Employment-Based Health Insurance and Aggregate Labor Supply*

Zhigang Feng[†]
University of Illinois

Kai Zhao[‡]
University of Connecticut

May 31, 2016

Abstract

We study the impact of the U.S. employment-based health insurance system on aggregate labor supply in a general equilibrium life cycle model with incomplete markets and idiosyncratic risks in both income and medical expenses. In contrast to Europeans, who get universal health insurance from the government, most working-age Americans get health insurance through their employers. We find that the employment-based health insurance system provides Americans with an extra incentive to work and is an important reason why they work much more hours than Europeans. We calibrate the benchmark model to match some key features of the US system using the Medical Expenditure Panel Survey dataset. Our quantitative results suggest that different health insurance systems account for more than one third of the difference in aggregate hours that Americans and Europeans work. In addition, our model implications are also consistent with the different employment rates and the different shares of full-time/part-time workers in the two areas. When our model is extended to include the different tax rates in the U.S. and Europe, a main existing explanation for the difference in aggregate labor supply, the extended model accounts for most of the difference in aggregate hours that Americans and Europeans work.

Keywords: Labor Supply, Employment-Based Health Insurance, General Equilibrium.
JEL Classifications: E20, E60

*We would like to thank Betsy Caucutt, Indraneel Chakraborty, Tianxu Chen, Gary Hansen, Hans Holter, Minchung Hsu, Ayse Imrohoroglu, Selo Imrohoroglu, John Jones, Sagiri Kitao, Karen Kopecky, Tatyana Koreshkova, Yue Li, Svetlana Pashchenko, Ponpoje Porapakkarm, Richard Suen, and Johanna Wallenius for their useful suggestions and comments. We would also like to thank participants in the seminars at CUNY-Hunter College, HKUST, Kansas State, Peking U, ST. Louis Fed, SUNY-Albany, Vanderbilt, and participants at the QSPS annual meeting (2014), the North American Summer Meeting of the Econometric Society (2014), the AEA Meeting (2015) for their helpful comments. All errors remain our own.

[†]Department of Economics, University of Illinois at Urbana-Champaign. E-mail: z.feng2@gmail.com

[‡]Corresponding author. Department of Economics, The University of Connecticut, Storrs, CT 06269-1063, United States. Email: kai.zhao@uconn.edu.

1. Introduction

Americans work many more hours than Europeans (see Prescott, 2004; Rogerson, 2006). For instance, the aggregate hours worked per person (aged 15-64) in the United States are approximately a third higher than in the major European economies (see Table 1).[1] Why do Americans work so much more than Europeans? This question has attracted increasing attention from macroeconomists, partly due to the importance of aggregate labor supply in the macroeconomy.[2] In this paper, we contribute to the literature by proposing a new explanation for the difference between the aggregate hours worked in the U.S. and Europe.

We argue that the unique employment-based health insurance (hereafter EHI) system in the U.S. is an important reason why Americans work much more than Europeans. In contrast to Europeans, who get universal health insurance from the government, most working-age Americans get health insurance through their employers.[3] Since medical care expenses are quite sizable and volatile, and there is no good alternative health insurance available in the private market, EHI can be highly valuable to risk-averse agents (much more than its actuarially fair cost). In addition, the value of EHI is amplified by a unique feature of U.S. tax policy-its cost is exempted from income taxation. Since, for the most part, only *full-time* workers are offered EHI, working-age Americans have a stronger incentive than Europeans both to work and to work full-time.[4]

Extensive empirical evidence suggests that health insurance plays an important role in working-age households' labor supply decisions. For instance, a recent study by Garthwaite, Gross and Notowidigdo (2014) finds that some workers (especially, low-income workers) are employed primarily in order to secure health insurance from their employers. Several other studies find that some workers postpone retirement simply to keep EHI, as they

[1] Here, the major economies include France, Germany, UK, and Italy, which are the four largest economies in Europe. As shown in Table 15 in the appendix, the fact remains true when the comparison is extended to include other developed European countries.

[2] For example, Prescott (2004), Rogerson (2006, 2007), Ohanian, Raffo, and Rogerson (2008), Rogerson and Wallenius (2009), Erosa, Fuster, and Kambrourov (2012), and Chakraborty, Holter, and Stepanchuk (2014).

