MACROECONOMIC IMPLICATIONS OF HEALTH POLICY IN THE UNITED STATES

by

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To my wife

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PREFACE

It was August 2004 that I came to the University of Michigan to pursue a Ph.D degree in Economics with a concentration in the field of international finance. During my tenure at the International Monetary Fund (IMF), I have met and seen many prominent and well-respected economists pursuing their academic research and making significant contributions in policy arenas at the same time. After being inspired by many, I came to this university with much enthusiasm and hope that one day I would like to become an economist who contributes to this global society.

In life, there is a little incidence that changes one's future course forever. It was the beginning of January 2005 that I came across a very intriguing chart that subsequently determined my research fields. Michigan's PhD program in Economics was structured in such that all first-year students had to take the first macroeconomics course during the second semester. At the first class meeting, Professor John Laitner handed out a course syllabus with a set of charts attached to its end. The last chart showed a time series of the U.S. medical-care spending in percent of GDP based on the National Income and Product Accounts (NIPA). I immediately noticed its unique profile that medical-care spending in percent of GDP had been climbing steadily since 1950 through 2003, accounting for less-than 3 percent in 1950 and 12 percent in 2003.

This chart led me to several questions, including how long this trend continues, what factors have been driving this increase, and what consequences, if there are any, the prolonged growth in medical-care expenditures instigates to impact the U.S. economy and people's lives. My initial investigation for finding reasons behind this secular increase in medical-care spending led me to a surprising realization that serious consequences lie ahead if the high growth in medical spending continues far into the future. Faster growth in medical expenditures that outpaces income growth impacts consumers' well-being, the cost of doing business, labor markets, health care provision, government balance sheet, and other activities in this economy. Its impacts can widely penetrate to influence many economic activities. On the other hand, the outpacing of medical-spending growth affects individuals differently based on their health and socio-economic status. This one chart, which led me to the awareness of health-care issues, thus, provided a research agenda. That is to analyze macroeconomic implications of health policy in the United States.

A pursuit of making a difference in this society has been a driving force of my research involving health-care issues in the United States. This research involves interdisciplinary fields, such as health economics, public finance, and labor economics to name a few. As the nation's health expenditures continue to grow at a pace exceeding its income growth, where the spending in percent of GDP is expected to grow further into the future, this nation's health-care reforms call for participation of macroeconomists and their analysis based on macroeconomic tools. As research methods vary across economists' disciplines, macroeconomists can shed some lights on how a health-care reform influences the well-being of people and the U.S. economy as a whole. Given the importance and the urgency of health-care reforms, debates over health policies must include views of macroeconomists. Due to the complexity of medical-care consumption and the fragmented health-care system in this country, few macroeconomists have looked at health-policy issues so far. This dissertation titled "Macroeconomic Implications of Health Policy in the United States" is my first effort to this challenge. When I am about to start a research career at this junction in my life, this dissertation is to show a commitment of my pursuit and to fulfill the first few items of my long research agenda.

As I am completing this dissertation in spring of 2009, the world economy is in the midst of the most severe recession since World War II. A bursting of U.S. housing-market bubble has triggered credit, financial, and economic turmoil around the world in the last quarter of 2008. According to the recent report by the IMF, the world economic activities in 2009 will experience the first contraction in 60 years.[1] The downfall in the

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[1] International Monetary Fund, "IMF Note on Global Economic Policies and Prospects — Executive Summary," downloaded from http://www.imf.org/external/np/g20/031909a.htm.

global activities is projected at 1.3 percent, according to the World Economic Outlook report by the IMF in April 2009. When we turn our focus onto the U.S. economy, the size of its contraction is projected at 2.8 percent, according to this report. U.S. Bureau of Labor Statistics reported that the nation's unemployment rate in March 2009 was 8.5 percent. The state of Michigan had 12.6 percent of unemployment and ranked the top among 50 states. Many economists appear to believe that the nation's unemployment rate will rise beyond 10 percent by the end of 2009. Even when this great recession ends in coming months, a sluggish economic recovery will take a toll for many households. Since most working-class households purchase health insurance through their employers, a lost employment implies a lost health-insurance coverage to many and raises their risks of foreclosures—a lost house— at the same time. When a gloomy mood and a depressed economy hang over this nation, yet I believe that the current global turmoil offers an opportunity to pursue a comprehensive health-care reform that brings benefits to many people in this country over the short as well as the long horizons.

The Obama administration, the first-ever African American President in the United States, is seriously committed for health-care reforms. His first step to fulfill his campaign promise came about on March 5, 2009. The Obama administration invited Democrats and Republicans, business and labor, consumer groups and health-care providers to hold the first Healthcare Summit. President Obama's acute awareness of health-care issues and empathy toward people who suffer from this broken health-care system may bring voice across the nation together for a healthcare reform. President Obama says at the opening of Healthcare Summit,

> "One undeniable truth brings everyone to the table: The continuing sharp escalation of health care costs for families, business and the government is simply unsustainable. Reform is needed to bring costs under control, to improve the quality health care you are receiving, and to help those who are losing their insurance."

While medicine brings many benefits to the people, it also creates side effects to the economy as the cost of health care keeps rising. Excessive cost inflation of health care adversely influences people's well-being, the government fiscal health of entitlement programs and state-run health programs, such as Medicaid and SCHIP, and the economy's balanced growth path in the long run. A health policy in the 21st century will not merely address issues pertaining to the health-care sector alone but also address issues that are central to economic activities. As the national health expenditure in percent of GDP continues to grow, a health-care reform will reallocate a large amount of resources. Thus, its influence is not limited to the health-care sector alone. The scope of health policy, therefore, must be understood in much broader perspectives.

My PhD degree is only meaningful if my work can take a part in building a better tomorrow. I believe that no one shall suffer from falling into a financial crisis as a consequence of his or her illness. No one shall be denied a medical coverage by insurance companies due to pre-existing conditions. I hope that medical technology will help cure illnesses that have not been treated before so that every man and women can live life to the fullest extent. If a nation was to satisfy the fundamental goals of medical care provision, every citizen has to be a responsible partner of institutions that provide medical care to those who need. Ultimately, this nation has to address how to optimally share the cost of medicine. A political will for a health-care reform, that supports an optimal cost-sharing structure, must entail empathy from the healthy and the rich toward those who suffer from illnesses and those who are financially vulnerable as a consequence of their illnesses. A panacea for the problem of this nation's health care must be based on prevention and cost-effective medicine that help improve people's health and contain medical cost inflation. I hope that tomorrow will build a better society based on affordable medical care to everyone.

April, 2009

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CHAPTER 1

A Stochastic Overlapping Generations Model in a Dynamic General Equilibrium

1.1 Motivations

This chapter provides reasons for this dissertation to use a stochastic overlapping generations (OLG) model in a dynamic general equilibrium framework to analyze macroeconomic implications of health policy in the United States.

It has past over four decades since the seminal work by Abel-Smith (1967), the first definitive study that uses comparable health-expenditure data for a cross-country analysis. He reported that the U.S. spent 5.8 percent of GNP in 1961, the second highest share of medical-care spending after Canada that spent 6.0 percent. Simanis (1973) updated the work of Abel-Smith (1967), and found that the U.S. spent 6.8 percent of GNP in 1969, again ranked the second after Canada that spent 7.3 percent.[2] Since then, the national health expenditures (NHE) have been growing faster than GDP for nearly four decades. In 2007, the NHE accounts for 16.2 percent of GDP, which translates to the per-capita spending of $7,421 in nominal value.[3] The U.S. today far exceeds all other nations in terms of its spending on health care in percent of GDP. A Congressional Budget Office report (2007) projects that the NHE will account for 25 percent of GDP in

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[2] Simanis reports that other countries such as Sweden spent 6.7 percent of GNP in 1969, increased from 5.4 percent in 1962, The Netherlands spent 5.9 percent in 1969, increased from 4.8 percent in 1963. Similarly, Federal Republic of Germany spent 5.7 percent in 1969, increased from 4.5 percent in 1961. France also spent 5.7 percent in 1969 while it spent 4.4 percent in 1963. United Kingdom spent 4.8 percent in 1969, up from 4.2 percent in 1961-1962.

[3] Centers for Medicare & Medicaid Services (CMS), “National Health Expenditures 2007 Highlights”, downloaded from http://www.cms.hhs.gov/NationalHealthExpendData/downloads/highlights.pdf.

year 2025 and 37 percent by 2050. Provided that underlying assumptions continue to hold, the same spending could reach almost 50 percent of GDP in 2082.[4]

If national health expenditures in percent of GDP double again over the next thirty years, what consequences will that lead to? Will our lives be affected by that? If so, how will we be affected? Does our past experience tell us anything about a future course of the U.S. economy? If this trend continues as CBO projects, there is one thing that is very clear to us. The U.S. economy in the 21st century will be driven by the influence of medicine. As I give this dissertation a title "Macroeconomic Implications of Health Policy in the U.S," this study investigates how medical-care spending growth, that outpaces income growth, influences the well-being of people, the balanced growth path of the U.S. economy, and the wealth inequality among the people. This study also analyzes health policies and their effects. For these purposes, it builds a stochastic overlapping generations (OLG) model and uses it in a dynamic general equilibrium context.

1.2 Building the Workhorse Model

1.2.1 OLG Model

This dissertation uses a 60-period overlapping generations (OLG) model as a workhorse, and is motivated by the seminal work by Auerbach and Kotlikoff (1987) who built a 55-period OLG model (the A-K OLG) to analyze tax policies in a dynamic general equilibrium context. An OLG model was first introduced by Allais (1947).[5] Samuelson (1958) uses a 3-period OLG model to analyze interest rates with or without money, applying consumption-saving dynamics. Diamond (1965) uses a 2-period OLG model with a production function that exhibits a technological progress to analyze long-run

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[4] Their projection is based on the assumptions of long-term rate of excess cost growth which is defined as the number of percentage points by which the growth of spending on medical care exceeds the growth of nominal GDP. Their projection is based on the assumptions that the excess cost growth is 2.4, 2.2, and 2.0 percentage points for Medicare, Medicaid, and all other spending on health through 2018 and slows down to 1.7, 0.9, and 0.6 percentage points at year 2082, respectively.

[5]

competitive equilibrium and investigate effects of government debt on this equilibrium. Geanakoplos (2008) says,

> "A vast literature in public finance and macroeconomics is based on the [OLG] model, including studies of the national debt, social security, the incidence of taxation and bequests on the accumulation of capital, the Phillips curve, the business cycle, and the foundations of monetary theory."

Any research that uses an OLG model, therefore, owes tremendously to these early pioneers. There are three essential features to an OLG model. First, agents face a finite life as oppose to an infinite life, typically assumed by the Ramsey-Cass-Koopmans (RCK) model, or the neoclassical growth model with endogenous saving rate. Second, multiple equilibriums can exist. Third, the equilibrium of the economy is not necessarily a Pareto efficient.

An OLG model with a limited number of periods is attractive for analytical tractability but does not capture a sufficient degree of heterogeneity that exists in micro-data. A many-period OLG model, in contrast, offers a way to capture the intergenerational heterogeneity and explain dynamics over people's lifecycles. In exploiting this feature, the A-K OLG model numerically finds dynamic general equilibriums at steady states under various tax policies and explains dynamic transition path from one steady state to another. Today, variations of A-K OLG model is widely used across economic disciplines. Kotlikoff (2000) says,

> "The model has been used to examine a host of policies, including tax reform, tax cuts, investment incentives, tax progressivity, expansion of social security, government spending, monetary policy, endogenous growth, the size of the informal sector, human capital accumulation, and educational policy."

The original A-K OLG model, however, lacks intra-generational heterogeneity. As a result, it failed to address intra-generational equity issues. (Kotlikoff 2000)

1.2.2 A Model with Intra- and Inter-generational Heterogeneity

This dissertation emphasizes heterogeneity among individuals whose actions ultimately guide the overall economy. In order to analyze health policy, it is imperative to capture heterogeneity of medical-care consumption that exists in micro-data. Since older generations tend to consume more medical care on average, encompassing inter-generational heterogeneity of a many-period OLG model is well suited for analyzing health policy. Another important dimension of heterogeneity is to capture a variation of medical-care consumption within each age-cohort. Those who are "poor" in health status, for example, tend to consume more medical services. As people get rich, given that medical services being normal goods, they may consume more medical care. Hence, incorporating intra-generational heterogeneity is also indispensable for health policy analysis. These two dimensions of heterogeneity in medical-care consumption are consistent with observations in micro-data. This dissertation captures a high degree of intra-as well as inter-generational heterogeneity of medical consumption in the OLG model.

An OLG model with intra-generational heterogeneity can be compared to a representative agent model which assumes that all households in the economy are homogeneous. Thus, the model does not distinguish individuals and the economy. No distributional analysis can follow due to the model's limitation. An OLG model, in contrast, separates individuals from the economy. It allows us to examine distributional effects of health-policy reforms.

This dissertation incorporates the following heterogeneity among individuals.

(i) age (25 through 84)
(ii) earning ability (low, middle, high)
(iii) insurance status
(iv) health status (excellent, very good, good, fair, and poor)
(v) medical consumption
(vi) wealth

In Chapter 2, the model has three categories of insurance status for workers: employer-sponsored health insurance (EHI); private non-group health insurance (PRI); and uninsured (UNI). For retirees, there is only one health insurance, Medicare (MC).

Workers must decide whether of not they purchase health insurance at the beginning of each period after they find out whether or not they received an EHI offer. Hence Chapter 2 captures the following source of heterogeneity in addition to (i)-(vi) above,

(vii) EHI offer

Chapter 2 also investigates impacts of price discrimination by insurance companies on the basis of pre-existing conditions. It analyzes health insurance markets and the economy's balanced growth path when insurance companies impose price discrimination. For this analysis, this chapter includes an additional heterogeneity,

(viii) Presence of pre-existing conditions

In contrast, Chapter 3 and 4 simplify the model by excluding endogenous decisions of insurance purchase. In these chapters, individuals make consumption and saving decisions only. Nature chooses their insurance status. For workers, there are two categories of insurance status: employer-sponsored health insurance (EHI); and uninsured (UNI). Retirees also face two categories of insurance status: Medicare plus a private supplemental insurance (MCS); and Medicare only (MCO).

Sources of heterogeneity are not independent to one another. For example, earning ability depends on age. Current health status depends on age, earning ability, and previous health status. Medical consumption depends on age, earning ability, insurance status, and a transition of health status.

1.2.3 Sources of Uncertainty – A Stochastic Model

There are three sources of uncertainty. First, this dissertation assumes that an EHI offer, which is a function of age and earning ability, is subject to uncertainty. As a result, agents face uncertain insurance status over time. Similarly, health status is uncertain and evolves according to a Markov transition. Medical consumption, which is conditional on a transition of health status as well as age, earning ability, and insurance status, follows a stochastic process. In essence, this dissertation assumes that nature chooses individual health status and the level of medical care consumption.

It is more appealing to incorporate a health production function in an OLG model, which was introduced by the seminal work of Grossman (1972), where people build health capital by optimally choosing the level of medical consumption as investment. It is, however, difficult to calibrate Grossman's model due to a lack of comprehensive data. People often build health capital by doing exercises, paying attention to what they eat, going cold turkey, taking a good rest, and etc. Furthermore, the U.S. distribution of medical expenditures indicates that, when population is ranked by medical expenditures, the top 5 percent of the population explains more than 50 percent of the aggregate medical expenditures. On the other hand, the top 50 percent of the population accounts for more than 95 percent of the total spending. More interestingly, the distribution of health expenditures for the U.S. population has been relatively stable since 1928. (Berk and Monheit 2001; Yu and Ezzati-Rice 2005) The concentration of medical-care expenditures implies that a majority of the population consumes either nothing or a very little medical care in this country. When medical care becomes more expensive, people's awareness toward good health rises. As a result, they take better care of themselves by prevention, which leads to less consumption of medical care. In order to fully appreciate Grossman's model in an OLG framework, we need a dataset that links people's health and insurance status, consumption of medical services, how they spend their time, and their eating habits. It would allow us to capture how people build their health capital based on their behavioral responses to changes in medical prices and wage rates.

1.2.4 A General Equilibrium Model

Health policy, which often entails fiscal policy, works through people's budget constraints. Thus, it inevitably affects households' consumption and saving decisions. Universal insurance policy with or without individual mandates, for example, influence their insurance purchasing decisions. These decisions will directly control nation's capital-labor ratio over time, which in turn influences equilibrium wage and interest rates, tax rates, and health insurance premiums. Health policy analysis must encompass dynamics of these equilibrium prices. For this reason, this study uses a model applied in a general equilibrium.

1.2.5 A Dynamic Model

How will a health-care reform today affect the economy in a distant future? To be able to answer this question, we must have a dynamic model. The model used in this study is an exogenous growth model, where it assumes a labor augmented technology that helps grow workers' earning ability over time. There are no aggregate shocks. This study does not incorporate idiosyncratic shocks to labor endowments. The benchmark model assumes that the economy is initially at the steady state. Then the model goes through a deviation period where medical demand and prices grow above the steady-state growth rate. As the excess cost and demand growth dissipates, a transition period follows. The economy, then, reaches a new steady state. Health policy of our interest is implemented at the beginning of the deviation period. This study uses a comparative statics analysis and evaluates the balanced path of the economy and the well-being of people at the new steady state.

1.3 Applications

The first essay integrates endogenous insurance purchasing and consumption-saving decisions in the model and compares universal insurance with and without individual mandates. This essay calls, as universal insurance, a health policy where the government provides a proportional subsidy to individuals who purchase non-group health insurance. This study evaluates whether or not such a policy will improve aggregate well-being of the people, measured by population-weighted average of individual flow utilities. It also analyzes the policy's impact on the wealth inequality and the balanced growth path of the economy. This study also investigates whether or not individual mandates matter for the outcomes. In addition, this essay evaluates a policy that forbids price discrimination by insurance companies on the basis of pre-existing conditions.

The second essay explores economic and welfare impacts of government payment policy for managing Medicare program. The 2008 report by the Centers for Medicare & Medicaid Services (2008) indicates that Medicare's Hospital Insurance (HI) Trust Funds will become insolvent in year 2019. They expect that the spending on HI rises annually by 7.4 percent for the next 10 years on average. Officials at the Centers for Medicare & Medicaid Services are seriously concerned that the spending on supplementary medical insurance (Medicare Part B) may grow annually by as much as 9.6 percent, an equivalent of the average growth rate over the past five years. One can easily see that the program cost will likely grow faster than workers' wages. How should the government finance the expected growth of Medicare cost in the future? In order to contain the program's cost growth, the government may lower hospital reimbursement rates in lieu of raising tax rates. In order for hospitals to stay in business, they must finance the revenue gap caused by government underpayments. As hospitals must break even, they charge higher prices to private payers, which is known as cost-shifting in health economics literature. The second essay evaluates the government reimbursement policy and compares its impacts on the economy and the well-being of people against a policy that raises tax rates to finance excess growth of the program cost.

The third essay analyzes elasticity of Social Security, Hospital Insurance, and wage income tax rates with respect to their determinants in a dynamic general equilibrium. Due to the payroll-tax-exclusion and the wage-income-tax-exclusion rules, a deviation in growth rate of workers' medical expenditures raises growth rate of tax expenditures—forgone tax revenues. As a result, equilibrium tax rates become more sensitive to workers' health insurance premium. The government fiscal health of entitlement programs is critically linked to the magnitude and the length of the growth deviation. This essay also explores a transition path of equilibrium Social Security tax, Hospital Insurance tax, and wage-income tax rates. This essay presents a policy experiment where the government abolishes the income-tax exclusion rule applied to workers' contribution of employer-sponsored health insurance premiums.

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CHAPTER 2

A General Equilibrium Analysis of Policies for Universal Insurance in the United States

2.1 Introduction

This chapter studies the long-run impacts of several possible health-policy reforms. One reform, which I label "universal insurance without mandate," would subsidize health insurance coverage for all individuals not covered by employers; a second, which this paper labels "universal insurance with mandate," would similarly subsidize the non-group health insurance and require all individuals to enroll in coverage. This paper also investigates the consequences of allowing, and disallowing, private health insurers to price discriminate against pre-existing conditions. In all cases, the analysis considers impacts upon the economy's steady-state equilibrium, transitions to the new steady-state equilibrium, and average household utility.

Due to the complexity of medical care consumption, the fragmented structure of health care markets, and the interdisciplinary nature of health policy issues, macroeconomic analysis of health policy has perhaps received less attention than it deserves. This study constructs a stochastic overlapping generations (OLG) model and applies it in a dynamic general equilibrium framework. The OLG model captures household behavior with 60-period life spans. Households have different earnings. The overall economy is closed; wages and interest rates are endogenous. Each household's health evolves according to a Markov process. Thus, households differ in their health status. In each period, a household chooses its saving and consumption, and it can accept or decline health insurance. There are two types of health insurance, group and non-group. Households can completely opt out of insurance markets. Hence, households differ in their insurance status. The analysis begins with a steady-state equilibrium. After an exogenous change, which might be a policy reform, this study computes the corresponding new steady state and simulates the economy's transition to it.

This paper attempts to make contributions in four areas. First, from a modeling perspective, this study includes a large degree of heterogeneity among agents (spanning in the order of 10^5 before including heterogeneity of asset holdings). An OLG model always includes age heterogeneity; this paper's framework also encompasses heterogeneity earnings, insurance status (i.e., some households, at some ages, are offered employer sponsored health insurance but others are not), health status and medical care consumption. The extensive "between" and "within" age structures allow realistic changes in probabilities for the emergence of health problems. It allows the study of pre-existing health problems. It also allows the model to study the impact of Medicare, including Medicare reimbursement policies, on the economy. Second, this paper calibrates its model from a variety of micro data sources. These include the Medical Expenditure Panel Survey (MEPS) and National Health Interview Survey (NHIS). This paper uses simulations of population averages to assess the validity of our calibrations. Third, the model incorporates household annual decisions of whether or not to purchase health insurance. Each decision is intertemporal in nature, as opposed to being strictly contemporaneous. Because of the endogeneity of insurance take-up, this paper's framework can be useful for studying the fraction of the population that is uninsured. Fourth, this paper analyzes various prospective policy reforms. We can use simulations to project macroeconomic consequences and changes in average household utility. We can study reforms leading to universal insurance coverage, with or without mandates, as described above. We can similarly study the effects of allowing, or prohibiting, insurers from price discriminating on the basis of pre-existing health conditions.

This paper's policy experiments show that subsidies under universal insurance without mandate do indeed lower the percentage of the uninsured workers and reduce the size of the financially vulnerable population. The impact on the overall economy's balanced growth path is, perhaps surprisingly, limited. For a reform offering subsidies but mandating the take-up of insurance, we can bring the financially vulnerable population close to zero. There is, however, lower welfare and lower steady-state output. Assume insurers cannot price discriminate against pre-existing conditions. Then reform with no mandate helps people with poor health obtain insurance. Healthy people, on the other hand, may be less inclined to insure themselves—as average health status within the insured pool declines, the price of insurance will rise. With a mandate that everyone must purchase insurance, healthy people who otherwise would not purchase must bear the negative consumer surplus in insurance markets. Their use of medical services rises. And, precautionary saving declines (due to increased use of insurance). Hence, the economy's steady-state capital-to-labor ratio falls.

This paper's organization is as follows. Section 2 surveys related literature. Section 3 lays out the model. Section 4 explains the calibrations. Section 5 presents benchmark simulations. Section 6 studies policy experiments. Section 7 concludes.

2.2 Related Literature

Hall and Jones (2007) apply a representative agent model that accommodates age-specific mortality to explain why the U.S. spend an increasing fraction of GDP for health care. Using aggregate health spending in the U.S., they claim that people's value toward spending on health rises as health care consumption allows them to extend their lives and to improve the quality of their lives. There are two critical factors that explain their result. First, people's statistical value of life rises with longevity and income. Second, marginal utility of health measured in statistical value does not diminish as fast as the marginal utility of non-health consumption does. They argue that health care is considered as a superior good which has an income elasticity far exceeding one. To the contrary, Newhouse (1992) reports that the income elasticity of medical care demand based on observations of cross-sectional households is 0.2 to 0.4.[6] Hall and Jones (2007) who are aware of his study note, "one source of evidence that runs counter to our prediction is the micro evidence on health spending and income." The 60-period OLG model in my study, which uses micro data from Medical Expenditure Panel Survey for calibration, can

[6] Newhouse (1992) also reports that international cross-sectional studies indicate that income elasticities of demand for medical care is around 1 or even higher on the aggregate level.

reconcile this difference in income elasticity and explain the increasing fraction of GDP for health care without assuming it as a superior good.

The analytical gap that stems from the use between aggregate and micro data is not new to economists. The Aiyagari-Bewley economic model, which bases modern dynamic macroeconomics, emphasizes that heterogeneity in micro data has important implications for aggregate activities and provide insights on the role of economic policies. (Eckstein and Peled 2008) The literature born out of Bewley (1986) and Aiyagari (1994) as well as Imrohoroglu (1992) and Huggett (1993) has paid closer attention to heterogeneity of individuals who experience idiosyncratic income shocks, and analyzed their impacts on precautionary demand for savings, distribution of income, and wealth and consumption inequalities.

Another stream of literature expands the seminal work by Auerbach and Kotlikoff (1987) who examined tax regimes based on 55-period overlapping generations (OLG) model. Hubbard, Skinner et al (1994), for example, expand their model by including heterogeneity within age-cohort by calibrating uncertainty of earnings, medical care expenditures, and life span from micro data as these factors are to explain precautionary demand for savings. (Kotlikoff 1989) Another study by Hubbard, Skinner et al (1995), which incorporates these sources of uncertainty, finds that the households with low income to accumulate less wealth in the presence of social insurance is their best response. In order to account for uncertainty of medical expenses and its impact on consumption-saving decisions, their study parameterizes the degree of uncertainty by estimating AR(1) coefficients from the cross-sectional data.[7] Underlying stochastic processes of medical care expenditures are unrelated to health status. Insurance status was not controlled in their regression. In my OLG model, uncertainty of medical expenditures are calibrated from longitudinal micro data from MEPS and depends on age, earning ability, insurance status, and a transition of health status.

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[7] Estimated coefficients are based on the 1977 cross sectional study of National Health Expenditure Survey and 1977 National Nursing Home Survey. Their regression results indicate that out-of-pocket medical expenditures are highly time persistent with the AR(1) coefficients of 0.901 for all three educational groups ("No high school", "High school plus", and "College plus"). Variances of the innovation on residuals are 0.175, 0.156, and 0.153 for these three groups, respectively.

Jeske and Kitao (2005) combine the earlier models and expand them by adding health insurance purchasing decision. Their analysis points out that U.S. tax policy toward employer-sponsored health insurance (EHI) sustains high take-up rate of EHI among workers who receive the EHI offer. While their model has many attractive features, it is a three-period OLG. There is only a single generation of workers that explains the distribution of insured and uninsured population. Since demand for health insurance is closely linked to agent's expected medical expenditures, a lack of heterogeneity across workers' age cohorts can limit distributional analysis of health policy. My study applies a 60-period OLG model instead, of which 40 generations of workers simultaneously make their insurance purchasing decisions.

Ballard and Goddeeris (1999) have analyzed efficiency and distributional effects of financing universal care in a general equilibrium framework based on their computational general equilibrium (CGE) model. [8] Their model incorporates heterogeneity of family size, income, age of head, and labor type (high and low skills), and three-factor trans-log production function. Their result indicates that aggregate efficiency loss under universal care ranges from 0.2 percent to 1 percent of net national product. They conclude that universal health care implemented under a "mandate-with-tax-credit" plan imposes less efficiency losses to the economy relative to a full finance plan. Their CGE model includes an insurance purchasing decision that is controlled by estimated coefficients of their Probit model.[9] Being able to explain the distribution of insured and uninsured population in a general equilibrium is the first of its kind. However, their model is static in nature. When health policy triggers a behavioral change in insurance take-up decisions, its consequence on consumption-saving decision is left out of their equation. Changes in the distribution of insurance status do not affect equilibrium wage and interest rate in their model. An OLG model applied in a dynamic general equilibrium can take into account the changes in equilibrium wage and interest

[8] They calibrate the model for 1991 based on 1992 March CPS.
[9] They control family size, the number of adults and children in the household, expected payment for medical care by an insurance contract, and a dummy variable of no earners in the household

rates as they, in turn, influence agents' decisions of insurance take-up, consumption, and savings.

Gruber (2004) uses a complex micro-simulation model to analyze how various tax interventions can help reduce the percentage of uninsured population. Applying regression estimates from various reduced models, Gruber incorporates both individual and firm behaviors that respond to tax policies in his model. His study finds that tax credits aimed at employers are the most efficient in terms of government spending per dollar of insurance. The credits targeted at non-group coverage yields a similar result. The question of how health policy influences the economy via changes in wage rate and interest rate is outside the scope of his simulation.

Each of the models I describe above offers merit to my study. In order to analyze the U.S. economy and welfare of the people under universal insurance, this study builds a 60-period OLG model based upon many of their attractive features. The following section describes detail of my model.

2.3 A Stochastic Overlapping Generations Model

2.3.1 Demographics

A generation of agents is born in every period *t*. They all live exactly 60 periods. There is no uncertainty of life span. One period in the model corresponds to one year of an individual life. The model accounts for actual age between 25 through 84. I use $a \in I_a = \{1,...,60\}$ to denote age. I assume that the population grows by the rate g_N, which is exogenously given. A specific age cohort ($N_{a,t}$) accounts for a constant fraction of the total population (N_t) across time. This fraction is denoted by:

$$\mu_a = \frac{N_{a,t}}{N_t} \qquad [2\text{-}1]$$

$$\text{where } \sum_{a \in I_a} \mu_a = 1 \text{ and } N_{a,t} = \left(1 + g_N\right) N_{a,t-1} \quad \forall a, t.$$

Each agent works during the first forty years, retires at the beginning of the 41st period (corresponding to the actual age of 65), and spends remaining 20 years in retirement.

2.3.2 Medical Care Consumption

Since there are an uncountable number of diseases and unobservable stochastic processes of health shocks, instead of modeling a health production function in which agents autonomously determine the level of medical care to consume and health capital to build (Grossman 1972), this study assumes that nature chooses an arrival of various health shocks conditional upon agent's age (a), earning ability (e), insurance status (i), and health status (h).[10] The level of medical care consumption by an individual agent in period t depends on a transition of health status ($h \times h$) as well as on age, earning ability, and insurance status.

$$m_t = m\left(a_t, e_t, i_t, h_{t-1} \times h_t\right) \qquad [2\text{-}2]$$

Given that medical care consumption is exogenous for agents, their medical care demand is perfectly inelastic.

2.3.3 Hospital Behavior and Cost-shifting

In every period t, the representative hospital updates a Charge Description Master (CDM) which reflects an average cost of each procedure. Given the fragmented structure of U.S. health care markets, it is the government which determines prices $\left(P_t^{M^O}\right)$ of medical care provided to Medicare patients under the Medicare Prospective Payment System[11] (PPS). While taking $P_t^{M^O}$ as given, the hospital sets medical care prices $\left(P_t^{M^Y}\right)$ for workers.

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[10] Under this assumption, agents consume medical care only when a health shock arrives.

[11] The Medicare Prospective Payment System (PPS) was introduced in 1983 by the federal government. The goal was to encourage hospitals to engage in a cost-efficient medical care provision. Under PPS, hospitals receive a payment from the Centers for Medicare and Medicaid Services (CMS) based on a patient's Diagnosis Related Group (DRG). Under this reimbursement system, each Medicare patient will be classified into the DRG on the basis of clinical information. When physicians take an assignment, they charge the government-approved prices to Medicare patients. Physicians accept reimbursements from the government based on the prices.

Under the assumption of perfect competition with a free entry and exit in the long run, the objective of the representative hospital is defined as follows:

$$0 = \max_{P_t^{M^Y}} \left\{ P_t^{M^Y} M_t^Y + P_t^{M^O} M_t^O - AC_t \left(M_t^Y + M_t^O \right) \right\}$$

$$\textit{subject to}$$
$$P_t^{M^Y} M_t^Y + P_t^{M^O} M_t^O = P_t^M M_t$$
$$M_t = M_t^Y + M_t^O$$
$$P_t^{M^O} = \varpi AC_t^M \text{ where } \varpi \in (0,1). \qquad [2\text{-}3]$$

Aggregate medical-care consumption among workers and retirees are denoted by $\left(M_t^Y, M_t^O\right)$, respectively. The solution to the problem [2-3] yields:

$$P_t^M = AC_t \qquad [2\text{-}4]$$

$$P_t^{M^Y} = \frac{AC_t^M \left\{ \left(1-\varpi_t\right) M_t^O + M_t^Y \right\}}{M_t^Y} = \frac{P_t^M \left\{ \left(1-\varpi_t\right) M_t^O + M_t^Y \right\}}{M_t^Y} \neq P_t^{M^O} \qquad [2\text{-}5]$$

This study assumes that the price set by the government does not meet the average cost of medical care delivery, $\varpi \in (0,1)$. As a result, the hospital incurs an economic loss by treating Medicare patients. Even under the assumption of perfect competition with free entry and exit in the long run, the hospital must apply a markup pricing to workers in order to break-even. Hence workers and retirees face different prices for the same treatment as the hospital engages in cost shifting, $P_t^{M^Y} \neq P_t^{M^O}$.[12] (Dranove 1988; Morrisey 1994; Kessler 2007)

[12] Morrisey (1994) refers to a static cost shifting as a price discrimination where the hospital charges different prices to different groups of patients. A price discrimination defined in the economic theory, however, does not fully capture the reasoning behind a static cost shifting by a hospital, according to Morrisey. A firm with a sufficient market power can impose a price discrimination in such to become better off under the economic theory of price discrimination. Morrisey claims that a price discrimination by a hospital, however, may not make the hospital better off when one group of payer pays less than the others.

2.3.4 Insurance Company

There is a representative insurance company that underwrites two insurance policies. One is the group health insurance policy that is provided by the representative firm in the form of employer-sponsored health insurance (EHI) benefit. The other policy is private non-group health insurance, denoted by PRI. Workers who do not receive an EHI offer have an option of purchasing the non-group health insurance policy on their own. Workers with an EHI offer can choose either EHI or PRI. Regardless of EHI-offer status, workers can opt out of insurance markets and become uninsured.

2.3.4.1 Employer-sponsored Health Insurance (EHI)

The representative insurance company takes the price of medical care $P_t^{M^Y}$ for workers, the synthetic coinsurance rate $\sigma_t^{EHI}(m)$ paid by EHI holders, medical care demand (*m*), insurance demand q_t^{EHI}, and the joint distribution $\mu_t(a,e,i=EHI,h\times h,m)$ as given. Under the assumption of zero loadings[13], the insurance company sets the health insurance premium Ω_t^{EHI} to break even.

$$\Omega_t^{EHI} = \Omega^{EHI}\left(1-\sigma_t^{EHI}(m), P_t^{M^Y}, m_t, q_t^{EHI}, \mu_t\left(a,e,i=EHI,h\times h,m\right)\right) \tag{2-6}$$

The synthetic coinsurance rate $\sigma_t^{EHI}(m)$ negatively depends on the level of medical care consumption.

2.3.4.2 Non-group Private Health Insurance (PRI)

Workers who do not receive an EHI offer can still purchase a health-insurance contract outside their employment. Under the zero-loading assumption, the insurance company sets the premium Ω_t^{PRI} to break even,

[13] The representative insurance company takes no commissions and fees for transactions.

$$\Omega_t^{PRI} = \Omega^{PRI}\left(1-\sigma_t^{PRI}\left(m\right), P_t^{M^Y}, m_t, q_t^{PRI}, \mu_t\left(a,e,i=PRI,h\times h,m\right)\right)$$

[2-7]

Likewise, the synthetic coinsurance rate $\sigma_t^{PRI}\left(m\right)$ is lower when *m* becomes higher.

2.3.5 Prices

There are three price indices in the economy. The term P_t^C is the price index for commodities, and the term P_t^M defines the price index for medical care goods and services. Based on these two price indices, I define the aggregate price index P_t^A as a weighted-geometric average of the two price indices:

$$P_t^A = \left(P_t^C\right)^{1-\vartheta}\left(P_t^M\right)^{\vartheta} \text{ where } \vartheta \in \left(0,1\right).$$

[2-8]

Nominal wage rate as well as nominal Social Security benefits are indexed to the aggregate price index.

2.3.6 Government

2.3.6.1 Social Security Program

The government runs a pay-as-you-go (PAYGO) Social Security program. It determines the Social Security tax rate τ_t^{SS} to balance its budget while taking the real Social Security benefits $\left(b_t\right)$ and tax base $\left(TAXBASE_t^{SS}\right)$ as given.

$$\tau_t^{SS} = \tau^{SS}\left(b_t, TAXBASE_t^{SS}\right)$$

[2-9]

$$\text{where } b_t = b\left(a,e,P_J^A,w_J,z_J\left(a,e\right),\theta\right)$$

$$TAXBASE_t^{SS} = TAXBASE\left(P_t^A,w_t,c_t^{EHI},z_t\left(a,e\right),\bar{l},\mu\left(a,e\right)\right).$$

The real Social Security benefits are computed based on the average indexed monthly earnings (AIME). [14]

The constant earnings replacement rate θ is applied.[15] The time subscript J in 0 denotes multi periods. The government applies the cost-of-living-adjustment (COLA) to maintain a purchasing power of retirees. The tax base depends on the wage rate, the marginal cost of employer-sponsored health insurance (EHI), labor endowments, labor supply in hours, and joint distribution of age and earning groups. Since firms, which offer an EHI benefit to their employees, can deduct their total cost of EHI provision from the payroll tax base—payroll tax exclusion rule, the marginal cost of EHI provision c_t^{EHI} critically controls the size of Social Security tax base.

2.3.6.2 Medicare Program

2.3.6.2.1 Hospital Insurance – Part A

The government runs a Medicare program for retirees. The program consists of two parts: Part A and Part B. Part A is an entitlement program for a hospital insurance that covers inpatient hospital services, care in skilled nursing facilities, hospice and home health care. Medicare Part A program is financed by a Hospital Insurance (HI) tax, one of the two components of the payroll tax which is paid by firms and workers equally. Upon retirement at age 41 (actual age of 65), all retirees join Part A. They must pay coinsurance for care provided under Part A program. In order to satisfy the balanced budget condition, the government determines the hospital insurance tax rate τ_t^{HI} which is computed as

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[14] The computation of AIME follows the description given by the US Social Security Administration at: http://www.ssa.gov/OACT/COLA/Benefits.html#aime.

[15] I do not apply the primary insurance amount (PIA) formula. Instead, I simply use an earning replacement rate θ_t. Hence regressivity applied to Social Security benefit calculation is left out of the model.

$$\tau_t^{HI} = \tau^{HI}\left(P_t^{M^O}, M_{(A),t}^G, 1-\sigma_{(A)}^{MCO}(m,), TAXBASE_t^{HI}\right)$$

$$\text{where } M_{(A),t}^G = M_{(A)}^G\left(m, \chi(m), \mu_t\left(m \middle| a,e,i,h \times h\right)\right) \qquad [2\text{-}10]$$

$$TAXBASE_t^{HI} = TAXBASE_t^{SS}.$$

The program expenditure depends on the price of medical care, the aggregate medical care consumption of Part A, and synthetic coinsurance rates paid by retirees. The fraction $\chi(m)$ of medical care m is devoted for Part A related care. It is an increasing function of medical care consumption (m). This implies that a high level of medical care consumption accompanies a high fraction of care under the Part A program. The payroll tax exclusion rule also applies to the Hospital Insurance tax base.

2.3.6.2.2 Supplemental Medical Insurance (SMI) – Part B

Upon retirement, all retirees join the Medicare Part B program. This program requires all participants to pay a monthly insurance premium. It covers medical care of outpatient care services and physicians services.[16] Under this program, the government decides the rate of subsidy for retirees to cover a part of their health insurance premium. The government also chooses the proportional wage income tax rate to finance the subsidy. Retirees are responsible for paying synthetic coinsurance $\sigma_{(B)}^{MCO}(m)$ rate, which depends on the level of medical care consumption. Given an exogenous rate of subsidy $\xi_t^{MCO} \in (0,1)$, the government determines the Part B premium Ω_t^{MCO} for retirees,

$$\Omega_t^{MCO} = \Omega^{MCO}\left(1-\xi_t^{MCO}, P_t^{M^O}, M_{(B),t}^G, 1-\sigma_{(B)}^{MCO}(m)\right),$$

$$\text{where } M_{(B),t}^G = M_{(B)}^G\left(m, 1-\chi(m), \mu_t\left(m \middle| a,e,i,h \times h\right)\right).$$

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[16] Starting 2006, the government introduced Part D, a prescription drug plan. Medicare also offers Part C called Medicare Advantage. Retirees with Part A and Part B can purchase this supplemental insurance which includes managed care plans, preferred provider organization plans, private-fee-for-service plans, and specialty plans. Retirees have an option of joining Part C or purchasing Medigap policy which helps fill in the gaps in coverage under Part A and Part B.

The government finances the subsidy by imposing a proportional labor income tax to workers. The retirees also pay the same tax rate applied to their social security benefits. The government chooses the tax rate τ_t^{fB} to balance the Part B program,

$$\tau_t^{fB} = \tau^{fB}\left(\xi_t^{MCO}, TAXBASE_t^{fB}\right) \tag{2-11}$$

where $TAXBASE_t^{fB}$ is a function of

a) $\left(P_t^A, w_t, z_t\left(a,e\right), \bar{l}, \xi_t^{EHI}, P_t^{M^Y}\Omega_t^{EHI}, \mu\left(a,e,i=EHI\right)\right)$ for workers with EHI,
b) $\left(P_t^A, w_t, z_t\left(a,e\right), \bar{l}, \mu\left(a,e,i=PRI\right)\right)$ for workers with PRI,
c) $\left(P_t^A, w_t, z_t\left(a,e\right), \bar{l}, \mu\left(a,e,i=UNI\right)\right)$ for uninsured workers, or
d) $\left(P_t^A, b_t\left(a,e\right), \xi_t^{MCO}, P_t^{M^O}, \Omega_t^{MCO}, \mu\left(a,e\right)\right)$ for retirees.

Under the income tax exclusion rule, workers who purchase an EHI policy can deduct their premium contribution from wage-income tax base. Similarly, retirees' Part B premium is deducted from their tax base. The tax exclusion rule provides a subsidy to the workers with an EHI policy by lowering their wage income tax base. Hence the workers with a PRI policy and the uninsured receive no subsidy.

2.3.6.3 "Medically Needy" Program

The government runs a "Medically Needy" program to provide a social safety net to the people.[17] When workers and retirees incur high medical care expenditures and cannot pay the bill in full amount, the government offers a financial assistance to them under this program. To become eligible for this program, they must "spend down" their income to the medically needy income limit (*MNIL*). When they become qualified for this financial assistance, workers and retirees pay some fraction of their total medical bills. This

[17] "Medically Needy" program is a state-run program that is administered as a part of the Medicaid program. It is sometimes called a "spend-down" program. This is because those with high income who are otherwise ineligible can spend down their income to be covered by the Medicaid program upon incurring and/or recurring high medical care expenses. Based on the 2001 data, there were 35 states that offered the Medically Needy program. Crowley, J. (2003). Medicaid Medically Needy Programs: An Important Source of Medicaid Coverage. Issue Paper: Medicaid and the Uninsured. Washington, D.C., Kaiser Commission.

safety-net program results in revenue losses for hospitals. To help the hospitals, the government makes Disproportionate Share Hospital (DSH_t) payments. In order to balance the budget for this program, the government determines the proportional wage income tax rate τ_t^{fMN} . Retirees are also responsible for paying this proportional tax.

$$\tau_t^{fMN} = \tau^{fMN}\left(UNPAID_t^{DSH}, TAXBASE_t^{fMN}\right)$$

$$UNPAID_t^{DSH} = UNPAID^{DSH}\left(MNIL_t, \Gamma\left(m_t, k_{t-1}^i\right)\right) \quad [2\text{-}12]$$

$$\text{where } TAXBASE_t^{fMN} = TAXBASE_t^{fB}$$

I use $\Gamma\left(m_t, k_{t-1}^i\right)$ to denote the level of wealth had workers and retirees paid their medical bills in full. The term k_{t-1}^i denotes the level of asset held at the beginning of period *t*.

2.3.7 Agents

There are three sources of uncertainties. First, an offer of employer-sponsored health insurance (EHI) benefit is dictated by a conditional probability that depends on age and earning ability. Second, even when agents purchase health insurance, their health status is subject to an uninsurable risk. Medical treatment cannot always restore people's health no matter how much they spend for health care. Third, medical care expenditures pose a financial risk to workers and retirees. There are, however, no risks associated with their life span and employment status. Labor endowments are not subject to any idiosyncratic shocks.

2.3.7.1 Insurance Purchasing Decision

Each worker makes two decisions sequentially in every period *t*: (1) insurance purchasing, and (2) the level of consumption. As retirees automatically enroll in Medicare program, they make a consumption-saving decision in every period. Workers must determine their insurance status at the beginning of each period before a health shock arrives. Some workers receive an EHI offer at work and choose their insurance status from $i \in I_i^Y = \{EHI, PRI, UNI\}$ where *PRI* denotes a private non-group health insurance outside their employment, and *UNI* denotes an uninsured status. Workers without an EHI offer can purchase a PRI policy or to become uninsured (*UNI)*. For retirees, they all purchase Medicare, $i \in I_i^O = \{MCO\}$. There is no option of purchasing a supplemental coverage for simplicity.

Insurance purchasing decision $i_t = i(\Theta_t, h_t, m_t)$ is made based on the state vector Θ_t that is known at the time of insurance take-up decision and the unknown state variables h_t and m_t. The known state variables include age (a_t), earning ability (e_t), receipt of EHI offer (o_t), health status (h_{t-1}), and asset holdings (k_t^i) at the beginning of period *t*.

2.3.7.1.1 Earning Ability

Agents born at time *t* receive an endowment of ability *e* where

$$e_t \in I_e = \{low(L), middle(M), high(H)\}$$

[2-13]

Their earnings over 40-year working life follow a hump-shaped pattern and are pre-determined based on the endowed ability level at birth.

2.3.7.1.2 An EHI Offer

An offer of employer-sponsored health insurance (*EHI*) at the beginning of each period is denoted by:[18]

$$o_t \in I_o = \{0,1\}$$

[2-14]

where $I_o = 1$ indicates that agents receive the offer. A chance of receiving an EHI offer depends on worker's age (*a*) and earning ability (*e*).

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[18] In reality, a firm that offers a health insurance cannot discriminate against some groups of workers by not providing the same benefit. Consider a situation where some firms offer health insurance, and others don't.

2.3.7.1.3 Transition of Health Status

Agents also receive an endowment of health at birth which is ranked by five categories of health status,

$$h_t \in I_h = \{E, V, G, F, P\} \tag{2-15}$$

where *E*, *V*, *G*, *F*, and *P* denote "excellent", "very good", "good", "fair", and "poor" health status, respectively. Given a particular health status $h_{t-1} \in I_h$ at the beginning of each period *t*, agents face an uninsurable idiosyncratic health shock after they make their insurance purchasing decisions. Their health status will make a transition to one of five categories of health status, $h_t \in I_h$. This transition is controlled by a Markov process. The notation $h_{t-1} \times h_t^E$ [19] indicates an expected transition of health status.

2.3.7.1.4 Expected Medical Care Consumption

This study needs to differentiate ex ante from ex post distribution of medical care consumption for uninsured workers.[20] In reality, insured workers consume more medical care than uninsured workers on average. Given that medical care demand is perfectly inelastic, this study applies the conditional distribution of medical care consumption faced by the insured to an ex ante distribution of medical care consumption by the uninsured. In choosing an insurance status, workers compute their expected medical care consumption:

$$m_t^E = E\left[m_t \middle| a_t, e_t, i = EHI, h_{t-1} \times h_t^E \right] \tag{2-16}$$

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[19] The conditional probability mass function (PMF) of medical care consumption depends also on a health status transition which is defined as the Cartesian product of two sets: $I_h \times I_h = \{(h_{t-1}, h_t) \mid h_{t-1} \in I_h \text{ and } h_t \in I_h\}$.

[20] Without this differentiation, a larger fraction of people chooses to opt out of the insurance markets. For this reason, the uninsured face the medical care distribution of the insured workers ex ante. This study assumes that the conditional distribution of EHI and PRI policy holders are identical.

2.3.7.2 Theory of Insurance Demand

In order to determine agent's demand for health insurance, economists have traditionally used Bernoulli utility function over expected wealth net of medical care expenditures at different states. (Zeckhauser (1970), Kihlstrom and Pauly (1971), Feldstein (1973), Chernew, Encionsa et al (2000), Schlesinger (2000), and Nyman (2003)) The choice of utility function to evaluate insurance purchasing decision is a critical matter for this study. Pertaining to the demand for health insurance, Feldstein (1973) says,

> "The demand for insurance is not like the demand for most goods and services. Health insurance is purchased not as a final consumption good but as a means of paying for the future stochastic purchases of health services. The influences of both price and income are therefore different from their usual roles in demand analysis."

Feldstein (1973) argues that a satisfactory theory would include a measure of health as well. The implication of his claim is that both wealth and health are two arguments in the utility function that controls the demand for health insurance. Arrow (1963) (1971) also argues, under the basic principles of optimal regime for risk bearing, that "individuals maximize an expected value of utility based on income after medical costs that is the ability to spend money on other goods which give satisfaction."[21]

In this study, I apply the same utility function which agents use to determine consumption-saving decisions. A traditional way of computing insurance demand is based on the contemporaneous expected net wealth. An approach taken in this study uses both intertemporal consumption and health status dynamics for a decision of insurance purchasing. The flow utility function is defined in the subsequent section. The Bellman equation to derive the worker's insurance purchasing decision is defined in the section 2.3.7.5.

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[21] Arrow (1963) also argues, "the illness which gives dissatisfaction should enter into the utility function as a separate variable."

2.3.7.3 Consumption-Saving Decision

After agents decide their insurance status, nature draws a health shock. As a result, agents receive a new health status. As nature draws a health shock, it also determines agent's demand for medical care. Then agents optimally make their consumption-saving decisions. They consume two kinds of goods: (1) commodities and (2) medical care goods and services. I use c to denote consumption of commodities and m to denote consumption of medical care. Since the level of medical care consumption m is determined exogenously, agents decide the level of commodity consumption c to maximize expected lifetime utility. Agents also obtain utility from health status (h_t) which nature assigns at every period. Hence a health status poses an uninsurable risk to agents. Medical care consumption itself will not directly provide any utility. Given these assumptions, I introduce the following expected lifetime utility for agents to maximize:

$$\underset{c}{Max}\ E_{t=1}\left[\sum_{t=1}^{60}\beta^{t-1}U\left(c_t, h_t\right)\right] \tag{2-17}$$

where β is a discount factor, and a subscript t indicates age of an agent in this formula of expected lifetime utility.

2.3.7.3.1 Flow Utility Function

A flow utility function is defined as follows:

$$U\left(c_{a,t}, h_{a,t}\right) = \frac{\left(c_{a,t}\right)^{1-\gamma^c}}{1-\gamma^c} + \frac{\left(\eta_t h_{a,t}\right)^{1-\gamma^h}}{1-\gamma^h} \tag{2-18}$$

$$\text{where } \eta_t = \left(1+g_z\right)^{t-1}\eta_0$$

A factor γ^c measures a coefficient of relative risk aversion (CRRA) with respect to the consumption of commodity goods. Its reciprocal becomes a factor of intertemporal substitution. A factor γ^H measures a coefficient of relative risk aversion with respect to agent's own health status. The factor η_t measures the relative importance of health status over consumption of commodities in terms of utility. As income per capita grows by the rate of labor augmented technological progress (g_z) over time, commodity consumption per capita grows by the same rate. I impose a condition that the factor η_t also grows by the same rate as the consumption per capita. Marginal utility of health status rises over time at the same rate as the marginal utility of consumption over time. Although the flow utility function is defined additively separable over consumption of commodities and health status, the ratio of the two marginal utilities—the marginal rate of substitution—remains constant over time for an agent with a given profile.[22]

2.3.7.3.2 Budget Constraints

2.3.7.3.2.1 Working Generations

The budget constraint is expressed in nominal terms.[23] Each worker supplies a fixed number of hours $\bar{l}$. The term $z_{a,e,t}$ denotes worker's labor efficiency which is conditional on age and earning ability. The real interest rate is denoted by r_t. The term π_t^A is the change in overall price level P^A. The nominal savings with an interest accrued from the previous period is expressed by $\left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i$. The term $MEXP_t^Y$ accounts for medical expenditures and the cost of health insurance, and its amount depends on worker's insurance status (i).

$$P_t^C c_{a,t} + MEXP_t^Y + P_t^A k_{a,t+1}^i \le \left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i + \left(1-\tau_t^f-\tau_t^{PAY}\right)P_t^A w_t z_{a,e,t}\bar{l} \qquad [2\text{-}19]$$

$$k_{0,t}^i = 0 \textit{ is given.}$$

$$\tau_t^f = \tau_t^{fB} + \tau_t^{fMN}$$

$$\tau_t^{PAY} = \tau_t^{SS} + \tau_t^{HI}$$

where the term $MEXP_t^Y$ takes:

a) $\left(1-\tau_t^f\right)\left(1-\xi_t^{EHI}\right)P_t^{M^Y}\Omega_t^{EHI} + \sigma_t^{EHI}P_t^{M^Y}m_t$ for workers with an EHI,

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[22] A profile is defined by age, earning ability, an EHI offer, insurance status, health status, medical care consumption, and asset level.

[23] A worker's budget constraint in real value is obtained by dividing through the expression [2-19] by the overall CPI, P_t^A.

b) $P_t^{M^Y}\Omega_t^{PRI} + \sigma_t^{PRI} P_t^{M^Y} m_t$ for workers with PRI, or
c) $P_t^{M^Y} m_t$ for workers without insurance (UNI)

When workers purchase an EHI contract, they pay a fraction $\left(1-\xi_t^{EHI}\right)$ of the premium $P_t^{M^Y}\Omega_t^{EHI}$. In addition, the income tax exclusion rule is applied to their contribution. As a result, the tax price of health insurance premium is $\left(1-\tau_t^f\right)\left(1-\xi_t^{EHI}\right)P_t^{M^Y}\Omega_t^{EHI}$. When workers do not receive an EHI offer, they have an option of purchasing a private non-group health insurance (PRI). They must pay a full price of insurance premium, $P_t^{M^Y}\Omega_t^{PRI}$. No tax exclusion rule is applied. Out-of-pocket medical expenditures are denoted by $\sigma_t^{EHI} P_t^{M^Y} m_t$ and $\sigma_t^{PRI} P_t^{M^Y} m_t$ for EHI and PRI policy holders, respectively.[24] Uninsured workers must pay the full price of medical care $P_t^{M^Y} m_t$.

2.3.7.3.2.2 Retired Generations

Workers retire at the beginning of the 41st period and collect their Social Security benefits $P_t^A b_{a,t}$ through the end of their life at 60. Retirement is exogenously determined. Upon retirement, they all join Medicare Part A and Part B programs. The premium of Medicare Part B is determined by the government. The budget constraint of retirees in nominal value is:

$$P_t^C c_{a,t} + MEXP_t^O + P_t^A k_{a,t+1}^i \le \left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i + \left(1-\tau_t^f\right)P_t^A b_{a,e,t}$$

$$k_{60,t+1}^i = 0 \textit{ is given.} \qquad [2\text{-}20]$$

where the term $MEXP^O$ takes:

$$\left(1-\tau_t^f\right)P_t^{M^O}\Omega_t^{MCO} + \sigma_{(A),t}^{MCO} P_t^{M^O} m_{(A),t} + \sigma_{(B),t}^{MCO} P_t^{M^O} m_{(B),t}$$

At the end of life, agents leave no assets behind (zero bequests), $k_{60,t+1}^i = 0$. Retirees' contribution toward Part B health insurance premium is directly deducted from their

[24] In essence, the term σ is a coverage rate which is a function of deductibles, co-pay, coinsurance rates, and medical care expenditures.

Social Security benefits so that the tax price of Medicare Part B premium is $\left(1-\tau_t^f\right)P_t^{M^O}\Omega_t^{MCO}$.

Depending on the size of health shocks, agents consume a varying fraction of medical care over Part A and Part B. At the lower level of health shocks, inpatient care through hospitalization is hardly necessary. Hence agents consume a larger fraction of medical care from Part B–outpatient care and physicians' services. The ratio of the two volumes (Part A and Part B) is defined in the following way:

$$\frac{m_{(A),t}}{m_{(B),t}} = \frac{\chi\left(m_t\right)}{1-\chi\left(m_t\right)}$$

$$\text{where } m_{(A),t} + m_{(B),t} = m_t \text{ and } \frac{d\chi\left(m_t\right)}{dm_t} > 0 \qquad [2\text{-}21]$$

The fraction $\chi\left(m_t\right)$ increases in the size of health shocks, which is proxied by the level of medical care consumption, since retirees will require higher intensity of inpatient care through hospitalization.

2.3.7.4 Timing of Events and Decisions

Figure 2-1 shows events and decisions in the order of timing. At the beginning of each period *t*, agents know their heath status h_{t-1} carried over from the previous period. Other state variables known at that time is denoted by the state vector Θ_t. Workers find out whether or not they received an EHI offer o_t. Then they make an insurance purchasing decision i_t. After this decision is made, nature draws a health shock which determines the level of medical care consumption m_t and agents' new health status h_t. Once m_t and h_t are realized, agents make a consumption-saving decision at time *t*.

2.3.7.5 Bellman Equations to Solve Lifecycle Problems

Agents maximize their expected lifetime utility defined by the expressions [2-17][2-18] subject to the budget constraints [2-19][2-20]. To do so, each worker solves two Bellman equations in a nested form. Given the prices $\left\{P_t^A, P_t^C, P_t^{M^Y}, P_t^{M^O}, w_t, r_t\right\}$, the firm's EHI benefit program $\left\{\sigma_t^{EHI}, \xi_t^{EHI}, \Omega_t^{EHI}\right\}$, the private non-group insurance contract $\left\{\sigma_t^{PRI}, \Omega_t^{PRI}\right\}$, the PAYGO Social Security program $\left\{b_t, \tau_t^{SS}\right\}$, the Medicare program $\left\{\tau_t^{HI}, \tau_t^{fB}, \sigma_{(A),t}^{MCO}, \sigma_{(B),t}^{MCO}, \Omega_t^{MCO}\right\}$, and the "Medically Needy" program $\left\{\tau_t^{fMN}, MNIL_t^{DSH}\right\}$, first, workers make an optimal insurance purchasing decision by solving the following Bellman equation:

(A) when an EHI was not offered ($o_t = 0$)

$$V_{o=0}\left(\Theta_t, h_{t-1}\right) = \max\left\{\mathrm{E}_{h_t, m_t}\left(V_{i=PRI}\left(\Theta_t, h_t, m_t\right)\middle| h_{t-1}, PRI\right), \mathrm{E}_{h_t, m_t}\left(V_{i=UNI}\left(\Theta_t, h_t, m_t\right)\middle| h_{t-1}, UNI\right)\right\} \tag{2-22}$$

(B) when an EHI was offered ($o_t = 1$)

$$[1] \qquad V_{o=1}\left(\Theta_t, h_{t-1}\right) = \max\left\{\mathrm{E}_{h_t, m_t}\left(V_{i=EHI}\left(\Theta_t, h_t, m_t\right)\middle| h_{t-1}, EHI\right), V_{o=0}\left(\Theta_t, h_{t-1}\right)\right\} \tag{2-23}$$

where $\Theta_t = \left(a_t, e_t, o_t, k_t^i\right)$ includes state variables that are known at the time of insurance-purchasing decision. The solution to the problems [2-22][2-23] gives us an optimal decision rule for insurance take-up:

$$\hat{i}_t = i_t\left(\Theta_t, h_{t-1}\right) \tag{2-24}$$

After agents make insurance take-up decisions, a health shock arrives. After a realization of medical care consumption and an arrival of new health status, workers and retirees make a consumption-saving decision to solve the second Bellman equation:

$$V_i\left(\Theta_t, i_t, h_t, m_t\right) = \max_{c_t}\left(u\left(c_t, h_t\right) + \beta \mathrm{E}\left(V_{o'}\left(\Theta', h_{t+1}, m_{t+1}\middle| i_{t+1}, \Theta\right)\right)\right) \tag{2-25}$$

subject to [2-19][2-20][2-24].

The solution to the problem [2-25] gives us the following optimal saving and consumption decision rules[25]:

$$k_{t+1}^{i}\left(\Theta_t, \hat{i}_t, h_t, m_t\right) \text{ and } c_t\left(k_{t+1}^{i}\left(\Theta_t, \hat{i}_t, h_t, m_t\right)\right). \qquad [2\text{-}26]$$

Note that this decision rule [2-26] depends on the optimal insurance take-up decision, $\hat{i}_t\left(\Theta_t, h_{t-1}\right)$.

2.3.8 Production

2.3.8.1 Technology

The representative firm uses a Cobb-Douglas production technology with constant returns to scale (CRS) in capital *K* and effective labor *E*. Since production by the representative firm integrates production of both commodities Y_t^C and medical care goods and services Y_t^M, I define the total production of the representative firm by:

$$Y_t = Y_t^C + Y_t^M = A\left[K_t\right]^{\alpha}\left[E_t\right]^{1-\alpha}$$
$$\text{where } E_t = \sum_{a=1}^{40}\sum_{e\in I_e}\left(z_{a,e,t} l_{a,e,t} N_{a,e,t}\right) \qquad [2\text{-}27]$$

There is no aggregate uncertainty. The representative firm employs workers from all 40 working age-cohorts. There are no labor endowment shocks. Within each age-cohort, there are three types of workers indexed by their earning ability, $e \in I_e = \{L, M, H\}$ such that

$$z_{a,L} < z_{a,M} < z_{a,H} \text{ for a} \in \{1,...,40\} \qquad [2\text{-}28]$$

[25] Consumption floor is set at the 10 percent of the poverty threshold level.

