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Aging and Health Financing in the US: A General Equilibrium Approach

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Aging and Health Financing in the U.S. A General Equilibrium Analysis*

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Abstract

We quantify the effects of population aging on the U.S. healthcare system. Our analysis is based on a stochastic general equilibrium overlapping generations model of endogenous health accumulation calibrated to match pre-2010 U.S. data. We find that population aging not only leads to large increases in medical spending but also a large shift in the relative size of private vs. public insurance. Without the *Affordable Care Act* (ACA), aging by itself leads to a 40 percent increase in health expenditures by 2060 and a 9.6 percent increase in GDP which is mainly driven by the increase of the fraction of older higher-risk individuals in the economy as well as behavioral responses to aging and the subsequent expansion of the healthcare sector. Aging increases the premium in *group-based health insurance* (GHI) markets and enrollment in GHI decreases, while the *individual-based health insurance* (IHI) market, Medicaid and Medicare expand significantly. The size of Medicare will double by 2060 as the elderly dependency ratio increases. Additional funds equivalent to roughly 2.8 percent of GDP are required to finance Medicare and Medicaid. The introduction of the ACA increases the fraction of insured workers to almost 100 percent by 2060, compared to 82 percent without the ACA. This increase is driven by the stabilization of GHI markets and the further expansions of Medicaid and the IHI market. The ACA mitigates the increase of healthcare costs by reducing the number of the uninsured who pay the highest market price for healthcare services. Overall, the ACA adds to the fiscal cost of population aging mainly via the Medicaid expansion. Our findings demonstrate the importance of accounting for behavioral responses, structural changes in the healthcare sector and general equilibrium adjustments when assessing the economy-wide effects of aging.

JEL: C68, H51, I13, J11, E21, E62

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1 Introduction

Unlike many other developed nations, the U.S. has a mixed public/private health insurance system, where public health insurance (Medicare and Medicaid) covers retirees and low income individuals and private health insurance covers most of the working population (see Figure 1). In 2010 this system left over 45 million Americans without health insurance. In addition, the U.S. healthcare system is the most expensive in the world. National health expenditure reached 17.7 percent of GDP in 2010 according to a study by the Centers for Medicare and Medicaid Services (Keehan et al. (2011)). The increase in healthcare costs at rates greater than the rate of GDP growth causes concerns about the long-term solvency of the health insurance system. The situation is made worse by projected population aging, compare Figure 2, which will increase the number of the elderly who, on average, spend more on healthcare and rely more heavily on Medicare and Medicaid. According to CBO (2016), the fiscal problems created by Medicare/Medicaid are already larger in magnitude relative to Social Security.[1] In March 2010 the Obama administration introduced a comprehensive health reform at the federal level via the *Affordable Care Act* (ACA). The reform encompasses many objectives including solving the problem of the uninsured and promoting universal health insurance coverage, fixing the Medicare program and controlling healthcare cost. Critics maintain that the reform is underfunded and will drive up healthcare prices and healthcare premiums. With population aging accelerating the possible adverse effects of the ACA become more unclear.

The long-term fiscal outlook in the U.S. is sensitive to assumptions about how healthcare spending will respond to the ACA as reported in CBO (2013, 2014, 2016). Auerbach and Gale (2013) point out that the long-term fiscal gap in the federal government budget depends on the assumed growth rate of healthcare expenditures and ranges between 3 to 7 percent of GDP. The behavioral responses to the demographic changes and their effects on insurance markets are important determinants of the growth in healthcare expenditures. Some of these health related behaviors are not considered in CBO (2007) projections as their models are not based on the micro foundations of dynamic household decision making in a lifecycle context. The current paper aims to fill this gap and focuses on two issues. First, we quantify the effects of population aging on healthcare spending and financing in the U.S. Second, we assess the implications of the ACA reform in the context of aging.

We use a general equilibrium, overlapping-generations model calibrated to reproduce the consumption-savings behavior of U.S. households. The framework embeds the micro foundations of the demand for medical services and the demand for health insurance together with optimal household consumption, labor supply and savings. We essentially combine a general equilibrium overlapping generations model with incomplete markets and heterogeneous agents similar to Huggett (1996) with the Grossman (1972a) health capital model and then add idiosyncratic health shocks. Most importantly, the model includes institutional details of the public health insurance system and distinguishes between private employer provided group insurance (GHI) and private individual health insurance (IHI). The model extends our previous framework in Jung and Tran (2016) and incorporates bequest motives and endogenous retirement

[1] Spending of the major healthcare programs are projected to grow to 6.6 percent of GDP by 2026 compared to 5.9 percent of Social Security spending. See also NRC (2012) and Lee (2014) for an overview of the macroeconomic effects of aging in the U.S.

similar to De Nardi (2004) and French (2005).

We calibrate the model to U.S. data before the ACA reform in 2010. The primary data sources are the Medical Expenditure Panel Survey, data from the National Health Expenditure Accounts, as well as population projections by CMS/OACT. The benchmark model matches lifecycle patterns of insurance take-up rates, health expenditures, the labor supply, private consumption and asset accumulation as well as important macroeconomic aggregates. We explicitly model the insurance take-up choice and healthcare spending decisions of U.S. households which captures adverse selection and ex-post moral hazard effects. Since the model is a general equilibrium model, it accounts for the price feedback effects that naturally arise as a consequence of the demographic changes and the introduction of the ACA. Our model also provides a rich description of the U.S. health insurance market and is therefore particularly suited for the analysis of institutional reforms like the ACA.

We first study the effects of changes in the population age composition followed by an analysis of the implications of the ACA. Our results can be summarized as follows. First, without the ACA population aging leads to large increases in medical spending as well as output growth effects due to increased capital accumulation. This result is driven by the fact that households optimally adjust their consumption, healthcare spending and savings in anticipation of a longer lifespan. We observe large increases in the size of government spending programs for the retired population. Aging alone, without the ACA, leads to a large increase in aggregate health expenditures of almost 40 percent. This subsequently causes an almost 100 percent increase in the size of Medicare and a 70 percent increase in the size of Medicaid. Additional funds equivalent to roughly 7.4 percent of GDP are required to finance Medicare, Medicaid and Social Security programs by 2060. The increase in investments into health capital by households trigger a large expansion of the healthcare sector which contributes to an overall increase of GDP of about 10 percent when solving the model with 2060 demographics. This positive growth outcome is the result of modeling both a health production sector and health investments as part of the household decision problem.

In addition, aging reduces the fraction of workers in the group based health insurance (GHI) market while it increases the fraction of workers in the IHI market and Medicaid. Overall, the expansion of the IHI-market and Medicaid dominates the reduction in the GHI market so that the overall insurance take-up rate for workers increases from 78 percent to 82 percent. This increase in insurance take-up of the working population goes hand in hand with lower overall premiums in IHI markets and a higher premium in the GHI market for the working age population. In anticipation of longer lifespans individuals maintain their health at higher levels. In addition more individuals are being treated under government programs. These channels are not operational in models that abstract from the institutional details of the U.S. health insurance system, general equilibrium effects as well as optimal household reactions to extended expected lifespans.

With the ACA in place, aging causes a smaller health expenditure increase of 37 percent by 2060. Thus, on net the ACA reduces overall health expenditures by as much as 1.75 percent. The reform reduces healthcare spending by shifting uninsured workers who pay higher prices for medical services into Medicaid which pays much lower prices. The combined effect of the increase in longevity and the ACA on labor supply is positive. Households adjust their lifecycle labor supply in response to longer expected lifespans and increase work hours after the age of 60 in addition to remaining in the labor force longer.

Moreover, the ACA reform strengthens the positive effects of aging on the overall insurance take-up rates of the working population. The ACA increases the fraction of insured workers to almost 100 percent for all demographic profiles that we analyzed. This expansion in take-up is driven by the expansion of Medicaid, the subsidies for IHI and the stabilization of the GHI market through the mandate as individuals face penalty payments if they remain uninsured. The ACA adds to the fiscal cost of population aging mainly via the expansion of Medicaid and the growth in Medicare. Overall, the fiscal distortion caused by new ACA taxes causes efficiency losses and decreases GDP by 1.8 percent with 2060 demographics.

Related Literature. Our work is connected to different branches of the quantitative macroeconomics and health economics literature. First, our paper contributes to the large literature on the economics of aging (compare Wise (2007), Bloom, Canning and Fink (2010) and De la Croix (2013) for an overview). In the context of dynamic lifecycle models, Auerbach and Kotlikoff (1987) are probably the first to include fertility rates into a large-scale deterministic framework. Follow up contributions (Faruqee (2002), Kotlikoff, Smetters and Walliser (2007) and others) have used either deterministic frameworks or stochastic frameworks (De Nardi, İmrohoroğlu and Sargent (1999), Kitao (2014*b*) and Nishiyama (2015)) to analyze the effects of aging on household decision making and pensions. Recently, Braun and Joines (2015) and Kitao (2015) quantify the fiscal cost of population aging in Japan, while Nishiyama (2015) analyzes the effects of aging in the U.S. Kudrna, Tran and Woodland (Forthcoming) analyze the effect of population aging and fiscal responses in Australia. However, none of these papers have addressed the effects of aging on the healthcare system, which is the focus of this paper.

There is a growing literature that extends lifecycle models to include both medical and non-medical consumption and analyze the determinants of rising healthcare cost in the U.S. including technological progress, economic growth and Social Security (e.g., Suen (2006), Hall and Jones (2007), Fonseca et al. (2013), Ozkan (2014) and Zhao (2014)). Similarly, we model both types of medical and non-medical consumption and the institutional features of the U.S. health financing system. Our model is based on the micro-foundations of health capital accumulation in the spirit of Grossman (1972a), which allows us to endogenize decisions on healthcare and insurance. In our setting, we are able to account for the two-way interaction between insurance status and health expenditures which is an important determinant of the behavioral responses (i.e., ex-post moral hazard) and general equilibrium adjustments arising from changes in health insurance policies and demographic factors. Scholz and Seshadri (2013) use a Grossman approach to develop a lifecycle model that is capable to match the wealth and health distribution. However, they do not model insurance choice and the insurance sector, which is a crucial component of our model. This approach enables us to analyze the effects of aging on healthcare expenditures, while taking into account the role of health financing. We demonstrate that the design of the health insurance system matters for understanding the rise of healthcare costs and vice versa. The fiscal effects of financing private or public health insurance tend to be underestimated in models that treat healthcare spending as exogenous and thus ignore moral hazard effects (Jung and Tran (2016)).

We contribute directly to the literature on the economic and fiscal implications of population aging in the U.S. Recent CBO (2013, 2014, 2016) reports quantify the long-term fiscal outlook of U.S. healthcare and admit that their results are sensitive to assumptions about the responsiveness of healthcare spending to the ACA. However, none of these health-related behaviors are depicted in CBO's reported projections as their models do not consider the micro foundations of health spending and financing over the lifecycle. In addition, neither of these reports directly account for behavioral responses to population aging that are an important component of our approach. That is, the growth effect channel through the healthcare sector expansion is not operational in the CBO framework as described in CBO (2007). Our findings confirm that behavioral responses, structural changes in the healthcare sector and general equilibrium adjustments are important for forecasting the fiscal cost of healthcare as well as economy-wide effects of aging.

Our paper is built on a large literature on incomplete markets macroeconomic models with heterogeneous agents as pioneered by Bewley (1986) and extended by Huggett (1993), Aiyagari (1994) and İmrohoroğlu, İmrohoroğlu and Joines (1995). There are a number of studies addressing the link between health risk and precautionary savings within dynamic household optimization frameworks (e.g., Kotlikoff (1988), Levin (1995), Hubbard, Skinner and Zeldes (1995) and Palumbo (1999)). Note that, these previous studies commonly assume exogenous health expenditure shocks. More recent studies have incorporated exogenous health expenditure shocks into large-scale dynamic general equilibrium models (e.g., Jeske and Kitao (2009) and Pashchenko and Porapakkarm (2013)). Unlike these studies, Jung and Tran (2016) develop a heterogeneous agent overlapping generations model with endogenous health expenditures to analyze the long-run effects of the ACA. The recent literature shows that health risk and insurance are important drivers of savings and labor supply decisions. French (2005) and Blau and Gilleskie (2008) show that health insurance is important for understanding labor market behavior. De Nardi, French and Jones (2010), Hugonnier, Pelgrin and St-Amour (2013) and Yogo (2016) show that health is one of important determinants of asset holdings and portfolio choice in retirement. In this paper, we build on Jung and Tran (2016) and incorporate endogenous retirement choice similar to French (2005) and "warm glow" bequest motives as in De Nardi (2004). With these extensions we are able to account for consumption, savings and labor supply responses to aging, interactions between health investment and insurance choices, and general equilibrium price adjustments. We demonstrate that it is important to model these features when quantifying the effects of population aging and the ACA.

The structure of the paper is as follows: Sections 2 and 3 present a description and calibration of the model. Section 4 presents simulation results grouped into (*i*) the effects of aging absent any health reform and (*ii*) the ACA reform in combination with the effects of aging. Section 5 concludes.

2 The Model

The model builds on the framework in Jung and Tran (2016) which includes a general equilibrium overlapping generations model with incomplete markets and heterogeneous agents (e.g., İmrohoroğlu, İmrohoroğlu and Joines (1995) and Huggett (1996)) and the Grossman (1972a) health capital model augmented with idiosyncratic health shocks. We allow for bequest motives and endogenous retirement. The overlapping generations feature recognizes that people at different stages in their lives may have different needs and priorities that are likely to affect the overall performance of the economy. Intra-cohort heterogeneity of agents incorporates other important differences among individuals and institutions. The Grossman health capital model combined with idiosyncratic health shocks postulates that individual health is much like a capital asset that appreciates or depreciates in value over the course of an individual's lifetime. Our framework specifies a household sector, a production sector for final consumption goods, a production sector for medical services, a health insurance sector and a government sector.

2.1 Technologies and Firms

The economy consists of two separate production sectors. Sector one is populated by a continuum of identical firms that use a Cobb-Douglas production technology with physical capital K and effective labor services L as inputs to produce non-medical consumption goods c with a normalized price of one. Firms are perfectly competitive and solve the standard profit maximization problem

$$\max_{\{K,\ L\}} \left\{ AK^{\alpha}L^{1-\alpha} - qK - wL \right\}, \tag{1}$$

taking the rental rate of capital q and the wage rate w as given. Capital depreciates at rate δ in each period.

Sector two, the medical sector, is also populated by a continuum of identical firms with Cobb-Douglas technology and use capital K_m and labor L_m to produce medical services m at a price of p_m. Firms in the medical sector maximize

$$\max_{\{K_m,\ L_m\}} \left\{ p_m A_m K_m^{\alpha_m} L_m^{1-\alpha_m} - qK_m - wL_m \right\}. \tag{2}$$

The price p_m is a base price for medical services. The price for healthcare paid by households is $p_j^{in_j} = \left(1 + \nu^{in_j}\right) p_m$ where the markup factor ν^{in_j} depends on a household's insurance state. This markup will generate a profit for medical care providers, denoted Profit^M, that is redistributed in equal amounts to all surviving individuals.

2.2 Demographics

The economy is populated with overlapping generations of individuals who live to a maximum of J periods. Individuals work for the first J_w periods and can choose to retire thereafter. In each period individuals of age j face the exogenous survival probability π_j.[2] Deceased individuals leave a bequest which is taxed and redistributed equally to all individuals alive. The population grows exogenously at a a cohort specific rate n_j. We assume stable demographic patterns, so that age j individuals make up a constant fraction μ_j of the entire population at any point in time.[3] The relative sizes of the cohorts alive μ_j and the mass of individuals dying $\tilde{\mu}_j$ in each period (conditional on survival up to the previous period) can be recursively defined as

$$\mu_j = \frac{\pi_j}{(1+n_j)^{years}} \mu_{j-1} \text{ and } \tilde{\mu}_j = \frac{1-\pi_j}{(1+n_j)^{years}} \mu_{j-1}, \tag{3}$$

where $years$ denotes the number of years per model period.

[2] Hall and Jones (2007) and Fonseca et al. (2013) model survival as function of health. We abstract from this channel in our analysis and impose exogenous survival probabilities.

[3] We discuss how changing the demographic structure can mimic population aging in Section 4.1.

2.3 Preferences and Endowments

In each period individuals are endowed with one unit of time that can be used for work ℓ or leisure. Individual utility, $u(c,\ell,h)$ where $u: R^3_{++} \to R$ is C^2, increases in consumption c and health h, and decreases in labor ℓ.[4] Specifically, they have a Cobb-Douglas type utility function of the form

$$u(c,\ell,h) = \frac{\left(\left(c^{\eta} \times \left(1-\ell-1_{[\ell>0]}\bar{\ell}_j\right)^{1-\eta}\right)^{\kappa} \times h^{1-\kappa}\right)^{1-\sigma}}{1-\sigma},$$

where, $\bar{\ell}_j$ is the age dependent fixed cost of working as in French (2005), η is the intensity parameter of consumption relative to leisure, κ is the intensity parameter of health services relative to consumption and leisure, and σ is the inverse of the intertemporal rate of substitution (or relative risk aversion parameter).

When the individual dies she values bequests of assets a_j according to function

$$b(a_j) = \theta_1^B \frac{\left(a_j + \theta_2^B\right)^{(1-\sigma)\eta}}{1-\sigma},$$

where θ_2^B determines the curvature of the function. This functional form is similar to the one in French (2005).[5]

Individuals are born with a specific skill type ϑ that cannot be changed over their lifecycle and that together with their health state h_j and idiosyncratic labor productivity shock ε_j^{ℓ} determines their age-specific labor efficiency unit $e\left(\vartheta, h_j, \varepsilon_j^{\ell}\right)$. The transition probabilities for the idiosyncratic productivity shock ε_j^{ℓ} follow an age dependent Markov process with transition probability matrix Π^{ℓ}. Let an element of this transition matrix be defined as the conditional probability $\Pr\left(\varepsilon_{i,j+1}^{\ell} | \varepsilon_{i,j}^{\ell}\right)$, where the probability of next period's labor productivity $\varepsilon_{i,j+1}^{\ell}$ depends on today's productivity $\varepsilon_{i,j}^{\ell}$.[6]

2.4 Health Capital and Expenditure

Health Capital. Health capital is a function of last period's health capital h_{j-1}, the amount of medical spending in the current period m_j, the health depreciation rate δ_j^h and an exogenous idiosyncratic health shock ε_j^h which can be expressed as

$$h_j = \phi_j m_j^{\xi} + \left(1-\delta_j^h\right) h_{j-1} + \varepsilon_j^h. \tag{4}$$

The first two components of this law of motion are similar to the original deterministic framework in Grossman (1972a). The last component represents a random age-dependent health shock, which can be

[4] Our specification implicitly assumes a linear relationship between health capital and service flows derived from health capital which is similar to the assumption in the original model in Grossman (1972a).

[5] This warm-glow type bequest motive was first introduced by Andreoni (1989) and used in a general equilibrium model in De Nardi (2004). A more sophisticated form of altruism would require an additional state variable and exceed our current computational capacity.

[6] We abstract from the link between health and lifetime so that health capital has no effect on survival probabilities. We are aware that this presents a limitation and that certain mortality effects cannot be captured (see Ehrlich and Chuma (1990) and Hall and Jones (2007)). However, given the complexity of the current model we opted to simplify this dimension to keep the computational structure and the calibration of the model more tractable.

thought of as a random depreciation rate as in Grossman (2000). The exogenous health shock follows a Markov process with age dependent transition probability matrix Π_j^h. Transition probabilities to next period's health shock ε_{j+1}^h depend on the current health shock ε_j^h so that an element of transition matrix Π_j^h is defined as the conditional probability $\Pr\left(\varepsilon_{j+1}^h|\varepsilon_j^h\right)$.