[3] In the U.S., over 90 percent of insured working-age people obtain health insurance from their employer. In Europe, while health care is provided through a wide range of different systems across countries, these systems are primarily publicly funded through taxation, which are in spirit similar to a universal health insurance system (Hsiao and Heller (2007).

[4] For instance, Farber and Levy (2000) estimate that the chance of being provided with employer-sponsored health insurance was less than 10% for new jobs that require less than 35 hours of work per week.

are not eligible for Medicare until age 65.[5] In addition, some studies find that the availability of spousal health insurance significantly reduces the labor supply of married women.[6]

Our paper is also motivated by the fact that there are many more full-time workers in the U.S. than in Europe. Using data from the OECD Labor Market Database, we document that a larger share of the American working-age population is working, and a larger share of American workers are working *full-time*. As Table 2 shows, the employment rate in the U.S. is 74.1%, while it is only 63.5%, on average, in four major European countries. In addition, among all American workers, 88.1% are working full-time, while this number is only 83.6% in these European countries. As a result, the full-time employment rate in the U.S. is much higher than in these European countries: 65% versus 53%.[7] A simple back-of-the-envelope decomposition calculation suggests that over two thirds of the difference in aggregate hours worked is due to the differences in the employment rate and full-time worker share.[8]

To formalize the mechanisms described previously, we develop a general equilibrium life-cycle model with endogenous labor supply and idiosyncratic risks in both income and medical expenses.[9] We use a calibrated version of the model to assess the extent to which different health insurance systems and uncertain medical expenses can account for the difference in aggregate labor supply between the U.S. and Europe. First, we calibrate the model to the key moments of the current U.S. economy. In particular, our benchmark model economy captures the key feature of the U.S. health insurance system: the EHI system for the working-age population and the universal government-provided public health insurance for the elderly. Then, we construct a counterfactual economy by replacing the EHI system in the model with a government-financed universal health insurance program that mimics the European system. We find that when the EHI system is replaced by a universal health insurance system financed by additional lump-sum taxes, the aggregate

[5]See Rust and Phelan (1997), Blau and Gilleskie (2006, 2008), and French and Jones (2011).

[6]Buchmueller and Valletta (1999), Olson (1998), Schone and Vistnes (2000), and Wellington and Cobb-Clark (2000)

[7]As shown in Table 15 in the appendix, the facts also remain true when it is extended to include other developed European countries.

[8]The details of the decomposition calculation can be found in the appendix.

[9]In terms of modeling, this paper is closely related to a number of recent papers that study an extended incomplete-markets model with uncertain medical expenses, such as Jeske and Kitao (2009), De Nardi, French, and Jones (2010), Kopecky and Koreshkova (2011), Hansen, Hsu, and Lee (2012), Pashchenko and Porapakkarm (2013), Janicki (2014), and Nakajima and Tuzemen (2014).

hours worked in the model decrease by 9%. This suggests that different health insurance systems can account for over a third of the difference in aggregate labor supply between the U.S. and the four major European countries. In addition, we show that the changes in the employment rate and in the share of full-time workers in the model are also consistent with the data. When the EHI system is replaced by a universal health insurance system, the employment rate decreases from 78% to 73% and the share of full-time workers drops from 86% to 81%. Both are consistent with the empirical regularities observed in the US and European countries.

We also extend our analysis to include the different tax rates in the U.S. and Europe, a main existing explanation for the different aggregate labor supply in the U.S. and Europe. As is well known in the literature, the average tax rate on labor income in Europe is approximately 20% higher than that in the U.S.. The higher labor income tax rate lowers the after-tax wage rate and, thus, discourages work. In a computational experiment, we introduce both the European health insurance system and its income tax rate into the benchmark economy, and we find that the aggregate hours worked in the model decreases by 23%. This result suggests that the health insurance hypothesis, together with the existing taxation explanation, can account for most of the difference between the aggregate hours worked in the U.S. and Europe.