Labor endowments z varies also across workers' age such that their earning profiles over their life create a hump-shaped pattern. Technology used by each worker makes him more productive year after year regardless of his ability. A skill-unbiased labor augmented technology grows by the rate g_z. Under this technological progress, the labor endowment for given age (a) and earning ability (e) at time t can be expressed as:

$$z_{a,e,t} = (1+g_z)^t z_{a,e,0}$$

where $z_{a,e,0}$ is given, $\forall a \in \{1,...,40\}, e \in I_e$ [2-29]

Each worker supplies a fixed amount of labor hours,

$$l_{a,e,t} = \bar{l} \quad \forall a \in \{1,...,40\}, e \in I_e, t$$

[2-30]

The population is normalized to one at the initial period t=0. The number of workers with a particular age (a) and skill (e) in period t is expressed by:

$$N_{a,e,t} = (1+g_N)^t \mu_{a,e}$$

[2-31]

Based on these assumptions, total labor hours in efficiency unit E_t is

$$E_t = (1+g_z)^t (1+g_N)^t \sum_{a=1}^{40} \sum_{e \in I_e} \left(z_{a,e} \bar{l} \ \mu_{a,e}^C \right) = (1+g_z)(1+g_N) E_{t-1}$$

[2-32]

2.3.8.2 Firm's Optimization Problem

The representative firm provides an employer-sponsored health insurance (EHI) to some employees based on their age and earning ability. A payroll tax exclusion rule is applied to the total cost of EHI provision. Taking the prices P_t^C and P_t^M in each period as given, the firm maximizes the real profit, Π_t. The firm's objective function is defined as:

$$\underset{K_t, l_{L,1,t},\ldots,l_{H,40,t}}{Max} \Pi_t = A\left[K_t\right]^{\alpha}\left[E_t\right]^{1-\alpha}$$
$$-\left(r_t+\delta^K\right)K_t - \left(1+g_N\right)^t\left(1+g_z\right)^t \sum_{a=1}^{40}\sum_{e\in I_e}\left\{\left(1+\tau_t^{PAY}\right)w_t + \left(1-\tau_t^{PAY}\right)c_t^{EHI}\right\} z_{a,e,0}l_{a,e,t}\mu_{a,e}$$

[2-33]

where c_t^{EHI} is the marginal cost of EHI provision. The term δ^K denotes the rate of capital depreciation. The total cost of EHI provision is

$$EHI_t = \left(1+g_N\right)^t \sum_{a=1}^{40}\sum_{e\in I_e} \xi^{EHI}\Omega_t^{EHI}\left(\zeta_{a,e,t}\mu_{a,e}\right)$$

where $\zeta_{a,e,t} = \zeta\left(i\left(\Theta_t, h_{t-1}\right)\right)$,

[2-34]

The marginal cost of providing the benefit is:

$$c_t^{EHI} = \frac{\xi^{EHI}P_t^M\Omega_t^{EHI}\zeta_{a,e,t}}{P_t^A z_{a,e,t}\bar{l}}$$

[2-35]

The worker's EHI take-up rate is denoted by $\zeta_{a,e,t}$ [2-34]. This rate is determined by the workers optimal insurance purchasing decision, $\hat{i}_t = i\left(\Theta_t, h_{t-1}\right)$ from the Bellman equations [2-22][2-23].[26]

[26] It is implicit in this maximization problem that workers who did not receive an EHI offer and those who did but decided not to take the offer still contributes to the firm's total cost of EHI provision by taking a lower net wage. I impose a condition that workers' EHI take-up decisions will not alter their net wage. Under this assumption, the firm can partially shift the cost of providing EHI benefit to workers without EHI benefit.

2.3.9 Linking Micro to Macroeconomic Environment: Stationary Equilibrium

Let $f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right)$ denote a joint probability density function (PDF) where the state space vector Θ_t^h is defined as $\Theta_t^h = \left(a_t, e_t, o_t, \hat{i}_t, h_{t-1}\right)$ [27]. When the economy reaches a stationary equilibrium at time *t*, the joint PDF converges at time *t* and satisfies the following condition thereafter:

$$1)\quad \sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{o_t \in I_o} \sum_{i_t \in \left(I_i^Y, I_i^O\right)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right) dk_t^i dm_t = 1 \text{ for } \forall t .$$

The stationary equilibrium is where all markets clear, factor prices and tax rates are pinned down, and the joint PDF $f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right)$ must satisfy 1). The following properties must be met for individual behaviors in micro environment and aggregate behaviors in macro environment to be consistent.

$$2)\quad N_t = \left(1 + g_N\right)^t N_0 = \left(1 + g_N\right)^t \text{ where } N_0 = 1$$

$$3)\quad E_t = \left(1 + g_z\right)^t \left(\sum_{a=1}^{40} \sum_{e \in I_e} z_{a,e,0} \bar{l}\ \mu_{a,e} \right) N_t$$

$$4)\quad K_{t+1} = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{o_t \in I_o} \sum_{i_t \in \left(I_i^Y, I_i^O\right)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} k_{t+1}^i\left(k_t^i, m_t, \Theta_t^h\right) f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right) dk_t^i dm_t \right) N_t$$

$$5)\quad I_t = \left\{ \left(1 + g_N\right)\left(1 + g_z\right) - \left(1 - \delta^K\right) \right\} K_t$$

$$6)\quad C_t = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{o_t \in I_o} \sum_{i_t \in \left(I_i^Y, I_i^O\right)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} c_t\left(k_t^i, m_t, \Theta_t^h\right) f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right) dk_t^i dm_t \right) N_t$$

$$7)\quad M_t = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{o_t \in I_o} \sum_{i_t \in \left(I_i^Y, I_i^O\right)} \sum_{h_{t-1} \in I_h} \sum_{h_t \in I_h} \int_{k^i > 0} m_t\left(h_t, \Theta_t^h\right) g_{\Theta_t^h}\left(k_t^i, h_t, \Theta_t^h\right) dk_t^i \right) N_t$$

where

[27] The agents cannot accumulate more assets than they earn over their life-time. Each state variable is bounded, and the entire state space Θ_t^m is also bounded.

$$\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{o_t \in I_o} \sum_{i_t \in \left(I_t^Y, I_t^O\right)} \sum_{h_{t-1} \in I_h} \sum_{h_t \in I_h} \int_{k^i > 0} g_{\Theta_t^h}\left(k_t^i, h_t, \Theta_t^h\right) dk_t^i = 1$$

The expression 2) is population accounting. It grows by the rate g_N. The aggregate labor in efficiency unit is expressed in 3) where it grows by the rate g_z, the rate of labor-augmented technological progress. The equation 4) represents aggregate savings which build nation's capital. Investment is defined in 5) based on the capital accumulation equation, $K_{t+1} = \left(1-\delta^K\right) K_t + I_t$. Aggregate consumption 6) must equal the sum of all agents optimal consumption which is based on the solution from the Bellman equation [2-25]. Agents' medical care consumption must add up to the aggregate medical care consumption as in 7). The equations 2) through 7) must conform with the national income accounting 8) for individual and aggregate behaviors to be consistent at the stationary equilibrium. Given an exogenous price levels $\left(P_t^C, P_t^M\right)$ at time *t*, the stationary equilibrium satisfies the following aggregate market clearing condition:

8) $P_t^A Y_t = P_t^C C_t + P_t^M M_t + P_t^A I_t$.

Market clearing factor prices are:

9) $r_t^* = \alpha A\left[k_t\right]^{\alpha-1} - \delta^K$

10) $w_t^* = \dfrac{\widehat{w}_t}{1+\tau_t^{PAY}} - \left(\dfrac{1-\tau_t^{PAY}}{1+\tau_t^{PAY}}\right) c_t^{EHI}$ where $\widehat{w}_t = \left(1-\alpha\right) A\left[k_t\right]^{\alpha} = MPL_t$

where r_t^* denotes the equilibrium net return to capital in real, and w_t^* is the equilibrium after-tax real money wage rate. The gross wage rate $\widehat{w}_t$ equals the marginal product of labor in efficiency unit. I use $k_t = \dfrac{K_t}{E_t}$ to denote the capital-labor ratio. Given that the aggregate efficiency labor grows by the factor $\left(1+g_z\right)\left(1+g_N\right)$ from 2)3), when the capital stock grows by the same factor, the capital-labor ratio reaches a fixed point $\overline{k}_{ss}$:

11) $k_t = \frac{K_t}{E_t} = \frac{(1+g_z)^t (1+g_N)^t K_0}{(1+g_z)^t (1+g_N)^t E_0} = k_0 = \bar{k}_{ss}$

In order for the model to reach the steady state $\bar{k}_{ss}$, this study makes the following assumptions:

12) $m_{t+1}(\Theta_t) = (1+g_z) m_t(\Theta_t)$ where $\Theta_t = \Theta(a_t, e_t, i_t, h_{t-1} \times h_t) \;\; \forall t$

13) $\pi_t^C = \pi_t^M \;\; \forall t$

The condition 12) indicates that the medical care demand grows by the rate of labor-augmented technological progress g_z over time for any individuals characterized by the state space vector Θ_t. When the economy reaches a stationary equilibrium, this condition implies that the health insurance premium in real term grows by the same factor. The condition 13) assumes that the average cost in each sector grows by the same rate.[28] The medical care prices for workers and retirees $\left(P_{t+1}^{M^Y}, P_{t+1}^{M^O}\right)$ rise by the factor π_t^M. The overall price P_t^A changes over time by the same rate. This assumption also implies that the relative price remains the same at the stationary equilibrium. The marginal cost of EHI provision [2-35] becomes time invariant at the stationary equilibrium $c_t^{EHI} = \bar{c}^{EHI}$.

Given the policy instruments, the government must balance budgets for the Social Security, the Medicare, and the "Medically Needy" programs by choosing the proportional tax rates $\left(\tau_t^{PAY}, \tau_t^f\right)$ where $\tau_t^{PAY} = \tau^{SS} + \tau_t^{HI}$, $\tau_t^f = \tau^{fB} + \tau^{fMN}$. At the stationary equilibrium, these tax rates are pinned down.

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[28] Under the balanced growth path, income and consumption per capita grow by the factor g_z. Real output (*Y*), consumption of commodities (*C*), medical care consumption (*M*), and investment (*I*) grow by the factor $g_z + g_N$ where g_N is the rate of population growth. Since prices increase exogenously by the growth rate of average cost, all aggregate variables in nominal value grow by the factor $g_z + g_N + \pi_A$.

2.4 Calibration

2.4.1 Demographics

The population grows by one percent per annum, g_N =0.01. The exogenously determined growth rate of population implies that the fraction of workers with age between 25 and 64 (model age of 1 through 40) and the fraction of retirees with age between 65 and 84 (model age of 41 through 60) are $\mu^Y = 0.73$ and $\mu^O = 0.27$. The old-age dependency ratio is 0.37.[29]

2.4.2 "Permanent" Earning

This study assumes three groups of earning ability, $e \in I_e = \{L, M, H\}$, denoted by low (L), middle (M), and high (H). Workers are classified as the "low" ability if their labor incomes fall between 125% and 200% of the federal poverty threshold (FPT). Workers in the "middle" earns between 200% and 400% of the FPT. Workers who make more than 400% of the FPT possess "high" earning ability. Based on this labor income classification, I compute a "permanent" earning of each group from the Household Component of 2005 Medical Expenditure Panel Survey (MEPS). Cross sectional labor endowments based on the "permanent" earnings for each earning group are plotted in Figure 2-5.[30]

2.4.3 Earning Distribution

A labor endowment at birth (the actual age of 25) determines agents' earning ability. Given the highly stylized labor market assumptions, this study computes the distribution of earning ability based on an educational attainment from U.S. Census Bureau, Current Population Survey, *2005 Annual Social and Economic Supplement*. In computing this

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[29] The old-age dependency ratio is defined as the ratio of retirees to workers. Based on the U.S. Census data from 2005 American Community Survey, the population with age 65 and above accounts for 12.1 percent of the population. The old-age dependency ratio is 19.3 percent. Please note that the official definition of old-age dependency ratio uses the population of 20-64 as the base.

[30] Given that there are no idiosyncratic labor endowment shocks, I assume that the distribution of skill groups (*H,M,L*) are fixed over lifecycle. Note also that agents do not face any uncertainty of unemployment, either. I assume that the high, the middle, and the low earning groups account for 30, 40, and 30 percent of the working population.

distribution, this study assumes that workers without high school diploma are always in the low earning group. Workers with high school diploma have a chance to make it to the middle earning group. This probability is computed based on the Medical Expenditure Panel Survey (MEPS). Agents with "some college" always belong to the middle earning group. When agents graduate from a four-year college, they face a chance of getting into the high earning group. This probability is also computed based on the MEPS. Agents with a Master's degree and above belong to the high earning group. The distribution of earning ability is: $\mu_{a,e=L} = 0.193$, $\mu_{a,e=L} = 0.566$, and $\mu_{a,e=L} = 0.241$.

2.4.4 Employer-sponsored Health Insurance Offer

Let $\mu_{a=1,e,o} = \mu(a_t = 1, e_t, o_t)$ denote the time-invariant joint probability mass function (PMF) of EHI offer at birth. Using MEPS from 1996-2005, this study computes 117 (39 × 3)[31] conditional transition matrices of EHI offer denoted by $\Lambda^{a,e}_{o \times o} = \Lambda\left(o_t \middle| a_t, e_t, o_{t-1}\right)$. Based on the initial joint PMF and the conditional transition matrices, I simulate conditional PMF of EHI offer for workers[32], which is shown in Figure 2-6. The offer rate among low-skilled workers is much lower than the rates among high- and middle-skilled workers at any given age. Volatility of EHI offer among low-skilled workers is another critical attribute which plays a significant role for explaining the fluctuation of insurance status among them.[33]

2.4.5 Health Status

Let $\mu_{a=1,e,s,h} = \mu(a_t = 1, e_t, s_t, h_{t-1})$ denote the time-invariant joint PMF of health status at birth. Using two sources of data: (1) National Health Interview Surveys (NHIS), 1995-2004 and (2) Medical Expenditure Panel Survey (MEPS), 1996-2005, this study computes 300 conditional transition matrices of health status denoted by

[31] Each agent makes 39 transition of EHI offer. Since there are three levels of skills, there are 117 transition matrices to estimate. See 0 for detail of data and its computation.
[32] See A 2.4.2 and A 2.5.2 for detail
[33] Some of the volatility comes from employment status. In my model, I do assume lifetime employment. Hence I implicitly incorporate an EHI offer as a result of changing employment status.

$\Lambda^{a,e,i}_{h\times h} = \Lambda\left(h_t \middle| a_t, e_t, i_t, h_{t-1}\right)$.[34] With the initial joint PMF and the conditional transition matrices of health status, I simulate health status over a life span of 60 years. Figure 2-7 and Figure 2-8 plot the simulated conditional probability mass function of health status $\mu_{h_t|a_t,e_t,s_t}$, sorted by the earning group and the insurance status.

2.4.6 Medical Care Expenditures

2.4.6.1 Discretization of Medical Care Consumption

Table 2-1 summarizes the discretization of medical care consumption based on percentile ranks at time *t*, where $p \in I_p = \{1,..,14\}$. Based on this table, I compute an average real value of medical care consumption for each percentile $p \in I_p$ among workers and retirees separately, and denote them $\overline{M}^Y_p$ and $\overline{M}^O_p$, respectively.[35] The values $\left(\overline{M}^Y_p, \overline{M}^O_p\right)$ for each $p \in I_p$ are plotted in Figure 2-9. Given a percentile rank $p \in I_p$, the average medical care consumption is much higher among retirees than among workers, $\overline{M}^Y_p < \overline{M}^O_p$ for $\forall\, p \in I_p$. In order to compute expected value of medical care consumption, this study computes conditional probability mass function (PMF), denoted by $\mu_{p|a,e,i,h\times h} = \mu\left(p_t \mid a_t, e_t, i_t, h_{t-1} \times h_t\right)$, based on the MEPS.[36]

2.4.6.2 Synthetic Coinsurance Rates

2.4.6.2.1 Workers

Let σ^{EHI}_p and σ^{PRI}_p be the synthetic coinsurance rates for EHI and PRI policies and computed as:

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[34] See A 2.4.3 and A 2.5.3 for data and computations in detail.

[35] This will allow us to keep the percentile structure among the retired and that among workers when the government shifts the cost of Medicare. See A 2.4.4 for calculations.

[36] I compute 7500 conditional PMF of medical care consumption $\mu_{p_t|a_t,e_t,s_t,h_{t-1}\times h_t}$ based on all combinations of $a_t \in I_a, e_t \in I_e, s_t \in \left(I^Y_s, I^O_s\right)$, and $h_{t-1} \times h_t \in \left(I_h \times I_h\right)$.

$$\sigma_p^{EHI} = \sigma_p^{PRI} = \frac{M_p^{OOP}}{M_p^{TOT}} \quad \text{for } p \in \{2,...,14\}$$

[2-36]

where M_p^{OOP} and M_p^{TOT} denote the out-of-pocket (OOP) and the total (TOT) medical care expenditures in each percentile. The higher the level of medical care consumption, the lower becomes the synthetic coinsurance rate.[37] [See Figure 2-11] Among workers, this rate ranges from 43 percent at the lowest percentile to 3 percent at the highest 0.1 percentile. Given the average medical expenditures and the synthetic coinsurance rates, the out-of-pocket medical expenditures range approximately from \$35 to \$5,700 on average for insured workers.

2.4.6.2.2 Retirees

There are two sets of synthetic coinsurance rates for retirees. One set applies to the Part A program, and the other set applies to the Part B program. In order to compute the synthetic coinsurance rates, first, I sort components of medical expenditures by Part A and Part B care for each agent. Then, I compute the fractions of Part A and Part B spending in total medical expenditures for a given percentile rank $p \in I_p$ based on the total. Figure 2-12 displays the fraction χ_p for Part A spending and the fraction $1-\chi_p$ for the Part B spending under each $p \in I_p$. As in [2-21], medical care under Part A is more concentrated for higher percentiles. Following [2-36], synthetic coinsurance rates are computed for Part A $\left(\sigma_{(A),p}^{MCO}\right)$ and Part B $\left(\sigma_{(B),p}^{MCO}\right)$ for each percentile group. [See Figure 2-13]

[37] A health-insurance contract often requires that policy holders pay deductibles before an insurance company starts to cover any medical expenses for them. After deductibles, they pay a coinsurance, a certain fraction of the medical bills. Depending on policies, workers pay a copayment (co-pay) for receiving certain medical treatments. To simplify the payment structure of insurance policies, I compute synthetic coinsurance rates for the holders of employer-sponsored health insurance (EHI). I apply the same rate structure to workers with a private non-group insurance (PRI) contract purchased outside their employment. The uninsured faces a full cost of medical care consumption. For retirees, I compute synthetic coinsurance rates for Part A and Part B separately under Medicare program.

2.4.7 Non-group Health Insurance Premium Schedule

This paper assumes that private non-group health insurance premium (PRI) rises with workers' age to reflect their underlying health risks. In order to compute the premium schedule, I generate weighted average of medical care expenditures that are conditional on age (*a*). Figure 2-10 plots this conditional mean and its 95 percent confidence interval. The schedule is:

$$\ln \Omega_t^{PRI}\left(a_t\right) = \left(1 + g_z t\right)\beta_0^{PRI} - 0.0085 a_t + 0.0010\, a_t^2 \qquad [2\text{-}37]$$

The model computes the coefficient $\left(\beta_0^{PRI}\right)$ for insurance companies to break even. This coefficient is also used as a shift parameter to reflect a time-series path of aggregate medical expenditures among non-group health insurance holders.

2.4.8 "Medically Needy" Program

Based on the 2001 data, there were 35 states that offered the Medically Needy program. (Crowley 2003) Since the Medically Needy program is run by the states, the established medically needy income limit (MNIL) varies widely across states. In this study, the MNIL is set at the 50% of the Federal Poverty Threshold (FPT) for singles.[38]

2.4.9 Measure of Utility for Health Status

How do we assign a value associated with each health status? The answer to this perplexing question is critical for evaluating how much a society should spend for medical care. Based on the recommendation by the U.S. Public Health Service Panel on Cost-Effectiveness in Health and Medicine in 1996, the Agency for Healthcare Research and Quality (AHRQ) has put a project together to estimate a preference-based quality of life weights based on the nationally representative population sample. They say,

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[38] Crowley (2003) reports that 13 states out of 35 that offer the Medically Needy program set the MNIL below 50% of the federal poverty line (FPL for single) for non-institutionalized people with disabilities in 2001. In 13 states, the MNIL was set between 51-74% of the FPL. The remaining 9 states set the MNIL above 75% of the FPL. The median MNIL was 55% of the FPL.

"The most important result derived from this project is the scoring algorithm that produces U.S. specific "off the shelf" health states preference indices for use henceforth by all cost-effectiveness analyses of health care interventions or programs which also use EQ-5D as part of the outcomes measurement tools." (AHRQ 2005)

Following their recommendations, I calibrate Quality of Life (QoL) weights[39] of each health status $h \in I_h = \{E, V, G, F, P\}$ conditional on age $a \in I_a = \{1, ..., 60\}$ from Nyman, Barleen et al (2007). With this calibration, health status h_t is measured in an index of preference based value. Figure 2-19 shows that the value associated with health status is lower when it deteriorates at any given age. Given a health status, it declines over age.

2.4.10 Prices and Cost Growth

Since the aggregate price is defined as $P_t^A = \left(P_t^C\right)^{1-\vartheta}\left(P_t^M\right)^{\vartheta}$, I compute the weight $\vartheta \in (0,1)$ in the following way:

$$\vartheta = \frac{\ln P_t^A - \ln\left(P_t^C\right)}{\ln\left(P_t^M\right) - \ln\left(P_t^C\right)} \tag{2-38}$$

Figure 2-21 displays the time series of the sectoral consumer price indices taken directly from the Bureau of Labor Statistics (BLS), their changes per annum, and the weight ϑ based on the equation [2-38]. This study calibrates ϑ as:[40]

$$\bar{\vartheta} = 0.06357. \tag{2-39}$$

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[39] They are computed based on the combination of five standardized instruments called EQ-5D and three ordinal response levels. The included instruments are (a) mobility, (b) pain and discomfort, (c) self-care, (d) anxiety and depression, and (e) usual activities. Response levels are (i) no health problems, (ii) moderate health problems, and (iii) extreme health problems. The combinations of (a)~(e) and (i)~(iii) make a total of 243 possible health states.

[40] This value corresponds to the average weight for the last 20 years.

This study applies 2.0 percent of exogenous cost growth per annum in both sectors at the steady state, $\pi_t^C = \pi_t^M = \pi_{t+1}^A = 0.02$.

2.4.11 Hospital Cost-shifting

The rate of reimbursement is calibrated based on the aggregate hospital payment-to-cost ratio for Medicare patients. I use the published data from American Hospital Association/The Lewin Group.[41] Figure 2-20 shows the hospital's cost-to-payment ratios for Medicare payers and privately insured payers. During the period of 1980-2004, the ratio for Medicare payer is 0.967 on average. The ratio for the private payer is 1.207 on average during the same period. Based on the report from the American Hospital Association, 65 percent of hospitals received Medicare payments less than their cost in 2005. (AHA 2006) As a result, an aggregate underpayment by the Medicare program amounted to \$15.5 billion, increased from \$15.0 billion in the year before. This study takes the payment-to-cost ratio of the Medicare payer as given. Since I do not have the data for 2005, I apply the data in 2004 for 2005 and calibrate ϖ by setting:[42]

$$\varpi_0 = 0.92 \tag{2-40}$$

2.5 Benchmark Model

In order to match the overall percentage of uninsured workers in the population to the actual data, this study chooses the coefficients of relative risk aversion $\left(\gamma^C, \gamma^H\right)$. With a restriction $\gamma^C = \gamma^H$ imposed, I choose a particular value of γ^C and let the model converge to the steady state at time *t=0*. Then I evaluate the overall percentage of uninsured workers. When the coefficient is low (high), both EHI take-up and the fraction of workers who purchase non-group insurance (PRI) are low (high). This leads to higher (lower) overall percentage of uninsured workers. The benchmark model is set at $\gamma^C = \gamma^H = 3.7$. At the initial steady state, the percentage of uninsured workers accounts

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[41] Trend Watch Chartbook 2006: Trends Affecting Hospitals and Health Systems, April 2006. I exclude the ratio for the Medicaid payer.
[42] The AHA reported that the underpayments by Medicare increase marginally from 2004 to 2005.

for 13.1 percent of the population in the model, relative to 12.8 percent based on the actual data in 2005.[43] Nearly all workers who receive an EHI offer purchase the group insurance policy. Workers with an EHI contract account for 55.5 percent of the population in the model, compared to the actual date of 59.8 percent in 2005. Workers who purchases non-group health insurance contract on their own accounts for 4.5 percent in the model, relative to 6% based on the Current Population Survey (CPS) data.[44] (ASPE Issue Brief 2005)

Figure 2-2 shows the conditional mean of uninsured workers in percentage by age and earning group. The solid (red) line represents the output from the benchmark model at the steady state. The thinner (blue) line is the actual data from MEPS. The bands represent a 95 percent confidence interval. The conditional mean for the uninsured workers with low and middle earning groups lie in between the intervals for most age cohorts. For high earning group, the conditional mean lies at or above the upper 95 percent interval. This figure shows that the percentage of uninsured workers declines with their level of earnings. Workers with higher earnings typically have a better chance of receiving an EHI offer. The percentage of uninsured workers across age is more volatile among workers with low earnings. This is directly attributable to the volatility of the EHI-offer rate among them. The greater uncertainty of EHI offer implies a difficulty of smoothing their income through a purchase of health insurance, which adversely affects savings and consumption for low earning group.

The equilibrium nominal wage rate under the benchmark model is $18.44, which translates to a weighted-average earning of $38,762 per year.[45] The model computes that

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[43] I only include those who are between the age of 25 and 64 in low, middle, and high earning groups. The uninsured in this study includes workers without any type of insurance for a full sample year. Rhoades and Chu (2007) report the size of uninsured population in three measures. One measure includes those who were uninsured at any point during the course of a year. Second measure includes those who were uninsured during the first half of year. The third measure includes those who were uninsured for a full year. They report that the uninsured population under 65 for a full year is 13.4 percent on average from 1996 through 2005. During those ten years, the minimum was 12.2 percent in 1999. The maximum was 14.2 percent reached in 2005. Based on their first measure, the size of uninsured is higher than the third measure by nearly 12 percentage points.

[44] These reported figures based on CPS include everyone under the age of 65.

[45] Based on the 2005 National Occupational Data from Occupational Employment Statistics, the mean wage rate was $18.2, and the mean earning was 37,870. An earning at 90 percentile was $70,180 which roughly corresponds to the average earning of high-skilled workers in our model. The earning at the 25

the low-skilled earns \$21,894 in 2005 US dollar on average. The middle- and the high-skilled earn \$33,897 and \$63,698, respectively. A real interest rate is 8.5%. The steady-state level of capital per output ratio is 2.48. The marginal cost of the EHI provision is \$0.82 per hour in nominal dollar, which corresponds to the EHI premium of \$2,777 per annum in nominal value. The worker's contribution is \$500, a 18 percent of the premium. Since I do not incorporate any family structure in the model, this EHI premium is applicable for a single coverage in the model. Based on the data from Agency for Health Research and Quality (AHRQ), *Center for Financing, Access and Cost Trends*, the average health insurance premium at private sector establishments was \$3,991, of which each enrollee paid \$723, a 18.1 percent of the premium in 2005. The weighted average of non-group health insurance premium is \$4,202 in the model. All retirees are covered by Medicare Part A and Part B upon retirement. Medicare Part B insurance premium is \$ 943.79 per annum in nominal value against the actual premium \$938.40 (=78.20 x 12 mo). The premium computed by the model is based on the assumption that the government contributes 59 percent of the Part B premium.

Social Security tax and Medicare Part A Hospital Insurance tax rates are 4.52 and 2.15 percent, respectively. These tax rates mean that the firm faces a payroll tax rate of 6.67 percent for each worker they employ. Each worker also faces the same payroll tax rate of 6.67 percent. The Social Security tax rate is computed based on the earning replacement rate of 35 percent. The actual Social Security and Hospital Insurance tax rates are 6.2 and 1.45 percent, respectively in 2005.[46] The federal wage income tax finances a part of the Medicare Part B program and the "Medically Needy" program. The proportional wage income tax rate consists of τ^{fB} and τ^{fMN}. The tax rate to finance Medicare Part B is $\tau^{fpB}=1.20$ percent. The tax rate to finance the "Medically Needy" program is $\tau^{fMN}=0.0017$ percent. Adding these two tax rates, I have the federal wage

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percentile was \$19,680. Based on the National Compensation Survey, the health insurance benefit per hour worked in 2005 accounts for 7.5 percent of total compensation or \$1.96.

[46] These rates have been applied since 1990. There is an annual limit on the Social Security tax base. In 2005, this limit was \$90,000. The Medicare's Hospital Insurance program does not impose any taxable limit on the tax base. The maximum taxable earnings, which had been imposed on Medicare's Hospital Insurance tax, were eliminated entirely in 1994.

income tax rate of $\tau^{f}=\tau^{fpB}+\tau^{fMN}=1.2017$ percent. I do not include any additional government programs for a redistributional purpose.

Aggregate medical expenditure is 786 billion in 2005 U.S. dollars in the model. This figure can be compared to $883 billion, the actual figure from the MEPS in 2005. Based on the National Health Expenditure (NHE) account produced by Centers for Medicare & Medicaid Services (CMS), aggregate personal health care was US$1.6 trillion in 2005. Hence the model only accounts for 49 percent of the national figure. Selden, Levit et al (2001) point out that the Medical Expenditure Panel Survey (MEPS) can account for roughly 50 percent of the national figure due to the differences in accounting. They carefully removed items in the NHE account to make it more comparable to the MEPS account of medical expenditures, and find that their estimates are both consistent to each other. More detail can be found in Appendix A 2.6. Aggregate medical expenditure accounts for 9.8 percent of total output. Aggregate consumption of commodities accounts for 67.8 percent. The share of investment is 22.4 percent of output. The Gini coefficient based on agent's wealth is 0.328. Other related outputs at the initial steady state are reported in Table 2-2.

2.6 Policy Experiments

2.6.1 Comparative Statics

This study applies comparative statics analysis following policy experiments. This analysis includes evaluations of the insured and uninsured-worker composition of the population, and insurance premium dynamics. This paper also investigates policy's impacts on the balanced growth path, welfare, and wealth inequality in the long run. Welfare is measured by the following utilitarian Social Welfare Function (SWF)—a population weighted-average utility:

$$SWF_t=\sum_{a_t\in I_a}\sum_{e_t\in I_e}\sum_{i_t\in\left\{I_i^Y,I_i^O\right\}}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\sum_{k_t^i\in I_k}U^*\left(a_t,e_t,i_t,h_t,p_t,k_t^i\right)\mu\left(a_t,e_t,i_t,h_t,p_t,k_t^i\right)$$

[2-41]

$$\text{where }\sum_{a_t\in I_a}\sum_{e_t\in I_e}\sum_{i_t\in\left\{I_i^Y,I_i^O\right\}}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\sum_{k_t^i\in I_k}\mu\left(a_t,e_t,i_t,h_t,p_t,k_t^i\right)=1$$

where $U^*\left(a_t, e_t, i_t, h_t, p_t, k_t^i\right)$[47] is the indirect utility function evaluated at the new steady state based on the solution from the Bellman equations [2-22][2-23][2-25].

2.6.1.1 Health policy

This paper simulates long-run impacts for the economy of health-policy reforms that provide subsidies for households to purchase private non-group health insurance with, or without, requiring (i.e., "mandating") them to do so. These two policy reforms are labeled as "universal insurance with mandate" and "universal insurance without mandate". "Universal insurance" in this case means subsidies for workers who purchase a non-group private health insurance (PRI) contract. Since the income tax exclusion rule unfairly provides subsidies to workers who purchase an EHI contract, the subsidies to PRI holders correct horizontal inequity.[48] The subsidies are financed by wage income tax.

After the economy reaches an initial steady state at *t=0*, the government chooses a policy reform and implements it at time *t=1* and thereafter. The government also chooses the level of subsidies $s_t = \psi\,\Omega_{a=1,t=0}^{PRI}$. The subsidies cost the government $SUBSIDY_t^{HC}$ in total at time t in [2-42]. The real subsidies s_t are indexed to the non-group health insurance premium paid by the youngest workers at the initial steady state (*t=0*), $\Omega_{a=1,t=0}^{PRI}$. The government can choose a parameter $\psi \in \left(0, \bar{\psi}\right)$ to adjust the size of subsidies. The nominal subsidies are indexed to the overall CPI, P_t^A so that the level of real subsidies remains constant over time. The total cost of providing subsidies depends on the quantity of non-group health insurance demanded $q_t^{PRI} = \mu\left(a_t, e_t, i_t = PRI\right)N_t$ at the equilibrium price. The proportional wage income tax rate τ_t^{fHC} to finance this policy is a function of total cost of subsidies $SUBSIDY_t^{HC}$ and the tax base $TAXBASE_t^{fHC}$ in [2-43].

$$SUBSIDY_t^{HC} = SUBSIDY\left(P_t^A, s_t, q_t^{PRI}\right) \qquad [2\text{-}42]$$

[47] Medical care consumption and savings are discretized. The term p_t indicates a particular percentile of medical care consumption.

[48] Workers with the same age and skill pay different wage income tax as a result of this tax exclusion rule.

$$\tau_t^{fHC} = \tau^{fHC}\left(TAXBASE_t^{HC}, SUBSIDY_t^{HC}\right)$$
$$\text{where } s_t = \psi\,\Omega_{a=1,t=0}^{PRI} \text{ and } \psi \in \left(0, \overline{\psi}\right) \qquad [2\text{-}43]$$
$$TAXBASE_t^{fHC} = TAXBASE_t^{fB}$$

A health-policy reform in this study encompasses a redistribution of wealth in such that it creates three groups of people: (1) workers and retirees who simply finance the subsidies; (2) infra-marginal workers who purchase PRI regardless of subsidies being provided; and (3) marginal workers who purchase PRI as being either induced by the subsidies—income effect, or forced by a government mandate. Under a general equilibrium analysis, the subsidies create two additional groups of people: (4) workers who opt out of insurance markets or purchase insurance as a result of the premium changes—price effect; and (5) workers who change their insurance status as a result of changes in their after-tax wage rate—wage income effect. In evaluating policy's impacts based on a dynamic general equilibrium model, this paper simply focuses on the net effect that composes effects of five groups of individual agents described above.

2.6.1.2 Projected Future: Excess Cost and Demand Growth of Medical Care Delivery

A component of CPI which measures the aggregate price of medical care has risen by four percent per year on average since 1995. This figure indicates that medical care price inflation is higher by 1.5 percentage points on average than the price inflation measured by CPI excluding medical care.[49] In implementing health policy reform, this study accounts for this gap in inflation rates. I assume that the average cost of medical care delivery rises from two percent to four percent per year for periods of 10 years and comes back to two percent thereafter. This implies that an excess cost growth in the medical care sector is two percentage points while a zero-excess-cost growth is assumed for all other sectors throughout. This study also imposes an excess demand growth of medical care to be two percentage points during the same period. When these temporally

[49] During 1960-1994, the inflation of all goods excluding medical care was 4.7 percent on average. The inflation of medical care was 6.8 percent during the same period.

increases in cost and demand growth are taken together, given the demand of insurance, nominal health insurance premiums rise by eight percent per year, which approximately matches the average premium increase per year in nominal term for the last 20 years. [50]

2.6.1.3 Timeline

Figure 2-3 shows a timeline of policy implementation in the background of excess cost and demand growth of medical care. At time *t=0*, the economy reaches the initial steady state which is characterized by the benchmark model. The government implements a health-policy reform at time *t=1* and thereafter. Excess cost and demand growth of medical care begin at *t=1* and continue through *t=10*. This deviation period ends at *t=11*. The excess growth dissipates, and the cost and demand growth of medical care come down to two percent per year. Then the economy reaches a new steady state in next 50 years following the deviation period.[51] (Laitner 1990)

2.6.2 Results

2.6.2.1 No Government Intervention: Initial vs. New Steady States

When the economy goes through 10 years of deviation period as being characterized above, while holding all other things equal, the percentage of uninsured workers (UNI) declines to 9.4 percent at the new steady state (*t=60*) from 13.1 percent at the initial steady state (*t=0*). Workers who purchase non-group health insurance (PRI) account for 8.1 percent of the population at *t=60* relative to 4.5 percent at *t=0*. When medical expenditure rises disproportionately against earnings, more workers demand health insurance as it offers a financial protection against rainy days of illness to smooth their income and consumption. While the demand for group insurance (EHI) rises only marginally among workers who have either excellent (E) or very good (V) health status, a

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[50] Kaiser/HRET Survey of Employer-Sponsored Health Benefits, 2007.

[51] Laitner (1990) analyzes with a mathematical rigor on how an overlapping generations model (OLG) in a general equilibrium can reach a stationary solution following a saddle path after a change in fiscal policy. Following the model put together by Auerbach and Kotlikoff (1987), Laitner computes eigenvalues of the system of equations under the OLG and proves that their model has a stable arm and indeed converge to a steady state. In his work, the model reaches a new steady state in 50 years following a temporary change on consumption tax.

significant increase in demand for non-group health insurance comes from younger workers in middle earning group who report their health status being better than or equal to good (G).

Medical care consumption also depends on worker's insurance status. As more workers choose to purchase health insurance, they consume more medical care. Excess cost and demand growth of medical care that accompany a higher fraction of insured workers raise the share of medical care consumed in GDP to 12.2 percent from 9.8 percent. While higher medical expenditure growth rate raises precautionary demand for savings during the deviation period, a permanently higher share of medical expenditure in workers' budget constraints offsets the effect on savings. As a consequence, nation's capital accumulation is curtailed, leading to 4.1 percent lower real wage rate at the new steady state relative to the initial steady state. The balanced growth path declines by 1.2 percent at $t=60$. Wealth inequality measured by the Gini coefficient increases by 6.3 percent, a change from 0.328 to 0.349.

There is 0.13 percent of the population that falls into the "Medically Needy" program at the initial steady state ($t=0$). Most of them are uninsured workers. Workers with middle earning ability and very good (V) health account for 66 percent of this financially vulnerable population. Workers with low earning ability who receive a financial support have good (G) health status prior to a medical-expenditure shock. There are hardly any workers with high earnings who require the financial support from the "Medically Needy" program. When the economy goes through the transition time, the size of population requiring the safety net at the new steady state ($t=60$) rises by a small margin to 0.14 percent in spite of lower percentage of uninsured population. This number constitutes 0.09 percent of workers and 0.05 percent of retirees. While the percentage of workers who fall into the safety net declines as a result of higher demand for non-group health insurance, the excess cost and demand growth of medical care have a disproportionate effect on savings for retirees. The deviation in growth rates spreads financially vulnerable retirees across all categories of health status and earning groups. The most vulnerable retirees have low income and good (G) or fair (F) health status. In order to finance the "Medically Needy" program, the government must raise the wage income tax rate by 0.012 percentage points at t=60.

2.6.2.2 "Universal Insurance without Mandate"

When the government implements a universal insurance policy without mandate, subsidies help further reduce the percentage of uninsured workers in the population across all categories of health status and earning groups. When the level of subsidies is $\psi = 0.5$ 0, the percentage of uninsured population falls further to 6.9 percent at the new steady state. The subsidies help workers who did not receive an EHI offer to purchase the non-group insurance (PRI), raising the fraction of workers who purchase PRI to 10.6 percent of the population. When older workers pay higher premium relative to younger workers in the non-group insurance (PRI) markets, the subsidies create disproportionate income and price effects. At the margin, the subsidies largely induce younger and healthier workers of the middle earning group to purchase PRI. As these workers are pooled into the PRI market, the average premium falls by 6.9 percent relative to the case of no government intervention.[52]

Subsidies create heterogeneous impacts on net savings. Workers who do not receive a subsidy experience both their consumption and savings to decline marginally as they face 0.31 percentage point higher wage income tax rate, $\tau^{fHC} = 0.31$. Majority of workers are in this category. Infra-marginal workers—approximately 8.1 percent of the population who would purchase non-group health insurance (PRI) regardless of subsidies being provided—increase their commodity consumption as a result of subsidies. Consumption smoothing mechanism dictates how the subsidies impact workers' net savings. While subsidies crowd out savings of young infra-marginal workers to some extent, it raises savings of older infra-marginal workers. On the other hand, changes in net savings by marginal workers—those who are induced to purchase PRI by the subsidies—depends on the cost of insurance and the size of their out-of-pocket expenditures before and after the reform. The government subsidies have a dynamic effect on savings among retirees. While the additional taxation to finance the policy

[52] In general, the higher the subsidies are, the lower becomes the percentage of uninsured workers in the population. When the subsidies become too high, however, the subsidized PRI premiums become cheaper than workers' contribution to pay for the EHI policy. Then, it will eventually lead to a collapse of EHI market (death spiral) as young and healthy workers opt out of the EHI market and purchase a PRI contract instead.

reduces their income, retirees who were infra-marginal workers before their retirement have more savings through consumption smoothing. Taking into account the subsidies' heterogeneous impacts on net savings at individual level, the aggregate savings at the new steady state is lower by a very small margin relative to the case of no government intervention. The balanced growth path is hardly affected by the subsidies at 50% level.

The subsidies have welfare implications among retirees as well as among workers. The number of those who fall into the "Medically Needy" program at an old age decline to 0.03 percent of the population under the policy reform from 0.046 percent under no government intervention. The number of workers who fall into the program goes down to 0.016 percent from 0.089 percent of the population. The overall reduction is 0.09 percentage points. The subsidies also help lower wealth inequality measured by Gini coefficient. Its value under the subsidies is 0.328 which is lower by 5.8 percent relative to the value under no government intervention, and it corresponds to the value of Gini at the initial steady state. The subsidies also help raise the commodity consumption among infra-marginal workers in particular. The value of social welfare function (SWF) at the new steady state under the reform is higher by 2 percent relative to the value under no government intervention.

2.6.2.3 "Universal Insurance with Mandate"

A government mandate can achieve a goal of eliminating the uninsured workers in the population. As workers who did not receive an offer of employer-sponsored health insurance (EHI) are forced to purchase non-group private insurance (PRI), a higher percentage of workers with PRI lowers their average premium by 27.7 percent relative to the case of no government intervention at the new steady state at $t=60$. The mandate also forces workers who receive an EHI offer to take it. Since the fraction of those who turn down the offer before the mandate is very small, the policy has little impact on the EHI premium.

The marginal workers—who are forced to purchase PRI—consume more medical care as a result of this mandate. Approximately 6.9 percent of workers incur negative consumer surplus in the insurance markets. The tax rate to finance this policy reform is higher by 0.2 percentage points relative to the policy without mandate. These effects lower the aggregate savings, which leads to 1.2 percent lower capital accumulation at the new steady state. The equilibrium real wage rate is lower by 0.5 percent. The balanced growth path is permanently lower by 0.5 percent under the mandate relative to the policy without mandate.

The government mandate lowers the percentage of workers who fall into the "Medically Needy" program nearly to zero. Among retirees, the percentage goes down to 0.02 percent under the policy with mandate from 0.03 percent under the policy without mandate. The policy with mandate, however, inadvertently raises wealth inequality and lowers the value of *SWF* by 3.8 percent relative to the value under no government mandate.

2.6.2.4 A Behavioral Response by Insurance Companies

2.6.2.4.1 Extension of the Benchmark Model

This paper also investigates impacts of a price discrimination against people with pre-existing health conditions on insurance take-up decisions. At the onset of excess cost and demand growth of medical care, insurance companies may impose the price discrimination. Such a behavioral response by private insurers can alter impacts of government-provided subsidies on the insured and uninsured-worker composition in the population and the economy. In order to analyze the effects of price discrimination, this study extends the benchmark model by adding an indicator variable $I_f\left(i_{t-1}, i_t, m_{t-1}, m_t, \overline{M}\right)$ in the state space vector Θ_t for insurance take-up and consumption-saving decisions [2-23][2-25]. Under the model with this extension, workers become subject to the price discrimination following high medical care consumption in two consecutive periods with new insurance purchased in between. Once they fall into the victim of price discrimination, they must pay the full price of medical expenditures out of their own pocket. Workers who keep the same insurance contract over any two consecutive periods are not subject to the price discrimination. Since there is a one-to-one mapping between medical care consumption and medical condition in this study, the extension of price discrimination is modeled in the following way:

$$I_f\left(i_{t-1}, i_t, m_{t-1}, m_t, \overline{M}\right) = \begin{cases} 1 & \text{if } m_{t-1} \geq \overline{M}_{t-1},\ m_t \geq \left(1+g_z\right)\overline{M}_t \text{, and } i_t \neq i_{t-1} \\ 0 & \text{otherwise} \end{cases}$$

[2-44]

The threshold imposed by insurance companies is denoted by $\overline{M}$ and rises annually by the growth rate of income per capita g_z. A purchase of new insurance contracts is denoted by $i_t \neq i_{t-1}$. Workers become subject to the price discrimination, $I_f\left(i_{t-1}, i_t, m_{t-1}, m_t, \overline{M}\right) = 1$, when their medical care consumption in two consecutive periods $\left(m_{t-1}, m_t\right)$ satisfy the condition [2-44]. Since medical care consumption is discretized in this numerical analysis, the threshold $\overline{M}_t$ is set at $\overline{M}_t = \overline{M}_{p=10}$ for the purpose of this exercise.[53] Insurance companies impose the discrimination at time *t=1* and thereafter.

2.6.2.4.2 Impacts of Price Discrimination against Pre-existing Conditions

The price discrimination raises the fraction of workers with PRI in the population by 0.9 percentage points at the new steady state relative to no price discrimination under the universal insurance without mandate. When insurance take-up is an intertemporal decision, the discrimination induces healthy individuals, who would otherwise opt out of the market, to purchase health insurance in this period to avoid the consequence of price discrimination in the future periods. The price discrimination raises workers' precautionary demand for non-group private insurance (PRI) when they do not receive an offer of group-health insurance (EHI) from their employer.[54] The higher enrollment in the PRI market lowers the average insurance premium by 5 percent. The market discrimination somewhat lowers the EHI take-up rate among workers who receive an EHI offer but purchased PRI in the previous period. This is because workers, who would become subject to the price discrimination otherwise, turn down the EHI offer to keep the

[53] The threshold $\overline{M}_{p=10,t=0}$ corresponds to approximately $9,300 in 2005 US$.

[54] If insurance purchasing is a contemporaneous decision, market discrimination will lower the value of health insurance even if the premiums remains the same for those subject to pre-existing conditions. Its effect will raise the percentage of uninsured population instead. The effect of subsidy on can be countervailed as a result of market discrimination. Hence how individuals make health insurance purchasing decision becomes a critical matter.

PRI instead. As a small fraction of workers with high expected medical expenditures is kept out of the EHI market, a lower enrollment in the EHI market reduces the premium instead by 0.4 percent at the new steady state. Switching insurance from PRI to EHI under the price discrimination becomes costly to some workers. When insurance purchasing is an intertemporal decision, uncertainty of an EHI offer in the future influences insurance purchasing decision today. Hence, the price discrimination restrains endogenous switching of insurance status. At the same time, price discrimination creates precautionary demand for insurance among workers who would otherwise choose to be uninsured when their employer did not offer EHI.

At the aggregate level, the percentage of uninsured population declines by one percentage point. The aggregate effect, however, masks underlying distributional effects on insured and uninsured-worker composition in the population. While the discrimination lowers the percentage of uninsured population among workers with excellent (E), very good (V), or good (G) health status, it raises the percentage of uninsured population with fair (F) or poor (P) health status across all earning groups. Clearly, the price discrimination lowers the value of insurance for those with lower health status and prices them out as a result. [See Table 2-4]

Interestingly, the price discrimination has a positive impact on nation's capital accumulation in a general equilibrium model. The risk of paying full price of medical care under the discrimination raises the precautionary demand for savings. As a result, nation's capital stock at the new steady state is higher by 1.2 percent. The increase in capital stock translates into 0.6 percent increase in equilibrium real wage rate at $t=60$, relative to the economy without the discrimination. The balanced growth path is permanently higher by 0.4 percent.

The percent of people who fall into the "Medically Needy" program rises to 0.084 percent from 0.046 percent. In spite of lower rate of aggregate uninsured population and higher real wage rate, the price discrimination increase the size of financially vulnerable workers—albeit small in percentage but large in the absolute number. A very small percentage of people with high earnings become also vulnerable. [See Table 2-5]

2.6.2.4.3 Forbidding Price Discrimination against Pre-existing Conditions

The policy experiment of the price discrimination has an important implication for the case where the government imposes a ban against such a practice. Forbidding the price discrimination will induce endogenous switching of insurance status in such that the percentage of uninsured population goes up, countervailing the effect of subsidies. Precautionary demand for insurance to avoid price discrimination in the future will dissipate among healthy workers in this period who expect bad health in the next period. They will simply wait to buy insurance until they become sick. Forbidding the discrimination, in essence, makes it easier to purchase insurance for those with fair or poor health status. As a consequence, adverse selection will raise the premium of non-group health insurance (PRI). Both price and income effect will reduce the demand for PRI at the margin. This implication is consistent with Nyman (2003) who argues that any inefficiency in health care system, such as moral hazard, adverse selection, and supplier-induced demand, results in higher insurance premiums, which can induce people to opt out of the insurance markets.

The ban against pre-existing conditions also lowers the precautionary demand for savings. The higher premium in the PRI market lowers savings among infra-marginal workers who purchase PRI regardless of the subsidies being provided. The balanced growth path will be negatively affected as a result. Hence the economy will not be immune from the impact of adverse selection. However, forbidding price discrimination reduces the size of financially vulnerable population, yielding a positive welfare implication. Table 2-6 shows the summary results of all experiments in this study.

2.6.2.5 Heterogeneous Saving Decisions across Earning Ability

This study emphasizes heterogeneity among individuals, whose actions ultimately guide the overall economy. It is particularly important to analyze individual saving decision across three groups of earning ability over their lifecycles. Analyzing heterogeneous saving decisions in response to healthcare policy helps understand well-being of the people at the disaggregate level. At the same time, it unveils insidious side effects that may result from policy reforms.

2.6.2.5.1 Policy 1: Subsidies without Individual Mandate

Figure 2-4 shows relative magnitude of savings at the new steady state in response to three policy reforms, sorted by three categories of earning ability.[55] The top panel shows savings by workers with age 1 through 40. When the government provides subsidies to encourage workers (without an EHI offer) to purchase non-group health insurance, this policy lowers savings of workers with low earning ability by 2.8 percent, relative to the case with no government intervention. This effect is based on the saving decisions of four subgroups within the same earning ability. First, savings of marginal workers—policy induced non-group insurance holders—decline. While health insurance helps smooth consumption over their lifecycle, it induces marginal workers to consume more medical care as a result. Proportional taxation to finance this policy also goes against accumulation of their savings. Second, inframarginal workers—those who purchase non-group health insurance regardless of the subsidies—raise their savings from the subsidies. Third, workers with EHI reduce their savings as they finance this policy through proportional taxation. Fourth, savings of uninsured workers similarly decline.

In contrast, workers with middle earning ability increase their savings, albeit marginal, by 0.4 percent. Gains in savings from a large fraction of inframarginal workers in this group (Table 2-4) outweigh losses in savings from marginal workers, the uninsured, and workers with EHI combined. Savings of workers with high earning ability decline by 0.4 percent. The fractions of both marginal and inframarginal workers in this earning group are small. Relatively large fraction of workers with EHI sees their savings decline as a result of financing this policy reform.

Analysis based on age cohorts indicates that subsidies induce younger workers most to purchase non-group health insurance. Declines in savings are most pronounced in the youngest age cohort with age between 1 and 10. Endogenous switching of their insurance status, thus accompanies lower savings as marginal workers are induced to consume more medical care.

2.6.2.5.2 Policy 2: Subsidies with Individual Mandate

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[55] Savings equal 100 under no government intervention.

When the government imposes individual mandate (Policy 2), the equilibrium health insurance premiums decline as healthy workers who would not purchase insurance otherwise are compelled to purchase one. The positive impact on savings that comes from lower premiums, however, is severely curtailed by losses in savings that result from negative consumer surplus in the non-group insurance markets. Savings by marginal workers—those who are induced by subsidies and those who are compelled to purchase insurance—decline as their consumption of medical care rises. The reduction in savings is most pronounced among workers with low earning ability. Their savings are lower by 5.3 percent, relative to the case with no government intervention. Savings of middle- and high-skilled workers decline by 0.2 percent and 2.2 percent respectively.

Heteregeneous impacts on their savings are explained by relative fractions of marginal and inframarginal workers in these two groups of earning ability. The impact of this policy is most magnified among workers in the younger age-cohorts. Within the youngest cohort (age between 1 and 10), savings by workers with low earning ability decline by almost 54 percent at the new steady state, relative to the case with no government intervention. Savings by workers with middle and high earning ability decline by 9 percent and 6 percent, respectively. As the individual mandate lowers the equilibrium wage rate in a dynamic general equilibrium, younger workers bear disproportionately high cost of this policy at the end.

2.6.2.5.3 Policy 3: Subsidies without Individual Mandate under Price Discrimination

When insurance companies impose price discrimination on the basis of pre-existing conditions, workers' demand for precautionary savings rises since they must bear the full cost of medical expenditures if an insurance company denies workers' coverage on the basis of their pre-existing conditions. The impact of proportional taxation on savings under the price discrimination (Policy 3) is mitigated by the rise in precautionary savings. The price discrimination raises overall savings of low-, middle-, and high-skilled workers, relative to Policy 1. The increase in savings is higher among workers with high earning ability. Analysis of cohort response to the price discrimination reveals that the youngest cohort (with age 1 through 10) of low earning ability, in contrast, lowers their savings in response to the price discrimination. Their savings decline by 15 percent, relative to the case with no government intervention. Under Policy 1, their savings decline by 10.8 percent. Hence, the price discrimination lowers savings of the youngest cohort by 4.2 percentage points. On the other hand, the discrimination raises savings of the youngest cohort with middle and high earning ability by 2.3 and 2.9 percentage points. It is very costly for workers in these earning groups to run down their assets when they face the price discrimination. In the presence of "Medically Needy" safety-net program, workers with low earning ability face low cost of running down their assets to be qualified for the safety net since their asset levels are low, yielding an implication of moral hazard. Workers in the next age cohort between 11 through 20 shows a similar response to the policy reform under price discrimination. Workers with age between 21 through 40 raise their savings, in response to the price discrimination, regardless of their earning ability.

2.6.2.6 Health Status and Well-being of the People

This study assumes no aggregate uncertainty on population health. At any given time, individuals with "excellent", "very good", "good", "fair", and "poor" health status account for 21.8, 33.5, 30.0, 10.5, and 4.3 percent of the population. Individuals, however, face idiosyncratic health shocks that are controlled by conditional Markov transition matrices. Consequently, as shown in Table 2-4, the conditional distribution of health status varies under each policy. Figure 2-18 displays that high consumption of medical expenditures is not necessarily associated with improvement of individual health status. As the fraction of population with at least one chronic condition increases in age, according to Machlin and Cohen (2008), the percentage of adults who consume medical care as a result of their chronic illness ranges from 36.4 percent among young adults (age 18-34) to 91.5 percent of the elderly (age 65 and above). In addition, top 5 percent of people who consume most medical-care explains more than a half of total medical expenditures in this country.

Taking these data together, we observe that a large fraction of national medical expenditures is explained by small fraction of the population with chronically ill whose health status may remain the same over time. The excessive growth of medical expenditures simply takes more resources away from consuming other goods that directly yield utility gains. It does not raise aggregate well-being of the people even when it was measured in their health status alone. When we take them into account both goods consumption and health status, the economy with excessive growth of medical expenditures has lower social welfare measured by [2-41] than the economy without it.

2.7 Conclusion

This paper's framework originates from the seminal Auerbach and Kotlikoff (1987) model. Introducing health status and health policy into the setup, this paper attempts to capture the varying impacts on, and responses from, different households. Our 60-period-of-life OLG model integrates endogenous insurance purchasing and consumption-saving decisions in a dynamic general equilibrium framework. Each household's health status evolves according to a Markov process which this study calibrates from micro data. Each household makes annual decisions facing uncertainty, though the aggregate wage and interest rate, while endogenous, are non-stochastic.

Using the model, this paper analyzes two possible health care reforms: universal insurance without mandate, and universal insurance with a mandate. "Universal insurance" in this case means substantial subsidies for households purchasing private non-group insurance. A reform including a "mandate" is one that requires all households to purchase insurance.

Under universal insurance without mandate, the analysis finds that subsidies can lower the percentage of uninsured workers in the population and reduce the number of financially vulnerable people who fall into the "Medically Needy" program. Such a policy helps narrow wealth inequality and improves, albeit marginally, social welfare relative to the case without government intervention. The policy's impact on the balanced growth path of the overall economy is limited.

If the government espouses the view that "one uninsured person is too many," a mandate reduces the population fraction without insurance to zero. A mandate can also lower the financially vulnerable fraction of the working population nearly to zero, and it can reduce the fraction of retirees who fall into the "Medically Needy" program. Such a policy, however, causes serious side effects according to the model. Compelling workers who would not otherwise turn to insurance to purchase it lowers their utility, thus creating negative consumer surplus. Their willingness to purchase health insurance is lower than the equilibrium premium. Most of these workers are healthy, yet their precautionary savings decline as workers with insurance typically consume more medical services. The economy's overall balanced-growth output is noticeably lower since the equilibrium wage rate is lower. The policy with mandate also lowers the financially vulnerable fraction of the working population to zero. As a result, this policy eliminates the social cost of financing medical expenditures for uninsured workers. Social welfare—measured by a population weighted average of individual flow utilities—is curtailed at the new steady state, as the lower equilibrium wage rate reduces consumption of commodities.

Reform should address the problem of price discrimination against people with pre-existing conditions. Because workers do not always receive an employer-sponsored health insurance (EHI) offer, those with a chronic illness, face a risk of price discrimination when they need to change their insurance status. Uninsured workers who fall into illness also face a risk of price discrimination when they try to purchase health insurance in the next period. Workers with non-group health insurance may not take an EHI offer this period if they expect that the offer may not be present next period. Workers who are denied coverage on the basis of pre-existing conditions end up facing the full cost of medical care. Thus, price discrimination leads relatively healthy (risk-averse) workers to purchasing health insurance, lowering the percentage of the uninsured population and health insurance premiums. At the same time, it drives a fraction of workers with a chronic illness out of insurance markets, raising the percentage of population who fall into the "Medically Needy" program. This problem is exacerbated by young workers with low earning ability, who face low opportunity cost of running down their assets. These workers are likely to save less as a result of price discrimination. Forbidding price discrimination makes it easier for people with a chronic illness to purchase health insurance in the non-group market if their employers stop offering insurance. On the other hand, it encourages healthier workers to go without insurance in the short run, which raises the fraction of uninsured workers in the population. That, in turn, raises health insurance premiums in the non-group market. Thus, forbidding price discrimination countervails the effect of subsidies that provide incentives to uninsured workers to purchase non-group health insurance.

In reality, the effectiveness of policy without a mandate may be short lived in terms of reducing the percentage of the uninsured population. The flow and the stock of the uninsured population are determined simultaneously by many factors. It is important to consider firms' behavior in offering group health insurance, employment status over the business cycle, the payment structure of a health insurance contract, and hospitals' behavior in shifting cost from Medicare patients to privately insured workers. Moreover, workers' preferences toward risk may not be time invariant. When there is bounded rationality (Simon 1982), agents may not be able to estimate correctly their future medical expenditures, and thus choose to be uninsured. Any changes that lower the value of health insurance may lead workers to opt out of insurance markets, creating a higher fraction of financially vulnerable workers in the population. Hence, there may be risks associated with universal insurance without a government mandate.

The government must ask the objective of implementing a universal insurance policy. It all comes down to the question of how to share the growing burden of medical-care costs. When the government becomes paternalistic and believes that "one uninsured person is too many," the side effects should be appreciated. If the government chooses not to impose a mandate, the side effects may be much more limited. Forbidding price discrimination in insurance markets under universal insurance reform may help government assistance reach those who need it most.

