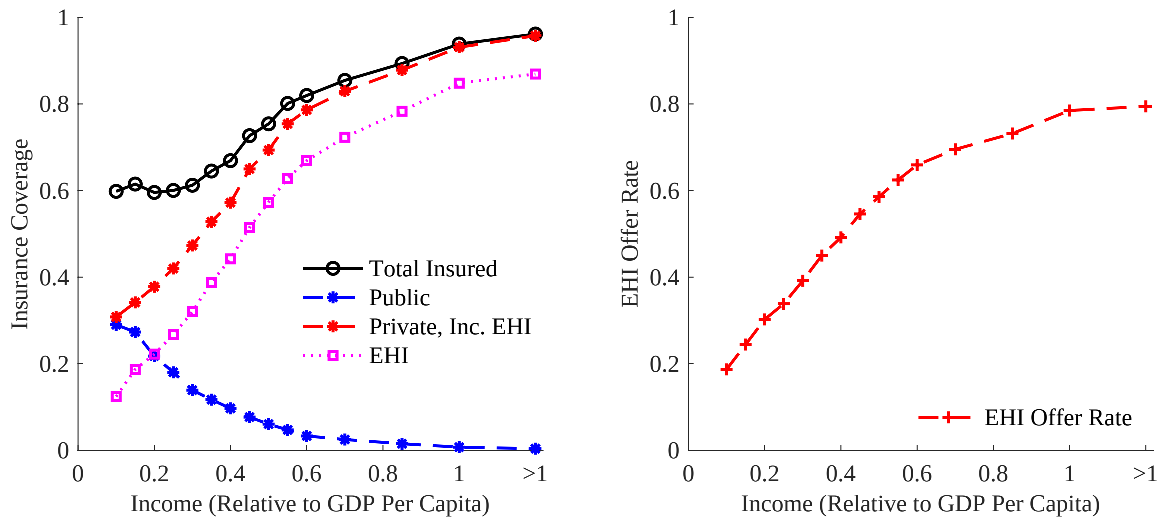
Note: The left panel shows the average annual income for healthy and unhealthy individuals for different ages, where annual income is normalized relative to per capita GDP. The right panel shows the average medical expenditure for healthy and unhealthy individuals for different ages, also normalized relative to per capita GDP. The sample comes from the Medical Expenditure Panel Survey (MEPS).

2.1 Interdependence between health and income

The most noticeable empirical facts based on our data resonate findings by a burgeoning literature that studies the impact of health on income inequality. Figure 1 reports average income and medical expenditure by individual's health status over the life cycle. The left panel indicates that unhealthy individuals have substantially lower income compared with healthy individuals for all ages, consistent with findings in Aizawa and Fang (2020). The right panel shows that unhealthy individuals have higher medical expenditure, especially among the elderly. The above two facts imply that that health disparity matters for income inequality, which echoes findings in de Nardi et al. (2023) .

Health, as an endogenous outcome, is shaped by numerous factors. Seminal research by Chetty et al. (2016) reveals a robust correlation between individual income and health, with the latter gauged by mortality risk. However, the role of income in health improvement is indirect, mediated by factors like medical services, healthy behaviors, exercise, and dietary choices. Estimating the health production function is challenging due to the ambiguity in health metrics, limited visibility of contributing factors, and the complexity in assessing the

Figure 2: Insurance Coverage by Income



Note: The left panel shows the insurance status of individuals by income levels. Public insurance includes Medicaid and Medicare. The right panel plots the average EHI offer rate by income levels. Annual income is normalized relative to per capita GDP.

relative cost of medical services (Suen, 2006). To navigate these complexities, our study focuses on the effect of health insurance choice on binary health status evolution, which offers observable metrics suitable for parameterization and estimation.

This focus is further justified by the strong link between insurance choice and income. The left panel of Figure 2 illustrates that insurance coverage among individuals aged 25 to 65 correlates with income level, notably for private and employer-provided health insurance (EHI). Specifically, while only 30% of individuals earning 20% of the per capita GDP receive EHI offers, this figure is close to 80% for those earning at or above per capita GDP levels (Figure 2 , right panel).

Importantly, emphasizing health insurance choice aligns with its well-established health benefits. Moreover, key government healthcare initiatives, such as the Affordable Care Act, are primarily aimed at enhancing health insurance coverage, underscoring the relevance of this focus in policy discourse.

2.1.1 Health insurance and health outcome

The interplay between health insurance and health outcomes is complex, with research providing multifaceted insights. Baicker et al. (2013) delve into the 2008 Medicaid expansion in Oregon and found that, initially, it did not lead to significant improvements in physical health. Nevertheless, it enhanced healthcare utilization, diabetes management, reduced depression rates, and lessened financial burden. Conversely, the RAND Health Insurance Experiment, as examined by Aron-Dine et al. (2013), suggests that the influence of health insurance on health expenditures is nuanced, with the potential impact on direct health outcomes being modest, primarily through the lens of out-of-pocket expenses.

The importance of possessing insurance is underscored by the Institute of Medicine (Institute of Medicine Committee on the Consequences of Uninsurance, 2002), which found an association between being uninsured and a marked increase in mortality risk. Similarly, recent research by Goldin et al. (2021) also highlights the advantages of health insurance. They demonstrate that the Internal Revenue Service (IRS)'s informational campaigns can lead to a reduction in adult mortality rates by improving insurance coverage.[2]

These studies collectively suggest that the implications of health insurance extend beyond immediate physical health to encompass a range of health-related outcomes and overall well-being. Moreover, the literature identifies key factors that mediate the insurance-health outcome relationship: access to preventive services, the ability to seek timely care, and wellness incentives under insurance policies. These elements are pivotal in understanding the comprehensive benefits that health insurance provides, highlighting its critical role in promoting public health.

Insurance and preventive care. The availability of preventive care and screening services is considerably higher among insured individuals, which enhances the prospects for early disease detection and chronic illness management. In our dataset, a substantial 70.2% of those with insurance underwent routine health check-ups by medical professionals within

[2] They investigate the outcomes of a randomized outreach initiative whereby the Internal Revenue Service (IRS) disseminated informational letters to 3.9 million households penalized for not having health insurance in compliance with the Affordable Care Act. The results of their study indicate that enhanced insurance coverage, stemming from these informational campaigns, could lead to a significant decrease in mortality rates among middle-aged adults within two years post-intervention.

Table 1: Preventive Care: Insured vs. Uninsured

Check-up Items	% among Insured	% among Uninsured
Within last year:		
Overall health assessment	70.2	36.7
Dental	61.9	31.8
Blood cholesterol	67.5	33.9
Flu shot	40.5	14.8
Prostate specific antigen (male)	42.7	12.7
Pap smear test (female)	55.3	41.4
Breast exam (female)	64.2	41.2
Mammogram (female)	47.3	23.9
Ever had:		
Blood stool test	20.9	6.9
Sigmoidoscopy or colonoscopy	28.1	7.1

Note: This table documents the percentage of individuals with certain preventive care by insurance status, calculated from the MEPS data. The insured are more likely to have preventive care, and this difference remains robust for all items after controlling for observables such as income, age, health status, and education (see Appendix A.8 for details).

the past year, in stark contrast to only 36.7% of their uninsured counterparts. This disparity extends to more specific health checks, including blood cholesterol and stool tests, as well as to broader healthcare services like dental examinations. Table 1 presents a detailed comparison.[3]

Insurance and health-care services once sick. Financial barriers often lead to reduced medical consultations, hospital admissions, and unfilled prescriptions among the uninsured. Doyle (2005) investigates a subset of patients with urgent medical needs–auto accident victims who survived until hospital admittance—and identifies a significant disparity in adult mortality rates for uninsured individuals in Wisconsin from 1992 to 1997. This disparity is ascribed to differences in the intensity of treatment rather than to pre-existing health differences prior to the accidents. Similarly, Card et al. (2009) leverage the insurance coverage transition that typically occurs at age 65 with Medicare eligibility. Utilizing a regression discontinuity design, their study reveals that insured patients receive a broader range of

[3] This difference persists across all measures of preventive care even after controlling for observable factors such as income, age, health status, and education levels. For additional details, refer to Appendix A.8.

hospital care services and experience a 20% reduction in the 7-day mortality rate compared to those without insurance.

Insurance and wellness program. The 2014 Kaiser Family Foundation (KFF) Employer Health Benefits Survey highlights that the majority of large employers integrate wellness programs into their group health plans. These programs typically support employees with smoking cessation, diabetes management, weight loss initiatives, and preventative health screenings. Such wellness offerings aim to foster improved health within the workforce while concurrently curbing healthcare expenses. Additionally, a Financial Times report reveals that advancements in technology enable the insurance sector to implement earlier and more varied interventions. A plethora of innovative schemes and prevention strategies by life and health insurers now incentivize healthier lifestyles in clients, mitigating risks and associated costs.[4] Similarly, government-funded public insurance programs, such as the Medicaid Incentives Initiative, encourage health-promoting behaviors among their beneficiaries to reduce healthcare outlays. Our analysis of the MEPS data corroborates this approach, revealing a statistically significant difference in weekly physical activity levels between insured and uninsured individuals.

2.2 An econometric framework for estimation

Our goal is to estimate the effects of health insurance on health. More specifically, we want to identify a "health premium", which measures the difference in the probability of maintaining favorable health outcome between insured and uninsured given identical health status in the previous period. The difficulty is that the choice of health insurance is endogenous: individuals may *choose to* opt in medical insurance plans if they expect poor health in the following period. This selection bias hence prevents us from directly estimating health transition separately for the insured versus the uninsured.

We employ an instrumental variable (IV) approach to address this endogeneity issue. Denote an individual's health status as y_i (the outcome variable), the insurance status as d_i

[4] "Rethinking insurance: how prevention is better than a claim", *Financial Times*, July 23, 2022. https://on.ft.com/3cCv4VD.

(the treatment variable), and our instrument variable as z_i. Given the binary nature of the endogenous treatment variable, we consider the following triangular model:

$$\begin{aligned} Y &= \mathbb{1}\left\{X'\beta + \delta D \geqslant U\right\}, \\ D &= \mathbb{1}\left\{X'\alpha + \gamma Z \geqslant V\right\}. \end{aligned} \tag{1}$$

In this context, δ represents our primary parameter of interest, with X encompassing a range of demographic control variables. These include gender, race, geographic region, logarithm of wages, marital status, and educational background.[5] Given that the effects of insurance on health transition may differ by age, we estimate δ separately for four age groups: 25–34, 35–44, 45–54, and 55–64 years. Additionally, we estimate δ separately for individuals who were healthy in the previous period and those who were unhealthy. This distinction is crucial, as the influence of insurance can vary based on one's existing health condition, and those in poorer health might derive greater benefits from having health insurance.

A potential instrument under consideration is the status of employer-sponsored health insurance (EHI) offers. The rationale behind this choice is that a firm's decision to offer EHI typically stands independent of its workers' individual characteristics, thanks to the non-discriminatory nature of group insurance policies. However, this EHI offer status may still contain some endogeneity. This is because workers anticipating adverse health events might preferentially seek employment with firms more likely to offer EHI, as suggested by Feng and Zhao (2018). To further address this endogeneity of firm-worker matching, we use the average EHI offer rate of firms within the same occupation and the same worker age group as an instrument of the insurance coverage in our baseline analysis. Intuitively, workers could change jobs but they are very unlikely to change occupations merely to search for an EHI offer. We discuss the validity of this instrument in details in Section 2.3.

In addition, parametric assumptions on the joint distribution of (U, V) are needed to point identify this triangular model. We employ a semi-parametric estimator proposed by Han and Lee (2019). Particularly, we assume non-parametric marginal distributions for both U and

[5] It is noteworthy that wage, included as a control variable in X, might be subject to endogeneity, and identifying a valid instrument for income poses challenges. We address the identification of δ and the health premium under such circumstances in Appendix A.2.1.