Recently, there has been a growing literature that uses quantitative macroeconomic models to account for the different aggregate hours worked in the U.S. and Europe.[10] The most well-known explanation says that different tax rates on labor income can explain the difference in aggregate hours worked in the U.S. and Europe (see Prescott (2004), and Rogerson (2006, 2007) for a detailed description of this hypothesis). However, this explanation has often been criticized for making strict assumptions about labor supply elasticity and how tax revenues are spent (for example, see Erosa, Fuster and Kambourov, 2012). Another important explanation comes from Erosa, Fuster and Kambourov (2012), who study the effects of governmental programs on labor supply. They find that the difference in public pension and disability insurance programs is important for understanding the cross-country difference in aggregate hours worked. However, their model abstracts

[10]Prescott (2004), Rogerson (2006, 2007), Ohanian, Raffo, and Rogerson (2008), Guner, Kaygusuz, and Ventura (2012), Erosa, Fuster and Kambourov (2012), Wallenius (2013), and Chakraborty, Holter, and Stepanchuk (2014), etc.

from health insurance and uncertain medical expenses. Our paper complements Erosa, Fuster and Kambourov (2012) by studying the role of health insurance in understanding the cross-country difference in aggregate labor supply. Our analysis suggests that health insurance may be quantitatively important because aggregate health expenditures have recently risen dramatically in developed countries, and the U.S. health insurance system is unique compared to its European counterparts.[11] In fact, Imrohoroglu (2012) points that "there is probably more significant differences between the U.S. and European countries regarding how health services are delivered" in his discussion of Erosa, Fuster, and Kambourov (2012). We take Imrohoroglu's point seriously by quantitatively evaluating the extent to which the different health insurance systems in the U.S. and Europe account for the difference in aggregate labor supply.[12]

The rest of the paper is organized as follows. In Section 2, we specify the model. We calibrate the model in Section 3 and present the main quantitative results in Section 4. We provide further discussion on related issues in Section 5, and conclude in Section 6.

2. The Model

2.1. The Individuals

Consider an economy inhabited by overlapping generations of agents whose age is $j = 1, 2, ..., T$. In each period, agents are endowed with one unit of time that can be used for either work or leisure. They face idiosyncratic labor productivity shocks ϵ, and medical expense shocks m in each period over the life cycle. An agent's state in each period can be characterized by a vector $s = \{j, a, m, e_h, h, y, \nu, e\}$, where j is age; a is assets; $\{y, \nu\}$ are the persistent and transitory productivity shocks that will be discussed further below; e is the education level; e_h indicates whether EHI is provided; and h indicates whether the

[11] According to OECD health dataset (2014), aggregate health expenditures currently account for approximately 10-20% of GDP in these countries.

[12] A contemporary paper by Laun and Wallenius (2013) also captures the role of health in understanding the cross-country difference in labor supply, but it features a very different model and, thus, emphasizes different mechanisms. In it, Laun and Wallenius develop a life-cycle model with endogenous health investment and study how public health insurance affects the level of health investment and, thus, the labor supply decision. In contrast, we emphasize the uncertainty of medical expenses in an incomplete market model with medical expense shocks, and we focus on the insurance value of employer-sponsored health insurance and its link to labor supply decisions.

agent is currently covered by EHI. Before the retirement age R ($j \leq R$), agents simultaneously make consumption, labor supply, and health insurance decisions in each period to maximize their expected lifetime utility, and this optimization problem can be formulated recursively as follows:

$(P1)$

$$V(s) = \max_{c,l,h'} u(c,l) + \beta P_j E[V(s')] \tag{1}$$

subject to

$$\frac{a'}{1+r} + c + (1-\kappa(h,m_d))m + ph' = a + \widetilde{w}(l)e\epsilon l - \tau[\widetilde{w}(l)e\epsilon l - ph'] + tr \tag{2}$$

$$l \in \{0, l_p, l_f\},\ c \geq 0, \text{ and } a' \geq 0$$

$$\begin{cases} h' \in \{0,1\} & \text{if } \ l = l_f \ \text{ and } \ e_h = 1 \\ h' \in \{0\} & \text{otherwise.} \end{cases} \tag{3}$$

Here, V is the value function, and $u(c,l)$ is the utility flow in the current period, which is a function of consumption c and labor supply l. β is the discounting factor, and P_j represents the conditional survival probability to the next period. Equation (2) represents the budget constraint facing the agent. The right-hand side of the equation captures all the resources available-that is, assets held at the beginning of the period, labor earnings net of taxation, and the welfare transfer tr (the transfer will be discussed in detail later). The left-hand side of the equation shows that the resources are allocated among consumption, out-of-pocket medical expenses, insurance premium (if any), and saving for the next period.