FIGURES

Figure 2-1 Timing of Events and Decisions

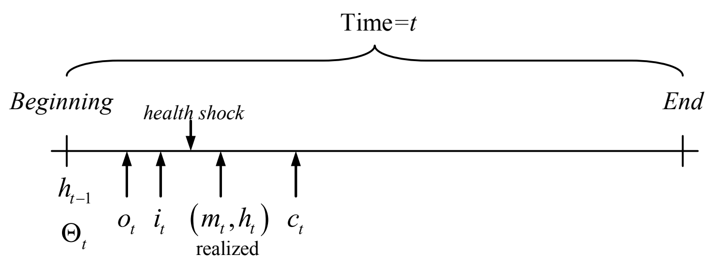


Figure 2-2 Uninsured Workers: Conditional Mean by Age and Earning Group
(*Fraction of the subpopulation*)

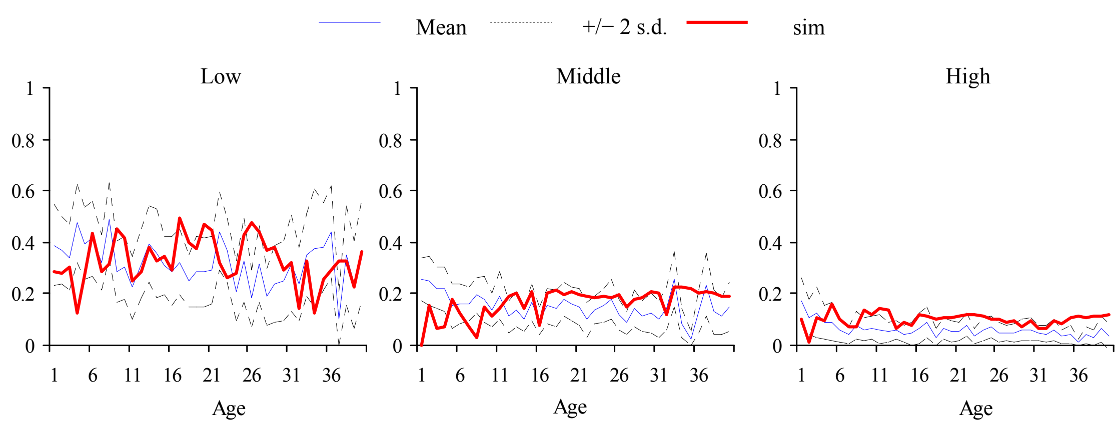


Figure 2-3 Timeline

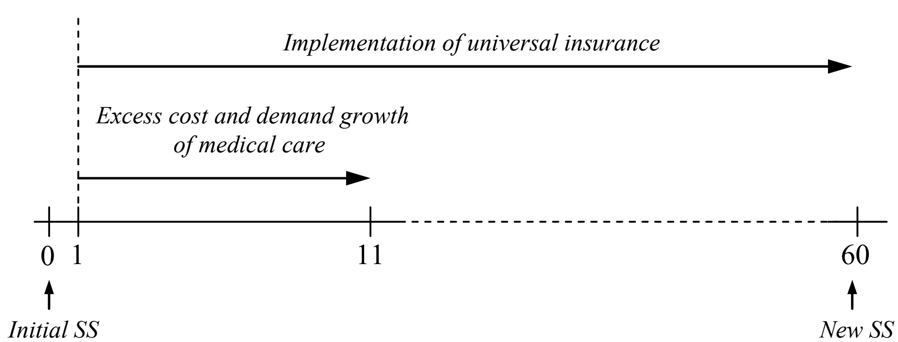
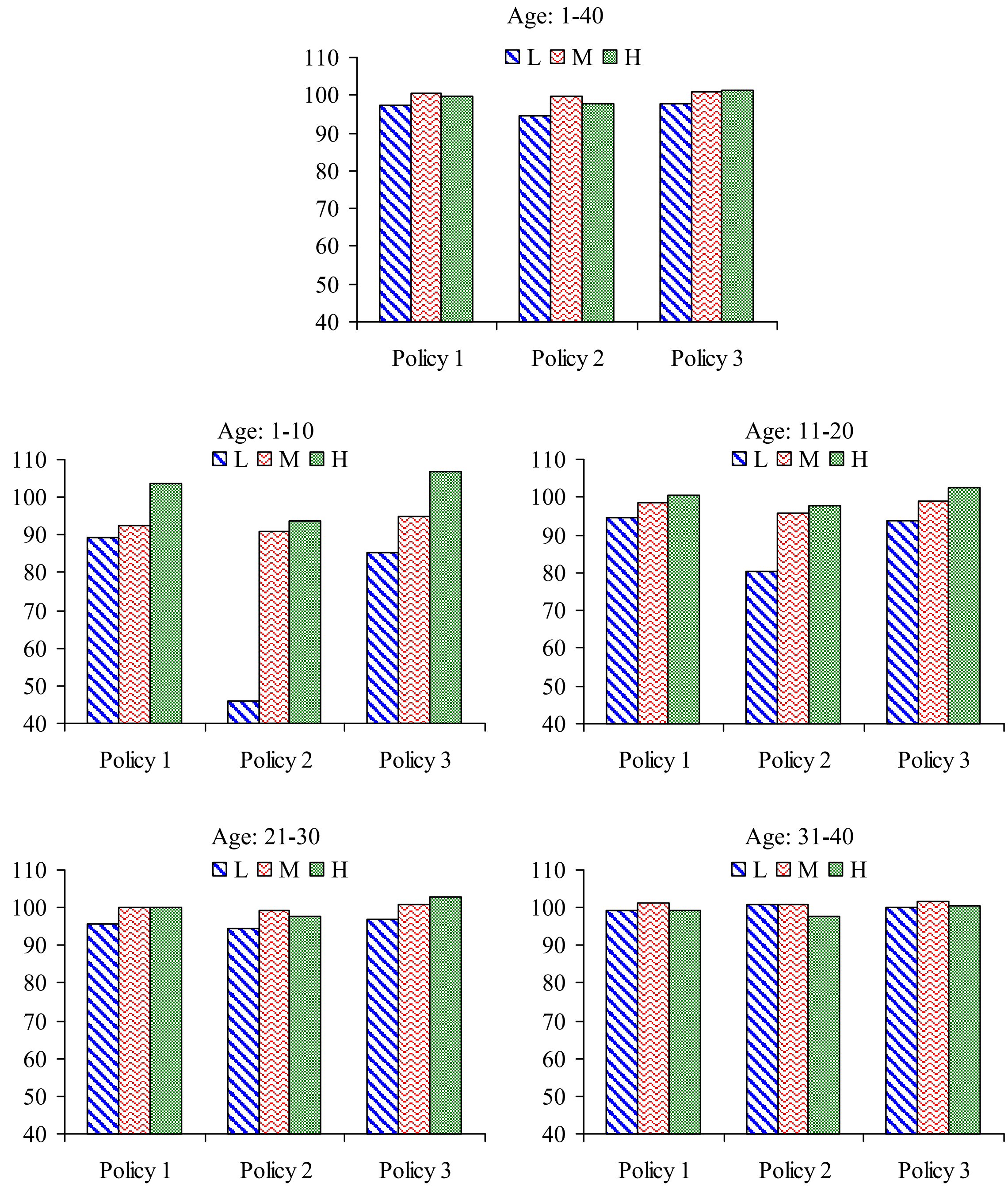


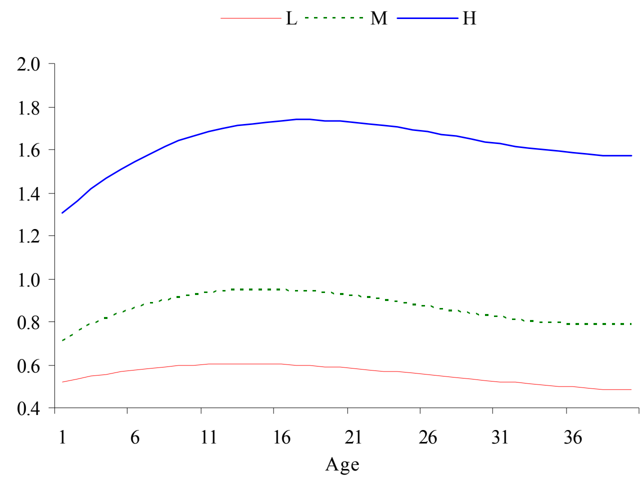
Figure 2-4 Policy Impacts on Savings: By Earning Ability 1/
(Index 2/)



1/ Policy 1 provides subsidy to workers who purchase non-group private health insurance. The government does not impose any individual mandates. Policy 2 imposes an individual mandate with subsidy given to workers with non-group health insurance. Policy 3 provides subsidies without the individual mandate while insurance companies impose a higher level of price discrimination against people with pre-existing conditions.

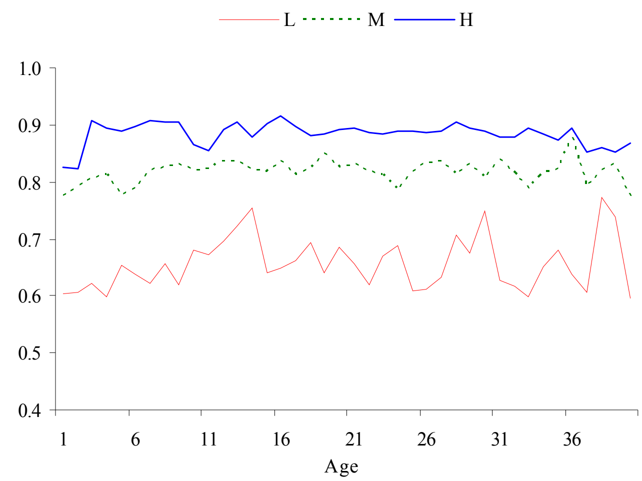
2/ The saving of each earning ability is indexed to 100 when no government intervention is assumed.

Figure 2-5 Lifecycle Profile of Labor Endowments
(*Index*)



Note: This profile is based on the cross-sectional labor income from 2005 Medical Expenditure Panel Survey (MEPS). The longitudinal profile of labor endowments can be obtained by multiplying the value of endowment, given age and earning ability, by the growth rate of labor-augmented technology.

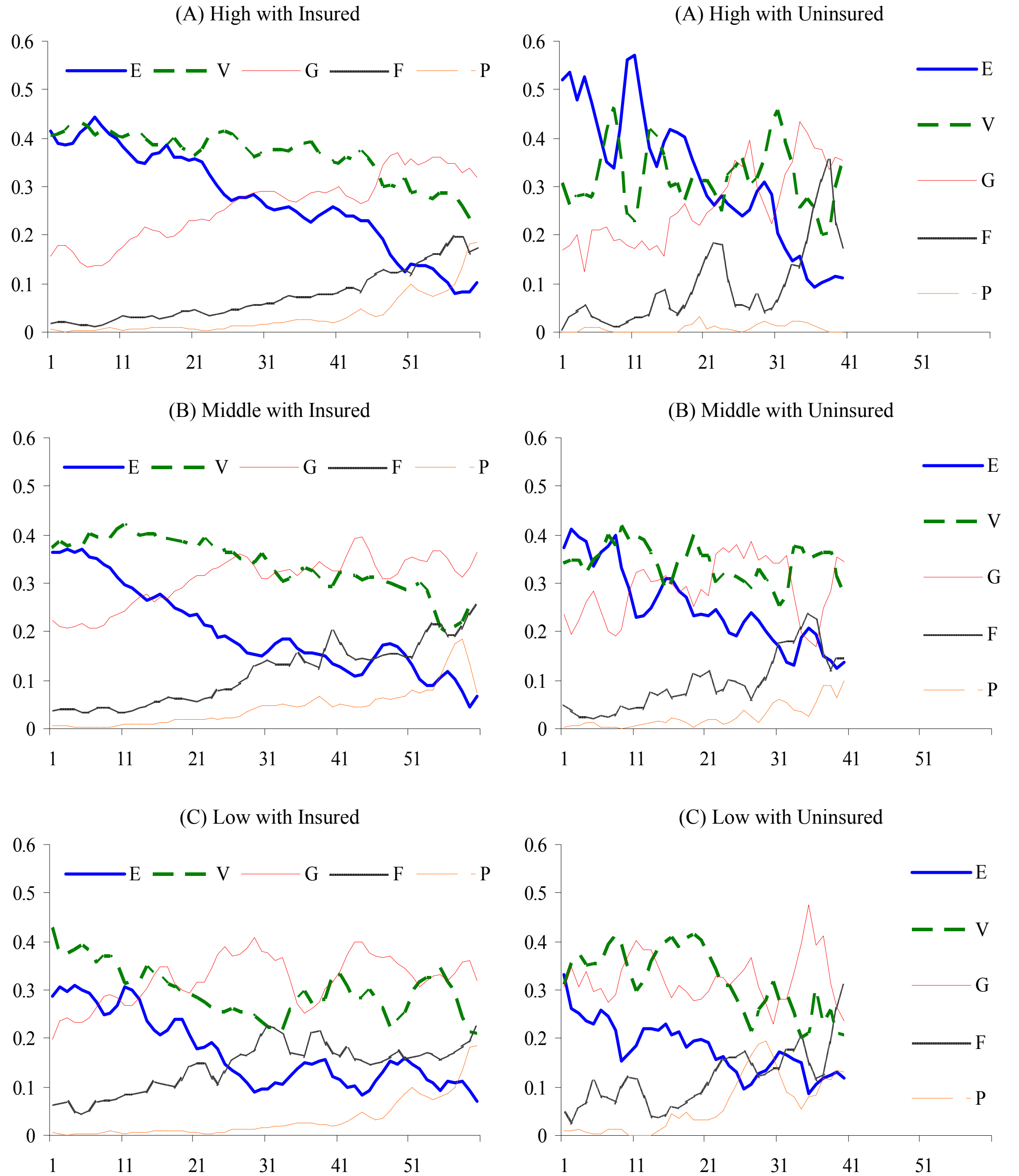
Figure 2-6 Offer Rate of Employer-Sponsored Health Insurance (EHI)
(*Fraction*)



Source: Medical Expenditure Panel Survey (MEPS), 1996-2005.

Figure 2-7 Conditional Distribution of Health Status

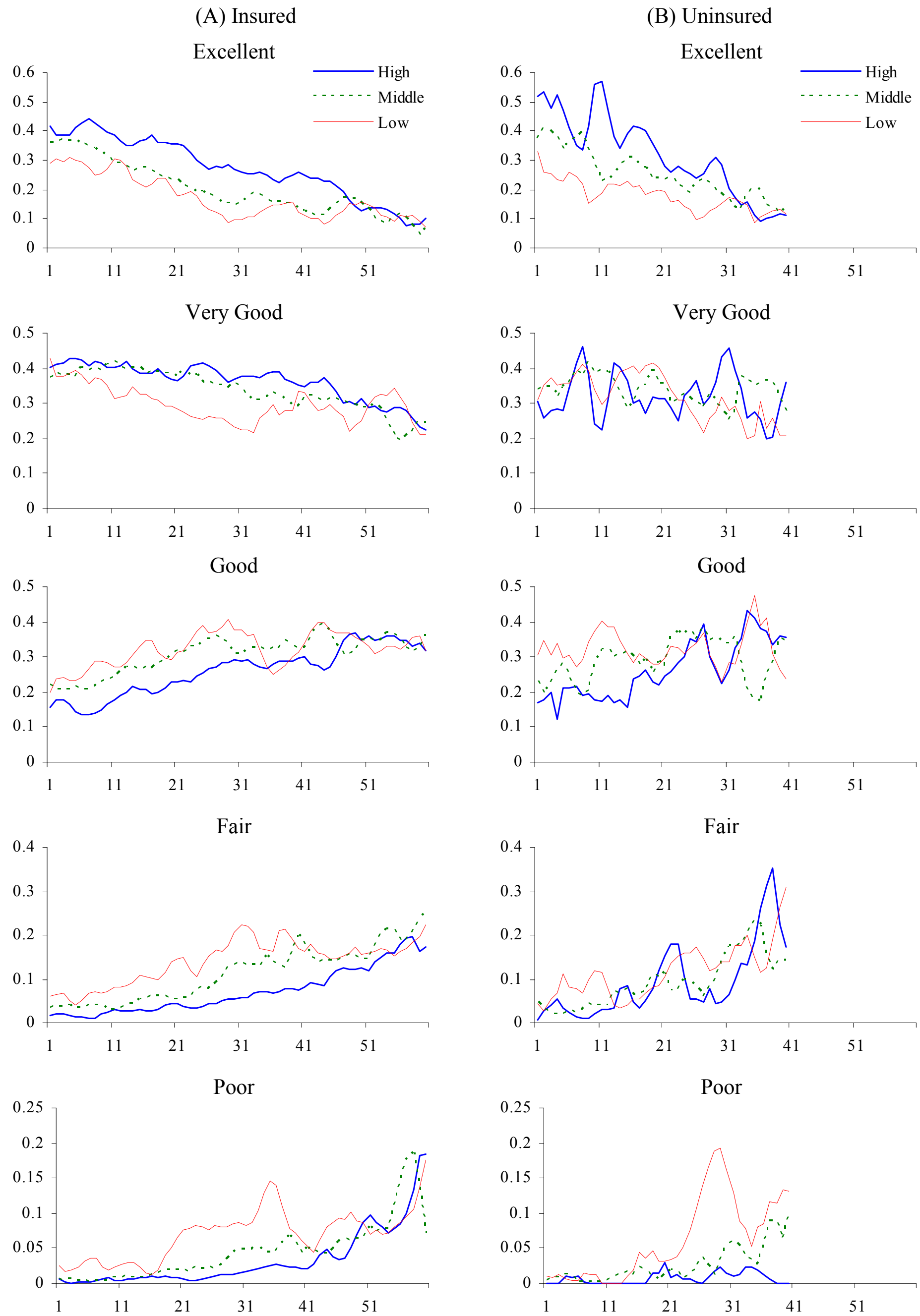
(*Fraction*)



Note: This figure shows the conditional distribution of health status, $\mu_{h|a,e,i}$ where $\sum_{h_t \in I_h} \mu_{h_t|a_t,e_t,i_t} = 1$ for $a_t \in I_a$, $e_t \in I_e$, and $i_t \in \{I_i^Y, I_i^O\}$.

Sources: AHRQ; Medical Expenditures Panel Surveys, 1996-2005, and CDC/NHCS; National Health Interview Surveys, 1995-2004.

Figure 2-8 Conditional Distribution of Health Status: By Earning Ability
(*Fraction*)

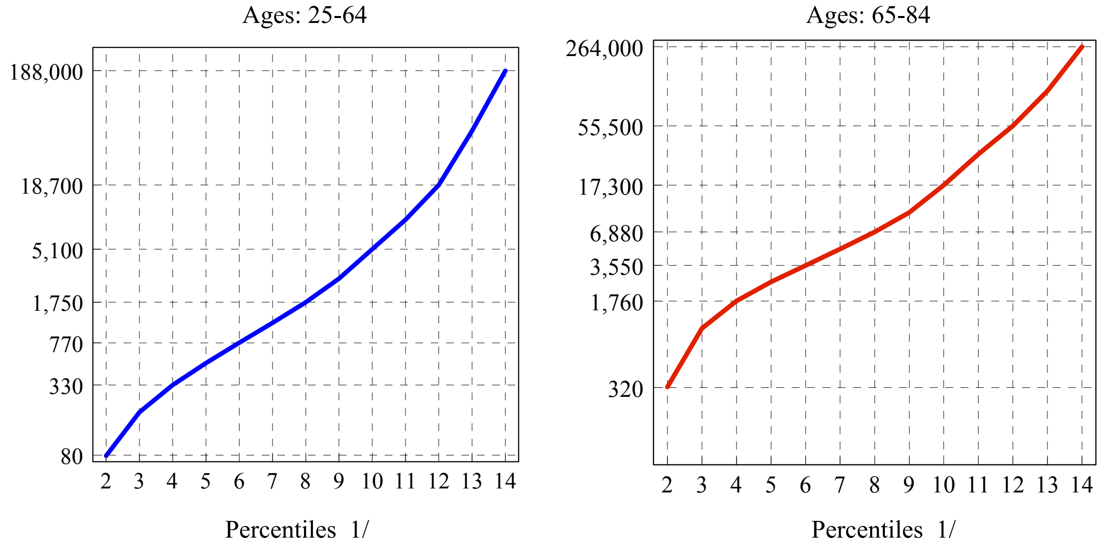


Note: This figure shows the conditional distribution of health status, $\mu_{h|a,e,i}$ where $\sum_{h_t \in I_h} \mu_{h_t|a_t,e_t,i_t} = 1$ for $a_t \in I_a$, $e_t \in I_e$, and $i_t \in \{I_i^Y, I_i^O\}$.

Sources: AHRQ; Medical Expenditures Panel Surveys, 1996-2005, and CDC/NHCS; National Health Interview Surveys, 1995-2004.

Figure 2-9 Mean Medical Care Expenditures: By Percentiles at t=0

(Log scale; US$ in 2005)



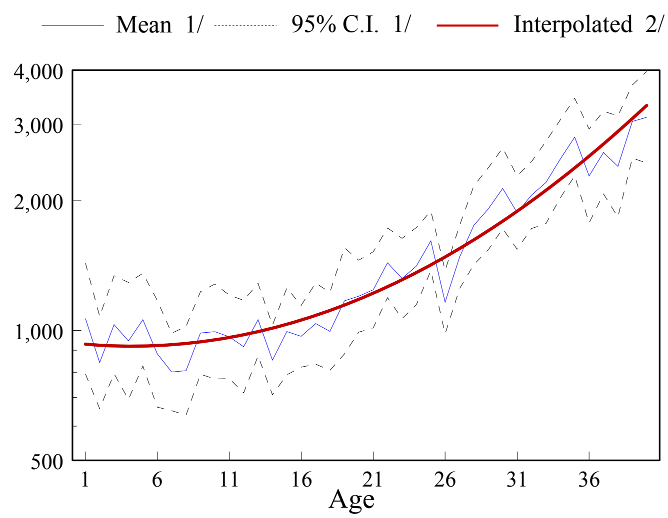
1/ The figures show 13 percentile ranks, $p \in \{2,...,14\}$: (2) 0-10, (3) 10-20, (4) 20-30, (5) 30-40, (6) 40-50, (7) 50-60, (8) 60-70, (9) 70-80, (10) 80-90, (11) 90-95, (12) 95-99, (13) 99-99.9, and (14) 99.9-100.

Note: These two figures are plotted in log scale. A vertical distance measures a percent change. The left panel shows $\overline{M}^{Y}_{p,t=0}$ where $p_t \in I_p$ for workers. The right panel shows $\overline{M}^{O}_{p,t=0}$ for retirees. $\overline{M}^{Y}_{p=1,t} = \overline{M}^{O}_{p=1,t} = 0$ for $\forall t$.

Source: AHRQ, Medical Expenditure Panel Surveys, 1996-2005.

Figure 2-10 Average Medical Care Expenditures in 2005: By Age

(Log scale, US$ in 2005)



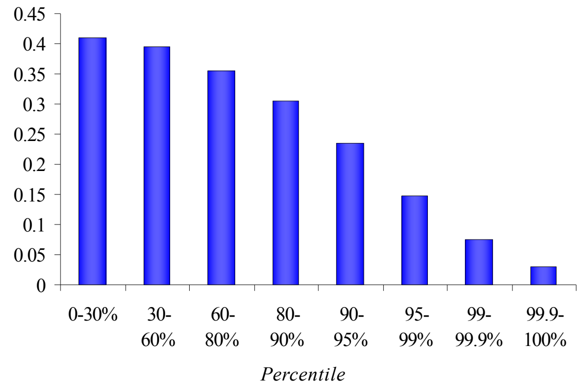
1/ These series are computed based on the sampling weights and strata from the source. The dotted lines represent a 95 percent confidence interval.

2/ The thick-solid (red) line shows a second-order polynomial interpolation. The coefficients for workers are -0.0085 (age), 0.0010 (age^2), and 6.8417 (constant).

Source: AHRQ, 2005 Medical Expenditure Panel Survey.

Figure 2-11 Synthetic Coinsurance Rates: Workers

(Ratio 1/)

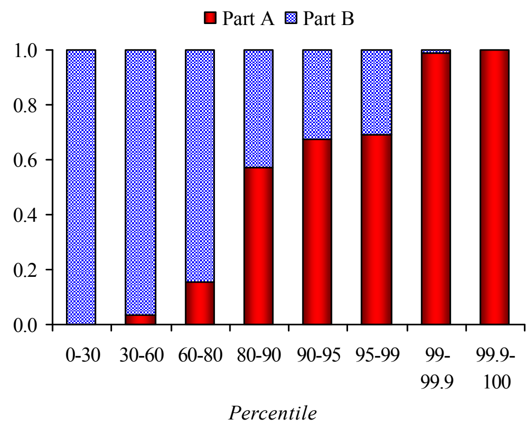


1/ Synthetic coinsurance rates are computed based on the weighted average of individual out-of-pocket expenditure in percent of the total medical expenditure.

Source: AHRQ, Medical Expenditure Panel Surveys, 1996-2005.

Figure 2-12 Types of Medical Expenditures: Retirees

(Ratio 1/)



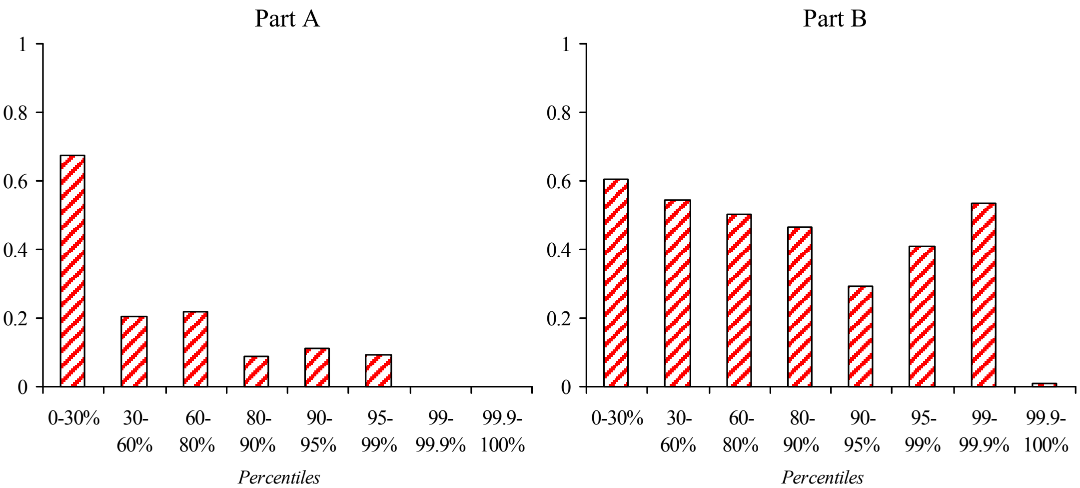
1/ It measures fractions of Part A and Part B expenditure in total medical spending. The ratio represents an average across surveys based on sample population weights. Part A expenditures include hospital's inpatient care and home health care. Part B includes all other care.

Note: The red (solid) bar indicates a fraction of medical care consumption devoted for Medicare Part A, denoted by χ_p where $p \in I_p$.

Source: AHRQ, Medical Expenditure Panel Surveys, 1996-2005.

Figure 2-13 Synthetic Coinsurance Rates: Retirees

(Ratio 1/)

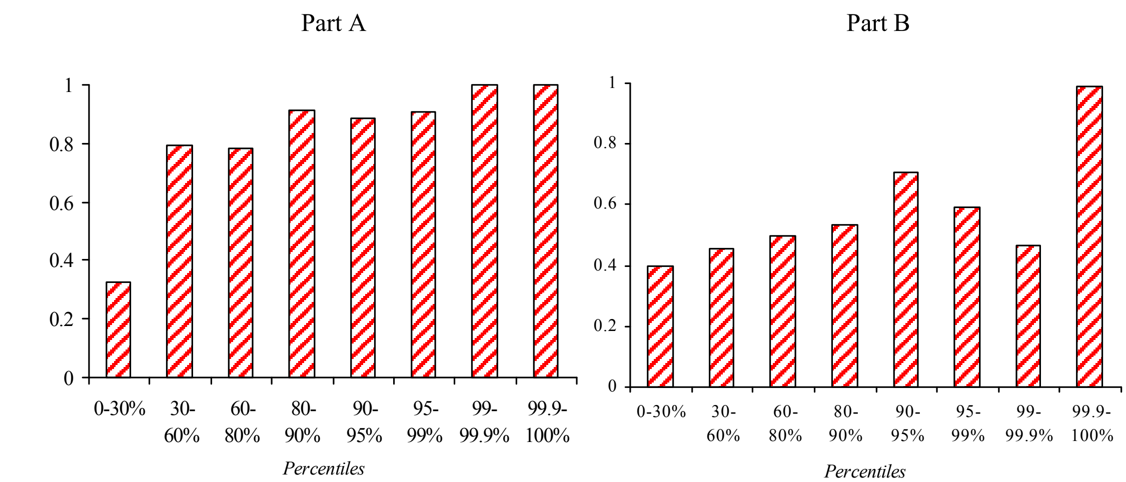


1/ Synthetic coinsurance rates are computed based on the weighted average of individual out-of-pocket expenditure in percent of the total medical expenditure for Part A and Part B, respectively.

Note: The synthetic coinsurance rates are denoted as $\left(\sigma_{(A),p}^{MCO}, \sigma_{(B),p}^{MCO}\right)$ for Part A and Part B where $p \in I_p$.

Source: AHRQ, Medical Expenditure Panel Surveys, 1996-2005.

Figure 2-14 Medicare Payment: Retirees
(Ratio 1/)



1/ It shows the fraction of total medical care cost paid by the government. The rate of reimbursement for Part A is denoted by $\left(1-\sigma^{MCO}_{(A),p}\right)$. The rate of reimbursement for Part B is denoted by $\left(1-\sigma^{MCO}_{(B),p}\right)$ where $p \in I_p$.

Source: AHRQ; Medical Expenditure Panel Surveys, 1995-2005.

Figure 2-15 Conditional Distribution of Medical Expenditures: By Age
(Fraction 1/)

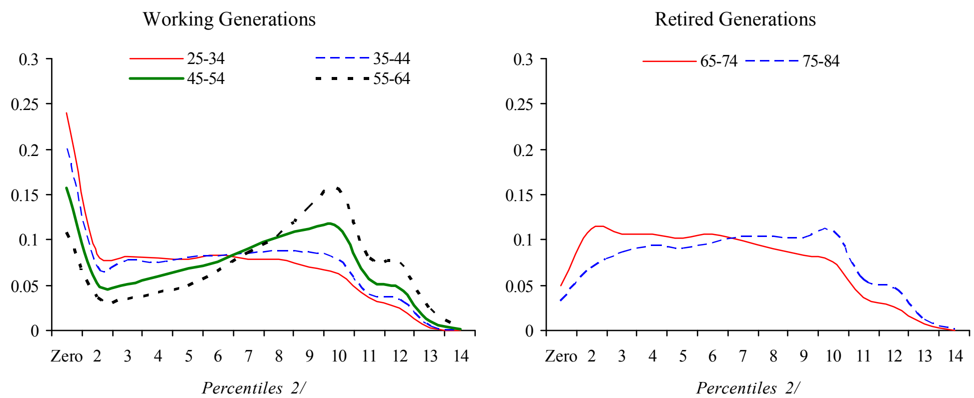
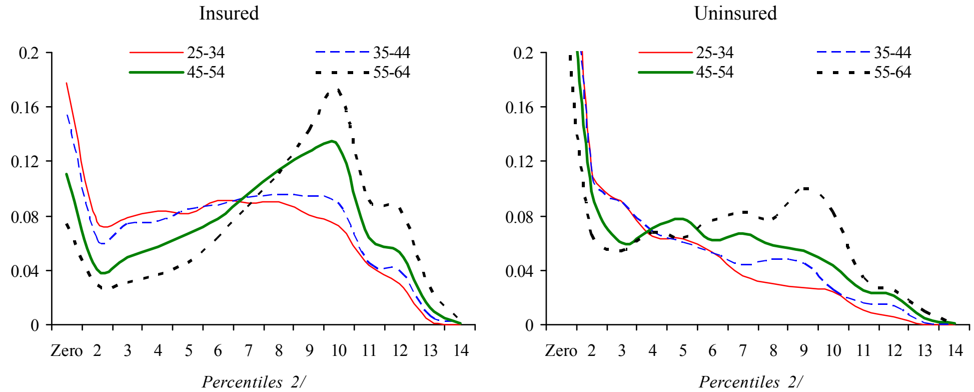


Figure 2-16 Conditional Distribution of Medical Expenditures: Workers by Age and Insurance Status

(Fraction 1/)



1/ The area under each line adds to one, $\sum_{p \in I_p} \mu_{p|a,i} = 1$

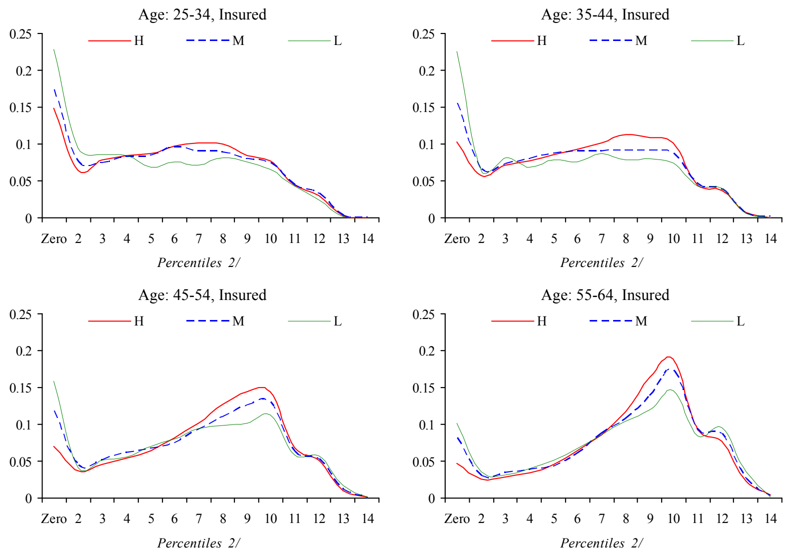
2/ The label "Zero" is for those with zero medical care consumption. Percentile groups $p \in I_p$ are sorted in the following: (2) 0-10, (3) 10-20, (4) 20-30, (5) 30-40, (6) 40-50, (7) 50-60, (8) 60-70, (9) 70-80, (10) 80-90, (11) 90-95, (12) 95-99, (13) 99-99.9, and (14) 99.9-100.

Source: AHRQ; Medical Expenditures Panel Surveys, 1996-2005, and CDC/NHCS; National Health Interview Surveys, 1995-2005.

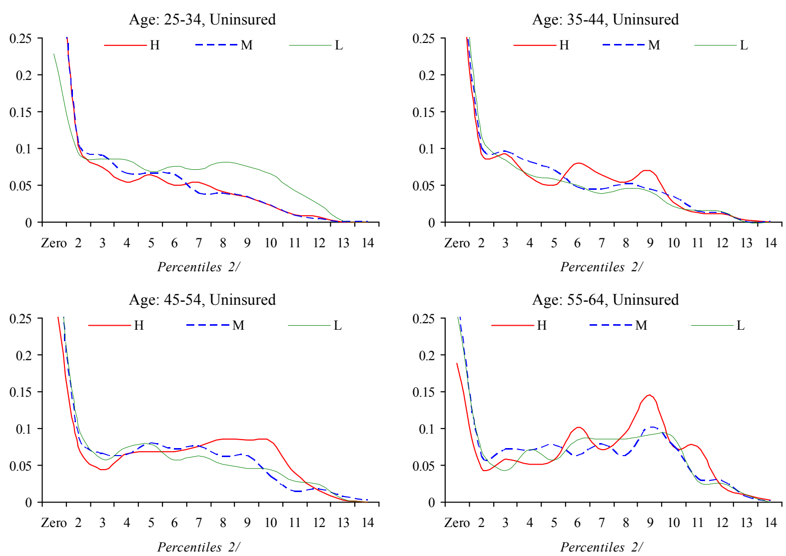
Figure 2-17 Conditional Distribution of Medical Expenditures: Workers by Age, Earning Ability and Insurance Status

(Fraction 1/)

(A) Insured Workers



(B) Uninsured Workers



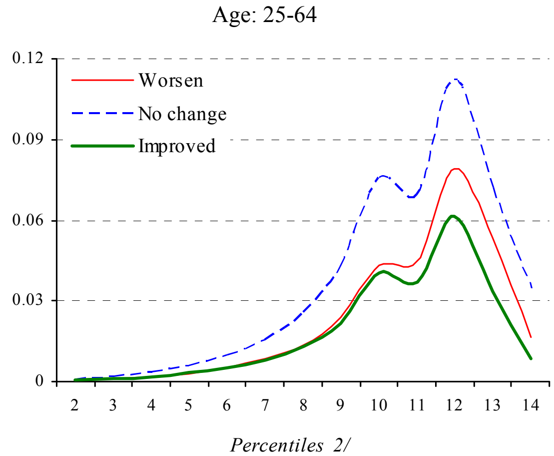
1/ The area under each line adds to one, $\sum_{p \in I_p} \mu_{p|a,e,i} = 1$.

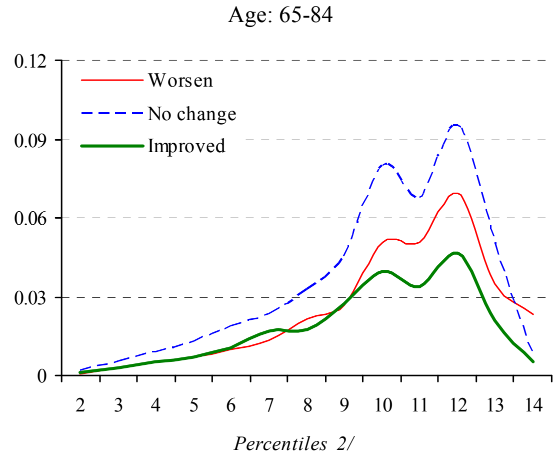
2/ The label "Zero" is for those with zero medical care consumption. Percentile ranks $p \in I_p$ are sorted in the following: (2) 0-10, (3) 10-20, (4) 20-30, (5) 30-40, (6) 40-50, (7) 50-60, (8) 60-70, (9) 70-80, (10) 80-90, (11) 90-95, (12) 95-99, (13) 99-99.9, and (14) 99.9-100.

Sources: AHRQ; Medical Expenditures Panel Surveys, 1996-2005, and CDC/NHCS; National Health Interview Surveys, 1995-2005.

Figure 2-18 Conditional Distribution of Medical Expenditures: By Transition of Health Status

(Fraction 1/)





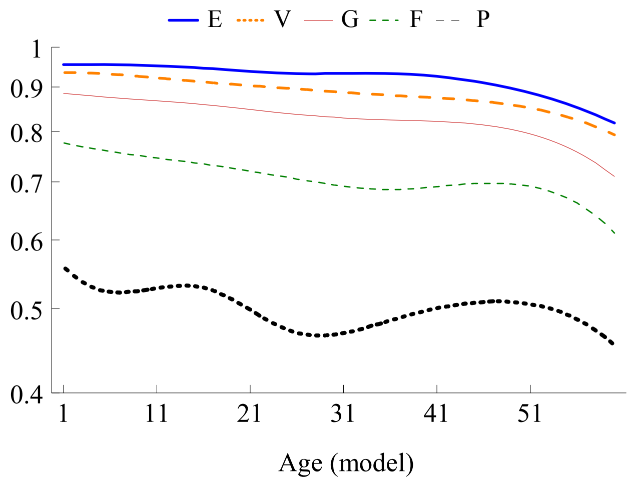
1/ This figure is based on the joint distribution of age, earning group, insurance status, health status, and percentiles of medical care expenditures. The "Worsen" is for those who reported their health status deteriorated from the previous year. The "No change" is for those with status quo in terms of their health status between two periods. The "Improved" is for those with their health status improved from a year before. Given the aggregate health expenditures among the people with age between 25 and 64, the categories of "worsen", "No change", and "Improved" account for 29%, 47%, and 24% respectively. Among the people with age between 65 and 84, the categories of "worsen", "No change", and "Improved" account for 32%, 45%, and 23% respectively.

2/ Percentile groups are not comparable between workers and retirees. Percentile ranks are denoted by $p \in I_p$: (2) 0-10, (3) 10-20, (4) 20-30, (5) 30-40, (6) 40-50, (7) 50-60, (8) 60-70, (9) 70-80, (10) 80-90, (11) 90-95, (12) 95-99, (13) 99-99.9, and (14) 99.9-100.

Sources: AHRQ; Medical Expenditure Panel Surveys, 1996-2005 and CDC/NHCS; National Health Interview Surveys, 1995-2005.

Figure 2-19 Quality of Life (QoL) Weights: Conditional on Age and Health Status

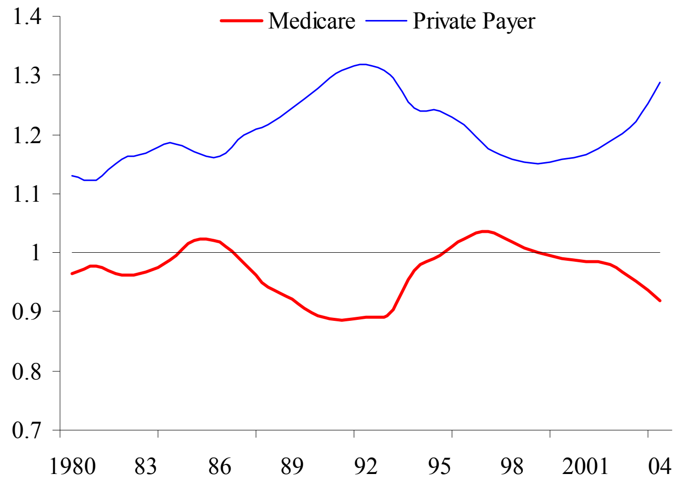
(Index in log scale)



1/ A cubic spline is applied to interpolate across ages within each age cohort for each health status: Excellent (E), Very good (V), Good (G), Fair (F), and Poor (P). Nyman, Barleen et al (2007) provide the estimates of their QoL weights for the following seven age cohorts: (1) 18-24, (2) 25-34, (3) 35-44, (4) 45-54, (5) 55-64, (6) 65-74, and (7) 75 plus.

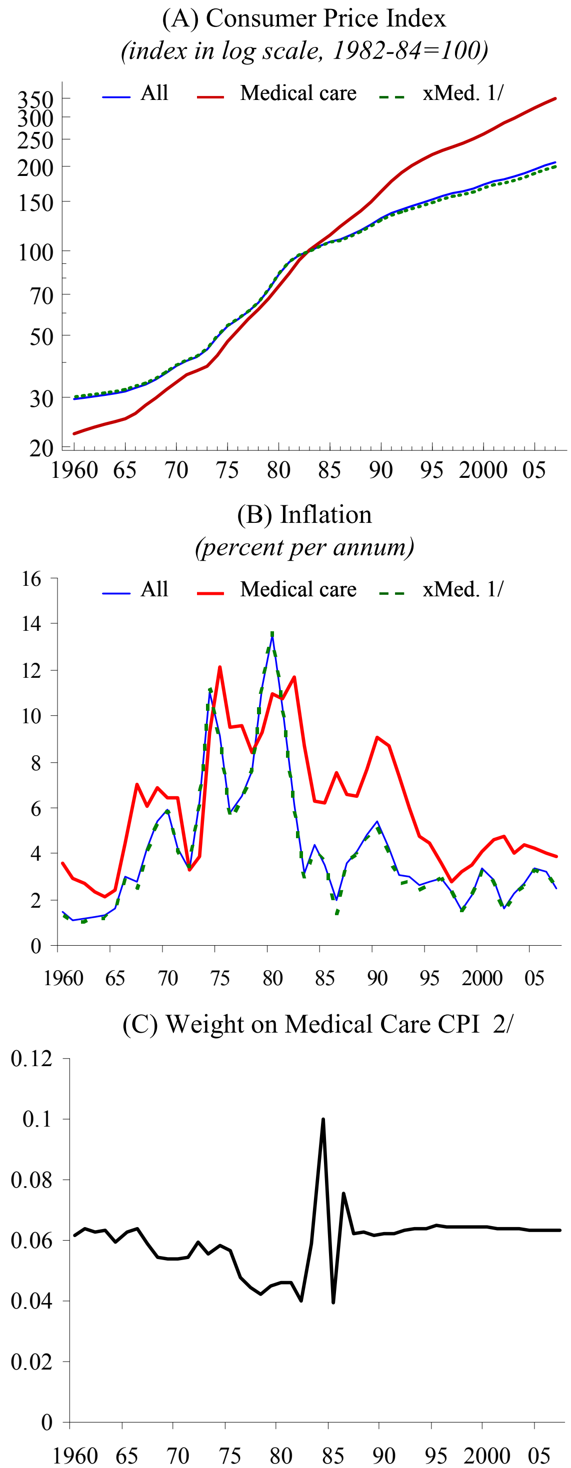
Source: Nyman, Barleen et al. (2007)

Figure 2-20 Aggregate Hospital Payment-to-Cost Ratios:
Private Payers vs. Medicare, 1981-2004



Note: The American Hospital Association reported that national underpayment for Medicare was $1.4, $2.4, $3.4, $8.1, $15.0, and $15.5 billions in years 2000 through 2005, respectively. (AHA 2006)
Source: American Hospital Association/The Lewin Group, Trend Watch Chartbook 2006: Trends Affecting Hospitals and Health Systems, April 2006. Downloaded from the following website, http://www.hospitalconnect.com/ahapolicyforum/trendwatch/chartbook2006.htm.

Figure 2-21 U.S. Consumer Price Indices, 1960-2007



1/ All items excluding medical care.
2/ The weight is for the medical care CPI to compute the geometric average of the overall CPI.
Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLES

Table 2-1 Discretization of Medical Care Consumption

I_p	volume size	I_p	volume size
1	zero	8	(60,70]
2	(0,10]	9	(70,80]
3	(10,20]	10	(80,90]
4	(20,30]	11	(90,95]
5	(30,40]	12	(95,99]
6	(40,50]	13	(99,99.9]
7	(50,60]	14	(99.9,100]

Table 2-2 Numerical Result, Part 1: Benchmark Case

Description	Variable	Benchmark: Real Value 1/	Benchmark: Nominal Value
(1) Demographics			
Population growth rate	g_N	1.0%	
Insured with EHI (group)	$\mu_{s=EHI}$	55.5%	
Insured with PRI (non-group)	$\mu_{s=PRI}$	4.5%	
Uninsured	$\mu_{s=UNI}$	13.1%	
(2) Production Sector			
Wage rate (Hourly)	w	$9.44	$18.44
Interest rate (Annual)	r	8.5%	9.5%
Marginal cost of EHI (Hourly equivalent)	c^{EHI}	$0.42	$0.82
EHI group premium (Annual)	Ω^{EHI}	$778.75	$2,777.33
EHI premium contribution rate	ξ^{EHI}	82.0%	
EHI takeup rate	ζ^{EHI}	99.8%	
PRI non-group premium (weighted average per year)	Ω^{PRI}	$1,178.28	$4,202.19
Share of capital in production	α	0.36	
Rate of depreciation of capital	δ_K	6.0%	
Total Factor Productivity	A	1.00	
Labor augmented technological progress	g_z	2.0%	
Fixed hours of labor supply (normalized 2/)	l	0.24	
(3) Consumers			
CRRA on consumption	γ^C	3.7	
CRRA on health	γ^H	3.7	
Weight placed on the utility of health	η	1.0	
Growth rate of weight	g_H	2.0%	
Discount factor	β	0.99	
Gross Earnings (weighted average)		$19,850	$38,762
Low-skilled		$11,212	$21,894
Middle-skilled		$17,359	$33,897
High-skilled		$32,619	$63,698
Social Security benefits (weighted average)		$4,749	$9,274
Low-skilled		$2,655	$5,185
Middle-skilled		$4,142	$8,089
High-skilled		$7,852	$15,332
(4) Tax rates			
Payroll	τ^{PAY}	6.67%	
Social Security	τ^{SS}	4.52%	
Hospital Insurance	τ^{HI}	2.15%	
Federal Labor Income (Medicare Part B)	τ^{fpB}	1.20%	
Federal Labor Income (Medically Needy)	τ^{fMN}	0.0017%	

Table 2-2 (continued) Numerical Result, Part 1: Benchmark

(5) Government Program			
Social security program, replacement rate	θ	35.0%	
Medicare Part B premium (Annual)	Ω^{MCRpB}	$317.38	$943.79
Rate of contribution to the Meciare Part B premium	ξ^{MCRpB}	59.0%	
(6) Aggregate Variables:			
(Billions of US$)			
Output	*Y*	$4,099.9	$8,006.1
Consumption of commodities	*C*	$2,779.2	$5,427.1
Medical care goods and services	*M*	$402.3	$785.6
Investment	*I*	$918.6	$1,793.8
Discrepancy		($0.2)	($0.4)
(Percent of output)			
Consumption of commodities	*C*	67.8%	67.8%
Medical care goods and services	*M*	9.8%	9.8%
Investment	*I*	22.4%	22.4%
Discrepancy		-0.005%	-0.005%
(7) Miscellaneous			
Capital-Output ratio	*K/Y*	2.48	2.48
"Medically Needy" Program (*Millons of US$*)		$43.9	$85.7
Poverty threshold *(Single person)* in 2005		$5,107.13	$9,973.00
Gini coefficient (*wealth*)		0.328	
(8) Prices 3/			
Aggregate price index	*PA*	195.28	
Price index excluding medical care goods and service	*PC*	188.71	
Medical care goods and services	*PM*	323.23	
Working generations	*PMy*	356.64	
Retired generations	*PMo*	297.37	
Weight placed on PM for computing PA.	bartheta	0.0636	
(9) Hospital: Payment-to-cost ratio:			
Workers		1.10	
Retirees	baromega	0.92	

1/ We use CPI to deflate the nominal values. Since the U.S. CPI has a base 1982-84=100, the real values share the same base.
2/ Labor hours is fixed and normalized. Assuming that there are 5 working days per week, the normalized value of 0.24 translates into 40 hours of work per week on average.
3/ Prices indices have a base, 1982-84=100.

Table 2-3 Growth Rate of Key Variables under the Balanced Growth Path

Descriptions	Variables	Benchmark		
Population growth rate	g_N	1.0%		
Labor augmented technological progress	g_z	2.0%		
Inflation	$P^A, P^C, P^M, P^{My}, P^{Mo}$	2.0%		
			Changes 1/	
			Real Value	Nominal Value
(1) Production Sector				
Wage rate (Hourly)	w		0.0%	2.0%
Interest rate (Annual)	r		0.0%	2.0%
Marginal cost of EHI (Hourly equivalent)	c^{EHI}		0.0%	2.0%
EHI premium (Annual)	Ω^{EHI}		2.0%	4.0%
(2) Government Program				
Medicare Part B premium (Annual)	Ω^{MCRpB}		2.0%	4.0%
Private supplemental policy premium (Annual)	Ω^{PRV}		2.0%	4.0%
(3) Aggregate Variables:				
Output	Y		3.0%	5.0%
Consumption of commodities	C		3.0%	5.0%
Medical care goods and services	M		3.0%	5.0%
Investment	I		3.0%	5.0%
(4) Miscellaneous				
Output per capita	Y/N		2.0%	4.0%
Capital-Output ratio	K/Y		0.0%	0.0%
Poverty threshold *(Single person)*			0.0%	2.0%

1/ Changes are based on a year-over-year on the balanced growth path.

Table 2-4 Distribution of Insurance Status by Health Status and Earning Group

(Percent of the population 1/)

	No subsidy				Subsidy (50%)				Subsidy (50%) with discrimination			
	Earning group				Earning group				Earning group			
Health status	Low	Middle	High	*All*	Low	Middle	High	*All*	Low	Middle	High	*All*
					Insurance status = EHI							
All group	*8.053*	*32.278*	*15.237*	*55.568*	*8.067*	*32.278*	*15.237*	*55.582*	*8.066*	*32.189*	*15.194*	*55.449*
Excellent (E)	1.546	7.634	4.617	*13.796*	1.546	7.634	4.617	*13.796*	1.578	7.620	4.612	*13.810*
Very good (V)	2.530	11.419	5.807	*19.756*	2.533	11.419	5.807	*19.758*	2.527	11.396	5.799	*19.723*
Good (G)	2.597	9.683	3.708	*15.988*	2.597	9.683	3.708	*15.988*	2.588	9.657	3.699	*15.944*
Fair (F)	0.986	2.709	0.847	*4.542*	0.997	2.709	0.847	*4.553*	0.989	2.694	0.834	*4.517*
Poor (P)	0.394	0.834	0.259	*1.486*	0.394	0.834	0.259	*1.486*	0.383	0.822	0.250	*1.455*
					Insurance status = PRI							
All group	*2.257*	*4.800*	*1.020*	*8.077*	*2.900*	*6.258*	*1.434*	*10.592*	*3.018*	*6.858*	*1.827*	*11.703*
Excellent (E)	0.353	1.145	0.268	*1.767*	0.409	1.234	0.321	*1.965*	0.443	1.351	0.481	*2.275*
Very good (V)	0.542	1.402	0.328	*2.272*	0.814	1.792	0.490	*3.096*	0.851	2.149	0.694	*3.693*
Good (G)	0.697	1.328	0.277	*2.302*	0.879	2.220	0.469	*3.568*	0.958	2.355	0.483	*3.796*
Fair (F)	0.436	0.686	0.115	*1.238*	0.551	0.772	0.118	*1.441*	0.541	0.759	0.128	*1.429*
Poor (P)	0.229	0.238	0.032	*0.499*	0.247	0.240	0.036	*0.523*	0.226	0.244	0.040	*0.510*
					Insurance status = UNI							
All group	*3.787*	*4.261*	*1.345*	*9.394*	*3.130*	*2.803*	*0.932*	*6.865*	*3.013*	*2.292*	*0.582*	*5.887*
Excellent (E)	0.869	0.983	0.475	*2.327*	0.814	0.894	0.421	*2.129*	0.748	0.792	0.266	*1.806*
Very good (V)	1.342	1.794	0.580	*3.716*	1.067	1.405	0.419	*2.890*	1.036	1.070	0.222	*2.328*
Good (G)	1.204	1.396	0.277	*2.877*	1.022	0.505	0.084	*1.611*	0.953	0.395	0.079	*1.427*
Fair (F)	0.310	0.085	0.007	*0.402*	0.183	0.000	0.004	*0.188*	0.202	0.027	0.007	*0.236*
Poor (P)	0.062	0.003	0.006	*0.071*	0.043	0.000	0.003	*0.046*	0.075	0.008	0.007	*0.090*

1/ Reported data is at the new steady state ($t=60$).

Table 2-5 "Medically Needy"

(Percent of the population 1/)

Insurance status	Health status: Excellent (E)	Very good (V)	Good (G)	Fair (F)	Poor (P)	*Total*
(1) No subsidy						
EHI (group)	0	0	0	0	0	*0*
PRI (non-group)	0	0	0	7.73E-07	7.39E-08	*8.47E-07*
UNI (uninsured)	3.01E-03	7.03E-03	5.44E-02	2.48E-02	6.46E-05	*8.93E-02*
MCO (medicare)	1.92E-03	5.96E-03	1.44E-02	1.90E-02	5.22E-03	*4.65E-02*
Total	*4.92E-03*	*1.30E-02*	*6.88E-02*	*4.37E-02*	*5.28E-03*	*1.36E-01*
(2) Subsidy (50%)						
EHI (group)	0	0	0	0	0	*0*
PRI (non-group)	0	0	0	0	2.52E-08	*2.52E-08*
UNI (uninsured)	2.53E-03	7.58E-04	4.08E-04	1.22E-02	8.91E-06	*1.59E-02*
MCO (medicare)	9.18E-04	2.95E-03	9.33E-03	1.41E-02	3.06E-03	*3.03E-02*
Total	*3.45E-03*	*3.71E-03*	*9.73E-03*	*2.63E-02*	*3.06E-03*	*4.62E-02*
(3) Subsidy (50%) with discrimination						
EHI (group)	2.85E-04	7.86E-04	2.25E-03	7.07E-04	6.29E-04	*4.65E-03*
PRI (non-group)	8.10E-04	2.37E-03	2.61E-03	3.11E-03	8.87E-04	*9.78E-03*
UNI (uninsured)	4.32E-03	8.35E-03	1.00E-02	1.40E-02	2.25E-04	*3.69E-02*
MCO (medicare)	1.01E-03	3.13E-03	9.76E-03	1.56E-02	3.18E-03	*3.27E-02*
Total	*6.42E-03*	*1.46E-02*	*2.46E-02*	*3.34E-02*	*4.92E-03*	*8.40E-02*

1/ "Medically Needy" are agents who take financial assistance from the safety net program. Reported data is at the new steady state (t=60).

Table 2-6 Summary Results

Variables	Initial SS (t=0) No intervention	New SS (t=60) No intervention	No mandate 2/	Mandate 2/	Price discrimination 2/
Insurance Status *(Fraction of the population)*					
Group (EHI)	0.555	0.556	0.556	0.556	0.554
Non-group (PRI)	0.045	0.081	0.106	0.174	0.117
Uninsured	0.131	0.094	0.069	0.000	0.059
Insurance Premiums 1/					
Group (EHI)		1.000	1.000	0.999	0.995
Non-group (PRI)		1.000	0.931	0.723	0.885
Tax rates *(Percent)*					
"Medically Needy"	0.002	0.026	0.006	0.002	0.008
"Universal Insurance"	n.a.	n.a.	0.310	0.506	0.339
Wage rate 1/	1.0429	1.0000	0.9992	0.9944	1.0047
Aggregate variables					
Output 1/		1.0000	0.9996	0.9950	1.0039
Capital stock 1/		1.0000	0.9984	0.9861	1.0108
K/Y	2.484	2.426	2.423	2.404	2.443
M/Y	0.098	0.122	0.123	0.126	0.123
Misc.					
SWF 1/		1.000	1.019	0.981	1.023
Gini (wealth)	0.328	0.349	0.328	0.353	0.327

1/ "No intervention" at new SS = 1.000.
2/ The level of subsidies is at 50 percent.

APPENDIX

A 2 Appendix

A 2.1 National Income Accounting

Based on the expenditure approach to national income accounting, the nominal GDP in this study is defined as:

$$P_t^A Y_t = P_t^C C_t + P_t^M M_t + P_t^A I_t$$

The term $P_t^A Y_t$ denotes the nominal GDP which consists of three categories of expenditures: (1) nominal expenditure of aggregate commodity consumption, $P_t^C C_t$; (2) nominal expenditure of aggregate medical care consumption, $P_t^M M_t$; and (3) nominal expenditure of gross investment, $P_t^A I_t$. The terms Y_t and I_t are expressed in real values. The terms C_t and M_t are expressed in volume. The real value of GDP is defined as:

$$Y_t = \left(\frac{P_t^C}{P_t^M}\right)^{\vartheta} C_t + I_t^C + \left(\frac{P_t^M}{P_t^C}\right)^{1-\vartheta} M_t + I_t^M = Y_t^C + Y_t^M$$

where $I_t = I_t^C + I_t^M$ and $P_t^A = \left(P_t^C\right)^{1-\vartheta}\left(P_t^M\right)^{\vartheta}$. The weighted price ratios $\left(\frac{P_t^C}{P_t^M}\right)^{\vartheta}$ and $\left(\frac{P_t^M}{P_t^C}\right)^{1-\vartheta}$ convert the volumes of commodity and medical care consumption into their real values, respectively.[56]

A 2.2 Private Insurance Markets

[56] In macroeconomic analysis, we often normalize the prices for simplicity, $\left(ie. P_t^C = P_t^M = 1\right)$. This normalization buys us an analytical convenience that we no longer need to distinguish variables measured in volume from ones measured in value or variables measured in current dollars (normal) from ones measured in 2005 dollars (real), for example. The normalization yields:
$Y_t = C_t + I_t^C + M_t + I_t^M = Y_t^C + Y_t^M$.

A 2.2.1 Employer-sponsored Health Insurance (EHI)

Let $\mu\left(a_t, e_t, i_t, h_{t-1}, h_t, \overline{M}^Y_{p,t}\right)$ be the joint probability mass function (PMF) where $\overline{M}^Y_{p,t}$ is the worker's average medical care consumption for a percentile rank $p \in I_p$. The EHI premium that gives insurance companies break-even profits is:

$$\Omega_t^{EHI} = \frac{\left(\sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\ldots,40\}}\sum_{e_t\in I_e}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\left(1-\sigma_p^{EHI}\right)\overline{M}^Y_{p,t}\mu\left(a_t, e_t, i_t = EHI, h_{t-1}, h_t, \overline{M}^Y_{p,t}\right)\right)}{\left(\sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\ldots,40\}}\sum_{e_t\in I_e}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\mu\left(a_t, e_t, i_t = EHI, h_{t-1}, h_t, \overline{M}^Y_{p,t}\right)\right)}.$$

A 2.2.2 Private Non-group Health Insurance (PRI)

Workers who did not receive an EHI offer can still purchase private non-group health insurance. Under the assumption of zero loadings, insurance companies satisfy the condition $REV_t^{PRI} = EXP_t^{PRI}$ where

$$REV_t^{PRI} = \left(\sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\ldots,40\}}\sum_{e_t\in I_e}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\Omega_t^{PRI}\left(a_t\right)\mu\left(a_t, e_t, i_t = PRI, h_{t-1}, h_t, \overline{M}^Y_{p,t}\right)\right)$$

$$EXP_t^{PRI} = \left(\sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\ldots,40\}}\sum_{e_t\in I_e}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\left(1-\sigma_{p,t}^{PRI}\right)\overline{M}^Y_{p,t}\mu\left(a_t, e_t, i_t = PRI, h_{t-1}, h_t, \overline{M}^Y_{p,t}\right)\right)$$

$$\ln\Omega_t^{PRI}\left(a_t\right) = \left(1+g_z t\right)\beta_0^{PRI} + \beta_1^{PRI}a_t + \beta_2^{PRI}a_t^2$$

A 2.3 Government

A 2.3.1 Social Security Program

The government runs a pay-as-you-go (PAYGO) Social Security program. It determines the social security tax rate τ_t^{SS} to satisfy the balanced budget, $REV_t^{SS} = EXP_t^{SS}$ where

$$REV_t^{SS} = \tau_t^{SS}\left(\sum_{a=1}^{40}\sum_{e\in I_e}P_t^A\left(w_t - c_t^{EHI}\right)z_{a,e,t}\bar{l}\mu_{a,e} + \sum_{a=1}^{40}\sum_{e\in I_e}P_t^A w_t z_{a,e,t}\bar{l}\mu_{a,e}\right)N_t$$

$$EXP_t^{SS} = \sum_{a=41}^{60}\sum_{e\in I_e}P_t^A b_{a,e,t}\mu_{a,e}N_t$$

The nominal social security benefit is denoted by $P_t^A b_{a,e,t}$. The benefits are computed based on the average indexed monthly earnings (AIME) and the earnings replacement rate θ. I compute the AIME based on the average earnings over 35 highest earnings years of work. The Social Security benefits at the time of retirement are:

$$P_t^A b_{a=41,e,t} = \theta_t AIME_{a=41,e,t}.$$

The benefits in the subsequent years are indexed to the cost-of-living-adjustment (COLA) to maintain a purchasing power of retirees:

$$P_{t+j}^A b_{41+j,e,t+j} = \left(\prod_{i=1}^{j} \left(1+\pi_{t+i}^A\right) \right) P_t^A b_{41,e,t} \quad \text{where } j = \{1,...,19\}$$

A 2.3.2 Medicare Program

A 2.3.2.1 Part A: Hospital Insurance

The government must satisfy the balanced budget condition: $REV_t^{HI} = EXP_t^{HI}$, where

$$REV_t^{HI} = \tau_t^{HI} \left(\sum_{a=1}^{40} \sum_{e \in I_e} P_t^A \left(w_t - c_t^{EHI} \right) z_{a,e,t} \bar{l} \ \mu_{a,e} + \sum_{a=1}^{40} \sum_{e \in I_e} P_t^A w_t z_{a,e,t} \bar{l} \ \mu_{a,e} \right) N_t$$

$$EXP_t^{HI} = \left(\sum_{h_{t-1} \in I_h} \sum_{a_t \in \{1,...,40\}} \sum_{e_t \in I_e} \sum_{h_t \in I_h} \sum_{p_t \in I_p} P_t^{M^O} \overline{M}_{(A)p,t}^{G} \mu\left(a_t, e_t, i_t = MCO, h_{t-1}, h_t, \overline{M}_{p,t}^{Y} \right) \right) N_t$$

$$P_t^{M^O} \overline{M}_{(A)p,t}^{G} = \left[\underbrace{\left(1 - \sigma_{(A),p}^{MCO}\right)}_{\substack{\text{the fraction which Gov't pays} \\ \text{for retirees}}} \right] \underbrace{\chi_p P_t^{M^O} \overline{M}_{p,t}^{O}}_{\substack{\text{avg. Part A} \\ \text{spending for } p \in I_p}}$$

A 2.3.2.2 Part B: Supplemental Medical Insurance (SMI)

A balanced budget condition for Medicare Part B program requires $REV_t^{pB} = EXP_t^{pB}$ where

$$REV_t^{pB} = \left(P_t^{M^O} \Omega_t^{MCO} \sum_{a=41}^{60} \mu_a \right) N_t$$

$$EXP_t^{pB} = \left(1-\xi_t^{MCO}\right) \left(\sum_{h_{t-1}\in I_h} \sum_{a_t\in\{41,\dots,60\}} \sum_{e_t\in I_e} \sum_{h_t\in I_h} \sum_{p_t\in I_p} P_t^{M^O} \overline{M}_{(B)p,t}^{O} \mu\left(a_t, e_t, i_t = MCO, h_{t-1}, h_t, \overline{M}_{p,t}^{Y}\right) \right) N_t$$

$$P_t^{M^O} \overline{M}_{(B)p,t}^{O} = \left[\underbrace{\left(1-\sigma_{(B),p}^{MCO}\right)}_{\substack{\text{the fraction which Gov't pays} \\ \text{for a "Medicare only" patient}}} \right] \underbrace{\left(1-\chi_p\right) P_t^{M^O} \overline{M}_{p,t}^{O}}_{\substack{\text{avg. Part } B \\ \text{spending for } p\in I_p}}$$

A 2.3.2.3 Subsidy to Retirees

Medicare Part B premium is subsidized by the rate ξ_t^{MCO}. The government finances the subsidies by wage income tax. A balanced budget condition for the subsidies is $REV_t^{fB} = EXP_t^{fB}$ where

$$REV_t^{fB} = \tau_t^{fB} TAXBASE_t^{fB} N_t$$

$$EXP_t^{fB} = \left(1-\xi_t^{MCO}\right) \left(\sum_{h_{t-1}\in I_h} \sum_{a_t\in\{41,\dots,60\}} \sum_{e_t\in I_e} \sum_{h_t\in I_h} \sum_{p_t\in I_p} P_t^{M^O} \overline{M}_{(B)p,t}^{O} \mu\left(a_t, e_t, i_t = MCO, h_{t-1}, h_t, \overline{M}_{p,t}^{Y}\right) \right) N_t \ .$$

The tax base ($TAXBASE_t^{fB}$) takes the followings:

- workers with EHI: $\sum_{a=1}^{40} \sum_{e\in I_e} \left(P_t^A w_t z_{a,e,t} \bar{l} \ - \left(1-\xi_t^{EHI}\right) P_t^{M^Y} \Omega_t^{EHI} \right) \mu_{a,e,i=EHI}$
- workers with PRI: $\sum_{a=1}^{40} \sum_{e\in I_e} \left(P_t^A w_t z_{a,e,t} \bar{l} \right) \mu_{a,e,i=PRI}$
- uninsured workers: $\sum_{a=1}^{40} \sum_{e\in I_e} \left(P_t^A w_t z_{a,e,t} \bar{l} \ \right) \mu_{a,e,i=UNI}$
- retirees: $\sum_{a=41}^{60} \sum_{e\in I_e} \left\{ P_t^A b_{a,e,t} - \left(1-\xi_t^{MCO}\right) P_t^{M^O} \Omega_t^{MCO} \right\} \mu_{a,e}$

A 2.3.3 "Medically Needy" Program

The government finances the "Medically Needy" program from the general tax revenue collected by the wage income tax. This program must be balanced, $REV_t^{MN} = EXP_t^{MN}$ where

$$REV_t^{MN} = \tau_t^{fMN} TAXBASE_t^{fMN} N_t$$

$$EXP_t^{fMN} = \left(\sum_{a_t \in \{1,\ldots,40\}} \sum_{e_t \in I_e} \sum_{i_t \in \{I_i^Y, I_i^O\}} \sum_{h_t \in I_h} \sum_{p_t \in I_p} \sum_{k_t^i \in I_k} UNPAID\left(a_t, e_t, i_t, h_t, p_t, k_t^i\right) \mu\left(a_t, e_t, i_t, h_t, p_t, k_t^i\right) \right) N_t$$
$$= DSH_t$$

$$\text{where } UNPAID\left(a_t, e_t, i_t, h_t, p_t, k_t^i\right) = \begin{cases} MNIL_t - \Gamma_{a_t, e_t, i_t, h_t, p_t, k_t^i} & \text{if } MNIL_t > \Gamma_{a_t, e_t, i_t, h_t, p_t, k_t^i} \\ 0 & \text{if } MNIL_t \le \Gamma_{a_t, e_t, i_t, h_t, p_t, k_t^i} \end{cases}$$

$$\sum_{a_t \in \{1,\ldots,40\}} \sum_{e_t \in I_e} \sum_{i_t \in \{I_i^Y, I_i^O\}} \sum_{h_t \in I_h} \sum_{p_t \in I_p} \sum_{k_t^i \in I_k} \mu\left(a_t, e_t, i_t, h_t, p_t, k_t^i\right) = 1$$

The term $\Gamma_{a_t, e_t, i_t, h_t, p_t, k_t^i}$ denotes the level of real wealth had agents paid their medical bills in full. The level of net wealth in real is conditional upon agent's age (a_t), earning ability (e_t), insurance status (i_t), health status (h_t), medical expenditure expressed in percentile (p_t), and the asset holdings (k_t^i) at the beginning of the *t*-th period. The government offers a financial assistance when the level of net wealth falls below the prevailing Medically Needy Income Limit (MNIL) in real at time *t*, $MNIL_t > \Gamma_{a_t, e_t, i_t, h_t, p_t, k_t^i}$. The MNIL in nominal term is indexed to the aggregate price level, $P_{t+1}^A MNIL_{t+1}$.