Healthcare Expenditure. Individuals can buy healthcare services from the medical sector at price $p_m^{in_j}$, which depends on the individual's insurance state in_j. Total health expenditure in any given period is $p_m^{in_j} \times m_j$.[7] An individual with no insurance pays fully out-of-pocket for all her medical expenses, while an individual with insurance only pays a fraction of her spending on healthcare. Out-of-pocket health expenditure is defined as

$$o\left(m_j\right) = \begin{cases} p_m^{in_j} \times m & \text{if } in_j = 0 \\ \gamma_j^{in_j}\left(p_m^{in_j} \times m_j\right) & \text{if } in_j > 0 \end{cases} \tag{5}$$

where $0 \leq \gamma_j^{in_j} \leq 1$ are the insurance type specific as well as age-dependent coinsurance rates.

2.5 Insurance Sector

We model the U.S. health insurance system, which consists of private health insurance markets and public health insurance programs. In the model there are two types of private insurance policies available: an individual health insurance plan (IHI) and a group health insurance plan (GHI). Individuals are required to buy insurance one period prior to the realization of the health shock in order to be covered by insurance. The insurance policy needs to be renewed every period.[8] IHI can be bought by any individual for an age and health dependent premium denoted, $\text{prem}^{\text{IHI}}\left(j,h\right)$. GHI can only be bought by individuals who have a GHI offer from their employer. GHI offers are randomly assigned to workers at the beginning of each period, which is indicated by random variable $\varepsilon^{\text{GHI}} = 1$. The GHI premium, prem^{GHI}, is tax deductible and insurance companies are not allowed to screen workers by health or age.[9] If a worker is not offered group insurance from the employer, i.e. $\varepsilon^{\text{GHI}} = 0$, the worker can still buy IHI. In this case the insurance premium is not tax deductible and the insurance company screens the worker by age and health status.

The Markov process that governs the group insurance offer probability is a function of the permanent skill type ϑ. Let $\Pr\left(\varepsilon_{j+1}^{\text{GHI}}|\varepsilon_j^{\text{GHI}},\vartheta\right)$ be the conditional probability of an individual's group insurance status at age $j+1$ given the individual's group insurance status at age j. We collect all conditional probabilities for group insurance status in the transition probability matrix $\Pi_{j,\vartheta}^{\text{GHI}}$ which has dimension 2×2 for each permanent skill type and age group.

There are two public health insurance programs available, Medicaid for the poor and Medicare for

[7]We only model discretionary health expenditures. Given the same magnitude of health shocks ε_j^h, a richer individual will therefore outspend a poor individual. This may be realistic in some circumstances, however, a large fraction of health expenditures in the U.S. is non-discretionary (e.g., health expenditures caused by catastrophic health events that require surgery etc.). In such cases a poor individual could still incur large healthcare costs. However, it is not unreasonable to assume that a rich person will outspend a poor person even under these circumstances.

[8]Agents in their first period are thus not covered by any insurance by construction.

[9]An employer can only force a worker to take the plan if the employer pays 100 percent of the premiums or if the worker agreed to take the plan as part of an employment or union agreement. Many GHI plans are not fully subsidized by the employer. If a worker chooses to opt out and buy an individual plan the worker forgoes the employer subsidy as well as the tax deductibility of the insurance premium. However, for a young low-risk worker a cheap individual plan may still be a better option than a GHI plan from an employer. (compare also: http://healthcoverageguide.org/affordable-care-act/additional-issues/employee-rules-and-rights/)

retirees. To be eligible for Medicaid, individuals are required to pass an income and asset test. Let in_j denote the health insurance status at age $j \leq J_w$:

$$in_j = \begin{cases} 0 & \text{if No insurance,} \\ 1 & \text{if Individual health insurance IHI,} \\ 2 & \text{if Group health insurance GHI,} \\ 3 & \text{if Medicaid.} \end{cases}$$

Once an individual reaches early retirement age $j > J_W$, she becomes eligible for social security payments and has the choice to retire. If she retires, she is covered by a combined Medicare/Medicaid program for which she pays premium prem^R. After the individual reaches age $j > J_R$ she is forced to retire so that there are no more labor market and insurance type choices available. The retirement choice periods are therefore restricted to $j \in (J_W, J_R]$.

For simplicity we abstain from modeling insurance companies as profit maximizing firms and simply allow for a premium markup ω to cover loading costs. Since insurance companies in the individual market screen customers by age and health, we impose a separate clearing condition for each age-health type (j, h) :

$$\begin{aligned} & \left(1+\omega_{j,h}^{\text{IHI}}\right)\mu_j \int \left[1_{[in_j(x_j,h)=1]}\left(1-\gamma_j^{\text{IHI}}\right)p_m^{\text{IHI}} m_{j,h}\left(x_{j,h}\right)\right] d\Lambda\left(x_{j,-h}\right) \qquad (6) \\ = \quad & R\mu_{j-1}\int \left(1_{[in_{j,h}(x_{j-1,h})=1]}\text{prem}^{\text{IHI}}\left(j-1,h\right)\right) d\Lambda\left(x_{j-1,-h}\right), \quad \text{for } j=\{2,...,J_R\} \end{aligned}$$

where $x_{j,h}$ is the state vector not containing h. The clearing condition for the GHI company is

$$\begin{aligned} & \left(1+\omega^{\text{GHI}}\right)\sum_{j=2}^{J_R}\mu_j \int \left[1_{[in_j(x_j)=2]}\left(1-\gamma^{\text{GHI}}\right)p_m^{\text{GHI}} m_j\left(x_j\right)\right] d\Lambda\left(x_j\right) \qquad (7) \\ = \quad & R\sum_{j=1}^{J_R-1}\mu_j \int \left(1_{[in_{j+1}(x_j)=2]}\text{prem}^{\text{GHI}}\right) d\Lambda\left(x_j\right), \end{aligned}$$

where $\omega_{j,h}^{\text{IHI}}$ and ω^{GHI} are markup factors that determine loading costs (fixed costs or profits), $1_{[in_j(x_j)=1]}$ is an indicator function equal to unity whenever individuals buy the IHI policy, $1_{[in_j(x_j)=2]}$ is an indicator function equal to unity whenever individuals buy the GHI policy, prem^{IHI} and prem^{GHI} are the insurance premiums, γ^{IHI} and γ^{GHI} are the coinsurance rates, and p_m^{IHI} and p_m^{GHI} are the prices for healthcare services for the two insurance types. The premium markups generate profits that are redistributed in equal amounts to all surviving individuals.

Notice that ex-post moral hazard and adverse selection issues arise naturally in the model due to information asymmetry. Insurance companies cannot directly observe an individual's idiosyncratic health shocks and have to reimburse her based on the observed levels of healthcare spending. Adverse selection arises because insurance companies cannot observe the risk type of individuals and therefore cannot price insurance premiums accordingly. They instead have to charge an average premium that clears the insurance companies' profit condition.[10]

2.6 Household Problem

Workers. Individuals at age $j \leq J_R$ make a labor market and insurance decision. Beginning at age $j > J_W$ they become eligible for pension benefits and, if they stop working, for public health insurance.[11] They then also pay a Medicare premium. The state vector of a worker is defined as $x_j = \left(a_j, h_{j-1}, \vartheta, \varepsilon_j^\ell, \varepsilon_j^h, \varepsilon_j^{GHI}, in_j\right)$, where a_j is the capital stock at the beginning of the period, h_{j-1} is the health state at beginning of the period, ϑ is the skill type (there will be four permanent skill-types), ε_j^ℓ is a positive labor productivity shock, ε_j^h is a negative health shock, $\varepsilon_j^{\text{GHI}}$is the employer matching indicator that determines whether an individual is able to purchase GHI, and in_j is the insurance state at the beginning of the period. Note that, $x_j \in D_W \equiv R_+ \times R_+ \times \{1,4\} \times R_+ \times R_- \times \{0,1\} \times \{0,1,2,3\}$.

Given state variables, individuals simultaneously decide their consumption c_j, labor supply ℓ_j, healthcare expenditures m_j, asset holdings for the next period a_{j+1}, and insurance choice in_{j+1} to maximize their expected lifetime utility. The household optimization problem for workers $j = \{1, ..., J_R\}$ can be formulated recursively as

$$\begin{aligned} V(x_j) &= \max_{\{c_j, \ell_j, m_j, a_{j+1}, in_{j+1}\}} \left\{ u(c_j, h_j, \ell_j) + \beta \left(\pi_j E\left[V(x_{j+1}) \mid \varepsilon_j^\ell, \varepsilon_j^h, \varepsilon_j^{GHI} \right] + (1-\pi_j) b(a_{j+1}) \right) \right\} \\ & \quad s.t. \end{aligned} \tag{8}$$

$$\begin{aligned} \left(1+\tau^C\right) c_j + (1+g) a_{j+1} + o(m_j) &+ 1_{\{\ell_j>0 \wedge in_{j+1}=1\}} \text{prem}^{\text{IHI}}(j,h) + 1_{\{\ell_j>0 \wedge in_{j+1}=2\}} \text{prem}^{\text{GHI}} \\ +1_{[\ell_j=0 \wedge j > J_W]} \text{prem}^{\text{Mcare}} &= y_j^W - tax_j + t_j^{\text{SI}}, \\ 0 &\leq a_{j+1},\ 0 \leq \ell_j \leq 1,\ \text{and } (4), \end{aligned}$$

where

$$\begin{aligned} y_j^W &= e\left(\vartheta, h_j, \varepsilon_j^\ell\right) \times \ell_j \times w + 1_{[j > J_W]} t_j^{\text{Soc}}(j_r) + R\left(a_j + t^{\text{Beq}}\right) + \text{profits}, \\ tax_j &= \tilde{\tau}\left(\tilde{y}_j^W\right) + tax_j^{SS} + tax_j^{\text{Mcare}}, \\ \tilde{y}_j^W &= y_j^W - a_j - t^{\text{Beq}} - 1_{[in_{j+1}=2]} \text{prem}^{\text{GHI}} - 0.5\left(tax_j^{SS} + tax_j^{\text{Med}}\right), \\ tax_j^{SS} &= \tau^{\text{Soc}} \times \min\left(\bar{y}_{ss},\ e\left(\vartheta, h_j, \varepsilon_j^\ell\right) \times \ell_j \times w - 1_{[in_{j+1}=2]} \text{prem}^{\text{GHI}}\right), \\ tax_j^{\text{Mcare}} &= \tau^{\text{Mcare}} \times \left(e\left(\vartheta, h_j, \varepsilon_j^\ell\right) \times \ell_j \times w - 1_{[in_{j+1}=2]} \text{prem}^{\text{GHI}}\right), \\ t_j^{\text{SI}} &= \max\left[0,\ \underline{c} + o(m_j) + tax_j - y_j^W\right]. \end{aligned}$$

[10]Individual insurance contracts do distinguish individuals by age and health status but not by their idiosyncratic health shock.

[11]In MEPS a significant number of individuals between $60-75$ report having GHI from their employers. We therefore assume that individuals who are eligible for social security benefits but continue to work are insured via private health insurance and not Medicare.

Variable τ^C is a consumption tax rate, $o(m_j)$ is out-of-pocket medical spending depending, y_j^W is labor income, assets, bequests, and profits. Variable w is the market wage rate, R is the gross interest rate, t_j^{Beq} denotes accidental bequests, tax_j is total taxes paid, and t_j^{SI} is social insurance (e.g., food stamp programs). Taxable income is denoted $\tilde{y}_j^W$ which is composed of wage income and interest income on assets, interest earned on accidental bequests, and profits from insurance companies and medical services providers minus the employee share of payroll taxes and the premium for health insurance. The payroll taxes are tax_j^{SS} for the Social Security paid on wage income below $\bar{y}_{ss}$ (i.e., \$106,800 in 2010) and tax_j^{Mcare} for Medicare. Individuals can only buy IHI or GHI if they have sufficient funds to do so. The social insurance program t_j^{SI} guarantees a minimum consumption level $\underline{c}$. If social insurance is paid out then automatically $a_{j+1} = 0$ and $in_j = 3$ (Medicaid) so that social insurance cannot be used to finance savings and private health insurance.

Retirement Choice. Individuals start receiving age dependent social security benefits once they hit the early retirement age of J_W. Individuals choose the time of retirement at age $j_r \in (J_W, J_R]$ via their labor supply choice, $\ell_j = 0$. After leaving the labor force, the only remaining idiosyncratic shock for retirees is the health shock ε_j^h. Retirees are also eligible for public health insurance (i.e., a combination of Medicare, Medicaid and Disability Insurance) and do not buy any more private health insurance but start paying the Medicare premium $\text{prem}^{\text{Mcare}}$.

Retirees. Individuals older than J_R are fully retired and do not make any labor market or insurance decisions anymore. Their state vector therefore reduces to $x_j = \left(a_j, h_{j-1}, \varepsilon_j^h\right) \in D_R \equiv R_+ \times R_+ \times R_-$ and the household problem is:

$$V(x_j) = \max_{\{c_j, m_j, a_{j+1}\}} \left\{ u(c_j, h_j) + \beta\left(\pi_j E\left[V(x_{j+1}) \mid \varepsilon_j^h\right] + (1-\pi_j)\, b(a_{j+1})\right)\right\} \quad (9)$$

$$s.t.$$

$$\begin{aligned} \left(1+\tau^C\right) c_j + (1+g)\, a_{j+1} + \gamma^{\text{Mcare}} \times p_m^{\text{Mcare}} \times m_j + \text{prem}^{\text{Mcare}} &= y_j^R - tax_j + t_j^{\text{SI}}, \\ a_{j+1} &\geq 0, \end{aligned}$$

where

$$\begin{aligned} y_j^R &= t_j^{\text{Soc}}(j_r) + R \times \left(a_j + t_j^{\text{Beq}}\right) + \text{profits}, \\ tax_j &= \tilde{\tau}\left(\tilde{y}_j^R\right), \\ \tilde{y}_j^R &= t_j^{\text{Soc}} + r \times \left(a_j + t_j^{\text{Beq}}\right) + \text{profits}, \\ t_j^{\text{SI}} &= \max\left[0, \underline{c} + \gamma^{\text{Mcare}} \times p_m^{\text{Mcare}} \times m_j + tax_j - y_j^R\right]. \end{aligned}$$

Variable y_j^R is wealth, $t_j^{\text{Soc}}(j_r)$ are pension payments that depend on the retirement age j_r and $\tilde{y}_j^R$ is total taxable income of a retired person. For each $x_j \in D_j$ let $\Lambda(x_j)$ denote the measure of age j individuals with $x_j \in D_j$. The fraction $\mu_j \Lambda(x_j)$ then denotes the measure of age-j individuals with $x_j \in D_j$ with respect to the entire population of individuals in the economy.

2.7 Government

The government runs a pay-as-you-go (PAYG) social security system and a tax and transfer system. The social security system is self-financed via a payroll tax according to

$$\sum_{j=J_W+1}^{J} \mu_j \int t_j^{\mathrm{Soc}}(x_j)\, d\Lambda(x_j) = \sum_{j=1}^{J_R} \mu_j \int tax_j^{SS}(x_j)\, d\Lambda(x_j) \tag{10}$$

In addition the government administers a social insurance program T^{SI} (e.g., foodstamps, Temporary Assistance for Needy Families (TANF), Supplemental Security Income (SSI), etc.), Medicaid, as well as exogenous government consumption C_G which is treated as unproductive. In order to quality for Medicaid an individual's income $\tilde{y}_j^W$ needs to be below a measure tied to the federal poverty level $\mathrm{FPL}_{\mathrm{Maid}}$ and her assets need to be below the asset threshold of $\bar{a}_{Maid}$.[12]

Health insurance for the old—a combination of Medicare, Medicaid and Disability Insurance—is included in the general budget constraint. The government uses a Medicare payroll tax on workers as well as Medicare Plan B premiums to cover some of the cost of this program. The government taxes consumption at rate τ^C and income at a progressive tax rate to finance its spending programs. The government budget is balanced in each period so that

$$\begin{aligned}
& C_G + \sum_{j=1}^{J} \mu_j \int t_j^{\mathrm{SI}}(x_j)\, d\Lambda(x_j) + \overbrace{\sum_{j=2}^{J_R} \mu_j \int \left(1-\gamma^{\mathrm{MAid}}\right) p_m^{\mathrm{MAid}} m_j(x_j)\, d\Lambda(x_j)}^{\text{Medicaid for workers}} \\
& \underbrace{+ \sum_{j=J_W+1}^{J} \mu_j \int \left(1-\gamma^{\mathrm{Mcare}}\right) p_m^{\mathrm{Mcare}} m_j(x_j)\, d\Lambda(x_j)}_{\text{Medicare/Medicaid}} \\
= & \sum_{j=1}^{J} \mu_j \int \left[\tau^C c(x_j) + tax_j(x_j)\right] d\Lambda(x_j) + \sum_{j=J_W+1}^{J} \mu_j \int \mathrm{prem}^{\mathrm{Mcare}}(x_j)\, d\Lambda(x_j) \\
& + \sum_{j=1}^{J_R} \mu_j \int tax_j^{\mathrm{Mcare}}(x_j)\, d\Lambda(x_j),
\end{aligned} \tag{11}$$

where γ^{MAid} is the coinsurance rate of Medicaid, p_m^{MAid} is the price of medical services for individuals on Medicaid, γ^{Mcare} is the coinsurance rate for individuals on Medicare and p_m^{Mcare} is the price for medical services for the retired.

Bequests are redistributed in a lump-sum fashion to working households

$$\sum_{j=1}^{J_W} \mu_j \int t_j^{\mathrm{Beq}}(x_j)\, d\Lambda(x_j) = \sum_{j=1}^{J} \int \tilde{\mu}_j a_j(x_j)\, d\Lambda(x_j), \tag{12}$$

[12] We do not use the FPL directly as this would grossly overstate the fraction of the population on Medicaid. The income threshold measure used in the model as well as the asset test threshold are both calibrated to match the fraction of the population on Medicaid by age group over the lifecycle.

where μ_j and $\tilde{\mu}_j$ denote the surviving and deceased population at age j in time t, respectively. We provide a definition of equilibrium in Appendix Section 6.1.

3 Parameterization and Calibration

We briefly discuss our calibration of the model. There are two sets of parameters: *externally* selected parameters and *internally* calibrated parameters. The former is either based on our own estimates from the Medical Expenditure Panel Survey (MEPS) or estimates provided by previous studies. The later is calibrated so that model-generated data match a given set of targets from U.S. data. We summarize the external parameters in Table 1 and the internal parameters in Table 2. Model generated data moments and target moments from U.S. data are juxtaposed in Table 3.[13]

3.1 Technologies and Firms

We set the capital share $\alpha = 0.33$ and the annual capital depreciation rate at $\delta = 0.1$, which are both similar to standard values in the calibration literature (e.g., Kydland and Prescott (1982)). The capital share in production in the healthcare sector is lower at $\alpha_m = 0.26$ which is based on Donahoe (2000) and our own calculations. Total factor productivity A is normalized to one. A_m is chosen to match the size of the healthcare sector. We abstract from changes in production technologies or other possible causes of excess cost growth in the U.S. health sector but do provide sensitivity analysis with respect to total factor productivity.

3.2 Demographics

One model period is defined as 5 years. We model households from age 20 to age 95 which results in $J = 15$ periods. The retirement choice periods are $j \in (J_W, J_R] = (8, 12]$. Once the individual enters period 13, i.e. age 80, she is forced to retire. The annual conditional survival probabilities, supplied by CMS, are adjusted for period length. We use the survival probabilities together with CMS estimates for the relative cohort sizes μ_j and solve for population growth as a residual using expression (3).[14] In the model the total population over the age of 65 is 17.7 percent which is very close to the 17.4 percent in the census.

3.3 Preferences and Endowments

Fixed cost of working $\bar{\ell}_j$ is set to match labor hours per age group. Parameter $\sigma = 3.0$ and the time preference parameter $\beta = 0.98$ to match the capital output ratio and the interest rate. The consumption intensity parameter η is 0.43 to match the aggregate labor supply and κ is 0.75 to match the ratio between final goods consumption and medical consumption. In conjunction with the health productivity parameters

[13]Our calibration strategy is similar to Jung and Tran (2016). More details of our calibration strategy and the solution algorithm can be found in that paper.