We assume that there are three labor supply choices: full-time, part-time, and no work. Note that equation (3) captures the key feature of the model. That is, if the agent chooses to work full-time and the job comes with EHI ($e_h = 1$), the agent would be eligible to buy EHI for the next period, which covers a fixed fraction of the total medical expenses and requires a premium payment p. Note that the premium payment is exempted from taxation (as shown in the right-hand side of the budget constraint above).[13] Following

[13]This is an important feature of the U.S. tax policy. For a detailed analysis of this issue, please see Jeske and Kitao (2009), Huang and Huffman (2010).

Jeske and Kitao (2009), we assume that the wage rate is simply $\widetilde{w}(l) = w(l) - c_e$ if EHI is offered and the agent works full-time, and $\widetilde{w}(l) = w(l)$ if otherwise. Here, c_e represents the fraction of the health insurance cost paid by the employer, which is transferred back to the worker via a reduced wage rate. In addition, we follow French (2005) and Rogerson and Wallenius (2013), and adopt the idea of non-linear wages. That is, the wage rate is increasing in hours worked, $w(l) = w_0 l^\theta$. The value of θ will be calibrated to match the shares of full-time/part-time workers in the data.

The health insurance coinsurance rates facing working-age agents are represented by $\kappa(h, m_d)$, which depends on whether the agent is covered by EHI (denoted by h) and whether she is qualified for Medicaid (denoted by m_d). Specifically, $\kappa(h, m_d) = \kappa_h$ if $h = 1$ and $m_d = 0$, $\kappa(h, m_d) = 1$ if $m_d = 1$, and $\kappa(h, m_d) = 0$ if otherwise. The eligibility of the Medicaid program will be specified in the next section. Note that, in this economy, agents face mortality risks in each period over the life cycle, thus, may die with positive assets-i.e., accidental bequests. We assume that they are equally redistributed back to the new-born agents in each period, which become their initial assets.

After retirement ($j > R$), agents live on their own savings and Social Security payments $SS(e)$, which depend on their education level. In each period, retirees make the consumption and saving decision to maximize their expected lifetime utility,

$(P2)$

$$V(s) = \max_{c} u(c, 0) + \beta P_j E[V(s')] \tag{4}$$

subject to

$$\frac{a'}{1+r} + c + (1 - \kappa_r(m_d))m = a + SS(e) + tr \tag{5}$$

$$c \geq 0, \text{ and } a' \geq 0.$$

Here the health coinsurance rates facing retirees are captured by $\kappa_r(m_d)$. It is equal to κ_m, the coinsurance rate of the Medicare program, if the agent is not eligible for Medicaid, and the value of $\kappa_r(m_d)$ is set to one if otherwise.

The log of the idiosyncratic labor productivity shock ϵ is determined by the following equation:

$$\ln \epsilon = b_j + y + \nu, \nu \sim N(0, \sigma_\nu^2), \tag{6}$$

where b_j is the deterministic age-specific component, ν is the transitory shock, and y is the persistent shock that is governed by a three-state Markov chain. The Markov chain is approximated from the AR(1) process

$$y' = \rho y + u', u' \sim N(0, \sigma_u^2), \tag{7}$$

where ρ is the persistence coefficient. The medical expense shock m is age-specific and is assumed to be governed by a six-state Markov chain that will be calibrated using the Medical Expenditure Panel Survey (MEPS) dataset. Medical expense shocks are assumed to be independent of labor productivity shocks.[14]

The distribution of the individuals is denoted by $\Phi(s)$, and it evolves over time according to the equation $\Phi' = R_\Phi(\Phi)$. Here, R_Φ is a one-period operator on the distribution, which will be specified in the calibration section.

2.2. The Government

There are four government programs: Social Security, Medicare, the consumption floor, and the Medicaid program. The Social Security program provides agents with annuities after retirement, which are financed by payroll taxes. The Medicare program provides health insurance to agents after retirement by covering a κ_m portion of their medical expenses, and it is financed by payroll taxes.