V and a parametric copula for the dependence structure. This is a substantial generalization from the bi-probit model that is often used: If we restrict the marginal distributions to be Gaussian and we assume a Gaussian copula, then we are back to the bi-probit model. When joint normality of (U, V) is misspecified, Han and Lee (2019) show that the bi-probit model estimates can exhibit substantial bias.[6]

To summarize, our baseline triangular model identifies the impact of health insurance coverage on the evolution of health status. The left panel of Figure 3 presents the estimated "health premium" for individuals who are healthy in the previous period, while the right panel plots the estimation for unhealthy counterparts. Based on our estimation, a healthy individual at age 40 is about 9 percentage points more likely to stay healthy in the next period if she has insurance coverage. The effect is even larger for the unhealthy, since the unhealthy individuals usually require more medical services and hence insurance coverage plays a bigger role. The 95 percent confidence intervals are obtained through bootstrap repetitions. Our estimations suggest that there exists a positive and significant health premium for all age-health groups.

2.3 Validity

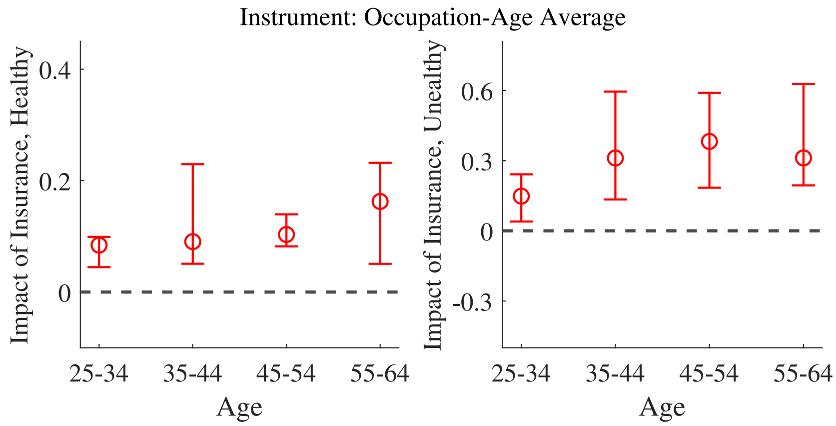
Our strong first-stage results for all age-health groups, reported in Appendix A.6, guarantee the relevance of the instrument (the average EHI offer rate within the occupation-age group). To ensure the validity of the instrument, we will assess the exclusion restriction assumption, in both the first stage ($Z \perp V$) and the second stage ($Z \perp U$).

2.3.1 Second stage ($Z \perp U$).

This assumption may be violated if the EHI offer rate is correlated with health through mechanisms other than insurance coverage. For instance, if unhealthy individuals self-select

[6] Regarding the correlation structure, we do not have direct evidence on how to choose the parametric form for copulas. Fortunately, Han and Lee (2019) show that the estimation results are insensitive to the choice of copulas once we allow for non-parametric marginal distributions. We hence choose frank copula which allows us to interpret the dependence structure more easily. In Appendix A.3, we report estimates based on Gaussian copula with non-parametric marginal, as well as the estimates assuming the Gaussian marginals on (U, V), which includes the bi-probit model estimates as a special case (Figure 4). Results are similar to those in Figure 3.

Figure 3: Health Premium of Insurance



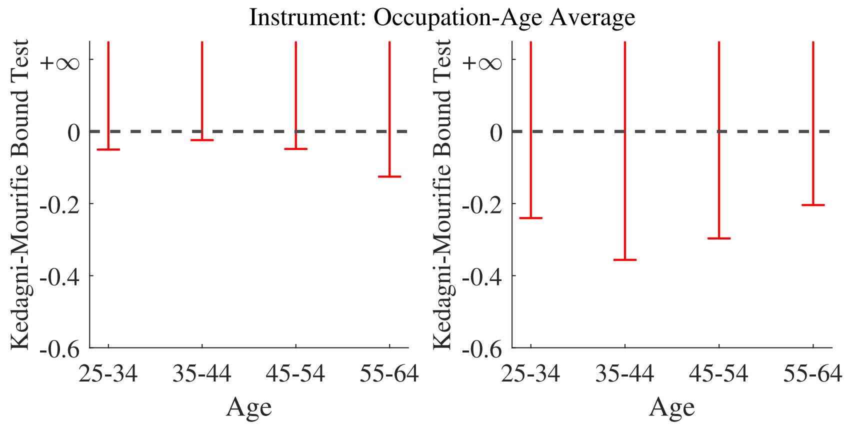
Note: This figure plots the "health premium", defined as the advantage of the insured over the uninsured in terms of the probability of transiting from healthy to healthy (left panel) or unhealthy to healthy (right panel). The circle indicates the point estimates while the bar indicates 95% confidence intervals.

into less demanding occupations which are lower in pay and less likely to offer EHI, then this instrument would be invalid. Indeed, there is a large literature studying occupational mobility and sorting into occupations based on unobserved characteristics.[7] We start by arguing that this sorting is unlikely to be crucial in our estimation, since we find similar results using an alternative instrument: the average EHI offer rates within industry-age groups. The intuition is that the pattern of sorting of individuals into occupations may differ from that between individuals and industries, and hence, if the sorting plays a key role then we expect to find different outcome with these two instruments. We note that occupations and industries are not necessarily highly correlated, and the rank correlation between these two instruments is only 0.37. In addition, we also construct our third and fourth instruments by further refining the categories by education, where the intuition is that, for most adults, the level of education stays unchanged. Again the results are very similar, and the details are in Appendix A.3.

We also employ a formal statistical test recently proposed by Kédagni and Mourifié (2020). They propose a sharp bound test to detect all observable violations of the instrument variable's independence assumption for models where treatment variable is binary,

[7] See, for instance, Kambourov and Manovskii (2009), Goldin (2014), Michaud and Wiczer (2018), Jolivet and Postel-Vinay (2020), Erosa et al. (2022), and Cubas et al. (2022).

Figure 4: Kedagni-Mourifie Test for Second-Stage Exclusion Restriction



Note: This figure plots the results of the sharp bound test proposed by Kédagni and Mourifié (2020) for healthy (left panel) or unhealthy individuals (right panel) by age group. The bounds are evaluated at the 95% one-sided confidence interval. The exclusion restriction would be rejected by data if the lower bound excludes zero.

exactly like our scenario here.[8] As shown in Kédagni and Mourifié (2020), exclusion restriction assumptions of the instruments can be formed as moment inequalities. They then construct the one-sided confidence interval using the intersection bound approach proposed in Chernozhukov et al. (2013). The exclusion restriction assumption would be rejected by data if the lower bound of the one-sided confidence interval excludes zero. As we see from Figure 4, for all health-age groups, the lower bound of the 95 percent one-sided confidence interval is negative, and hence the data do not reject the hypothesis that our instrument is independent to U. Note that all our alternative instruments survive this test, see Appendix A.4 for details.

2.3.2 First stage ($Z \perp V$).

This assumption may be violated if our instrument is correlated with unobservables that affects one's insurance status. For instance, workers who are more eager to opt in insurance may choose to work for jobs that are more likely to offer EHI. For this first stage exclusion

[8] To provide some examples of the power of this test, Kédagni and Mourifié (2020) assess the validity of various instruments used in the returns to college literature, and find that parental education—which is often used as an instrument for one's college education status—is not a valid one even conditional on experience and a measure of ability. On the contrary, the college tuition fees—another commonly used instrument—is valid when controlling on measures of ability.

restriction assumption, unfortunately we do not have a formal statistical test to assess its validity. We instead employ a potential outcome framework that does not require a first stage model to assess its robustness. Briefly speaking, we do not restrict the relationship between the insurance status and the instrument (i.e. the model on D in equation (1)), and hence do not rely on the assumption of $Z \perp V$ for identification. As a result, our identification will not be contaminated by any potential violation to the $Z \perp V$ assumption. The cost is that we lose point estimation of the health premium. Yet, we are able to find informative bounds of the premium and for most of the age-health group, the lower bound is larger than zero. This provides further evidence on the positive effect of insurance on health outcome even with less restrictive model assumptions. This approach has recently been used in the labor literature, see for instance De Haan and Leuven (2020).

We now outline the potential outcome framework as follows. To ease the exposition, we do not use any additional control variables with the understanding that more control variables result in tighter bounds. The treatment equation can be written as

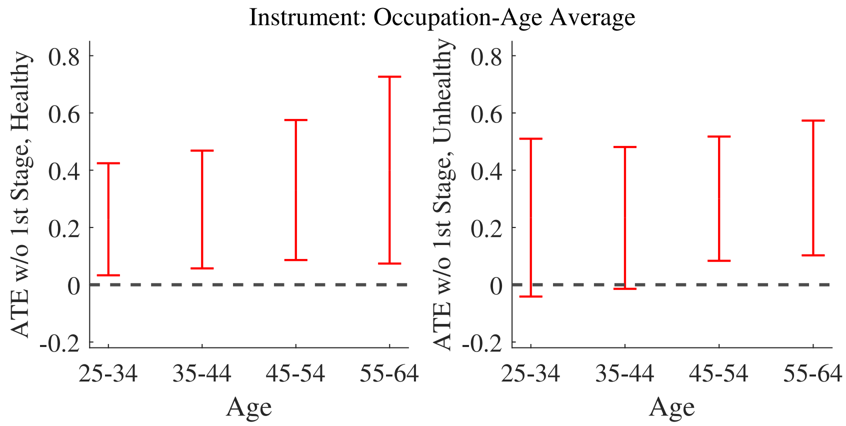
$$Y = DY(1) + (1 - D)Y(0),$$

where $Y(1)$ and $Y(0)$ are potential outcomes. $Y(1)$ indicates the health status with health insurance coverage, and $Y(0)$ indicates health status without insurance. The average treatment effect (ATE), or our health premium, can then be written as

$$\text{ATE} = \text{Prob.}[Y(1) = 1] - \text{Prob.}[Y(0) = 1].$$

The difficulty of identification is that for each individual, only one of the potential outcome $Y(1)$ and $Y(0)$ is observed. Under this setting, we ask whether the data provide any information on the ATE. As expected, without further assumption, the bound for ATE is not informative. However, if we have an instrument variable Z that is correlated with D and is assumed to be independent from $(Y(1), Y(0))$, or equivalently $Z \perp U$ in equation (1) (but not necessarily $Z \perp V$), then the joint distribution (Y, D, Z) may impose enough restrictions on the joint distribution of $(Y(1), Y(0))$ and thus yields an informative bound on ATE. This potential outcome model with instrument variables has been well studied in

Figure 5: Bounds of Health Premium without First Stage Assumptions



Note: This figure plots the results of our potential outcome framework. Specifically, we estimate the health premium without a first stage model. As a result, we do not have any concern regarding the exclusion restriction assumption ($Z \perp V$). Without a first stage specification, we cannot obtain a point estimate. We report the 95 percent confident set for the identified set of the health premium.

the literature (e.g. Balke and Pearl, 1994). To further tighten the bounds on ATE, we follow Manski (1997) and Manski and Pepper (1998) and assume monotone treatment response, i.e., either $Y(1) \geqslant Y(0)$ or $Y(1) \leqslant Y(0)$. Our data reject $Y(1) \leqslant Y(0)$, hence we maintain the assumption $Y(1) \geqslant Y(0)$, which can be interpreted as health insurance may have no effects on one's health but it should not negatively affects one's health. We then again use the intersection bound approach to construct a confidence set for ATE following Acerenza et al. (2020). More details are provided in Appendix A.5.