[14]Population growth does not enter the household maximization problem directly. Is used as a normalization factor in the aggregation of household variables.

ϕ_j and ξ from expression (4) these preference weights also ensure that the model matches total health spending and the fraction of individuals with health insurance per age group.

The age-specific labor efficiency unit $e\left(\vartheta, h_j, \varepsilon_j^{\ell}\right)$ has three components: (i) a deterministic lifecycle component depending on skill type, (ii) a relative health status component and (iii) a stochastic labor productivity component. We assume the following function

$$e_j\left(\vartheta, h_j, \varepsilon^{\ell}\right) = \overbrace{\left(\overline{e}_{j,\vartheta}\right)^{\chi}}^{(i)} \times \overbrace{\left(\exp\left(\frac{h_j - \overline{h}_{j,\vartheta}}{\overline{h}_{j,\vartheta}}\right)\right)^{1-\chi}}^{(ii)} \times \overbrace{\varepsilon^{\ell}}^{(iii)} \text{ for } \ j = \{1, ..., J_R\}. \tag{13}$$

We allow 4 permanent skill types ϑ based on wage quartiles using MEPS data. Variable $\overline{e}_{j,\vartheta}$ is approximated by average hourly wages per skill type, it is hump-shaped over the lifecycle and reflects the productivity of an individual with average health status of this particular age j and skill type ϑ. The idiosyncratic health effect is measured as deviation from the average health status $\overline{h}_{j,\vartheta}$ of a particular age/skill group. In order to avoid negative numbers we use the exponent function. Parameter $\chi = 0.85$ measures the relative weight of the average productivity vs. the individual health effect. Finally, the idiosyncratic labor productivity shock ε^{ℓ} is based on Storesletten, Telmer and Yaron (2004). We discretize this process into a five state Markov process following Tauchen (1986).

3.4 Health Capital

We use the health index Short-Form 12 Version 2 ($SF-12v2$) from MEPS as a measure of health capital.[15] In the model we define a 15 point grid for health capital with a minimum health capital level of h_m^{min} and a maximum health capital level of h_m^{max}. We first set h_m^{max} as a free parameter and map the health index from MEPS data to the health capital grid in the model using h_m^{max} as normalization parameter. The lower bound of the health grid $h_m^{\min}$ is calibrated. We chose a relatively low number of grid points to reduce the computational burden.

We next place individuals of each age group into four health groups based on health capital quartiles where group 1 has health capital in the top quartile (best health) whereas group 4 has health capital in the bottom quartile (worst health). We then assume that individuals in group 1 only experience negligibly small or no health shocks, whereas individuals of the other health groups experience negative health shocks of larger magnitudes that we refer to as "small" for group 2, "moderate" for group 3 and "large" for group 4.

In order to compute the magnitudes of health shocks, we calculate the average health capital of group i at age j, $\bar{h}_{j,d}^{i}$ with $i = \{1, 2, 3, 4\}$. The average health capital per age group is denoted $\left\{\bar{h}_{j,d}^{1} > \bar{h}_{j,d}^{2} > \bar{h}_{j,d}^{3} > \bar{h}_{j,d}^{4}\right\}$. We measure the shock magnitude in terms of relative distance from an average health state of each group to the average health state of group 1, $\left(\bar{h}_{j,d}^{\{i\}} - \bar{h}_{j,d}^{1}\right)$. The vector of shock magnitude in percentage deviation is defined as $\varepsilon_j^{h\%} = \left\{0, \frac{\bar{h}_{j,d}^{2}-\bar{h}_{j,d}^{1}}{\bar{h}_{j,d}^{1}}, \frac{\bar{h}_{j,d}^{3}-\bar{h}_{j,d}^{1}}{\bar{h}_{j,d}^{1}}, \frac{\bar{h}_{j,d}^{4}-\bar{h}_{j,d}^{1}}{\bar{h}_{j,d}^{1}}\right\}$. This vector is scaled by the maximum health capital

[15] The $SF-12v2$ is a continuous variable with values between 0 (worst health) and 100 (best health). It includes twelve health measures of physical and mental health and is widely used to assess health improvements after medical treatments in hospitals. See Ware, Kosinski and Keller (1996) for further details about this health index.

level in the model $h_m^{\max}$ and used as the shock levels in the model. The transition probability matrix of health shocks Π^h is calculated by counting how many individuals move across health groups between two consecutive years using MEPS data. We adjust these annual probabilities for period length.

The natural rate of health depreciation δ_j^h per age group is calculated by focusing on individuals with group insurance and zero health spending in any given year. We assume that such individuals did not incur a negative health shock in this period as they could easily afford to buy medical services m to replenish their health due to their insurance status. This allows us to pin down the deterministic age-dependent depreciation rate from expression (4).

There are no suitable estimates for health production processes in the macro/health literature. A recent empirical contribution by Galama et al. (2012) finds weak evidence for decreasing returns to scale which implies $\xi < 0$. We calibrate ξ and ϕ_j together to target aggregate health expenditures and the medical expenditure profile over the lifecycle (see Figure 3).

3.5 Insurance Sector

Group Insurance Offer. MEPS data contain information about whether individuals have received a group health insurance offer from their employer i.e., offer shock $\varepsilon^{GHI} = \{0, 1\}$.[16] The transition matrix Π^h with elements $\Pr\left(\varepsilon_{j+1}^{\text{GHI}} | \varepsilon_j^{\text{GHI}}, \vartheta\right)$ depends on the permanent skill type ϑ. We then count how many individuals with a GHI offer in year j are still offered group insurance in $j+1$. We smooth the transition probabilities and adjust for the five-year period length.

Coinsurance Rates and Insurance Premiums. The coinsurance rate is defined as the fraction of out-of-pocket health expenditures over total health expenditures. Coinsurance rates therefore include deductibles and copayments. Estimates of coinsurance rates of γ^{IHI}, γ^{GHI}, γ^{MAid} and γ^{Mcare} for individual, group, Medicaid and Medicare insurance are based on MEPS data.

Insurance premiums are set according to a person's age and health status in IHI markets. The IHI company sets premium, $\text{prem}^{\text{IHI}}(j,h)$, to clear expression (6). Age and health dependent markup profits $\omega_{j,h}^{\text{IHI}}$ are calibrated to match the IHI take-up rate for each age group in the model. Similarly, the GHI company sets premium, prem^{GHI}, to clear expression (7) and the markup profit ω^{GHI} is calibrated to match the insurance take-up rate of GHI.

Price of Medical Services. The healthcare sector produces and supplies medical services. The base price of medical services p_m is endogenous and clears the medical services market. The actual prices that households pays differ from the base price and depend on insurance specific markups. Shatto and Clemens (2011) report that reimbursement rates of Medicare and Medicaid are close to 70 percent of the price paid by private health insurance who themselves pay lower prices than the uninsured due to their market power (see Phelps (2003)). Various studies have found that uninsured individuals pay an average markup of 60 percent or more for prescription drugs as well as hospital services (see *Playing Fair, State Action to Lower Prescription Drug Prices* (2000), Brown (2006), Anderson (2007), Gruber and Rodriguez (2007)).

[16] We use OFFER31X, OFFER42X, and OFFER53X where the numbers 31, 42, and 53 refer to the interview round within the year (individuals are interviewed five times in two years). We assume that an individual was offered GHI when either one of the three variables indicates so.

Based on this information we assume the following markup factors that together with the base price p_m determine the medical prices per insurance type in the model:

$$\left[p_m^{\text{noIns}}, p_m^{\text{IHI}}, p_m^{\text{GHI}}, p_m^{\text{Maid}}, p_m^{\text{Mcare}}\right] = p_m \times [1.70,\, 1.25,\, 1.10,\, 1.0,\, 0.90].$$

Medicaid and Medicare remain the programs that pay the lowest prices for medical services. This relative markup structure is held constant throughout all experiments. Thus, we implicitly assume that healthcare providers cannot renegotiate reimbursement rates.

3.6 Government

Social Security. The standard retirement age in the model is 65, however, early retirement benefits are available at age 62. In the model individuals start drawing social security benefits one period before the standard retirement age of 65 but do not receive full benefits in that period. Benefit payments are a function of age and skill type so that $t_j^{\text{Soc}}(\vartheta) = \Psi_j(\vartheta) \times w \times \bar{L}(\vartheta)$, where $w \times \bar{L}(\vartheta)$ is average labor income by skill type and $\Psi_j(\vartheta)$ is an age-dependent replacement rate. We adjust replacement rates to match the total size of pension payments by skill type as well as the fractions of retirees receiving social security benefits beginning with age 60. Total pension payments amount to 6.1 percent of GDP, similar to the number reported in the budget tables of the Office of Management and Budget (OMB) for 2008.

Medicare and Medicaid. According to data from CMS (Keehan et al. (2011)) the share of total Medicaid spending of individuals older than 65 is about 36 percent. Adding this amount to the total size of Medicare results in public health insurance payments to the old of 4.16 percent of GDP. Given a coinsurance rate of $\gamma^R = 0.20$, the size of the combined Medicare/Medicaid program in the model is 3.1 percent of GDP.[17] The premium for Medicare is 2.11 percent of per capita GDP as in Jeske and Kitao (2009).

According to MEPS data, 9.2 percent of working age individuals are on some form of public health insurance. We therefore set the Medicaid eligibility level in the model to 70 percent of the FPL so that $\text{FPL}_{\text{Maid}} = 0.7 \times \text{FPL}$, which is close to the average state eligibility level according to Kaiser (2013) and calibrate the asset test level, $\bar{a}_{Maid}$, to match the Medicaid take-up rate.[18] Setting the age dependent coinsurance rate for Medicaid γ_j^{Maid} to MEPS levels, Medicaid for workers is 0.56 percent of GDP in the model which underestimates Medicaid spending of workers in MEPS.[19]

Taxes. We use the formula from Gouveia and Strauss (1994) to calculate the progressive federal income tax as

$$\tilde{\tau}(\tilde{y}) = a_0 \left[\tilde{y} - \left(\tilde{y}^{-a_1} + a_2\right)^{-1/a_1}\right],$$

where $\tilde{y}$ is taxable income. The parameter estimates for this tax polynomial are $a_0 = 0.258$, $a_1 = 0.768$ and $a_2 = 0.031$. The Social Security system is self-financed via a payroll tax of $\tau^{SS} = 9.4$ percent similar to Jeske and Kitao (2009). The Social Security payroll tax is collected on labor income up to a maximum

[17] Our model cannot match the NIPA number because it is calibrated to MEPS which only accounts for about 65-70 percent of healthcare spending in the national accounts (see Sing et al. (2006) and Bernard et al. (2012)).

[18] Compare Remler and Glied (2001) and Aizer (2003) for additional discussions of Medicaid take-up rates.

[19] Overall Medicaid spending in MEPS, workers and retirees, accounts for about 0.95 to 1.02 percent of GDP according to Sing et al. (2006), Keehan et al. (2011) and Bernard et al. (2012).

of \$97,500. The Medicare tax τ^{Mcare} is set to 2.9 percent and is not restricted by an upper limit (see *Social Security Update 2007* (2007)). Finally, the consumption tax rate is set to 5.0 percent (Mendoza, Razin and Tesar (1994) report 5.67 percent). Overall, the model results in total tax revenue of 19.83 percent of GDP. This finances a consumption floor of \$4,000 and residual (unproductive) government consumption of 10.2 percent of GDP.

3.7 Model Performance

Figures 3, 4 and 5 and Table 3 in the Appendix show that the benchmark model matches the relevant and necessary elements of the MEPS data quite well.

Medical Expenditures and Insurance Take-Up. The model closely tracks average medical expenditures by age group (Figure 3, Panel 1) and reproduces the distribution of health expenditures quite well (Figure 3, Panel 2 and 3). Overall, the model generates total health expenditures of 12.6 percent of GDP. In addition, the model matches the insurance take-up percentages of IHI, GHI and Medicaid by age group (Figure 3, Panels 4, 5 and 6 respectively).

Income, Consumption and Labor Supply. The model provides a close fit of average household income over the lifecycle (Figure 4, Panel 2). The model also reproduces the hump-shaped patterns of asset holdings. Due to the warm glow bequest motive individuals maintain relatively large asset holdings until the end of their lifecycle. Finally, the model provides a close fit of consumption and the labor supply over the lifecycle (Panel 4). In addition. the model replicates the labor force participation rates at the end of the lifecycle.

Income Distribution. Figure 5 compares the model income and wage distribution to data from MEPS. The model matches the lower and upper tails of the income distribution with around 12 percent individuals with income below 133 percent of the Medicaid eligibility level (MaidFPL).

Macroeconomic Aggregates. Table 3 summarizes model generated moments and aggregate ratios and compares them to data from MEPS, CMS, and NIPA.

4 Policy Experiments and Results

In this section we conduct a number of policy experiments to understand the effects of population aging on the health insurance system and the effects of the ACA reform in combination with population aging.

4.1 The Effects of Aging without the ACA Reform

In our first experiment, we study the effects of population aging without reforming the healthcare sector. We start from the benchmark economy in 2010 and introduce population aging by adjusting the survival probabilities in the model to match the demographic structure of the U.S. population based on CMS/OACT population forecasts in Figure 6. We then fix the particular demographic structure in a given year and resolve the model for a new steady state leaving all other parameters at their benchmark levels.[20]

[20] We focus on steady state analysis due to computational constraints. We are not able to solve for the full transition paths where all economic variables evolve endogenously with changing demographic structures.

We report the main results in Table 4. In particular, the second column in Table 4 presents the steady state results with the population age structure fixed to projections for 2030. We then repeat this procedure using the predicted demographic structures of the years 2040 and 2060 and repeatedly solve for steady states. "Updating" the age profile of the economy in this way essentially creates a larger share of older individuals in the model by appropriately increasing individual survival probabilities. This allows us to identify the long-run effects of having more older individuals in the economy.

When conducting this type of experiment, crucial assumptions about government policies need to be made. Medicare will grow if we assume that the policymaker does not change the generosity level of Medicare and needs to be financed in a certain way. We need to make assumptions about how the government treats programs like Medicare/Medicaid in reaction to an increased share of elderly individuals. In our benchmark experiment, we assume the following fiscal rules.

The government fixes the Medicare payroll tax at the benchmark level of 2.9 percent. As the size of the older cohorts increases, Medicare spending will grow. Since Medicare is part of the overall budget constraint—compare expression (11)—we adjust the consumption tax rate to cover the extra resources needed for Medicare/Medicaid of the old.[21] On the other hand, Social Security in the model is a self-financing program as can be seen in expression (10). An increase in Social Security spending—due to a larger share of retired cohorts in the overall population—is met by an increase in the Social Security payroll tax τ_{SS}.

Health Insurance Coverage. The results in Table 4 show a fraction of insured workers of around 82 percent by 2060. The fraction of workers covered by IHI increases from 6.97 percent in 2010 to almost 17.98 percent with 2060 demographics. At the same time, the number of workers in GHI decreases significantly from 60.93 to 51.24 percent. These reversed outcomes in IHI and GHI markets are caused by the difference in the premium adjustment process in the two markets. IHI market premiums are charged according to risk type (i.e., age and health capital in the model). Due to the longer lifespans health becomes more desirable. As a consequence health insurance becomes more desirable as well as it helps to insure against large negative health shocks at higher ages that individuals are now more likely to experience. As a result, the take-up of IHI increases and the insurance pools become larger as well as healthier on average so that premiums drop further.

The situation is different for GHI markets. GHI companies do not price discriminate by age and health capital which causes an adverse selection spiral. As the population ages, the GHI pool will contain more of the older, high-risk, types. The GHI premium, an average price for the entire pool, will therefore increase. Despite the fact that insurance itself becomes more desirable overall, the increase in the GHI premiums causes a large group of the younger, low risk types to drop out. As can be seen in Panel [2] of Figure 7, a large group of young individuals in their 20s move out of the GHI market into the IHI market. Overall this leads to a decrease in the GHI take-up rates compared to the benchmark economy with 2010 demographics and an increase in the average GHI premium. This adverse selection spiral is operational despite the fact that GHI premiums are tax deductible which provides an implicit subsidy for GHI. This subsidy becomes larger with population aging as the Social Security tax increases from 9.28 to 14.93 percent with 2060 demographic profiles. In addition we abstract from employers making contributes

[21] In Section 4.3 we alternatively use a payroll tax or residual government consumption to clear the government constraint.

to GHI premiums directly and assume a perfect pass-through to wages. Allowing employer contributions would serve as an additional pooling mechanism that could slow down the unraveling of GHI markets for the younger cohorts.[22]

We also observe an increase in the fraction of workers insured by Medicaid from 9.61 percent with 2010 age profiles to 12.33 percent with 2060 age profiles. This expansion is due to the fact that the Medicaid eligibility threshold, i.e. the Federal Poverty Level, is pegged to median income in the model. As median income increases more individuals become eligible for Medicaid. Finally, the growing fraction of retirees in the population generates a large increase in the fraction of the population on Medicare from 25 percent with 2010 age structure up to 34.5 percent with the age structure predicted for 2060. Among the 60 to 75 year old individuals—that in the model actively decide on whether to retire or not—the fraction of individuals on Medicare increases from 40.15 to 42.52 percent.

We observe a small decrease, down to 79.21 percent, in the fraction of insured workers in 2040. The main reason for this "dip" is that the 2040 demographic profile weighs the population most heavily towards retirees as can be seen in Figure 6. This has repercussions on the insurance markets of the working-age population. The change in the demographics of 2040 causes an unusually large drop in the IHI market share. As can be seen in Panel [1] of Figure 7, IHI take-up rates increase among 25 to 40 year olds but decrease for 40 to 55 year olds. The overall reduction of the higher risk working population leads to the shrinking of the IHI market. In addition, the shrinking of the risk sharing pool of the working population causes an increase in GHI premiums. This effect leads to some of the younger low-risk workers dropping out of the GHI markets as depicted in Panel [2] of Figure 7. Overall, the participation in the GHI market decreases due to higher premiums. A fraction of the lower risk population that chooses to exit the GHI markets moves into Medicaid. This subsequently leads to an extension of Medicaid coverage across all working ages.

Health Spending. The increased proportion of retirees, who face larger health shocks in general, also generates a substantial increase in medical spending as reported in Table 4. Aggregating the entire sector we find that the level of health spending increases 28.6 percent with 2030 demographics and 39.84 percent with 2060 demographics, compared to 2010. It is important to note that the increases in health spending are not only driven by the increase in demand for healthcare but also by changes in health financing sources. The later is caused by movements within the health insurance system and changes in health insurance coverage. There is a significant drop in health expenditure of the uninsured as the fraction of the uninsured falls. On the other hand, there is a massive increase in health expenditure covered by public insurance programs. By 2060 health expenditures covered by Medicare and Medicaid will be higher by 90.24 percent and 70.12 percent, respectively. Health expenditure, financed via IHI, increases by 58 percent. Despite the decrease in GHI take-up, health expenditure covered by GHI still increases by 11.88 percent with 2060 demographics. This result indicates that the increase in health spending is mainly funded by public insurance.

Fiscal Cost. Aging results in large fiscal costs associated with the three age-related government spending programs: PAYG Social Security, Medicare and Medicaid. The consumption tax rate increases

[22] We would like to thank an anonymous referee for bringing the increase in the implicit subsidies due to higher Social Security taxes as well as the employer contribution restriction and its pooling effect to our attention.

from 5 percent in the benchmark to 9.09 percent with 2060 demographics when more tax revenue is required to fund Medicare. The remaining tax implications are as expected. The Social Security tax rate increases from 9.28 percent with 2010 demographics to 14.93 percent with 2060 demographics in order to keep the Social Security system in balance. Overall, in response to the change in age-related government spending, the total tax revenue as a share of GDP rises from 19.83 percent with 2010 demographics up to 25.23 percent with 2060 demographics if we keep the fraction of government consumption as percent of GDP at the benchmark level of 2010. This increase is predominantly driven by the growth of Medicare/Medicaid as well as Social Security.