The consumption floor program is financed by tax revenues and it guarantees a minimum consumption floor $\underline{c}$ for everyone by conditioning the welfare transfer tr on each agent's total resources (net of medical expenses). That is,

$$\begin{cases} tr(s,l) = \max\{\underline{c} + (1-\kappa(h,m_d))m - \widetilde{w}(l)e\epsilon l - \tau[\widetilde{w}(l)e\epsilon l] - a, 0\} & \text{if } j \leq R \\ tr(s) = \max\{\underline{c} + (1-\kappa_r(m_d))m - SS(e) - a, 0\} & \text{if } j > R \end{cases}$$

The Medicaid program is a means-tested public health insurance program, and a working-

[14] This assumption significantly simplifies the analysis here. In addition, this assumption is supported by some empirical evidence. For instance, Daniel Feenberg and Jonathan Skinner (1994) find a very low income elasticity of catastrophic health care expenditures, suggesting that expenditure (at least for large medical shocks) does not vary much with income. Livshits, MacGee, and Tertilt (2007) find in the MEPS 1996/1997 dataset that income does not significantly decrease in response to a medical shock.

age agent is qualified for this program (i.e., $m_d = 1$) if her income and assets are below certain thresholds. Therefore, we assume that the agent is automatically enrolled in the Medicaid program if $\widetilde{w}e\epsilon l(s) \leq \Theta_{income}$, $a \leq \Theta_{asset}$.

The government budget constraint is specified as follows,

$$\begin{cases} \int_1^R [tr(s, l(s)) + m_d(1-\kappa_h)m] d\Phi(s) + \int_{R+1}^T [tr(s) + SS(e) + m_d(1-\kappa_m)m + \kappa_m m] d\Phi(s) \\ +G_w = \int_1^R \tau[\widetilde{w}(l)e\epsilon l(s) - ph'(s)] d\Phi(s). \end{cases} \tag{8}$$

Here the first two terms on the left-hand side of the constraint are the the aggregate spending on the four public programs, and G_w represents the extra tax revenues that are thrown away in each period. The right-hand side of the constraint represents the aggregate tax revenues raised through τ, which will be specified further in the calibration section.

2.3. The Production Technology

On the production side, the economy consists of two sectors: the consumption goods sector and the health care sector. Production in the two sectors is governed by the same (Cobb-Douglas) production function but with sector-specific total productivity factor (TFP). Assuming that production is taken in competitive firms and that factors can move freely between the two sectors, it is easy to obtain that the model can be aggregated into a one-sector economy and that the relative price of health care is inversely related to the relative TFPs in the two sectors.[15] For simplicity, we assume that the TFPs in both sectors are the same so that the relative price of health care is equal to one. Let the aggregate production function take the following form,

$$Y = AK^{\alpha}L^{1-\alpha}.$$

Here, α is the capital share, A is the TFP, K is capital, and L is labor. Assuming that capital depreciates at a rate of δ, the firm chooses K and L by maximizing profits $Y - w_0 L - (r+\delta)K$.

[15]Specifically, the relative price of health care q is equal to $\frac{A_c}{A_m}$, where A_c and A_m are the sector-specific TFPs.

The profit-maximizing behaviors of the firm imply that,

$$w_0 = (1-\alpha)A(\frac{K}{L})^{\alpha}$$

$$r = \alpha A(\frac{K}{L})^{\alpha-1} - \delta.$$

2.4. The EHI Market

EHI is community-rated. That is, its premium is the same for everyone covered. In addition, we assume that it is operated by competitive insurance companies. Note that the employer and the employee share the total cost of EHI. Let π represent the fraction of the cost paid by the employee. Then, the price of the insurance paid by the employee, p, can be expressed as follows:

$$p = \pi\kappa_h \frac{\int P_j E(m'(s))h'(s)d\Phi(s)}{1+r}. \tag{9}$$

The rest of the cost is paid by the firm with c_e; that is,

$$c_e \int e\epsilon l(s) I_{c_e} d\Phi(s) = (1-\pi)\kappa_h \frac{\int P_j E(m'(s))h'(s)d\Phi(s)}{1+r}. \tag{10}$$

Here I_{c_e} is the indicator function for the case that the agent works full-time and the EHI is offered.