Based on results shown in Figure 5, we find that, without the first stage model, there exists a positive and significant ATE for most of the age-health groups, i.e., we find Prob.$[Y(1) = 1] >$ Prob.$[Y(0) = 1]$ with strict inequality for most of our population. The advantage of this approach is that, without any first stage specification, we are no longer concerned about the exclusion restriction assumption of $Z \perp V$ and thus provide robustness evidence of a positive effect of health insurance on health outcome. Note that we assume $Y(1) \geqslant Y(0)$ but not $Y(1) > Y(0)$, hence the bounds of ATE excluding zero is not by construction. Since we get non-empty bound for ATE, it implies the data supports the assumption of $Y(1) \geqslant Y(0)$ as well as $Z \perp U$. Further results using three alternative IV's are reported in Appendix A.5.

2.3.3 The sign of endogeneity bias.

In our semi-parametric estimation strategy, we employ the frank copula for dependence between U and V. An advantage of assuming a parametric (frank) copula in the correlation structure is that we can interpret the correlation between (U, V) and hence recover the sign of endogeneity bias. In all our settings and health-age groups, we find negative and significant correlation between (U, V). For illustration purposes, let us consider an observation with negative v_i and positive u_i. From equation (1), a more negative v_i means that the inequality of $x_i'\alpha + \gamma z_i \geqslant v_i$ is more likely to hold ceteris peribus, and hence this individual is more likely to have health insurance coverage. A more positive u_i means that the inequality of $x_i'\beta + \delta d_i \geqslant u_i$ is less likely to hold and hence this individual is more likely to be unhealthy. This correlation then suggests that individuals who will be unhealthy are more likely to obtain health insurance, and hence the endogeneity bias is negative.

This estimated negative correlation between U and V suggests that a plausible selection mechanism is that individuals expecting negative health shocks may choose to opt in health insurance. It follows immediately that the actual health premium will be even larger if the instrument is inadequate in addressing the endogeneity issue. Moreover, mechanisms that require a positive correlation between U and V are unlikely to be important here—for instance, certain jobs are mentally and physically demanding and attract only healthy individuals, while these jobs provide generous compensations including EHI—which implies that individuals who will be healthy are more likely to obtain health insurance.

2.3.4 Discussions

Health premium by income. Income affects health through health insurance choice; in addition, it also directly affects health (Pijoan-Mas and Rios-Rull, 2014). In our analysis, income is explicitly accounted for at both stages of estimation, though we do not allow for the interaction between income and insurance status. To assess the interaction, we also separately estimate the health premium for poor and rich individuals. We find positive and significant health premium in both groups, with details relegated to Appendix A.7. With smaller sample sizes the magnitudes are less tightly estimated and hence we choose not to use this specification as our baseline.

Public insurance and non-workers. The identification strategy outlined previously employs the EHI offer rate as an instrumental variable for health insurance coverage. Consequently, our results are primarily relevant to the working population. However, health transitions among non-workers might follow a different pattern. For instance, if unhealthy individuals tend to quit the labor force, then non-workers may benefit more from health insurance. In addition, in our sample, just over a third of non-workers possess private health insurance, predominantly through a spouse's or other family member's EHI coverage. Among the remaining non-workers, a majority are solely covered by public insurance schemes like Medicaid or Medicare. Public insurance often provides less comprehensive coverage compared to private insurance, and the demographic composition of Medicaid recipients is likely distinct from that of workers with private insurance. Therefore, the health premium we have estimated for workers may not be directly applicable to non-workers relying on public insurance. To address this issue, we distinguish these two types of insurances and their health premium when we estimate our baseline model.

2.4 Comparison to findings in the literature

Although literature has rarely focused on the causal effect of health insurance on health, a few researches have estimated the causal effect of health insurance on the mortality rate, which is closely related to health status. It is therefore useful to compare our empirical findings to those in the literature. To make such comparisons, we separately estimate mortality rate by health status using data from the Panel Study of Income Dynamics (PSID) Mortality (with details in Section 4). We then translate our estimated health premium, i.e., differences in health, into differences in mortality rates. For example, a healthy 55-year-old who has health insurance is estimated to be 13.3 percentage points more likely to stay healthy in the following period. The discrepancy in the annual mortality rate between healthy and unhealthy individuals stands at 1.85 percentage points. Therefore, having health insurance reduces mortality rate by 0.25 percentage points for this individual.

Our results are comparable to those of Goldin et al. (2021), who explore the variations of health insurance coverage using experimental evidence from taxpayer outreach. They estimate the effect of monthly insurance coverage on two-year mortality among individuals aged 45 to 65. They find a point estimate of 0.178, with a confidence interval ranging from 0.041 to 0.315, the lower bound of which they deem more plausible. This translates to an annual coverage effect on annual mortality rate ranging from 0.25 to 1.44 percentage points. Our estimates, averaged for the same age group, indicate a 0.37 percentage points reduction in annual mortality rate due to health insurance, which falls into the estimate of Goldin et al. (2021) and if anything more conservative as it is closer to their lower bound.

Additionally, our results are in line with studies examining the effects stemming from the Affordable Care Act's Medicaid expansions. For example, Miller et al. (2021) found that for individuals aged 55–64, the expansion led to an average increase in insurance coverage of 0.128 years and a decrease in annual mortality by 0.089 percentage points, translating to a 0.70 percentage points reduction in mortality rate due to annual coverage. The confidence interval ranged from 0.14 to 1.25 percentage points. Our findings suggest a 0.47 percentage points decrease in mortality rate for this age group, a result not substantially different from their point estimate and closer to their lower bound. Similarly, Borgschulte and Vogler (2020) reported that annual health insurance coverage reduces the mortality rate by 0.27 percentage points for those aged 20 to 64, with a confidence interval of 0.10 to 0.44. Our estimates, targeting individuals aged 25 and above, point to a 0.22 reduction in mortality rate, aligning closely with their findings and being slightly more conservative.

In conclusion, our analysis of the effect of health insurance on health appears to cohere with and be conservatively aligned with empirical findings in existing literature.

3 Model

We now present our baseline model that extends the prototypical macro-health model by incorporating the "health premium" of insurance identified in previous section. Households are endowed with one unit of time in each period that can be supplied to the labor market, work until retirement age J_R, and maximize discounted lifetime utility. They live to a maximum of J periods, face idiosyncratic labor productivity shocks z and medical expense shocks m in addition to health shocks in each period over the life cycle. The financial market is incomplete with a risk-free bond traded in the economy. Households can purchase health insurance to hedge against health expenditure shocks, where their endogenous insurance choice affects the evolution of health as detailed below.

A representative firm produces final good Y using capital K and efficiency units of labor N through a neoclassical production function: $Y = AK^{\alpha}N^{1-\alpha}$. At an interior solution rental prices equal their respective marginal productivity: $r + \delta = AF_K(K, N), w = AF_N(K, N)$, where δ is the depreciation rate of capital. If EHI is offered, the firm adjusts the wage to ensure the zero-profit condition by shifting the cost of providing EHI c_E to the employees. The production of the final good can be used for private consumption, investment, medical service, and public spending. The law of motion for capital K is given by $K_{t+1} = (1-\delta)K_t + I_t$. To ease exposition, we may denote x' the value of variable x in the next period.

3.1 Demographics, preference, and endowment

Preference. Individual preferences are described by

$$\mathbb{E}\sum_{j=1}^{J}\left[\beta^{j-1}\prod_{t=0}^{j-1}\rho_{h,t}u_h(c_j, n_j)\right], \tag{2}$$

where β denotes the time-invariant discount factor, and $\rho_{h,t}$ represents the probability of survival contingent upon age and health status. The variables c_j and n_j denote consumption and labor supply, respectively. The parameter $h \in \{H, U\}$ indicates the individual's health status, with H for healthy and U for unhealthy conditions. The utility function $u_h(\cdot, \cdot)$, depending on the health status h, is assumed to be strictly increasing in consumption, strictly decreasing in labor supply, and concave with respect to consumption.

Endowment. Labor income e_j^i of household i at age $j \leqslant J_R$ is a function of the household's productivity $\hat{z}_j^i$, labor supply n_j^i, the wage rate w, and the EHI offer status i_E:

$$e_j^i = (w - i_E c_E)\hat{z}_j^i n_j^i, \tag{3}$$

where $\hat{z}_j^i$ represents the adjusted labor productivity, which is the product of the actual realized labor productivity z_j^i and a modifier $g(h_j^i)$ that accounts for the influence of individual health status h on labor productivity.

Health. In each period, agent's health status evolves according to a Markov process, whose transition matrix varies with the endogenous health insurance coverage i_{hi}:

$$\pi^{j,i_{hi}} = \begin{bmatrix} \pi_{HH}^{j,i_{hi}} & \pi_{HU}^{j,i_{hi}} \\ \pi_{UH}^{j,i_{hi}} & \pi_{UU}^{j,i_{hi}} \end{bmatrix}. \tag{4}$$

Here, $\pi_{hh'}^{j,i_{hi}}$ denotes the probability that an age-j agent's health status changes from h to h' conditional on their health insurance status $i_{hi} \in \{\textit{uninsured, private, EHI, Medicaid, Medicare}\}$.

At each period, agents receive an idiosyncratic health expenditure shock m, whose distribution varies with the agent's age, health status, and health insurance coverage. Health status also affects her survival probability at age j, with $\rho_{H,j} \geqslant \rho_{U,j}$.

3.2 Market arrangement

Financial and insurance markets. Households may save by purchasing a' units of a risk-free bond at the market interest rate r. However, borrowing is subject to a constraint, specifically $a \geqslant -\underline{a}$. The health insurance choice of an individual, denoted by i_{hi}, dictates the premium paid $\tilde{\pi}(i_{hi})$ and the portion $\tilde{\phi}(m, i_{hi})$ of realized medical expenses m that the insurance will cover. Agents with current income e and a past EHI status η_E are offered EHI with a probability $p_E(e, \eta_E)$.[9] Upon receiving an offer, an employee must decide whether to opt in the EHI, which comes with a premium π_E and a co-insurance rate $\phi_E(m)$. In accordance with U.S. law, the premium is uniform across all employees, disregarding previous health history or any other individual circumstances. Employers contribute a fraction $\psi \in (0, 1)$ towards the insurance premium, with the remainder being the responsibility of the insured employee.

[9] The EHI offer rate is positively correlated with both firm size and the employee's wage (Aizawa and Fang, 2020). Instead of modeling the firm's EHI decision-making process and the labor market dynamics, we postulate a stochastic process that governs the EHI offers received by employees, allowing the probability p_E to vary with income and be history-dependent.

Should an EHI offer not be forthcoming, employees have the option to procure health insurance on the private market at a premium $\pi_P(m)$ with a co-insurance rate $\phi_P(m)$. In this competitive market, premiums for both EHI and private plans are set based on expected expenditures per contract plus a proportional markup η.

Medicaid is a means-tested public health insurance scheme for the working-age population with limited income and savings: $e \leqslant \Theta_{\mathrm{e}}$ and $a \leqslant \Theta_{\mathrm{a}}$, where Θ_{e} and Θ_{a} denote the thresholds for income and assets respectively to qualify for Medicaid. This program covers a fraction $\phi_{md}(m)$ of medical costs at no premium cost to the beneficiaries. Additionally, the Medicare program provides coverage for all retirees, charging a fixed premium π_{mr} and offering a coverage ratio of $\phi_{mr}(m)$ for their medical expenses.

Medical bankruptcy. Households have the option to declare bankruptcy over the out-of-pocket medical expenses. If bankruptcy is declared ($\iota = 1$), agents experience a linear garnishment of their earnings, defined by $\lambda = \gamma \max\{y - \bar{y}, 0\}$, and incur a one-time non-pecuniary utility penalty ν, as described by Livshits et al. (2007). Herein, λ represents the total sum garnished and subsequently redirected to the hospital (and eventually to the government). The threshold $\bar{y}$ delineates the earnings that are protected from garnishment, and $\gamma \in (0, 1)$ characterizes the marginal rate of garnishment. Importantly, this garnishment mechanism incurs no associated costs.