A 2.4 Distributions

A 2.4.1 Joint Distribution of Age Cohorts and Earning Ability

The conditional probability mass function (PMF) of a particular earning ability given age is:

$$\mu_{e|a} = P\left(I_e = e \mid I_a = a\right) = \frac{P\left(I_e = e \text{ and } I_a = a\right)}{P\left(I_a = a\right)} = P\left(I_e = e\right) = \mu_e$$

where the last equality is based on the assumption of independence between age and ability. The joint PMF of age and earning ability is

$$\mu_{ae} = P\left(I_a = a \text{ and } I_e = e\right) = P\left(I_a = a\right) P\left(I_e = e\right) = \mu_a \mu_e = \mu_{ea}.$$

A 2.4.2 Dynamics of EHI Offer

Let $\Lambda^{a,e}_{o\times o}$ denote a time-invariant conditional transition matrix of an EHI offer at work. The term $o \in I_o = \{0,1\}$ where $o_t = 1$ indicates a receipt of an EHI offer at time *t*. At any given time *t*, this offer rate depends on agent's age (*a*) and earning ability (*e*). The time-invariant conditional transition matrix is defined in the following way.

$$\Lambda^{a,e}_{o\times o} = \begin{bmatrix} \lambda^{a,e}_{1,1} & \lambda^{a,e}_{1,0} \\ \lambda^{a,e}_{0,1} & \lambda^{a,e}_{0,0} \end{bmatrix}$$

$$\text{where} \sum_{o_t \in I_o} \lambda^{a,e}_{o_{t-1},o_t} = 1 \quad \forall\, o_{t-1} \in I_o$$

$$\lambda^{a,e}_{o_{t-1},o_t} = P\left(o_t \middle| o_{t-1}, a_t, e_t\right)$$

$$\mu_{a_t=1,e_t,o_t} \text{ given for } e_t \in I_e \text{ and } \mathrm{o}_t \in I_o \text{ at birth.}$$

Applying the probability chain rue, I can rewrite the joint probability into a conditional probability as follows:

$$\mu_{a=1,e,o} = P\left(I_o = o \mid I_a = 1, I_e = e\right) P\left(I_e = e \mid I_a = 1\right) P\left(I_a = 1\right) = \mu_{o|a=1,e}\mu_e\mu_{a=1}$$

Conditional PMF of EHI offer for agents with age $a \in \{1,...,40\}$ and earning ability $e \in I_e$ can be computed as follows:

$$\Lambda_{o|a,e,t-1}\Lambda^{a,e}_{o\times o} = \Lambda_{o|a,e,t}$$

$$\text{where } \Lambda_{o|a,e,t-1} = \left[\mu_{I_o=1|a,e,t-1}, \mu_{I_o=0|a,e,t-1}\right] \text{ and } \sum_{o\in I_o} \mu_{o|a,e,t-1} = 1$$

$$\Lambda_{o|a,e,t} = \left[\mu_{I_o=1|a,e,t}, \mu_{I_o=0|a,e,t}\right] \text{ and } \sum_{o\in I_o} \mu_{o|a,e,t} = 1$$

A 2.4.3 Dynamics of Health Status

Let $\Lambda^{a,e,i}_{h\times h}$ denote a time-invariant conditional transition matrix of health status. It is defined as:

$$\Lambda^{a,e,i}_{h\times h} = \begin{bmatrix} \lambda^{a,e,i}_{EE} & \lambda^{a,e,i}_{EV} & \lambda^{a,e,i}_{EG} & \lambda^{a,e,i}_{EF} & \lambda^{a,e,i}_{EP} \\ \lambda^{a,e,i}_{VE} & \lambda^{a,e,i}_{VV} & \lambda^{a,e,i}_{VG} & \lambda^{a,e,i}_{VF} & \lambda^{a,e,i}_{VP} \\ \lambda^{a,e,i}_{GE} & \lambda^{a,e,i}_{GV} & \lambda^{a,e,i}_{GG} & \lambda^{a,e,i}_{GF} & \lambda^{a,e,i}_{GP} \\ \lambda^{a,e,i}_{FE} & \lambda^{a,e,i}_{FV} & \lambda^{a,e,i}_{FG} & \lambda^{a,e,i}_{FF} & \lambda^{a,e,i}_{FP} \\ \lambda^{a,e,i}_{PE} & \lambda^{a,e,i}_{PV} & \lambda^{a,e,i}_{PG} & \lambda^{a,e,i}_{PF} & \lambda^{a,e,i}_{PP} \end{bmatrix}$$

$$\text{where } \sum_{h_t} \lambda^{a,e,i}_{h_{t-1}h_t} = 1 \quad \forall\, h_{t-1}, h_t \in I_h$$

$$\mu_{a=1,e,i,h} \text{ given for } e \in I_e,\ i \in I_i \text{ and } h \in I_h$$

I define a conditional transition probability of health status as:

$$\lambda^{a,e,i}_{h_{t-1}h_t} = P\left[h_t \mid h_{t-1}, a_t, e_t, i_t \right].$$

Then I compute the conditional PMF of health status for agents with age $a \in \{1,...,40\}$, earning ability $e \in I_e$, and an insurance status $i \in I^Y_i$ based on the conditional transition matrix:

$$\Lambda_{h|a,e,i,t-1} \Lambda^{a,e,i}_{h\times h} = \Lambda_{h|a,e,i,t}$$

$$\text{where } \Lambda_{h|a,e,i,t-1} = \left[\mu_{E|a,e,i,t-1}, \mu_{V|a,e,i,t-1}, \mu_{G|a,e,i,t-1}, \mu_{F|a,e,i,t-1}, \mu_{P|a,e,i,t-1} \right]$$

$$\Lambda_{h|a,e,i,t} = \left[\mu_{E|a,e,i,t}, \mu_{V|a,e,i,t}, \mu_{G|a,e,i,t}, \mu_{F|a,e,i,t}, \mu_{P|a,e,i,t} \right]$$

$$\sum_{h\in I_h} \mu_{h|a,e,i,t-1} = 1 \text{ and } \sum_{h\in I_h} \mu_{h|a,e,i,t} = 1.$$

Figure 2-7 and Figure 2-8 plot simulated conditional distributions of health status based on the Markov process from the expressions above.

A 2.4.4 Dynamics of Medical Care Consumption

The term $\overline{M}^Y_{p,t}$ is an unconditional average of worker's medical care consumption for a percentile $p \in I_p$ at time *t*. It is defined as:

$$\overline{M}^Y_{p,t} = \int_{\underline{m}^Y_{p,t}}^{\overline{m}^Y_{p,t}} m^Y_{p,t} f_{M^Y_{p,t}}\left(m^Y_{p,t}\right) dm^Y_{p,t} \quad \text{where } P\left(\underline{m}^Y_{p,t} < m^Y_{p,t} \le \overline{m}^Y_{p,t}\right) = \int_{\underline{m}^Y_{p,t}}^{\overline{m}^Y_{p,t}} f_{M^Y_{p,t}}\left(m^Y_{p,t}\right) dm^Y_{p,t}.$$

Note that $f_{M_{p,t}^{Y}}\left(m_{p,t}^{Y}\right)$ is the PDF of medical care consumption for workers before discretization. I use $m_{p,t}^{Y}=\left(\underline{m}_{p,t}^{Y},\overline{m}_{p,t}^{Y}\right]$ where $\underline{m}_{p,t}^{Y},\overline{m}_{p,t}^{Y}$ denote a lower and an upper bound of medical care that corresponds to each percentile, $p\in I_p$. Likewise, an unconditional average of retirees' medical care consumption for a percentile $p\in I_p$ is:

$$\overline{M}_{p,t}^{O}=\int_{\underline{m}_{p,t}^{O}}^{\overline{m}_{p,t}^{O}} m_{p,t}^{O} f_{M_{p,t}^{O}}\left(m_{p,t}^{O}\right)dm_{p,t}^{O} \text{ where } P\left(\underline{m}_{p,t}^{O}<m_{p,t}^{O}\le\overline{m}_{p,t}^{O}\right)=\int_{\underline{m}_{p,t}^{O}}^{\overline{m}_{p,t}^{O}} f_{M_{p,t}^{O}}\left(m_{p,t}^{O}\right)dm_{p,t}^{O}.$$

When medical care consumption (m) is discretized, an expected value of m—conditional upon age, earning ability, insurance status, and transition of health status—for workers is expressed as:

$$\begin{aligned} m_t^E\left(h_{t-1},a_t,e_t,i_t,h_t\right) &= E\left[m_t \middle| h_{t-1},a_t,e_t,i_t,h_t\right] \\ &= \sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\dots,40\}}\sum_{e_t\in I_e}\sum_{i_t\in I_i}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\overline{M}_{p,t}^{Y}\mu\left(\overline{M}_{p,t}^{Y}\middle| a_t,e_t,i_t,h_{t-1},h_t\right)\end{aligned}$$

Similarly, an expected value of m conditional upon the same set of state variables for retirees is:

$$\begin{aligned} m_t^E\left(h_{t-1},a_t,e_t,i_t,h_t\right) &= E\left[m_t \middle| h_{t-1},a_t,e_t,i_t,h_t\right] \\ &= \sum_{h_{t-1}\in I_h}\sum_{a_t\in\{1,\dots,40\}}\sum_{e_t\in I_e}\sum_{i_t\in I_i}\sum_{h_t\in I_h}\sum_{p_t\in I_p}\overline{M}_{p,t}^{O}\mu\left(\overline{M}_{p,t}^{O}\middle| a_t,e_t,i_t,h_{t-1},h_t\right)\end{aligned}$$

Figure 2-15 through Figure 2-18 plots conditional distribution of medical care consumption. Distribution of medical care consumption is skewed to the left. Top 10 percentile of workers explain 62 percent of their aggregate medical care consumption.

Likewise, retirees in top 10 percentile account for 50 percent of their total medical care consumption.[57] Figure 2-18 displays the conditional distribution of medical care consumption by transition of health status, plotted separately for workers and retirees.[58] Workers with no change in their health status spend the most, followed by those who experience deterioration of health status. Workers who report their health status being improved explain the smallest fraction of the conditional distributions at all percentile ranks. Machlin and Cohen et al. (2008) report that more than 50 percent of medical expenses for adults in 2005 were explained by those with chronic conditions.[59] The fraction of population with at least one chronic condition increases in age. According to their report, the percentage of adults who consume medical care as a result of their chronic illness ranges from 36.4 percent among young adults (age 18-34) to 91.5 percent of the elderly (age 65 and above).

A 2.5 Data

A 2.5.1 Construction of longitudinal datasets

This study uses Medical Expenditure Panel Survey (MEPS) from 1996 through 2005 as well as National Health Interview Survey (NHIS) from 1995 through 2004. Each MEPS consists of two panels of respondents. Each panel can be linked to the same panel of respondents from a year before or after to create a two-year longitudinal dataset. Taking an advantage of this survey structure, one can create nine two-year longitudinal datasets based on the 1996 through 2005 MEPS. To take a further advantage of sampling structure, this study links NHIS to MEPS. Since the sub-sample of NHIS is included in

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[57] These figures are largely consistent with the data reported by Yu, W. W. and M. T. Ezzati-Rice (2005). Concentration of Health Care Expenditures in the U.S. Civilian Noninstitutionalized Population. Statistical Brief #81. Rockville, MD, Agency for Healthcare Research and Quality.

[58] There are three curves for each group. The area under these three curves add up to one.

[59] This figure is based on the total medical expenses excluding dental care and medical equipment and services. Chronic conditions are defined as "conditions that are expected to last at least one year and result in limitations in self-care, independent living, and social interactions or in the need for ongoing medical intervention." Machlin and Cohen et al. Machlin, S., J. W. Cohen, et al. (2008). Health Care Expenses for Adults with Chronic Conditions. Statistical Brief #203. Rockville, MD, Agency for Healthcare Research and Quality.

the MEPS, one can make either nine three-year longitudinal datasets or nineteen two-year longitudinal datasets by linking these two sources of surveys.

A 2.5.2 Conditional Transition Probabilities of EHI Offer

There are 117 (39 × 3) transition matrices[60] of EHI offer $\Lambda_{o\times o}^{a,e}$ to compute. With the use of sampling weights, I compute conditional frequency distribution from each longitudinal dataset. Then I average them based on the weights from each longitudinal dataset.[61] In addition, I compute the joint probability mass functions (PMF) $\mu_{a_t=1,e_t,o_t}$ for agents with age 1 (actual age of 25) from each survey and average them based on the sampling weights. Given these values, I simulate rates of EHI offer for workers with age $a_t \in \{2,...,40\}$ and earning ability $e_t \in I_e$.

A 2.5.3 Conditional Transition Probabilities of Health Status

I compute 300 conditional transition matrices[62] of health status from 19 two-year longitudinal dataset with the weights provided by the source.

A 2.5.4 Conditional Medical Care Consumption

I first tabulate reported medical care expenditures by percentiles among workers and retirees separately. Then, I compute 7,500 conditional probability mass function (PMF) of medical care consumption, $\mu_{p_t|a_t,e_t,i_t,h_{t-1}\times h_t}$ with the use of sampling weights from MEPS.[63]

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[60] Each worker makes 39 transitions of EHI offer during her working life.

[61] I first compute weights which reflect the size of subsample that computes each conditional probability in such that the structure of transitional matrix averaged over the nine two-year longitudinal datasets is preserved, $\sum_{i\in\{I_i^Y,I_i^O\}} \mu_{i|a,e} = 1$ for $a \in \{2,...,41\}$ and $e \in I_e$.

[62] There are 240 conditional transition matrices for workers, and 60 conditional transition matrices for retirees.

[63] I compute 6000 conditional PMF of medical care consumption $\mu_{p_t|a_t,e_t,i_t,h_{t-1}\times h_t}$ for workers where the number 6000 comes from all combinations of $a_t \in I_a, e_t \in I_e, i_t \in I_i^Y$, and $h_{t-1}\times h_t \in \left(I_h \times I_h\right)$. The remaining 1500 conditional PMF of medical care consumption are for retirees.

A 2.6 Comparison Between MEPS and National Health Expenditures (NHE)

Medical Expenditures Panel Survey (MEPS) provides the estimate for civilian's health care expenditures for the non-institutionalized population. Based on the data from 1996, for example, the estimated total was $548 billion. On the other hand, the personal health care component of the National Health Expenditures in 1996 was $910, accounting for 11.6% of GDP. Much of the expenditure difference arises from the scope between MEPS and NHE rather than from differences in estimates for comparably defined expenditures. (Selden, Levit et al. 2001)[64] They also indicate that the MEPS reports individuals' health expenditures at the time of medical events. The NHE, on the other hand, reports the revenues received by types of establishments.

[64] They argue that four broad adjustments needs to be performed to the NHE data to make it more consistent to the scope of the MEPS. These adjustments include (1) construct service type categories that align more closely with those defined under the MEPS; (2) remove goods and services expenditures from the NHE that are out of scope for the MEPS; (3) remove expenditures associated with people who are not included in the MEPS; and (4) remove provider revenues that are not associated with patient care.

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CHAPTER 3

Medicare Inflation Tax:
Its Implications on the Balanced Growth Path and Welfare

3.1 Introduction

This chapter compares two methods of financing Medicare program. One method is to raise tax rates—both payroll and wage income taxes—to finance excess cost growth of Medicare program. As we all know, the payroll tax finances Medicare Part A. On the other hand, a part of general tax revenue finances Medicare Part B program. Alternatively, the government can lower reimbursement rates of health care providers and implicitly shift the excess cost growth to workers, what is known as cost shifting in health economics literature. In the United States, it is the federal government that determines prices which health care providers charge to Medicare patients. Private payers, on the other hand, pay the prices set by hospitals and physicians. Under this fragmented health-care financing system in the U.S., when the government has a strong incentive to keep the payroll and wage income tax rates fixed, balancing budget for the Medicare program may require cutting the reimbursement rates. In fact, the U.S. has kept Hospital Insurance tax—a component of payroll tax—fixed at 1.45 percent since 1986 while the government expenditures on hospital insurance (Part A) has risen to $182.9 billion in 2005 from $50.4 billion in 1986, an average nominal growth rate of 7.0 percent. Government expenditures on supplementary medical insurance (Part B) has risen to $153.5 billion in 2005 from $27.3 billion in 1986, accounting for a 9.5 percent growth per annum on average in nominal term.[65] Hospital's payment-to-cost ratio on Medicare patients has been less than one for most periods since then. [See Figure 2-10] It indicates that government payments do not meet hospital's cost of providing medical care to Medicare patients.

When the government cuts reimbursement rates of health care providers, its underpayments have a lasting impact on the economy and the well-being of the people. When excess cost growth of medical treatment is accompanied by excess demand growth of retirees' medical care, the Medicare's payment policy has a large implication on the rate of workers' medical-price inflation. The literature of cost-shifting has focused on the price level thus far, but has not paid much attention to the rate of inflation of medical price. This chapter argues that, in a truly dynamic context, hospitals' cost-shifting behavior raises medical price inflation of private payers. When the government decides to finance excess cost growth of Medicare program by higher payroll and wage income taxes, if the government-induced price distortion is present, this study also claims that the pre-existing price distortion raises the rate of workers' medical price inflation. After all, workers face higher rate of medical price inflation and pay the excess cost growth of Medicare program. In this chapter, I distinguish this taxation from the payroll and wage income taxes by calling it a Medicare inflation tax.

When the government chooses to impose this Medicare inflation tax, either knowingly or unknowingly, it creates a redistribution of wealth that is quite different from the one created by higher payroll and wage income taxes. Medicare inflation tax makes workers with "fair" and "poor" health status financially more vulnerable by reducing their wealth. As Medicare inflation tax raises real present discounted value (PDV) of life-time medical expenditures, it has much larger income effect on consumption of goods excluding medical care and more importantly on savings. Uninsured without medical care consumption can avoid paying the Medicare inflation tax. Retirees, on the other hand, receive subsidies in the form of discounted medical-price inflation where retirees' medical price rises by less than the average cost growth of their

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[65] EBRI Databook on Employee Benefits, Chapter 5: Government Mandated Employment-Based and Need-Based Programs. Downloaded from http://www.ebri.org/publications/books/index.cfm?fa=databook.

medical treatment. While their consumption during retirement would be higher than the situation where the government finances excess program cost by payroll and wage income taxes, their savings also decline in the direction of higher Medicare inflation tax. At the new steady state, reductions in savings among workers also lower savings of retirees. At the end, the higher the Medicare inflation tax is, the lower becomes the long-run balanced growth path. Aggregate well-being will not improve by Medicare inflation tax at any levels. Wealth inequality deteriorates as the low- and the middle-income households have higher share of people with "fair" and "poor" health status. When the government explores a way to finance excess cost of Medicare program, they must understand the dynamics of and the consequences of Medicare inflation tax.

This chapter builds a 60-period overlapping generation (OLG) model, following Auerbach and Kotlikoff (1987). This model includes medical care consumption in the household budget constraint, health insurance markets, and health status in the flow utility function. I expand their model by adding Part A and Part B of Medicare program. In addition, my model incorporates labor augmented technological progress. In order to capture Medicare inflation tax and its impact on well-being among workers and retirees, this model includes exogenous price variables. There are three sources of uncertainties: (1) insurance status, (2) health status, and (3) medical care expenditures. Labor endowments are not subject to idiosyncratic shocks. However, agents are subject to idiosyncratic health shocks. As a result, uncertainty on medical expenditures influences consumption-saving decisions over agents' lifecycles. Lifetime employment is assumed. Agents face no mortality until the end of 60th period. There are neither bequests nor inheritances. The model incorporates a large degree of heterogeneity that exists among agents: (1) ages, (2) earning ability, (3) insurance status, (4) health status, and (5) medical care expenditure shocks.

Chapter 3 is organized in the following way. Section 2 provides literature on the subject of cost shifting. Section 3 provides a simple 2-period lifecycle model to illustrate how medical care consumption enters agent's utility maximization problem. Section 4 defines Medicare inflation tax and how government underpayments influence medical-care prices and their rates of inflation. Section 5 lays out a 60-period OLG in detail. Section 6 explains calibration. Section 7 presents numerical results from the dynamic optimization problem defined in section 5. Section 8 performs policy experiments by varying the degree of cost-shifting. I will compare the policy of raising payroll and wage income taxes against the policy of raising Medicare inflation tax. Section 9 concludes this study.

3.2 Literature Review

A number of researchers have extensively studied hospital cost-shifting since early 1980s. In order to show a validity of cost-shifting in real data, Dranove (1988), for example, analyzed how Illinois hospitals responded to Medicaid cutback in payments in early 1980s. He claims that when hospitals' objectives include both output and profits, they raise prices in response to a reduction in Medicaid payment. Using the data from 1981 through 1983, Dranove (1988) empirically identifies hospitals' cost-shifting behavior based on the correlation between changes in private payers' prices and changes in hospitals' profits following a Medicaid payment-cutback. Based on 79 out of 280 hospitals in the state of Illinois then, results from a OLS regression indicates that Illinois hospitals raised private payers' price per admission by $0.15 dollars for every one thousand dollars loss in revenues from Medicaid.[66] Dranove (1988) points out that cost-shifting behaviors may persist when private payers are less sensitive to prices, and hospitals face limited market competition.

As Health Maintenance Organizations (HMOs) widely penetrated in the market and started aggressively negotiating medical prices, hospitals' ability to shift their costs to private payers waned in 1990s. (Clement 1997) The Balanced Budget Act of 1997 put a further constraint to the hospitals' ability to shift their cost in response to the government underpayments. (Dobson, DaVanzo et al. 2006) A shift in balance of powers between health care providers and health plans surfaced in early 2000s. Hospitals and physicians gained a negotiating power in terms of their pricing. (Strunk, Devers et al. 2001) Hospitals have recouped their ability to engage in cost-shifting since then. Their leverage, however, fluctuates over time.

[66] Based on this regression results, a $1.88 million reduction in revenues translates to an increase of $282 per admission. (Dranove, 1988).

The most recent study by Zwanziger and Bamezai (2006) and Kessler (2007) find empirical evidence of cost-shifting in the state of California. Results from Zwanziger and Bamezai (2006), based on the private hospitals' data from 1993 and 2001, indicate that the private payer's price rose by a 0.17 percent and a 0.04 percent in response to a 1 percent reduction in average prices of Medicare and Medicaid, respectively. These estimates imply that underpayments by the government contributed to cost-shifting that explains 12.3 percent of the total increase in private payers' prices between 1997 and 2001. Kessler (2007) uses the hospital-level data from 2000 to 2005 and finds that cost shifting from Medicare and MediCal in state of California. Their cost-shifting explains about 35 percent of the markup pricing imposed on the private payer. On the other hand, cost-shifting from the uninsured is minimal as hospitals often receive revenues from philanthropic donations, charity care, and payments from federal, state, and local programs to compensate the care extended to the uninsured population. (Cogan, Gunn et al. 2007)

Welfare implications of cost-shifting hardly exist in the literature. Rexford (2005) computes efficiency loss due to cost-shifting in a partial equilibrium framework. Based on the Harberger triangle (Harberger 1954) with a price elasticity of demand being -1.0, he estimates that the loss is at most 0.84 percent of private hospital expenditures in the U.S. for 1992. Meyer and Johnson (1983) analyzes issues concerning efficiency and equity under cost-shifting relative to tax financing through payroll and wage income taxes. Imposing no behavioral changes on the part of households in response to changes in medical prices, they claim that cost-shifting impose a higher share of tax burden to low- and middle-income households. Tax financing, on the other hand, shift the burden of financing Medicare and Medicaid programs to higher income households. They claim that it is more equitable in terms of tax paid per income earned if the government uses tax financing instead of cost-shifting.

Literature has so far paid much attention to verify hospital's cost-shifting behavior based on economic theories and empirical evidence. There is little study done on how their behavior impacts households' consumption and savings, thus contributing to the long-term performance of the economy, well-being of the people, and inequality in the nation. This chapter makes an attempt to fill in the gap in this literature. The following section lays out a simple analytical model to address household's behavioral response to changes in medical prices. I will analyze impacts of cost-shifting on the key indicators mentioned above numerically.

3.3 A Simple Model – Impact of Cost-shifting on Consumption and Saving

3.3.1 Agents

Before introducing a 60- period overlapping generations (OLG) model in the following section, I use a simple two-period lifecycle model to address how a government-induced price distortion in medical care affects households' consumption and saving behaviors. This model assumes that individuals live exactly two periods. There is no population growth in this economy. They all work during the first period of their life and earn a fixed real wage *w*. They retire at the beginning of the second period. There is no Social Security program. They consume two goods: commodities denoted by *C*, and medical care denoted by *M*. In order to consume one unit of commodity, individuals must pay P^C, the average cost of production. The average cost of providing medical care is P^M. Workers and retirees pay different prices for medical care, denoted by $P_t^{M^Y}$ and $P_t^{M^O}$, respectively. The economy-wide price is denoted by P^A, which is a geometric average of the two prices,

$$P_t^A = \left(P_t^C\right)^{1-\vartheta}\left(P_t^M\right)^{\vartheta}.$$

[3-1]

Nominal wage is indexed to this overall price.

Let C_t^Y and C_t^O denote the consumption of commodities in period *t* for the young and the old, respectively. Consumption of medical care is exogenously determined and is denoted by M_t^Y and M_t^O. This simple model assumes that medical-care consumption stays at some fixed level over time:

$$M_t^Y = M_{t+s}^Y \text{ and } M_t^O = M_{t+s}^O \quad \forall s.$$

[3-2]

The government runs a Medicare program which subsidizes the cost of retirees' medical cost by ξ percent. This program is financed by workers' wage income tax. Individuals born at t maximize the following life-time utility U_t subject to the budget constraint:

$$\underset{C_t^Y, C_{t+1}^O}{Max} U_t = \ln C_t^Y + \frac{1}{1+\rho} \ln C_{t+1}^O$$

[3-3]

$$subject\ to\ P_t^C C_t^Y + \frac{P_{t+1}^C C_{t+1}^O}{1+i} + P_t^{M^Y} M_t^Y + \frac{\xi P_{t+1}^{M^O} M_{t+1}^O}{1+i} = (1-\tau) P_t^A w_t$$

[3-4]

Consumption of medical care does not yield any utility. I use ρ to denote the discount rate. The nominal interest rate is denoted by i such that we have the following relationship, $(1+i) = (1+r)(1+\pi)$. I use r to denote the real interest rate. The solution to the problem above is:

$$C_t^Y = \frac{(1-\tau) w_t - F_{t,t+1}^R}{R_t^C \left\{ 1 + \left(\frac{R_{t+1}^C}{R_t^C} \right)^{1-\frac{1}{\gamma}} (1+r)^{\frac{1}{\gamma}-1} (1+\rho)^{-\frac{1}{\gamma}} \right\}}$$

[3-5]

$$C_{t+1}^O = \frac{(1-\tau) w_t - F_{t,t+1}^R}{\left(\frac{R_{t+1}^C}{1+r} \right) \left\{ 1 + \left(\frac{R_t^C}{R_{t+1}^C} \right)^{1-\frac{1}{\gamma}} (1+\rho)^{\frac{1}{\gamma}} (1+r)^{1-\frac{1}{\gamma}} \right\}}$$

[3-6]

Saving in the first period is:

$$s_t = (1-\tau) w_t - \frac{(1-\tau) w_t - F_{t,t+1}^R}{\left\{ 1 + \left(\frac{R_{t+1}^C}{R_t^C} \right)^{1-\frac{1}{\gamma}} (1+r)^{\frac{1}{\gamma}-1} (1+\rho)^{-\frac{1}{\gamma}} \right\}} - R_t^M M_t^Y$$

[3-7]

The Euler equation is:

$$\frac{C_{t+1}^{O}}{C_t^{Y}}=\left(\left(\frac{R_t^{C}}{R_{t+1}^{C}}\right)\left(\frac{1+r}{1+\rho}\right)\right)^{\frac{1}{\gamma}}$$

[3-8]

Relative prices are expressed by R_t^C and R_t^M and take the following form:

$$R_t^C=\frac{P_t^C}{P_t^A}=\left(\frac{P_t^C}{P_t^M}\right)^{\vartheta} \text{ and } R_t^M=\frac{P_t^M}{P_t^A}=\left(\frac{P_t^M}{P_t^C}\right)^{1-\vartheta}$$

[3-9]

Real present discounted value (PDV) of life-time medical expenditures is denoted by $F_{t,t+1}^{R}$:

$$F_{t,t+1}^{R}=\frac{P_t^{M^Y}}{P_t^A}M_t^Y+\frac{\xi P_{t+1}^{M^O}M_{t+1}^{O}}{P_{t+1}^{A}\left(1+r\right)}$$

[3-10]

3.3.2 Government

The government must satisfy the following condition to balance the budget for Medicare program at every period *t*:

$$\left(1-\xi\right)P_t^{M^O}M_t^O=\tau P_t^A w_t$$

[3-11]

Given zero population growth, the model normalizes the population, $N_t^Y=N_t^O=1$.[67]

Under the prospective payment system (PPS), the government determines the price of medical care $\left(P_t^{M^O}\right)$ when hospitals treat retirees. This model assumes that the

[67] Since medical care demand and wage grows by the same rate, the tax rate does not change over time as long as medical price of retirees and hospital's average cost grow by the same rate.

reimbursement rate is $\omega \in (0,1)$, and the price set by the government does not cover hospital's average cost of treating Medicare patients.

$$P_t^{M^O} = \omega AC_t^M \text{ where } \omega \in (0,1).$$

[3-12]

While taking the price $\left(P_t^{M^O}\right)$ set by the government as given, hospitals must make zero profits to stay in business. Since medical-care demand is exogenously given, hospitals set medical-care price for workers $P_t^{M^Y}$ in period *t* by solving the following problem.

$$0 = \max_{P_t^{M^Y}} \left\{ P_t^{M^Y} M_t^Y + P_t^{M^O} M_t^O - AC_t^M \left(M_t^Y + M_t^O \right) \right\}$$

[3-13]

subject to

$$P_t^{M^Y} M_t^Y + P_t^{M^O} M_t^O = P_t^M M_t$$

$$M_t = M_t^Y + M_t^O$$

The solution to the problem above gives:

$$P_t^M = AC_t^M$$

$$P_t^{M^Y} = \frac{AC_t^M \left\{ \left(1-\omega_t\right) M_t^O + M_t^Y \right\}}{M_t^Y} = \frac{P_t^M \left\{ \left(1-\omega_t\right) M_t^O + M_t^Y \right\}}{M_t^Y} \neq P_t^{M^O}$$

[3-14]

The government-induced price distortion by [3-12] raises the price for workers above the average cost of treating private payers, $P_t^{M^Y} > P_t^M = AC_t^M$.

3.3.3 Relative Price Matters

Consumption of medical care goods that does not add to one's utility, however, controls consumption and saving behaviors of agents. When workers' medical price rises relative to the commodity price in period *t*, lower relative price R_t^C raises consumption of commodities through the substitution effect. At the same time, higher medical price raises real PDV of life-time medical expenditures in [3-10]. As a result, the income effect works in the opposite direction to reduce consumption of commodities in [3-5]. When retiree's medical price goes down relative to the commodity price in period *t+1*, the opposite effect takes a place. Higher relative price R_{t+1}^{C} lowers consumption of commodities through the substitution effect in period *t+1*. As the real PDV of life-time medical expenditures declines, the income effect raises the commodity consumption. The net effect must take into account both the substitution and the income effects.

When the relative price changes in one period, it also affects intertemporal consumption of commodities, according to the Euler equation [3-8]. In particular, when the relative price R_{t}^{C} declines as a result of higher P_{t}^{M}, agents consume commodities more in period *t* than in period *t+1*. Savings declines as a result.

3.3.4 Consumption and Saving Behavior under Cost-shifting

When medical-care cost rises at hospitals, it leads to higher cost of Medicare program. One way to finance the program is to raise wage income tax in this two-period model. Alternatively, the government lowers the reimbursement rate ω [3-12] in lieu of raising the tax rate [3-11]. When the government raises the tax rate, the income effect lowers the commodity consumption in both periods. When the government lowers the reimbursement rate, given exogenous medical demand, hospitals must fill their revenue shortfalls by raising prices for workers to break even. This cost-shifting behavior raises real PDV of life-time medical expenditures, which creates the income effect that works to reduce commodity consumption in both periods. Section 6 compares the magnitude of these income effects on consumption and saving between these two policies in a general equilibrium framework.

3.4 Medicare Inflation Tax

When the government that confronts excess cost growth of Medicare program chooses to lower reimbursement rates, it's decision inevitably leads to hospital's revenue shortfall. The government underpayment raises workers' medical price since hospitals must break even to stay in business. Given that medical demand is perfectly inelastic in this model, the incidence of Medicare cost falls onto the workers' shoulder at the end. Hence workers pay Medicare inflation tax. The government must understand the dynamics of Medicare inflation tax for financing excess cost growth of Medicare program.

3.4.1 Static and Dynamic Cost-shifting

This model assumes that all hospitals take the Medicare's assignment and do not reject any Medicare patients.[68] Even under the assumption of perfect competition with free entry and exit in the long run, hospitals must apply a markup pricing to workers in order to break-even when government reimbursements do not adequately cover the average cost of providing medical care to Medicare patients. Workers and retirees face different prices for the same treatment received as hospitals engage in static cost shifting—a price discrimination represented by $P_t^{M^Y} \neq P_t^{M^O}$ [3-12][3-13][3-14].[69]

Morrisey (1994) distinguishes dynamic cost shifting from static cost shifting. He argues that a provider charges other payers more (less) in response to charging less (more) to one payer. He claims that dynamic cost shifting can occur when a hospital has a sufficient unexploited market power.[70] Yet, traditional economic assumptions do not lead to dynamic cost shifting, Morrisey argues. If hospitals raise their prices against one category payers in response to charging less to other category of payers, it will lower its profit as the volume of sale will be reduced. Based on the traditional economic theory, a profit maximizing hospital should lower the price instead for one payer in response to charging less to the other payer. When a hospital faces a downward sloping demand curve, critics argue that hospital's behavior characterized by dynamic cost shifting is to

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[68] When health care providers accept a Medicare's assignment under Part B, they agree to take the Medicare-approved amount as the total payment for the serviced provided to Medicare patients. At the same time, they bill the patients based on the approved rate as assigned. When health care providers do not accept a Medicare's assignment, they can charge Medicare patients up to a 15 percent over the approved rate (excess charge).

[69] A price discrimination defined in the economic theory, however, does not fully capture the reasoning behind a static cost shifting by a hospital, according to Morrisey. A firm with a sufficient market power can impose a price discrimination in such to become better off under the economic theory of price discrimination. Morrisey claims that a price discrimination by a hospital, however, may not make the hospital better off when one group of payer pays less than the others.

[70] Morrisey (1994) provides necessary conditions for unexploited market power to exist. Unexploited market power essentially means that there is a room for a hospital to charge higher prices to one category of payer if it chose to do so. The necessary conditions include that (1) the hospital's decision maker must have an objective other than profit maximization; and (2) the hospital must value the private payers whom the hospital shift the cost against.

maximize the revenue not its profits. When hospitals' objectives include output and profits, Dranove (1988) shows that cost-shifting can prevail when private payers are less sensitive to prices, and hospitals face limited market competition. Non-profit hospitals, being widely spread in the nation, may have objectives besides a motive of profit maximization when they provide medical care. This study assumes that medical care demand is perfectly inelastic to prices as the demand is exogenously determined by nature. Hospitals must practice cost-shifting in order to break even when the government makes underpayments.

3.4.2 Medical Price and Its Inflation under Dynamic Cost-shifting

3.4.2.1 Pre-existing Price Distortion is Costly

Suppose that medical demand by workers and by retirees grow by the factor g_Z, the growth rate of real wage. The average cost at hospitals grows by the rate π^M. I also assume that the population grows by the factor g_N. Starting at period *t+1*, hospital experience *s* periods of excess cost growth by the factor $\varepsilon^M > 0$. At the same time, retirees' medical demand grows by an additional rate of $\varepsilon^Z > 0$. Hospital's average cost of providing medical care at time *t+s* is

$$P_{t+s}^M = \left(1+\pi_t^M + \varepsilon^M\right)^s P_t^M .$$

[3-15]

Aggregate medical demand among retirees in period *t+s* is:

$$M_{t+s}^O = \left[\left(1+g_Z+\varepsilon^Z\right)\left(1+g_N\right)\right]^s M_t^O .$$

[3-16]

Proposition 1: When retirees' medical demand grows faster than workers' medical demand, pre-existing price distortion $P_t^{M^Y} > AC_t^M > P_t^{M^O}$ in health care market causes workers' medical price inflation to be higher than the growth rate of hospital's average cost. [See Appendix A 3.1 for proof.]

Workers' medical price in period *t+s* is expressed as:

$$P_{t+s}^{M^Y} = \left(1+\pi+\varepsilon^M\right) P_{t+s-1}^{M^Y} \left(1+T_{t+s-1}^{M^Y}\right) \quad [3\text{-}17]$$

While retirees medical price grows by the factor $\left(1+\pi+\varepsilon^M\right)$, workers' medical price grows by the factor $\left(1+\pi+\varepsilon^M\right)\left(1+T_{t+s-1}^{M^Y}\right)$ where $T_{t+s-1}^{M^Y} > 0$. Even when the government chooses to finance excess cost growth of Medicare program by wage income tax, the government induced price distortion that pre-existed will increase workers' medical price inflation higher than hospital's average cost growth, raising workers' real PDV of life-time medical expenditures.

Proposition 2: Workers face accelerating medical-price inflation when retirees' medical demand grows faster than workers' medical demand under the pre-existing price distortion in health care market. [See Appendix A 3.2 for proof.]

Based on the expression [3-17], we have $T_{t+s-1}^{M^Y} > T_{t+s-2}^{M^Y}$. In the two-period lifecycle model, agents devote a single period for working. Acceleration of medical price inflation does not affect their consumption and saving behaviors. When agents work more than one period, acceleration of medical price inflation means that their real PDV of lifetime medical expenditures keeps going up as they continue to work over their lives. Under the government-induced price distortion that pre-exists, faster growth of retirees' medical demand becomes increasingly costly to workers.

3.4.2.2 Lowering Reimbursement Rate is More Costly

When the government chooses to cut the reimbursement rate in lieu of raising wage income tax rate, given a perfectly price-inelastic medical demand, hospitals engage in a dynamic cost-shifting to break even. Suppose that the new reimbursement rate is ω_{t+s} after the government cuts the reimbursement rate by Δ_{t+s}^{ω} percent. We have:

$$\omega_{t+s} = \left(1-\Delta^{\omega}_{t+s}\right)\omega_t \; > 0$$

[3-18]

Workers and retirees face the following prices[71] for their medical care in period *t+s*:

(A) Workers:

$$\begin{aligned}\left(P^{M^Y}_{t+s}\right)^{C/S} &= P^{M}_{t+s}\left\{\left(1-\left(1-\Delta^{\omega}_{t+s}\right)\omega_t\right)\frac{M^{O}_{t+s}}{M^{Y}_{t+s}}+1\right\} \\ &= \left(1+\pi+\varepsilon^{M}\right)\left(P^{M^Y}_{t+s-1}\right)^{C/S}\left\{1+\left(T^{M^Y}_{t+s-1}\right)^{C/S}\right\}\end{aligned}$$

[3-19]

$$\text{where } \left(T^{M^Y}_{t+s-1}\right)^{C/S} = \frac{\left\{1-\left(1-\Delta^{\omega}_{t+s}\right)\omega_t\right\}\left(\dfrac{1+g_Z+\varepsilon^{Z}}{1+g_Z}\right)^{s}\left(\dfrac{M^{O}_{t}}{M^{Y}_{t}}\right)+1}{\left\{1-\left(1-\Delta^{\omega}_{t+s-1}\right)\omega_t\right\}\left(\dfrac{1+g_Z+\varepsilon^{Z}}{1+g_Z}\right)^{s-1}\left(\dfrac{M^{O}_{t}}{M^{Y}_{t}}\right)+1} - 1 > 0$$

(B) Retirees:

$$\begin{aligned}\left(P^{M^O}_{t+s}\right)^{C/S} &= \omega_{t+s}P^{M}_{t+s} \\ &= \left(1-\Delta^{\omega}_{t+s}\right)\omega_t\left(1+\pi+\varepsilon^{M}\right)^{s}P^{M}_{t} \\ &= \left(1+\pi+\varepsilon^{M}\right)\left(P^{M^O}_{t+s-1}\right)^{C/S}\left\{1-\left(T^{M^O}_{t+s-1}\right)^{C/S}\right\}\end{aligned}$$

[3-20]

$$\text{where } \left(T^{M^O}_{t+s-1}\right)^{C/S} = \frac{\Delta^{\omega}_{t+s}-\Delta^{\omega}_{t+s-1}}{1-\Delta^{\omega}_{t+s-1}} > 0 \quad \text{since } \Delta^{\omega}_{t+s} > \Delta^{\omega}_{t+s-1}.$$

$$\Delta^{\omega}_{t+s} = \alpha\left\{1-\left(\frac{(1+\pi)(1+g_Z)}{\left(1+\pi+\varepsilon^{M}\right)\left(1+g_Z+\varepsilon^{Z}\right)}\right)^{s}\right\} \text{ where } \Delta^{\omega}_{t+s}(\alpha=0)=0$$

[3-21]

[71] See Appendix A 3.3 for derivations.

Note that the government can choose how much they cut their reimbursement rate to hospitals by choosing the parameter $\alpha \in (0,1)$. When $\alpha = 1$, the government makes underpayment by 100 percent that equals total extra Medicare cost defined as:

$$\mathrm{E}_{t+s}\left(\varepsilon^M, \varepsilon^Z\right) = \left\{\left(1+\pi+\varepsilon^M\right)^s \left(1+g_Z+\varepsilon^Z\right)^s - \left(1+\pi\right)^s \left(1+g_Z\right)^s\right\}\left(1-\xi\right) P_t^{M^O} M_t^O .$$

When $\alpha = 0$, the government makes zero additional underpayment. The government raises the wage income tax to finance the extra Medicare cost $\mathrm{E}_{t+s}\left(\varepsilon^M, \varepsilon^Z\right)$. Higher the percent of cost shifting $\alpha \in (0,1)$, the higher becomes the government's cut in the reimbursement rate Δ_{t+s}^{ω} where $\partial \Delta_{t+s}^{\omega} / \partial \alpha > 0$. From the expression [3-17], the medical price faced by workers $\left(P_{t+s}^{M^Y}\right)^{C/S}$ rises, $\partial \left(P_{t+s}^{M^Y}\right)^{C/S} \Big/ \partial \alpha > 0$. On the other hand, the larger cut in the reimbursement rate means $\partial \left(P_{t+s}^{M^O}\right)^{C/S} \Big/ \partial \alpha < 0$ for retirees. [See the expression [3-20]]. Lower reimbursement rate to hospitals reduces retirees' medical price inflation.

3.4.3 Medicare Inflation Tax and Subsidy

When the average cost at hospital grow in excess by ε^M, in the absence of government-induced price distortion in health care sector, workers face medical price inflation of $\left(1+\pi+\varepsilon^M\right)$. With the price distortion, workers' medical price grows by the factor $\left(1+\pi+\varepsilon^M\right)\left(1+T_{t+s-1}^{M^Y}\right)$ based on [3-17].

Proposition 3: The larger the cut in the reimbursement rate, the higher becomes the medical price paid workers. (Dynamic cost shifting) In addition, workers' medical price inflation is higher, the larger becomes the cut. [See Appendix A 3.4 for proof.]

Definition 1: Medicare inflation tax is the rate of workers' medical price inflation in excess of cost inflation of medical care at hospitals, and is denoted by $T_{t+s}^{M^Y}$.

Definition 2: Medicare inflation subsidy is the rate of retirees' medical price discount below the cost inflation of medical care at hospitals, and is denoted by $T_{t+s}^{M^O}$.

Corollary 1: When government-induced price distortion exists, faster growth of retirees' medical demand raises Medicare inflation tax. Similarly, higher percentage of cost shifting raises Medicare inflation tax.

Corollary 2: When government-induced price distortion exists, faster growth of retirees' medical demand raises subsidies for retirees. Similarly, higher percentage of cost shifting raises their subsidies as they face lower medical price inflation..

It has been argued that a dynamic cost shifting raises private payers' price level. In a truly dynamic context, however, the cost shifting resulting from government underpayments raises private payers' medical price inflation. Thus, workers pay high Medicare inflation tax in the presence of excess cost growth at hospitals with retirees' excess demand growth outpacing workers' medical demand growth.

3.5 A Stochastic Overlapping Generations Model

This chapter follows the basic setup of the stochastic overlapping generations (OLG) model explained in Chapter 2. Following subsections highlight some changes that I applied to the model from the previous chapter.

3.5.1 Agents

There are three sources of uncertainties. First, an insurance status is dictated by nature based on a conditional probability of age and earning ability. Agents no longer endogenously choose to purchase health insurance. Second, even when agents purchase health insurance, their health status is subject to an uninsurable risk. Medical treatment cannot always restore agents' health no matter how much they spend for medical care. Third, medical care expenditures pose a financial risk to workers and retirees. There are, however, no risks associated with their life span and employment status. Labor endowments are not subject to any idiosyncratic shocks.

3.5.1.1 Insurance Status (I_i)

There are two categories of insurance status at any given age. Workers face the following insurance status:

$$I_i^Y = \left\{ \text{Insured}\left(EHI\right), \text{Uninsured}\left(UNI\right) \right\}$$

[3-22]

When agents retire, they must purchase Medicare Part B medical insurance. All retirees receive Medicare Part A hospital insurance without paying any premium. Nature sorts retirees into two categories of insurance status at the beginning of retirement based on their earning ability and health status:

$$I_i^O = \left\{ \text{Medicare plus supplement}\left(MCS\right), \text{Medicare only}\left(MCO\right) \right\}$$

[3-23]

3.5.1.2 Consumption-Saving Decision

As nature draws a health shock, it determines agent's demand for medical care. Then agents make their consumption-saving decisions. They consume two kinds of goods: (1) commodities and (2) medical care. I use c to denote consumption of commodities and m to denote consumption of medical care at an individual level. Since the level of medical care consumption m is determined exogenously, agents decide the level of commodity consumption c to maximize expected lifetime utility. Agents also obtain utility from health status (h_t) which nature assigns at every period. Medical care consumption itself will not directly provide any utility. The expected lifetime utility which each agent maximizes is:

$$\underset{c}{Max}\ E_{t=1}\left[\sum_{t=1}^{60} \beta^{t-1} U\left(c_t, h_t\right)\right]$$

[3-24]

where β is a discount factor, and a subscript t indicates age in this expression.

3.5.1.2.1 Flow Utility Function

A flow utility function is defined as follows:

$$U\left(c_{a,t}, h_{a,t}\right) = \frac{\left(c_{a,t}\right)^{1-\gamma^c}}{1-\gamma^c} + \frac{\left(\eta_t h_{a,t}\right)^{1-\gamma^h}}{1-\gamma^h}$$

$$\text{where } \eta_t = \left(1+g_z\right)^{t-1}\eta_0 \qquad [3\text{-}25]$$

A factor γ^c measures a coefficient of relative risk aversion (CRRA) with respect to the consumption of commodity goods. Its reciprocal becomes a factor of intertemporal substitution. A factor γ^H measures a coefficient of relative risk aversion with respect to agent's own health status. The factor η_t measures the relative importance of health status over consumption of commodities in terms of utility. As income per capita grows by the rate of labor augmented technological progress (g_z) over time, commodity consumption per capita grows by the same rate. I impose a condition that the factor η_t also grows by the same rate as the consumption per capita. Marginal utility of health status rises over time at the same rate as the marginal utility of consumption over time. Although the flow utility function is defined additively separable over consumption of commodities and health status, the ratio of the two marginal utilities—the marginal rate of substitution—remains constant over time for an agent with a given profile.[72]

3.5.1.2.2 Budget Constraints

3.5.1.2.2.1 Working Generations

The budget constraint is expressed in nominal terms.[73] Each worker supplies a fixed number of hours $\bar{l}$. The term $z_{a,e,t}$ denotes worker's labor efficiency which is conditional on age and earning ability. The real interest rate is denoted by r_t. The term

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[72] A profile is defined by age, earning ability, an EHI offer, insurance status, health status, medical care consumption, and asset level.

[73] A worker's budget constraint in real value is obtained by dividing through the expression [2-19] by the overall CPI, P_t^A.

π_t^A is the change in overall price level P^A. The nominal savings with interest accrued from the previous period is expressed by $\left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i$. The term $MEXP_t^Y$ accounts for medical expenditures and the cost of health insurance, and its amount depends on worker's insurance status (*i*).

$$P_t^C c_{a,t} + MEXP_t^Y + P_t^A k_{a,t+1}^i \le \left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i + \left(1-\tau_t^f-\tau_t^{PAY}\right)P_t^A w_t z_{a,e,t}\bar{l} \qquad [3\text{-}26]$$

$$k_{0,t}^i = 0 \textit{ is given.}$$
$$\tau_t^f = \tau_t^{fB} + \tau_t^{fMN}$$
$$\tau_t^{PAY} = \tau_t^{SS} + \tau_t^{HI}$$

where the term $MEXP_t^Y$ takes:

a) $\left(1-\tau_t^f\right)\left(1-\xi_t^{EHI}\right)P_t^{M^Y}\Omega_t^{EHI} + \sigma_t^{EHI}P_t^{M^Y}m_t$ for workers with an EHI, or

b) $P_t^{M^Y}m_t$ for workers without insurance (UNI)

When workers purchase an EHI contract, they pay a fraction $\left(1-\xi_t^{EHI}\right)$ of the premium $P_t^{M^Y}\Omega_t^{EHI}$. In addition, the income tax exclusion rule is applied to their contribution. As a result, the tax price of health insurance premium is $\left(1-\tau_t^f\right)\left(1-\xi_t^{EHI}\right)P_t^{M^Y}\Omega_t^{EHI}$. Out-of-pocket medical expenditures are denoted by $\sigma_t^{EHI}P_t^{M^Y}m_t$ for EHI policy holders [74] Uninsured workers must pay the full price of medical care $P_t^{M^Y}m_t$.

3.5.1.2.2.2 Retired Generations

Workers retire at the beginning of the 41st period and collect their Social Security benefits $P_t^A b_{a,t}$ through the end of their life at 60. Retirement is exogenously determined. Upon retirement, they all join Medicare Part A and Part B programs. The premium of Medicare Part B is determined by the government. The budget constraint of retirees in nominal value is:

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[74] In essence, the term σ is a coverage rate which is a function of deductibles, co-pay, coinsurance rates, and medical care expenditures.

$$P_t^C c_{a,t} + MEXP_t^O + P_t^A k_{a,t+1}^i \le \left(1+r_t\right)\left(1+\pi_t^A\right)P_{t-1}^A k_{a,t}^i + \left(1-\tau_t^f\right)P_t^A b_{a,e,t}$$

$$k_{60,t+1}^i = 0 \textit{ is given.} \qquad [3\text{-}27]$$

where the term $MEXP^O$ takes:

a) $\left(1-\tau_t^f\right)P_t^{M^O}\Omega_t^{MC} + P_t^{M^O}\Omega_t^{MCS} + \sigma_{(A),t}^{MCS}P_t^{M^O}m_{(A),t} + \sigma_{(B),t}^{MCS}P_t^{M^O}m_{(B),t}$ for retirees with a supplemental insurance, or

b) $\left(1-\tau_t^f\right)P_t^{M^O}\Omega_t^{MC} + \sigma_{(A),t}^{MCO}P_t^{M^O}m_{(A),t} + \sigma_{(B),t}^{MCO}P_t^{M^O}m_{(B),t}$ for retirees with Medicare only.

At the end of life, agents leave no assets behind (zero bequests), $k_{60,t+1}^i = 0$. Retirees' contribution toward Part B health insurance premium is directly deducted from their Social Security benefits so that the tax price of Medicare Part B premium is $\left(1-\tau_t^f\right)P_t^{M^O}\Omega_t^{MC}$.

3.5.1.3 Timing of Events and Decisions

At the beginning of each period *t*, agents know their heath status h_{t-1}. Other state variables known at that time includes age a_t, earning ability e_t, and the amount of asset holding k_{t-1}^i. Nature draws an insurance status of agents and draws a health shock. This shock determines the level of medical-care consumption m_t and agents' new health status h_t. Once m_t and h_t are realized, agents make a consumption-saving decision at time *t*.

3.5.1.4 Bellman Equations to Solve Lifecycle Problems

Agents maximize their expected lifetime utility defined by the expressions [3-24][3-25] subject to the budget constraints [3-26][3-27]. Given the prices $\left\{P_t^A, P_t^C, P_t^M, P_t^{M^Y}, P_t^{M^O}, w_t, r_t\right\}$, the firm's EHI benefit program $\left\{\sigma_t^{EHI}, \xi_t^{EHI}, \Omega_t^{EHI}\right\}$, the PAYGO Social Security program $\left\{b_t, \tau_t^{SS}\right\}$, the Medicare program $\left\{\tau_t^{HI}, \tau_t^{fB}, \sigma_{(A),t}^{MCO}, \sigma_{(B),t}^{MCO}, \sigma_{(A),t}^{MCS}, \sigma_{(B),t}^{MCS}, \Omega_t^{MC}\right\}$, the Medicare supplemental insurance $\left\{\Omega_t^{MCS}\right\}$, and the "Medically Needy" program $\left\{\tau_t^{fMN}, MNIL_t^{DSH}\right\}$, workers make an optimal consumption-saving decision by solving the following Bellman equation:

$$V\left(\Theta_t, i_t, h_t, m_t\right) = \max_{c_t}\left(u\left(c_t, h_t\right) + \beta \mathrm{E}\left(V'\left(\Theta', i', h', m' \middle| \Theta\right)\right)\right)$$

[3-28]

subject to [3-26][3-27].

where $\Theta_t = \left(a_t, e_t, h_{t-1}, k_t^i\right)$. The solution to the problem [3-28] gives us the following optimal saving and consumption decision rules[75]:

$$k_{t+1}^i\left(\Theta_t, i_t, h_t, m_t\right) \text{ and } c_t\left(k_{t+1}^i\left(\Theta_t, i_t, h_t, m_t\right)\right).$$

[3-29]

3.5.2 Insurance Company

The representative insurance company underwrites two insurance policies. One is the group health insurance policy, namely employer-sponsored health insurance (EHI) benefit. The other policy is a supplemental insurance for Medicare enrollees, denoted by MCS.

3.5.2.1 Employer-sponsored Health Insurance (EHI)

The representative insurance company takes the price of medical care $P_t^{M^Y}$ for workers, the synthetic coinsurance rate $\sigma_t^{EHI}(m)$ paid by EHI holders, and medical care demand (m) as given. The joint distribution $\mu_t\left(a, e, i = EHI, h \times h, m\right)$ is know to the insurer. Under the assumption of zero loadings[76], the insurance company sets the health insurance premium Ω_t^{EHI} to break even.

$$\Omega_t^{EHI} = \Omega^{EHI}\left(1 - \sigma_t^{EHI}(m), P_t^{M^Y}, m_t, q_t^{EHI}, \mu_t\left(a, e, i = EHI, h \times h, m\right)\right)$$

[3-30]

The synthetic coinsurance rate $\sigma_t^{EHI}(m)$ negatively depends on the level of medical care consumption.

[75] Consumption floor is set at the 10 percent of the poverty threshold level.
[76] The representative insurance company takes no commissions and fees for transactions.

3.5.2.2 A Private Supplemental Coverage for Retirees

The representative insurance company also offers a supplemental coverage (i.e., Medigap) to retirees. Upon retirement, nature sorts retirees into two categories of insurance status based on their earning ability and health status. Those with Medicare plus a supplemental coverage pay an additional premium to get an extra coverage. The supplemental coverage lowers out-of-pocket medical expenditures. Given the synthetic coinsurance rates $\sigma_{(A),p}^{MCS}$ and $\sigma_{(B),p}^{MCS}$ for Medicare Part A and Part B, the insurer covers $\left(1-\upsilon_{(A),p}^{MCS}\right)$ and $\left(1-\upsilon_{(B),p}^{MCS}\right)$ for respective medical care. The insurer determines the premium of supplemental coverage Ω^{MCS} to break even.

$$\Omega^{MCS}=\Omega^{MCS}\left(1-\upsilon_{(A),p}^{MCS},1-\upsilon_{(B),p}^{MCS},1-\sigma_{(A),p}^{MCS},1-\sigma_{(B),p}^{MCS},\chi_p,P_t^{M^O},m_t,\mu_t\left(a,e,i=MCS,h\times h,m\right)\right)$$

[3-31]

3.5.3 Government

3.5.3.1 Social Security Program

The government runs a pay-as-you-go (PAYGO) Social Security program. It determines the Social Security tax rate τ_t^{SS} to balance its budget while taking the real Social Security benefits $\left(b_t\right)$ and tax base $\left(TAXBASE_t^{SS}\right)$ as given.

$$\tau_t^{SS}=\tau^{SS}\left(b_t,TAXBASE_t^{SS}\right)$$

[3-32]

$$\text{where } b_t=b\left(a,e,P_J^A,w_J,z_J\left(a,e\right),\theta\right)$$

$$TAXBASE_t^{SS}=TAXBASE\left(P_t^A,w_t,c_t^{EHI},z_t\left(a,e\right),\bar{l},\mu\left(a,e\right)\right).$$

The real Social Security benefits are computed based on the average indexed monthly earnings (AIME). [77]

[77] The computation of AIME follows the description given by the US Social Security Administration at: http://www.ssa.gov/OACT/COLA/Benefits.html#aime.

The constant earnings replacement rate θ is applied.[78] The time subscript J in [3-32] denotes multi periods. The government applies the cost-of-living-adjustment (COLA) to maintain a purchasing power of retirees. The tax base depends on the wage rate, the marginal cost of employer-sponsored health insurance (EHI), labor endowments, labor supply in hours, and joint distribution of age and earning groups. Since firms can deduct their total cost of EHI provision from the payroll tax base (payroll tax exclusion rule), the marginal cost of EHI provision c_t^{EHI} critically controls the size of Social Security tax base.

3.5.3.2 Medicare Program

3.5.3.2.1 Hospital Insurance – Part A

The government runs a Medicare program for retirees. The program consists of two parts: Part A and Part B. Part A is an entitlement program for a hospital insurance that covers inpatient hospital services, care in skilled nursing facilities, hospice and home health care. Medicare Part A program is financed by a Hospital Insurance (HI) tax, one of the two components of the payroll tax which is paid by firms and workers equally. Upon retirement at age 41 (actual age of 65), all retirees join Part A. They must pay coinsurance for care provided under Part A program. In order to satisfy the balanced budget condition, the government determines the hospital insurance tax rate τ_t^{HI} which is computed in the following way:

$$\tau_t^{HI} = \tau^{HI}\left(P_t^{M^O}, M_{(A),t}^{G}, 1-\sigma_{(A)}^{MCS}(m,), 1-\sigma_{(A)}^{MCO}(m,), \upsilon_{(A),p}^{MCS}, TAXBASE_t^{HI}\right)$$
$$\text{where } M_{(A),t}^{G} = M_{(A)}^{G}\left(m, \chi(m), \mu_t\left(m \middle| a,e,i,h\times h\right)\right)$$
$$TAXBASE_t^{HI} = TAXBASE_t^{SS}. \qquad [3\text{-}33]$$

[78] I do not apply the primary insurance amount (PIA) formula. Instead, I simply use an earning replacement rate θ_t. Hence regressivity applied to Social Security benefit calculation is left out of the model.