2.5. Market-Clearing Conditions

The market-clearing conditions for the capital and labor markets are, respectively, as follows:

$$K' = \int a'(s)d\Phi(s) \tag{11}$$

$$L = \int e\epsilon l(s)^{1+\theta} d\Phi(s) \tag{12}$$

2.6. Stationary Equilibrium

A stationary equilibrium is defined as follows.

Definition: A **stationary equilibrium** is given by a collection of value functions $V(s)$; individual policy rules $\{a', l, h'\}$; the distribution of individuals $\Phi(s)$; aggregate factors $\{K, L\}$; prices $\{r, w_0\}$; Social Security, Medicare, Medicaid, and the consumption floor; and private health insurance contracts defined by pairs of price and coinsurance rate $\{p, \kappa_h, c_e\}$, such that

1. *Given prices, government programs, and private health insurance contracts, the value function $V(s)$ and individual policy rules $\{a', l, h'\}$ solve the individual's dynamic programming problems (P1) and (P2).*
2. *Given prices, K and L solve the firm's profit maximization problem.*
3. *The capital and labor markets clear-that is, conditions (11)-(12) are satisfied.*
4. *The government budget constraint holds-that is, condition (8) is satisfied.*
5. *The health insurance companies are competitive, and, thus, the insurance contracts satisfy conditions (9)-(10).*
6. *The distribution $\Phi(s)$, evolves over time according to the equation $\Phi' = R_\Phi(\Phi)$, and satisfies the stationary equilibrium condition: $\Phi' = \Phi$.*
7. *The amount of bequest transfers received by the new-born agents is equal to the amount of accidental bequests from the last period.*

We focus on stationary equilibrium analysis in the rest of the paper, using numerical methods to solve the model, as analytical results are not obtainable. Since agents can live only up to T periods, the dynamic programming problem can be solved by iterating backwards from the last period.

3. Calibration

We calibrate the benchmark model to match the current U.S. economy. The calibration strategy adopted here is the following: The values of some standard parameters are predetermined based on previous studies, and the values of the rest of the parameters are then *simultaneously* chosen to match some key moments in the current U.S. economy.

3.1. Demographics and Preferences

One model period is one year. Individuals enter the economy at age 21 ($j = 1$), retire at age 65 ($R = 45$), and die at age 85 ($T = 65$).

The utility function is assumed to take the following form:

$$u(c, l) = \frac{c^{1-\sigma}}{1-\sigma} + \zeta \frac{(1-l)^{1-\gamma}}{1-\gamma}.$$

The value of σ is set to two in the benchmark calibration, which falls in the middle of the range of values used in the literature studying incomplete-markets models with medical expense shocks.[16] The value of γ is set to two in the benchmark following the recent literature on labor elasticity (see Chetty, 2012). We also explore a variety of other values for σ and γ in the sensitivity analysis. The disutility parameter for labor supply ζ is calibrated to match the employment rate in the data: 74.1%. The discount factor β is set to match an annual interest rate of 4%, and the resulting value is $\beta = 0.98$.

3.2. Production

The capital share α in the production function is set to 0.36, and the depreciation rate δ is set to 0.06. Both are commonly-used values in the macro literature. The labor-augmented technology parameter A is calibrated to match the current U.S. GDP per capita.

3.3. Medical Expense Shock and EHI

We use the Medical Expenditure Panel Survey (MEPS) dataset to calibrate the health expenditure process and the probabilities of being offered EHI. The data on total medical expenses are used to calibrate the distribution of medical expenses, and six states are constructed with bins of the size $(25\%, 25\%, 25\%, 15\%, 5\%, 5\%)$ for the medical expense shock m. To capture the life-cycle profile of medical expenses, we assume that the medical expense shock m is age-specific and calibrate the distribution of medical expenses for each ten- or 15-year group. Table 4 reports the medical expense grids.