Upon declaring bankruptcy, the individual's outstanding medical bills, quantified by $[1-\phi(m, i_{hi})]m$, are waived. Consequently, they face a temporary ban from the credit market, leading to $a' = 0$. The cost of the uncompensated medical care, given by $[1 - \phi(m, i_{hi})]m - \lambda$, is shouldered by the government.

3.3 Government programs

Besides Medicaid and Medicare, the government administers a means-tested welfare program and a pay-as-you-go Social Security program. The welfare program offers transfers to households whose after-tax disposable income falls below $\underline{c}$, as described in Hubbard et al. (1995). This program is designed to efficiently represent both unemployment insurance and food stamp benefits. Retirees receive Social Security benefits $ss(\bar{e})$, which depend on the economy-wide average earnings $\bar{e}$.[10]

Employed individuals contribute to the Social Security system through a proportional tax τ_{ss} and also pay a Medicare tax τ_{mr}. Earnings above y^{ss}_{max} are not subject to the Social Security tax. Additionally, the government imposes a progressive income tax $T(\cdot)$ and a proportional consumption tax τ_c to fund its expenditure G and the aforementioned programs. The government maintains a balanced budget in each period.

3.4 Optimization and equilibrium

The timing of the economy is given as follows: (1) Households of age j enter a new period with asset position a, health insurance status i_{hi} and past EHI offer status η_E; (2) Idiosyncratic shocks z, m, h, and i_E are realized for survivors and newborns; (3) Households make decisions regarding their health insurance status for the next period i'_{hi}, medical bankruptcy ι, labor supply n, consumption c, and savings a'; (4) Firms engage in production, and all markets clear.

Households. The state of households can be summarized by vector $s_w = \{j, a, z, m, h, i_{hi}, i_E, \eta_E\}$ for workers and $s_r = \{j, a, m, h\}$ for retirees.[11] Let $\varphi(s)$ be the population density function of individuals at the beginning of each period and $S = \left\{\tilde{\pi}, \tilde{\phi}, r, w, T(\cdot)\right\}$ the aggregate variables. The young worker's $(j < J_R)$ solves for the following optimization problem.

$$\mathbf{V}(s_w) = \max_{\left\{c, a', i'_{hi}, n, \iota\right\}} \left\{ \; u_h(c, n) - \iota\nu + \beta\rho_{h,j}\mathbb{E}\mathbf{V}(s'_w) \; \right\} \tag{5}$$

[10] To reduce computational costs, we assume uniform Social Security payments across individuals. Given that our model primarily addresses health insurance for the working-age population, this simplification is not expected to significantly alter the quantitative findings.

[11] Following Jeske and Kitao (2009), we distinguish newly retired agents from the rest of the retired agents as new retiree health bills are covered by insurance and not by Medicare if $i_{hi} = 1$. Hence, this age group's state variable is given by $\{j, a, m, h, i_{hi}\}$.

subject to

$$(1+\tau_c)c + a' + \tilde{\pi}^j(i'_{hi}) + (1-\phi(m,i_{hi}))m = (w - c_E i_E)\hat{z}n + (1+r)a - \text{Tax} + \text{TR}, \text{ if } \iota = 0; \quad (6)$$

$$(1+\tau_c)c + \tilde{\pi}^j(i'_{hi}) = (w - c_E i_E)\hat{z}n + (1+r)a - \text{Tax} + \text{TR} - \lambda, \text{ if } \iota = 1; \quad (7)$$

$$a' \geqslant -\underline{a} \quad (8)$$

where

$$\tilde{\pi}^j(i'_{hi}) = \begin{cases} \pi_E(1-\psi), & \text{if } i'_{hi} = EHI,\ i_E = 1; \\ \pi^j_P(m), & \text{if } i'_{hi} = private; \\ 0, & \text{if } i'_{hi} = uninsured, \text{ or } e \leqslant \Theta_e \text{ and } a \leqslant \Theta_a; \end{cases} \quad (9)$$

$$y = \max\{(w - c_E i_E)\hat{z}n + ra - i'_{hi} i_E \tilde{\pi}^j, 0\}; \quad (10)$$

$$\text{Tax} = T(y) + \tau_{mr}(y - ra) + \tau_{ss}\min\{y - ra, y^{ss}_{max}\}; \quad (11)$$

$$\text{TR} = \max\{0, (1+\tau_c)\underline{c} + (1-\iota)(1-\phi(m,i_{hi}))m + T(\tilde{y}) - (w - c_E i_E)\hat{z}n - (1+r)a\}; \quad (12)$$

$$\tilde{y} = (w - c_E i_E)\hat{z}n + ra. \quad (13)$$

The budget constraint, as stated in equation (6), indicates that household finances consumption c, savings a' (which are subject to a borrowing constraint as per equation (8)), the purchase of health insurance $\tilde{\pi}$, and out-of-pocket health expenditure $(1-\phi(m,i_{hi}))m$, are supported by after-tax capital and labor income $(w - c_E i_E)\hat{z}n + (1+r)a$. Wages are adjusted to reflect EHI offerings. The health insurance premium is determined by the policy chosen by the household, as specified in equation (9). In the event of bankruptcy, the budget constraint, detailed in equation (7), outlines similar financial conditions. The government provides subsidies for EHI based on the product $i_{hi} i_E \tilde{\pi}$. The household incurs consumption tax, income tax, and Medicare and Social Security taxes, as formulated in equation (11). Social insurance ensures a minimum consumption level $\underline{c}$ via a lump-sum transfer, governed by equation (12). Moreover, beneficiaries of this welfare program are prohibited from saving, as discussed in Hubbard et al. (1995).

Retired agents approach an analogous optimization problem; however, they are automatically enrolled in Medicare, incurring a fixed premium π_{mr}. Their income streams comprise the Social Security benefit $ss(\bar{e})$ and returns on savings $(1+r)a$.

Health insurance company. In the health insurance market, there is free entry, and due to perfect competition, the insurance premium π_E is set to cover the expected total medical expenditure $\phi_E(m)\cdot m$ among the insured, plus a proportional markup η to account for administrative costs:

$$\pi_E = (1+\eta)\frac{\int i_{hi}(s) i_E \phi_E(m) m \varphi(s)\, ds}{\int i_{hi}(s) i_E \varphi(s)\, ds}. \tag{14}$$

The cost to a representative firm for providing EHI to its workers is given by

$$c_E = \frac{\int \psi \pi_E i_E i_{hi}(s)\varphi(s)\, ds}{\int i_E z(s) g(h(s)) n(s) \varphi(s)\, ds}. \tag{15}$$

In the individual health insurance market, insurers set the premium $\pi_p^j(m)$ based on a zero-profit condition for each contract, which is indexed by the worker's age and the expected health expenditure shock they experience:

$$\pi_p^j(h) = \frac{(1+\eta)\mathbb{E}\{\rho^j \phi_p(m')m'|h\}}{1+r}. \tag{16}$$

Definition 1 *Given government policies, including income tax function $T(\cdot)$, consumption tax τ_c, Medicare, social security, and social insurance program, a stationary competitive equilibrium consists of factor prices w, r; aggregate labor and capital N, K; allocation functions for workers $\{c(\cdot), a'(\cdot), i'_{hi}(\cdot), n(\cdot), \iota(\cdot)\}$ and for retirees $\{c(\cdot), a'(\cdot), \iota(\cdot)\}$; value functions $\mathbf{V}(\cdot)$; health insurance contracts $\left\{\pi_E, \phi_E(\cdot); \pi_P^j(\cdot), \phi_P(\cdot)\right\}$; and distribution of households $\varphi(s)$ over state space $\mathbb{S}$ such that*

1. *Given prices, government policies, and health insurance contracts, the allocations solve the individual's problem;*

2. *All markets clear: $N = \int z(s)g(h(s))n(s)\varphi(s)ds$, $K = \int a(s)\varphi(s)ds$, $C + K' - (1-\delta)K + M + G = Y$, and equations (14) and (16) are always satisfied;*

3. Government's budget is balanced:

$$\begin{aligned}
&G + \int_s [ss(\bar{e}(s)) + \phi_{mr} m(s) - \pi_{mr}] \mathbf{1}_{j \geqslant j_R} \varphi(s) ds + \int_s TR(s) \varphi(s) ds \\
&+ \int_s \iota(s)[(1 - \phi(m))m(s) - \lambda(s)] \varphi(s) ds + \int_s \phi_{md}(m) m(s) \mathbf{1}_{e \leqslant \Theta_e, a \leqslant \Theta_a} \varphi(s) ds \qquad (17) \\
= &\int \left[\tau_c c(s) + T(y(s)) + \tau_{mr}(y(s) - ra) + \tau_{ss} \min\left\{(y(s) - ra, y^{ss}_{max}\right\}\right] \varphi(s) ds;
\end{aligned}$$

4. The distribution of agents is stationary: $\varphi(s) = \mathbb{L}[\varphi(s)]$.

4 Calibration and Estimation

We have described our identification strategy for health premiums, as well as the results that we have obtained using the MEPS data in Section 2.2. Note that we assume private insurance and EHI have the same health premium as estimated previously, while the health premium of public insurance is set to zero. In this section, we explain our strategy for estimating other parameters of the model. We use the MEPS data to estimate the medical expenditure shocks and parameters related to health insurance. The income process, particularly the causality from health to income, is estimated using the PSID data. We also use the PSID Mortality data to estimate the mortality rate. Parameters that govern welfare and taxation programs are determined directly from relevant macro data, such as tax documents. All other parameters, including the discount factor, the depreciation rate, and the preference parameters, are calibrated to match moment conditions from the data. The values of these parameters are summarized in Table 6 of Appendix C.3.

4.1 Income process

We estimate the income process directly from the data, independent of the general equilibrium. Recall that the labor income of an individual i of age $j \leqslant j_R$ is given by

$$e^i_j = \tilde{w} g(h^i_j) z^i_j n^i_j,$$

where $g(h^i_j)$ captures the effect of health on income and z^i_j represents the underlying income process net of effect from health. We start by describing how we separately identify $g(h^i_j)$ from the underlying income process z^i_j by exploring the timing assumption.

Since MEPS only provides a short panel (two periods for most individuals), we estimate the income process using PSID, which maintains a longer panel of information on U.S. households. There is a long list of literature on income dynamics using PSID data.[12] Unfortunately, we cannot use the literature's estimates of labor income processes directly as they do not account for individual health dynamics. In other words, their estimated income process conflates the income process of the healthy with that of the unhealthy, which may lead to bias. For instance, consider an individual whose health status changes from healthy to sick suffers a drop in her earnings as a result of missing work. Ignoring the health transition information would hence downward bias the income persistence parameter.

Consider the following econometric model that we use to separately identify the underlying income process z_{it} from the health component $g(h_{it})$. Denote y_{it} as the (log) observed income of an individual i for year t, denominated by the nominal per capita GDP of year t, and $g(h_{it})$ as the effect of health status on labor income. We assume

$$\begin{aligned} y_{it} &= y^*_{it} n_{it}, \\ y^*_{it} &= g(h_{it}) + \beta_{a1}\text{age}_{it} + \beta_{a2}\text{age}^2_{it} + u_{it}, \\ u_{it} &= \alpha_i + \rho u_{it-1} + \varepsilon_{it}, \end{aligned} \tag{18}$$

with $\varepsilon_{it} \sim N(0, \sigma^2_u)$ and $\alpha_i \sim N(\mu_\alpha, \sigma^2_\alpha)$. y^*_{it} is the latent variable of y_{it} and hence $y_{it} = y^*_{it}$ if an individual supplies labor ($n_{it} = 1$) and $y_{it} = 0$ otherwise. The term $\beta_{j1}j + \beta_{j2}j^2$ controls for life-cycle profiles of earning.