Household and Aggregate Variables. Households optimally adjust their consumption, savings and labor supply over the lifecycle to respond to the increase in longevity. We observe an increase in the average weekly work hours as well as a delay of retirement. Among the group of 60-75 year olds who, in the model, decide on whether to retire or not, the fraction of retirees increases from 40.15 to 42.52 percent with 2060 age profiles. We also observe a large shift in the consumption patterns of households. Households increase their consumption of medical services by up to 45.36 percent whereas the consumption of the aggregate consumption good almost stagnates and only increases by 3.23 percent despite the large increase of GDP of 9.64 percent with 2060 demographics. As individuals start to invest not only in physical capital but also into their health (capital) due to the longer lifespans, the large growth in the medical sector leads is the main driver of overall GDP growth (compare the first row of Table 4). This growth channel is the result of including health investments as part of the household decision problem as well as explicitly modeling the the medical production sector.

The aggregate implications of aging center around three main developments. First, the average worker is becoming older and is thus earning a higher level of labor income. Second, the older households also hold more assets which generates a larger capital stock for the production sectors. Third, the higher probability of survival adds savings incentives. The first feature dominates the results with 2030 demographics. We observe a 8.11 percent rise in capital stock used for non-medical services production and a 40.89 percent rise in capital stock used for medical services production. With 2040 demographics the growth in the number of retirees dominates the growth in the working age population. This can be seen by the slight drop in the health capital and labor supply aggregates. Still the medical sector continues to expand due to the effects described earlier. It is important to note that the growth channel is not operational in previous models that abstract from health investments and treat healthcare spending as exogenous shocks.

Aging has fairly standard effects on market prices. The decline in the proportion of working age households restricts the supply of labor and increases wages. At the same time, older households hold more assets/capital which increases the supply of capital and decreases interest rates. We find that aging increases wages by about 3.72 percent and interest rates decrease from 4.49 to 3.77 percent when comparing the economy with 2060 demographics to steady states calculated based on 2010 demographics.

4.2 The Effects of Aging in Combination with the Affordable Care Act

In March 2010 the Obama administration introduced a comprehensive health reform at the federal level via the *Affordable Care Act* (ACA). The reform is intended to be a serious effort toward solving the problem of the uninsured and promoting universal health insurance coverage. From an economic point of view, the most notable features of the ACA are intended to correct partial market failures in the insurance markets which will allow more individuals to participate in the insurance markets. The reform has two key features: (*i*) an insurance mandate enforced by penalties and subsidies, and (*ii*) an expansion of Medicaid. The former is a market based approach that relies on new regulation of private health insurance markets, while the latter relies on extending already existing public health insurance programs. Most of the reform is financed by taxes on higher income individuals which add an element of wealth redistribution.[23]

In this section we analyze the effects of population aging and the ACA reform. In order to calculate these effects, we first change the population profiles using projections from CMS/OACT for the depicted target years as in the previous section. We then fix the population structure for a specific target year and then re-solve for a new steady state including the ACA features discussed in Appendix B. Table 5 provides the effects of aging under the ACA in levels, normalized to the benchmark values in 2010. This is similar to the normalization in Table 4 where we discussed aging without the ACA. However, in order to isolate the net effects of the ACA reform in an aging economy we differentiate Table 4 from Table 5 and present each variable as percentage deviation:

$$\frac{(\text{Table 5: Aging \& ACA in year } t\text{) - (Table 4: Aging only in year } t\text{)}}{(\text{Table 4: Aging only in year } t\text{)}} \times 100$$

for $t \in \{2010, 2030, 2040, 2060\}$ in Table 6. Our discussion focuses on this table.

Health Insurance Coverage. The long-run impact of the ACA changes significantly with the population age structure. Solving the model with 2060 demographics, the net impact of the ACA reform is a 18.23 percent rise in worker insurance take-up (see last column in Table 6). We also report the effects of aging on the insurance take-up rates with and without the ACA in Figure 8 where we show the health insurance take-up rates over the lifecycle for 2060 with and without the ACA.

Panel [1] shows that the ACA increases the market share of IHI for 30 to 75 year olds but decreases the market share of IHI for the youngest cohort. Many of the young become eligible for Medicaid as the ACA expands the income eligibility threshold and removes the asset test as depicted in Panel [3]. In addition, the ACA stabilizes the GHI market as shown in Panel [2] (dotted line with star markers). The insurance mandate effectively prevents the adverse selection spiral in GHI that was triggered by aging in the previous section. However, some low income workers between 55 to 75 do become eligible for Medicaid so that the GHI market share for those cohorts shrinks. Finally, the ACA also induces individuals to delay retirement as can be seen in Panel [4] which shows a markedly lower fraction of individuals between age 60-75 on Medicare. Figures 9 and 10 demonstrate the importance of the ACA in extending the insurance coverage for workers for all simulation periods. Overall, the ACA expands the market shares of IHI, GHI and Medicaid for all demographic environments between 2010 and 2060.

We calculate large changes in insurance premiums over time with the introduction of the ACA. The average IHI premium (averaged over all age and health types) increases by 68.71 percent whereas the GHI premium decreases by 27.77 percent. The latter is the result of the youngest cohort staying in the GHI pool as can be seen in Panel 2 of Figure 8. These premium effects remain fairly stable across all demographic simulations.

[23]See Appendix B for a detailed description of how the ACA is implemented in our model.

Health Spending. The effects of the ACA on healthcare spending vary greatly depending on the scope of the analysis. As reported in Table 6, aggregate consumption of medical services increases by 1.17 percent, while medical spending decreases by 2.8 percent with 2010 demographics. The decrease in health spending due to the ACA shrinks to about 1.75 with 2060 demographics. This decrease is brought on by changes in the financing source of medical spending. The ACA moves a large group of uninsured individuals into insurance markets where they are charged lower prices for medical services. Dis-aggregating medical spending further we find that the ACA reduces medical spending by the uninsured by 80.94 percent, while it increases medical spending of both Medicaid and IHI participants by 65.77 percent and 72.6 percent, respectively. The expansion of Medicaid is caused by expanding the eligibility income thresholds, whereas the increase in IHI spending is triggered by subsidies and shifts in spending types within IHI. The subsidies make it possible for high risk types to enter into IHI contracts so that overall spending of IHI types as a group is higher.

On the flip side, we observe a large drop in the spending of the uninsured due to the ACA. Using the 2030 age structure the ACA decreases the medical spending of the uninsured by 80.96 percent. This of course has to do with the fact that the total number of uninsured workers is much lower under the ACA. Only 0.24 percent of workers under age 60 are uninsured under the ACA with 2030 demographics (compare Table 5) as opposed to 22.49 percent of workers without the ACA and 2030 demographics (compare column 2 in Table 4). As the population ages, the ability of the ACA to insure additional workers diminishes. Using 2060 demographics we calculate that the ACA adds a net of 18.23 percent of workers into insurance. In an economy with an older age structure more individuals are covered by Medicare, so that the effect of the ACA, which in our model primarily affects the working age cohorts, is weaker.

Fiscal Cost. The tax implications are as expected. The introduction of the ACA is primarily financed by a payroll tax of 3.64 percent with 2010 demographics and 3.94 percent with 2060 demographics. The consumption tax is the residual tax that clears the government budget and specifically finances the expansion of Medicare (due to the larger share of elderly in the economy) as well transfers that are tied to the overall size of GDP (e.g., government consumption is a fixed fraction of GDP). The consumption tax rate that finances aging as Medicare is part of the overall government budget constraint is 1.44 percentage point lower with the ACA than without. The other tax rates and sources of revenue remain relatively stable over the duration of the simulation compared to the results without the ACA reform. With the ACA the total tax revenue as a fraction of GDP increases to 26.8 percent in 2060 (up from 19.83 percent in the 2010 benchmark without the ACA), which is roughly 1.57 percent higher than when comparing to the 2060 case without ACA. We can interpret this as an aggregate measure of the fiscal cost of the ACA.

The fiscal costs of Medicare and Medicaid measured in terms of GDP are smaller compared to recent CBO estimates. According to CBO (2012) the size of Medicare and Medicaid in 2037 will be around 210 percent and 160 percent of 2012 levels, respectively. In our analysis, we find that the size of Medicare and Medicaid in 2040 will be 164.38 percent and 270.11 percent of 2010 levels, respectively or 5.12 and 1.63 percent of GDP, respectively. These differences are mainly due to the differences in the modeling approaches. Our micro-founded macroeconomic model fully accounts for behavioral responses, structural changes in the U.S healthcare sector, and general equilibrium price adjustments, which are partly missing in the CBO forecasts (compare CBO (2007)). We discuss why the size of Medicare in a general equilibrium setting is smaller than in a partial equilibrium analysis in Section 4.3.

Household and Aggregate Variables. Figure 11 presents the combined effects on the average labor market behavior over the lifecycle. Households younger than 60 decrease their labor supply slightly due to tax distortions and households older than 60 increase their labor supply as depicted in Panel [1]. In addition, they stay longer in the labor force as depicted in Panel [2]. One of the reasons is that the ACA leads to better health which maintains a relatively higher labor productivity as the individual ages. Individuals take advantage of this by increasing their labor supply (slightly) towards the end of their work-life compared to a world without the ACA where they work fewer hours and drop out of the labor force sooner. At the aggregate level, we observe a small increase in average weekly work hours by 1.6 hours in 2060. The combined effects of aging and the ACA on average work hours is similar to Kitao (2014*a*) who analyzes the effects of aging and social security reform in the U.S.

The ACA causes tax distortions which decrease GDP by 2.35 percent using the 2010 population-age structure. The adverse effect on GDP is relatively stable as we "age" the cohorts but decreases slightly with each decade. The decrease in GDP is partly caused by a redistribution of capital between the two sectors. Capital in the non-medical sector K_c decreases by about 2.31 percent, whereas capital in the medical sector K_m increases by about 0.32 percent. Human capital follows a similar trend. These changes in capital persist when solving the model with a higher percentage of older cohorts (i.e. 2030, 2040, and 2060), though at muted levels. One of the explanations for this shift is the increase in the consumption tax rate which increases the relative price of consumption compared to medical consumption. In addition, the negative income effect at the aggregate level caused by the drop in GDP further lowers consumption. Overall, we observe roughly a 3.04 to 3.79 percent drop in consumption due to the ACA with 2030, 2040 and 2060 demographics. This drop is strongly affected by the share of the elderly. Given the decrease in capital we find the fairly standard effects on market prices including small changes in wages due to the ACA across all demographic simulations.

4.3 Sensitivity Analysis

In this section we relax some assumptions in the benchmark model and check if the results are robust. The sensitivity checks include the following three changes: (*i*) different financing instruments for the effects of aging, (*ii*) different levels of total factor productivity in the two sectors , and (*iii*) partial equilibrium effects.

Alternative Financing Instruments. In our setting, Medicare is part of the overall budget constraint as described in expression (11). We first assume that the government lets the consumption tax rate adjust to cover the extra resources needed for Medicare/Medicaid of the old when the population ages. We next consider a new payroll tax τ_2^V (case 2) or adjustments in residual government consumption C_G (case 3) to finance the effects of aging. We repeat the earlier experiments and let either one of these two financing instruments adjust to clear the government budget constraint. We report the effects of population aging without the ACA in Table 7 and with the ACA in Table 8. The ACA itself is still financed with a payroll tax τ^V on households with income higher than $\$200,000$.

Aging triggers an adjustment of the consumption tax rate from 5 percent to 9.09 percent with 2060 demographic profiles. If a payroll tax is used to finance the effects of aging a 3.49 percent tax is needed. Finally, residual government consumption as fraction of GDP would adjust from 10.24 percent down to 7.38 percent in order to accommodate aging. The insurance take-up rates are fairly stable across all three financing versions. In general, the version where a new payroll tax adjusts—the τ_2^V columns in Tables 7 and 8— generates the largest tax distortions and results in lower output and household income than the other versions. It also leads to the smallest increase in aggregate consumption of 1.48 percent in the aging only case and in the case with the ACA to a decrease of aggregate consumption of roughly 1 percent compared to the 2010 benchmark economy. All other cases lead to an increase in aggregate consumption. The remaining results are similar across all three cases and not too sensitive to alternative financing instruments. The cases with the ACA are similarly robust with respect to alternative financing instruments of aging.

Technological Progress. This section investigates how higher levels of total factor productivity (TFP) change the effects of population aging. There are two sectors in the model. We first consider cases where TFP in either one of the two sectors increases by 10 percent in isolation followed by a case with an overall increase in TFPs of 10 percent in both sectors. We use population age profiles for year 2060 for all cases and report the combined effects of population aging and TFP increases with the ACA in Table 9. For completeness we again report the benchmark 2010 results (column 1), the results for 2060 with the ACA and benchmark values for TFP (column 2) and the results for 2060 with the ACA and TFP changes (columns 3-5). The latter are reported as percent deviations from steady state results for 2060 with the ACA and benchmark values for TFP so that only the net effects of the TFP increases are reported in the last three columns of Table 9.

Increases in TFP (or innovations in the production sectors) result in sizable increases of GDP of up to 15.42 percent. The largest drop in medical spending is realized when TFP in the medical sector increases by 10 percent relative to the rest of the economy. The technical advance in medical services production leads to a lower base price p_m which results in an overall drop in healthcare expenditure of 7.99 percent despite higher medical services consumption levels of about 1.06 percent. If TFP in the rest of the economy increases as well, then income effects dominate and overall spending on medical services increases well above the benchmark levels.

Partial Equilibrium Analysis. In our partial equilibrium analysis, we keep all prices including the wage rate, interest rate, medical prices and premiums at the benchmark levels of 2010. Figures 12 and 13 display the effects of aging on the insurance take-up rates over the lifecycle. Table 10 compares the partial- and general equilibrium results. There are significant differences between the partial- and general equilibrium outcomes. The general equilibrium channels reduce medical spending of Medicare recipients. The size of Medicare, one indicator of the fiscal cost of aging, is much larger under the partial equilibrium setting. In the partial equilibrium setting individuals do not fully adjust to the reality of longer expected lifespans and drop out of the labor force earlier than under general equilibrium where individuals continue to work longer over their lifecycle in order to take advantage of the higher real wages.

The changes in the insurance take-up rates are larger when accounting for general equilibrium effects. In addition, the overall consumption levels differ by almost 10 percent in the case without the ACA and almost 8 percent with the ACA as the sectoral shifts are not fully realized in the partial equilibrium setting.

5 Conclusion

We develop a realistic overlapping generations, general-equilibrium model with endogenous health capital and evaluate the effects of population aging on the U.S. healthcare system. The general equilibrium approach that we propose is essential to capture the dynamics between health accumulation, health spending, health insurance and the remaining portfolio decisions of U.S. households. Our results indicate that population aging leads to large increases in medical expenditures and induces workers to join IHI markets and Medicaid whereas young workers drop out of GHI markets due to adverse selection. The ACA reform reduces adverse selection problems that are prevalent in private health insurance markets and increases the fraction of insured workers. A combination of population aging and the ACA reform causes large increases in the level of health expenditures, by 37.39 percent, and a large expansion of the health production sector, which leads to an increase in GDP. This growth effect is almost entirely explained by modeling health investment and the healthcare sector. The ACA, on net, reduces overall health expenditures by as much as 2.8 percent but the effect of the ACA itself diminishes with the fraction of older individuals in the economy.

Our results highlight the importance of modeling health investments as part of the household decision problem together with the institutional details of the U.S. healthcare sector. It is important to note that the growth effect channel through the expansion of the healthcare sector is not operational in models that abstract from health production. In addition, the fiscal effects channel operating through Medicare and Medicaid is missing in models that treat healthcare spending and financing as exogenous variables in the household budget.

Important limitations to our modeling approach are discussed next. First, the analysis focuses on comparisons between steady state solutions. We are not able to solve for transitions between steady state due to computational constraints. Our analysis therefore can only provide a long-run perspective and we abstain from providing welfare calculations. First, the model does not include a provision for differential treatment of the Medicaid expansion by U.S. states. In addition, some states have used a §115 demonstration application approved by the Centers for Medicare and Medicaid Services to expand coverage of low income individuals using Medicaid funds as premium assistance for marketplace qualified health plans. Funding private insurance subsidies from Medicaid funds is not without controversy as arguments have been made that a direct expansion of Medicaid may be more cost effective (CBO, 2012). Our modeling framework can be extended to shed some light on this issue.

A further limitation of the current model is that the relative pricing structure of healthcare services is fixed exogenously. However, all prices do increase/decrease according to a base (production) price that the model generates endogenously. This modeling choice is an ad-hoc approximation of differential pricing by providers with market power. Relaxing this assumption could shed some light on how competition in the health insurance market is affected by the ACA as well as aging.

In addition, we currently do not account for the possibility that providers may refuse to treat Medicare/Medicaid patients if the prices that these programs pay decrease strongly. This assumption also drives the simulated decrease in overall medical expenditures triggered by the ACA. Allowing for profit maximization on the provider side is a possible extension that could address this issue.

Finally, aging is imposed exogenously which abstracts from the causal link of health on survival as highlighted in the papers of Hall and Jones (2007) and Fonseca et al. (2013). It is not obvious whether our health expenditures are upward or downward biased because of this omission as this would ultimately depend on the mechanism that generates aging in the model. One possible explanation could be innovations in the medical sector that lead to better or cheaper healthcare. The exact nature of these type of innovations could lead to higher or lower health expenditures in the presence of aging. We leave these issues for future research.

References

Aiyagari, Rao S. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *The Quarterly Journal of Economics* 109(3):659–684.

Aizer, Anna. 2003. "Low Take-Up in Medicaid: Does Outreach Matter and for Whom?" *The American Economic Review* 93(2):238–241.

Anderson, Gerard. 2007. "From 'Soak The Rich' To 'Soak The Poor': Recent Trends In Hospital Pricing." *Health Affairs* 26(3):780–789.

Andreoni, J. 1989. "Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence." *Journal of Political Economy* 97:1447–58.

Auerbach, Alan J. and William G. Gale. 2013. "Fiscal Myopia." *Working Paper* .

Auerbach, J. Alan and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy.* Cambridge: Cambridge University Press.

Bernard, Didem, Cathy Cowan, Thomas Selden, Lining Cai, Aaron Catling and Stephen Heffler. 2012. "Reconciling Medical Expenditure Estimates from the MEPS and NHEA, 2007." *Medicare & Medicaid Research Review* 2(4):1–19.

Bewley, Truman. 1986. Stationary Monetary Equilibrium with a Continuum of Independently Fluctuating Consumers. In *Werner Hildenbrand, Andreu Mas-Colell (Eds.), Contributions to Mathematical Economics in Honor of Gerard Debreu.* North-Holland.

Blau, David M. and Donna B. Gilleskie. 2008. "The Role of Retiree Health Insurance in the Employment Behavior of Older Men." *International Economic Review* 49(2):475–514.

Bloom, David E, David Canning and Günther Fink. 2010. "Implications of population ageing for economic growth." *Oxford Review of Economic Policy* 26(4):583–612.

Braun, A. and D. Joines. 2015. "The Implications of a Graying Japan for Government Policy." *Journal of Economic Dynamics & Control* 57:1–23.

Brown, Paul. 2006. *Paying the Price: The High Cost of Prescription Drugs for Uninsured Californians.* CALPIRG Education Fund.

CBO. 2007. "CBO's Health Insurance Simulation Model: A Technical Description." Congressional Budget Office Background Paper.

CBO. 2012. "The 2012 Long-Term Budget Outlook." Congressional Budget Office.

CBO. 2013. "Health-Related Options for Reducing the Deficit: 2014 to 2023." Congressional Budget Office.