The value of e_h determines whether EHI is available when the agent chooses to work

[16] See Jeske and Kitao (2009), De Nardi, French, and Jones (2010), Kopecky and Koreshkova (2011), Pashchenko and Porapakkarm (2013), etc.

full-time. We assume that this variable follows a two-state Markov chain. Since higher-income jobs are more likely to provide EHI, we assume that the transition matrix for e_h is specific to each education level. The transition matrices are calibrated using the MEPS dataset.

The value of κ_h represents the fraction of medical expenses covered by EHI. We set its value to 0.8 in the benchmark calibration because the coinsurance rates of most private health insurance policies in the U.S. fall into the $65\% - 85\%$ range.

3.4. Labor Productivity Parameters

Since a full-time job requires approximately 2000 hours of work per year, and hours available per year (excluding sleeping time) total about 5000 hours, we set the value of $l_f = 0.4$. The number of working hours for a part-time job is approximately half of that for a full-time job; therefore, we set the value of l_p to 0.2.

There are three education levels in the model-$e \in \{e^1, e^2, e^3\}$-which represent agents with no high school, high school graduates, and college graduates, respectively. The value of e^2 is normalized to one, and the values of e^1 and e^3 are calibrated to match the relative wage rates for individuals with no high school and college graduates in the data. The resulting values are $e^1 = 0.70$ and $e^3 = 1.73$.

The age-specific deterministic component b_j in the labor productivity process is calibrated using the average wage income by age in the MEPS dataset. The transitory and persistent productivity shocks, ν and y, follow the process specified by equation (6) and (7). We discretize the process using the method described in Tauchen (1986). As for the three parameters in the process $\{\rho, \sigma_\mu^2, \sigma_\nu^2\}$, we use the values provided in Krueger, Mitman, and Perri (2016) who estimate the same process using the PSID dataset, that is, $(\rho, \sigma_\mu^2, \sigma_\nu^2) = (0.9695, 0.0384, 0.0522)$.

As for the parameter in the non-linear wage schedule, θ, we calibrate its value to match the part-time/full-time share of workers in the data. The resulting value for θ is 0.37, which implies that the wage rate for part-time workers is approximately 80% of that for full-time workers. This value is also very close to the estimates provided in the literature.[17]

[17]Please see Rogerson and Wallenius (2013) for a discussion of this parameter value.

3.5. Government

The tax function $\tau(.)$ includes two components, a proportional social security tax and the income tax. Following Jeske and Kitao (2009), the income tax is modeled as a combination of a progressive part and a proportional part, where the progressive part takes the functional form proposed by Gouveia and Strauss (1994). That is, the tax function is specified as

$$\tau(x) = \tau_s x + a_0[x - (x^{-a_1} + a_2)^{-1/a_1}] + \overline{\tau} x.$$

Here x is the taxable income. The first term in the tax function is the social security tax, in which τ_s is set to 12.4% according to the Social Security Administration. The second term is the progressive income tax, which is simply the function form studied by Gouveia and Strauss (1994). We use their estimates for $\{a_0, a_1\}$, that is, $a_0 = 0.258$ and $a_1 = 0.768$. Following Jeske and Kitao (2009), the value of a_2 is calibrated to match the share of income tax revenues from the progressive part, that is, 65%. The last term is the proportional income tax, where the value of $\overline{\tau}$ is chosen so that the average tax rate (including both the social security tax and the income tax) in the model is consistent with the estimation in Prescott (2004), that is, 40%.

Social Security in the model is designed to capture the main features of the U.S. Social Security program. Following Fuster, Imrohoroglu, and Imrohoroglu (2007), the Social Security payment is a non-linear function of the agent's lifetime earnings history. Specifically, we choose the values of $SS(\cdot)$ so that the Social Security marginal replacement rates are consistent with the estimates in Fuster et al. (2007). In addition, we rescale every beneficiary's payments so that the Social Security program is exactly self-financing.

Medicare is a public health insurance program that provides health insurance to every individual after age 65 by covering a κ_m fraction of their medical expenses. Here, we assume that Medicare and EHI provide the same coinsurance rate-i.e., $\kappa_m = \kappa_h$.