The program expenditure depends on the price of medical care, the aggregate medical care consumption of Part A, and synthetic coinsurance rates paid by retirees with Medicare plus a supplemental coverage and those with Medicare only. The fraction $\chi(m)$ of medical care *m* is devoted for Part A related care. It is an increasing function of medical care consumption (*m*). This implies that a high level of medical care consumption accompanies a high fraction of care under the Part A program. The payroll tax exclusion rule also applies to the Hospital Insurance tax base.

3.5.3.2.2 Supplemental Medical Insurance (SMI) – Part B

Upon retirement, all retirees join the Medicare Part B program. This program requires all participants to pay a monthly insurance premium. It covers medical care of outpatient care services and physicians services.[79] Under this program, the government decides the rate of subsidy for retirees to cover a part of their health insurance premium. The government also chooses the proportional wage income tax rate to finance the subsidy. Retirees are responsible for paying synthetic coinsurance $\sigma_{(B)}^{MCO}(m)$ rate, which depends on the level of medical care consumption. Given the rate of subsidy $\xi_t^{MC} \in (0,1)$ exogenously determined, the government sets the Part B premium Ω_t^{MCO} for retirees,

$$\Omega_t^{MC} = \Omega^{MC}\left(1-\xi_t^{MC}, P_t^{M^O}, M_{(B),t}^{G}, 1-\sigma_{(B)}^{MCS}(m,), 1-\sigma_{(B)}^{MCO}(m,), \upsilon_{(B),p}^{MCS},\right)$$

$$\text{where } M_{(B),t}^{G} = M_{(B)}^{G}\left(m, 1-\chi(m), \mu_t\left(m \middle| a,e,i,h \times h\right)\right). \qquad [3\text{-}34]$$

The government finances the subsidy by imposing a proportional income tax to workers and retirees. The government chooses the tax rate τ_t^{fB} to balance the Part B program,

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[79] Starting 2006, the government introduced Part D, a prescription drug plan. Medicare also offers Part C called Medicare Advantage. Retirees with Part A and Part B can purchase this supplemental insurance which includes managed care plans, preferred provider organization plans, private-fee-for-service plans, and specialty plans. Retirees have an option of joining Part C or purchasing Medigap policy which helps fill in the gaps in coverage under Part A and Part B.

$$\tau_t^{fB} = \tau^{fB}\left(\xi_t^{MC}, TAXBASE_t^{fB}\right)$$

[3-35]

where $TAXBASE_t^{fB}$ is a function of

a) $\left(P_t^A, w_t, z_t(a,e), \bar{l}, \xi_t^{EHI}, P_t^{M^Y}\Omega_t^{EHI}, \mu(a,e,i=EHI)\right)$ for workers with EHI,

b) $\left(P_t^A, w_t, z_t(a,e), \bar{l}, \mu(a,e,i=UNI)\right)$ for uninsured workers, or

c) $\left(P_t^A, b_t(a,e), \xi_t^{MC}, P_t^{M^O}, \Omega_t^{MC}, \mu(a,e)\right)$ for retirees.

Under the income tax exclusion rule, workers who purchase an EHI policy can deduct their premium contribution from wage-income tax base. Similarly, retirees' Part B premium is deducted from their tax base. The tax exclusion rule provides a progressive subsidy to the workers with an EHI policy by lowering their wage income tax base.

3.5.3.3 "Medically Needy" Program

The government runs a "Medically Needy" program to provide a social safety net to the people.[80] When workers and retirees incur high medical expenditures and cannot pay the bill in full amount, the government offers a financial assistance to them under this program. To become eligible for this program, they must "spend down" their income to the medically needy income limit (*MNIL*). When they become qualified for this financial assistance, workers and retirees pay some fraction of their total medical bills. This safety-net program results in revenue losses for hospitals. To help the hospitals, the government makes Disproportionate Share Hospital (DSH_t) payments. In order to balance the budget for this program, the government determines the proportional wage income tax rate τ_t^{fMN} . Retirees are also responsible for paying this proportional tax.

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[80] "Medically Needy" program is a state-run program that is administered as a part of the Medicaid program. It is sometimes called a "spend-down" program. This is because those with high income who are otherwise ineligible can spend down their income to be covered by the Medicaid program upon incurring and/or recurring high medical care expenses. Based on the 2001 data, there were 35 states that offered the Medically Needy program. Crowley, J. (2003). Medicaid Medically Needy Programs: An Important Source of Medicaid Coverage. Issue Paper: Medicaid and the Uninsured. Washington, D.C., Kaiser Commission.

$$\tau_t^{fMN} = \tau^{fMN}\left(UNPAID_t^{DSH}, TAXBASE_t^{fMN}\right)$$

$$UNPAID_t^{DSH} = UNPAID^{DSH}\left(MNIL_t, \Gamma\left(m_t, k_{t-1}^i\right)\right)$$

$$\text{where } TAXBASE_t^{fMN} = TAXBASE_t^{fB}$$

[3-36]

I use $\Gamma\left(m_t, k_{t-1}^i\right)$ to denote the level of wealth had workers and retirees paid their medical bills in full. The term k_{t-1}^i denotes the level of asset held at the beginning of period t.

3.5.4 Firm's Optimization Problem

The representative firm offers an employer-sponsored health insurance (EHI) to its employees by contributing a ξ_t^{EHI} percent of health insurance premium Ω_t^{EHI} for each insured worker.[81] We denote the worker's EHI participation rate by $\zeta_{a,e}$. This rate is determined exogenously and controls the size of insured and uninsured population among workers in the economy. We assume that the participation rate is time-invariant and expressed as:

$$\zeta_{a,e} = \frac{\mu_{a,e}^{EHI}}{\mu_{a,e}}$$

[3-37]

Note that a payroll tax exclusion rule is applied to the total cost of EHI provision. Taking the prices P_t^C and $P_t^{M^Y}$ in each period as given, the firm maximizes the real profit, Π_t. The firm's objective function is defined as:

$$\underset{K_t, l_{L,1,t},\ldots,l_{H,40,t}}{Max} \Pi_t = A\left[K_t\right]^{\alpha}\left[E_t\right]^{1-\alpha}$$
$$-\left(r_t + \delta^K\right)K_t - \left(1+g_N\right)^t\left(1+g_z\right)^t \sum_{a=1}^{40}\sum_{e\in I_e}\left\{\left(1+\tau_t^{PAY}\right)w_t + \left(1-\tau_t^{PAY}\right)c_t^{EHI}\right\} z_{a,e,0}\, l_{a,e,t}\, \mu_{a,e}$$

[3-38]

[81] The EHI premium Ω_t^{EHI} is measured in a real term.

where c_t^{EHI} is the real marginal cost of EHI provision. The term δ^K denotes the rate of capital depreciation. The total cost of EHI provision in nominal term is

$$EHI_t = \left(1+g_N\right)^t \sum_{a=1}^{40} \sum_{e \in I_e} \xi^{EHI} P_t^{M^Y} \Omega_t^{EHI} \left(\zeta_{a,e} \mu_{a,e}\right)$$

[3-39]

The marginal cost of providing the benefit is:

$$c_t^{EHI} = \frac{\xi^{EHI} P_t^{M^Y} \Omega_t^{EHI} \sum_a \sum_e \zeta_{a,e}}{P_t^A \sum_a \sum_e z_{a,e,t} \bar{l}\, \mu_{a,e}}$$

[3-40]

3.5.5 Stationary Equilibrium

Let $f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right)$ denote a joint probability density function (PDF) where the state space vector Θ_t^h is defined as $\Theta_t^h = \left(a_t, e_t, i_t, h_{t-1}\right)$ [82]. When the economy reaches a stationary equilibrium at time *t*, the joint PDF converges at time *t* and satisfies the following condition thereafter:

1) $\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in \left(I_i^Y, I_i^O\right)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right) dk_t^i dm_t = 1$ for $\forall t$.

The stationary equilibrium is where all markets clear, factor prices and tax rates are pinned down, and the joint PDF $f_{\Theta_t^h}\left(k_t^i, m_t, \Theta_t^h\right)$ must satisfy 1). The following properties must be met for individual behaviors in micro environment and aggregate behaviors in macro environment to be consistent.

[82] The agents cannot accumulate more assets than they earn over their life-time. Each state variable is bounded, and the entire state space Θ_t^m is also bounded.

2) $N_t = (1+g_N)^t N_0 = (1+g_N)^t$ where $N_0 = 1$

3) $E_t = (1+g_z)^t \left(\sum_{a=1}^{40} \sum_{e \in I_e} z_{a,e,0} \bar{l} \ \mu_{a,e} \right) N_t$

4) $K_{t+1} = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in (I_i^Y, I_i^O)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} k_{t+1}^i \left(k_t^i, m_t, \Theta_t^h \right) f_{\Theta_t^h} \left(k_t^i, m_t, \Theta_t^h \right) dk_t^i dm_t \right) N_t$

5) $I_t = \left\{ (1+g_N)(1+g_z) - \left(1-\delta^K\right) \right\} K_t$

6) $C_t = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in (I_i^Y, I_i^O)} \sum_{h_{t-1} \in I_h} \int_{m_t > 0} \int_{k_t^i > 0} c_t \left(k_t^i, m_t, \Theta_t^h \right) f_{\Theta_t^h} \left(k_t^i, m_t, \Theta_t^h \right) dk_t^i dm_t \right) N_t$

7) $M_t = \left(\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in (I_i^Y, I_i^O)} \sum_{h_{t-1} \in I_h} \sum_{h_t \in I_h} \int_{k^i > 0} m_t \left(h_t, \Theta_t^h \right) g_{\Theta_t^h} \left(k_t^i, h_t, \Theta_t^h \right) dk_t^i \right) N_t$

where

$$\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in (I_i^Y, I_i^O)} \sum_{h_{t-1} \in I_h} \sum_{h_t \in I_h} \int_{k^i > 0} g_{\Theta_t^h} \left(k_t^i, h_t, \Theta_t^h \right) dk_t^i = 1$$

The expression 2) is population accounting. It grows by the rate g_N. The aggregate labor in efficiency unit is expressed in 3) where it grows by the rate g_Z, the rate of labor-augmented technological progress. The equation 4) represents aggregate savings that build nation's capital. Investment is defined in 5) based on the capital accumulation equation, $K_{t+1} = \left(1-\delta^K\right) K_t + I_t$. Aggregate consumption 6) must equal the sum of all agents' optimal consumption which comes from the solution of the Bellman equation[3-28]. Agents' medical-care consumption must add up to the aggregate medical consumption as in 7). The equations 2) through 7) must conform with the national income accounting 8) for individual and aggregate behaviors to be consistent at the stationary equilibrium. Given an exogenous price levels $\left(P_t^C, P_t^M \right)$ at time *t*, the stationary equilibrium satisfies the following aggregate market clearing condition:

8) $P_t^A Y_t = P_t^C C_t + P_t^M M_t + P_t^A I_t$.

Market clearing factor prices are:

9) $r_t^* = \alpha A\left[k_t\right]^{\alpha-1} - \delta^K$

10) $w_t^* = \dfrac{\widehat{w}_t}{1+\tau_t^{PAY}} - \left(\dfrac{1-\tau_t^{PAY}}{1+\tau_t^{PAY}}\right)c_t^{EHI}$ where $\widehat{w}_t = (1-\alpha)A\left[k_t\right]^{\alpha} = MPL_t$

where r_t^* denotes the equilibrium net return to capital in real, and w_t^* is the equilibrium after-tax real money wage rate. The gross wage rate $\widehat{w}_t$ equals the marginal product of labor in efficiency unit. I use $k_t = \dfrac{K_t}{E_t}$ to denote the capital-labor ratio. Given that the aggregate labor in efficiency unit grows by the factor $(1+g_z)(1+g_N)$ based on 2)3), when the capital stock grows by the same factor, the capital-labor ratio reaches a fixed point $\bar{k}_{ss}$:

11) $k_t = \dfrac{K_t}{E_t} = \dfrac{(1+g_z)^t(1+g_N)^t K_0}{(1+g_z)^t(1+g_N)^t E_0} = k_0 = \bar{k}_{ss}$

In order for the model to reach the steady state $\bar{k}_{ss}$, this study makes the following assumptions:

12) $m_{t+1}(\Theta_t) = (1+g_z)m_t(\Theta_t)$ where $\Theta_t = \Theta(a_t, e_t, i_t, h_{t-1}\times h_t)\ \forall t$

13) $\pi_t^C = \pi_t^M\ \ \forall t$

The condition 12) indicates that the medical care demand grows by the rate of labor-augmented technological progress g_Z over time for any individuals characterized by the state space vector Θ_t. When the economy reaches a stationary equilibrium, this condition implies that the health insurance premium in real term grows by the same factor. The condition 13) assumes that the average cost in each sector grows by the same rate.[83]

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[83] Under the balanced growth path, income and consumption per capita grow by the factor g_z. Real output (*Y*), consumption of commodities (*C*), medical care consumption (*M*), and investment (*I*) grow by the factor

The medical care prices for workers and retirees $\left(P_{t+1}^{M^Y}, P_{t+1}^{M^O}\right)$ rise by the factor π_t^M. The overall price P_t^A changes over time by the same rate. This assumption also implies that the relative price remains the same at the stationary equilibrium. The marginal cost of EHI provision [3-40] becomes time invariant at the stationary equilibrium $c_t^{EHI} = \overline{c}^{EHI}$.

Given the policy instruments, the government must balance budgets for the Social Security, the Medicare, and the "Medically Needy" programs by choosing the proportional tax rates $\left(\tau_t^{PAY}, \tau_t^f\right)$ where $\tau_t^{PAY} = \tau^{SS} + \tau_t^{HI}$, $\tau_t^f = \tau^{fB} + \tau^{fMN}$. At the stationary equilibrium, these tax rates are pinned down.

3.6 Calibration

This chapter follows the calibration from Chapter 1. The following subsections provide some highlights that are specific to this chapter.

3.6.1 Insurance Status

Let $\mu_{a=1,e,i} = \mu\left(a_t = 1, e_t, i_t\right)$ denote the time-invariant joint probability mass function (PMF) of insurance status at birth. Using MEPS from 1996-2005, this study computes 117 (39 × 3) conditional transition matrices of insurance status for workers, denoted by $\Lambda_{i \times i}^{a,e} = \Lambda\left(i_t \middle| a_t, e_t, i_{t-1}\right)$. Based on the initial joint PMF and the conditional transition matrices, I simulate conditional PMF of insurance status for workers. Figure 3-1 plots the conditional PMF of insurance status for workers, $\mu_{i=EHI|a,e}$, sorted by age and earning ability. This simulation accounts for 12.5 percent of uninsured population. This number is approximately in line with the estimate from Rhoades and Chu (2007) [84] The

$g_z + g_N$ where g_N is the rate of population growth. Since prices increase exogenously by the growth rate of average cost, all aggregate variables in nominal value grow by the factor $g_z + g_N + \pi_A$.

[84] Our definition of uninsured only includes those without a health insurance for a full sample year. Rhoades and Chu (2007) reports the size of uninsured population in three measures. One mea sure includes those who were uninsured at any point during the course of a year. Second measure includes those who were uninsured during the first half of year. The third measure includes those who were uninsured for a full year. They report that the uninsured population under 65 for a full year is 13.4 percent on average from 1996 through 2005. During those ten years, the minimum was 12.2 percent in 1999. The maximum was 14.2 percent reached in 2005. Based on their first measure, the size of uninsured is higher than the third measure by nearly 12 percentage points.

conditional probability of being insured at any given age is higher as earning ability becomes higher.

Retirees are sorted into two categories of insurance status at the time of their retirement. Conditional probability of purchasing the supplemental policy is controlled by the conditional PMF $\Lambda_{i \times i}^{a=41,e,h} = \Lambda\left(i_t \middle| a_t = 41, e_t, i_{t-1}, h_{t-1}\right)$ where $i_t \in I_i^O$ and $i_{t-1} \in I_i^Y$. The left panel of Figure 3-2 displays a conditional transition probability of insurance status. The right panel of Figure 3-2 shows a conditional PMF of insurance status at the time of retirement. Notice that the probability of getting the supplemental coverage is higher for retirees "fair (F)" and "poor (P)" health status. This result is largely consistent with the finding by Fang and Keane et al (2008) who reported that those with high expected medical expenditures are more likely to purchase a supplemental insurance, namely Medigap. It is also noticeable that the probability of purchasing the supplemental policy is high among those with "excellent (E)" health status among high and middle earning groups. This may be supported by an evidence of advantageous selection in Medigap insurance market. Agents in this particular category can lower their out-of-pocket medical expenditures by purchasing a private supplemental insurance. (Fang, Keane et al. 2008) The evidence of advantageous selection is also reflected on the right panel of Figure 3-2 . The fraction of agents who purchase a private supplemental insurance is lower when their earnings level is lower. As workers' earning ability become higher, agents can afford to purchase a supplemental insurance which provides better financial protection against a catastrophic illness.

3.6.2 Medical Care Expenditures

3.6.2.1 Synthetic Coinsurance Rates

3.6.2.1.1 Workers

Let σ_p^{EHI} be the synthetic coinsurance rates for EHI policy and computed as:

$$\sigma_p^{EHI} = \frac{M_p^{OOP}}{M_p^{TOT}} \quad \text{for } p \in \{2,...,14\}$$

[3-41]

where M_p^{OOP} and M_p^{TOT} denote the out-of-pocket (OOP) and the total (TOT) medical care expenditures in each percentile. The higher the level of medical care consumption, the lower becomes the synthetic coinsurance rate.[85] [See Figure 2-11] Among workers, this rate ranges from 43 percent at the lowest percentile to 3 percent at the highest 0.1 percentile. Given the average medical expenditures and the synthetic coinsurance rates, the out-of-pocket medical expenditures range approximately from \$35 to \$5,700 on average for insured workers.

3.6.2.1.2 Retirees

There are two sets of synthetic coinsurance rates for retirees. One set applies to the Part A program, and the other set applies to the Part B program. In order to compute synthetic coinsurance rates, first, I sort medical expenditures based on Part A and Part B care for each person. Then, I compute ratios of Part A and Part B spending in total medical expenditures for a given percentile rank $p \in I_p$. Figure 3-3 displays the fraction χ_p for Part A spending and the fraction $1-\chi_p$ for the Part B spending under each $p \in I_p$ based on insurance status among retirees. Figure 3-4 shows synthetic coinsurance rates for Part A $\left(\sigma_{(A),p}^{MCS}, \sigma_{(A),p}^{MCO}\right)$ and Part B $\left(\sigma_{(B),p}^{MCS}, \sigma_{(B),p}^{MCO}\right)$ for each percentile group.

3.6.2.2 Other Sources of Payment for Retirees' Medical Expenditures

When retirees have a supplemental policy, the Medicare program must coordinate with private insurers in terms of cost sharing. Based on the MEPS 1996-2005, Medicare covers most care under Part A. When retirees consume medical care under Part B program, retirees pay more. On average, private insurance companies pay 25 percent of

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[85] A health-insurance contract often requires that policy holders pay deductibles before an insurance company starts to cover any medical expenses for them. After deductibles, they pay a coinsurance, a certain fraction of the medical bills. Depending on policies, workers pay a copayment (co-pay) for receiving certain medical treatments. To simplify the payment structure of insurance policies, I compute synthetic coinsurance rates for the holders of employer-sponsored health insurance (EHI). I apply the same rate structure to workers with a private non-group insurance (PRI) contract purchased outside their employment. The uninsured faces a full cost of medical care consumption. For retirees, I compute synthetic coinsurance rates for Part A and Part B separately under Medicare program.

the medical bills for Part A care and 33 percent of the bills for Part B care. [See Figure 3-5]

3.6.3 Hospital Cost-shifting:

The rate of reimbursement is calibrated based on the aggregate hospital payment-to-cost ratio for Medicare patients. I use the published data from American Hospital Association/The Lewin Group.[86] Figure 2-20 shows the hospital's cost-to-payment ratios for Medicare payers and privately insured payers. During the period of 1980-2004, the ratio for Medicare payer is 0.967 on average. The ratio for the private payer is 1.207 on average during the same period. Based on the report from the American Hospital Association, 65 percent of hospitals received Medicare payments less than their cost in 2005. (AHA 2006) As a result, an aggregate underpayment by the Medicare program amounted to $15.5 billion, increased from $15.0 billion in the year before. This study takes the payment-to-cost ratio of the Medicare payer as given. Since I do not have the data for 2005, I apply the data in 2004 for 2005 and calibrate ω by setting:[87]

$$\omega_0 = 0.92$$

3.7 Benchmark Model

3.7.1 Numerical Results

Table 3-1 reports numerical results of the benchmark model. This model assumes that the economy reached a steady state at $t=0$.[88] The model yields a nominal wage rate of $18.43 and a real interest rate of 8.3 percent that correspond to the steady-state level of capital-to-output ratio of 2.5. The low-, the middle- and the high-skilled earn $21,680, $33,558, and $63,021 on average, respectively. The marginal cost of the EHI provision is $0.91 per hour in nominal dollar, which corresponds to the EHI premium of $2767 per

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[86] Trend Watch Chartbook 2006: Trends Affecting Hospitals and Health Systems, April 2006. I exclude the ratio for the Medicaid payer.

[87] The AHA reported that the underpayments by Medicare increase marginally from 2004 to 2005.

[88] We model that $t=0$ is the actual year of 2005.

annum. The marginal cost of the EHI provision is 5 percent of the wage rate. Since this model does not incorporate any family structure, the EHI premium corresponds to a single coverage. Worker's contribution is \$498, a 18 percent of the premium. Based on the data from Agency for Health Research and Quality (AHRQ), *Center for Financing, Access and Cost Trends*, the average health insurance premium at private sector establishments was \$3,991, of which each enrollee paid \$723, a 18.1 percent of the premium in 2005. This model parameterizes the EHI contribution rate by the firm at 82 percent ($\xi^{EHI} = 0.82$).

Social Security tax and Medicare Part A Hospital Insurance tax rates are 4.53 and 1.49 percent. Both employees and the employer pay 6.0 percent for the payroll tax. The Social Security tax rate is based on the earning replacement rate of 35 percent. The actual Social Security and Hospital Insurance tax rates are 6.2 and 1.45 percent, respectively.[89] The federal wage income tax finances a part of Medicare Part B program and the "Medically Needy" program. The wage income tax rate consists of two tax rates, τ^{fB} and τ^{fMN}. The Medicare Part B tax is $\tau^{fpB} = 0.74$ percent. The "Medically Needy" program requires a tax rate of $\tau^{fMN} = 0.15$ percent. Adding these two tax rates, we have the federal wage income tax rate of $\tau^{f} = \tau^{fpB} + \tau^{fMN} = 0.9$ percent.

When agents retire, they have an option of purchasing a private supplemental policy. We assume that all agents are covered by Medicare Part A and Part B. Medicare Part B insurance premium is \$938.64 per annum in nominal value at *t=0*. The actual Part B insurance premium in 2005 was \$938.40 (=78.20 x 12 mo.).[90] The private supplemental insurance premium is \$2,776.34 per annum in nominal term. The

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[89] These rates have been applied since 1990. There is an annual limit imposed on the Social Security tax base. In 2005, this limit was \$90,000. For the Medicare's Hospital Insurance program does not impose any taxable limit on the tax base. The maximum taxable earnings which had been imposed on Medicare's Hospital Insurance tax were eliminated entirely in 1994.

[90] Beginning in 2007, as a result of the Medicare Modernization Act of 2003, the government introduced a five-tier premium calculation. Based on this new calculation, those with higher income pay a higher Part B insurance premium. While the most people pay a standard premium, there are four levels of premium above the standard rate. Beginning 2009, high income beneficiaries will pay, depending on their income, 35, 50, 65, and 80 percent of the total Part B cost. (See http://www.socialsecurity.gov/pubs/10161.html) The government expects that the new law will affect only 4 to 5 percent of the population.

benchmark model parameterizes the rate of government contribution to the Part B premium at 46.7 percent.

Table 3-2 reports growth rate of key variables on the balanced growth path. This model must assume that the medical demand, which is exogenously determined, must grow by the same rate as the real wage growth driven by the rate of labor-augmented technological progress at 2 percent per annum. Since population growth rate of 1.0 percent is assumed, real aggregate variables including output, consumption of commodities, consumption of medical care, and investment grow annually by 3 percent.

3.7.2 Health and Wealth

Changes in health policy impact a distribution of wealth. In general, people with good health spend less on medical care. As we age, we typically increase our spending on medical care. Given these facts, it is critical to analyze how a policy change influences the joint distribution of wealth and health status at given age. We must be aware that its impact can be more pronounced during the time when medical cost growth outpaces the income growth. The top panel of Figure 3-6 shows savings by health status, conditional on age-cohorts. We find a typical pattern that agents accumulate wealth during their working lives. As they retire, their savings diminish as to smooth their consumption. This figure also tells us that a variability of wealth across health status rises until well into one's retirement. Agents with "excellent" health status tend to have more wealth than those with "very good" health status. As health status deteriorates, consumption of medical care rises. Agents with "poor" health status typically have less wealth at any given age. Hence a variability of medical care consumption translates into the variability of wealth. The bottom panel of Figure 3-6 proves that "excellent" and "very good" health status means savings above average of those in the same age cohort. Their savings are 4 percent and 1.6 percent higher than the average, respectively. Agents with "good" health status have 0.8 percent less savings than the average. When their health status becomes "fair" or "poor", savings decline even further. Relative to the average, their savings are lower by 4.3 percent and 6.3 percent, respectively. The wealth gap between people with "excellent" health status and those with "poor" health status widens considerably as we age. Agents in the 40-50 age cohort, corresponding to retirees in the actual age-cohort of 65-75, face a 13 percentage point gap.

3.8 Policy Experiments

One of the objectives of this chapter is to find how government underpayments to hospitals influence the economy and the well-being of the people. When the Medicare program cost grows by the same rate as the economy on the balanced growth path, there are no incentives for the government to cut the reimbursement rate. We must consider the situation where the Medicare program faces an excess cost growth, and the government must implement a policy to finance it. Policy experiments in this section accommodate this situation by including two sources of deviation from the steady state. One is an excess cost growth at hospitals. The other source of deviation is an excess demand growth of medical care by retirees. When the government experiences the excess program cost, it can choose to (1) raise payroll and wage income taxes, (2) cut the reimbursement rate, yielding Medicare inflation tax, in lieu of raising payroll and wage income taxes, or (3) cut the reimbursement rate partially and raise tax rates at the same time. Policy experiments must show different level of cost-shifting and evaluate their impacts on the economy and the well-being of the people.

In order to evaluate each policy, I will compare key indicators at the new steady state. Experiments assume 10 years of deviation period. New steady state reaches at period 80.[91] (Laitner 1990) I will use the following utilitarian Social Welfare Function (SWF) to evaluate aggregate well-being of the people:

$$SWF_t = \sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in \{I_i^Y, I_i^O\}} \sum_{h_t \in I_h} \sum_{p_t \in I_p} \sum_{k_t^i \in I_k} U^*_{a_t, e_t, i_t, h_t, p_t, k_t^i} \mu_{a_t, e_t, i_t, h_t, p_t, k_t^i}$$

[3-42]

[91] Laitner (1990) analyzes with a mathematical rigor on how an overlapping generations model (OLG) in a general equilibrium can reach a stationary solution following a saddle path after a change in fiscal policy. Following the model put together by Auerbach and Kotlikoff (1987), Laitner computes eigenvalues of the system of equations under the OLG and proves that their model has a stable arm and indeed converge to a steady state. In his work, the model reaches a new steady state in 50 years following a temporary change on consumption tax.

where

$$\sum_{a_t \in I_a} \sum_{e_t \in I_e} \sum_{i_t \in \{I_i^Y, I_i^O\}} \sum_{h_t \in I_h} \sum_{p_t \in I_p} \sum_{k_t^i \in I_k} \mu_{a_t, e_t, i_t, h_t, p_t, k_t^i} = 1$$

Note that $U^*_{a_t, e_t, i_t, h_t, p_t, k_t^i}$ is the indirect utility function based on the consumer's maximization problem.

3.8.1 Excess Cost and Demand Growth of Medical Care

The benchmark model assumes that the average cost grows by 2 percent per annum in both commodity and medical sectors on the balanced growth path. There is no sectoral gap in annual cost inflation. The actual CPI data, on the other hand, indicates that the average annual inflation of medical care has been around 4 percent in recent years, and higher than the annual inflation of "CPI excluding medical care" by approximately 2 percentage points. Based on this fact, I will exogenously raise the average cost growth to 4 percent per year in medical-care sector. This cost-growth deviation lasts for 10 years, starting at period 1 though 10 in this experiment. Then, the average cost growth comes back to 2 percent per annum at period 11, and continues at 2 percent thereafter.

Retirees medical demand grows by 2 percent per year at the initial steady state. During the deviation period between 1 through 10, I also raise retirees' medical demand by 2 percentage points to 4 percent per year. Their medical demand comes back to a 2 percent growth at period 11, and remains at this growth rate thereafter.

3.8.2 Medicare Financing Policies

I will vary the degree of cost-shifting by lowering reimbursement rate in percentage. When the degree of cost-shifting is 0%, the government chooses to maintain existing reimbursement rate and raise payroll and wage income taxes to finance the excess cost growth of Medicare program. When the degree is 100%, the government cuts the reimbursement rate in lieu of raising payroll and wage income taxes. I will evaluate impacts of each policy at the new steady at period 80.

3.8.3 Results

Government underpayments that impose Medicare inflation tax is very expensive to the economy as oppose to the payroll and wage income tax to finance the excess cost of Medicare program. Medicare inflation tax, which is triggered by the government underpayments and hospital's cost-shifting under the excess growth of Medicare program, raises workers' medical price inflation and results in higher real PDV of lifetime medical expenditures. While payroll and wage income taxes are paid by employers and employees, the incidence of Medicare inflation tax falls onto workers who purchase health insurance and those who consume medical care. Uninsured workers who do not consume medical care do not pay Medicare inflation tax. Retirees, on the other hand, receive subsidies in the form of lower medical-price inflation while workers pay Medicare inflation tax. The effects of payroll and wage income taxes are very different from the effects of Medicare inflation tax. Comparison of these effects will be examined in the following subsections.

3.8.3.1 Cost-shifting and Medicare Inflation Tax

Changes in medical prices have real effects. Since relative prices matter for both consumption of commodities and savings, accounting for the magnitude of cost-shifting and Medicare inflation tax is critical to this study. Table 3-3 shows how government decision of shifting Medicare's excess cost growth creates workers' medical price inflation. Under the assumption that average cost at hospitals and retirees' medical demand grow in excess by 2 percentage points per annum for 10 years, starting at period 1 through 10, workers' medical price inflation rises by more than the excess growth of average cost. As the magnitude of cost-shifting rises, their medical price inflation rises during the ten-year period. At the same time, retirees' medical price inflation goes down in the direction of higher government underpayments. A lower reimbursement rate brings hospitals' payment-to-cost ratio down as they treat Medicare patients. As hospitals' cost shifting raises workers' medical price inflation, payment-to-cost ratio for workers goes up. [See Table 3-4]

When hospitals' cost inflation is accompanied by excess growth of retirees' medical demand, according to Proposition 1, pre-existing price distortion accelerates inflation of workers medical care price even when the government finances the excess program cost by raising payroll and wage income taxes. As a result, workers still pay Medicare inflation tax under a 0 percent level of cost shifting. Based onTable 3-5 , this Medical inflation tax appears to be marginal, ranging from 0.19 percent to 0.22 percent, corresponding to Medicare inflation tax $T_{t+s}^{M^Y}$ in Definition 1. When the government cuts the reimbursement rate to avoid paying excess program cost (100% level of cost shifting), workers pay Medicare inflation tax that ranges from 3.3 percent to 4.5 percent.

A lower reimbursement rate translates into lower medical price inflation for retirees. When the government chooses to cut the reimbursement rate, while workers pay Medicare inflation tax, retirees receive subsidies. These subsidies help retirees face lower medical price inflation. At the bottom panel of Table 3-5, subsidies amount to a 2 percent reduction in retirees' medical price inflation at 50% of cost shifting. The maximum level of subsidies is a 4 percent reduction in retirees' medical price inflation at 100% of cost shifting. In this situation, retirees' medical price hardly changes year after year during the time of excess cost and demand growth of medical care. These changes in medical price inflation lead us to a question of how Medicare inflation tax and subsidies impact the economy and well-being of the people.

3.8.3.2 Aggregate Savings, Consumption, Medical Expenditures, and Well-being

Figure 3-7 shows the aggregate effects of government policy to finance excess cost growth of Medicare program. When the government decides to finance the excess cost in full by raising payroll and wage income taxes, aggregate savings, consumption, out-of-pocket medical expenditures, and well-being are all indexed to 100. When the government uses Medicare inflation tax by shifting the excess program cost, Figure 3-7 shows that aggregate savings decline. The income effect of Medicare inflation tax on savings is larger than the effect of payroll and wage income tax on savings. As Medicare inflation tax raises workers' medical price, it raises the real PDV of life-time medical expenditures. As workers save less, retirees accumulate less saving at the new steady state. The decline in savings is, however, much larger for workers than for retirees.

As the government cuts the reimbursement rate to finance the excess growth of Medicare program, retirees implicitly receive subsidies in the form of discounted medical price inflation. The subsidies grow in the magnitude of cost-shifting. While this Medicare inflation tax lowers workers' consumption, it raises retirees' consumption relative to the level under which the government finances it through higher payroll and wage income taxes. The aggregate effect of Medicare inflation tax on aggregate consumption consists of these two offsetting effects from workers and retirees. As workers accounts for much larger fraction of the population, the aggregate consumption declines in cost shifting. At 100 percent level, the aggregate consumption is lower by 1.5 percent.

Medicare inflation tax has a surprisingly large cumulative effect on aggregate out-of-pocket medical expenditures at the new steady state. At 100 percent level of cost-shifting, workers' out-of-pocket medical expenditures are higher by 40 percent than the case where the government imposes higher payroll and wage income taxes. On the other hand, retirees' out-of-pocket medical expenditures are lower by 32 percent. While retirees account for smaller fraction of the population, their medical expenditures explains much larger fraction of aggregate medical care spending. As the government imposes Medicare inflation tax, subsidies given to retirees, albeit they may be marginal, raises workers' medical prices substantially. As a result, workers' out-of-pocket medical expenditures in real—nominal expenditures divided by the overall CPI —increases considerably in the magnitude of cost-shifting.

Aggregate well-being based on the equation [3-42] diminishes as the government imposes higher Medicare inflation tax. As consumption declines among workers, their well-being is lower. Since agents face diminishing marginal utility in consumption, even when subsidies to retirees raise their commodity consumption, their well-being as a group does not rise as much as one might expect. Reduction in consumption among workers, on the other hand, curtails the aggregate well-being in a significant way.

3.8.3.3 Equilibrium Prices, Balanced Growth Path, and a Measure of Inequality

Figure 3-8 shows impacts of government policy on key variables at the new steady state. When the government chooses to finance the excess cost of Medicare program by raising payroll and wage income taxes, after-tax wage rate reaches $9.30 in 1982-84 dollar. As the government cuts the reimbursement rate, Medicare inflation tax lowers the wage rate.

At 100% level of cost-shifting, the wage rate is lower by 4.6 percent. Real interest rate is higher by 71 basis points relative to the policy at zero percent of additional cost-shifting.

As Medicare inflation tax makes workers medical price inflation higher than the real wage growth, real marginal cost of employer-sponsored health insurance (EHI) provision rises. Subsequently, the marginal cost accounts for a much larger fraction of the real wage. It grows to 9 percent of the real wage rate at 100 percent level of cost-shifting relative to 6.1 percent at 0 percent level of cost-shifting. Real output also declines in the magnitude of Medicare inflation tax as cost-shifting substantially lowers the nation's savings. A 100 percent level of cost shifting reduces steady-state level of output by 2.7 percent. Wealth Gini coefficient indicates that relatively modest increase in Medicare inflation tax improves the level of inequality as cost-shifting provides subsidies to retirees. At the highest level of Medicare inflation tax, the level of inequality measured by wealth Gini coefficient deteriorates.

When the government chooses to raise payroll and wage income taxes, high earners contribute more to the government tax revenues. When the government chooses to cut reimbursement rate instead, a larger share of Medicare inflation tax is paid disproportionately by workers who consume large amount of medical care. In particular, workers with "fair" and "poor" health status bear a higher burden of Medicare inflation tax. Uninsured without medical-care consumption can avoid paying Medicare inflation tax. As a result, Medicare inflation tax creates redistribution of wealth that is quite different from how payroll and wage income taxes do.

3.8.3.4 Wealth and Health under Medicare Inflation Tax

Workers with "fair" and "poor" health status, who devote larger fraction of their income for medical care consumption, disproportionately pay high Medicare inflation tax. As a result, it widens the wealth gap between those with "excellent" and those with "poor" health status. This point is well illustrated by Figure 3-9. At the initial steady state at $t=0$, workers with "excellent" and "very good" health status have 3 percent and 1.5 percent higher savings than the average savings among workers, respectively. Workers with "good", "fair", and "poor" health status have 0.6 percent, 4.3 percent, and 6.5 percent lower savings than the average, respectively. Medicare inflation tax raises precautionary demand for savings. Workers with “excellent” and “very good” health status are able to save more in net relative to the average. As the percent of cost-shifting rises, their savings relative to the average rise to 4.2 percent and 2 percent at 100% cost shifting, respectively. On the other hand, workers with high medical-care consumption reduce their savings as a result of Medicare inflation tax. Workers with “fair” and “poor” health status disproportionately increase their share of financing Medicare inflation tax. Their savings relative to the average are lower by 6 percent and 9.5 percent, respectively.

Medicare inflation tax has an opposite effect on retirees’ wealth accumulation. As the government cuts the reimbursement rate, retirees with “fair” and “poor” health status can increase their savings, albeit they are marginal, relative to the average savings among retirees. The overall impact of Medicare inflation tax on wealth redistribution is largely dictated by how it affects wealth redistribution among workers. Medicare inflation tax allows workers with “excellent” and “very good” health status to accumulate more wealth through higher precautionary demand for savings, while it creates a substantial disadvantage for those with “fair” and “poor” health status. A wealth gap between workers with “excellent” health status and those with “poor” health status widens, thus contributing to higher level of wealth inequality, as suggested by the Gini coefficient.

Another related point about widening wealth gap among workers can be illustrated by the magnitude of those who fall into the “Medically needy” safety net. Figure 3-10 well illustrates this point above. As Medicare inflation tax raises workers’ medical price and its rate of inflation, it increases the percentage of workers who fall into the safety net. At 0 percent of cost shifting, there is 1.07 percent of workers who fall into the safety net. As Medicare inflation tax rises in the magnitude of higher cost shifting, the population of workers with “Medically needy” assistance goes up to 1.90 percent.

3.8.4 Raising Retiree’s Premium Contribution

A policy that raises workers’ real PDV of life-time medical expenditures curtails the level of real output and reduces well-being of the people at the new steady state. How should the government finance the excess cost growth of Medicare program? In this subsection, I will evaluate the impact of government policy that raises retirees' contribution rate to Medicare Part B premium.

This policy experiment raises retirees' contribution for purchasing Medicare Part B insurance to 63 percent from 53 percent, starting at period 1.[92] A 10 percentage increase in their contribution translates into a 18.7 percent increase in retirees' Medicare Part B premium at the new steady state. Figure 3-11 compares this policy experiment against the previous one. Comparative statics results show that, as a result of this higher contribution rate, the key variables move to the direction as we anticipate. Raising retirees' contribution rate, thereby lowering wage income tax, increases nation's capital by 0.4 to 1.1 percent at the new steady state. The marginal increase in wage rate does not contribute much to improve workers' well-being. Retirees' well-being, on the other hand, does not deteriorate as much as one might expect. Retirees will simply increase their savings to finance the higher contribution rate. The population of retirees who fall into the "Medically needy" safety net rises, albeit very marginal, by 0.02 to 0.08 percent. Making retirees pay a higher share of excess growth of their medical demand does not provide much help to the long-run balanced growth path.

3.9 Conclusion

This chapter investigates Medicare financing policy when the government confronts periods of excess growth of medical costs. In particular, it explores two methods of financing excess cost growth. Under the assumption of keeping budget balance, the first method imposes a constraint that the government raise payroll and wage-income tax rates to finance excess cost growth. The second method assumes that the government lowers hospital reimbursement rates in lieu of raising taxes. This study calls the second method a "Medicare inflation tax." It is paid ultimately by workers who purchase health insurance and/or consume medical services. In this second case, hospitals must engage in cost-shifting to stay in business in the long run. The cost-shifting, in turn, raises workers medical price inflation. After the period of rising costs, this study, under each method,

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[92] At the initial steady state at $t=0$, retirees pay \$938.64 for Part B insurance premium in 2005 dollars, which is about what they paid in 2005. We assume that the initial steady state corresponds to 2005. The contribution rate of 53 percent corresponds to this premium.

evaluates the new balanced growth path of the economy. It measures well-being by the population weighted average of individual flow utilities. It compares the two methods of Medicare financing based on the steady state output and well-being of people at period *t=60*. This chapter assumes that the Medicare financing policy does not influence workers' insurance take-up decisions.

When the government raises payroll and wage-income taxes to finance excess growth of medical costs, the balanced growth path and well-being of the people are higher at the new steady state than the government uses the Medicare inflation tax. Since workers pay payroll and wage-income taxes regardless of their insurance status, the burden of this taxation is shared according to earning ability. Its impact on workers' savings is not as pronounced as the effect of the Medicare inflation tax. Since retirees pay the full cost of medical price inflation, their demand for precautionary savings is higher under the policy of raising payroll and wage-income tax rates. The equilibrium wage rate at the new steady state is higher under this policy than under the Medicare inflation tax.

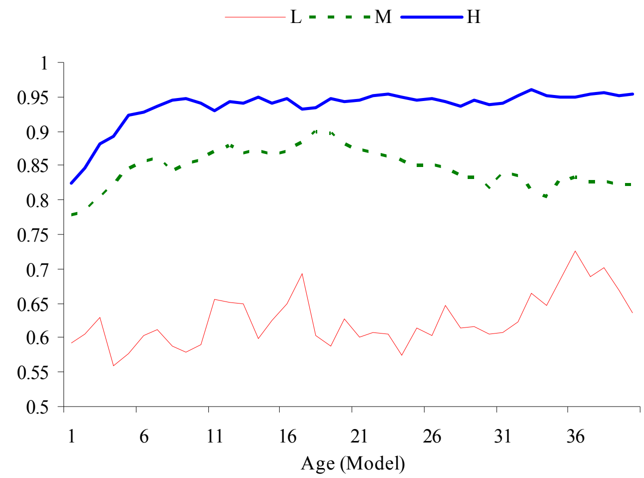
In contrast, the Medicare inflation tax is costly to the economy. Reductions in government reimbursements to finance excess cost growth raise workers' medical price inflation in a dynamic general equilibrium. As workers face higher medical price inflation, their real present discounted value (PDV) of lifetime medical expenditures rises. As a result, medical price inflation reduces workers' consumption of goods excluding medical care. In addition, their savings decline. Workers who consume more medical services pay a higher share of the Medicare inflation tax. Uninsured workers without medical consumption escape from paying the Medicare inflation tax. Hence, this policy creates a redistribution of wealth that exacerbates the level of inequality as low- and middle-income households with "fair" and "poor" health status pay a higher share of the Medicare inflation tax. It disproportionately raises their financial vulnerability. On the other hand, the Medicare inflation tax provides subsidies to retirees in the form of lower medical price inflation, which in turn raises their consumption of commodities and lowers their precautionary saving. As a consequence, it lowers the equilibrium wage rate at the new steady state. The balanced growth path of the economy and well-being of the people are permanently lower at the new steady state.

A myopic policy prescription by the government to help contain Medicare cost growth by cutting hospital reimbursement rates can create inharmonious welfare implications among workers, as well as between workers and retirees. Comparing a Medicare inflation tax with payroll and wage-income taxes, it seems better to finance excess growth by the latter.

FIGURES

Figure 3-1 Conditional Distribution of Insurance Status: Insured

(Fraction of subpopulation)

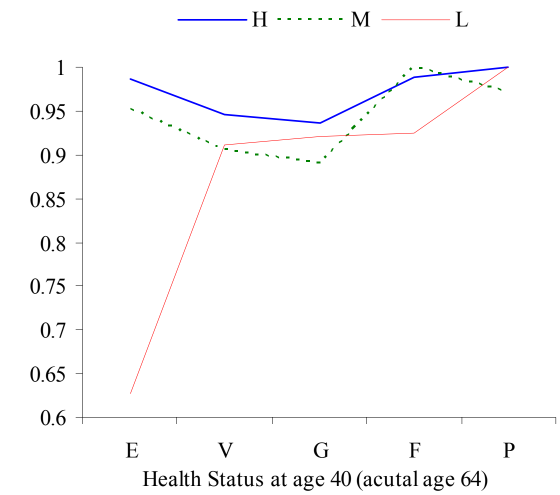


Note: The above graph shows the conditional probability mass function (PMF) of insured population, $\mu_{i=EHI|a,e}$ where $\sum_{i \in I_i^Y} \mu_{i|a,e,} = 1$ for $a \in \{1,\ldots,40\}$ and $e \in I_e$.

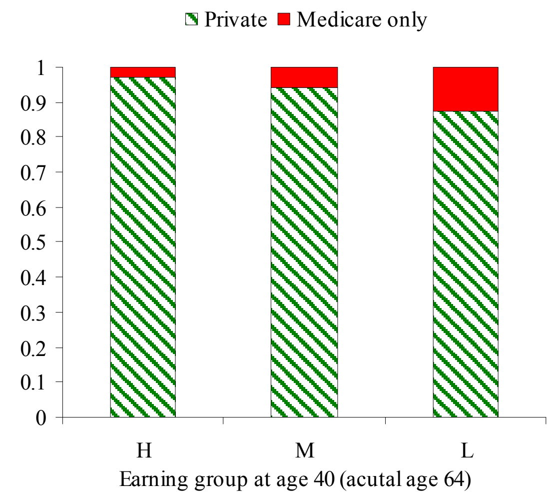
Figure 3-2 Conditional Distribution of Insurance Status: Retirees

(Percent)

(a) Transition to the joint plan at the time of retirement 1/



(b) Distribution of insurance status among retirees 2/



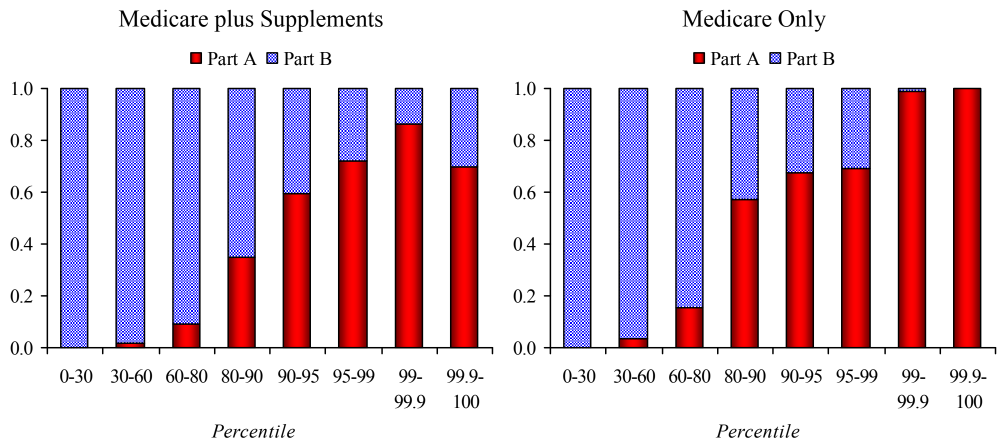
1/ A transition probability of insurance status at the time of retirement is conditional on earnings group and health status of agents at age 40 (actual age 64). A joint plan indicates Medicare plus a private supplemental insurance.

2/ The label "private" indicates a Medicare policy with a private supplemental insurance. The distribution of insurance status among the retirees is based on the earning group and health status at age 40. Once they retire, their insurance status will not change.

Note: The lines on the left panel represent the sum of the conditional transition probability of insurance status at the time of retirement: $\lambda_{EHI,MCS}^{a_t=40,e_t,h_t} + \lambda_{UNI,MCS}^{a_t=40,e_t,h_t}$ where $e_t \in I_e$ and $h_t \in I_h$. The panel on the right, on the other hand, displays the conditional PMF of health status at the time of retirement. Each bar represents the following values: $\mu_{i_t=MCS|a_t=41,e_{t-1}} + \mu_{i_t=MCO|a_t=41,e_{t-1}} = 1$.

Figure 3-3 Types of Medical Expenditures: Retirees 1/

(Ratio 2/)



1/ They include people with age between 65 and 84.

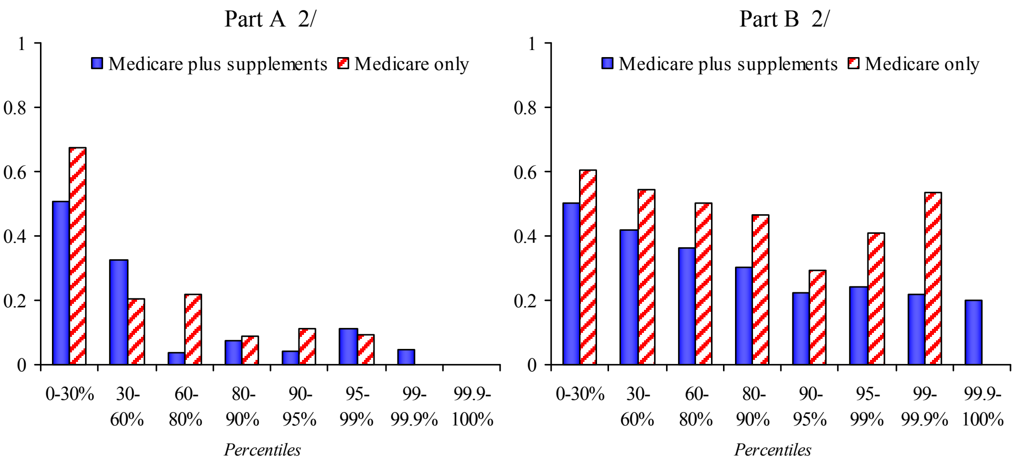
2/ Part A and Part B expenditures in total medical spending. The ratios are averaged across surveys based on sample population weights. Part A expenditures include hospital's inpatient care and home health care. Part B includes all other care.

Note: The red (solid) bar indicates a fraction of medical care consumption devoted for Medicare Part A, denoted by χ_p where $p \in I_p$.

Source: AHRQ, *Medical Expenditure Panel Surveys*, 1996-2005.

Figure 3-4 Synthetic Coinsurance Rates: Retirees

(Ratio 1/)



1/ They include people with age between 25 and 64.

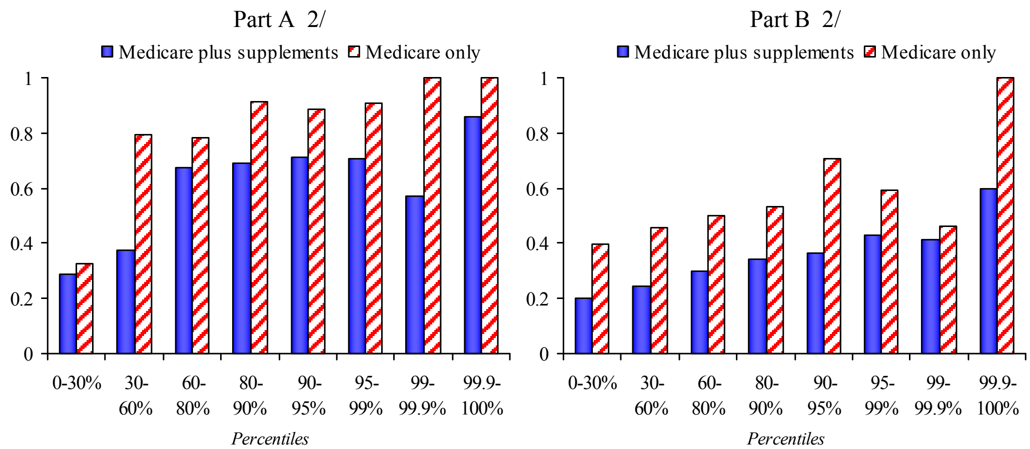
2/ Synthetic coinsurance rates are computed based on the out-of-pocket expenditures in percent of total medical care expenditures.

Note: The synthetic coinsurance rates are denoted as $\left(\sigma^{MCS}_{(A),p}, \sigma^{MCO}_{(A),p}\right)$ for retirees with a "Medicare plus supplements (*MCS*)" and a "Medicare only (*MCO*)" for Part A where $p \in I_p$. The set of synthetic coinsurance rates for Part B are denoted by $\left(\sigma^{MCS}_{(B),p}, \sigma^{MCO}_{(B),p}\right)$.

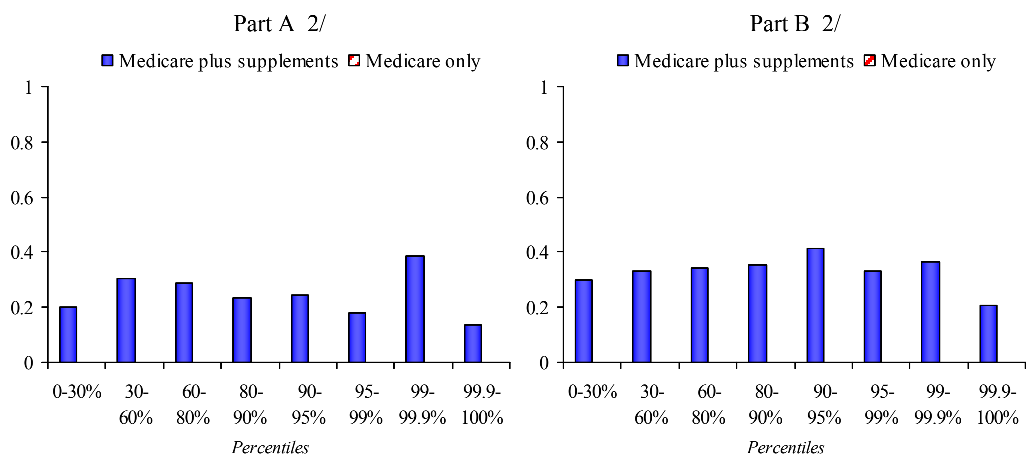
Source: AHRQ, Medical Expenditure Panel Surveys, 1996-2005.

Figure 3-5 Other Sources of Payment for Medical Expenditures: Retirees
(Ratio 1/)

(A) Medicare's Payment



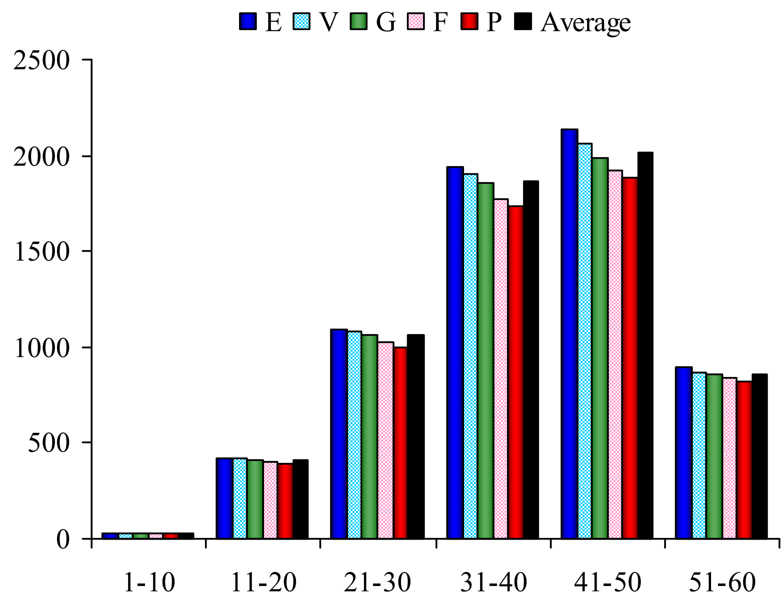
(B) Private Insurance Companies' Payments



1/ They include people with age between 65 and 84.
2/ The figure shows two sources of payments: (A) Medicare (government), and (B) the representative insurance company. Their reimbursement rates to the hospital differ across retirees with different insurance status and the magnitude of medical care consumption as well as Part A and Part B expenditure types. Part A expenditures include hospital's inpatient care and home health care. Part B includes all other care.
Note: Panel (A) shows the fraction of total medical care cost paid by the government. The rate of reimbursement for Part A is denoted by $\upsilon_{(A),p}^{MCS}\left(1-\sigma_{(A),p}^{MCS}\right)$ and $\left(1-\sigma_{(A),p}^{MCO}\right)$ for retirees with a "Medicare plus supplement (*MCS*)" and a "Medicare only (*MCO*)" policy, respectively. The rate of reimbursement for Part B is denoted by $\upsilon_{(B),p}^{MCS}\left(1-\sigma_{(B),p}^{MCS}\right)$ and $\left(1-\sigma_{(B),p}^{MCO}\right)$ where $p \in I_p$. Panel (B) shows the fraction of total cost paid by the representative insurance company. They pay to the hospital the fractions $\left(1-\upsilon_{(A),p}^{MCS}\right)\left(1-\sigma_{(A),p}^{MCS}\right)$ and $\left(1-\upsilon_{(B),p}^{MCS}\right)\left(1-\sigma_{(B),p}^{MCS}\right)$ for Part A and Part B, respectively.
Source: AHRQ; Medical Expenditure Panel Surveys, 1995-2005.

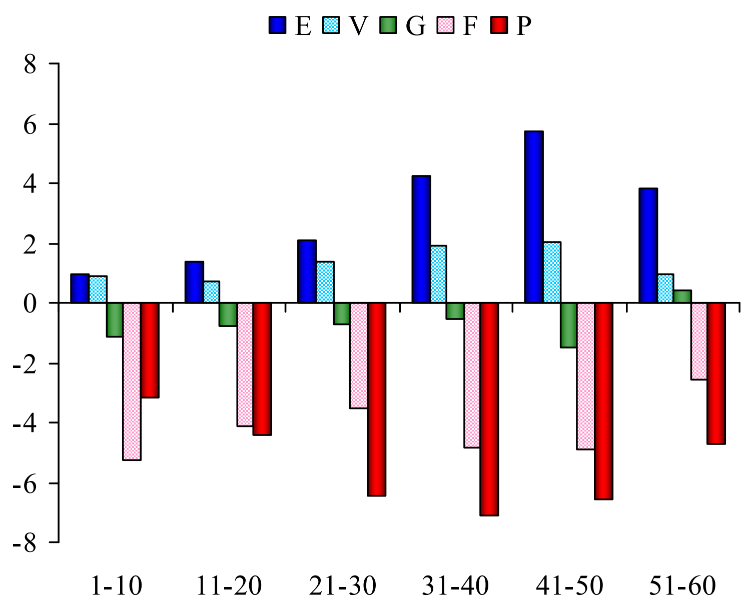
Figure 3-6 Savings by Health Status, Conditional on Age-cohorts

(1982-84 U.S. dollars)



Deviation from the Weighted Average

(Percent)

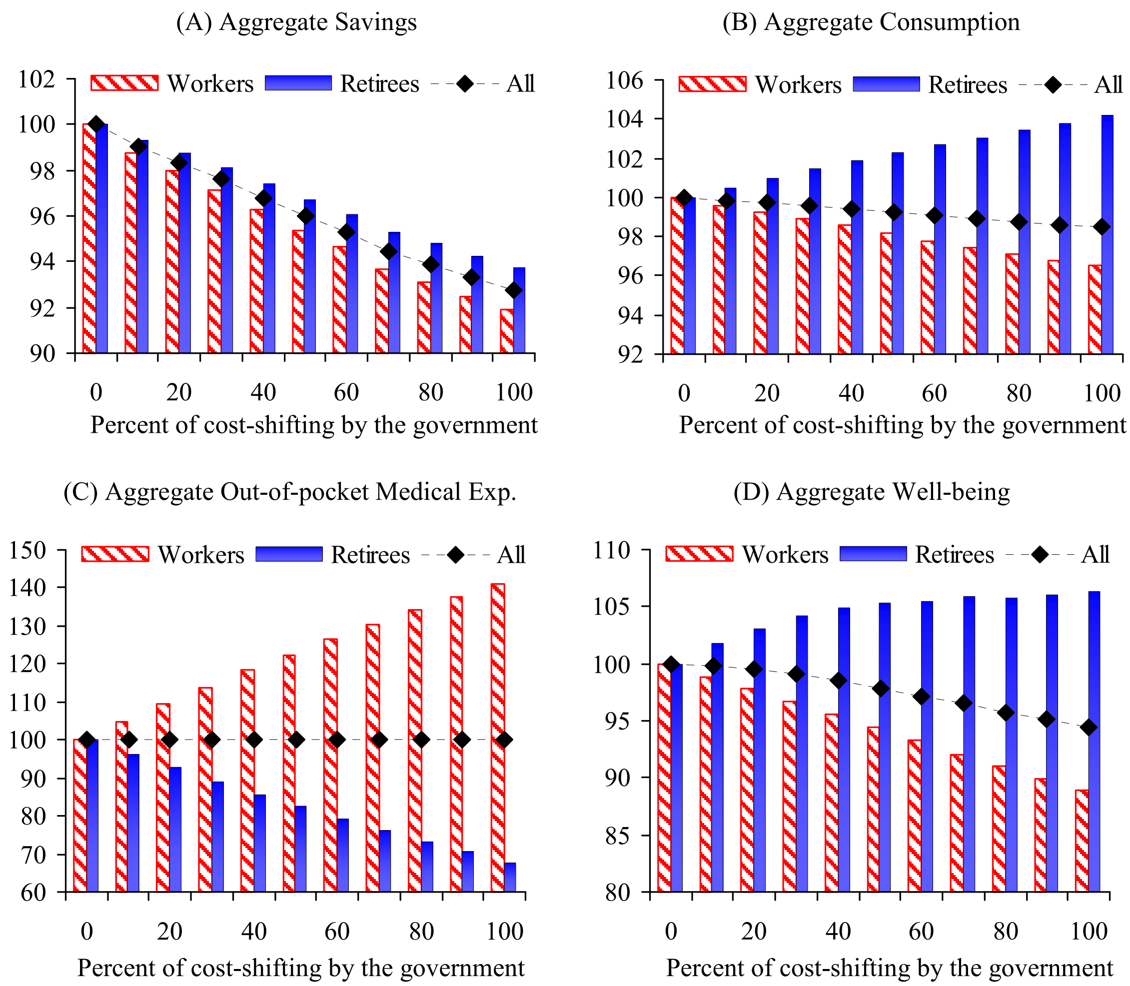


Note: Health status is labeled as "E" for excellent, "V" for very good, "G" for good, "F" for fair, and "P" for poor. The x-axis shows six 10 year age-cohorts.