CBO. 2014. "The Budget and Economic Outlook: 2014-2024." Congressional Budget Office.

CBO. 2016. "The Budget and Economic Outlook: 2016-2026." Congressional Budget Office.

De la Croix, David. 2013. *Fertility, Education, Growth and Sustainability.* Cambridge University Press.

De Nardi, Mariacristina. 2004. "Wealth Inequality and Intergenerational Links." *Review of Economic Studies* 71:743–768.

De Nardi, Mariacristina, Eric French and John Bailey Jones. 2010. "Why Do the Elderly Save? The Role of Medical Expenses." *Journal of Political Economy* 118(1):39–75.

De Nardi, Mariacristina, Selahattin İmrohoroğlu and Thomas J Sargent. 1999. "Projected U.S. Demographics and Social Security." *Review of Economic Dynamics* 2(3):575–615.

Donahoe, Gerald F. 2000. "Capital in the National Health Accounts." Health Care Financing Administration, Sept. 28, 2000.

Ehrlich, Isaac and Hiroyuki Chuma. 1990. "A Model of the Demand for Longevity and the Value of Life Extension." *Journal of Political Economy* 98(4):761–82.

Faruqee, Hamid. 2002. *Population Aging and Its Macroeconomic Implications: A Framework for Analysis.* Vol. 2 International Monetary Fund.

Fonseca, Raquel, Pierre-Carl Michaud, Titus Galama and Arie Kapteyn. 2013. "On the Rise of Health Spending and Longevity." IZA DP No. 7622.

French, Eric. 2005. "The Effects of Health, Wealth and Wages on Labor Supply and Retirement Behaviour." *Review of Economic Studies* 72(2):395–427.

Galama, Titus J., Patrick Hullegie, Erik Meijer and Sarah Outcault. 2012. "Empirical Evidence for Decreasing Returns to Scale in a Health Capital Model." Working Paper, Health, Econometrics and Data Group at the University of York.

Gouveia, Miguel and Robert P. Strauss. 1994. "Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis." *National Tax Journal* 47:317–339.

Grossman, Michael. 1972a. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80(2):223–255.

Grossman, Michael. 2000. *Handbook of Health Economics.* Elsevier North Holland chapter The Human Capital Model, pp. 347–408.

Gruber, Jonathan and David Rodriguez. 2007. "How Much Uncompensated Care Do Doctors Provide?" *Journal of Health Economics* 26(6):1151–1169.

Hall, Robert E. and Charles I. Jones. 2007. "The Value of Life and the Rise in Health Spending." *Quarterly Journal of Economics* 122(1):39–72.

Hubbard, Glenn R., Jonathan Skinner and Stephen P. Zeldes. 1995. "Precautionary Saving and Social Insurance." *The Journal of Political Economy* 103(2):369–399.

Huggett, Mark. 1993. "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies." *The Journal of Economic Dynamics and Control* 17(5-6):953–969.

Huggett, Mark. 1996. "Wealth Distribution in Life-Cycle Economies." *Journal of Monetary Economics* 38:469–494.

Hugonnier, Julien, Florian Pelgrin and Pascal St-Amour. 2013. "Health and (Other) Asset Holdings." *Review of Economic Studies* 80(2):663–710.

İmrohoroğlu, Ayşe, Selahattin İmrohoroğlu and Douglas Joines. 1995. "A Life Cycle Analysis of Social Security." *Economic Theory* 6(1):83–114.

Jeske, Karsten and Sagiri Kitao. 2009. "U.S. Tax Policy and Health Insurance Demand: Can a Regressive Policy Improve Welfare?" *Journal of Monetary Economics* 56(2):210–221.

Jung, Juergen and Chung Tran. 2016. "Market Inefficiency, Insurance Mandate and Welfare: U.S. Health Care Reform 2010." *Review of Economic Dynamics* 20:132–159.

Kaiser. 2013. "Where Are States Today? Medicaid and CHIP Eligibility Levels for Children and Non-Disabled Adults." Kaiser Family Foundation Fact Sheet.
URL: *Http://Kff.Org/Medicaid/Fact-Sheet/Where-Are-States-Today-Medicaid-and-Chip/*

Keehan, Sean P., Andrea M. Sisko, Christopher J. Truffer, John A. Poisal, Gigi A. Cuckler, Andrew J. Madison, Joseph M. Lizonitz and Sheila D. Smith. 2011. "National Health Spending Projections Through 2020: Economic Recovery And Reform Drive Faster Spending Growth." *Health Affairs* 30(8):1594–1605.

Kitao, S. 2014*a*. "Sustainable Social Security : Four Options." *Review of Economic Dynamics* 17(4):756–779.

Kitao, S. 2015. "Fiscal Cost of Demographic Transition in Japan." *Journal of Economic Dynamics and Control* 54:37–58.

Kitao, Sagiri. 2014*b*. "Sustainable Social Security: Four Options." *Review of Economic Dynamics* 17(4):756–779.

Kotlikoff, Laurence J. 1988. Health Expenditures and Precautionary Savings. In *What Determines Saving?* Cambridge MIT Press chapter 6.

Kotlikoff, Laurence J., Kent Smetters and Jan Walliser. 2007. "Mitigating America's Demographic Dilemma by Pre-funding Social Security." *Journal of Monetary Economics* 54(2):247–266.

Kudrna, G., C. Tran and A. Woodland. Forthcoming. "Facing Demographic Challenges: Pension Cuts or Tax Hikes." *Macroeconomic Dynamics* .

Kydland, Finn E. and Edward C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50(6):1345–1370.

Lee, Ronald. 2014. "Macroeconomic Consequences of Population Aging in the United States: Overview of a National Academy Report." *American Economic Review: Papers and Proceedings* 104(5):234–239.

Levin, Laurence. 1995. "Demand for Health Insurance and Precautionary Motive for Savings among the Elderly." *Journal of Public Economics* 57:337–367.

Mendoza, Enrique, G., Assaf Razin and Linda L. Tesar. 1994. "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Ratees on Factor Incomes and Consumption." *Journal of Monetary Economics* 34(3):297–323.

Nishiyama, Shinichi. 2015. "Fiscal Policy Effects in a Heterogeneous-Agent OLG Economy with an Aging Population." *Journal of Economic Dynamics and Control* 61(C):114–132.

NRC. 2012. *Aging and the Macroeconomy. Long-Term Implications of an Older Population.* Washington, D.C.: The National Academies Press.

Ozkan, Serdar. 2014. "Preventive vs. Curative Medicine: A Macroeconomic Analysis of Health Care over the Life Cycle." Working Paper, University of Toronto.

Palumbo, Michael G. 1999. "Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle." *Review of Economic Studies* 66(2):395–421.

Pashchenko, Svetlana and Ponpoje Porapakkarm. 2013. "Quantitative Analysis of Health Insurance Reform: Separating Regulation from Redistribution." *Review of Economic Dynamics* 16 (3):383–404.

Phelps, Charles E. 2003. *Health Economics.* Upper Saddle River, New Jersey: Pearson Education Inc.

Playing Fair, State Action to Lower Prescription Drug Prices. 2000. Center for Policy Alternatives.

Remler, Dahlia K., Jason E. Rachling and Sherry A. Glied. 2001. "What Can the Take-Up of Other Programs Teach Us About How to Improve Take-Up of Health Insurance Programs?" NBER Working Paper 8185.

Scholz, John Karl and Ananth Seshadri. 2013. "Health and Wealth in a Life Cycle Model." *Working Paper* .

Shatto, John D. and Kent M. Clemens. 2011. "Projected Medicare Expenditures Under AnIllustrative Scenario with Alternative Payment Updates to Medicare Providers." Centers for Medicare and Medicaid Services, Office of the Actuary (May 13).

Sing, Merrile, Jessica Banthing, Thomas Selden, Cathy Cowan and Sean Keehan. 2006. "Reconciling Medical Expenditure Estimates from the MEPS and NHEA, 2002." *Health Care Financing Review* 28(1):25–40.

Social Security Update 2007. 2007. SSA Publication No. 05-10003.

Storesletten, Kjetil, Christopher I. Telmer and Amir Yaron. 2004. "Consumption and Risk Sharing Over the Life Cycle." *Journal of Monetary Economics* 51(3):609–633.

Suen, Richard M. H. 2006. "Technological Advance and the Growth in Health Care Spending." Economie D'Avant Garde, Research Report No. 13. University of Rochester.

Tauchen, George. 1986. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions." *Ecomomics Letters* 20:177–181.

Ware, John E., Mark Kosinski and Susan D. Keller. 1996. "A 12-Item Short-Form Health Survey: Construction of Scales and Preliminary Tests of Reliability and Validity." *Medical Care* 34(3):220–233.

Wise, David A. 2007. *Studies in the Economics of Aging*. University of Chicago Press.

Yogo, Motohiro. 2016. "Portfolio Choice in Retirement: Health Risk and the Demand for Annuities, Housing and Risky Assets." 80:17–34.

Zhao, Kai. 2014. "Social Security and the Rise in Health Spending." *Journal of Monetary Economics* 64:21–37.

6 Appendix

6.1 Appendix A: Definition of Recursive Equilibrium

Given the transition probability matrices $\left\{\Pi_j^{\ell}, \Pi_j^{h}, \Pi_j^{\text{GHI}}\right\}_{j=1}^{J}$, the survival probabilities $\{\pi_j\}_{j=1}^{J}$ and the exogenous government policies $\left\{tax\left(x_j\right), \tau^C, \text{prem}^R, \tau^{SS}, \tau^{\text{Mcare}}\right\}_{j=1}^{J}$, a competitive equilibrium is a collection of sequences of distributions $\{\mu_j, \Lambda_j\left(x_j\right)\}_{j=1}^{J}$ of individual household decisions $\{c_j\left(x_j\right), \ell_j\left(x_j\right), a_{j+1}\left(x_j\right), m_j\left(x_j\right), in_{j+1}\left(x_j\right)\}_{j=1}^{J}$, aggregate stocks of physical capital and effective labor services $\{K, L, K_m, L_m\}$, factor prices $\{w, q, R, p_m\}$, markups $\left\{\omega^{\text{IHI}}, \omega^{\text{GHI}}, \nu^{in}\right\}$ and insurance premiums $\left\{\text{prem}^{\text{GHI}}, \text{prem}^{\text{IHI}}\left(j, h\right)\right\}_{j=1}^{J}$ such that:

(a) $\{c_j\left(x_j\right), \ell_j\left(x_j\right), a_{j+1}\left(x_j\right), m_j\left(x_j\right), in_{j+1}\left(x_j\right)\}_{j=1}^{J}$ solves the consumer problem (8) and (9),

(b) the firm first order conditions hold in both sectors

$$\begin{aligned} w &= F_L\left(K, L\right) = p_m F_{m,L}\left(K_m, L_m\right), \\ q &= F_K\left(K, L\right) = p_m F_{m,K}\left(K_m, L_m\right), \\ R &= q + 1 - \delta, \end{aligned}$$

(c) markets clear

$$\begin{aligned} K + K_m &= \sum_{j=1}^{J} \mu_j \int \left(a\left(x_j\right)\right) d\Lambda\left(x_j\right) + \sum_{j=1j}^{J} \int \tilde{\mu}_j a_j\left(x_j\right) d\Lambda\left(x_j\right) \\ &+ \sum_{j=1}^{J_R} \mu_j \int \left(1_{[in_{j+1}=2]}\left(x_j\right) \times \text{prem}^{\text{IHI}}\left(j, h\right) + 1_{[in_{j+1}=3]}\left(x_j\right) \times \text{prem}^{\text{GHI}}\right) d\Lambda\left(x_j\right), \\ T^{\text{Beq}} &= \sum_{j=1}^{J} \int \tilde{\mu}_j a_j\left(x_j\right) d\Lambda\left(x_j\right), \\ L + L_m &= \sum_{j=1}^{J_R} \mu_j \int e_j(x_j) \ell_j\left(x_j\right) d\Lambda\left(x_j\right), \end{aligned}$$

(d) the aggregate resource constraint holds

$$C_G + \left(1 + g\right) S + \sum_{j=1}^{J} \mu_j \int \left(c\left(x_j\right) + p_m^{in_j(x_j)} m\left(x_j\right)\right) d\Lambda\left(x_j\right) + \text{Profit}^M = Y + \left(1 - \delta\right) K,$$

(e) the government programs clear so that (10), (11), and (12) hold,

(f) the budget conditions of the insurance companies (6) and (7) hold, and

(g) the distribution is stationary

$$\left(\mu_{j+1}, \Lambda\left(x_{j+1}\right)\right) = T_{\mu,\Lambda}\left(\mu_j, \Lambda\left(x_j\right)\right),$$

where $T_{\mu,\Lambda}$ is a one period transition operator on the distribution.

6.2 Appendix B: The Model Implementation of the Affordable Care Act

We discuss the specific implementation of each of the elements of the reform that we have included into our model simulation.

Medicaid Expansion. The ACA expands the Medicaid eligibility threshold to 133 percent of the FPL and removes the asset test.[24] After the reform is implemented all individuals with incomes lower than 133 percent of the $\mathrm{FPL}_{\mathrm{Maid}}$ will be enrolled in Medicaid.

Subsidies. Workers who are not offered insurance from their employers and whose income is between 133 and 400 percent of the FPL are eligible to buy health insurance through insurance exchanges at subsidized rates according to

$$subsidy_j \quad = \quad \begin{cases} \max\Big(0, \mathrm{prem}_j^{\mathrm{IHI}} - 0.03\tilde{y}_j\Big) \text{ if } 1.33 \text{ FPL}_{\mathrm{Maid}} \leq \tilde{y}_j < 1.5 \text{ FPL}_{\mathrm{Maid}}, \\ \max\Big(0, \mathrm{prem}_j^{\mathrm{IHI}} - 0.04\tilde{y}_j\Big) \text{ if } 1.5 \text{ FPL}_{\mathrm{Maid}} \leq \tilde{y}_j < 2.0 \text{ FPL}_{\mathrm{Maid}}, \\ \max\Big(0, \mathrm{prem}_j^{\mathrm{IHI}} - 0.06\tilde{y}_j\Big) \text{ if } 2.0 \text{ FPL}_{\mathrm{Maid}} \leq \tilde{y}_j < 2.5 \text{ FPL}_{\mathrm{Maid}}, \\ \max\Big(0, \mathrm{prem}_j^{\mathrm{IHI}} - 0.08\tilde{y}_j\Big) \text{ if } 2.5 \text{ FPL}_{\mathrm{Maid}} \leq \tilde{y}_j < 3.0 \text{ FPL}_{\mathrm{Maid}}, \\ \max\Big(0, \mathrm{prem}_j^{\mathrm{IHI}} - 0.095\tilde{y}_j\Big) \text{ if } 3.0 \text{ FPL}_{\mathrm{Maid}} \leq \tilde{y}_j < 4.0 \text{ FPL}_{\mathrm{Maid}}. \end{cases} \tag{14}$$

The subsidies ensure that the premiums that an individual pays at the health insurance exchange for IHI will not exceed a certain percentage of her taxable income $\tilde{y}_j$ at age j.

Penalties. Private health insurance is compulsory for all workers. Workers who do not have health insurance face a tax penalty of 2.5 percent of their income which enters the budget constraint as[25]:

$$penalty_j = 1_{[ins_{j+1}=0]} \times 0.025 \times \tilde{y}_j,$$

where $1_{[ins_j=0]}$ is an indicator variable equal to one if the household has no health insurance. We abstract from employer penalties in the model.

Screening. The reform puts new restrictions on the price setting and screening procedures of insurance companies. In the model we do not allow for screening in the IHI market anymore, so that the price setting in group and individual markets is now identical except for the fact that group insurance premiums are still tax deductible.

Financing. The reform bill is financed by increases in payroll taxes for individuals with incomes higher than \$200,000 per year (or \$250,000 for families).[26] In the model we use a flat income tax on individuals with incomes higher than \$200,000.

Summarizing, we can write the new household budget constraint with the ACA as

[24]The model does not use actual the FPL to assess Medicaid eligibility in the benchmark (pre-reform) economy as this would grossly overstate the percentage of the population currently on Medicaid as discussed in the calibration section. Instead, we calculate a "Medicaid eligibility" federal poverty level, $\mathrm{FPL}_{\mathrm{Maid}}$, to match the percent of the population that is currently on Medicaid according to MEPS data.

[25]We do not model exemptions from the penalty for certain low income and high risk groups.

[26] We do not account for the various other sources that are used to generate additional revenue in order to pay for the reform (e.g., funds from Social Security, cuts to Medicare, funds from student loans, taxes on "Cadillac" insurances, taxes on medical devices and others.

$$
\begin{aligned}
\left(1+\tau^{C}\right) c_j+(1+g)\, a_{j+1}+o\left(m_j\right) &+ 1_{\{\ell_j>0 \wedge in_{j+1}=1\}} \text{prem}^{\text{IHI}}(j,h)+1_{\{\ell_j>0 \wedge in_{j+1}=2\}} \text{prem}^{\text{GHI}} \\
+1_{[\ell_j=0 \wedge j\,>\,J_W]} \text{prem}^{\text{Mcare}} &= y_j^W - tax_j + t_j^{\text{SI}} - 1_{\{in_{j+1}=0\}} penalty_j + 1_{\{in_{j+1}=1\}} subsidy_j - tax_j^{\text{ACA}}, \\
0 &\leq a_{j+1},\ 0 \leq \ell_j \leq 1,\ \text{and}\ (4),
\end{aligned}
$$

6.3 Appendix C: Tables and Figures

Parameters	Values	Explanation/Source
- Maximum lifetime (periods)	$J = 15$	
- Retirement choice interval	$j \in (J_W, J_R] = (8, 12]$	
- Population growth rate	$n = 1.2\%$	CMS 2010
- Years modeled	$years = 75$	from age 20 to 95
- Total factor productivity	$A = 1$	Normalization
- Growth rate	$g = 2\%$	NIPA
- Capital share in production	$\alpha = 0.33$	Kydland and Prescott (1982)
- Capital in medical services prod.	$\alpha_m = 0.26$	Donahoe (2000)
- Capital depreciation	$\delta = 10\%$	Kydland and Prescott (1982)
- Health depreciation	$\delta_{h,j} = [0.6\% - 2.13\%]$	MEPS 1999/2009
- Survival probabilities	π_j	CMS 2010
- Health Shocks	Technical Appendix	MEPS 1999/2009
- Health transition prob.	Technical Appendix	MEPS 1999/2009
- Productivity shocks	see Section 3	MEPS 1999/2009
- Productivity transition prob.	Technical Appendix	MEPS 1999/2009
- Group ins. transition prob.	Technical Appendix	MEPS 1999/2009
- Price for medical care for uninsured	$\nu^{\text{noIns}} = 0.7$	MEPS 1999/2009
- M price markup for IHI insured	$\nu^{\text{IHI}} = 0.25$	Shatto and Clemens (2011)
- M price markup for GHI insured	$\nu^{\text{GHI}} = 0.1$	Shatto and Clemens (2011)
- M price markup for Medicaid	$\nu^{\text{Maid}} = 0.0$	Shatto and Clemens (2011)
- M price markup for Medicare	$\nu^{\text{Mcare}} = -0.1$	Shatto and Clemens (2011)
- Coinsurance rate: IHI in %	$\gamma_j^{IHI} \in [22, 46, 48, 49, 50, 53, 52, 50]$	MEPS 1999/2009
- Coinsurance rate: GHI in %	$\gamma_j^{GHI} \in [33, 33, 33, 34, 36, 36, 45, 50]$	MEPS 1999/2009
- Medicare premiums/GDP	2.11%	Jeske and Kitao (2010)
- Medicaid coinsurance rate in %	$\gamma_j^{Maid} \in [11, 14, 17, 16, 17, 18, 20, 22]$	Center for Medicare and Medicaid Services (2005)
- Public coinsurance rate retired in %	$\gamma^R = 20$	Center for Medicare and Medicaid Services (2005)
- Payroll tax Social Security:	$\tau^{Soc} = 9.4\%$	IRS
- Consumption tax:	$\tau^{C=}5.0\%$	Mendoza et al. (1994)
- Payroll tax Medicare:	$\tau^{Med} = 2.9\%$	Social Security Update (2007)

Table 1: **External Parameters**.
These parameters are based on our own estimates from MEPS and CMS data as well as other studies.