The estimation process is, however, complicated due to the following two challenges. The first challenge is to deal with sample selection—unhealthy individuals may choose not to work and hence we do not observe their income process. We follow Wooldridge (1995) and Semykina and Wooldridge (2010) who propose a panel-data version of the Heckman correction approach (Heckman, 1974). Specifically, we estimate a probit specification of

[12] See, for instance, Meghir and Pistaferri (2004), Guvenen (2009), Hospido (2012), and Gu and Koenker (2017), among others.

labor supply, as a function of health (h_{it}) and the age profile and then calculate the inverse Mills ratio, denoted as $\mathbb{M}_{it}$. We then explicitly control for this calculated inverse Mills ratio in the following steps of estimating income process such that our estimates are not biased by sample selection.

The second challenge arises from the potential simultaneity issue between health and income, since health depends on health insurance choice which is in turn a function of past income. To address this issue, we explore the following assumption on timing. Specifically, we assume that health affects income contemporaneously, while income affects the choice of health insurance coverage and health in the next period. This assumption is in line with reality: Once an individual gets sick, her labor productivity reduces immediately. On the contrary, opting in health insurance coverage is subject to waiting period, and moreover, the effects of health insurance through, for instance, preventive care or health screening, takes time to translate to impacts on health. This assumption is also consistent with our macro model setup. Under this assumption, we can consistently estimate the effect of $g(h_{it})$ without simultaneity bias, after explicitly accounting for dynamic panel data features that we describe in detail in Appendix B.

With the constructed inverse Mills ratio $\hat{\mathbb{M}}_{it}$ from the selection regression, we rewrite our econometric model as follows:

$$\begin{aligned} y_{it} &= \beta_{\mathbb{M}}\hat{\mathbb{M}}_{it} + \beta_H h_{it} + \beta_{a1}\text{age}_{it} + \beta_{a2}\text{age}_{it}^2 + u_{it}, \\ u_{it} &= \alpha_i + \rho u_{it-1} + \varepsilon_{it}. \end{aligned} \tag{19}$$

Note that our model in Equations (19) is now a standard dynamic panel data specification and we employ the random effects estimator by assuming that α follows a normal distribution.[13] Importantly, we find that the key parameter, β_H, to be 0.404 which is significant at the one percent level. In other words, health positively affects income with a large magnitude: Being healthy on average increases income by 40.4 percent.

We then map our estimated income process back to our macro model. Specifically, the effect of health corresponds to $g(h)$ in the model, while the model component of z_j^i consists of the effects of age, individual types α_i, and the idiosyncratic shocks ε_{it}. We discretize the

[13] The fixed effects estimator is biased due to the incidental parameter problem.

distribution of individual types by taking grid points for the estimated normal distribution, and discretize the shocks arising from the auto-regressive process using a Markov chain as in Tauchen (1986). Each individual i at age j then draw a realization of z_j^i that is a sum of these components. We relegate the details of this process to Appendix B.

4.2 Demographics, preferences, and endowments

Individuals enter the model economy at age 25 ($j = 1$) and retire at age 65 ($j = 41$ since one period in the model corresponds to one year). The utility function takes the form of Constant Relative Risk Aversion (CRRA)[14]:

$$u_h(c, n) = b + \frac{c^{1-\sigma} - 1}{1 - \sigma} - [\gamma_l + \mathbf{1}_{(h=U)}\gamma_h]\frac{n^{(1+\chi_l)}}{1 + \chi_l}.$$

In line with Attanasio et al. (2011), we choose $\sigma = 3$, which implies an inter-temporal elasticity of substitution of 0.3. This σ also roughly reconciles for the fraction of individuals with health insurance. We set $\chi_l = 1.0$, and let $\gamma_l = 2.7$ and $\gamma_h = 4.0$ to match the labor force participation rates of the healthy and unhealthy, respectively, for the working age population.[15]

We add a constant b in the utility function to guarantee a positive value of flow utility to ensure that all individuals prefer a *longer* life expectancy (Hall and Jones, 2007). The value of b is chosen such that the model-implied value of statistical life (VSL) among the working-age population equals to \$6.5 million, which is within the range of its empirical estimations.[16]

The survival rate ($\rho_{h,t}^j$), and therefore the mortality rate, differs between healthy and unhealthy individuals. We use the National Center for Health Statistics publication *Health,*

[14]To ease the computational burden, we simplify the labor supply decision by considering it as a binary choice with $n \in \{0, 1\}$. Thus, we can express the utility function without the curvature in labor supply, simplifying the computation without loss of generality for our analysis.

[15]We focus on the household head in the PSID data when we calculate the labor force participation rate to be consistent with our sample in the income process estimation.

[16]In our model, the VSL is measured by the monetary value associated with a marginal reduction in mortality risk that is equivalent to prevent one death on average (or in statistical terms). More specifically, we calculate $VSL = \frac{dV/d\rho}{dV/da}$. Most estimates for the VSL typically range from \$1 million to \$10 million. For example, the United States FEMA estimated the value of a statistical life at \$7.5 million in 2020.

United States 2016 to determine the aggregate mortality rate. Then, we use the restricted *PSID Mortality* data to estimate the difference in mortality rates between healthy and unhealthy individuals, with details documented in Appendix C.1. In addition, we assume a maximum life expectancy of age 85 ($j = 61$). It is important to note that our findings are robust to this assumed age limit, as all individuals in retirement are covered by Medicare.

We set the annual discount factor β to 0.92 to match the equilibrium interest rate of 0.04. The capital share in the production function is set to 0.33, and the depreciation rate is set to 0.06. Total factor productivity A is normalized to one in the baseline model. The borrowing limit $\underline{a}$ is set to 0.

4.3 Medical expenditure and health insurance

Medical expenditure shocks. We separately estimate the medical expenditure shocks by age, health, and insurance coverage. We consider these shocks to be identically and independently distributed across individuals and over time. For each subgroup defined by age, health, and insurance status, we discretize medical expenditure shocks using a grid that corresponds to key percentiles-specifically, the 10th, 25th, 50th, 75th, 90th, 95th, and 99th-based on the MEPS dataset. The inclusion of the 95th and 99th percentiles enables us to more accurately capture the upper tail of the medical expenditure distribution.

Health insurance. We adopt a non-parametric approach to estimate co-insurance rates $\phi_E(m)$, $\phi_P(m)$, $\phi_{md}(m)$, and $\phi_{mr}(m)$ from MEPS data. We calculate the proportion of medical expenses paid by the insurer and construct a piecewise linear representation of the co-insurance rate as a function of medical expenditure m.

The employer-sponsored health insurance (EHI) offer rate $p_E(e, \eta_E)$ is also estimated non-parametrically. We fit a piecewise linear model to the observed probabilities of EHI offerings in the MEPS data, which vary according to income and whether an individual was previously offered EHI.

For the firm's contribution to health insurance premiums, denoted by ψ, we set the rate at 80%, reflecting common employer contribution levels. We set the parameter η to 0.1, consistent with findings from Gruber (2008) that the administrative costs for private insurance represent approximately 10% of the premium amount. We define the Medicare premium π_{mr} as 2.1% of the per capita GDP, informed by MEPS data.

Eligibility for Medicaid is determined by income and assets, with thresholds denoted as Θ_e and Θ_a, respectively. Following Pashchenko and Porapakkarm (2017), we set Θ_e at 31.1% of per capita GDP and Θ_a at 53.8% of per capita GDP, reflective of the variations in income threshold across different states and family sizes.

4.4 Government programs

Medical bankruptcy. To represent the partial repayment obligations of medical bills post-bankruptcy, we set $\gamma = 0.35$, following Livshits et al. (2007). The exemption on earnings, denoted by $\bar{y}$, is fixed at 20% of per capita GDP. The non-pecuniary penalty of declaring bankruptcy, ν, is calibrated to match the observed proportion of the population declaring medical bankruptcy in a stationary equilibrium.

Consumption floor. In adherence to Jeske and Kitao (2009), the consumption floor $\underline{c}$ is set to \$4600, equivalent to 9.5% of GDP per capita. This calibration ensures that wealth inequality within the model mirrors empirical data, with the wealth of the bottom half of individuals being approximately 9% of that held by individuals in the 50th to 90th percentiles as in the PSID data.

Social security. The social security payment structure is modeled after the U.S. system, represented by the function $ss(\bar{e})$ with varying marginal replacement rates s_1, s_2, and s_3, and threshold levels τ_1, τ_2, and τ_3. These are calibrated to reflect empirical income distributions and replacement rates from social security income data.

Taxes and government expenditure. The consumption tax rate τ_c is set to 5.67%, as per the OECD Tax Database (OECD (2020)). The social security tax rate τ_{ss} amounts to 12.4%, with both employers and employees contributing equally. The Medicare tax rate τ_{mr} is established at 2.9%. The income tax function $T(y)$ is adopted from Heathcote et al. (2017). The government expenditure G is fixed at 18% of GDP in the baseline model.

Summary of calibration. We summarize the calibration results in Table 6 of Appendix C.4. Out of all parameters, β, b, γ_l, γ_h, λ_p, $\underline{c}$, and ν are determined in the equilibrium while other parameters and functions, including health process, income process, medical expenditure shocks, mortality rates, co-insurance rates, and EHI offer rates are determined independent of the general equilibrium.

5 Model Fit and Validation

This section discusses the model fit for most salient features of the data. We also report statistics that are not directly targeted as a validation of our benchmark model.

Aggregate moments. We start by comparing the benchmark model to the data on the aggregate variables. Our model succeeds in matching those moments targeted directly in our calibration. For instance, the model reproduces the observed gap in the labor force participation rate between healthy and unhealthy individuals, as shown on the top two rows of Table 2. The wealth share of the bottom 50 percent individuals relative to the wealth share of the 50–90 percent individuals is 7%, compared with 9% in the data. Fewer people declare medical bankruptcy in the model economy, most of who use it as an implicit health insurance. The model also replicates 0.68 autocorrelation for EHI offer rate as observed in the data. In addition, we match the value of statistical life and the equilibrium interest rate, see the last two rows of Table 2.

As a validation of our model, we reports some moments that are not directly targeted by the benchmark economy. A comparison with the data counterparts as listed in Table 3 indicates that our model performs well in several fronts. In our model, there are 73% of working age population choose to obtain some forms of insurance coverage, which is close to 78% based on the MEPS data. In addition, we match the decomposition of different types of insurances, see the first four rows of Table 3. In the model, 86% of individuals remain in healthy status, compared with 84% in the data. Note that health is endogenous in our model via individual's health insurance choice. As a result, matching the fraction of healthy individuals is reassuring that our health transition matrix conditional on insurance

Table 2: Model Fit: Aggregate Moments—Directly Targeted

	Model	Data
Labor force participation rate:		
Healthy	0.94	0.95
Unhealthy	0.83	0.83
Statistics on wealth inequality		
Wealth share, bottom 50 vs 50-90	0.07	0.09
Fraction of medical bankruptcy	0.001	0.004
Autocorrelation of EHI offer	0.68	0.68
Statistical value of life	\$6.6M	\$6.5M
Interest rate	0.04	0.04

Note: This table compares the model's prediction on targeted aggregate moments with data for the working age population.

is precisely estimated. We also match the EHI take-up rate and the average out-of-pocket medical expenditure as a fraction of GDP per capita. The subsequent four rows of Table 3 shows that our model matches the level of income inequality reasonably well. For instance, the Gini index of income in our model is 0.44, closely aligning with the 0.48 found in empirical data. The distribution of income shares among the top 10%, top 25%, and bottom 50% in our model also mirrors these segments in actual data. Again, income is endogenous in our model and hence matching income inequality indicates that we correctly estimate the income process, and we get the health distribution right since health affects income. Lastly, our model is consistent with data that healthier individuals tend to possess greater wealth. Specifically, in the model, the net asset holdings of healthy individuals are, on average, 1.52 times greater than those of unhealthy individuals, compared to a 1.33-fold difference observed in the data.