Figure 3-7 Distributional Effects of Government Underpayment

(2% Excess Cost Growth and 2% Excess Demand Growth among Retirees)

(Index 1/)



1/ When cost shifting by the government is 0 percent, aggregate savings, consumption, out-of-pocket medical expenditures, and well-being are all indexed to 100. At the opposite end, the government finances the excess growth of Medicare program cost altogether by Medicare inflation tax in lieu of raising payroll and wage income taxes. In between, percent of cost-shifting by the government varies. In these cases, the government finances excess program cost by a combination of payroll and wage income taxes and Medicare inflation tax. The higher becomes the percent of cost-shifting by the government, the higher the proportion of Medicare inflation tax is in financing the excess cost.

Figure 3-8 Comparative Statics Results at the New Steady State

(Two-percent Excess Cost Growth and Two-percent Excess Demand Growth)

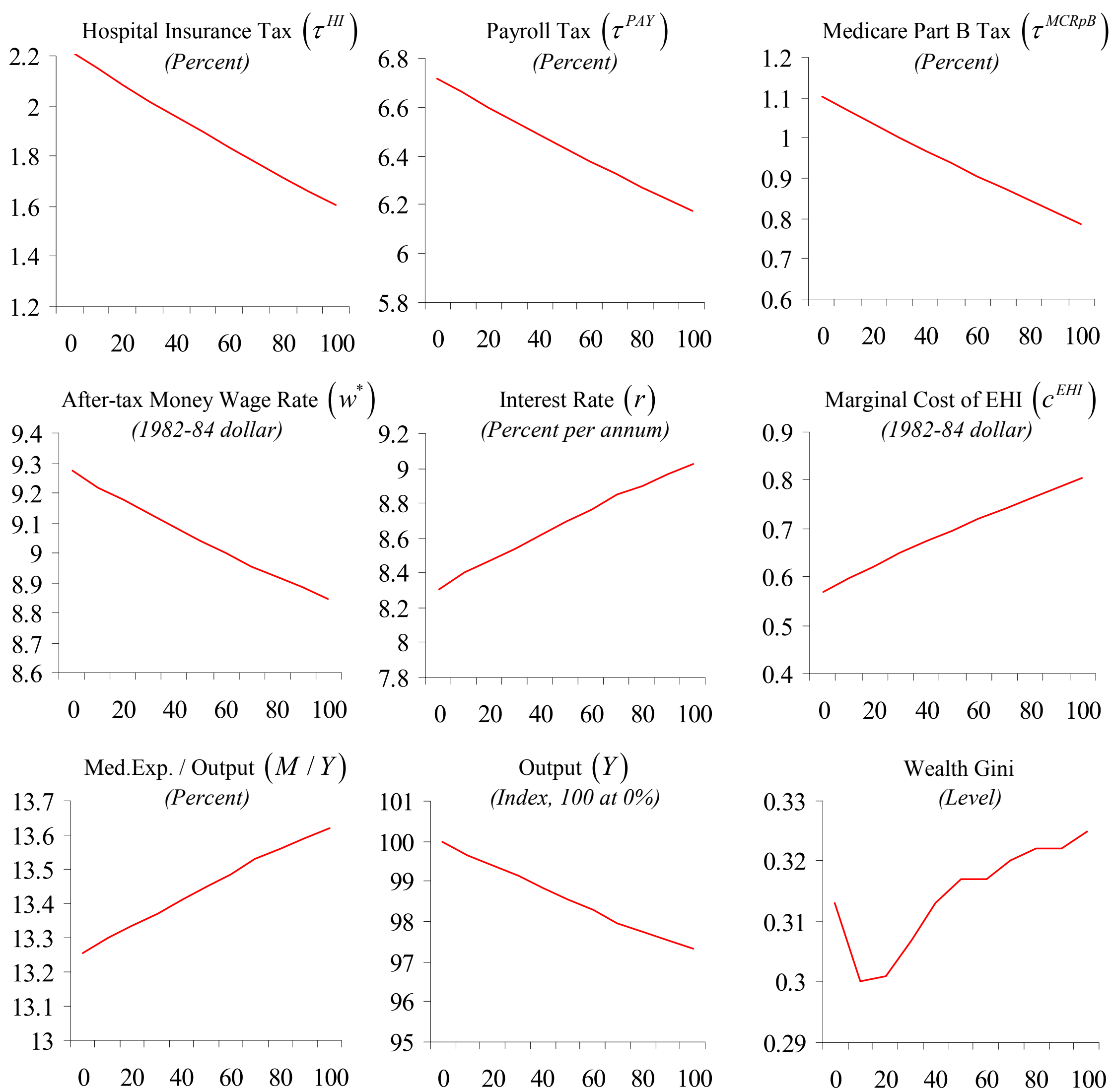
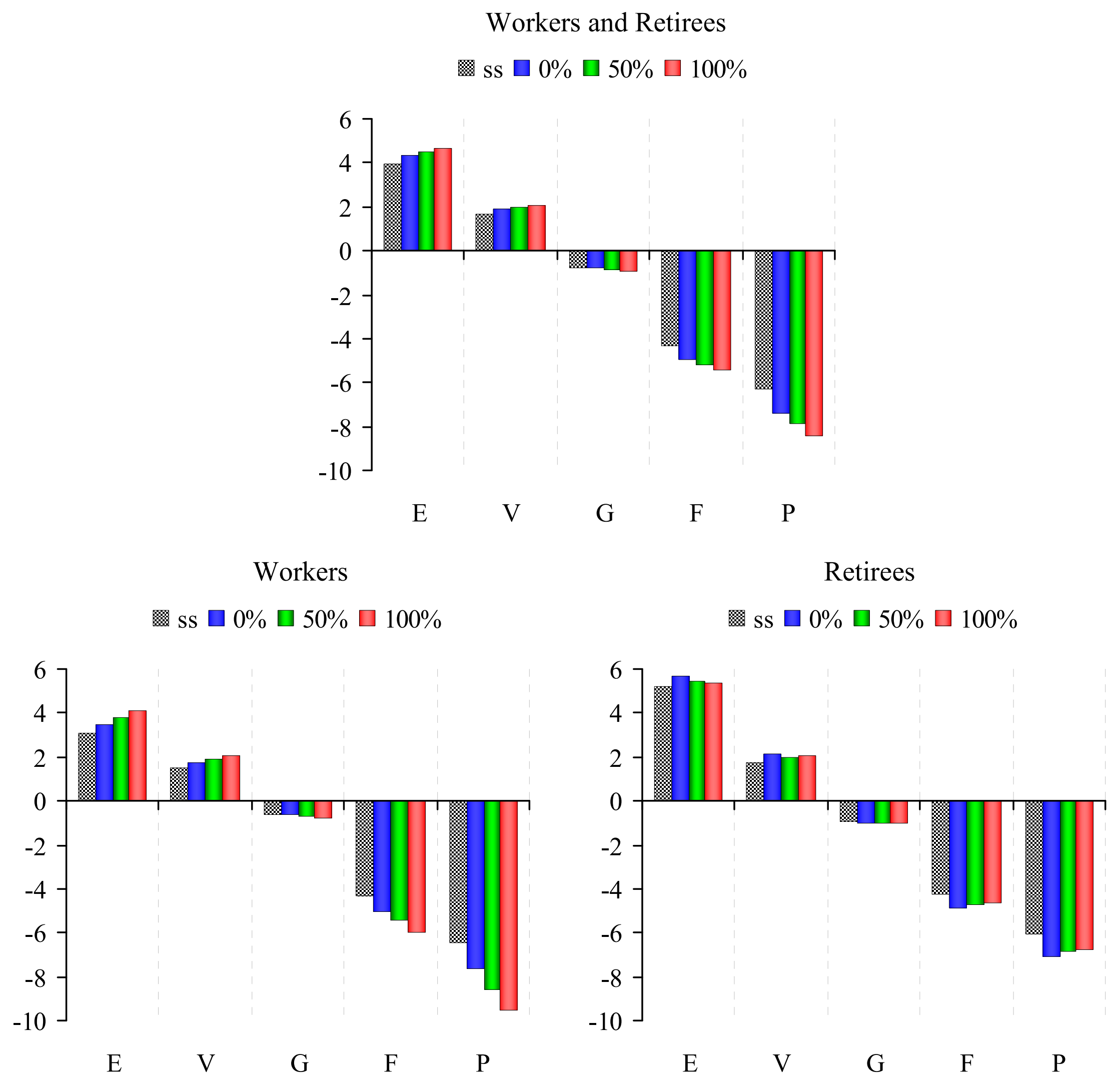


Figure 3-9 Deviation from the Average Savings by Health Status
(Percent)



Note: The label "ss" denotes the initial steady state (ss). Its deviation from the average saving is computed at time *t=0*. Labels "0%", "50%", and "100%" indicate percent of cost-shifting by the government. Their deviations from average saving are computed at the new steady state at time *t=80*.

Figure 3-10 Distribution of People in the “Medically Needy” Program
(Percent)

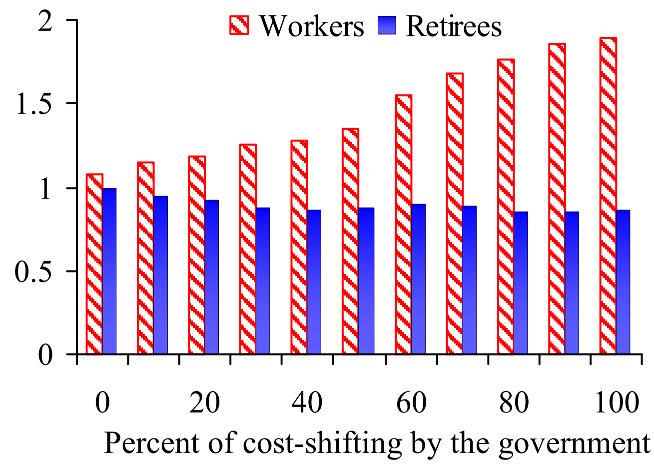
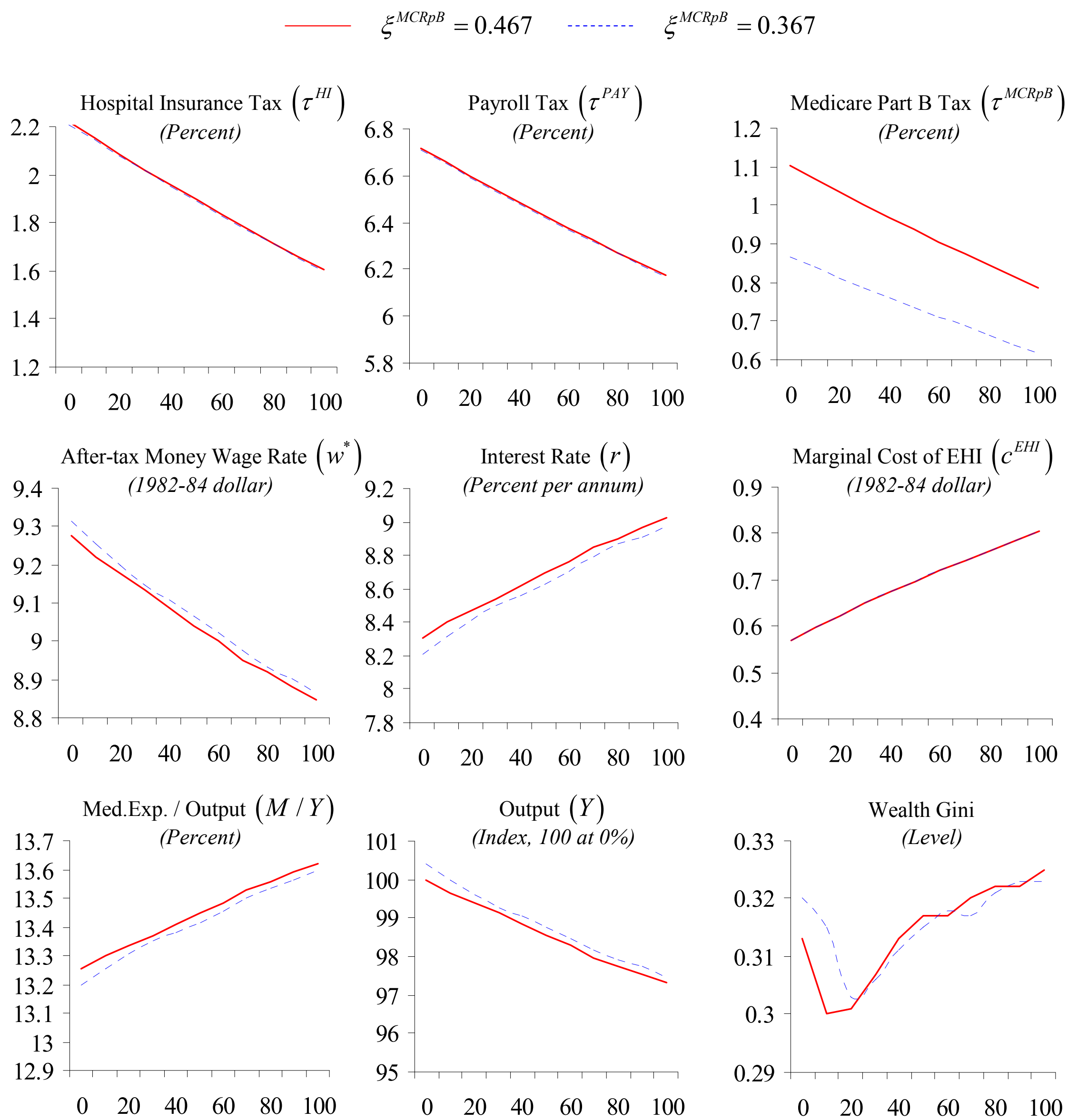


Figure 3-11 Impact of Higher Medicare Part B Premium Contributions by Retirees



TABLES

Table 3-1 Numerical Results: Benchmark
[2]

Description	Variable	Benchmark	
		Real Value 1/	Nominal Value
(1) Demographics			
Population growth rate	g_N	1.0%	
(2) Production Sector			
Mean Annual Gross Earnings		$19,647.16	$38,366.23
- Low-skilled		$11,102.39	$21,680.33
- Middle-skilled		$17,184.87	$33,557.96
- High-skilled		$32,272.89	$63,021.27
Wage rate (Hourly)	w	$9.44	$18.43
Interest rate (Annual)	r	8.3%	10.4%
Marginal cost of EHI (Hourly equivalent)	c^{EHI}	$0.47	$0.91
EHI premium (Annual)	Ω^{EHI}	$775.75	$2,766.60
EHI premium contribution rate	ξ^{EHI}	82.0%	82.0%
EHI participation rate	ζ^{EHI}	87.5%	87.5%
Share of capital in production	α	0.36	0.36
Rate of depreciation of capital	δ_K	6.0%	6.0%
Total Factor Productivity	A	1.00	1.00
Labor augmented technological progress	g_z	2.0%	2.0%
Fixed hours of labor supply (normalized 2/)	l	0.238	
(3) Consumers			
CRRA on consumption	γ^C	3.7	
CRRA on health	γ^H	3.7	
Weight placed on the utility of health	η	1.0	
Growth rate of weight	g_H	2.0%	
Discount factor	β	0.99	
(4) Tax rates			
Payroll	τ^{PAY}	6.02%	
Social Security	τ^{SS}	4.53%	
Hospital Insurance	τ^{HI}	1.49%	
Federal Labor Income (Medicare Part B)	τ^{fpB}	0.74%	
Federal Labor Income (Medically Needy)	τ^{fMN}	0.15%	
(5) Government Program			
Social security program, replacement rate	θ	35.0%	35.0%
Medicare Part B premium (Annual)	Ω^{MCpB}	$315.65	$938.64
Private supplemental policy premium (Annual)	Ω^{MCS}	$933.64	$2,776.34
Rate of contribution to the Meciare Part B premium	ξ^{MCpB}	46.7%	46.7%

Table 3-1 (continued) Numerical Results: Benchmark

(6) Aggregate Variables:			
(Billions of US$)			
Output	*Y*	$4,415.41	$8,622.25
Consumption of commodities	*C*	$2,905.51	$5,673.77
Medical care goods and services	*M*	$393.49	$768.39
Investment	*I*	$1,115.85	$2,178.99
Discrepancy		$0.56	$1.10
(Percent of output)			
Consumption of commodities	*C*	65.8%	65.8%
Medical care goods and services	*M*	8.9%	8.9%
Investment	*I*	25.3%	25.3%
Discrepancy		0.01%	0.01%
(7) Miscellaneous			
Mean Annual Gross Earnings		$21,531.96	$42,046.80
Capital-Output ratio	*K/Y*	2.80	2.80
"Medically Needy" Program (*Millons of US$*)		$54.75	$106.91
Poverty threshold *(Single person)*		$5,107.13	$9,973.00
(8) Prices 3/			
Aggregate price index	*PA*	195.28	
Price index excluding medical care goods and service	*PC*	188.71	
Medical care goods and services	*PM*	323.23	
Working generations	*PMy*	356.64	
Retired generations	*PMo*	297.37	
Weight placed on PM for computing PA.	bartheta	0.0636	
(9) Hospital: Payment-to-cost ratio:			
Workers		1.10	
Retirees	baromega	0.92	

1/ We use CPI to deflate the nominal values. Since the U.S. CPI has a base 1982-84=100, the real values share the same base.
2/ Labor hours is fixed and normalized. Assuming that there are 5 working days per week, the normalized value of 0.3 translates into 36 hours of work per week on average.
3/ Prices indices have a base, 1982-84=100.

Table 3-2 Growth Rate of Key Variables on the Balanced Growth Path

Descriptions	Variables	Real 1/	Nominal 1/
Population growth rate	g_N	1.0%	
Labor augmented technological progress	g_z	2.0%	
Inflation	$P^A, P^C, P^M, P^{My}, P^{Mo}$	2.0%	
(1) Production Sector			
Wage rate (Hourly)	w	0.0%	2.0%
Interest rate (Annual)	r	0.0%	2.0%
Marginal cost of EHI (Hourly equivalent)	c^{EHI}	0.0%	2.0%
EHI premium (Annual)	Ω^{EHI}	2.0%	4.0%
(2) Government Program			
Medicare Part B premium (Annual)	Ω^{MCpB}	2.0%	4.0%
Medicare supplemental policy premium (Annual)	Ω^{MCS}	2.0%	4.0%
(3) Aggregate Variables:			
Output	Y	3.0%	5.0%
Consumption of commodities	C	3.0%	5.0%
Medical care goods and services	M	3.0%	5.0%
Investment	I	3.0%	5.0%
(4) Miscellaneous			
Output per capita	Y/N	2.0%	4.0%
Capital-Output ratio	K/Y	0.0%	0.0%
Poverty threshold *(Single person)*		0.0%	2.0%

1/ Changes are based on a year-over-year on the balanced growth path.

Table 3-3 Medical-Care Price Inflation: Workers and Retirees, 4 Percent Hospital-cost Growth and 4 Percent Medical Demand Growth by Retirees
(*Percent per annum*)

(A) Workers

Period	Steady state	Percent of cost-shifting 1/ 0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1	2.00	4.19	4.63	5.06	5.49	5.93	6.36	6.80	7.23	7.67	8.10	8.54
2	2.00	4.19	4.64	5.08	5.51	5.94	6.36	6.77	7.17	7.57	7.96	8.35
3	2.00	4.20	4.66	5.10	5.53	5.95	6.35	6.74	7.12	7.48	7.84	8.18
4	2.00	4.20	4.67	5.12	5.55	5.95	6.34	6.71	7.07	7.40	7.72	8.03
5	2.00	4.20	4.69	5.14	5.56	5.96	6.34	6.69	7.02	7.33	7.62	7.89
6	2.00	4.21	4.70	5.16	5.58	5.97	6.33	6.66	6.97	7.25	7.52	7.76
7	2.00	4.21	4.72	5.18	5.60	5.98	6.32	6.64	6.93	7.19	7.42	7.64
8	2.00	4.22	4.74	5.20	5.61	5.99	6.32	6.62	6.88	7.12	7.34	7.53
9	2.00	4.22	4.75	5.22	5.63	5.99	6.31	6.59	6.84	7.06	7.25	7.42
10	2.00	4.22	4.77	5.24	5.65	6.00	6.31	6.57	6.81	7.01	7.18	7.33
11	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

(B) Retirees

Period	Steady state	Percent of cost-shifting 1/ 0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
2	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
3	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
4	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
5	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
6	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
7	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
8	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
9	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
10	2.00	4.00	3.60	3.21	2.81	2.42	2.02	1.62	1.23	0.83	0.43	0.04
11	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

1/ The deviation from the steady state starts at period 1 and continues through period 10. "0%" of cost shifting indicates that the government finances excess program cost in full by raising taxes. In this scenario, the government keeps the reimbursement rate fixed. "100%" cost shifting means that the government lowers the reimbursement rate so that hospitals must shift the excess program cost to workers.

Note: Excess hospital-cost growth is 2 percent, and excess medical demand by retirees is 2 percent from period 1 through 10. Cost and demand go back to the steady state growth of 2 percent per year after.

Table 3-4 Payment-to-cost Ratio: Workers and Retirees, 4 Percent Hospital-cost Growth and 4 Percent Medical Demand Growth by Retirees

(A) Workers

		Percent of cost-shifting 1/										
Period	Steady state	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	1.103	1.103	1.103	1.103	1.103	1.103	1.103	1.103	1.103	1.103	1.103	1.103
1	1.103	1.105	1.110	1.114	1.119	1.124	1.128	1.133	1.137	1.142	1.147	1.151
2	1.103	1.107	1.117	1.126	1.135	1.145	1.154	1.163	1.172	1.181	1.190	1.199
3	1.103	1.109	1.124	1.138	1.152	1.166	1.180	1.194	1.207	1.221	1.234	1.248
4	1.103	1.112	1.131	1.150	1.169	1.188	1.206	1.225	1.243	1.261	1.279	1.296
5	1.103	1.114	1.138	1.163	1.187	1.210	1.234	1.256	1.279	1.301	1.323	1.344
6	1.103	1.116	1.146	1.176	1.205	1.233	1.261	1.289	1.315	1.342	1.368	1.393
7	1.103	1.118	1.154	1.189	1.223	1.257	1.289	1.321	1.353	1.383	1.413	1.442
8	1.103	1.121	1.162	1.203	1.242	1.281	1.318	1.355	1.390	1.424	1.458	1.491
9	1.103	1.123	1.171	1.217	1.262	1.305	1.347	1.388	1.428	1.466	1.504	1.540
10	1.103	1.125	1.179	1.231	1.282	1.330	1.377	1.423	1.467	1.509	1.550	1.589
11	1.103	1.125	1.179	1.231	1.282	1.330	1.377	1.423	1.467	1.509	1.550	1.589

(B) Retirees

		Percent of cost-shifting 1/										
Period	Steady state	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920
1	0.920	0.920	0.916	0.913	0.909	0.906	0.902	0.899	0.895	0.892	0.888	0.885
2	0.920	0.920	0.913	0.906	0.899	0.892	0.885	0.878	0.872	0.865	0.858	0.851
3	0.920	0.920	0.910	0.899	0.889	0.879	0.868	0.858	0.848	0.838	0.829	0.819
4	0.920	0.920	0.906	0.892	0.879	0.865	0.852	0.839	0.826	0.813	0.800	0.788
5	0.920	0.920	0.903	0.885	0.869	0.852	0.836	0.820	0.804	0.788	0.773	0.758
6	0.920	0.920	0.899	0.879	0.859	0.839	0.820	0.801	0.782	0.764	0.746	0.729
7	0.920	0.920	0.896	0.872	0.849	0.826	0.804	0.783	0.761	0.741	0.721	0.701
8	0.920	0.920	0.892	0.865	0.839	0.814	0.789	0.765	0.741	0.718	0.696	0.674
9	0.920	0.920	0.889	0.859	0.830	0.801	0.774	0.747	0.721	0.696	0.672	0.649
10	0.920	0.920	0.886	0.852	0.820	0.789	0.759	0.730	0.702	0.675	0.649	0.624
11	0.920	0.920	0.886	0.852	0.820	0.789	0.759	0.730	0.702	0.675	0.649	0.624

1/ The deviation from the steady state starts at period 1 and continues through period 10. "0%" of cost shifting indicates that the government finances excess program cost in full by raising taxes. In this scenario, the government keeps the reimbursement rate fixed. "100%" cost shifting means that the government lowers the reimbursement rate so that hospitals must shift the excess program cost to workers.

Note: Excess hospital-cost growth is 2 percent, and excess medical demand by retirees is 2 percent from period 1 through 10. Cost and demand go back to the steady state growth of 2 percent per year after.

Table 3-5 Rates of Medicare Inflation Tax and Subsidies
4 Percent Hospital-cost Growth and 4 Percent Medical Demand Growth by Retirees
(*Percent*)

(A) Workers

		Percent of cost-shifting 1/										
Period	Steady state	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.191	0.625	1.060	1.494	1.929	2.363	2.797	3.232	3.666	4.101	4.535
2	0.000	0.194	0.640	1.080	1.512	1.938	2.356	2.768	3.174	3.572	3.965	4.351
3	0.000	0.198	0.656	1.100	1.530	1.946	2.350	2.740	3.118	3.485	3.839	4.183
4	0.000	0.201	0.671	1.120	1.547	1.955	2.343	2.713	3.066	3.403	3.723	4.029
5	0.000	0.205	0.687	1.140	1.564	1.963	2.337	2.688	3.017	3.326	3.616	3.888
6	0.000	0.208	0.703	1.160	1.581	1.971	2.331	2.663	2.970	3.254	3.516	3.757
7	0.000	0.212	0.719	1.180	1.598	1.979	2.325	2.639	2.926	3.186	3.423	3.638
8	0.000	0.216	0.735	1.200	1.615	1.986	2.319	2.617	2.883	3.122	3.336	3.527
9	0.000	0.219	0.752	1.219	1.631	1.993	2.313	2.595	2.843	3.062	3.255	3.424
10	0.000	0.223	0.768	1.239	1.647	2.000	2.307	2.574	2.805	3.006	3.179	3.328
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(B) Retirees

		Percent of cost-shifting 1/										
Period	Steady state	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
2	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
3	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
4	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
5	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
6	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
7	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
8	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
9	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
10	0.000	0.000	-0.396	-0.792	-1.188	-1.585	-1.981	-2.377	-2.773	-3.169	-3.565	-3.962
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1/ The deviation from the steady state starts at period 1 and continues through period 10. “0%” of cost shifting indicates that the government finances excess program cost in full by raising taxes. In this scenario, the government keeps the reimbursement rate fixed. “100%” cost shifting means that the government lowers the reimbursement rate so that hospitals must shift the excess program cost to workers.

Note: Excess hospital-cost growth is 2 percent, and excess medical demand by retirees is 2 percent from period 1 through 10. Cost and demand go back to the steady state growth of 2 percent per year after.

APPENDIX

A 3 Appendix

A 3.1 Pre-existing Price Distortion and Medical Price Inflation

When retirees' medical demand grows faster than workers' medical demand, pre-existing price distortion in health care market causes workers' medical price inflation to be higher than the growth rate of hospital's average cost.

Proof:

Suppose that the excess growth of hospital's average cost is ε^M , and the excess growth of retirees' medical demand is ε^Z . Assume that the government keeps pre-existing price distortion at:

$$\omega_t = \omega_{t+1} = \cdots = \omega_{t+s-1} = \omega_{t+s} \in (0,1) \;\; \forall s .$$

Workers' medical price in period *t+s* is expressed as:

$$\begin{aligned} P_{t+s}^{M^Y} &= AC_{t+s}^M \left\{ (1-\omega_{t+s}) \frac{M_{t+s}^O}{M_{t+s}^Y} + 1 \right\} \\ &= \left(1+\pi+\varepsilon^M\right)^s AC_t^M \left\{ (1-\omega_{t+s}) \frac{\left(1+g_Z+\varepsilon^Z\right)^s M_t^O}{\left(1+g_Z\right)^s M_t^Y} + 1 \right\} \\ &= \left(1+\pi+\varepsilon^M\right) P_{t+s-1}^{M^Y} \left(1+T_{t+s-1}^{M^Y}\right) \end{aligned}$$

$$\text{where } T_{t+s-1}^{M^Y} = \frac{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^s \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}}{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-1} \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}} - 1 > 0 \qquad [3\text{-}43]$$

We have $\lim_{\varepsilon^Z = 0} T_{t+s-1}^{M^Y} = 0$ so that $\lim_{\varepsilon^Z = 0} P_{t+s}^{M^Y} = \left(1+\pi+\varepsilon^M\right) P_{t+s-1}^{M^Y}$.

A 3.2 Acceleration of Workers' Medical Price Inflation

Workers face accelerating medical-price inflation when retirees' medical demand grows faster than workers' medical demand under the pre-existing price distortion in health care market.

Proof:

$$T_{t+s-1}^{M^Y} = \frac{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s} \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}}{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-1} \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}} - 1$$

$$T_{t+s-2}^{M^Y} = \frac{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-1} \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}}{\left\{ (1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-2} \left(\frac{M_t^O}{M_t^Y} \right) + 1 \right\}} - 1$$

We have $T_{t+s-1}^{M^Y} > T_{t+s-2}^{M^Y}$ if

$$\frac{(1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s} \left(\frac{M_t^O}{M_t^Y} \right) + 1}{(1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-1} \left(\frac{M_t^O}{M_t^Y} \right) + 1} > \frac{(1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-1} \left(\frac{M_t^O}{M_t^Y} \right) + 1}{(1-\omega_t) \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-2} \left(\frac{M_t^O}{M_t^Y} \right) + 1}$$

$$(1-\omega_t) \left(\frac{M_t^O}{M_t^Y} \right) \left(\frac{\varepsilon^Z}{1+g_Z} \right)^2 \left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z} \right)^{s-2} > 0$$

Hence workers face accelerating inflation of medical price when retirees' medical demand grows faster than workers' medical demand under the pre-existing price distortion in the medical care sector.

A 3.3 Dynamic Cost Shifting under Excess Growth of Medicare Cost

Suppose that the excess growth of hospital's average cost is ε^{M}, and the excess growth of retirees' medical demand is ε^{Z}. In order to keep the balanced budget condition, the government must set the tax rate τ to equate the following condition:

$$(1-\xi)P_{t+s}^{M^O}M_{t+s}^{O}=\tau_{t+s}P_{t+s}^{A}w_{t+s}$$
$$\left(1+\pi+\varepsilon^{M}\right)^{s}\left(1+g_{Z}+\varepsilon^{Z}\right)^{s}(1-\xi)P_{t}^{M^O}M_{t}^{O}=\tau_{t+s}P_{t+s}^{A}w_{t+s}$$

The excess cost of Medicare program $\mathrm{E}_{t+s}\left(\varepsilon^{M},\varepsilon^{Z}\right)$ is defined as:

$$\mathrm{E}_{t+s}\left(\varepsilon^{M},\varepsilon^{Z}\right)=\left\{\left(1+\pi+\varepsilon^{M}\right)^{s}\left(1+g_{Z}+\varepsilon^{Z}\right)^{s}-(1+\pi)^{s}\left(1+g_{Z}\right)^{s}\right\}(1-\xi)P_{t}^{M^O}M_{t}^{O}$$

If the government shift α percent of the excess cost $\mathrm{E}_{t+s}\left(\varepsilon^{M},\varepsilon^{Z}\right)$ to workers and finance the remainder of the excess cost $(1-\alpha)\mathrm{E}_{t+s}\left(\varepsilon^{M},\varepsilon^{Z}\right)$ by wage taxation, the tax rate must increase to:

$$(1+\pi)^{s}\left(1+g_{Z}\right)^{s}(1-\xi)P_{t}^{M^O}M_{t}^{O}+(1-\alpha)\mathrm{E}_{t+s}\left(\varepsilon^{M},\varepsilon^{Z}\right)=\tau_{t+s}P_{t+s}^{A}w_{t+s}$$
$$\frac{\left\{(1-\alpha)\left(1+\pi+\varepsilon^{M}\right)^{s}\left(1+g_{Z}+\varepsilon^{Z}\right)^{s}+\alpha(1+\pi)^{s}\left(1+g_{Z}\right)^{s}\right\}}{\left[(1+\pi)^{1-\vartheta}\left(1+\pi+\varepsilon^{M}\right)^{\vartheta}\right]^{s}\left(1+g_{Z}\right)^{s}}(1-\xi)P_{t}^{M^O}M_{t}^{O}=\tau_{t+s}P_{t}^{A}w_{t}$$

[3-44]

When the government shifts the excess growth of Medicare program cost by 100% $(\alpha=1)$, the equation [3-44] becomes:

$$\tau_{t+s}=\left(\frac{1+\pi}{(1+\pi)^{1-\vartheta}\left(1+\pi+\varepsilon^{M}\right)^{\vartheta}}\right)^{s}\frac{(1-\xi)P_{t}^{M^O}M_{t}^{O}}{P_{t}^{A}w_{t}}\approx\tau_{t}$$

When the government does not shift at all $(\alpha=0)$, the equation [3-44] becomes:

$$\tau_{t+s}=\left(\frac{1+\pi+\varepsilon^{M}}{1+\pi}\right)^{s(1-\vartheta)}\left(\frac{1+g_Z+\varepsilon^{Z}}{1+g_Z}\right)^{s}\frac{(1-\xi)P_t^{M^O}M_t^O}{P_t^A w_t}$$
$$=\left(1+\frac{\varepsilon^{M}}{1+\pi}\right)^{s(1-\vartheta)}\left(1+\frac{\varepsilon^{Z}}{1+g_Z}\right)^{s}\tau_t>\tau_t$$

When the government partially shift the excess program cost $(0<\alpha<1)$,

$$\tau_{t+s}=\frac{\left\{(1-\alpha)\left(1+\pi+\varepsilon^M\right)^s\left(1+g_Z+\varepsilon^Z\right)^s+\alpha(1+\pi)^s\left(1+g_Z\right)^s\right\}}{\left[(1+\pi)^{1-\vartheta}\left(1+\pi+\varepsilon^M\right)^{\vartheta}\right]^s\left(1+g_Z+\varepsilon^Z\right)^s}\tau_t$$

We also know that $P_{t+s}^{M^O}=\omega_{t+s}P_{t+s}^{M}=\left(1-\Delta_{t+s}^{\omega}\right)\omega_t P_{t+s}^{M}$. The following equation must hold:

$$\left\{(1-\alpha)\left(1+\pi+\varepsilon^M\right)^s\left(1+g_Z+\varepsilon^Z\right)^s+\alpha(1+\pi)^s\left(1+g_Z\right)^s\right\}(1-\xi)\omega_t P_t^M M_t^O$$
$$=(1-\xi)\left(1-\Delta_{t+s}^{\omega}\right)\omega_t P_{t+s}^M M_{t+s}^O$$
$$\left\{(1-\alpha)\left(1+\pi+\varepsilon^M\right)^s\left(1+g_Z+\varepsilon^Z\right)^s+\alpha(1+\pi)^s\left(1+g_Z\right)^s\right\}(1-\xi)\omega_t P_t^M M_t^O$$
$$=(1-\xi)\left(1-\Delta_{t+s}^{\omega}\right)\omega_t\left(1+\pi+\varepsilon^M\right)^s P_t^M\left(1+g_Z+\varepsilon^Z\right)^s M_t^O$$
$$\Delta_{t+s}^{\omega}=\alpha\left\{1-\left(\frac{(1+\pi)\left(1+g_Z\right)}{\left(1+\pi+\varepsilon^M\right)\left(1+g_Z+\varepsilon^Z\right)}\right)^s\right\}\text{ where }\Delta_{t+s}^{\omega}(\alpha=0)=0$$

[3-45]

Workers and retirees face the medical prices $\left(P_{t+s}^{M^Y}\right)^{C/S}$ and $\left(P_{t+s}^{M^O}\right)^{C/S}$ at period t+s where

$$\left(P_{t+s}^{M^Y}\right)^{C/S}=AC_{t+s}^M\left\{\left(1-\omega_{t+s}\right)\frac{M_{t+s}^O}{M_{t+s}^Y}+1\right\}$$
$$=\left(1+\pi+\varepsilon^M\right)^s AC_t^M\left[\left\{1-\left(1-\Delta_{t+s}^{\omega}\right)\omega_t\right\}\left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z}\right)^s\left(\frac{M_t^O}{M_t^Y}\right)+1\right]$$
$$=\left(1+\pi+\varepsilon^M\right)\left(P_{t+s-1}^{M^Y}\right)^{C/S}\left\{1+\left(T_{t+s-1}^{M^Y}\right)^{C/S}\right\}$$

[3-46]

$$\text{where } \left(T_{t+s-1}^{M^Y}\right)^{C/S} = \frac{\left\{1-\left(1-\Delta_{t+s}^{\omega}\right)\omega_t\right\}\left(\dfrac{1+g_Z+\varepsilon^Z}{1+g_Z}\right)^s\left(\dfrac{M_t^O}{M_t^Y}\right)+1}{\left\{1-\left(1-\Delta_{t+s-1}^{\omega}\right)\omega_t\right\}\left(\dfrac{1+g_Z+\varepsilon^Z}{1+g_Z}\right)^{s-1}\left(\dfrac{M_t^O}{M_t^Y}\right)+1}-1>0$$

$$\begin{aligned}\left(P_{t+s}^{M^O}\right)^{C/S} &= \omega_{t+s}P_{t+s}^{M} \\ &= \left(1-\Delta_{t+s}^{\omega}\right)\omega_t\left(1+\pi+\varepsilon^M\right)^s P_t^M \\ &= \left(1+\pi+\varepsilon^M\right)\left(P_{t+s-1}^{M^O}\right)^{C/S}\left\{1-\left(T_{t+s-1}^{M^O}\right)^{C/S}\right\}\end{aligned}$$

[3-47]

$$\text{where } \left(T_{t+s-1}^{M^O}\right)^{C/S} = \frac{\Delta_{t+s}^{\omega}-\Delta_{t+s-1}^{\omega}}{1-\Delta_{t+s-1}^{\omega}}>0 \quad \text{since } \Delta_{t+s}^{\omega}>\Delta_{t+s-1}^{\omega}.$$

A 3.4 Magnitude of Medical Price Inflation

The larger the cut in the reimbursement rate, the higher becomes the medical price paid by workers. (Dynamic cost shifting) In addition, workers' medical price inflation becomes higher, the larger the cut is.

Proof:

The government cuts the reimbursement rate $\omega \in (0,1)$ by Δ_{t+s}^{ω} in period *t+s* by raising the percent of cost-shifting $(\alpha \uparrow)$. Based on [3-45], we have:

$$\frac{\partial \Delta_{t+s}^{\omega}}{\partial \alpha} = 1-\left(\frac{(1+\pi)(1+g_Z)}{\left(1+\pi+\varepsilon^M\right)\left(1+g_Z+\varepsilon^Z\right)}\right)^s > 0 \text{ and}$$

$$\frac{\partial \Delta_{t+s-1}^{\omega}}{\partial \alpha} = 1-\left(\frac{(1+\pi)(1+g_Z)}{\left(1+\pi+\varepsilon^M\right)\left(1+g_Z+\varepsilon^Z\right)}\right)^{s-1} > 0$$

Since $\dfrac{\partial \Delta_{t+s}^{\omega}}{\partial \alpha} > \dfrac{\partial \Delta_{t+s-1}^{\omega}}{\partial \alpha}$, we obtain: $\dfrac{\partial\left(T_{t+s-1}^{M^Y}\right)^{C/S}}{\partial \alpha} > 0$.

A 3.5 Medicare Inflation Tax

Based on [3-46], Medicare inflation tax rate is defined as

$$\left(T_{t+s-1}^{M^Y}\right)^{C/S} = \frac{\left\{1-\left(1-\Delta_{t+s}^{\omega}\right)\omega_t\right\}\left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z}\right)^{s}\left(\frac{M_t^O}{M_t^Y}\right)+1}{\left\{1-\left(1-\Delta_{t+s-1}^{\omega}\right)\omega_t\right\}\left(\frac{1+g_Z+\varepsilon^Z}{1+g_Z}\right)^{s-1}\left(\frac{M_t^O}{M_t^Y}\right)+1}-1>0$$

[3-48]

When the government does not cut the reimbursement rate $(\alpha = 0)$, the Medicare inflation tax [3-48] becomes the same as the expression [3-43]. As workers pay Medicare inflation tax, retirees receive subsidies. The rate of Medicare subsidies is:

$$\left(T_{t+s-1}^{M^O}\right)^{C/S} = \frac{\Delta_{t+s}^{\omega}-\Delta_{t+s-1}^{\omega}}{1-\Delta_{t+s-1}^{\omega}} > 0$$

[3-49]

A 3.6 Insurance Status

We use $\Lambda_{i\times i}^{a,e}$ to denote a time-invariant conditional transition matrix of insurance status (*i*), $i \in I_i^Y$ for workers. This conditional transition matrix depends on age (*a*) and earning ability (*e*). We impose a condition that health status does not control the transition of insurance status. When agents make a transition to their retirement at age 65 (model period of 41), they face another transition matrix that depends on their health status (*h*), $h \in I_h$ as well as their earning ability. I specify the conditional transition matrix at the time before retirement by $\Lambda_{i\times i}^{a,e,h}$. During the retirement, the model imposes a condition that agents' insurance status will not change. They carry insurance status (*i*), $i \in I_i^O$ that is determined at the time of retirement for the remainder of their lives. Based on these assumptions, I have the following time-invariant conditional transition matrices:

(1) Working period: $a_t \in \{1,...,39\}$

$$\Lambda_{i\times i}^{a,e}=\begin{bmatrix}\lambda_{EHI,EHI}^{a,e} & \lambda_{EHI,UNI}^{a,e}\\ \lambda_{UNI,EHI}^{a,e} & \lambda_{UNI,UNI}^{a,e}\end{bmatrix}$$

$$\text{where} \sum_{i_{t+1}\in I_i^Y}\lambda_{i_t,i_{t+1}}^{a,e}=1 \quad \forall i_t \in I_i^Y$$

$$\lambda_{i_t,i_{t+1}}^{a,e}=\mathrm{P}\left(I_i^Y=i_{t+1}\middle|I_i^Y=i_t, I_a=a_{t+1}, I_e=e_{t+1}\right)$$

(2) At the last working period: $a_t=40$

$$\Lambda_{i\times i}^{a,e,h}=\begin{bmatrix}\lambda_{EHI,MCS}^{a,e,h} & \lambda_{EHI,MCO}^{a,e,h}\\ \lambda_{UNI,MCS}^{a,e,h} & \lambda_{UNI,MCO}^{a,e,h}\end{bmatrix}$$

$$\text{where} \sum_{i_{t+1}\in I_i^O}\lambda_{i_t,i_{t+1}}^{a,e,h}=1 \quad \forall i_t \in I_i^Y$$

$$\lambda_{i_t,i_{t+1}}^{a,e,h}=\mathrm{P}\left(I_i^O=i_{t+1}\middle|I_i^Y=i_t, I_a=a_{t+1}, I_e=e_{t+1}, I_h=h_t\right)$$

(3) Retirement phase: $a_t \in \{41,...,60\}$

$$\Lambda_{i\times i}^{a,e,h}=\begin{bmatrix}\lambda_{MCS,MCS}^{a,e,h} & \lambda_{MCS,MCO}^{a,e,h}\\ \lambda_{MCO,MCS}^{a,e,h} & \lambda_{MCO,MCO}^{a,e,h}\end{bmatrix}$$

$$\text{where } \lambda_{MCS,MCS}^{a,e,h}=\lambda_{MCO,MCO}^{a,e,h}=1 \text{ and } \lambda_{MCS,MCO}^{a,e,h}=\lambda_{MCO,MCS}^{a,e,h}=0$$

A 3.7 A Private Supplemental Coverage for Retirees (MCS)

The representative insurance company also offers a supplemental coverage (i.e., Medigap) to retirees. Upon retirement, nature sorts them into two categories of insurance status. Those with Medicare plus a private supplemental coverage pay an extra premium to get an additional coverage. Retirees can lower their out-of-pocket medical expenditures with this supplemental insurance coverage.

The total disbursement of the supplemental insurance for the representative insurance company is:

$$EXP_t^{MCS} =$$

$$\left(\begin{array}{l} \sum_{h_{t-1}\in I_h} \sum_{a_t\in\{41,...,60\}} \sum_{e_t\in I_e} \sum_{i_t\in I_i^O} \sum_{h_t\in I_h} \sum_{p_t\in I_p} \left(1-\upsilon_{(A),p}^{MCS}\right)\left(1-\sigma_{(A),p}^{MCS}\right)\chi_p P_t^{M^O}\overline{M}_{p,t}^O \mu_{a_t,e_t,i_t,h_{t-1}\times h_t,p_t} \\ +\sum_{h_{t-1}\in I_h} \sum_{a_t\in\{41,...,60\}} \sum_{e_t\in I_e} \sum_{i_t\in I_i^O} \sum_{h_t\in I_h} \sum_{p_t\in I_p} \left(1-\upsilon_{(B),p}^{MCS}\right)\left(1-\sigma_{(B),p}^{MCS}\right)\left(1-\chi_p\right) P_t^{M^O}\overline{M}_{p,t}^O \mu_{a_t,e_t,i_t,h_{t-1}\times h_t,p_t} \end{array} \right)\left(1+g_N\right)^t N_0$$

The revenue that they collect from retirees with a supplemental coverage is:

$$REV_t^{MCS} = \left(\sum_{a_t\in\{41,...,60\}} \sum_{e_t\in I_e} P_t^{M^O}\Omega_t^{MCS}\mu_{a_t,e_t,i_t=MCS} \right)\left(1+g_N\right)^t N_0$$

The representative insurance company makes zero profits in the long-run while they take the price $P_t^{M^O}$ set by the government on Medicare patients as given. The break even condition results in:

$$\Omega_t^{MCS} = \frac{EXP_t^{MCS}}{P_t^{M^O}\left(\sum_{a_t\in\{41,...,60\}} \sum_{e_t\in I_e} \mu_{a_t,e_t,i_t=MCS} \right)\left(1+g_N\right)^t N_0}$$

A 3.8 Medicare Program

A 3.8.1 Part A: Hospital Insurance

Medicare Part A is an entitlement program and is mostly financed by a Hospital Insurance (*HI*) tax, one of the two components of the payroll tax that is paid by the firm and workers equally. Upon retirement at age 41 (actual age of 65), agents join Part A. When they are hospitalized, agents pay a coinsurance under Medicare Part A. Hence this entitlement program is an insurance waiver program and does not offer a free care to retirees. A balanced budget under Medicare Part A must satisfy the following condition.

$$REV_t^{HI} = EXP_t^{HI}$$

where

$$REV_t^{HI} = \tau_t^{HI}\left(\sum_{a=1}^{40}\sum_{e\in I_e} P_t^A\left(w_t - c_t^{EHI}\right) z_{a,e,t}\bar{l}\ \mu_{a,e} + \sum_{a=1}^{40}\sum_{e\in I_e} P_t^A w_t z_{a,e,t}\bar{l}\ \mu_{a,e}\right)\left(1+g_N\right)^t N_0$$

$$EXP_t^{HI} = \left(\sum_{h_{t-1}\in I_h}\ \sum_{a_t\in\{41,\ldots,60\}}\ \sum_{e_t\in I_e}\sum_{i_t\in I_i^O}\sum_{h_t\in I_h}\sum_{p_t\in I_p} P_t^{M^O}\overline{M}_{(A)p,t}^{G}\mu_{a_t,e_t,i_t,h_{t-1}\times h_t,p_t}\right)\left(1+g_N\right)^t N_0$$

$$P_t^{M^O}\overline{M}_{(A)p,t}^{G} = \left[\underbrace{\upsilon_{(A),p}^{MCS}\left(1-\sigma_{(A),p}^{MCS}\right)}_{\text{Gov't pays for agents with a "Medicare plus supplement"}} + \underbrace{\left(1-\sigma_{(A),p}^{MCO}\right)}_{\text{Gov't pays for agents with a "Medicare only"}}\right]\underbrace{\chi_p P_t^{M^O}\overline{M}_{p,t}^{O}}_{\text{avg. Part A spending for } p\in I_p}$$

$$\overline{M}_{(A),p=1,t}^{G} = \overline{M}_{p=1,t}^{O} = 0\ \forall t$$

An average Part A medical expenditure for each percentile group is denoted by $\chi_p P_t^{M^O}\overline{M}_{p,t}^{O}$ where $p \in I_p = \{1,\ldots,14\}$. The term χ_p represents the fraction of medical care volume which is devoted for inpatient care qualified under Medicare Part A. The fraction $\chi_p \in [0,1]$ increases in $p \in I_p$. In order to finance the Medicare Part A program, the government must specifically account for the insurance status of retirees. The government pays the fractions $\upsilon_{(A),p}^{MCS}\left(1-\sigma_{(A),p}^{MCS}\right)$ and $\left(1-\sigma_{(A),p}^{MCO}\right)$ of the Part A medical care expenditures for the retirees with a "Medicare plus supplement (*MCS*)" and "Medicare only (*MCO*)", respectively. A private insurance company that offers a supplemental insurance coverage to the retirees pays the fraction for $p \in I_p$:

$$\left(1-\upsilon_{(A),p}^{MCS}\right)\left(1-\sigma_{(A),p}^{MCS}\right)\chi_p P_t^{M^O}\overline{M}_{p,t}^{O} \quad \text{where } p \in I_p$$

A 3.8.2 Part B: Medical Insurance

Upon retirement, all agents join Medicare Part B program. This program requires all participants to pay a monthly insurance premium. In addition, retirees are still responsible for paying a synthetic coinsurance with its rate depending on the volume (or intensity) of medical care received. The government finances the program based on the monthly premium they collect from the program participants and a wage-income-tax revenue. A balanced budget requires the following condition:

$$REV_t^{pB} = EXP_t^{pB}$$

where

$$\begin{aligned} REV_t^{pB} = & \left(\left(1-\xi_t^{MCO}\right) P_t^{M^O} \Omega_t^{MCO} \sum_{a=41}^{60} \mu_a \right) \left(1+g_N\right)^t N_0 \\ & + \tau_t^{fB} \left(\sum_{a=1}^{40} \sum_{e \in I_e} \left(P_t^A w_t z_{a,e,t} \bar{l} - \left(1-\xi_t^{EHI}\right) P_t^{M^Y} \Omega_t^{EHI} \right) \mu_{a,e,s=I} \right) \left(1+g_N\right)^t N_0 \\ & + \tau_t^{fB} \left(\sum_{a=1}^{40} \sum_{e \in I_e} \left(P_t^A w_t z_{a,e,t} \bar{l} \right) \mu_{a,e,s=U} \right) \left(1+g_N\right)^t N_0 \end{aligned}$$

$$EXP_t^{pB} = \left(\sum_{h_{t-1} \in I_h} \sum_{a_t \in \{41,\ldots,60\}} \sum_{e_t \in I_e} \sum_{i_t \in I_s^O} \sum_{h_t \in I_h} \sum_{p_t \in I_p} P_t^{M^O} \overline{M}^G_{(B)p,t} \mu_{a_t, e_t, i_t, h_{t-1} \times h_t, p_t} \right) \left(1+g_N\right)^t N_0$$

$$P_t^{M^O} \overline{M}^G_{(B)p,t} = \left[\underbrace{\upsilon_{(B),p}^{MCS} \left(1-\sigma_{(B),p}^{MCS}\right)}_{\substack{\text{Gov't pays for agents with} \\ \text{a "Medicare plus supplement"}}} + \underbrace{\left(1-\sigma_{(B),p}^{MCO}\right)}_{\substack{\text{Gov't pays for agents with} \\ \text{a "Medicare only"}}} \right] \underbrace{\left(1-\chi_p\right) P_t^{M^O} \overline{M}^O_{p,t}}_{\substack{\text{avg. Part } B \\ \text{spending for } p \in I_p}}$$

$$\overline{M}^G_{(B),p=1,t} = \overline{M}^O_{p=1,t} = 0 \ \forall t$$

The term $\left(1-\chi_p\right) P_t^{M^O} \overline{M}^O_{p,t}$ accounts for the medical care expenditures under Part B program for each percentile $p \in I_p = \{1,\ldots,14\}$. The term $\left(1-\chi_p\right)$ represents the fraction of medical care volume which is devoted for outpatient care under Medicare Part B. The tax exclusion rule is applied to the workers contribution to the EHI premium. While this tax treatment provides a favor to the insured workers by lowering their wage income tax base, the uninsured workers pay wage income tax in full. The government pays the fractions $\upsilon_{(B),p}^{MCS}\left(1-\sigma_{(B),p}^{MCS}\right)$ and $\left(1-\sigma_{(B),p}^{MCO}\right)$ of the Part B medical care expenditures for the retirees with a "Medicare plus supplement (*MCS*)" and "Medicare only (*MCO*)", respectively. A private insurance company that offers a supplemental insurance coverage to the retirees pays the fraction:

$$\left(1-\upsilon_{(B),p}^{MCS}\right)\left(1-\sigma_{(B),p}^{MCS}\right)\left(1-\chi_{p}\right)P_{t}^{M^{O}}\,\overline{M}_{p,t}^{O} \quad \text{where } p \in I_{p}\,.$$

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CHAPTER 4

A Side Effect of Medicine: Fiscal Health under Rising Tax Expenditures

4.1 Introduction

This study includes some important policy implications for the U.S. Social Security Administration and the Centers for Medicare & Medicaid Services to consider for their fiscal health of entitlement programs. It investigates whether or not tax-exclusion rules leak revenues out of the current tax system at an increasing pace. A payroll-tax-exclusion rule, applied to employers' cost of sponsoring health insurance (EHI), lowers their payroll tax base as employers deduct the cost of EHI provision as business expenses. An income-tax-exclusion rule reduces workers' wage-income tax base by their contribution to the EHI premium. When the EHI-premium growth outpaces workers' income growth, holding everything else fixed, tax revenues to finance the entitlement programs inevitably diminish, aggravating fiscal outlook in the foreseeable future. Thus, excess growth in workers' medical consumption accompanies insidious side effects that impact the fiscal health of entitlement programs.

The most recent annual report by the U.S. Social Security Administration (The Board of Trustees of the Federal OASI and DI Trust Funds 2008) indicates that the year of exhaustion of trust fund[93] is projected at 2041. A more looming and serious problem draws our attention to Medicare program. The 2008 report by the Centers for Medicare & Medicaid Services (2008) indicates that Medicare's Hospital Insurance (HI) Trust

[93] "Year of exhaustion" is formally defined as "The year in which a trust fund would become unable to pay benefits when due because the assets of the fund were exhausted," according to the annual report.

Funds will become insolvent in year 2019. Their projections are based on assumptions that the spending on HI rises annually by 7.4 percent for the next 10 years on average. Officials at the Centers for Medicare & Medicaid Services are also concerned that the spending on supplementary medical insurance (Medicare Part B) may grow annually by as much as 9.6 percent, the average growth rate of the past five years. Similarly, workers' health insurance premium at their employment has risen 8.9 percent for a single coverage and 9.1 percent for a family coverage on average during 1999 through 2008. (The Kaiser Family Foundation and Health Research & Educational Trust 2008) Personal income in nominal value, on the other hand, has grown by 4.6 percent on average over the period between 1999 and 2008.[94]

Given the fragmented healthcare-financing system that is partly driven by the convoluted tax policy in the U.S., the fiscal health of entitlement programs is influenced by the growth rate of workers' health insurance premiums. In addition, its influence rises increasingly with the level of their insurance premiums. Thus, tackling issues of looming insolvency, policy makers must consider also how the tax exclusion rules affect the fiscal health. Consequently, it is critical for them to draw an attention to the concept of tax expenditures, first introduced by Surrey (1973). While tax exclusion rules provide incentives for both employers to sponsor health insurance (EHI) and employees to purchase an EHI, the exclusion rules lead to growing tax expenditures in workers EHI premiums. Excessive growth in tax expenditures results in excessive growth in foregone tax revenues that magnifies fiscal problem.

In order to analyze how tax expenditures influence the fiscal health, this study turns our focuses to elasticities of Social Security (SS) tax, Hospital Insurance (HI) tax, and wage-income (W) tax rates with respect to workers' health insurance premiums in a dynamic general equilibrium. This chapter also identifies determinants of equilibrium tax rates and computes sensitivity of these taxes with respect to each determinant. As the capital-labor ratio is one of the critical determinants of equilibrium tax rates, this study emphasizes that analysis of tax expenditures and their influence on fiscal health must

[94] This figure is based on the NIPA Table 2.1 Personal Income and Its Disposition, line 3 "Wage and salary disbursements", downloaded from Bureau of Economic Analysis, http://www.bea.gov/national/nipaweb.

incorporate behavioral responses of individuals that include consumption and saving decisions.

This study finds that tax sensitivity with respect to each of the determinants changes in response to the growth rate of workers' medical expenditures. In particular, tax sensitivity with respect to workers' health insurance premiums rises over time in excess growth of their medical consumption and prices. Rising sensitivity implies that a one-percent deviation in their growth rate requires a growing percentage-increase in tax rates to keep the government budget balanced. When the government keeps tax rates fixed during the time of excess growth, revenue losses in the entitlement programs is inevitable and becomes magnified based on the duration and the size of excess growth. In considering the risk of fiscal insolvency, policy makers must pay their attention (besides the duration and the size) to the way in which equilibrium tax rates adjust to the excess growth of workers' health insurance premiums. The dynamics of their adjustment differs between the Social Security tax and the Hospital Insurance tax rates. This study also finds that repealing income tax exclusion rule has a little impact on the economy. As long as the government promotes private provision of health insurance through employment, excess growth in health insurance premiums lowers the equilibrium wage rate. As a result, tax revenues will decline. Repealing tax exclusion rule will not entirely solve the problem of insolvency.

This research applies stochastic OLG model in a dynamic general equilibrium framework that incorporates households' decisions for consumption and savings. The stochastic OLG model captures idiosyncratic health and medical expenditure shocks that are additions to the benchmark model introduced by the seminal work of Auerbach and Kotlikoff (1987). In addition, this OLG model incorporates a large degree of intra- as well as inter-generational heterogeneity that exists in microdata of medical expenditures. Wage and interest rates are computed in the model. Similarly, tax rates and health insurance premiums are determined endogenously. It is imperative that a general equilibrium model links interactions between workers and retirees through intergenerational transfers for this study.

This chapter is organized as follows. Section 2 covers literature on tax expenditures. Section 3 highlights some aspects of the model. Section 4 explains the dynamics of payroll and wage income tax elasticities and identifies determinants of equilibrium tax rates in a dynamic general equilibrium. Section 5 explains calibration. Section 6 shows the results based on the benchmark model. Section 7 runs simulations that incorporate excess cost and demand growth of medical care. The deviation period lasts 10 years initially, and rises, by an increment of one year, up to 20 years at maximum. Section 8 shows a policy experiment and its results. Section 9, then, concludes.

4.2 Literature Review: Tax Expenditures

4.2.1 Concept, Historical Background, and Definition of Tax Expenditures

Concept and understanding of tax expenditures owe much to Stanley S. Surrey. He first used this term in his speech in 1967. (Surrey 1973) Surrey was Assistant Secretary for Tax Policy in the Treasury Department then. According to him, tax expenditures are special tax provision that is often called tax incentives or tax subsidies. Hence tax expenditures provide a special tax treatment to a particular industry, activity, or class of person. Tax expenditures, according to Surrey (1973), "take many different forms, such as permanent exclusions from income, deductions, deferrals of tax liabilities, credits against tax, or special rates." His research back in 1968 provided the first tax expenditure budget. The Congressional Budget and Impoundment Control Act of 1974 incorporated the definition of tax expenditures and included them in the budget process. Since then, the tax expenditure budget has been tabulated and analyzed as an integral part of a new congressional budget process. (Surrey and McDaniel 1985) According to the Joint Committee on Taxation (2007), tax expenditures are officially defined as

> *"revenue losses attributable to provisions of the Federal tax laws which allow a special exclusion, exemption, or deduction from gross income or which provide a special credit, a preferential rate of tax or a deferral of tax liability."*

Historical background of how tax expenditures became a part of a budget process reveals some resemblances to fiscal health in 2009 and to an outlook of fiscal and economic conditions beyond 2009. Fiscal history around the time when Surrey was

Assistant Secretary indicates that the U.S. government confronted a severe deficit and was concerned by an inflationary pressure. According to Surrey (1973),

> *"the combination of expanded domestic spending under the President's Great Society programs and of increased Vietnam war expenditures is producing a growing budget deficit that in turn threatens to create inflationary conditions."*

President Johnson then recommended a surcharge of 10 percent imposed on individual and corporate income to control government deficits. On the other hand, most members of the Ways and Means Committee of the House of Representatives thought that the inflationary environment could be better addressed by cutting government expenditures. It was then that the Ways and Means Committee and the Budget Director examined the Federal Budget line by line. At the end, however, the committee and the Budget Director looked only into the direct government spending for reductions, and dismissed tax expenditure dollars as they were not readily available to account for. When the Revenue and Expenditure Control Act of 1968 became law, it included both a 10 percent increase in surcharge and a $6 billion reduction in the direct budget expenditures. (Surrey 1973) The Revenue and Expenditure Control Act of 1968, however, failed to control a deficit reduction at the end. A part of this failure owes to the tax system then that did not account for tax expenditures. Provided that they had been available at that time, tax expenditures would have been under the close scrutiny of the Congress. It was around then that a full accounting for tax expenditures became a critical part of tax reform. Surrey (1973) says,

> "*I believe that the principal ways to tax reform and improvement of our federal tax system lie in the concept of tax expenditures*".

4.2.2 Tax Exclusion Rules and Tax Expenditures

Based on the Congressional Budget Office Study (1994), the Internal Revenue Service (IRS) has treated employer's contributions for health insurance as nontaxable fringe benefits since 1913. As a result, employers exclude the cost of insurance provision as business expenses from their payroll taxes. Based on the 2005 Medical Expenditure Panel Survey (MEPS)[95], employers contribute 82 percent of health insurance premium for a single coverage and 76 percent for a family coverage. Employees who purchase employer-sponsored health (EHI) insurance pay the remaining premiums based on the income before tax. Hence employees' premium contributions are deducted from wage income tax base.