Parameters	Values	Explanation/Source	Nr.M.
- Relative risk aversion	$\sigma = 3.0$	to match $\frac{K}{Y}$ and R	1
- Preference on consumption vs. leisure:	$\eta = 0.43$	to match labor supply and $\frac{p \times M}{Y}$	1
- Preference on c and ℓ vs. health	$\kappa = 0.75$	to match labor supply and $\frac{p \times M}{Y}$	1
- Discount factor	$\beta = 0.98$	to match $\frac{K}{Y}$ and R	1
- GHI markup profits	$\omega^{\mathrm{GHI}} = 0$	to match GHI take-up	1
- IHI markup profits	$\omega^{\mathrm{IHI}}_{j,h} \in [0.6 - 1.5]$	to match spending profile	8
- Health production productivity	$\phi_j \in [0.2 - 0.45]$	to match spending profile	15
- TFP in medical production	$A_m = 0.4$	to match $\frac{p \times M}{Y}$	1
- Production parameter of health	$\xi = 0.26$	to match $\frac{p \times M}{Y}$	1
- Effective labor services production	$\chi = 0.85$	to match labor supply	1
- Health productivity	$\theta = 1.0$	used for sensitivity analysis	1
- Pension replacement rate	$\Psi = [0.24 - 0.29]$	to match τ^{soc}	4
- Fixed time cost of labor	$\bar{\ell}_j \in [0.0 - 0.7]$	to match average work hours	12
- Minimum health state	$h_{\min} = 0.01$	to match health spending	1
- Asset test level	$\bar{a}_{Maid} = \$150,000$	to match Medicaid take-up	1
-Total number of internal parameters:			50

Table 2: **Internal Parameters**.
We choose these parameters in order to match a set of target moments in the data.

Moments	Model	Data	Source	Nr.M.
- Medical expenses HH income	17.9%	17.07%	CMS communication	1
- Workers IHI	7.0%	7.2%	MEPS 1999/2009	1
- Workers GHI	60.9%	62.2%	MEPS 1999/2009	1
- Workers Medicaid	9.6%	9.2%	MEPS 1999/2009	1
- Capital output ratio: K/Y	2.7	$2.6 - 3$	NIPA	1
- Interest rate: R	4.5%	4%	NIPA	1
- Size of Social Security/Y	6.1%	5%	OMB 2008	1
- Size of Medicare/Y	3.2%	$2.5 - 3.1\%$	U.S. Department of Health (2007)	1
- Medical spend. profile	Figure 3	Figure 3	MEPS 1999/2009	15
- IHI insurance take-up profile	Figure 3	Figure 3	MEPS 1999/2009	7
- Medicaid insurance take-up profile	Figure 3	Figure 3	MEPS 1999/2009	8
- Average labor hours	Figure 4	Figure 4	PSID 1984-2007	12
Total number of moments				50

Table 3: **Matched Data Moments**.
We choose internal parameters so that model generated data matches data from MEPS, CMS, and NIPA.

	2010	2030	2040	2060
GDP	100.00	105.67	105.42	109.64
Capital: K_c	100.00	108.11	108.40	112.90
Capital: K_m	100.00	140.89	150.57	157.76
Consumption: C	100.00	101.50	99.79	103.23
Health capital: H	100.00	111.46	110.83	114.40
Weekly hours worked:	33.20	34.43	34.11	34.88
Medical services (units): M	100.00	132.27	139.90	145.36
Medical spending ($): $p_m M$	100.00	128.60	134.42	139.84
Med. spending/GDP (%)	12.54	15.27	16.00	16.00
Med. spending ($) by ins. type				
+ No Insurance	100.00	89.64	97.73	88.90
+ IHI	100.00	157.57	131.61	158.00
+ GHI	100.00	110.27	106.11	111.88
+ Medicaid	100.00	159.03	167.22	170.12
+ Medicare	100.00	158.88	181.73	190.24
Workers insured (%):	77.51	80.66	79.21	81.55
+ IHI (%)	6.97	17.83	16.33	17.98
+ GHI (%)	60.93	51.04	50.90	51.24
+ Medicaid (%)	9.61	11.79	11.98	12.33
Medicare (% among 60-75)	40.15	42.95	43.39	42.52
Interest Rate (%)	4.49	3.93	3.79	3.77
Wages: w	100.00	102.86	103.60	103.72
IHI average premium	100.00	58.80	57.94	60.43
GHI base premium	100.00	108.09	111.50	109.54
Consumption tax (%): τ^C	5.00	7.96	9.75	9.09
Soc. security tax (%): τ^{SS}	9.28	14.18	14.97	14.93
Medicare tax (%): τ^{Med}	2.90	2.90	2.90	2.90
Total tax rev./GDP (%)	19.83	24.31	25.79	25.23
Social security/GDP (%)	6.09	9.31	9.50	9.81
Medicare/GDP (%)	3.22	4.84	5.55	5.58
Medicaid/GDP (%)	0.63	0.94	0.99	0.97

Table 4: **The Effects of Population Aging without ACA.**
The consumption tax τ^C adjusts to clear the government budget constraint. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and Medicaid are financed by general government revenues.
Data in rows marked with % are either fractions in percent or tax rates in percent. The other rows are indexes with 2010 benchmark levels equal to 100. Each column presents steady-state results based on population profiles predicted for the given year.

	2010	2030-ACA	2040-ACA	2060-ACA
GDP	100.00	103.42	103.34	107.63
Capital: K_c	100.00	105.05	105.62	110.29
Capital: K_m	100.00	141.42	151.01	158.27
Consumption: C	100.00	98.00	96.61	100.10
Health capital: H	100.00	111.55	110.89	114.46
Weekly hours worked:	33.20	34.34	34.09	34.86
Medical services (units): M	100.00	133.12	139.74	145.94
Medical spending ($): $p_m M$	100.00	126.29	132.57	137.39
Med. spending/GDP (%)	12.54	15.32	15.97	16.01
Med. spending ($) by ins. type				
+ No Insurance	100.00	17.07	17.16	16.95
+ IHI	100.00	268.94	259.72	272.70
+ GHI	100.00	112.70	109.36	114.02
+ Medicaid	100.00	275.06	270.11	282.01
+ Medicare	100.00	141.06	164.38	172.06
Workers insured (%):	77.51	99.76	99.79	99.78
+ IHI (%)	6.97	22.71	22.77	22.66
+ GHI (%)	60.93	58.91	58.98	58.68
+ Medicaid (%)	9.61	18.14	18.04	18.44
Medicare (% among 60-75)	40.15	33.51	33.56	32.88
Interest Rate (%)	4.49	3.96	3.81	3.78
Wages: w	100.00	102.73	103.52	103.68
IHI average premium	100.00	101.79	105.05	101.95
GHI base premium	100.00	77.18	76.57	79.12
Consumption tax (%): τ^C	5.00	6.76	8.43	7.66
Soc. security tax (%): τ^{SS}	10.64	14.31	14.63	15.09
Medicare tax (%): τ^{Med}	2.90	2.90	2.90	2.90
ACA-Payroll tax (%): τ^v	0.00	4.06	4.04	3.94
Total tax rev./GDP (%)	19.83	26.01	26.93	26.80
Social security/GDP (%)	6.09	9.31	9.51	9.81
Medicare/GDP (%)	3.22	4.39	5.12	5.14
Medicaid/GDP (%)	0.63	1.66	1.63	1.63

Table 5: **The Effects of Population Aging with ACA.**
The consumption tax τ^C adjusts to clear the government budget constraint. In all cases a flat income tax τ^V on income $> \$200,000$ finances the ACA-reform. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.
Data in rows marked with % are either fractions in percent or tax rates in percent. The other rows are indexes with 2010 benchmark levels equal to 100. Each column presents steady-state results based on population profiles predicted for the given year.

	Deviations due to the ACA			
	2010	**2030**	**2040**	**2060**
%ΔGDP	−2.35	−2.13	−1.98	−1.83
%ΔCapital: K_c	−3.05	−2.83	−2.56	−2.31
%ΔCapital: K_m	+0.90	+0.37	+0.29	+0.32
%ΔConsumption: C	−3.79	−3.45	−3.20	−3.04
%ΔHealth capital: H	+0.10	+0.08	+0.06	+0.05
%ΔWeekly hours worked: H	−0.53	−0.09	−0.02	−0.03
%ΔMedical services (units): M	+1.17	+0.64	+0.46	+0.40
%ΔMedical spending ($): $p_m M$	−2.80	−1.80	−2.12	−1.75
%ΔMed. spending ($) by ins. type				
+ %ΔNo Insurance	−83.14	−80.96	−82.45	−80.94
+ %ΔIHI	+136.03	+70.68	+97.33	+72.60
+ %ΔGHI	−0.13	+2.21	+3.07	+1.91
+ %ΔMedicaid	+88.48	+72.96	+61.53	+65.77
+ %ΔMedicare	−10.83	−11.22	−9.55	−9.55
%ΔWorkers insured (%):	+22.43	+19.09	+20.58	+18.23
+ %ΔIHI (%)	+16.23	+4.88	+6.44	+4.68
+ %ΔGHI (%)	−0.33	+7.87	+8.08	+7.44
+ %ΔMedicaid (%)	+6.52	+6.34	+6.06	+6.11
%Δ Medicare among 60-75	−8.97	−9.44	−9.83	−9.65
%Δ IHI average premium	+4.46	+73.11	+81.30	+68.71
%Δ GHI base premium	−33.41	−28.60	−31.33	−27.77
%ΔConsumption tax (%): τ^C	−0.14	−1.20	−1.33	−1.44
%ΔSoc. security tax (%): τ^{SS}	+0.10	−0.13	+0.16	+0.16
%ΔMedicare tax (%): τ^{Med}	0.00	0.00	0.00	0.00
%ΔPayroll tax (%): τ^v	+3.64	+4.06	+4.04	+3.94
%ΔTotal tax rev./GDP (%)	+1.91	+1.70	+1.64	+1.57
%ΔSocial security/GDP (%)	0.00	0.00	0.00	0.00
%ΔMedicare/GDP (%)	−0.28	−0.45	−0.43	−0.44
%ΔMedicaid/GDP (%)	+0.60	+0.72	+0.65	+0.67

Table 6: **The Net Effects of the ACA.**
Difference table expressed as percentage change of the no-ACA steady state to the ACA steady state for a given demographic structure. The numbers therefore represent the net effects of the ACA in the context of population aging as the comparison benchmark is not the 2010 steady state anymore but the steady state solved with the demographic structure of the target decade without the ACA.
The consumption tax adjusts to clear the government budget constraint. In all cases a flat income tax on income $> \$200,000$ finances the ACA-reform. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.

	2010	2060		
		τ^C	τ_2^V	C_g
GDP	100.00	109.64	107.84	109.76
Consumption: C	100.00	103.23	101.48	107.31
Health capital: H	100.00	114.40	114.37	114.40
Weekly hours worked:	33.20	34.88	34.22	34.91
Medical services (units): M	100.00	145.36	139.10	145.36
Medical spending (\$): $p_m M$	100.00	139.84	134.45	139.85
Med. spending/GDP(%)	12.54	16.00	16.16	15.98
Workers insured (%):	77.51	81.55	82.41	81.62
+ IHI (%)	6.97	17.98	18.39	18.09
+ GHI (%)	60.93	51.24	51.00	51.26
+ Medicaid (%)	9.61	12.33	13.02	12.27
Medicare (% among 60-75)	40.15	42.52	44.02	42.49
Consumption tax (%): τ^C	5.00	9.09	5.00	5.00
Payroll tax (%) : τ_2^V	0.00	0.00	3.49	0.0
Government cons/GDP: C_g	10.24	9.34	9.49	7.38
Soc. security tax (%): τ^{SS}	9.28	14.93	14.97	14.93
Medicare tax (%): τ^{Med}	2.90	2.90	2.90	2.90

Table 7: **The Effects of Population Aging: Alternative Financing Instruments.**
The consumption tax τ^C, a new general payroll tax τ_2^V or residual government consumption C_g adjust to clear the government budget constraint. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.

	2010	2060+ACA		
		τ^C	τ_2^V	C_g
GDP	100.00	107.64	106.41	107.74
Consumption: C	100.00	100.10	98.97	102.69
Health capital: H	100.00	114.46	114.42	114.46
Weekly hours worked:	33.20	34.86	34.43	34.89
Medical services (units): M	100.00	145.94	145.49	145.94
Medical spending ($): $p_m M$	100.00	137.39	136.62	137.42
Med. spending/GDP(%)	12.54	16.01	16.11	16.00
Workers insured (%):	77.51	99.78	99.79	99.78
+ IHI (%)	6.97	22.66	22.54	22.69
+ GHI (%)	60.93	58.68	58.39	58.71
+ Medicaid (%)	9.61	18.44	18.86	18.39
Medicare (% among 60-75)	40.15	32.88	34.13	32.84
Consumption tax (%): τ^C	5.00	7.66	5.00	5.00
Payroll tax (%) : τ_2^V	0.00	0.00	2.42	0.00
Government cons/GDP: C_g	10.24	9.04	9.42	8.26
ACA-Payroll tax (%) : τ^V	0.00	3.19	3.99	3.93
Soc. security tax (%): τ^{SS}	9.28	17.20	15.09	15.09
Medicare tax (%): τ^{Med}	2.90	2.90	2.90	2.90

Table 8: **The Combined Effects of Population Aging and the ACA: Alternative Financing Instruments.**
The consumption tax τ^C, a new general payroll tax τ_2^V or residual government consumption C_g adjust to clear the government budget constraint. In all cases a flat income tax τ^V on income $> \$200,000$ finances the ACA-reform. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.

	2010 Benchm.	2060+ACA	%Δ from 2060+ACA		
			$A_m \uparrow 10\%$	$A \uparrow 10\%$	A & $A_m \uparrow 10\%$
GDP	100.00	107.63	−1.10	+15.42	+14.16
Consumption: C	100.00	100.10	+1.90	+19.67	+21.72
Health capital: H	100.00	114.46	+0.12	−0.03	+0.05
Weekly hours worked	33.20	34.86	+0.12	+0.01	+0.12
Med. services (units): M	100.00	145.94	+1.06	−0.12	+0.67
Med. spending (\$): $p_m M$	100.00	137.39	−7.99	+10.68	+1.60
Med. spending/GDP(%)	12.54	16.01	−1.12	−0.66	−1.76
Base medical price: p_m	100	99.97	−9.27	+10.97	+0.70
Workers insured (%):	77.51	99.78	+0.01	−0.02	−0.00
+ IHI (%)	6.57	22.66	+0.08	+1.62	+1.67
+ GHI (%)	60.93	58.68	+0.08	+4.28	+4.36
+ Medicaid (%)	9.61	18.44	−0.15	−5.92	−6.04
Medicare (% among 60-75)	40.15	32.88	−2.61	+6.02	+3.37

Table 9: **TFP Growth and Changes in the Combined Effects of Population Aging and the ACA.**

TFPs increase by 10 percent by 2060. The consumption tax τ^C adjusts clear the government budget constraint. The last 3 columns present percentage changes between $2060 + ACA$ to $2060 + ACA + TFP \uparrow 10\%$. In all cases a flat income tax τ^V on income $> \$200,000$ finances the ACA-reform. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.

	2010	2060		2060+ACA	
		(a) Part. Equ.	(b) Gen. Equ.	(a) Part. Equ.	(b) Gen. Equ.
GDP	100.00	n/a	109.64	n/a	107.63
Consumption: C	100.00	112.57	103.23	107.96	100.10
Health capital: H	100.00	114.38	114.40	114.64	114.46
Medical services (units): M	100.00	153.28	145.36	147.76	145.94
Medical spending ($): $p_m M$	100.00	146.50	139.84	137.88	137.39
Med. spending/GDP (%)	12.54	n/a	16.00	n/a	16.01
Med. spending ($) by ins. type					
+ No Insurance	100.00	112.30	88.89	18.45	16.95
+ IHI	100.00	99.34	158.00	280.12	272.70
+ GHI	100.00	116.64	111.88	109.69	114.02
+ Medicaid	100.00	82.82	170.12	208.46	282.01
+ Medicare	100.00	222.27	190.23	190.30	172.06
Workers insured (%):	77.51	75.93	81.55	99.02	99.78
+ IHI (%)	6.57	5.52	17.68	24.30	22.66
+ GHI (%)	60.93	61.05	51.24	57.79	58.68
+ Medicaid (%)	9.61	9.36	12.33	16.92	18.44
Medicare (% among 60-75)	40.15	50.56	42.52	42.78	32.88
IHI average premium	100.00	n/a	60.43	n/a	101.95
GHI base premium	100.00	100.00	109.54	100	79.12

Table 10: **The Effects of Population Aging + the ACA on Health Spending and Financing: General vs Partial Equilibrium Outcomes**. For the general equilibrium results the consumption tax τ^C adjusts to clear the government budget constraint and a flat income tax τ^V on income > $200,000 finances the ACA-reform. The government adjusts the social security tax τ^{SS} to pay for social security (self-financing). Medicare and pre-ACA-Medicaid are financed by general government revenues.The consumption tax is a financing instrument.

For the partial equilibrium results we impose a flat income tax on income > $200,000 of 3.19 percent to finance the ACA-reform. This is the same tax level as in the general equilibrium case with 2060 age profiles.

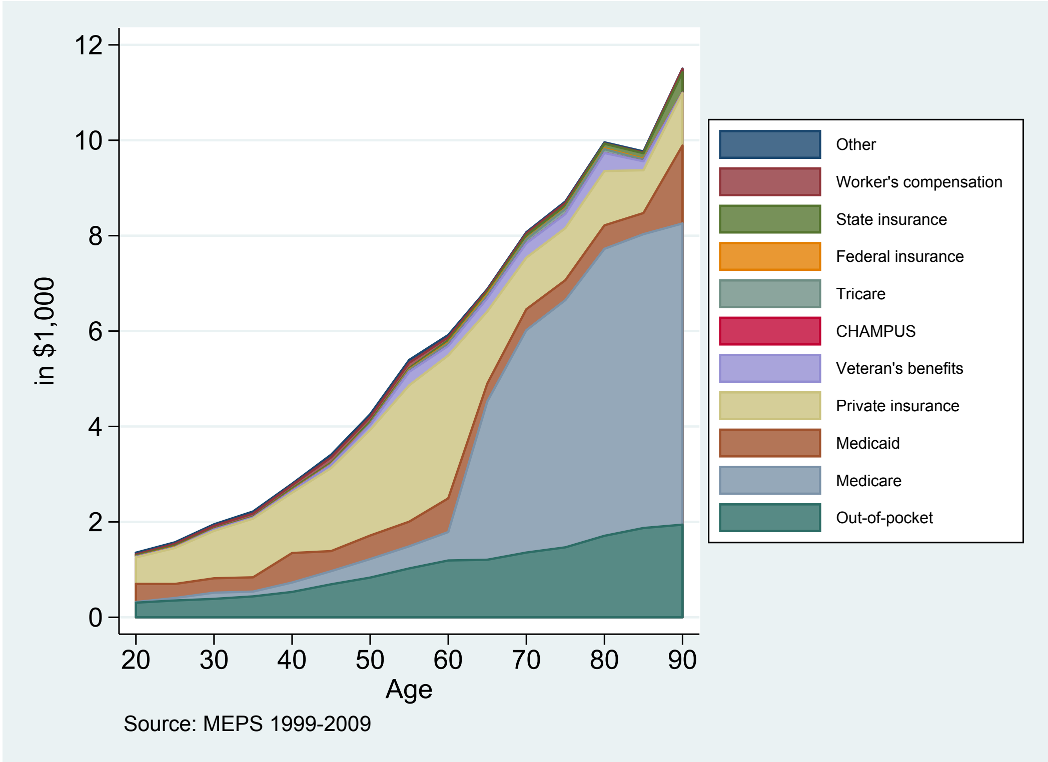

Figure 1: **Health Spending over the Lifecycle by Financing Source.**
We present average health spending per 5-year age cohort based on MEPS 1999-2009. We break down health spending by spending source. Spending values are inflation adjusted to 2009-dollar values.