Characteristics of the uninsured. Given our focus on insurance and insurance policy, it is important that the model matches the data along the dimension of who remain uninsured. We assess the model's predictions on the insured versus the uninsured and find that they are broadly in line with the data. Specifically, in our model, the uninsured tend to be younger than the insured, with average age of 40 and 46 respectively, and this pattern also holds in the data (with average age of 41 and 45). The model also predicts that

Table 3: Model Validation: Moments not Directly Targeted

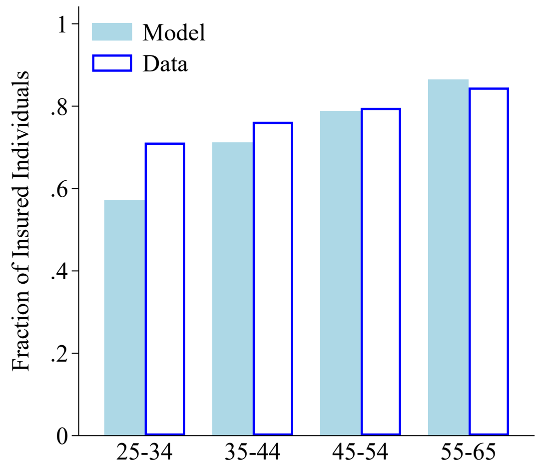
	Model	Data
Fraction of insured individuals	0.73	0.78
EHI	0.47	0.46
Other private	0.12	0.17
Public	0.14	0.14
EHI take-up rate	0.83	0.84
Fraction of healthy individuals	0.86	0.84
Out-of-pocket medical expenditure	0.016	0.014
Statistics on income inequality		
Gini index	0.44	0.48
Income share of top 10 percentile	0.34	0.31
Income share of top 25 percentile	0.59	0.56
Income share of bottom 50 percentile	0.17	0.17
Wealth, healthy relative to unhealthy	1.52	1.33

Note: This table compares the model's prediction on aggregate moments with data for the working age population for moments that are not directly targeted in our calibration.

the uninsured are overall poorer, with average income at 74 percent of the economy-wide average, while the insured have average income at 110 percent of the economy-wide average. These statistics are also similar to the data (55 percent and 113 percent). The model also predicts a small difference in health between the insured and the uninsured—83 percent of the uninsured are healthy while 87 percent of the insured are healthy. The difference is also small the data (83 percent and 84 percent). Note that although there is a significant health premium associated with insurance, the insured do not appear substantially healthier than the uninsured in equilibrium, primarily due to two factors: firstly, those in poorer health are often economically disadvantaged, making them more likely to qualify for public insurance; secondly, individuals with poorer health are more inclined to enroll in EHI.

Life-cycle profiles of medical expenditure, insurance, and health. Our baseline model successfully captures life cycle profiles observed in the data, even though these profiles were not explicitly targeted in our estimation. This is evidenced in Figure 6, where the fraction of insured individuals over the life cycle is depicted. In this figure, simulated outcomes are shown in light blue bars, while empirical moments are represented by hollow blue bars. The model accurately reflects the observed increase in health insurance coverage

Figure 6: Insurance Coverage over Life Cycle



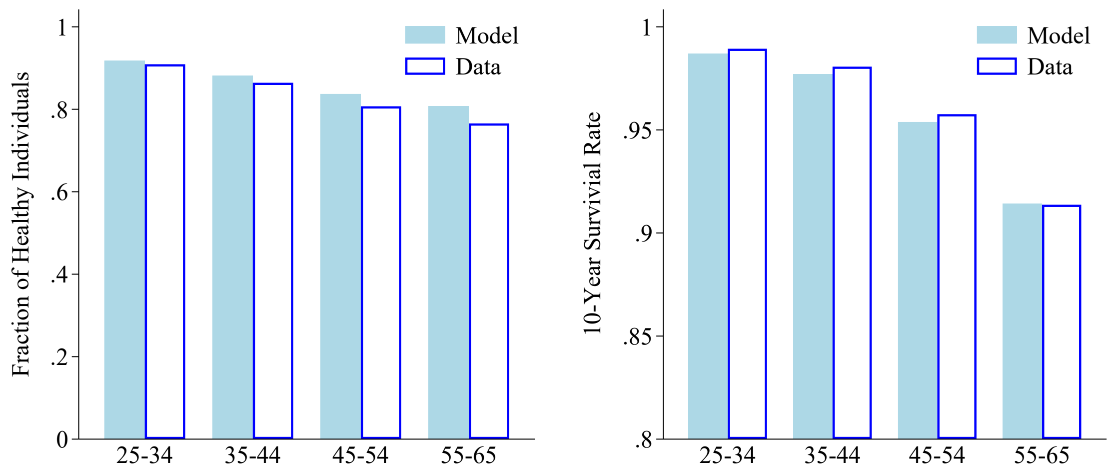
Notes: This figure illustrates the portion of insured individuals over the life cycle. The light blue bars represent simulated outcomes, and the hollow blue bars represent empirical moments calculated from the data.

throughout the life cycle, which aligns with the concurrent rise in earnings and the perceived value of health insurance with age. Moreover, the model is generally consistent with the data regarding the composition between types of insurance over the life cycle, and we report the comparison in details in Appendix C.4. Over all age groups, EHI is the most common type of insurance coverage among individuals, while the portions of individuals covered under other private insurance and public insurance are relatively small and stable over the life cycle.

Additionally, the model's implied fraction of healthy individuals over the life cycle, as seen in the left panel of Figure 7, matches the trends found in empirical data. This alignment extends to the declining aggregate survival rate by age depicted in the right panel of Figure 7, mirroring the deterioration in health that typically occurs throughout the life cycle. It's important to note that while the survival rate by health status is estimated directly, the model incorporates endogenous health dynamics, making the life cycle survival rates an outcome of the model rather than a direct target of estimation.[17] Furthermore, Figure 8 demonstrates the model's fit regarding average out-of-pocket medical expenditure over the life cycle. Since medical expenditure is influenced by health status, insurance coverage, and

[17] Given the importance, in Appendix C.4, we also discuss the patterns of health status and survival rates for each age rather than for age groups, while results remain similar.

Figure 7: Health Status and Survival Rates over Life Cycle



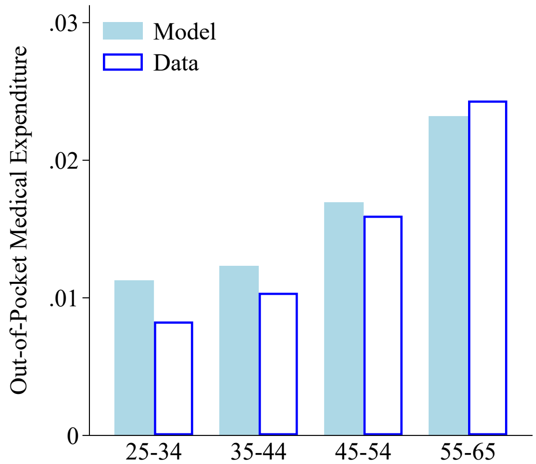
Notes: This figure illustrates the portion of healthy individuals (left panel) and the 10-year survival rates (right panel) over the life cycle. The light blue bars represent simulated outcomes, and the hollow blue bars represent empirical moments calculated from the data.

co-insurance rates, it is also endogenous within our model framework.

Life-cycle profile of wealth. Validating equilibrium wealth inequality is crucial in our model since choices regarding health insurance coverage and labor supply are substantially influenced by the asset holdings of agents. As depicted in Figure 9, our model captures the observed pattern in net asset accumulation across different age groups, particularly the tendency for older individuals to hold more wealth than their younger counterparts. It is important to note that the baseline model targets the aggregate wealth inequality, specifically the 50-90 wealth ratio, rather than the distribution throughout the life cycle. Without extra ingredients, such as varying discount factors as in de Nardi et al. (2023), our model does a reasonable job in matching the wealth inequality over the life cycle.

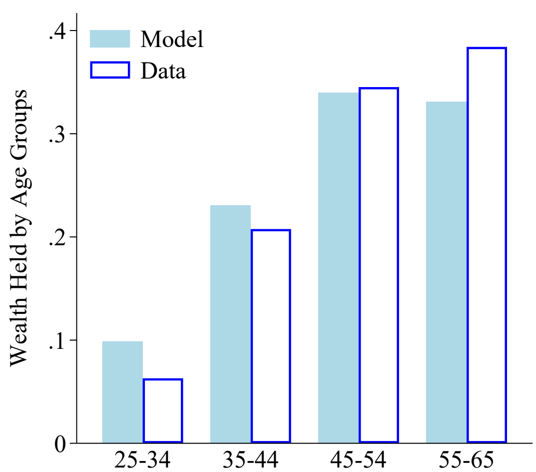
Health insurance and health by income. We now turn to the analysis of health insurance coverage in relation to income. It is crucial to recognize that that insurance choices play a significant role in shaping health outcomes, which subsequently influence earnings and inform future decisions regarding insurance. The left panel of Figure 10 illustrates that the model broadly replicates the data pattern that individuals with higher incomes are more

Figure 8: Out-of-Pocket Medical Expenditure over Life Cycle



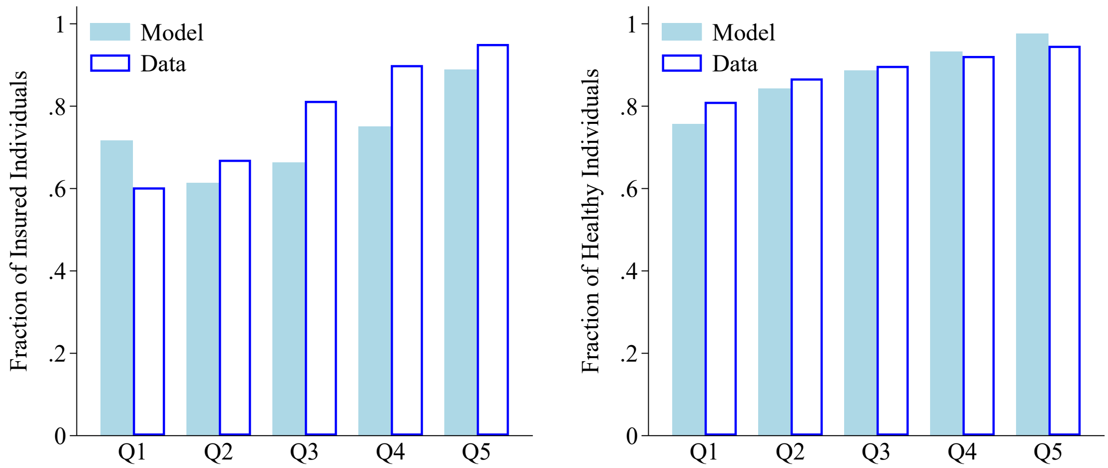
Notes: This figure illustrates the average out-of-pocket medical expenditure over the life cycle normalized by GDP per capita. The light blue bars represent simulated outcomes, and the hollow blue bars represent empirical moments calculated from the data.

Figure 9: Asset Holdings over Life Cycle



Notes: This figure illustrates the portion of net asset held by individuals of different age groups. The light blue bars represent simulated outcomes, and the hollow blue bars represent empirical moments calculated from the data.