An income-tax-exclusion rule applied to the employees' contributions to the EHI premium has been accounted for as a part of tax expenditures. However, the government estimates of tax expenditures has not accounted for a payroll tax exclusion rule applied to the employers' contributions to the EHI provision. (Burman 2003) This was the case when Surrey first put together the first tax expenditure budget in 1968. The reason for this omission is related to the definition of what constitutes individual and corporate income. Sheils and Haught (2004) account for the payroll tax exclusion rule in their estimate of "health benefit tax expenditures", which provides a more comprehensive picture of aggregate tax incentives given to employer-sponsored health insurance. According to Sheils and Haught (2004), federal "health benefits tax expenditures" amount to $188.5 billion in 2004, of which $101.0 billion (53.6 percent) comes from an income-tax-health-benefit exclusion, $52.2 billion (27.7 percent) from the Social Security OASDI tax, and $14.2 billion (7.5 percent) from Medicare Hospital Insurance tax.[96]

Tax expenditure budget in 1972 was approximately $65 billion. [See Table 4-1] It accounted for a quarter of the regular budget. "Medical insurance premiums and medical care" was $2.5 billion, a 3.9 percent of the total tax-expenditure budget. "Net exclusion of pension contributions and earnings" was $4.2 billion, or equivalently a 6.6 percent of the total expenditure budget. These fractions can be compared to fractions of the budget for the fiscal year 2009. Expected receipts of the government are $2,700

[95] For details, please refer to Table I.C.3 and Table I.D.3 of "Private-Sector Data by Firm Size, Industry Group, Ownership, Age of Firm, and Other Characteristics: Premium and contribution tables only".
[96] See Exhibit 1 from Sheils and Haught (2004). Other categories included in their "health benefits tax expenditures" are "retiree exclusion", "self-employed deduction", "health reimbursement accounts", and "out-of-pocket deduction".

billion.[97] Tax expenditure budget for 2009 is $1,033 billion, accounting for 38.2 percent of the regular budget. "Medical insurance premiums and medical care" is the largest item and is expected to be $168.4 billion, accounting for 16.3 percent of the total tax expenditure budget and 6.2 percent of the regular budget. Tax expenditure of "Medical insurance premiums and medical care" has grown substantially from 1972 when it accounted for only 3.9 percent. This is attributable to the wage-income tax exclusion rule and growth of medical expenditure outpacing income growth.

4.2.3 Inequity of Tax Expenditures

Equity is one of the principles in tax policy. Based on the definition of vertical equity, workers who have high ability, subsequently receive high income, should pay higher tax or tax rates. Workers in higher tax brackets face higher marginal tax rate under this consideration. In contrast, horizontal equity claims that workers who earn the same level of income pay the same amount of tax or tax rate.

Considering vertical equity in health policy, we must realize that workers with high income receive high tax subsidies under the income-tax-exclusion rule. Since they face a higher income tax bracket, the exclusion rule gives them higher tax subsidies. Their subsidies as a percent of income, however, are highly regressive. Workers with high ability have a better chance of receiving an EHI offer and tax subsidies as a result. Workers with low ability, on the other hand, may have a lower chance of working for employers who offer an EHI. When we take horizontal equity into considerations, we need to remember that workers with employer-sponsored health insurance (EHI) receive tax subsidies under the income-tax-exclusion rule. In contrast, workers with the same ability without EHI do not receive the same subsidies.

Congressional Budget Office (1994) reports that one of the critical issues with regard to income-tax-exclusion rule is a violation of horizontal equity as workers with the same ability may or may not receive tax subsidies. When health insurance premium

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[97] Table 1.1—Summary of Receipts, Outlays, and Surpluses or Deficits: 1789–2013. Downloaded from http://www.gpoaccess.gov/usbudget/fy09/hist.html.

growth outpaces income growth, the amount of subsidies received by workers with EHI becomes magnified, exacerbating horizontal inequity under the income-tax exclusion rule.

4.2.4 Behavioral Response to Tax Expenditures

According to Joint Committee on Taxation (2008), tax expenditures are calculated in a partial equilibrium where behavioral consequences to any tax-policy changes are left out of their estimates of tax expenditures. This indicates that the government is unable to address how changes in tax expenditures may alter the government revenues through behavioral response of individuals in a general equilibrium. (Burman 2003) As tax expenditures are, by tradition, computed based on a static basis (Joint Committee on Taxation 2008), there is no study done for analyzing macroeconomic effects that may be accompanied by, for example, excessive growth of tax expenditures. It is important, for this reason, that we include households' consumption and saving decisions in our analysis of tax expenditures and their influence on tax revenues.

4.3 Model

This chapter adds two new components to the stochastic OLG model introduced in the previous chapter. One of the new components is government consumption. The other new component is non-linear wage income taxation. Previously, the government imposed a proportional wage income tax to finance subsidies for retirees' Medicare Part B insurance premium and the "Medically Needy" safety-net program. The benchmark result from the previous chapter indicates that the equilibrium tax rate is 0.9 percent. In order to capture impacts of tax expenditures on fiscal balance, it is important to introduce non-linear wage income taxation that reflects the current tax structure in the U.S. As the government collects large enough revenue, this model assumes that the government also purchases commodity goods.

4.3.1 Government Consumption

The federal government purchases commodities for its own consumption in period t, denoted by G_t^C. This model assumes that the government consumption in real value grows by the growth rate of income-per-capita plus population growth. We have:

$$G_{t+s}^{C} = \left(1+g_Z\right)^s \left(1+g_N\right)^s G_t^C \;\; \forall s.$$

[4-1]

where g_Z is equivalently the rate of labor augmented technological progress. Government consumption in nominal value is indexed to the overall price leve.

4.3.2 Non-linear Wage Income Taxation

I assume there are n tax brackets. The marginal tax rates at period t are denoted by $\tau_{1,t}^W, \ldots, \tau_{n-1,t}^W, \tau_{n,t}^W$. The taxable income that corresponds to these tax brackets are denoted by:

$$\begin{aligned}
\tau_{1,t}^W &: \; \left(INC_{1,t}, INC_{2,t}\right] \\
\tau_{2,t}^W &: \; \left(INC_{2,t}, INC_{3,t}\right] \\
&\vdots \\
\tau_{n-1,t}^W &: \; \left(INC_{n-1,t}, INC_{n,t}\right] \\
\tau_{n,t}^W &: \; \left(INC_{n,t}, \overline{INC}_t\right]
\end{aligned}$$

[4-2]

where $INC_{1,t} = 0$ and $\overline{INC}_t$ represents any upper bound of taxable income. The model assumes that taxable income brackets are indexed to the overall CPI and rise by the rate of labor augmented technological progress in real value.

4.3.3 Government Balanced Budget Conditions

The federal government runs three programs: (1) PAY-GO Social Security program, (2) Medicare program, and (3) "Medically Needy" safety-net program. Medicare program is financed by two different sources of taxation. Medicare Part A is financed by a component of payroll tax, called Hospital Insurance tax. Medicare Part B is financed by a general tax-revenue. Wage income tax revenue in this model finances Medicare Part B (*MCpB*), "Medically Needy" safety-net program (*MN*), and government consumption G_t^C. The government must balance the budget by satisfying the following conditions:

Payroll taxation: Social Security (SS)

$$\widehat{REV}_t^{SS} = REV_t^{SS} - TAXEXP_t^{SS} = EXP_t^{SS}$$

Payroll taxation: Hospital Insurance (HI)

$$\widehat{REV}_t^{HI} = REV_t^{HI} - TAXEXP_t^{HI} = EXP_t^{HI}$$

Wage income taxation (W):

$$\widehat{REV}_t^{W} = REV_t^{W} - TAXEXP_t^{W} = EXP_t^{W}$$

$$\text{where } EXP_t^{W} = EXP_{MCpB,t}^{W} + EXP_{MN,t}^{W} + EXP_{C,t}^{W}$$

$$EXP_{C,t}^{W} = P_t^{A} G_t^{C}$$

Due to the payroll-tax-exclusion rule applied to the firm's cost of insurance provision and the income-tax-exclusion rule applied to households' contribution to the employer sponsored health insurance (EHI) premium, this study distinguishes tax revenues (*REV*) before and after the tax expenditures (*TAXEXP*) by REV_t and $\widehat{REV}_t$. At the equilibrium, we have the following balanced budget conditions:

$$REV_t^{SS} = EXP_t^{SS} + TAXEXP_t^{SS} \Rightarrow BAL_t^{SS} = 0$$

$$REV_t^{HI} = EXP_t^{HI} + TAXEXP_t^{HI} \Rightarrow BAL_t^{HI} = 0$$

$$REV_t^{W} = EXP_t^{W} + TAXEXP_t^{W} \Rightarrow BAL_t^{W} = 0$$

[4-3]

As tax expenditures rise, the balanced budget conditions require that tax revenues before tax expenditures rise.

4.4 Dynamics of Payroll and Wage-income Tax Elasticities

Due to the tax-exclusion rules, changes in the cost growth of employer-sponsored health insurance directly influence the growth of tax expenditures for the federal government. As tax expenditures grow, their influence on the government balance sheets cannot be overlooked. The government must raise tax rates in response to excessive growth in tax expenditures to keep its budget balanced. The sensitivity of tax rate to tax expenditures becomes increasingly critical as nation's health expenditures grow faster than its income. For this reason, this study measures tax elasticities for keeping solvency of the Social Security and the Medicare programs. The government must pay a closer attention to the dynamics of tax elasticity as programs' revenue sensitivity to tax expenditures grows in excess growth of EHI premium. To understand the dynamics of tax elasticity, this section shows how tax-revenue sensitivity to tax expenditures may change over time in a general equilibrium. This study also identifies determinants of tax elasticity and investigates tax-elasticity dynamics.

4.4.1 Revenue Sensitivity to Tax Expenditures

How do changes in tax expenditures influence tax revenues for keeping fiscal programs financially sound? To answer this question, let us totally differentiate the system of three equations [4-3] to obtain:

$$\begin{aligned}
d\ln\left(REV_t^{SS}\right)\Big|_{BAL^{SS}=0} &= \phi_{1,t}^{SS}\left[d\ln\left(EXP_t^{SS}\right)\right]+\phi_{2,t}^{SS}\left[d\ln\left(TAXEXP_t^{SS}\right)\right] \\
d\ln\left(REV_t^{HI}\right)\Big|_{BAL^{HI}=0} &= \phi_{1,t}^{HI}\left[d\ln\left(EXP_t^{HI}\right)\right]+\phi_{2,t}^{HI}\left[d\ln\left(TAXEXP_t^{HI}\right)\right] \\
d\ln\left(REV_t^{W}\right)\Big|_{BAL^{W}=0} &= \phi_{1,t}^{W}\left[d\ln\left(EXP_t^{W}\right)\right]+\phi_{2,t}^{W}\left[d\ln\left(TAXEXP_t^{W}\right)\right]
\end{aligned}$$

[4-4]

$$\text{where } \phi_{1,t}^{SS}=\frac{EXP_t^{SS}}{REV_t^{SS}} \text{ and } \phi_{2,t}^{SS}=\frac{TAXEXP_t^{SS}}{REV_t^{SS}},$$

$$\phi_{1,t}^{HI}=\frac{EXP_t^{HI}}{REV_t^{HI}} \text{ and } \phi_{2,t}^{HI}=\frac{TAXEXP_t^{HI}}{REV_t^{HI}}$$

$$\phi_{1,t}^{W}=\frac{EXP_t^{W}}{REV_t^{W}} \text{ and } \phi_{2,t}^{W}=\frac{TAXEXP_t^{W}}{REV_t^{W}}$$

The coefficients $\left(\phi_{1,t}^{SS},\phi_{2,t}^{SS}\right)$, $\left(\phi_{1,t}^{HI},\phi_{2,t}^{HI}\right)$, and $\left(\phi_{1,t}^{W},\phi_{2,t}^{W}\right)$ in [4-4] represent revenue sensitivity to changes in expenditures and tax expenditures for each fiscal program to be balanced. Since these coefficients are not time invariant, the equations [4-4] imply that one percent increase in tax expenditures may require an increasingly-high-percent change in tax revenues for balancing the budget if tax expenditures continue to grow faster than revenues. This sensitivity dynamics has important implications for fiscal programs to be financially sound over time. An excessive growth of workers' employer-sponsored health insurance (EHI) premium, for example, triggers an increase in the marginal cost of EHI provision. Since a rise in the marginal cost of EHI leads to excess growth in tax expenditures under the payroll-tax-exclusion rule, the Social Security and the Hospital Insurance tax rate must rise for their programs to be balanced, holding everything else fixed. A magnitude of tax rate hike is largely controlled by the revenue sensitivity $\phi_{2,t}^{SS}$ and $\phi_{2,t}^{HI}$ in [4-4].

4.4.2 Tax Elasticity: Determinants

4.4.2.1 Payroll Tax Elasticity

Based on the balanced budget conditions in a general equilibrium, we have the following expression for Social Security tax elasticity. [See Appendix A 4.1 for derivation]:

$$
\begin{aligned}
d\ln\tau_t^{SS} = {} & X_{1,t}^{SS}\left[d\ln E_t\right] + X_{2,t}^{SS}\left[d\ln P_t^{A}\right] + X_{3,t}^{SS}\left[d\ln\bar{k}\right] + X_{4,t}^{SS}\left[d\ln b_t\left(w^{*}\right)\right] \\
& + X_{5,t}^{SS}\left[d\ln P_t^{M^{O}} + d\ln M_t^{O,(A)}\right] + X_{6,t}^{SS}\left[d\ln P_t^{M^{Y}} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]
\end{aligned}
$$

[4-5]

where the coefficients $X_{1,t}^{SS}, X_{2,t}^{SS}, \ldots, X_{6,t}^{SS}$ represent sensitivity of SS tax rate with respect to changes in each variable to keep the budget balanced. [See Appendix [4-17]] These coefficients are time invariant at the steady state.

Similarly, we have the following expression for Hospital Insurance tax elasticity under balancing its budget. [See Appendix A 4.1 for derivation]

$$
\begin{aligned}
d\ln\tau_t^{HI} = {} & X_{1,t}^{HI}\left[d\ln E_t\right] + X_{2,t}^{HI}\left[d\ln P_t^{A}\right] + X_{3,t}^{HI}\left[d\ln\bar{k}\right] + X_{4,t}^{HI}\left[d\ln b_t\left(w^{*}\right)\right] \\
& + X_{5,t}^{HI}\left[d\ln P_t^{M^{O}} + d\ln M_t^{O,(A)}\right] + X_{6,t}^{HI}\left[d\ln P_t^{M^{Y}} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]
\end{aligned}
$$

[4-6]

where the coefficients $X_{1,t}^{HI}, X_{2,t}^{HI}, \ldots, X_{6,t}^{HI}$ represent sensitivity of HI tax rate with respect to changes in each variable to keep the budget balanced. [See Appendix [4-18]] These coefficients are time invariant at the steady state.

4.4.2.2 Wage-Income-Tax Elasticity

Following the derivation of payroll tax elasticity, the balanced budget conditions in a general equilibrium yields the following expression for wage-income tax elasticity. [See Appendix A 4.1 for derivation]

$$\begin{aligned} d\ln\tau_t^W &= X_{1,t}^W\left[d\ln E_t\right] + X_{2,t}^W\left[d\ln P_t^A\right] + X_{3,t}^W\left[d\ln\overline{k}\right] + X_{4,t}^W\left[d\ln b_t\left(w^*\right)\right] \\ &+X_{5,t}^W\left[d\ln P_t^{M^O} + d\ln M_t^{O,(A)}\right] + X_{6,t}^W\left[d\ln P_t^{M^Y} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right] \\ &+X_{7,t}^W\left[d\ln P_t^{M^O} + d\ln M_t^{O,(B)}\right] + X_{8,t}^W\left[d\ln EXP_{MN,t}^W\right] + X_{9,t}^W\left[d\ln EXP_{C,t}^W\right] \end{aligned}$$

[4-7]

where the coefficients $X_{1,t}^W, X_{2,t}^W, \ldots, X_{9,t}^W$ represent sensitivity of wage-income (W) tax rate with respect to changes in each variable to keep the budget balanced. [See Appendix [4-19]] These coefficients are time invariant at the steady state.

4.4.2.3 Determinants of Tax Elasticity

4.4.2.3.1 Aggregate Labor in Effective Unit

This model assumes fixed labor supply. Labor augmented technological progress and population growth are exogenously given. Hence aggregate labor in effective unit E_t grows exogenously. Since high labor efficiency leads to high earnings, the equilibrium tax rates will become lower when aggregate labor in effective unit grows faster. The coefficients in [4-5][4-6][4-7] are all negative $X_{1,t} < 0$.

4.4.2.3.2 Overall Price

This study assumes that real wage is indexed to the overall price level. Growth in the price level leads to higher nominal earnings and government tax revenues. Holding everything else fixed, the equilibrium tax rates are lower when overall price level is higher. The coefficients in [4-5][4-6][4-7] are all negative $X_{2,t} < 0$.

4.4.2.3.3 Capital-Labor Ratio

At the steady state, the ratio of capital-to-labor does not change. When the economy is off the balanced growth path, higher capital-to-labor ratio raises equilibrium wage rate and lowers tax rates to balance the budget. We have $X_{3,t} < 0$ in [4-5][4-6][4-7].

4.4.2.3.4 Total Disbursements of Social Security Benefits

Higher growth rate of Social Security benefits must raise the equilibrium Social Security tax rate $X_{4,t}^{SS} < 0$ in [4-5]. As the equilibrium Social Security tax rate becomes higher, the equilibrium wage rate is lower. In order to balance the budgets for Medicare and all other fiscal programs and to finance government consumption, other equilibrium tax rates must rise, $X_{4,t}^{HI}, X_{4,t}^{W} < 0$ in [4-6][4-7].

4.4.2.3.5 Retirees' Medical Price and Demand

Higher cost growth of Medicare Part A program leads to the higher equilibrium Hospital Insurance tax rate, $X_{5,t}^{HI} > 0$ in [4-6]. As a result, other tax rates must move in the same direction at the equilibrium, $X_{5,t}^{SS}, X_{5,t}^{W} > 0$ in [4-5][4-7]. The same reason applies to Medicare Part B program. We have $X_{7,t}^{W} > 0$ in [4-7].

4.4.2.3.6 Workers' Medical Price and Demand

Excessive growth of workers' medical expenditures that lead to high growth of EHI premium raises growth rate of tax expenditures, resulting in higher equilibrium tax rates, $X_{6,t} > 0$ in [4-5][4-6][4-7].

Proposition 1. Abolishing the income-tax-exclusion rule ($\phi_{2,t}^{W} = 0$) applied to workers' contribution to their EHI premium will not make the equilibrium wage-income tax rate independent of workers' medical-expenditure growth. [See Appendix A 4.2 for proof.]

Proposition 2. Abolishing the payroll-tax-exclusion rule ($\phi_{2,t}^{SS} = \phi_{2,t}^{HI} = 0$) applied to employers' cost of EHI provision will not make the equilibrium payroll tax rate independent of workers' medical-expenditure growth. [See Appendix A 4.3 for proof.]

Proposition 3. The wage income tax elasticity with respect to change in EHI premium is larger before than after abolishing the income-tax-exclusion rule ($\phi_{2,t}^{W} = 0$) if $J_{2,t}^{HI} = \dfrac{\tau_t^{HI}\left(w^* - c^{EHI}\right)}{\left(1+\tau_t^P\right)w^*}$ is sufficiently small. [See Appendix A 4.4 for proof.]

In a general equilibrium, the wage rate is a function of health insurance premium as long as employers sponsor workers' health insurance. As a result, repealing the income-tax- and the wage-income-tax-exclusion rules will not completely negate their tax elasticity with respect to changes in EHI benefit, $X_6 \neq 0$ in [4-7].

Proposition 4. The Social Security (SS) tax elasticity and the Hospital Insurance (HI) tax elasticity with respect to the aggregate labor in effective unit, capital-labor ratio, and EHI benefits are identical since $\phi_{2,t}^{SS} = \phi_{2,t}^{HI}$ holds in [4-17][4-18]. [See Appendix A 4.5 for proof.]

4.4.2.3.7 Cost of "Medically Needy" Safety-net Program and Government Consumption

Higher growth of "Medically Needy" safety-net and government consumption raise equilibrium tax rate. We have $X_{8,t}, X_{9,t} > 0$ in [4-7].

4.5 Calibration

Main calibration follows what have been applied in the previous chapter. This section highlights calibration of the new variables introduced in this chapter.

4.5.1 Non-linear Wage Income Tax Rates

This model assumes that the initial steady state is reached at *t=0* which corresponds to year 2005. Given that there is no family structure, I apply a filling status of single based on 2005 tax rate schedules from the Internal Revenue Service (IRS). The IRS imposes six tax brackets, $n = 6$. Since the model computes the equilibrium tax rates, I impose the following constraints:

$$\tau_{2,t}^{W} = \tau_{1,t}^{W} + \alpha_2 \text{ where } \alpha_2 = 0.05$$

$$\tau_{3,t}^{W} = \tau_{2,t}^{W} + \alpha_3 \text{ where } \alpha_3 = 0.10$$

$$\tau_{4,t}^{W} = \tau_{3,t}^{W} + \alpha_4 \text{ where } \alpha_4 = 0.03$$

$$\tau_{5,t}^{W} = \tau_{4,t}^{W} + \alpha_5 \text{ where } \alpha_5 = 0.05$$

$$\tau_{6,t}^{W} = \tau_{5,t}^{W} + \alpha_6 \text{ where } \alpha_6 = 0.03$$

To calibrate the degree of non-linearity based on the 2005 tax rate schedule, I set α s to take some specific values. These constraints will simplify the model's computation for the equilibrium wage-income tax rates. The model computes the equilibrium $\tau_{1,t}^{W}$ to balance the budget under the nonlinearity imposed by α s.

4.5.2 Government Consumption

This model assumes that the government purchase commodity goods for consumption and makes no savings. Hence national savings comes only from the private savings. In order to compute the equilibrium wage-tax rates to follow the 2005 wage-income-tax-rate schedule, I adjust the level of government consumption at the steady state. Note that the government consumption grows by the same rate as the aggregate output in real value.

4.6 Benchmark Model

This model assumes that the economy reached the steady state in year 2005. Under this assumption, Table 1 shows the results of equilibrium factor prices, insurance premiums, tax rates, marginal cost of the EHI provision, and other key indicators at the steady state.

Our benchmark model computes the equilibrium wage rate of $9.35 in 1982-84 dollars and the equilibrium real interest rate of 10.6 percent that correspond to the steady-state level of capital per output ratio of 2.17. This equilibrium wage rate corresponds to nominal earnings of $21,484, $33,254, and $62,450 for low-, middle-, and high-skilled workers in 2005 dollars. Weighted average of labor income is $38,018. The marginal cost of the EHI provision in nominal value is $0.91 per hour which corresponds to the EHI premium of $2766.60 per annum. Since this model does not incorporate any family structures, the EHI premium is for a single coverage.

Social Security tax and Medicare Part A Hospital Insurance tax rates are 4.53 and 1.50 percent. Both employers and employees pay a payroll tax rate of 6.03 percent. The Social Security tax rate is computed based on the earning replacement rate of 35 percent. The actual Social Security and Hospital Insurance tax rates are 6.2 and 1.45 percent, respectively.[98] The average wage-income-tax rate is 15.4 percent at the equilibrium. This rate corresponds to the marginal tax rates of 8.8, 13.8, 23.8, 26.8, 31.8, and 34.8 percent for tax brackets 1 through 6, respectively. This tax rate schedule can be compared to the actual 2005 tax rate schedule for the filing status of single, 10, 15, 25, 28, 33, and 38 percent. Based on labor income reported by respondents in the Medical Expenditure Panel Survey in 2005, the model creates a distribution of workers who belong to the 2nd and the 3rd tax brackets only. The government consumption accounts for 8.3 percent of GDP.

There are two groups of retirees. One group purchase a private supplemental insurance with Medicare. The other group holds only Medicare insurance. This model assumes that all agents are covered by Medicare Part A and Part B. Medicare Part B insurance premium is $938.64 per annum. The private supplemental insurance premium is $2,776.34 per annum. This calibration includes the government contribution of 46.7

---

[98] The Social Security tax rate consists of two parts, old-age and survivors insurance (OASI) and disability insurance (DI). Both rates have been fluctuating over time. Since 2000, the OASI rate has been 5.3 percent, and DI rate has been 0.9 percent. In contrast, Medicare's Hospital Insurance (HI) tax rate has been 1.45 percent since 1986. There is an annual limit imposed on the Social Security tax base. In 2005, this limit was $90,000. For the Medicare's Hospital Insurance program does not impose any taxable limit on the tax base. The maximum taxable earnings which had been imposed on Medicare's Hospital Insurance tax were eliminated entirely in 1994.

percent for the Part B insurance premium. The actual Part B insurance premium was \$938.40 (=78.20 x 12 mo.) in 2005.[99]

At the aggregate level, consumption of commodities account for 62.1 percent of GDP. Medical expenditures account for 10 percent. Investment accounts for 19.6 percent. At the equilibrium, the model's discrepancy is nearly zero.

Tax expenditures of payroll and wage income tax account for 2.6 percent and 1.5 percent of its corresponding revenue at *t=0*. Using these ratios, the model computes coefficients $X_{1,t}^{tax},\ldots,X_{5,t}^{tax},X_{6,t}^{tax}$, and $X_{7,t}^{W},X_{8,t}^{W},X_{9,t}^{W}$ where $tax=\{SS,HI,W\}$ at the initial steady state. [See Figure 4-1] Signs of these coefficients match one's expectation. Tax elasticity with respect to capital-labor ratio and the aggregate labor in effective unit has the same order of magnitude in explaining the sensitivity of Social Security (SS), Hospital Insurance (HI), and wage-income (W) tax rates. The coefficient of capital-labor ratio has the most explanatory power for these three tax elasticities. The size of this sensitivity suggests that households' consumption and saving decisions play a critical role in explaining changes in equilibrium tax rates in response to policy changes. For this reason, it is important for any analysis to capture households' behavioral responses on their consumption-saving decisions to policy changes. In contrast, the tax elasticity with respect to a one-percent change in workers' medical price or health insurance premium is 0.075 percent for payroll tax and 0.064 percent for wage-income tax. When real marginal-cost of employer-sponsored health insurance (EHI) remains at \$0.47, sensitivity of equilibrium tax rates with respect to the payroll-tax- and the wage-income-tax-exclusion rules is limited at the steady state.

4.7 Simulations

We have observed in the past 10 to 20 years that medical-care price index, a component of CPI, has risen by approximately 4 percent per annum on average, two percentage

[99] Beginning in 2007, as a result of the Medicare Modernization Act of 2003, the government introduced a five-tier premium calculation. Based on this new calculation, those with higher income pay a higher Part B insurance premium. While the most people pay a standard premium, there are four levels of premium above the standard rate. Beginning 2009, high income beneficiaries will pay, depending on their income, 35, 50, 65, and 80 percent of the total Part B cost. (See http://www.socialsecurity.gov/pubs/10161.html) The government expects that the new law will affect only 4 to 5 percent of the population.

points above the CPI inflation that excludes medical care. On the other hand, workers' health insurance premium in nominal value has risen above 8 percent annually on average during the same period. Simulations that reflect these facts incorporate excess cost and demand growth of medical care. Following the simulations, this chapter analyzes how such a deviation in medical expenditure growth impact the economy in the long-run. The first simulation starts by assuming that the deviation period lasts 10 years. I will run 10 additional simulations. Each simulation includes a deviation period that lasts longer than 10 years by raising it by an increment of 1 year. The maximum deviation is set at 20 years. After the deviation period, a transition period follows before the economy reaches the new steady state at period 80.

In order to raise the growth rate of workers' health insurance premium, I assume that excess cost growth of medical treatment at hospitals is 2 percentage points above the steady-state growth rate. At the same time, workers' medical demand grows in excess by 2 percentage points. Since their steady state growth rates are 2 percent per year, the inclusion of excess cost and demand growth raise a percent change in nominal health insurance premium to 8 percent per year. Similarly, I assume that retirees' medical price and demand grow in excess by two percentage points each. As a result, retirees' health insurance premium also grows by 8 percent per year during the deviation period.

Simulations results are evaluated at period $t=80$. These simulations are differentiated by the length of deviation periods characterized by the excess growth in medical care above. I will also analyze dynamics of equilibrium tax rates between two steady states.

4.7.1 Results: Key Variables

Length of the deviation period directly influences the balanced growth path and the aggregate-well-being of the people at the new steady state. Inequality measured by a Gini coefficient is also affected. Figure 4-2 shows that the steady-state level of output at period 80 is lower by 4.7 percent when the deviation period lasts 20 years instead of 10 years. Aggregate well-being becomes substantially lower in the length of deviation period. When this period lasts 20 years, the aggregate well-being is substantially lower than the period lasting 10 years by 76.2 percent. Wealth Gini coefficient rises from 0.30 to 0.41 at the new steady state.

Higher growth rate of medical expenditures has two effects on households' savings. It reduces savings through the income effect. At the same time, households increase precautionary demand for savings as their expected medical expenditures rise in the future. Since these effects are countervailing, its effect on net savings depends on the relative magnitude of actual spending on medical care and a gain in savings from precautionary motive. As capital-labor ratio declines, equilibrium money wage rate falls. The longer becomes the deviation period, the more amplified the decline in real wage. The equilibrium real wage rate declines by 9.1 percent at the new steady state when the deviation period lasts 20 years instead of 10 years. Equilibrium interest rate rises in the length of deviation period. Equilibrium tax rates also rise to keep the government budget balanced.

4.7.2 Wealth and Health

The length and the magnitude of deviation matter for the distribution of net savings as it is illustrated by the wealth Gini coefficient. The longer the deviation period becomes, the more disproportionately agents with "fair" and "poor" health status reduce their net savings. As a result, the savings gap between those with "excellent" and "poor" health status widens. Excess cost and demand growth of medical care raises agents' expected medical expenditures. As a result, their demand for precautionary savings rises. Since agents with "fair" and "poor" health status consume more medical care than those with "excellent" and "very good" health status on average, the income effect disproportionately reduces savings of those who consume more medical care. As a result, their net savings decline. In contrast, precautionary demand for savings raises net savings of workers with "excellent" and "very good" health status.

Figure 4-3 shows that savings by workers with "excellent" health status is higher by 3.6 percent than the average savings among workers when the deviation period lasts 10 years. Savings by workers with "poor" health status is lower than the average by 7.9 percent. When the deviation period doubles, net savings by workers with "excellent" and "poor" health status become 7.7 percent higher and 20.3 percent lower than the average, respectively. The savings gap rises from 11.5 percent to 28.0 percent. Since workers with "fair" and "poor" health status are relatively more concentrated among low-skilled working households, a longer deviation period exacerbates their financial vulnerability. In addition, the uninsured population pays increasingly high medical prices if they fall into ill.

Savings gap among retirees also grows as the deviation period lasts longer. However, its increase is not as pronounced as that among workers. Social Security and Medicare programs help alleviate a considerable widening of inequality among retirees. Savings gaps are 11.6 percent and 16.0 percent at the new steady state when the deviation period last 10 years and 20 years, respectively. Savings by retirees and workers with "good" health status are lower than the average.

4.7.3 Dynamics of Tax Elasticity

Excess cost and demand growth of medical care raises tax expenditures in the share of revenues under the payroll-tax-exclusion and the wage-income-tax-exclusion rules. Tax expenditures at the new steady state account for 3.8 percent of the revenue for the payroll tax and 2.2 percent for the wage-income tax when the deviation period lasts 10 years. ($\phi_{2,80}^{SS} = \phi_{2,80}^{HI} = 0.038$, $\phi_{2,80}^{W} = 0.022$) When the deviation periods lasts 20 years, the share of tax expenditures in revenue become 6.1 percent for the payroll tax and 3.1 percent for the wage-income tax. Subsequently, sensitivity of taxes with respect to each determinant in expressions [4-5][4-6][4-7] changes at the new steady state and varies across the length of deviation period.

Figure 4-4 indicates that tax elasticity with respect to the aggregate labor in effective unit rises at an increasing pace in the length of deviation period. The magnitude of excess growth and the length of deviation period critically influence this tax elasticity. We can observe a similar pattern on how workers' EHI benefit influences tax elasticity. The rising tax elasticity with respect to workers' health insurance premium suggests that the equilibrium tax rates are progressively influenced by changes in the insurance premium. A 1 percent change in EHI premium require increasingly higher percent change in tax rates for balancing the budget. This effect illustrates that the Social Security tax program becomes critically sensitive to the payroll-tax-exclusion rule. In contrast, the tax elasticity with respect to capital-labor ratio declines. Yet, a one-percent change in capital-labor ratio has the largest impact on the equilibrium Social Security tax rate and twice as large impact as a one-percent change in aggregate Social Security benefits in magnitude.

Hospital Insurance (HI) tax elasticity with respect to its determinants displays some similarities. According to Figure 4-5, the tax sensitivity with respect to the aggregate labor in effective unit, capital-labor ratio, and EHI benefits are identical since $\phi_{2,t}^{SS} = \phi_{2,t}^{HI}$ holds. [See Proposition 4] In contrast to Social Security (SS) tax elasticity with respect to the overall CPI, Hospital Insurance (HI) tax elasticity is much larger in absolute value. The HI tax revenue in nominal value is indexed to the overall CPI while its expenditure in nominal value is linked to the medical price, a component of the overall CPI. Holding everything else constant, the higher is the inflation of commodity price relative to the medical-care price, the overall CPI rises faster than the medical price index. As a result, the HI tax revenue rises faster than its expenditure, pushing the equilibrium HI tax rate down, $X_{2,t}^{HI} < 0$.

Likewise, wage income (W) tax elasticity with respect to the capital-labor ratio is most sensitive among all key variables in absolute value. [See Figure 4-6] In computing tax elasticity, therefore, it is important to capture behavioral responses of households with regard to their consumption and savings decisions. As the deviation period prolongs, high cost of medical expenditures create larger population of financially vulnerable households. Higher fraction of population falls into the "Medically Needy" safety-net program. Subsequently, the government expenditure to run the program rises. For this reason, tax elasticity with respect to this safety-net program rises.

4.7.4 Dynamics of Equilibrium Tax Rates

The expressions [4-5][4-6][4-7] provide the dynamics of equilibrium tax rates at the steady state as well as the tax rates that balance the government budgets during the deviation and transition periods.

Proposition 5. The steady state pins down the payroll as well as the wage income tax rates such that the following conditions hold when given the steady-state growth rates: [See Appendix A 4.6 for proof.]

$$d\ln\tau_t^{SS}=0$$
$$d\ln\tau_t^{HI}=0$$
$$d\ln\tau_t^{W^a}=0$$

where the steady-state growth rates of key variables are:

$$\begin{gathered}\left[d\ln\overline{k}\right]=0\%,\ \left[d\ln N_t^{EHI}\right]=1\%,\ \left[d\ln\Omega_t^{EHI}\right]=2\% \\ \left[d\ln P_t^{A}\right]=\left[d\ln P_t^{M^Y}\right]=\left[d\ln P_t^{M^O}\right]=2\%, \\ \left[d\ln E_t\right]=\left[d\ln M_t^{O,(A)}\right]=\left[d\ln M_t^{O,(B)}\right]=\left[d\ln b_t\left(w^*\right)\right]=3\%, \\ \left[d\ln EXP_{MN,t}^{W}\right]=\left[d\ln EXP_{C,t}^{W}\right]=5\%\end{gathered}$$

[4-8]

Corollary 1. Given the negative coefficients $\left\{X_{1,t}^{tax},X_{2,t}^{tax},X_{3,t}^{tax}\right\}$ in the expressions [4-5][4-6][4-7], where $tax=\left\{SS,HI,W\right\}$, when the aggregate labor in effective unit, overall price level, and/or capital-labor ratio change by less (more)-than the steady state growth rate, the tax rates must adjust upwardly (downwardly) to balance the government budgets.

Corollary 2. Given the positive coefficients $\left\{X_{4,t}^{tax},X_{5,t}^{tax},X_{6,t}^{tax},X_{7,t}^{tax},X_{8,t}^{tax},X_{9,t}^{tax}\right\}$ in the expressions [4-5][4-6][4-7], where $tax=\left\{SS,HI,W\right\}$, when the aggregate Social Security benefits, Medicare Part A and Part B, EHI benefit, safety-net payment, and.or government consumption change by more (less)-than the steady state growth rate, the tax rates must adjust upwardly (downwardly) to balance the government budgets.

Corollary 1 and Corollary 2 have very important implications for explaining dynamics of tax rates during the deviation and the transition periods.

4.7.4.1 Social Security (SS) Tax Rate

The equilibrium Social Security (SS) tax rate at $t=0$ is 4.528 percent. At the new steady state at $t=80$, the equilibrium tax rate is 4.533 percent when the deviation period lasts 10 years. When it lasts 20 years, the equilibrium tax rate reaches 4.586 percent. When the deviation period lasts anywhere between 10 years and 20 years, the equilibrium tax rate falls between 4.533 percent and 4.586 percent at the new steady state. [See Figure 4-2] They appear to indicate that the payroll tax exclusion rule applied to the employer's cost of EHI provision does not make much impact on the equilibrium Social Security tax.

When the economy is on the balanced growth path, the government disbursement in Social Security benefits grow by 3 percent per annum in real term. Since they apply an Average Indexed Monthly Earnings (AIME) to compute beneficiaries' monthly earning average during their work life of up to 35 years, the adjustment of Social Security benefits goes beyond the deviation period. As the capital-labor ratio continues to decline and moves toward the new steady state, the real wage declines and continues to adjust. As a result, the government disbursement of Social Security benefits grows by less-than three percent even after the excess cost and demand growth dissipates completely.

Taken these effects together, the Social Security tax rate that balances the budget in each period goes through a distinguished adjustment process during the deviation and the transition periods. Figure 4-7 illustrates this process. During the first phase, the economy is at the initial steady state. The SS tax rate is $\bar{\tau}_{OLD}^{SS}$. When excess cost and demand growth of medical care emerges, the dynamics of SS tax rate to balance the budget is dictated by declines in capital-to-labor ratio and rises in workers' and retirees' medical expenditures in phase 2. The SS tax rate reaches $\tau_{\max}^{SS}$ at the end of the deviation period. As the capital-labor ratio and the real wage rate continues to adjust in the downward direction, the aggregate Social Security benefits continue to grow by less-than three percent in phase 3. As the excess cost and demand growth completely dissipates, the dynamics of SS tax rate is dictated by the growth rate of SS disbursement. During the third phase, the adjustment process of SS benefits partially countervails the initial rise in the SS tax rate that is attributed to the excess growth of tax expenditures. As the real wage rate finds the new steady-state equilibrium, the government disbursement in SS benefits grow annually by three percent. The economy reaches the new steady state where the SS tax rate is equilibrated at $\bar{\tau}_{NEW}^{SS}$ in phase 4.

Equilibrium Social Security (SS) tax rates that correspond to the initial and the new steady states mask the dynamics of SS tax rate during the deviation and the transition periods. How far does the maximum SS tax rate $\tau_{\max}^{SS}$ reach to balance the budget for each year? The answer depends on the magnitude of growth deviation in medical expenditures and the length in deviation. Figure 4-8 illustrates $\bar{\tau}_{OLD}^{SS}$, $\tau_{\max}^{SS}$, and $\bar{\tau}_{NEW}^{SS}$ from simulations. When the deviation period lasts 20 years, the maximum SS tax rate reaches 4.63 percent, a 0.1 percentage point above the rate at the initial steady state.

4.7.4.2 Hospital Insurance (HI) and Wage-Income Tax Rates

The dynamics of Hospital Insurance (HI) and wage-income (W) tax rates differ from that of Social Security (SS) tax rate. Their tax elasticities with respect to the aggregate SS benefits are marginal. Their sensitivity measures at 0.041~0.044 for the HI and the wage-income tax rates in Figure 4-5 and Figure 4-6 relative to 1.04 for the SS tax rate in Figure 4-4. The small sensitivity of HI and W tax rates to a change in SS benefits disbursement restrict the downward adjustment of these tax rates after the devation period ends. The countervailing effect that comes from the adjustment of SS benefit is, therefore, restrictive during the transition period. As in Figure 4-9, the dynamics of HI and W tax rates are dictated by the magnitude of excess cost and demand growth of medical care and the length of the deviation period in phase 2.

4.7.5 Policy Implications

These simulation results provide important policy implications. Any remaining OASI Trust Funds at the initial steady state will surely go down in the foreseeable future if the government keeps the Social Security tax rate at the initial steady state while the economy goes through some deviation period where medical care expenditures grow faster than income growth. Even when the government successfully finds the new equilibrium SS tax rate at the new steady state and changes the rate to the new level, the government still faces a risk of losses in OASI Trust Funds since the budget-balancing SS tax rate during the deviation period is higher than the rate at the new steady state. This risk depends on the magnitude and the length of the excess growth in medical expenditures. Policy maker must also remember that the tax elasticity grows in the magnitude of excess growth and the deviation period. This implies that holding the SS tax rate constant, the loss in the OASI Trust Funds grow in percent.

By the same token, fixing the HI and wage-income (W) tax rates during or at the onset of deviation period is costly. Assuming workers' and retirees' medical expenditures grow by 8 percent in nominal term during the deviation period. If the period lasts 20 years, the new equilibrium HI tax rate rises to 3.8 percent from the initial equilibrium rate of 1.5 percent. The average wage-income tax rate must rise to 23.0 percent from 15.4 percent, which includes the distributional effect resulting from households falling into the government safety-net at higher rate. The magnitude of increase in these tax rates suggests that the HI Trust Funds decline faster than the OASI Trust Funds. Likewise, policy makers must remember that the sensitivity of HI and W tax rates rises in the magnitude of excess growth of medical care and the length of deviation period. The longer they wait to fix the problem of looming insolvency, the earlier comes the depletion of HI Trust Funds.

4.8 Policy Experiment

4.8.1 Repealing Income-tax-exclusion Rule

The income-tax-exclusion rule essentially provides tax subsidies to workers who purchase health insurance through their employers. The higher the tax bracket workers face, the larger the subsidies they receive. Similarly, the payroll-tax-exclusion rule gives incentives for employers to sponsor health insurance for their workers. As employers often contribute a large part of the EHI premium, employees receive a hefty discount for their insurance. This implies that the government essentially provides tax subsidies to workers who purchase EHI even when their money wage rate is lower as a result of the EHI benefits. For these reasons, the income-tax-exclusion and the payroll-tax exclusion rules create inequity as the amount of tax subsidies rises in wage income, and as tax subsidies are given to workers with EHI, but not to those without EHI.

Abolishing these tax-exclusion rules all together have been called for by many. Sheils and Haught (2004) and Fronstin (2009) compute potential benefits from tax reforms that alter the payroll-tax-exclusion and the wage income-tax-exclusion rules. Their estimates, however, are based on the static model without including any behavioral responses from tax reforms. In contrast, Jeske and Kitao (2009) show that repealing these special tax treatments applied to the EHI reduces the coverage of group health insurance, thus altering composition of workers pooled into the group insurance market. They claim that this policy leads to a higher insurance premium and lower welfare. Their model, however, does not include any growth assumptions of labor productivity and medical expenditures. Their experiment does not include any excess cost and demand growth of medical care. Tax expenditures are, therefore, kept fixed in nominal value over time.

As long as the government provides incentives to the firms through the payroll tax exclusion rule, this model assumes that employers' behaviors are such that they continue to provide the EHI benefits to their employees. Under this assumption, I will repeal the wage-income-tax-exclusion rule as a policy experiment. Since the EHI premium is heavily subsidized, the model further assumes that individuals' take-up decision for EHI will not be altered. This policy becomes effective at time $t=1$ and remains effective thereafter. Excess cost and demand growth remain the same from simulations above.

4.8.2 Results

Repealing income-tax-exclusion rule first alters the distribution of workers across tax brackets. While infra-marginal workers belong to the same tax brackets before and after the repeal, this policy pushes marginal workers to a higher tax bracket. As a result, both infra-marginal and marginal workers pay higher wage-income tax. The increase in income-tax payment by marginal workers is attributable to higher marginal tax rate and tax base. [See Figure 4-10] Repealing the exclusion rule raises the fraction of workers who pay higher marginal tax rate under any given deviation period assumed. As the deviation period prolongs, excess cost and demand growth of medical care significantly lowers the steady-state equilibrium wage rate. Assuming that the tax brackets in real value continue to rise by the rate of growth in labor-augmented technological progress, the prolonged deviation period leads to higher fraction of workers with a lower tax bracket. When the government implements this policy in a revenue-neutral way, repealing the exclusion rule lowers equilibrium tax rates. A combination of higher tax base with lower tax rates countervails effects on household budgets, thus limiting the policy's impact on the economy.

Repealing the tax-exclusion rule also changes the wage-income tax elasticity with respect to its determinants. Figure 4-11 shows that tax sensitivity with respect to the aggregate labor in effective unit, capital-labor ratio, the aggregate SS benefit, and EHI benefit all diminishes. As in Proposition 1, abolishing the tax-exclusion rule will not completely eliminate the sensitivity of wage-income tax in response to a change in EHI premium. As long as the government promotes employer-sponsor health insurance provision, the equilibrium wage rate continues to reflect the cost growth of health insurance benefits. In a general equilibrium model, the repeal of tax-exclusion rule will not dismount this causal effect.

4.9 Conclusion

This chapter uses a stochastic OLG model to compute elasticities of Social Security, Hospital Insurance, and wage-income tax rates with respect to their determinants. It finds that equilibrium tax rates at the new steady state are more sensitive to the capital-labor ratio than other determinants. This finding emphasizes the importance of encompassing household consumption and saving decisions for analysis of tax expenditures and their influence on the fiscal health of entitlement programs. Excess growth in workers' employer-sponsored health insurance (EHI) premiums leads to excess growth in tax expenditures under tax exclusion rules. Tax sensitivity with respect to workers' EHI premiums at the new steady state incorporates a compounded effect of tax expenditure growth over time. As a period of excess growth in tax expenditure prolongs, the tax elasticity with respect to EHI premiums rises at the new steady state. A one-percent change in their premiums requires a larger percentage change in tax rates to keep the budget balanced.

In considering a risk of insolvency of entitlement programs, policy makers must also pay their attention to adjustment processes of equilibrium tax rates that keep the government budget balanced during the deviation and the transition periods. A dynamic adjustment of the equilibrium Social Security tax rate differs from the equilibrium

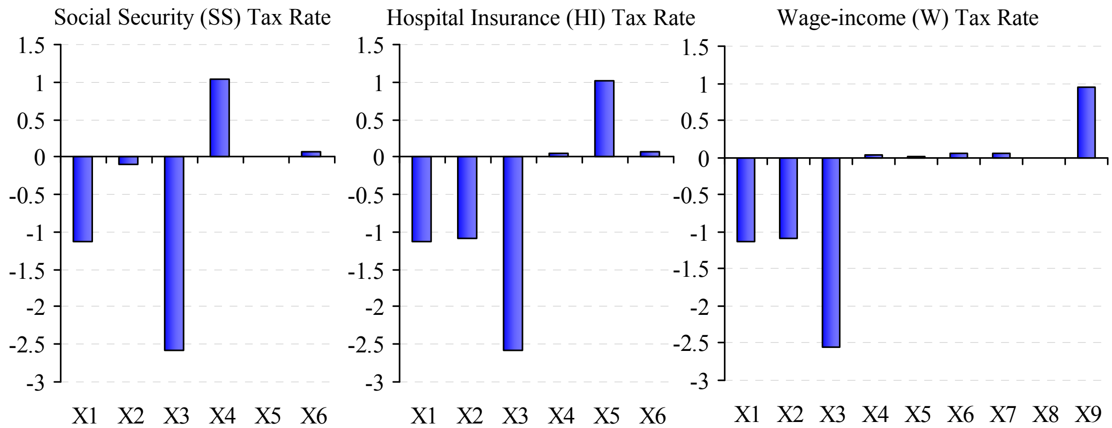
Hospital Insurance or wage income tax rates. Even after the deviation period dissipates completely, capital stock adjusts during the transition period. As a result, the equilibrium wage rate changes over time. As a consequence, the growth rate of aggregate Social Security payments continues to adjust until the economy reaches a new steady state. The elasticity of the Social Security tax rate with respect to the aggregate disbursement is always higher than elasticities of Hospital Insurance and wage-income tax rates with respect to the variable. Changes in equilibrium wage rate during the transition period influence the dynamics of the Social Security tax rate.

This study also investigates impacts of repealing the income-tax-exclusion rule. This policy addresses the problem of inequity pertaining to tax subsidies that are given only to workers with an EHI benefit. Repealing the exclusion rule pushes some fraction of workers to a higher tax bracket as it raises their income tax base. When the government implements this policy in a revenue-neutral way, repealing the exclusion rule lowers equilibrium tax rates. A combination of higher tax base with lower tax rates countervails effects on household budgets, thus limiting the policy's impact on the economy.

As long as the government promotes an employment-based health-insurance provision, excess growth in workers' EHI premiums that outpaces their income growth has nonlinear effects on equilibrium tax rates. Tax exclusion rules magnify the nonlinear effects as high growth in EHI premiums directly leads to high growth in tax expenditures, which in turn raises forgone tax revenues of entitlement programs. An insidious side-effect of medicine, thus, continues to influence fiscal health under an excessive growth in workers' medical expenditures.

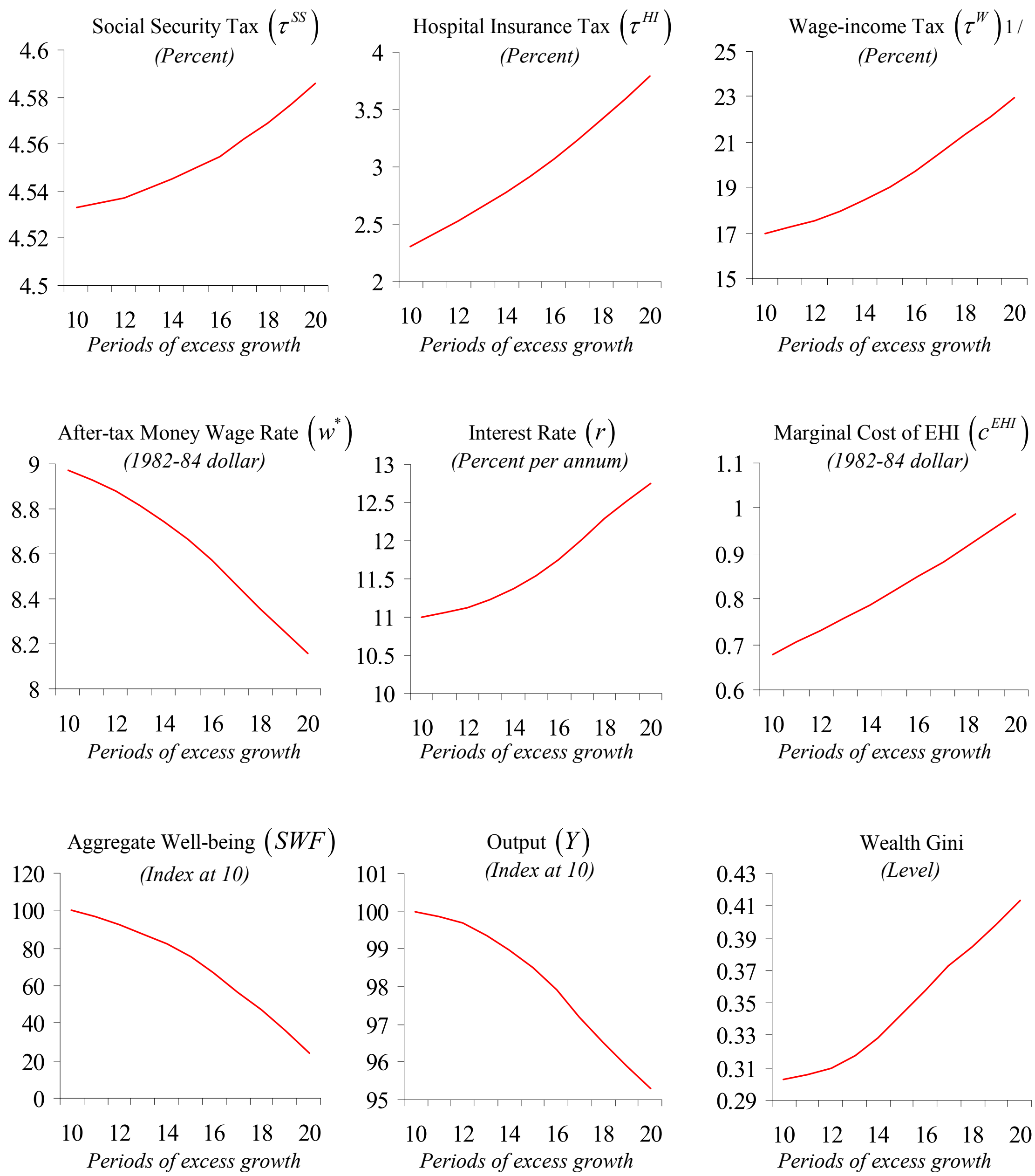
FIGURES

Figure 4-1 Coefficients of Tax Elasticity at the Initial Steady State 1/



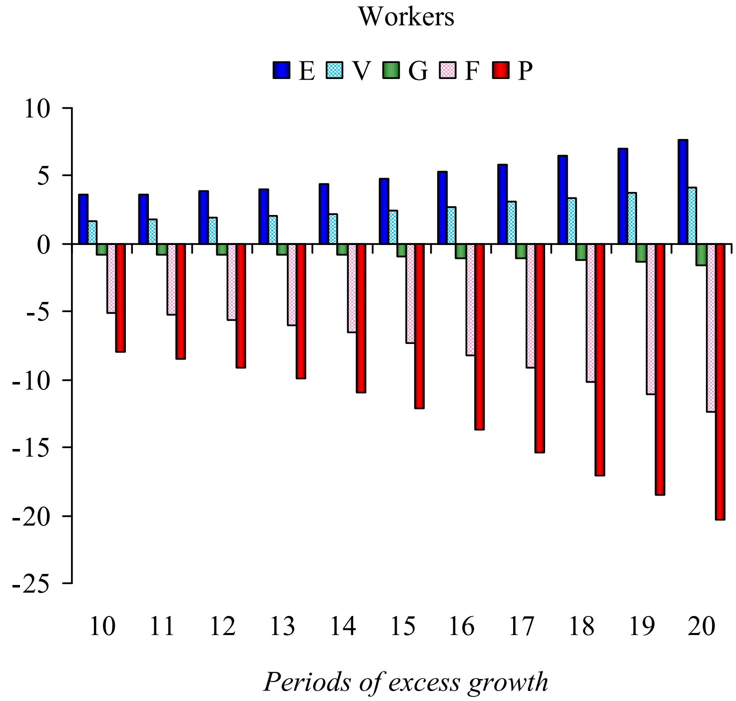
1/ X1 through X9 correspond to the coefficients in expressions [4-5][4-6][4-7], measuring sensitivity of tax with respect to the corresponding variable under balancing budgets.

Figure 4-2 Comparative Statics Results at the New Steady State: 2-percent excess cost growth and 2-percent excess demand growth by workers and retirees



1/ This is based on the average wage income tax rate.

Figure 4-3 Savings Gap by Health Status: Workers and Retirees
(*Percent, relative to the average savings of each cohort*)



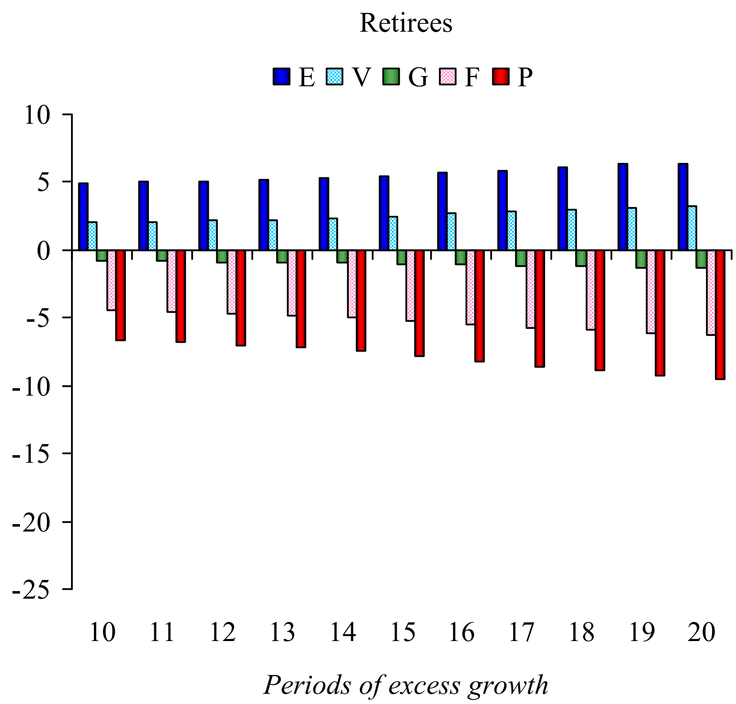
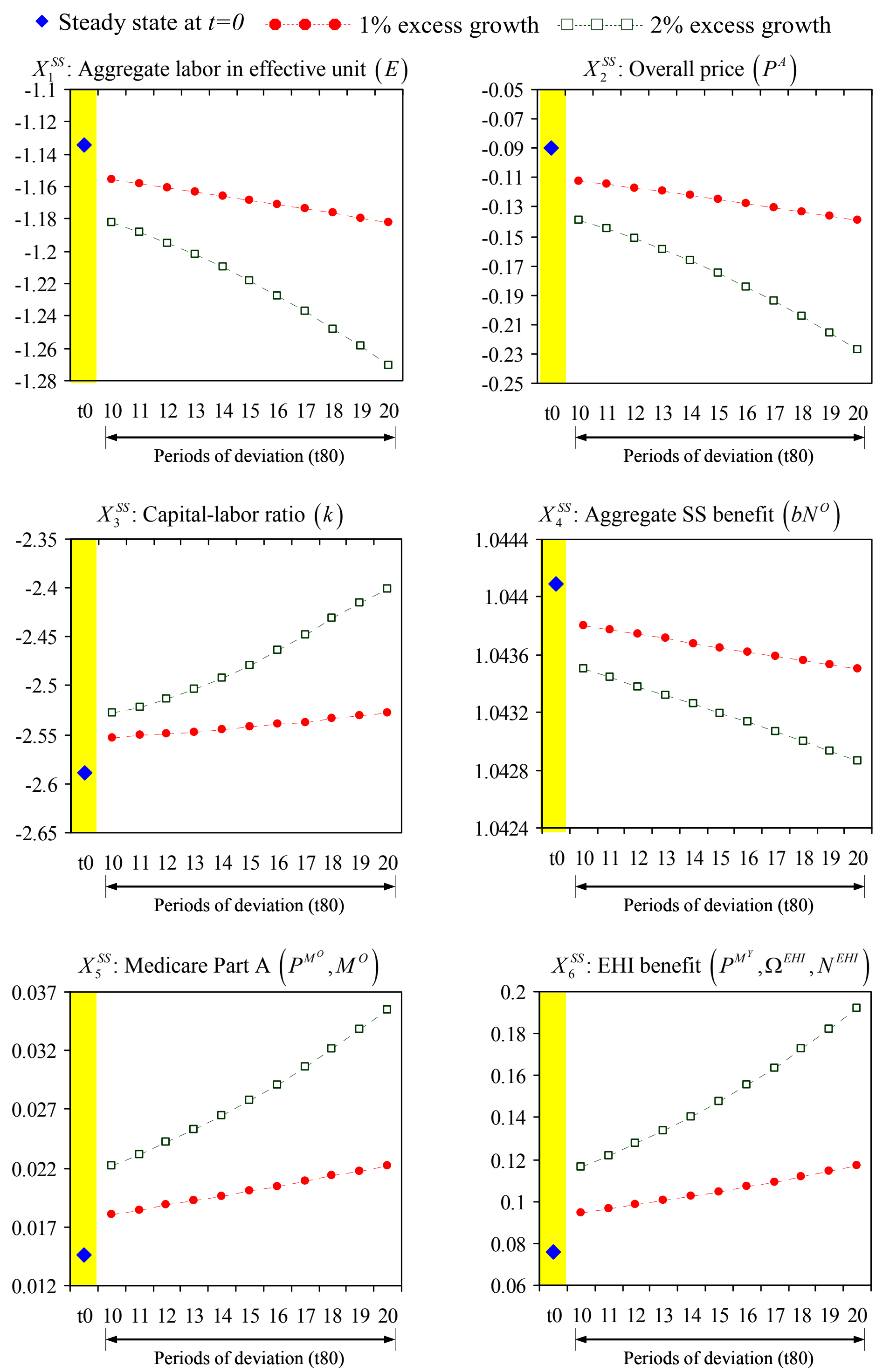
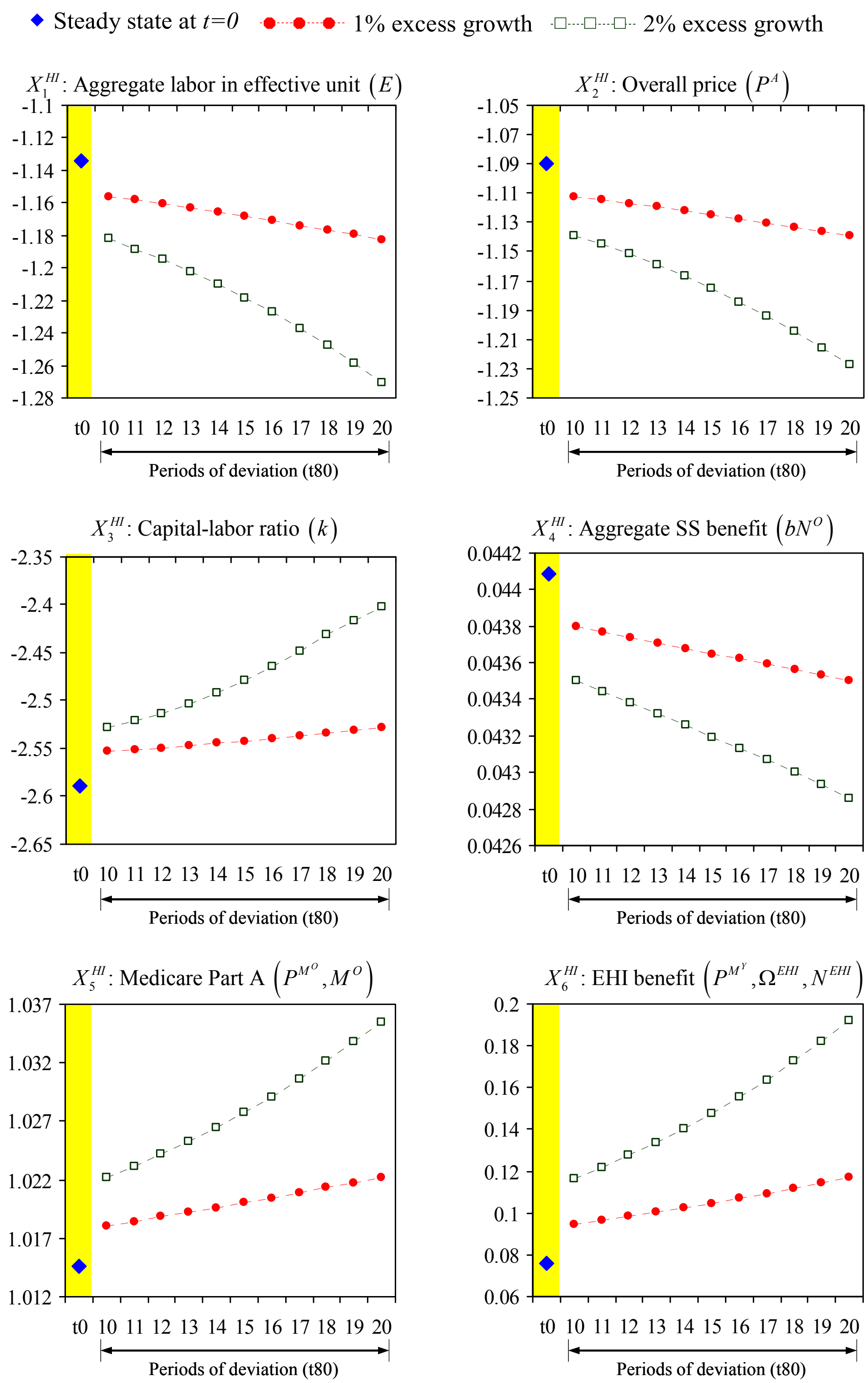


Figure 4-4 Elasticity of Social Security (SS) Tax Rate at the New Steady States 1/



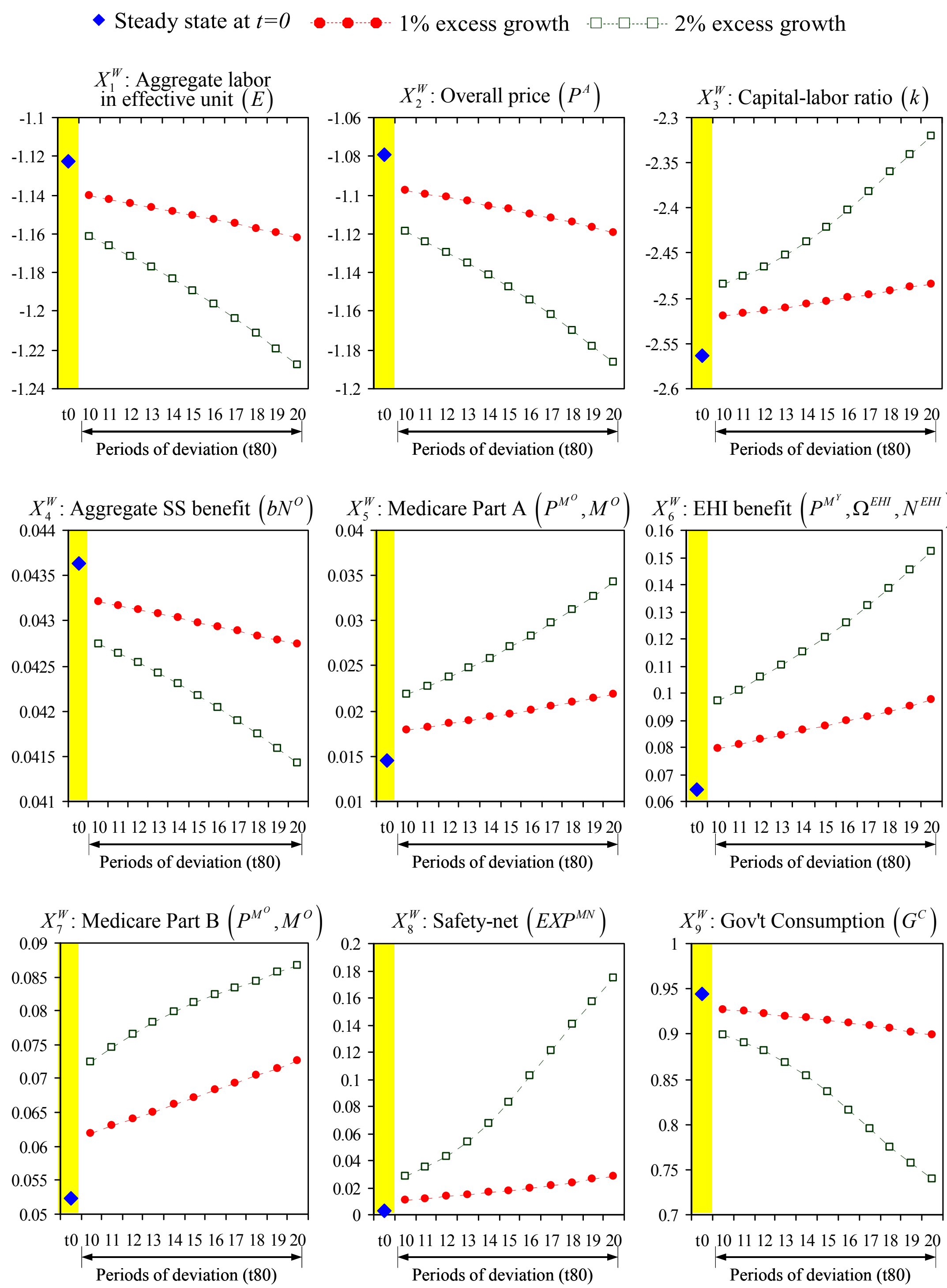
1/ The x-axis shows two steady states, one at *t=0* and the other at *t=80*. Comparative statics results vary across the number of deviation periods.