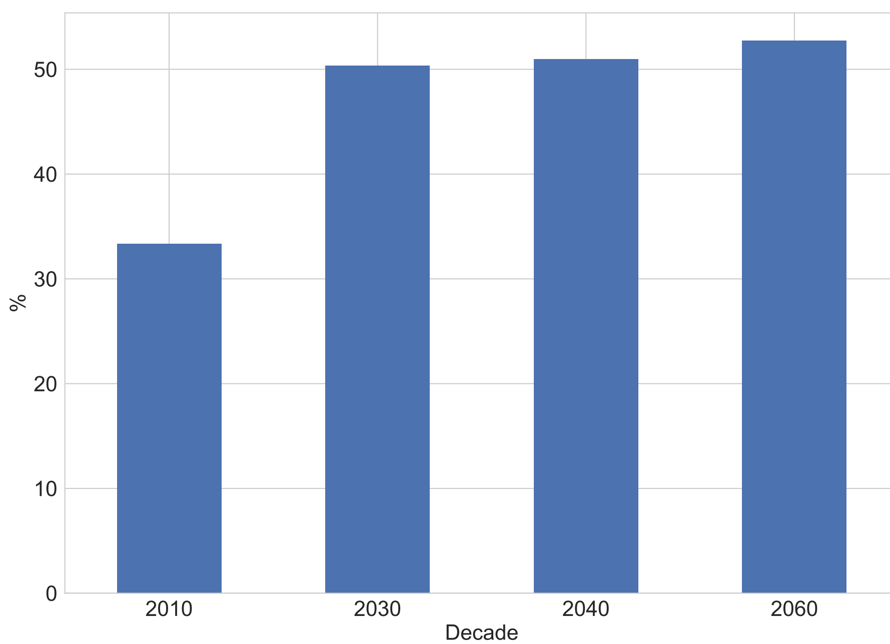

Figure 2: **Old Age Dependency Ratios over Time.** (Source: CMS/OACT)
The old age dependency ratio is defined as the population older than 65 divided by the workforce of 20-64 year olds.

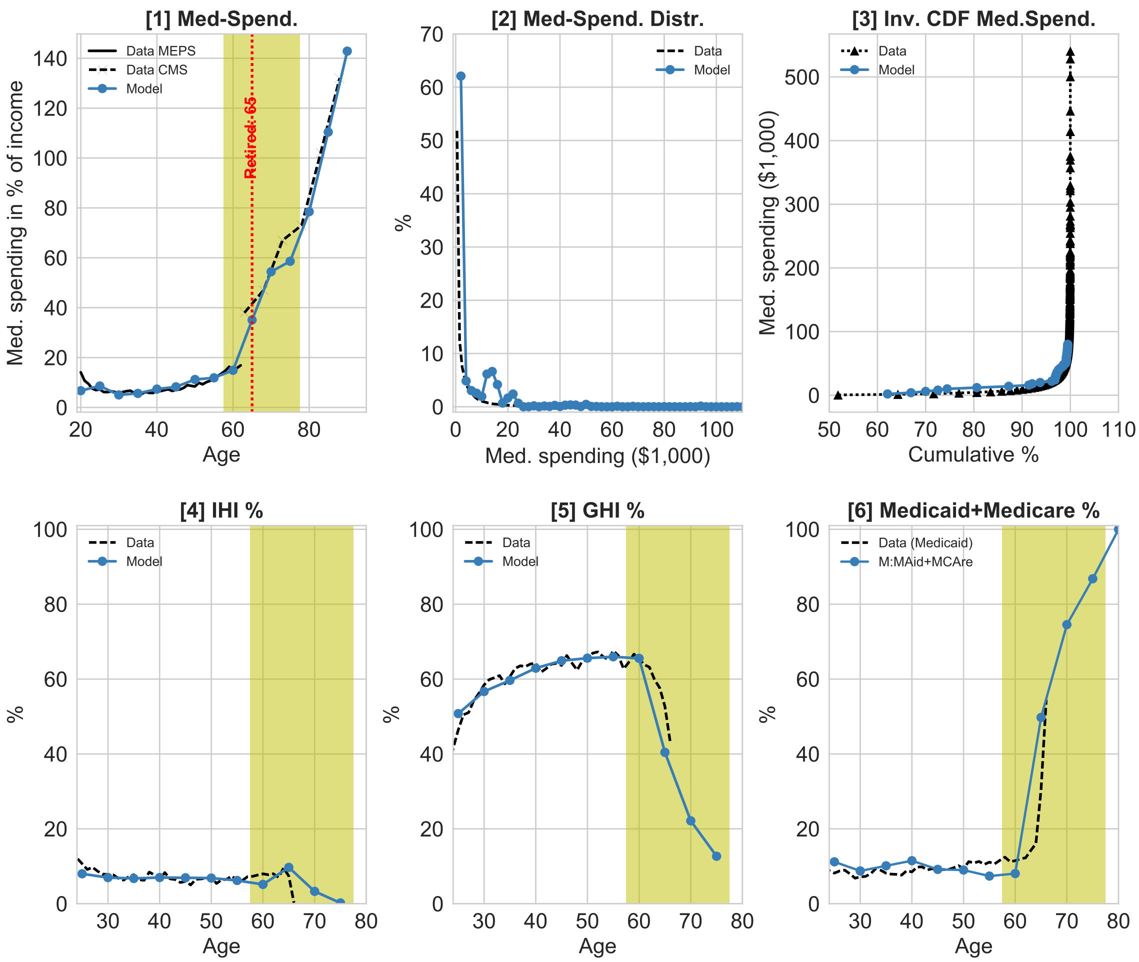

Figure 3: **Moment Matching using MEPS Data 2000-2009.**
Blue lines are model generated data moments and black dotted lines are MEPS data. Panel [1] depicts the percentage of average medical spending as percent of total household income of a 5-year age-cohort. Panel [2] shows the health expenditure distribution of heads of households from MEPS vs. model generated health spending. Panels [3-4] show the fraction of individual, group and Medicaid insurance for the working age population. The shaded area indicates the time periods where households become eligible for retirement benefits.

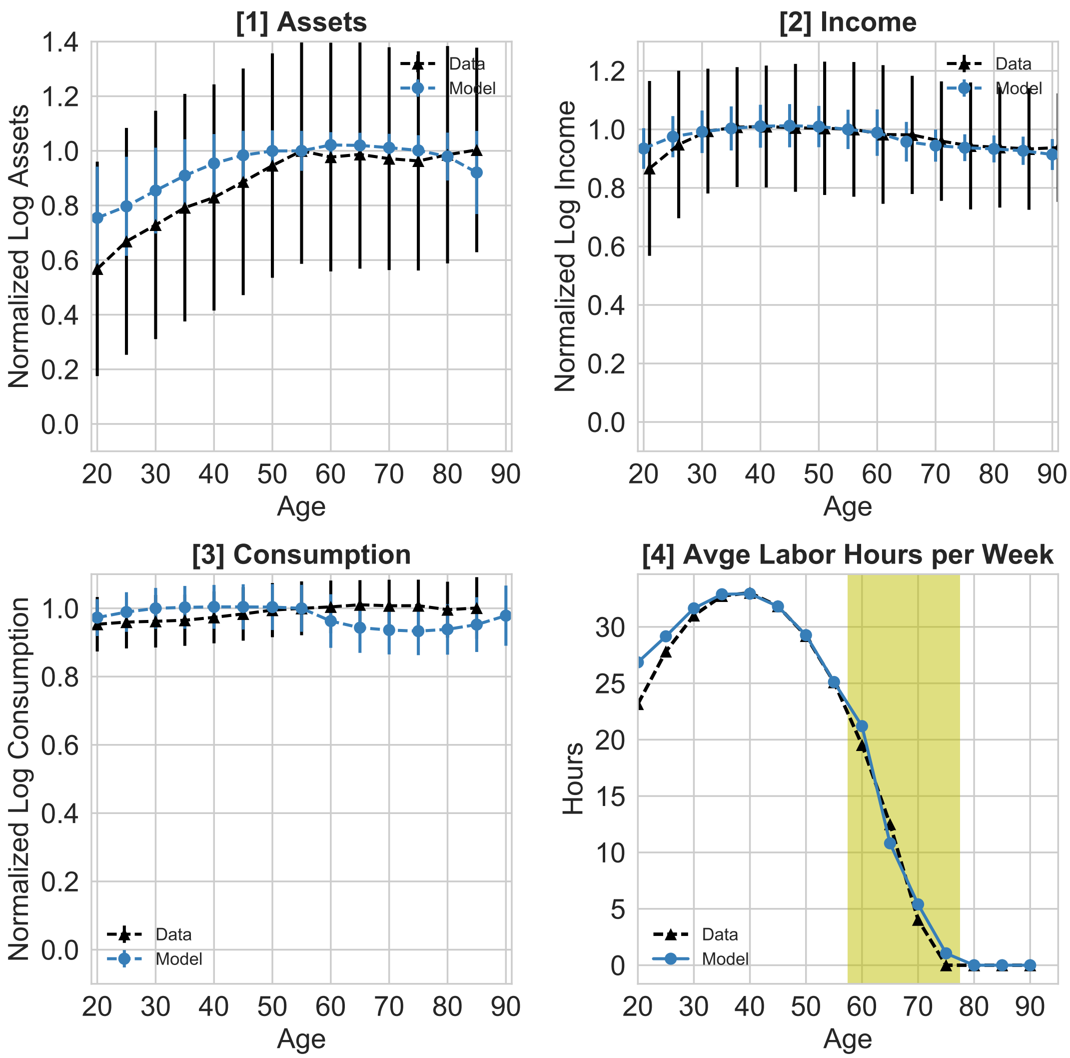

Figure 4: **Model vs. Data.**

Average lifecycle profiles normalized to values from the age 55 cohort. The vertical lines in panels [1]-[3] are standard deviations of log-values. Asset data in Panel [1] is from PSID 1984-2007. Income data for panel [2] is from MEPS 2000-2009. Consumption data in panel [3] is from CEX 1980-2007. Data on weekly work-hours by age-cohort in panel [4] is from CPS 1999-2007. The shaded area indicates the time periods where households become eligible for retirement benefits.

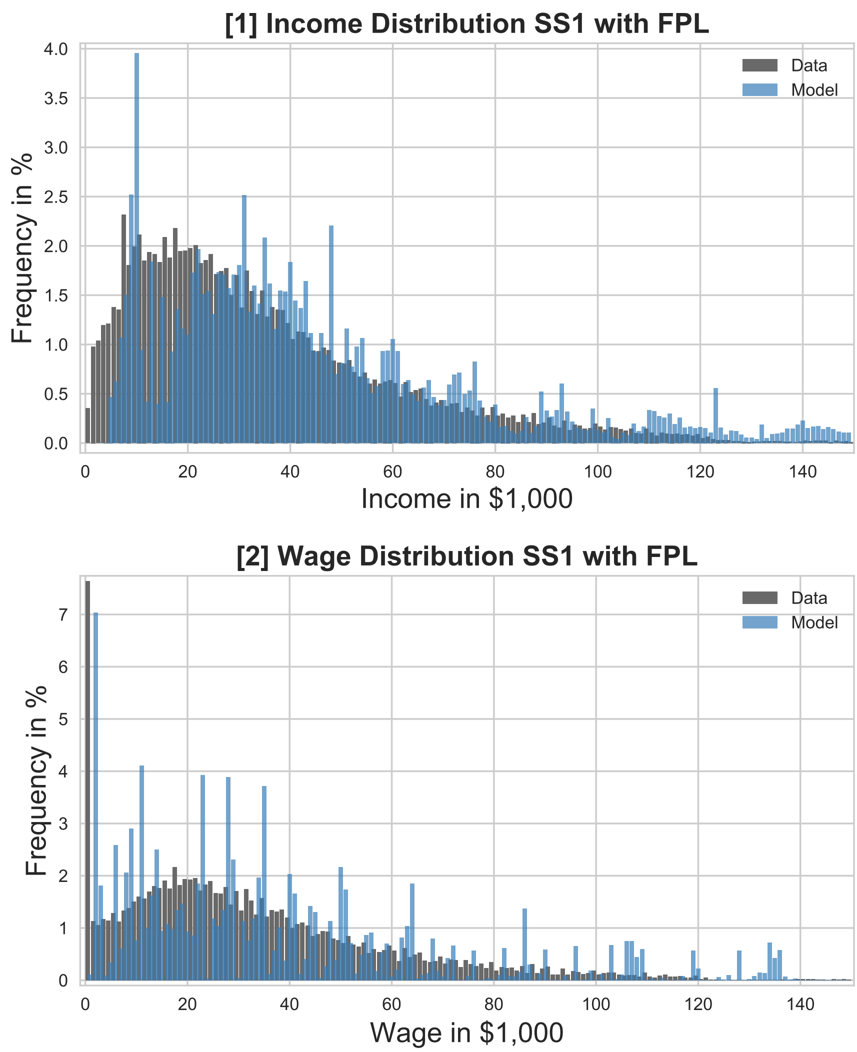

Figure 5: **Moment Matching using MEPS 2000-2009.**
Blue dots are model generated data moments and green dots lines are from PSID 1984-2007.

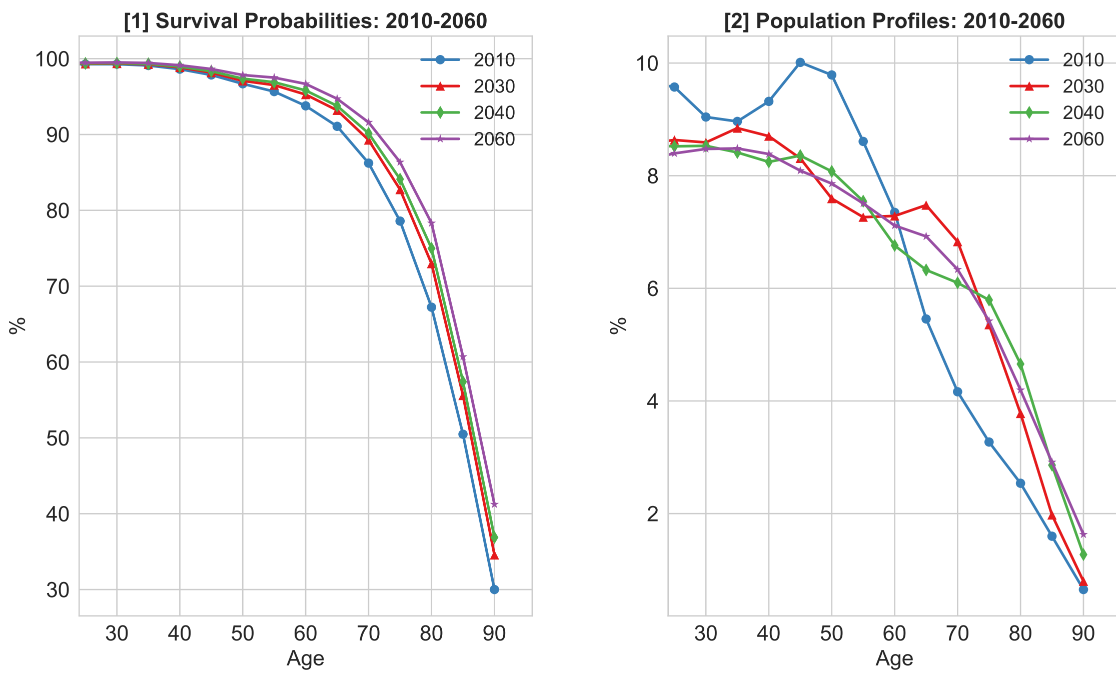

Figure 6: **Survival Probabilities and Cohort Sizes from 2010-2060.**
The average projected survival probabilities for each decade from 2010-2060 in panel [1] and the relative cohort sizes for each decade from 2010-2060 in panel [2] were both attained via personal communication from CMS/OACT. We observe that both survival probabilities and the fraction of older cohorts increase over time.

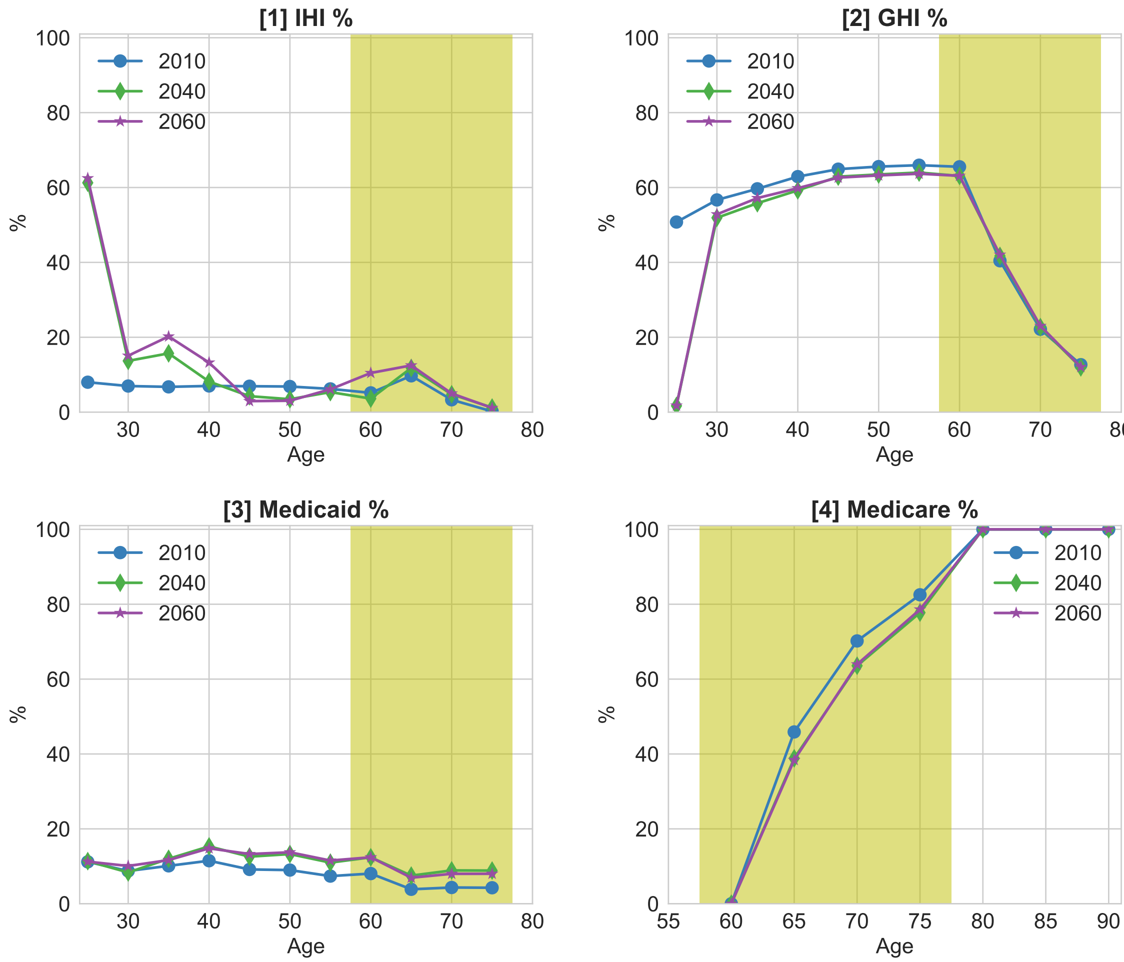

Figure 7: **Insurance Take-Up: Aging.**
We present insurance take-up rates over the lifecycle by insurance type using population profiles from 2010, 2040 and 2060. Panel [1] presents the insurance take-up rates of individual health insurance (IHI), panel [2] present the insurance take-up rates for group health insurance (GHI) and panel [3] presents the take-up rates for Medicaid. The shaded area indicates the time periods where households become eligible for retirement benefits.