Figure 10: Insurance Coverage and Health by Income



Note: The figure shows the insurance coverage rate (left panel) and the portion of healthy individuals (right panel) over income quintiles. The light blue bars represent simulated outcomes, and the hollow blue bars represent empirical moments calculated from the data.

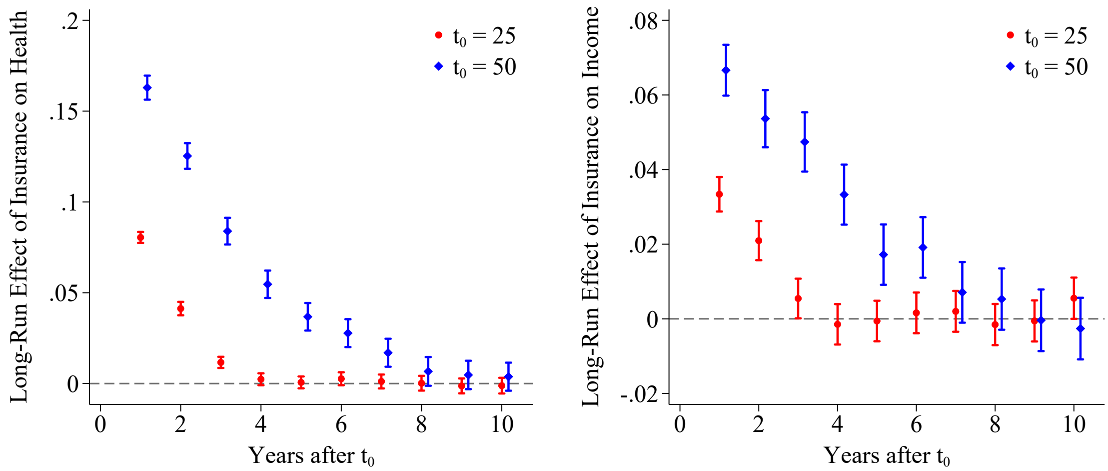
likely to have health insurance.

A fundamental aspect of our model is the interdependence of health and income in equilibrium. This is depicted in the right panel of Figure 10, which displays the proportion of healthy individuals across income quantiles. Our baseline model successfully captures the observed trend where higher-income individuals are more likely to maintain good health. However, it modestly underestimates the proportion of healthy individuals in lower-income brackets. Due to the limitationof data, our identification strategy of health premium only applies to private insurance. In our conservative approach, we assume that public insurance does not contribute to a health premium. Modifying this assumption to acknowledge some health benefits of public insurance, predominantly used by lower-income households, could enhance the model's accuracy in reflecting the health-income gradient.

6 The Long-Run Effects of Health Insurance

In this section, our baseline model serves as a tool to examine the long-run effects of health insurance on an individual's health status and earning potential throughout their lifetime.

Figure 11: Long-Run Effects of Health Insurance



Note: The figure shows the long-run effect of insurance on future health (left panel) and income (right panel), estimated using model simulated panel data. The red bars show the effects of insurance at the age of 25, and the blue ones show that at the age of 50. The middle dots represent point estimates, and the bands show the 95 percent confidence interval.

For instance, by comparing a 25-year-old with health insurance to an identical individual without it, we aim to project the differences in their health by the time they reach 30 years of age. Since our baseline model reproduces most salient features of the joint distribution of health and income, it allows us to use the simulated data to study such questions. Compared with the survey data, we can simulate a panel with sufficient length without attrition bias. Additionally, we can control for unobserved heterogeneity in the simulated data. This control is crucial for isolating the effect of health insurance on health and earnings.

Health insurance and health, income. We consider the following regression based on the simulated data. We regress the variable of interest, for instance, an individual's health at the age of t, on this individual's initial health status ($h_{i,t0}$), initial health insurance coverage status ($i^{hi}_{i,t0}$), and initial income shock ($\varepsilon_{i,t0}$), controlling for this individual's type (α_i). Note that controlling for initial income shock and type is important since income is correlated with health insurance coverage, and such controls are only available with model simulated data.

The long-term effects of having health insurance at age 25 are illustrated by the red bars (labeled as $t_0 = 25$) in Figure 11. Our analysis reveals that a typical worker entering the labor market at 25 with health insurance has an 8 percentage point higher probability of remaining healthy after one year compared to a similar individual without insurance. This disparity stems from the health premium identified in earlier sections of our analysis. Additionally, the positive influence of health insurance on health outcomes is statistically significant over a span of three years.

The benefit of better health also extends to earnings, as healthier individuals typically earn more than their less healthy counterparts. Consequently, individuals who are insured at the age of 25 are likely to experience approximately a 3.3 percentage point increase in income at the age of 26 when compared with an identical individual who is uninsured. The economic implications of health insurance, as reflected in income, are depicted by the red bars in the right panel of Figure 11.

The effect of health insurance is age-dependent, with the magnitude and persistence of its long-term impacts increasing as workers age. This is demonstrated by the blue bars (labeled as $t_0 = 50$) in Figure 11. For example, a 50-year-old with health insurance coverage has an approximate 16.3 percentage point greater probability of being healthy at age 51 compared to their uninsured counterpart. This health effect is very persistent; a one-year change in health insurance coverage at age 50 can produce a health status differential that lasts for the next decade. Being insured and consequently healthier at age 50 is associated with an expected increase in income of about 6.7 percentage points at age 51. Again this effect is also persistent.

The observed variation in the health insurance effect by age can be explained by an increasing health premium throughout the life cycle, which is detailed in Figure 3. Intuitively, individuals at the age of 25 tend to be relatively healthy, even in the absence of health insurance. Therefore, providing health insurance to these younger individuals has a small impact on their health trajectory and, consequently, their lifetime income. In contrast, for older individuals, the health premium is substantial, which implies that providing health insurance to the elderly can lead to significant improvements in both their health and income over time. This observation is particularly pertinent to the policy debate presented in Section 7.

Additionally, this experiment allows us to evaluate the relative significance of initial insurance status versus initial health on future health outcomes. Taking a 50-year old individual as an example, when we analyze the impact on health at age 51, the regression coefficient for initial insurance is 0.16 (as shown in the left panel of Figure 11), while the coefficient for initial health is 0.39. Thus, initial insurance status is slightly less than half as influential as initial health in determining future health. Consequently, initial insurance status also bears roughly half the weight in explaining future income, since its impact on income operates indirectly through its effect on future health.

Model with no health premium. To assess the importance of incorporating a health premium in modeling and to understand its effects on equilibrium dynamics, we examine a variation of the baseline model that excludes this premium. For a valid comparison, we first re-estimate the health process without conditioning on insurance status. We then recalibrate the model, this time omitting the health premium, to match the observed uptake of health insurance. After recalibration, these two models can replicate similar levels of income inequality at equilibrium, but by construction the economy without health premium features a smaller correlation between health and income than our baseline model due to the lack of feedback effect from income to health through health insurance. In addition, these two models diverge substantially in two key areas.

Firstly, our baseline model with the health premium suggests that having health insurance initially can have lasting effects on an individual's future health and income. Conversely, the conventional model, which treats health as an exogenous factor not influenced by insurance status, shows no such enduring impact of initial insurance on health or income.

Secondly, although both models may exhibit comparable baseline inequalities, their responses to changes in health insurance policy diverge markedly. In the model that omits the health premium, expanding health insurance coverage does not impact health inequality levels. Conversely, in our baseline model which accounts for the health premium, extending health insurance coverage is projected to substantially decrease both health and income inequalities.

The implications of these differences will be further explored in the next section, which studies the consequences of health policy change on economic disparities.

7 Quantitative Analysis: Universal Health Coverage

The findings from our prior analysis highlight the substantial and persistent impact of health insurance on various economic outcomes, including health. In this section, we explore the macroeconomic consequences of implementing "Universal Health Coverage" (UHC) using our baseline economic model, where insurance is provided to all individuals within the working-age population and such insurance is associated with the health premium that we estimated in Section 2. We select this policy for our analysis due to its widespread implementation in numerous OECD countries in diverse forms, its alignment with the goals of the Affordable Care Act (ACA) enacted during the Obama administration which aimed to move the United States closer to a universal healthcare system, and its prominence in the recent U.S. general election debates concerning healthcare system reform.

By simulating the introduction of UHC, our analysis aims to provide insightful implications for policymaking, particularly in the context of addressing and mitigating the long-term effects of health inequality. We assume that policy changes will be financed by a consumption tax to abstract away from labor market distortion caused by income tax. This simplification helps to isolate the impact of UHC on health outcomes and economic inequality, providing clearer guidance on policy design.

Level effects. Incorporating endogenous health transitions and the dependency of labor productivity on health status, healthcare system reforms can yield noticeable effects on aggregate demographic variables and the supply of human capital. As shown in Table 4, the implementation of UHC results in an increase in the proportion of healthy individuals from 86.5 percent to 90.0 percent. This health improvement corresponds to a decrease in the mortality rate and an increase in life expectancy: for 25-year-old, the life expectancy increases by 0.6 years, from 77 to 77.6.[18] The changes in mortality rate and life expectancy in turn yield a 0.7 percent increase in the total working-age population. Moreover, the efficiency units of labor ($\tilde{z}$), which represent the average human capital as a combination of intrinsic productivity (z) and a health component ($g(h)$) for the working-age population, increase

[18] In the baseline model, the average life expectancy, which is not specifically targeted, is slightly lower than what is observed in the data. This discrepancy primarily stems from an assumption in our model that individuals invariably reach mortality at the age of 85.

Table 4: Level Effects of UHC

	Baseline	No health premium
Working-age population (%)	+0.7	+0.0
Healthy individuals (p.p.)	+3.5	+0.0
Life expectancy (years)	+0.6	+0.0
Efficiency units of labor		
Aggregate (%)	+1.2	+0.0
Average (%)	+0.5	+0.0
Out-of-pocket med. exp. (%)	−6.1	−5.4
Labor supply (p.p.)	−2.3	−5.2

Note: This table shows the change in aggregate moments when we implement UHC. Human capital is measured by efficiency units of labor $\tilde{z}$, which is the product of underlying productivity and health component $g(h)$ for the working age population.

by 0.5 percent. The overall aggregate human capital increases by 1.2 percent, because of both the increased average human capital and the expanded population size. These results arise from the channel that insurance coverage promotes individual health—a factor that is largely overlooked in canonical macroeconomic models that exclude a health premium.

For contrast, we replicate this analysis within an model that omits the health premium. Within this alternative framework, the extension of health insurance coverage has no effect on the total population size by design. This stark contrast underscores the pivotal role of the identified health premium in economic modeling, particularly in evaluating the effects of health policy reforms. Consequently, incorporating the health premium is not merely a technicality but an essential element for a more precise and holistic understanding of the ways in which health insurance reforms influence population health and economic patterns.

We also assess the implied changes in out-of-pocket medical expenditure after implementing UHC. Specifically, we computed the discounted present value of these expenditures from age 25 to 65, applying a discount rate of 4%, which is the interest rate in our calibrated economy. Upon introducing UHC, which increases insurance coverage rates, we observed a notable decrease in out-of-pocket medical expenses. In our baseline economy, the reduction is 6.1 percent, compared to 5.4 percent in an economy without a health premium. This greater decrease in our baseline scenario is mainly due to improved individual health, resulting in lower medical expenses. This occurs despite the typically higher healthcare spending associated with increased life expectancy.

The adoption of UHC leads to a decrease in labor supply, a trend observed not only in our baseline economy but also in scenarios without health premium. This highlights the significant role of EHI in shaping labor supply choices, as some individuals may work full-time primarily to qualify for EHI. Under UHC, this incentive diminishes, resulting in a reduced labor supply. Notably, the decrease in labor supply due to UHC is less marked in an economy with a health premium than in one without it. In our baseline model, UHC improves overall health and in turn increases labor supply (recall that the unhealthy are less likely to work), which helps offset the initial drop in labor supply.