Figure 4-5 Elasticity of Hospital Insurance Tax Rate at the New Steady States 1/



1/ The x-axis shows two steady states, one at *t=0* and the other at *t=80*. Comparative statics results vary across the number of deviation periods.

Figure 4-6 Elasticity of Wage-Income Tax Rate at the New Steady States 1/



1/ The x-axis shows two steady states, one at *t=0* and the other at *t=80*. Comparative statics results vary across the number of deviation periods.

Figure 4-7 Dynamics of Equilibrium Social Security Tax Rate

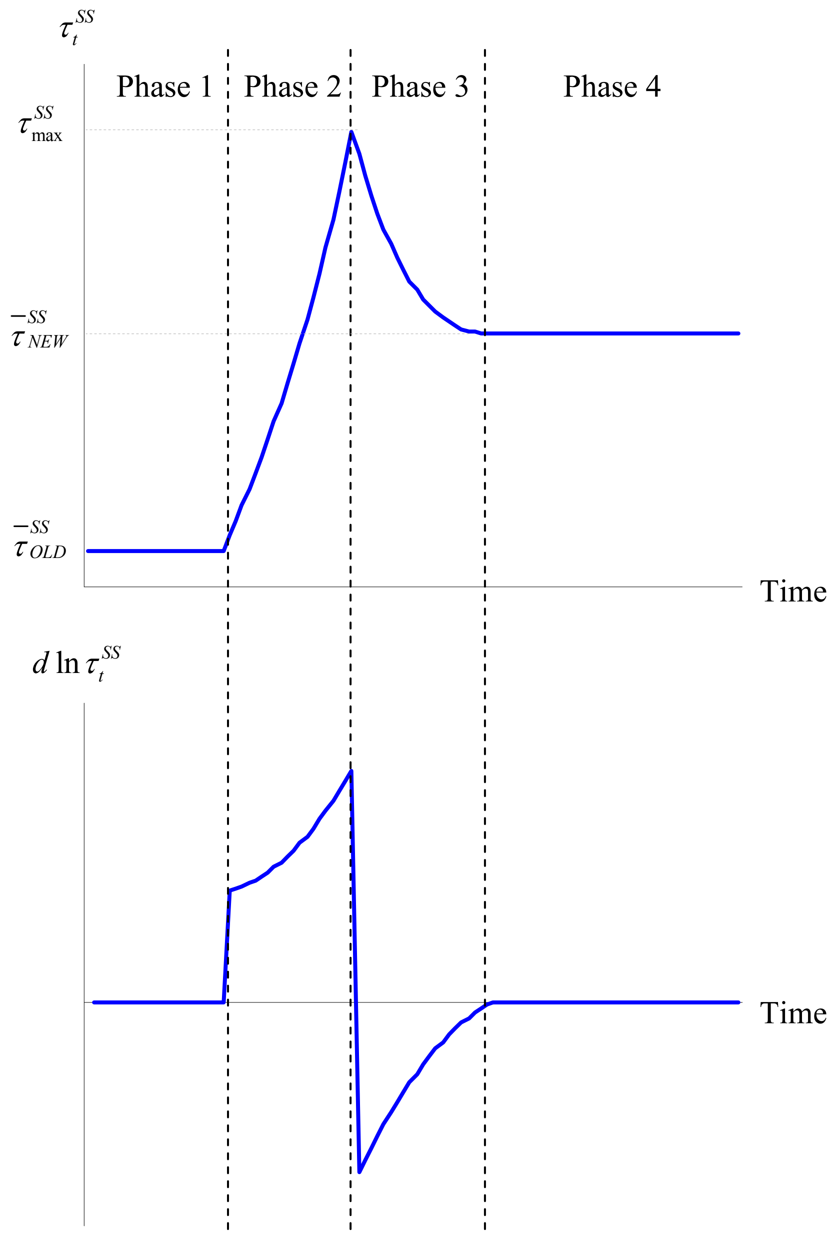


Figure 4-8 Equilibrium Social Security Tax Rates During Transition
(*Percent*)

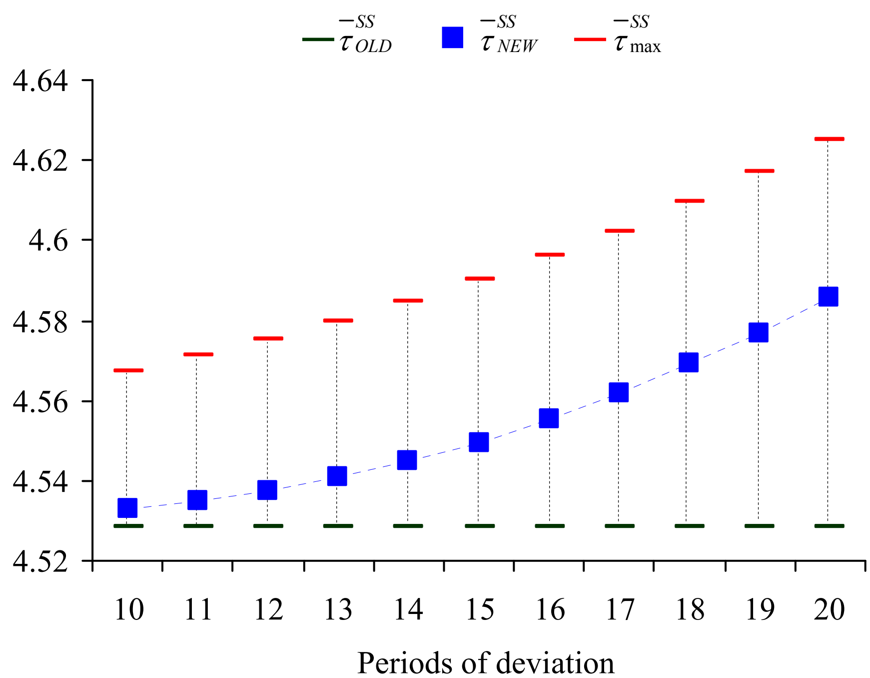


Figure 4-9 Dynamics of Equilibrium Hospital Insurance Tax Rate

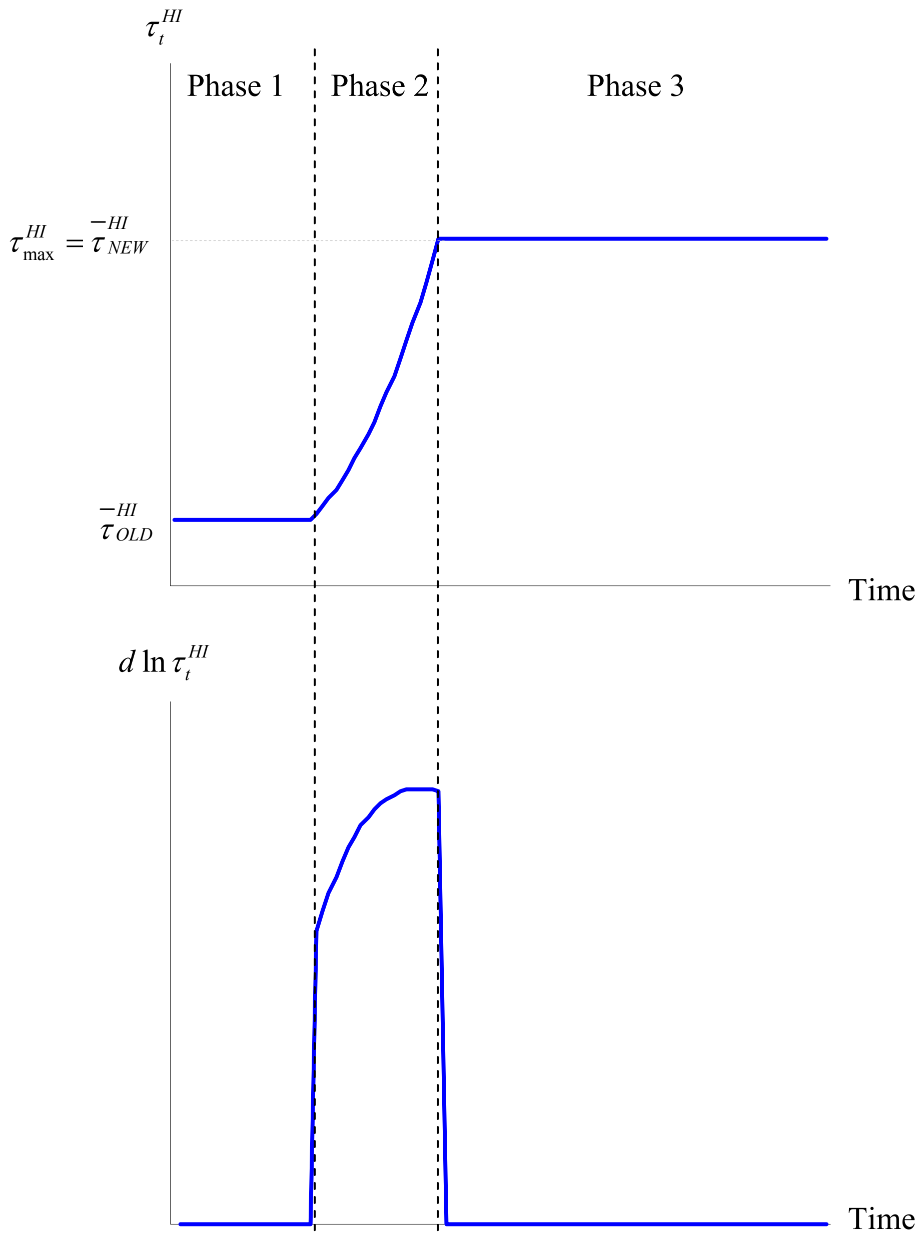
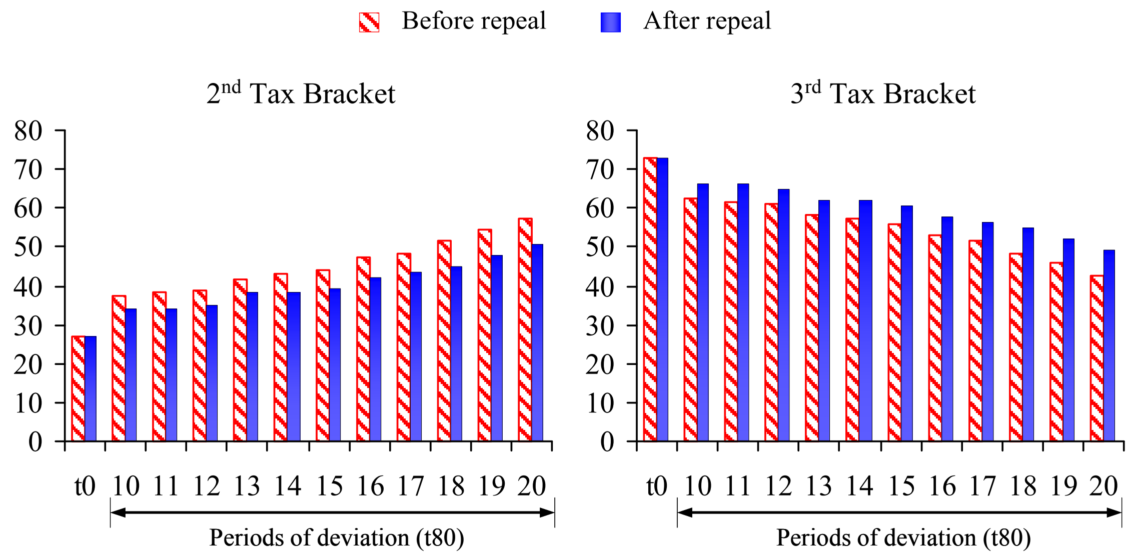


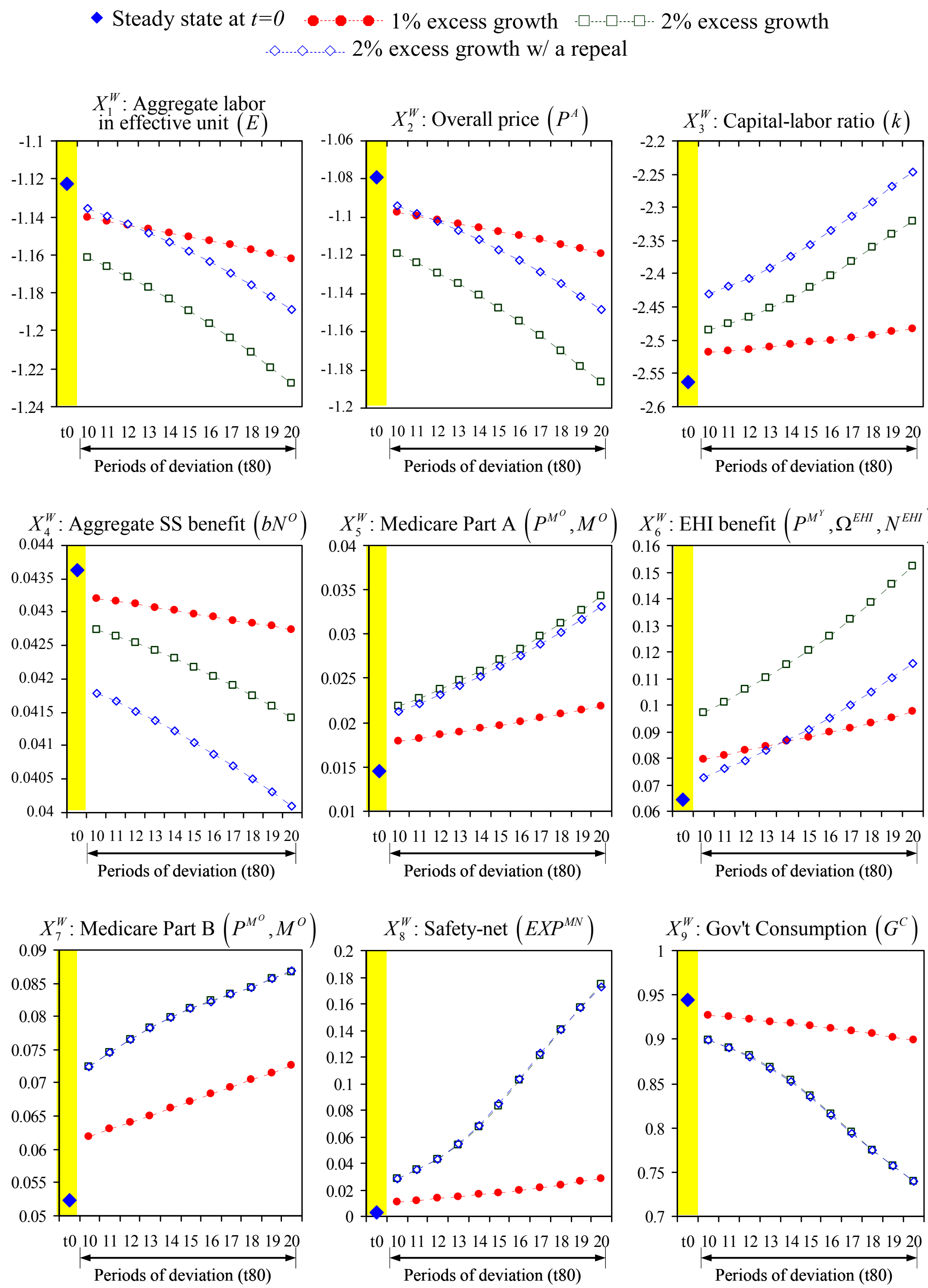
Figure 4-10 Distribution of Workers by Tax Brackets at the Steady States 1/

(*Percent*)



1/ The x-axis shows two steady states, one at *t=0* and the other at *t=80*. Comparative statics results vary across the number of deviation periods.

Figure 4-11 Elasticity of Wage-Income Tax Rate at the New Steady States: Repeal of the Income-tax-exclusion Rule 1/



1/ The x-axis shows two steady states, one at *t=0* and the other at *t=80*. Comparative statics results vary across the number of deviation periods.

TABLES

Table 4-1 Federal Income Tax Expenditures, Calendar Year 1972 (US$ Millions)

Budget function:	Corporations	Individuals	Total
National Defense		700	700
International Affairs and Finance	730	85	815
Agriculture	175	900	1,075
Natural Resources	1,985	370	2,355
Commerce and Transportation	9,550	11,520	21,070
Housing and Community Development	415	7,100	7,515
Health, Labor, and Welfare	55	20,130	20,185
Net exclusion of pension contributions and earnings:		4,200	4,200
Medical insurance premiums and medical care		2,500	2,500
Education		1,040	1,040
Veterans Benefits and Services		480	480
General Government		100	100
Aid to State and Local Financing	1,900	6,300	8,200
Total	14,810	48,725	63,535

Source: Surrey (1973)

Table 4-2 Federal Tax Expenditures, Fiscal Year 2009

Budget function:	Millions US$	Percent
National Defense	3,480	0.3
International Affairs and Finance	21,070	2.0
General Science, Space, and Technology	7,090	0.7
Energy	3,670	0.4
Natural Resources and Environment	1,860	0.2
Agriculture	1,330	0.1
Commerce and Housing	373,529	36.2
Transportation	3,690	0.4
Community and Regional Development	3,740	0.4
Education, Training, Employment, and Social Services	104,188	10.1
Health	190,630	18.4
Medical insurance premiums and medical care	168,460	16.3
Income Security and Social Security	169,050	16.4
Net exclusion of pension contributions and earnings:	122,270	11.8
Veterans Benefits and Services	4,440	0.4
General purpose fiscal assistance and Interest	60,420	5.8
Aid to State and Local Financing	85,040	8.2
Total	1,033,227	100.0

Source: Analytical Perspectives: Budget of the United States Government, Fiscal Year 2009, Office of Management and Budget.

Table 4-3 Numerical Results: Benchmark

Description	Variable	Benchmark	
		Real Value 1/	Nominal Value
(1) Demographics			
Population growth rate	g_N	1.0%	
(2) Production Sector			
Mean Annual Gross Earnings		$19,469.05	$38,018.42
- Low-skilled		$11,001.74	$21,483.78
- Middle-skilled		$17,029.08	$33,253.74
- High-skilled		$31,980.32	$62,449.95
Wage rate (Hourly)	w	$9.35	$18.26
Interest rate (Annual)	r	10.6%	12.8%
Marginal cost of EHI (Hourly equivalent)	c^{EHI}	$0.47	$0.91
EHI premium (Annual)	Ω^{EHI}	$775.75	$2,766.60
EHI premium contribution rate	ξ^{EHI}	82.0%	82.0%
EHI participation rate	ζ^{EHI}	87.5%	87.5%
Share of capital in production	α	0.36	0.36
Rate of depreciation of capital	δ_K	6.0%	6.0%
Total Factor Productivity	A	1.00	1.00
Labor augmented technological progress	g_z	2.0%	2.0%
Fixed hours of labor supply (normalized 2/)	l	0.238	
(3) Consumers			
CRRA on consumption	γ^C	3.5	
CRRA on health	γ^H	3.5	
Weight placed on the utility of health	η	1.0	
Growth rate of weight	g_H	2.0%	
Discount factor	β	0.983	
(4) Tax rates			
Payroll	τ^{PAY}	6.03%	
Social Security	τ^{SS}	4.53%	
Hospital Insurance	τ^{HI}	1.50%	
Federal Labor Income (Medicare Part B)	$\tau^{W\text{ - }average}$	15.4%	
(5) Government Program			
Social security program, replacement rate	θ	35.0%	35.0%
Medicare Part B premium (Annual)	Ω^{MCpB}	$315.65	$938.64
Private supplemental policy premium (Annual)	Ω^{MCS}	$933.64	$2,776.34
Rate of contribution to the Meciare Part B premium	ξ^{MCpB}	46.7%	46.7%

Table 4-3 (continued) Numerical Results: Benchmark

(6) Aggregate Variables:			
(Billions of US$)			
Output	*Y*	$4,014.55	$7,839.46
Consumption of commodities	*C*	$2,494.67	$4,871.50
Medical care goods and services	*M*	$398.58	$778.33
Investment	*I*	$787.03	$1,536.88
Government consumption	*G*	$334.27	$652.75
Discrepancy		($0.00)	($0.00)
(Percent of output)			
Consumption of commodities	*C*	62.1%	62.1%
Medical care goods and services	*M*	9.9%	9.9%
Investment	*I*	19.6%	19.6%
Government	*G*	8.33%	8.33%
Discrepancy		0.00%	0.00%
(7) Miscellaneous			
Capital-Output ratio	*K/Y*	2.17	2.17
"Medically Needy" Program (*Millons of US$*)		$1,068.01	$2,085.58
Poverty threshold *(Single person)*		$5,107.13	$9,973.00
(8) Prices 3/			
Aggregate price index	*PA*	195.28	
Price index excluding medical care goods and service	*PC*	188.71	
Medical care goods and services	*PM*	323.23	
Working generations	*PMy*	356.64	
Retired generations	*PMo*	297.37	
Weight placed on PM for computing PA.	bartheta	0.063574753	
(9) Hospital: Payment-to-cost ratio:			
Workers		1.10	
Retirees	omega	0.92	

1/ We use CPI to deflate the nominal values. Since the U.S. CPI has a base 1982-84=100, the real values share the same base.
2/ Labor hours is fixed and normalized. Assuming that there are 5 working days per week, the normalized value of 0.2375 translates into 40 hours of work per week on average.
3/ Prices indices have a base, 1982-84=100.

APPENDIX

A 4 Appendix

A 4.1 Tax Elasticity of Employer-sponsored Health Insurance Premium

We can express revenues, expenditures, and tax expenditures for each tax account in the following way:

$$REV_t^{SS} = 2\tau_t^{SS} P_t^A w_t E_t \text{ , } TAXEXP_t^{SS} = \tau_t^{SS} P_t^A c_t^{EHI} E_t \text{ , } EXP_t^{SS} = P_t^A \left(\sum_a \sum_e b_{e,a,t} N_{e,a,t} \right)$$

$$REV_t^{HI} = 2\tau_t^{HI} P_t^A w_t E_t \text{ , } TAXEXP_t^{HI} = \tau_t^{HI} P_t^A c_t^{EHI} E_t \text{ , } EXP_t^{HI} = \left(1-\sigma_{(A)}\right) P_t^{M^O} M_t^{O,(A)}$$

$$REV_t^{W^a} = \tau_t^{W^a} P_t^A w_t E_t \text{ , } TAXEXP_t^{W} = \tau_t^{W^a} \left(1-\xi^{EHI}\right) P_t^{M^Y} \Omega_t^{EHI} N_t^{EHI} \text{ ,}$$

$$EXP_t^W = EXP_{MCpB,t}^W + EXP_{MN,t}^W + EXP_{C,t}^W$$

$$EXP_{MCpB,t}^W = \left(1-\sigma_{(B)}\right) P_t^{M^O} M_t^{O,(B)}$$

Notice that $\tau_t^{W^a}$ is the average tax rate.

In order to compute payroll tax elasticity of EHI premium in a general equilibrium, we must totally differentiate equations that account for revenues, expenditures, and tax expenditures at the balanced growth path.

STEP 1: Totally differentiating both sides of the balanced budget equations yields:

<u>SS program:</u>

$$d\ln REV_t^{SS} = d\ln E_t + d\ln P_t^A + d\ln \tau_t^{SS} + d\ln w^*$$

$$d\ln EXP_t^{SS} = d\ln P_t^A + d\ln b_t \left(w^*\right)$$

$$d\ln TAXEXP_t^{SS} = d\ln E_t + d\ln P_t^A + d\ln \tau_t^{SS} + d\ln c_t^{EHI}$$

[4-9]

<u>HI program:</u>

$$d\ln REV_t^{HI} = d\ln E_t + d\ln P_t^A + d\ln \tau_t^{HI} + d\ln w^*$$

$$d\ln EXP_t^{HI} = d\ln P_t^{M^O} + d\ln M_t^{O,(A)}$$

$$d\ln TAXEXP_t^{HI} = d\ln E_t + d\ln P_t^A + d\ln \tau_t^{HI} + d\ln c_t^{EHI}$$

[4-10]

<u>Medicare Part B and other fiscal programs:</u>

$$d\ln REV_t^W = d\ln \tau_t^{W^a} + d\ln P_t^A + d\ln w^* + d\ln E_t$$

$$d\ln EXP_t^W = \varphi_{1,t}^{EXP}\left[d\ln EXP_{MCpB,t}^W\right] + \varphi_{2,t}^{EXP}\left[d\ln EXP_{MN,t}^W\right] + \varphi_{3,t}^{EXP}\left[d\ln EXP_{C,t}^W\right]$$

$$\text{where } \varphi_{1,t}^{EXP} = \frac{EXP_{MCpB,t}^W}{EXP_t^W}, \varphi_{2,t}^{EXP} = \frac{EXP_{MN,t}^W}{EXP_t^W}, \varphi_{3,t}^{EXP} = \frac{EXP_{C,t}^W}{EXP_t^W}$$

$$d\ln EXP_{MCpB,t}^W = d\ln P_t^{M^O} + d\ln M_t^{O,(B)}$$

$$d\ln TAXEXP_t^W = d\ln \tau_t^{W^a} + d\ln P_t^{M^Y} + d\ln \Omega_t^{EHI} + d\ln N_t^{EHI}$$

[4-11]

Step 2: Totally differentiating equilibrium conditions for firms' EHI provision and labor market yields:

(A) Marginal cost of EHI provision:

$$\underbrace{P_t^A c_t^{EHI} \sum\sum z_{a,e,t}\bar{l} N_{a,e,t}}_{\text{Amount paid by the employer}} = \underbrace{\xi P_t^{M^Y} \Omega_t^{EHI} \sum\sum \zeta_{a,e} N_{a,e,t}}_{\text{Total cost of EHI}}$$

$$c_t^{EHI} = \frac{\xi P_t^{M^Y} \Omega_t^{EHI} N_t^{EHI}}{P_t^A E_t}$$

[4-12]

where E_t is the aggregate effective labor, and N_t^{EHI} is the size of labor with EHI benefit. Totally differentiating [4-12] yields:

$$d\ln c_t^{EHI} = d\ln P_t^{M^Y} + d\ln \Omega_t^{EHI} + d\ln N_t^{EHI} - d\ln P_t^A - d\ln E_t$$

[4-13]

(B) Equilibrium after-tax (money) wage rate at the steady state $\bar{k}$ is

$$w^{*}=\frac{\widehat{w}}{1+\tau_{t}^{P}}-\left(\frac{1-\tau_{t}^{P}}{1+\tau_{t}^{P}}\right)c^{EHI}$$

$$\text{where } \widehat{w}=(1-\alpha)A\left(\bar{k}\right)^{\alpha}=MPL$$

[4-14]

Totally differentiating [4-13] yields:

$$d\ln w^{*}=\frac{\alpha\widehat{w}}{\left(1+\tau_{t}^{P}\right)w^{*}}\left[d\ln\bar{k}\right]-\left(\frac{1-\tau_{t}^{P}}{1+\tau_{t}^{P}}\right)\left(\frac{c^{EHI}}{w^{*}}\right)\left[d\ln c^{EHI}\right]$$
$$-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{SS}}{1+\tau_{t}^{P}}\right)\left[d\ln\tau_{t}^{SS}\right]-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{HI}}{1+\tau_{t}^{P}}\right)\left[d\ln\tau_{t}^{HI}\right]$$

[4-15]

Step 3: Substituting [4-9][4-10][4-11][4-13][4-15] into [4-4] yields:

$$\begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix}\begin{bmatrix} d\ln\tau_{t}^{SS} \\ d\ln\tau_{t}^{HI} \\ d\ln\tau_{t}^{W^{a}} \end{bmatrix}=\begin{bmatrix} J \\ K \\ L \end{bmatrix}$$

[4-16]

where

$$A=\left\{1-\phi_{2,t}^{SS}-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{SS}}{1+\tau_{t}^{P}}\right)\right\}$$

$$B=-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{HI}}{1+\tau_{t}^{P}}\right)$$

$$C=0$$

$$D=-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{SS}}{1+\tau_{t}^{P}}\right)$$

$$E=\left\{1-\phi_{2,t}^{HI}-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{HI}}{1+\tau_{t}^{P}}\right)\right\}$$

$$F=0$$

$$G=-\left(1-\frac{c^{EHI}}{w^{*}}\right)\left(\frac{\tau_{t}^{SS}}{1+\tau_{t}^{P}}\right)$$

$$H = -\left(1 - \frac{c^{EHI}}{w^*}\right)\left(\frac{\tau_t^{HI}}{1+\tau_t^P}\right)$$

$$I = \left(1 - \phi_{2,t}^{W}\right)$$

$$J = -\left\{1 + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln E_t\right] - \left\{1 - \phi_{1,t}^{SS} + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^A\right] - \frac{\alpha\widehat{w}}{\left(1+\tau_t^P\right)w^*}\left(d\ln\overline{k}\right)$$
$$+\phi_{1,t}^{SS}\left[d\ln b_t\left(w^*\right)\right] + \left\{\phi_{2,t}^{SS} + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^{M^Y} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]$$

$$K = -\left\{1 + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln E_t\right] - \left\{1 + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^A\right] - \frac{\alpha\widehat{w}}{\left(1+\tau_t^P\right)w^*}\left[d\ln\overline{k}\right]$$
$$+\phi_{1,t}^{HI}\left[d\ln P_t^{M^O} + d\ln M_t^{O,(A)}\right] + \left\{\phi_{2,t}^{HI} + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^{M^Y} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]$$

$$L = -\left\{1 + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln E_t\right] - \left\{1 + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^A\right] - \frac{\alpha\widehat{w}}{\left(1+\tau_t^P\right)w^*}\left[d\ln\overline{k}\right]$$
$$+\phi_{1,t}^{W}\varphi_{1,t}^{EXP}\left[d\ln P_t^{M^O} + d\ln M_t^{O,(B)}\right] + \phi_{1,t}^{W}\varphi_{2,t}^{EXP}\left[d\ln EXP_{MN,t}^{W}\right] + \phi_{1,t}^{W}\varphi_{3,t}^{EXP}\left[d\ln EXP_{C,t}^{W}\right]$$
$$+\left\{\phi_{2,t}^{W} + \left(\frac{1-\tau_t^P}{1+\tau_t^P}\right)\left(\frac{c^{EHI}}{w^*}\right)\right\}\left[d\ln P_t^{M^Y} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]$$

Solving [4-16] yields the following results:

$$d\ln\tau_t^{SS} = X_1^{SS}\left[d\ln E_t\right] + X_2^{SS}\left[d\ln P_t^A\right] + X_3^{SS}\left[d\ln\overline{k}\right] + X_4^{SS}\left[d\ln b_t\left(w^*\right)\right]$$
$$+X_5^{SS}\left[d\ln P_t^{M^O} + d\ln M_t^{O,(A)}\right] + X_6^{SS}\left[d\ln P_t^{M^Y} + d\ln\Omega_t^{EHI} + d\ln N_t^{EHI}\right]$$

[4-17]

where

$$X_{1,t}^{SS} = \frac{-\left(1+J_{1,t}\right)\left(1-\phi_{2,t}^{HI}\right)}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_2^{SS}J_2^{HI}}$$

$$X_{2,t}^{SS} = \frac{-\left\{\left(1-\phi_{1,t}^{SS}+J_{1,t}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)+\left(1+J_{1,t}\right)J_{2,t}^{HI}\right\}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{3,t}^{SS} = \frac{-\left(1-\phi_{2,t}^{HI}\right)\left(\frac{\alpha\widehat{w}}{\left(1+\tau_t^P\right)w^*}\right)}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{4,t}^{SS} = \frac{\phi_{1,t}^{SS}\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{5,t}^{SS} = \frac{\phi_{1,t}^{HI}J_{2,t}^{HI}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{6,t}^{SS} = \frac{\left(\phi_{2,t}^{SS}+J_{1,t}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)+\left(\phi_{2,t}^{HI}+J_{1,t}\right)J_{2,t}^{HI}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$\begin{aligned} d\ln\tau_t^{HI} = {} & X_{1,t}^{HI}\left[d\ln E_t\right]+X_{2,t}^{HI}\left[d\ln P_t^A\right]+X_{3,t}^{HI}\left[d\ln\bar{k}\right]+X_{4,t}^{HI}\left[d\ln b_t\left(w^*\right)\right] \\ & +X_{5,t}^{HI}\left[d\ln P_t^{M^O}+d\ln M_t^{O,(A)}\right]+X_{6,t}^{HI}\left[d\ln P_t^{M^Y}+d\ln\Omega_t^{EHI}+d\ln N_t^{EHI}\right] \end{aligned}$$

[4-18]

where

$$X_{1,t}^{HI} = \frac{-\left(1+J_{1,t}\right)\left(1-\phi_{2,t}^{SS}\right)}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{2,t}^{HI} = \frac{-\left\{\left(1+J_{1,t}\right)\left(1-\phi_{2,t}^{SS}\right)-\phi_{1,t}^{SS}J_{2,t}^{SS}\right\}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{3,t}^{HI} = \frac{-\left(1-\phi_{2,t}^{SS}\right)\left(\dfrac{\alpha\widehat{w}}{\left(1+\tau_t^P\right)w^*}\right)}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{4,t}^{HI} = \frac{\phi_{1,t}^{SS}J_{2,t}^{SS}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{5,t}^{HI} = \frac{\phi_{1,t}^{HI}\left(1-\phi_{2,t}^{SS}\right)-\phi_{1,t}^{HI}J_{2,t}^{SS}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$X_{6,t}^{HI} = \frac{\left(\phi_{2,t}^{HI}+J_{1,t}\right)\left(1-\phi_{2,t}^{SS}\right)+\left(\phi_{2,t}^{SS}-\phi_{2,t}^{HI}\right)J_{2,t}^{SS}}{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}}$$

$$\begin{aligned} d\ln\tau_t^{W^a} = {} & X_{1,t}^{W}\left[d\ln E_t\right]+X_{2,t}^{W}\left[d\ln P_t^A\right]+X_{3,t}^{W}\left[d\ln\bar{k}\right]+X_{4,t}^{W}\left[d\ln b_t\left(w^*\right)\right] \\ & +X_{5,t}^{W}\left[d\ln P_t^{M^O}+d\ln M_t^{O,(A)}\right]+X_{6,t}^{W}\left[d\ln P_t^{M^Y}+d\ln\Omega_t^{EHI}+d\ln N_t^{EHI}\right] \\ & +X_{7,t}^{W}\left[d\ln P_t^{M^O}+d\ln M_t^{O,(B)}\right]+X_{8,t}^{W}\left[d\ln EXP_{MN,t}^{W}\right]+X_{9,t}^{W}\left[d\ln EXP_{C,t}^{W}\right] \end{aligned}$$

[4-19]

where

$$X_{1,t}^{W} = \frac{-\left(1-\phi_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}\right)\left(1+J_{1,t}\right)}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{2,t}^{W} = \frac{-\left\{\left(1+J_{1,t}\right)\left(1-\phi_{2,t}^{SS}\right)-J_{2,t}^{SS}\phi_{1,t}^{SS}\right\}\left(1-\phi_{2,t}^{HI}\right)}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{3,t}^{W} = \frac{-\left(1-\phi_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}\right)\dfrac{\alpha\widehat{w}}{\left(1+\tau_{t}^{P}\right)w^{*}}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{4,t}^{W} = \frac{\left(1-\phi_{2,t}^{HI}\right)J_{2,t}^{SS}\phi_{1,t}^{SS}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{5,t}^{W} = \frac{\left(1-\phi_{2,t}^{SS}\right)\phi_{1,t}^{HI}J_{2,t}^{HI}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{6,t}^{W} = \frac{\left\{\begin{array}{l}\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}\right)\left(J_{1,t}+\phi_{2,t}^{W}\right)\\ +\left(\phi_{2,t}^{HI}-\phi_{2,t}^{W}\right)\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)J_{2,t}^{HI}\\ -\left(\phi_{2,t}^{W}-\phi_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}\right)J_{2,t}^{SS}\end{array}\right\}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{7,t}^{W} = \frac{\left\{\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)-\left(1-\phi_{2,t}^{SS}\right)J_{2,t}^{HI}\right\}\phi_{1,t}^{W}\varphi_{1,t}^{EXP}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{8,t}^{W} = \frac{\left\{\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)-\left(1-\phi_{2,t}^{SS}\right)J_{2,t}^{HI}\right\}\phi_{1,t}^{W}\varphi_{2,t}^{EXP}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

$$X_{9,t}^{W} = \frac{\left\{\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)-\left(1-\phi_{2,t}^{SS}\right)J_{2,t}^{HI}\right\}\phi_{1,t}^{W}\varphi_{3,t}^{EXP}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

where $J_{1,t} = \left(\dfrac{1-\tau_{t}^{P}}{1+\tau_{t}^{P}}\right)\left(\dfrac{c^{EHI}}{w^{*}}\right)$, $J_{2,t}^{SS} = \left(1-\dfrac{c^{EHI}}{w^{*}}\right)\left(\dfrac{\tau_{t}^{SS}}{1+\tau_{t}^{P}}\right)$, and $J_{2,t}^{HI} = \left(1-\dfrac{c^{EHI}}{w^{*}}\right)\left(\dfrac{\tau_{t}^{HI}}{1+\tau_{t}^{P}}\right)$

A 4.2 Proof of Proposition 1

Abolishing the income-tax-exclusion rule applied to workers' contribution to their EHI premium will not make the equilibrium wage-income tax rate independent of workers' medical-expenditure growth.

Proof:

Based on the expression [4-4], repealing the income tax exclusion rule applied to the EHI means $\phi_{2,t}^{W}=0$ in [4-19]. Adding this constraint to the expression for $X_{6,t}^{W}$ yields:

$$X_{6,t}^{W}\Big|_{\phi_{2,t}^{W}=0}=\frac{\left\{\left(1-\phi_{2,t}^{HI}\right)\left\{J_{1,t}\left(1-\phi_{2,t}^{SS}\right)+\phi_{2,t}^{SS}J_{2,t}^{SS}\right\}+\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)\phi_{2,t}^{HI}J_{2,t}^{HI}\right\}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}}>0$$

Q.E.D.

A 4.3 Proof of Proposition 2

Abolishing the payroll-tax-exclusion rule applied to employers' cost of EHI provision will not make the equilibrium payroll tax rate independent of workers' medical-expenditure growth.

Proof:

Based on the expression [4-4], repealing the payroll tax exclusion rule means $\phi_{2,t}^{SS}=\phi_{2,t}^{HI}=0$ in [4-17][4-18]. Adding these constraints to the expression for $X_{6,t}^{SS}$ and $X_{6,t}^{HI}$ yields:

$$X_{6,t}^{SS}\Big|_{\phi_{2,t}^{SS}=0}=X_{6,t}^{HI}\Big|_{\phi_{2,t}^{HI}=0}=\frac{J_{1,t}}{1-J_{2,t}^{SS}-J_{2,t}^{HI}}\neq 0$$

Q.E.D.

A 4.4 Proof of Proposition 3

The wage income tax elasticity with respect to EHI premium is larger before than after abolishing the income tax exclusion rule ($\phi_{2,t}^{W}=0$) applied to workers' contribution to their EHI premium if $J_{2,t}^{HI}=\dfrac{\tau_{t}^{HI}\left(w^{*}-c^{EHI}\right)}{\left(1+\tau_{t}^{P}\right)w^{*}}$ is sufficiently small.

Proof:

Based on the proof of Proposition 1, we have:

$$X_{6,t}^{W}\Big|_{\phi_{2,t}^{W}=0}=\frac{\left\{\left(1-\phi_{2,t}^{HI}\right)\left\{J_{1,t}\left(1-\phi_{2,t}^{SS}\right)+\phi_{2,t}^{SS}J_{2,t}^{SS}\right\}+\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)\phi_{2,t}^{HI}J_{2,t}^{HI}\right\}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}}>0$$

When the wage income tax exclusion rule applies ($\phi_{2,t}^{W}\neq 0$), we have

$$X_{6,t}^{W}\Big|_{\phi_{2,t}^{W}\neq 0}=\frac{\begin{Bmatrix}\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}\right)\left(J_{1,t}+\phi_{2,t}^{W}\right)\\+\left(\phi_{2,t}^{HI}-\phi_{2,t}^{W}\right)\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)J_{2,t}^{HI}\\-\left(\phi_{2,t}^{W}-\phi_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}\right)J_{2,t}^{SS}\end{Bmatrix}}{\left\{\left(1-\phi_{2,t}^{SS}-J_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}-J_{2,t}^{HI}\right)-J_{2,t}^{SS}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)}$$

We have $X_{6,t}^{W}\Big|_{\phi_{2,t}^{W}\neq 0}>X_{6,t}^{W}\Big|_{\phi_{2,t}^{W}=0}$ if the following condition holds.

$$\begin{aligned}&\left(1-\phi_{2,t}^{HI}\right)\left(1-\phi_{2,t}^{SS}\right)\left(J_{1,t}+\phi_{2,t}^{W}\right)+\left(\phi_{2,t}^{HI}-\phi_{2,t}^{W}\right)\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)J_{2,t}^{HI}-\left(\phi_{2,t}^{W}-\phi_{2,t}^{SS}\right)\left(1-\phi_{2,t}^{HI}\right)J_{2,t}^{SS}\\&>\left\{\left(1-\phi_{2,t}^{HI}\right)\left\{J_{1,t}\left(1-\phi_{2,t}^{SS}\right)+\phi_{2,t}^{SS}J_{2,t}^{SS}\right\}+\left(1-J_{2,t}^{HI}\phi_{2,t}^{SS}\right)\phi_{2,t}^{HI}J_{2,t}^{HI}\right\}\left(1-\phi_{2,t}^{W}\right)\end{aligned}$$

The expression above simplifies to:

$$\left\{\left(1+J_{1,t}-J_{2,t}^{SS}-J_{2,t}^{HI}\right)-\phi_{2,t}^{SS}\left(1+J_{1,t}-J_{2,t}^{SS}-J_{2,t}^{HI}J_{2,t}^{HI}\right)\right\}\left(1-\phi_{2,t}^{HI}\right)\phi_{2,t}^{W}>0$$

We must show:

$$\left(1+J_{1,t}-J_{2,t}^{SS}-J_{2,t}^{HI}\right)-\phi_{2,t}^{SS}\left(1+J_{1,t}-J_{2,t}^{SS}-J_{2,t}^{HI}J_{2,t}^{HI}\right)>0$$

$$\left(1+J_{1}-J_{2}^{SS}\right)\left(1-\phi_{2,t}^{SS}\right)>J_{2}^{HI}\left(1-\phi_{2,t}^{SS}J_{2}^{HI}\right)$$

The inequality above holds if $J_{2,t}^{HI}=\dfrac{\tau_{t}^{HI}\left(w^{*}-c^{EHI}\right)}{\left(1+\tau_{t}^{P}\right)w^{*}}$ is sufficiently small.

Q.E.D.

A 4.5 Proof of Proposition 4

The Social Security (SS) tax elasticity and the Hospital Insurance (HI) tax elasticity with respect to the aggregate labor in effective unit, capital-labor ratio, and EHI benefits are identical since $\phi_{2,t}^{SS} = \phi_{2,t}^{HI}$ holds.

Proof:

From the expression [4-4], we have

$$\phi_{2,t}^{SS} = \frac{TAXEXP_t^{SS}}{REV_t^{SS}} \text{ and } \phi_{2,t}^{HI} = \frac{TAXEXP_t^{HI}}{REV_t^{HI}}$$

where

$$REV_t^{SS} = 2\tau_t^{SS} P_t^A w_t E_t \text{ , } TAXEXP_t^{SS} = \tau_t^{SS} P_t^A c_t^{EHI} E_t$$

$$REV_t^{HI} = 2\tau_t^{HI} P_t^A w_t E_t \text{ , } TAXEXP_t^{HI} = \tau_t^{HI} P_t^A c_t^{EHI} E_t$$

Under the balanced budget condition for the Social Security and Hospital insurance programs, the elasticity of tax revenue with respect to the tax expenditure is the same in both programs, $\phi_{2,t}^{SS} = \phi_{2,t}^{HI}$.

Substituting the condition $\phi_{2,t}^{SS} = \phi_{2,t}^{HI}$ in the expressions [4-17][4-18] yields the following relationships:

$$X_{1,t}^{SS} = X_{1,t}^{HI}$$
$$X_{3,t}^{SS} = X_{3,t}^{HI}$$
$$X_{6,t}^{SS} = X_{6,t}^{HI}$$

Q.E.D.

A 4.6 Proof of Proposition 5

The steady state pins down the payroll tax rate as well as the wage income tax rate such that the following conditions must hold:

$$d \ln \tau_t^{SS} = 0$$
$$d \ln \tau_t^{HI} = 0$$
$$d \ln \tau_t^{W^a} = 0$$

Proof:

(A) $d\ln\tau_t^{SS}=0$

We simply plug in the conditions [4-8] into the expressions [4-17][4-18][4-19] to compute $d\ln\tau_t^{SS}$, $d\ln\tau_t^{HI}$, and $d\ln\tau_t^{W^a}$. Based on the Cramer's rule, we have:

$$
\begin{aligned}
\det\begin{bmatrix} J & B & C \\ K & E & F \\ L & H & I \end{bmatrix} &= \left(1-\phi_{2,t}^{W}\right)\begin{bmatrix} -3-3J_{1,t}+3\phi_{2,t}^{HI}+3\phi_{2,t}^{HI}J_{1,t} \\ -2+2\phi_{2,t}^{HI}+2\phi_{1,t}^{SS}-2\phi_{1,t}^{SS}\phi_{2,t}^{HI}-2\phi_{1,t}^{SS}J_{2,t}^{HI}-2J_{1,t}+2J_{1,t}\phi_{2,t}^{HI} \\ 3\phi_{1,t}^{SS}-3\phi_{1,t}^{SS}\phi_{2,t}^{HI}-3J_{2,t}^{HI}\phi_{1,t}^{SS}+5\phi_{1,t}^{HI}J_{2,t}^{HI} \\ +5\phi_{2,t}^{SS}-5\phi_{2,t}^{SS}\phi_{2,t}^{HI}-5\phi_{2,t}^{SS}J_{2,t}^{HI}+5J_{1,t}-5J_{1,t}\phi_{2,t}^{HI}+5\phi_{2,t}^{HI}J_{2,t}^{HI} \end{bmatrix} \\
&= \left(1-\phi_{2,t}^{W}\right)\begin{bmatrix} -3-3J_{1,t}+3\phi_{2,t}^{HI}+3\phi_{2,t}^{HI}J_{1,t} \\ -2+2\phi_{2,t}^{HI}+2\phi_{1,t}^{SS}-2\phi_{1,t}^{SS}\phi_{2,t}^{HI}-2\phi_{1,t}^{SS}J_{2,t}^{HI}-2J_{1,t}+2J_{1,t}\phi_{2,t}^{HI} \\ 3\phi_{1,t}^{SS}-3\phi_{1,t}^{SS}\phi_{2,t}^{HI}-3J_{2,t}^{HI}\phi_{1,t}^{SS}+5\phi_{1,t}^{HI}J_{2,t}^{HI} \\ +5\phi_{2,t}^{SS}-5\phi_{2,t}^{SS}\phi_{2,t}^{HI}-5\phi_{2,t}^{SS}J_{2,t}^{HI}+5J_{1,t}-5J_{1,t}\phi_{2,t}^{HI}+5\phi_{2,t}^{HI}J_{2,t}^{HI} \end{bmatrix} \\
&= \left(1-\phi_{2}^{W}\right)\begin{bmatrix} -5+5\phi_{2,t}^{HI}+5\left(\phi_{1,t}^{SS}+\phi_{2,t}^{SS}\right)-5\left(\phi_{1,t}^{SS}+\phi_{2,t}^{SS}\right)\phi_{2,t}^{HI}-5\left(\phi_{1,t}^{SS}+\phi_{2,t}^{SS}\right)J_{2,t}^{HI} \\ +5\left(\phi_{1,t}^{HI}+\phi_{2,t}^{HI}\right)J_{2,t}^{HI} \end{bmatrix} \\
&= \left(1-\phi_{2}^{W}\right)\left[-5+5\phi_{2,t}^{HI}+5-5\phi_{2,t}^{HI}-5J_{2,t}^{HI}+5J_{2,t}^{HI}\right] \\
&= 0
\end{aligned}
$$

Hence the determinant of the above matrix becomes zero, indicating $d\ln\tau_t^{SS}$ =0.

(B) $d\ln\tau_t^{HI}=0$ and $d\ln\tau_t^{W^a}=0$

Similarly, we can show that the determinant of the following matrix is zero at the steady state:

$$
\det\begin{bmatrix} A & J & C \\ D & K & F \\ G & L & I \end{bmatrix} = 0 = \det\begin{bmatrix} A & B & J \\ D & E & K \\ G & H & L \end{bmatrix}
$$

Q.E.D.

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CHAPTER 5

Conclusion

5.1 Essay 1

In constructing a many-period overlapping generations (OLG) model, this dissertation follows the framework of Auerback and Kotlikoff (1987) and expands their A-K OLG model by introducing a high degree of intra-generational heterogeneity, uncertainty of employer-sponsored health insurance (EHI) offer, and idiosyncratic health shocks that stochastically control medical expenditures. Hence this study transforms the A-K OLG model into a stochastic OLG model with the intra-generational heterogeneity. This dissertation emphasizes an inclusion of inter- as well as intra-generational heterogeneity in the model for health policy analysis. This emphasis is based on a belief that individuals' responses to a health policy collectively guide the whole economy.

With a focus on macroeconomic implications of health policy in the United States, the first essay (Chapter 2) analyzes two possible health care reforms: universal insurance without mandate, and universal insurance with a mandate. "Universal insurance" in this case means substantial subsidies for households who purchase private non-group insurance. A reform including a "mandate" is one that requires all households to purchase insurance. Under universal insurance without mandate, the analysis finds that subsidies can lower the percentage of uninsured workers in the population and reduce the number of financially vulnerable people who fall into the "Medically Needy" program. Such a policy helps narrow wealth inequality and improves, albeit marginally, social welfare relative to the case without government intervention. The policy's impact on the balanced growth path of the overall economy is limited.

An individual mandate reduces the population fraction without insurance to zero. A mandate can also lower the financially vulnerable fraction of the working population nearly to zero, and it can reduce the fraction of retirees who fall into the "Medically Needy" program. Such a policy, however, causes serious side effects according to the model. Compelling workers who would not otherwise turn to insurance to purchase it lowers their utility, thus creating negative consumer surplus. Their willingness to purchase health insurance is lower than the equilibrium premium. Most of these workers are healthy, yet their precautionary savings decline as workers with insurance typically consume more medical services. The economy's overall balanced-growth output is noticeably lower since the equilibrium wage rate is lower. The policy with mandate also lowers the financially vulnerable fraction of the working population to zero. As a result, this policy eliminates the social cost of financing medical expenditures for uninsured workers. Social welfare—measured by a population weighted average of individual flow utilities—is curtailed at the new steady state, as the lower equilibrium wage rate reduces consumption of commodities.

Reform should address the problem of price discrimination against people with pre-existing conditions. Because workers do not always receive an employer-sponsored health insurance (EHI) offer, those with a chronic illness, face a risk of price discrimination when they need to change their insurance status. Uninsured workers who fall into illness also face a risk of price discrimination when they try to purchase health insurance in the next period. Workers with non-group health insurance may not take an EHI offer this period if they expect that the offer may not be present next period. Workers who are denied coverage on the basis of pre-existing conditions end up facing the full cost of medical care. Thus, price discrimination leads relatively healthy (risk-averse) workers to purchasing health insurance, lowering the percentage of the uninsured population and health insurance premiums. At the same time, it drives a fraction of workers with a chronic illness out of insurance markets, raising the percentage of population who fall into the "Medically Needy" program. This problem is exacerbated by young workers with low earning ability, who face low opportunity cost of running down their assets. These workers are likely to save less as a result of price discrimination. Forbidding price discrimination makes it easier for people with a chronic illness to purchase health insurance in the non-group market if their employers stop offering insurance. On the other hand, it encourages healthier workers to go without insurance in the short run, which raises the fraction of uninsured workers in the population. That, in turn, raises health insurance premiums in the non-group market. Thus, forbidding price discrimination countervails the effect of subsidies that provide incentives to uninsured workers to purchase non-group health insurance.

5.2 Essay 2

The second essay (Chapter 3) investigates Medicare financing policy when the government confronts periods of excess growth of medical costs. In particular, it explores two methods of financing excess cost growth. Under the assumption of keeping budget balance, the first method imposes a constraint that the government raise payroll and wage-income tax rates to finance excess cost growth. The second method assumes that the government lowers hospital reimbursement rates in lieu of raising taxes. This study calls the second method a "Medicare inflation tax." It is paid ultimately by workers who purchase health insurance and/or consume medical services. In this second case, hospitals must engage in cost-shifting to stay in business in the long run. The cost-shifting, in turn, raises workers medical price inflation. After the period of rising costs, this study, under each method, evaluates the new balanced growth path of the economy. It measures well-being by the population weighted average of individual flow utilities. It compares the two methods of Medicare financing based on the steady state output and well-being of people at period $t=60$. This chapter assumes that the Medicare financing policy does not influence workers' insurance take-up decisions.

When the government raises payroll and wage-income taxes to finance excess growth of medical costs, the balanced growth path and well-being of the people are higher at the new steady state than the government uses the Medicare inflation tax. Since workers pay payroll and wage-income taxes regardless of their insurance status, the burden of this taxation is shared according to earning ability. Its impact on workers' savings is not as pronounced as the effect of the Medicare inflation tax. Since retirees pay the full cost of medical price inflation, their demand for precautionary savings is higher under the policy of raising payroll and wage-income tax rates. The equilibrium wage rate at the new steady state is higher under this policy than under the Medicare inflation tax.

In contrast, the Medicare inflation tax is costly to the economy. Reductions in government reimbursements to finance excess cost growth raise workers' medical price inflation in a dynamic general equilibrium. As workers face higher medical price inflation, their real present discounted value (PDV) of lifetime medical expenditures rises. As a result, medical price inflation reduces workers' consumption of goods excluding medical care. In addition, their savings decline. Workers who consume more medical services pay a higher share of the Medicare inflation tax. Uninsured workers without medical consumption escape from paying the Medicare inflation tax. Hence, this policy creates a redistribution of wealth that exacerbates the level of inequality as low- and middle-income households with "fair" and "poor" health status pay a higher share of the Medicare inflation tax. It disproportionately raises their financial vulnerability. On the other hand, the Medicare inflation tax provides subsidies to retirees in the form of lower medical price inflation, which in turn raises their consumption of commodities and lowers their precautionary saving. As a consequence, it lowers the equilibrium wage rate at the new steady state. The balanced growth path of the economy and well-being of the people are permanently lower at the new steady state.

A myopic policy prescription by the government to help contain Medicare cost growth by cutting hospital reimbursement rates can create inharmonious welfare implications among workers, as well as between workers and retirees. Comparing a Medicare inflation tax with payroll and wage-income taxes, it seems better to finance excess growth by the latter.

5.3 Essay 3

The third essay (Chapter 4) analyzes elasticities of Social Security, Hospital Insurance, and wage-income tax rates with respect to their determinants. It finds that equilibrium tax rates at the new steady state are more sensitive to the capital-labor ratio than other determinants. This finding emphasizes the importance of encompassing household consumption and saving decisions for analysis of tax expenditures and their influence on the fiscal health of entitlement programs. Excess growth in workers' employer-sponsored health insurance (EHI) premiums leads to excess growth in tax expenditures under tax exclusion rules. Tax sensitivity with respect to workers' EHI premiums at the new steady state incorporates a compounded effect of tax expenditure growth over time. As a period of excess growth in tax expenditure prolongs, the tax elasticity with respect to EHI premiums rises at the new steady state. A one-percent change in their premiums requires a larger percentage change in tax rates to keep the budget balanced.

In considering a risk of insolvency of entitlement programs, policy makers must also pay their attention to adjustment processes of equilibrium tax rates that keep the government budget balanced during the deviation and the transition periods. A dynamic adjustment of the equilibrium Social Security tax rate differs from the equilibrium Hospital Insurance or wage income tax rates. Even after the deviation period dissipates completely, capital stock adjusts during the transition period. As a result, the equilibrium wage rate changes over time. As a consequence, the growth rate of aggregate Social Security payments continues to adjust until the economy reaches a new steady state. The elasticity of the Social Security tax rate with respect to the aggregate disbursement is always higher than elasticities of Hospital Insurance and wage-income tax rates with respect to the variable. Changes in equilibrium wage rate during the transition period influence the dynamics of the Social Security tax rate.

This study also investigates impacts of repealing the income-tax-exclusion rule. This policy addresses the problem of inequity pertaining to tax subsidies that are given only to workers with an EHI benefit. Repealing the exclusion rule pushes some fraction of workers to a higher tax bracket as it raises their income tax base. When the government implements this policy in a revenue-neutral way, repealing the exclusion rule lowers equilibrium tax rates. A combination of higher tax base with lower tax rates countervails effects on household budgets, thus limiting the policy's impact on the economy.

As long as the government promotes an employment-based health-insurance provision, excess growth in workers' EHI premiums that outpaces their income growth has nonlinear effects on equilibrium tax rates. Tax exclusion rules magnify the nonlinear effects as high growth in EHI premiums directly leads to high growth in tax expenditures, which in turn raises forgone tax revenues of entitlement programs. An insidious side-effect of medicine, thus, continues to influence fiscal health under an excessive growth in workers' medical expenditures.

5.4 Final Words

A health policy in the 21st century will not merely address issues pertaining to the health-care sector alone but also address issues that are central to economic activities. As the national health expenditure in percent of GDP continues to grow, a health-care reform will reallocate a large amount of resources. The scope of health policy, therefore, must be understood in much broader perspective. While medicine brings many benefits to the people, it also creates side effects to the economy as the cost of health care keeps rising. Excessive cost inflation of health care adversely influences people's well-being, the government fiscal health of entitlement programs, and the economy's balanced growth path in the long run. Three essays in this dissertation indicate that the economy in the 21st century will be driven by the influence of medicine. Health policies will greatly impact health of the U.S. economy.