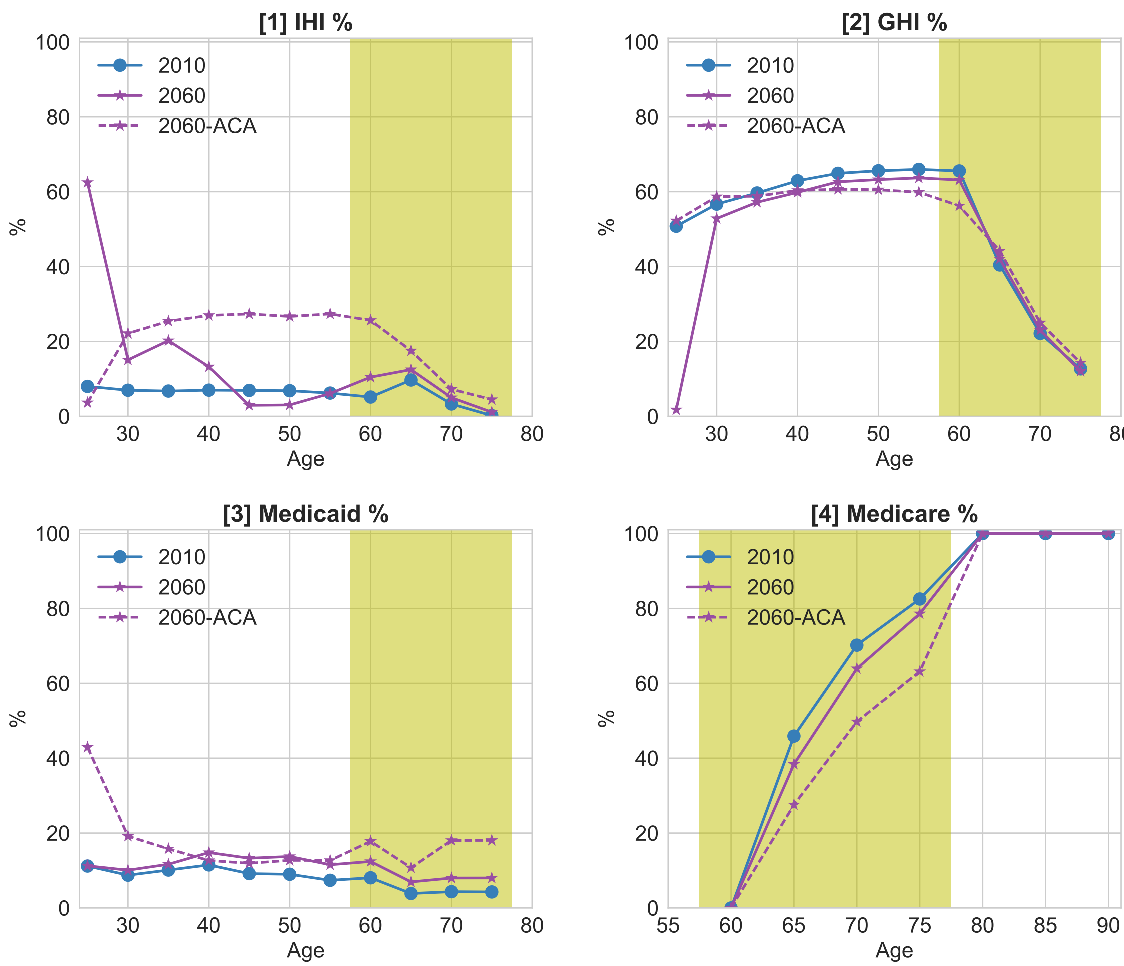

Figure 8: **Insurance Take-Up: Aging and ACA.**
We present insurance take-up rates over the lifecycle by insurance type using population profiles from 2010 and 2060. In addition, we present the take-up rates with 2060 profiles with the ACA fully implemented (dotted line). Panel [1] presents the insurance take-up rates of individual health insurance (IHI), panel [2] present the insurance take-up rates for group health insurance (GHI) and panel [3] presents the take-up rates for Medicaid. The shaded area indicates the time periods where households become eligible for retirement benefits.

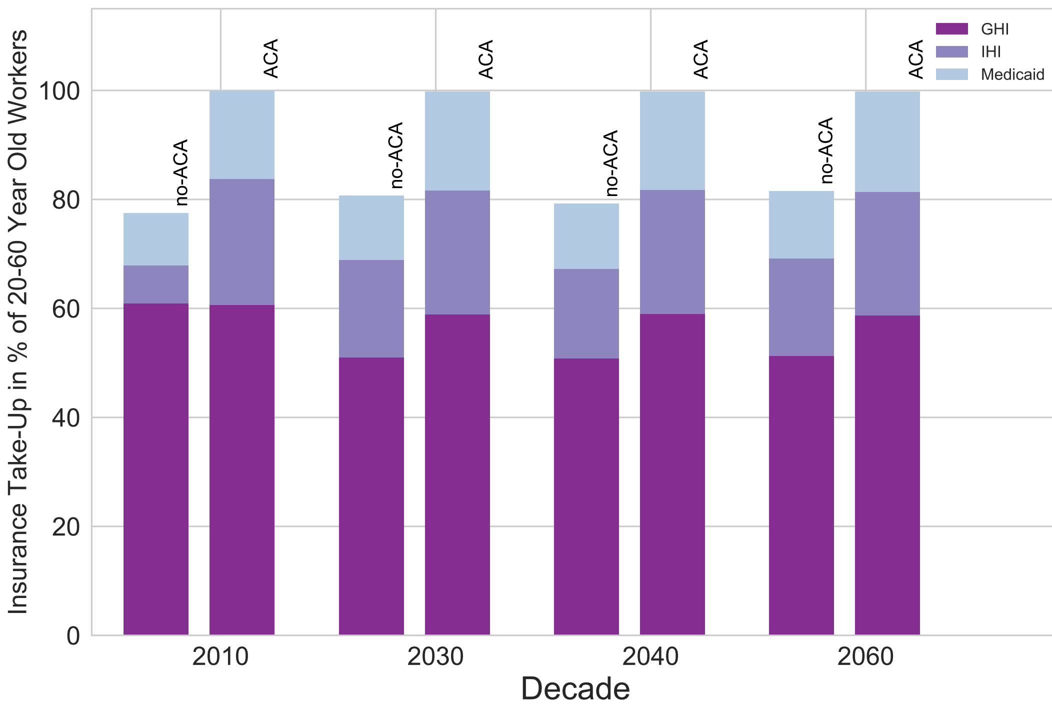

Figure 9: **Insurance Take-up of Workers Aged 20-60 by Insurance Type over Time**.
We present the decomposition of insurance coverage type of workers based on different demographic structures using projections of the U.S. population by CMS/OACT. The insurance take-up rates are steady state results that we calculate holding the demographic structure fixed at the projected population levels for each decade.

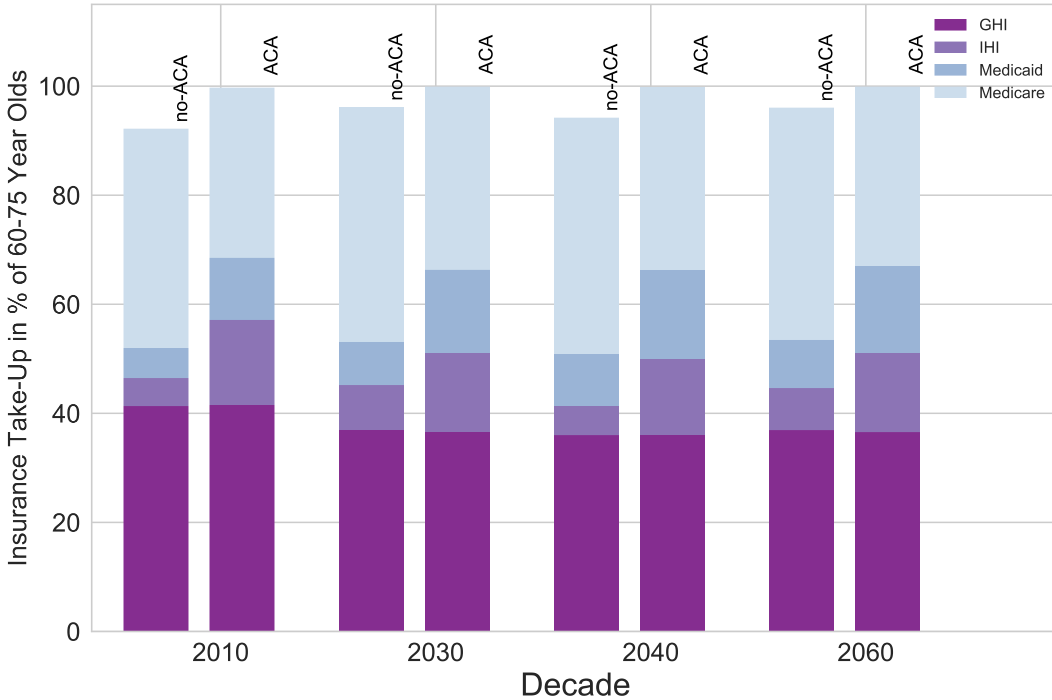

Figure 10: **Insurance Take-up of 60-75 Year Olds by Insurance Type over Time**.
We present the decomposition of insurance coverage type of 60-75 year old individuals that can work or retire based on different demographic structures using projections of the U.S. population by CMS/OACT. The insurance take-up rates are steady state results that we calculate holding the demographic structure fixed at the projected population levels for each decade.

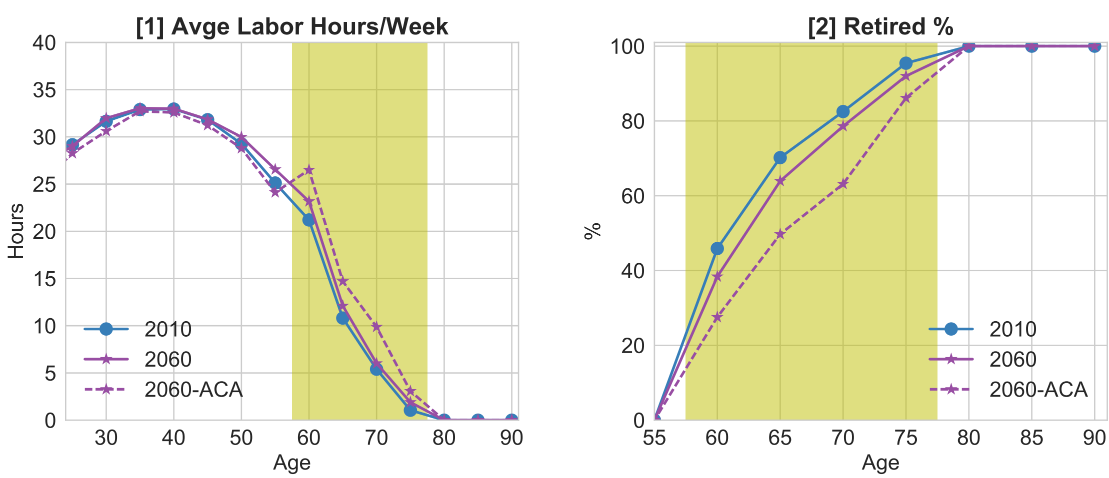

Figure 11: **Labor Hours and Retirement Percentage: Aging and ACA.**
We present average weekly labor hours in Panel [1] and the percentage of the retired population over the lifecycle in Panel [2]. The shaded area indicates the time periods where households become eligible for retirement benefits.

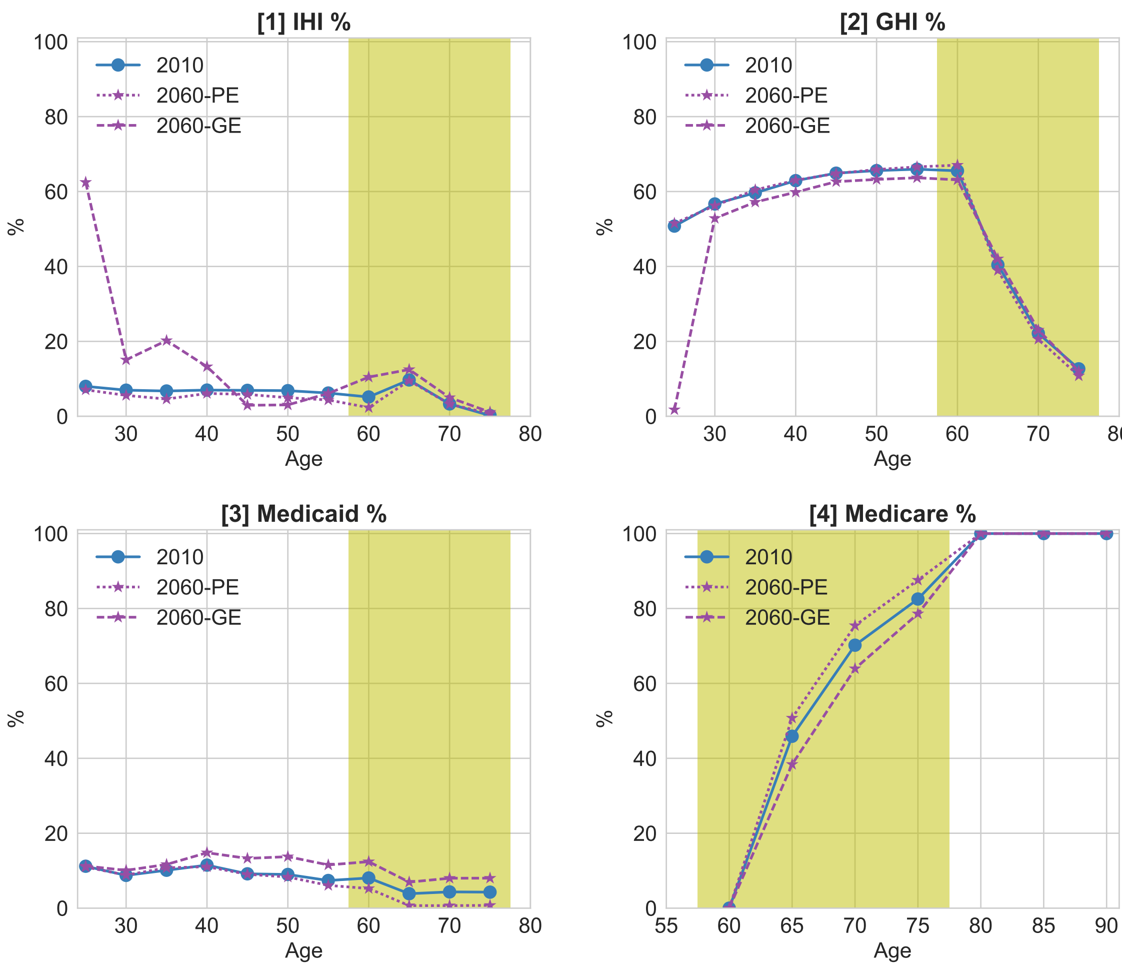

Figure 12: **Insurance Take-Up: Aging - Partial and General Equilibrium.**
We present insurance take-up rates over the lifecycle by insurance type using population profiles from 2010 Benchmark, 2060 Partial Equilibrium and 2060 General Equilibrium. Panel [1] presents the insurance take-up rates of individual health insurance (IHI), panel [2] present the insurance take-up rates for group health insurance (GHI) and panel [3] presents the take-up rates for Medicaid. The shaded area indicates the time periods where households become eligible for retirement benefits.

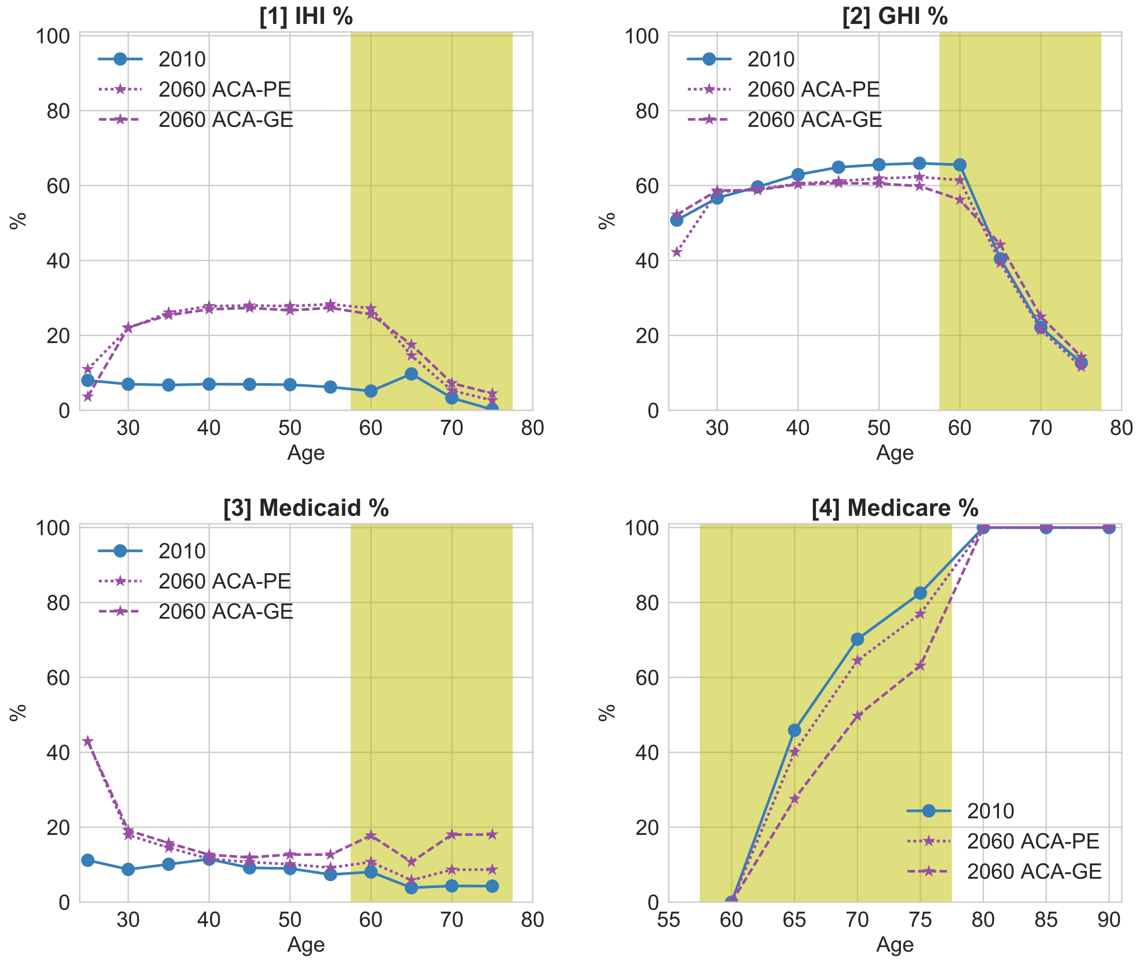

Figure 13: **Insurance Take-Up: Aging and ACA - Partial and General Equilibrium.** We present insurance take-up rates over the lifecycle by insurance type using population profiles from 2010 Benchmark. In addition, we present the take-up rates with 2060 profiles with the ACA fully implemented (dotted line) for Partial Equilibrium and General Equilibrium. Panel [1] presents the insurance take-up rates of individual health insurance (IHI), panel [2] present the insurance take-up rates for group health insurance (GHI) and panel [3] presents the take-up rates for Medicaid. The shaded area indicates the time periods where households become eligible for retirement benefits.