Distribution of health. We next explore the distributional impact of UHC on health across various demographic segments. UHC, designed to provide health insurance coverage universally, is expected to enhance overall health. Nonetheless, its benefits may vary significantly among different age and income groups.

As illustrated in Table 5, our study delves into the differences in the proportion of healthy individuals and life expectancy across income quintiles. The findings clearly indicate that UHC disproportionately benefits those in lower income brackets. For instance, life expectancy in the lowest income quintiles (1 and 2) sees an increase of nearly one year, whereas the highest income quintile (5) experiences a modest gain of only 0.1 years. This discrepancy stems from the higher likelihood of high income individuals having health insurance prior to UHC implementation.

Additionally, the last column of Table 5 reveals the changes in out-of-pocket medical expenses. A substantial decrease in these costs is predominantly observed among the lowest income quintiles (1 and 2), in stark contrast to the minimal changes seen in the highest income quintile (5). This is mainly due to two reasons: a more substantial improvement in health among lower-income individuals and a greater expansion of insurance coverage within this demographic group, leading to reduced out-of-pocket expenses.

Conversely, the introduction of UHC in an economy without a health premium does not affect individual health outcomes, as evidenced by Table 4, and hence, it does not affect health or life expectancy disparities.

Table 5: UHC and Health Inequality

	Healthy individuals (%)			Life expectancy (years)			Med. exp.
	Baseline	UHC	change	Baseline	UHC	change	change (%)
By income:							
Q1	73.6	81.0	+7.4	76.7	77.5	+0.8	−4.2
Q2	83.0	88.5	+5.5	76.7	77.6	+0.9	−10.5
Q3	87.7	90.8	+3.1	76.9	77.5	+0.7	−9.3
Q4	91.7	93.3	+1.5	77.2	77.7	+0.4	−5.7
Q5	95.0	95.5	+0.5	77.5	77.6	+0.1	−0.0

Notes: This table shows the change in the percentage of healthy individuals, life expectancy, and out-of-pocket medical expenditure when we implement UHC, by income quintiles where Q1 represents the poorest individuals while Q5 represents the richest individuals.

Income, consumption, and wealth inequality. We now turn to the effect of UHC on income inequality. As previously discussed, UHC influences labor supply, which subsequently affects income disparity. In this section, our analysis centers on the UHC's effect on wage rate inequality, specifically on the underlying productivity $z \cdot g(h)$ in our model. We categorize individuals into two groups based on their wage rates: the top 25 percentiles and the bottom 50 percentiles of the population. The income shares of these groups are calculated and presented in the top panel of Table 6. Our findings indicate that UHC reduces income inequality in our baseline model, which includes a health premium. For example, the income share of the top 25 percentile group decreases by 0.2 percentage points, while that of the bottom 50 percentile group increases by the same margin. This shift is attributed to UHC's role in enhancing health, and consequently earnings, particularly among lower-income individuals. Such improvements contribute to the simultaneous reduction in both health and income inequalities.

The apparent reduction in income inequality following UHC implementation might be underestimated due to shifts in mortality rates. Specifically, UHC has a pronounced effect on improving the health of lower-income individuals, leading to a more significant decrease in mortality for this group. Consequently, their increased representation in the total population can counterbalance the reduction in income inequality. To analyze income disparity more accurately, we regress mortality rates against log income using baseline equilibrium data.

Table 6: UHC and Income Inequality

	Changes post-UHC	
	Baseline	No health premium
Income share		
Top 25	−0.2	+0.0
Bottom 50	+0.2	+0.0
Consumption share		
Top 25	+0.2	+0.5
Bottom 50	−0.4	−1.2
Wealth share		
Top 25	+1.1	+1.7
Bottom 50	−0.8	−2.4

Notes: The top panel shows the percentage point changes of income share of the top 25 percent and bottom 50 percent individuals between the baseline economy and the UHC. The middle and bottom panels show the changes in consumption share and wealth share.

Leveraging this relationship, we then infer a hypothetical mortality rate for the UHC scenario and adjust the sample weighting in the UHC economy accordingly. Post-adjustment, UHC appears to further decrease income inequality: the income share of the top 25 percentile reduces by 0.4 percentage points, while that of the bottom 50 percentile increases by 0.3 percentage points. In contrast, in models without a health premium, UHC does not alter health status or labor productivity, leaving income inequality unchanged.

We also examine consumption and wealth inequality, again sorting individuals into the top 25 percentiles and bottom 50 percentiles based on their wage rates. The corresponding shares of consumption and wealth are detailed in the middle and bottom panels of Table 6. Intriguingly, post-UHC implementation, both consumption and wealth inequality rise, a finding initially counterintuitive, especially considering the reduction in income inequality. A key factor here is the shifting tax burden from the rich to the poor. Given that UHC is funded by an increased consumption tax, and considering that poorer individuals have a higher marginal propensity to consume, the constant-rate tax inadvertently becomes regressive. Thus, lower-income individuals may face higher effective tax rates on their total income, exacerbating consumption and wealth inequality even in the face of reduced income inequality. This scenario emphasizes the critical need to address optimal taxation in financing UHC, a compelling topic for future research.

To finance UHC, consumption tax rate increases substantially to 32.7 percent. While initially seeming large, it is important to recognize that with UHC introduction, all other individual- and firm-level health-related taxes would be eliminated. Considering that health-care accounts for over 18 percent of U.S. GDP, and with two-thirds of GDP being consumption, consumption excluding health care is around half of GDP. To solely finance healthcare through consumption tax would hence require an increase of consumption tax rate by about 30 percentage points, contextualizing the 27 percentage point rise (from 5.7 to 32.7 percent).

Moreover, UHC incurs lower costs in our baseline economy compared to an economy without a health premium. In the baseline economy, UHC enhances labor productivity, thereby expanding the tax base, and improves health status, reducing overall medical expenses. For comparison, introducing UHC with exogenous health would necessitate a 29.5 percentage point increase in consumption tax, as opposed to a 27 percentage point increase in our baseline. This difference also partly explains why UHC exacerbates consumption and wealth inequality more in the economy without a health premium, as indicated in the second column of Table 6.

Welfare implications. To assess the welfare impact of a policy change, we calculate the consumption equivalent variation. For an agent born with characteristics denoted by the state $s_w = \{j = 0, a, z, m, h, i_{hi}, i_E, \eta_E\}$, we compute the welfare effect according to the following formula:

$$x = \frac{\left[\left(V_{\text{new}}(s_w) - V_{\text{old}}(s_w)\right)(1-\sigma) + c_{\text{old}}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}}{c_{\text{old}}} - 1. \tag{20}$$

In this equation, V_{old}, and c_{old} denote the value function, and consumption choice under the prevailing policy, respectively, while V_{new} denotes the value function under the proposed new policy. The variable x represents the household's willingness to pay, expressed as a fraction of current consumption, to be indifferent between the existing and the new policies. This variable is hence a summary measure of the steady state welfare comparison, in terms of changes in one period of consumption.

Despite the substantial increase in the consumption tax, the introduction of UHC brings about notable welfare gains. For the median households, welfare increases by 11.6 percent in terms of current consumption, rendering UHC politically feasible. Concerning the distribution of these welfare gains, one might initially presume that low-income and unhealthy individuals benefit the most. However, as depicted in Table 7, it is the middle-income and healthy individuals who experience the largest welfare gains. This seemingly paradoxical outcome is due to the fact that many low-income and unhealthy individuals are already covered by public insurance in our baseline economy, even without UHC. In contrast, middle-income earners who do not qualify for Medicaid and do not receive EHI benefit substantially from UHC.

Integrating UHC into a model without health premiums results in relatively smaller welfare gains for households with median income and for both healthy and unhealthy individuals. This difference primarily results from the fact that, in such a model, increased insurance coverage does not significantly improve health or income. However, it still offers protection against the financial impact of medical expenditure shocks, thereby contributing to notable, albeit reduced, welfare improvements.

Our analysis also uncovers a fundamental tension in reforming the health insurance market. While UHC can correct market inefficiencies, such as adverse selection, it might simultaneously introduce distortions in individuals' long-term financial decisions. UHC's potential to extend the life expectancy of poorer individuals effectively alters their discount factor. Without supplemental redistributive mechanisms, this increased longevity may lead to insufficient savings, raising concerns about financial security over a prolonged lifespan. In some hypothetical cases, individuals might prefer trading insurance coverage for increased immediate consumption, viewing UHC as a compulsory savings tool that mandates investment in a specific type of human capital: their health. This observation might elucidate why UHC implementation in an economy with a health premium does not result in substantially larger welfare gains compared to its introduction in a setting without a health premium.

This intricate dynamics underscores that effective policy must strike a delicate balance between providing insurance against health risk and ensuring income stability. Although it is clear that while UHC addresses critical issues in the current healthcare system, it also

Table 7: Welfare Effect of UHC

	CEV(%) at birth	
	Baseline	No health premium
Median household	+11.6	+10.8
By health:		
Healthy	+11.8	+11.0
Unhealthy	+10.0	+9.5
By income:		
Q1	+8.9	+9.5
Q2	+16.1	+15.7
Q3	+28.6	+32.3
Q4	+12.6	+11.1
Q5	+8.8	+5.3

Note: We calculate the percentage changes in current consumption equivalence as a measure of welfare gain associated with UHC. We then separately assess the welfare gain in our baseline economy with health premium and in the economy without health premium.

raises questions about the interplay between health, savings, and consumption, particularly for the less affluent. Policymakers must carefully consider these factors to craft a system that not only provides extended insurance coverage but also supports the overall economic well-being of the population.

8 Concluding Remarks

In this paper, we delve into the intricate dynamics governing the joint distribution of health and income. We identify a "health premium" associated with insurance coverage and construct a quantitative framework that encapsulates the endogenous evolution of health status and its influence on labor productivity. Our baseline economy reproduces the observed joint distribution of health, health insurance, medical expenditure, and income over the life cycle. These results rest on a rich dynamic equilibrium model featuring a novel channel through which income affects health. This is coupled with innovative econometric methods that enable consistent estimation of income and health trajectories. Utilizing our model, we analyze the determinants influencing household choices regarding health insurance and simulate its enduring effects on individual health and earnings across the lifespan. Our quantitative analysis uncovers the profound and lasting impact of initial insurance status on health, which not only reinforces but also magnifies the impact of health on labor earnings and income inequality. Utilizing our benchmark model as a laboratory, we investigate the macroeconomic consequences of healthcare reforms aimed at expanding insurance coverage. Implementing "Universal Health Coverage" would likely reduce health disparities and income inequality, primarily aiding lower-income households. Nevertheless, this policy exerts contrasting effects on income inequality. The reduction in mortality among the poorer population and their consequent increased presence in the income distribution, may offset the positive effects of improved health on reducing income disparity. These conflicting influences contribute to a nuanced and intricate dynamic in the overall income distribution.

There are a number of potentially interesting extensions, contingent on data availability for health, health investment, and model tractability. Our current focus is on the influence of income on health via the endogenous choice of health insurance. Incorporating other dimensions of household resources or efforts that affect health evolution could significantly amplify the interaction between income and health. For example, besides the higher likelihood of obtaining insurance coverage among affluent individuals, as suggested in our model, they may also lead healthier lifestyles, affording better nutrition and gym memberships. Therefore, our results, quantifying the health-income interplay, might represent a conservative estimate. Modeling these additional aspects would likely intensify this interaction. Additionally, our study reveals that both initial health and income of workers profoundly and persistently shape their health trajectory throughout their lives. Yet, our current analysis is silent on the cost of providing enhanced health. Addressing this gap could pave the way to pinpoint the optimal policy intervention for addressing health disparity and income inequality.

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