The means-tested Medicaid program provides free health insurance to the poor whose assets and income are below certain thresholds. By law, it is the payer of last resort, that is, it covers the remaining medical costs that are not covered by the other payers for the eligible individual. Before the Affordable Care Act reform, the eligibility requirements for Medicaid differed substantially across the states. According to Pashchenko and Porapakkarm (2013), the income thresholds vary from below 50% to over 100% of the Federal Poverty Line (FPL). In the benchmark, we set the income threshold, Θ_{income}, to 100% of the FPL, and we explore alternative values for Θ_{income} in the sensitivity analysis.[18] The asset threshold, Θ_{asset}, is set to $2000 because this is the maximum amount of cash allowed for the Medicaid program among a majority of the states.

The consumption floor captures a variety of welfare programs available to the U.S. population, such as AFDC/TANF, SNAP (formerly food stamps), SSI, etc. It insures the poor against large negative shocks by guaranteeing a minimal level of consumption. The existing estimates for this floor vary substantially, from $2000 to over $7000.[19] We calibrate the value of $\underline{c}$ within the model. As Zhao (2016) points out, the minimum consumption floor also provides implicit insurance against potential large health shocks for agents who are currently not on the floor, and thus it has a crowding out effect on their demand for other health insurance policies. We make use of this result and calibrate the value of the consumption floor $\underline{c}$ to match the take-up rate for employment-based health insurance, that is, 96% according to the MEPS data.

The revenues from the Social Security tax is used to finance the Social Security program, and the income tax revenues are used to finance the other three government programs: Medicare, Medicaid, and the consumption floor. Note that the income tax revenues are more than enough to finance the other three public programs. We assume that the extra tax revenues, denoted by G_w, are thrown away in each period.

3.6. Baseline Economy

The key results of the benchmark calibration are summarized in Table 5. Our model succeeds in matching several aspects of the macroeconomy, including consumption, hours worked, and the patterns of health insurance coverage over the life cycle. Table 6 summarizes the key statistics of the benchmark model. Aggregate hours worked are 0.29 (approximately 1450 hours per year), and the employment rate is 78.1%-both consistent with the data. In addition, the share of full-time workers in the model is 86.1%, compared to 88.1%

[18]The federal poverty line in 2000 was $8959 for one-person families according to U.S. Census Bureau.
[19]See Kopecky and Koreshkova (2011) for a quick review of these studies

in the data. On the health insurance side, 55.1% of the working-age population are covered by EHI, and the EHI take-up rate is 97%. Both are close to what we observe in the data.

Figures 1 and 2 plot the life-cycle profiles of the key variables in the model. As can be seen, the life-cycle profile for saving in the baseline economy is hump shaped, which is a standard result in life-cycle models. As shown in Figure 2, the hours worked increase as agents move into their 30s, and decline as the mandatory retirement age approaches. The life-cycle profile of hours worked in the model is fairly close to its empirical counterpart.

Our model features rich individual heterogeneities. In Table 16 and 17 in the appendix, we present labor supply decisions by various of individual characteristics in the baseline economy. In particular, we show in Table 16 that the labor supply decisions by EHI status in the baseline economy is consistent with what we documented in the 2008 Survey of Income and Program Participation (SIPP) Panel Data. That is, the employment rate among individuals with EHI is much higher and they work for much more hours than those without EHI. In the model, the average hours worked by individuals currently with EHI are 0.34, while the average hours worked by those withou EHI are only 0.23. In the 2008 SIPP dataset, we find that individuals with EHI are indeed work much more than those without EHI. Individuals with EHI on average work for 37.5 hours, while those without EHI on average only work for 20.1 hours. In Table 17, we present further information on labor supply in a variety of subgroups in the benchmark model. We find that individuals with higher medical expenses tend to work more hours, which is consistent with our hypothesis about the relationship between EHI and labor supply decisions. In addition, individuals with low transitory productivity in the model tend to work less as leisure is cheap for them, and individuals with low permanent productivity work more due to the income effect.

4. Quantitative Results

In this section, we use the calibrated model to assess the quantitative importance of the effect of different health insurance systems on aggregate labor supply. We answer the following quantitative question: To what extent can different health insurance systems account for the difference between the aggregate hours worked in the U.S. and the four major European countries?

4.1. EHI v.s. Universal Health Insurance

Specifically, we run the following thought experiment. We construct a counterfactual economy (experiment I) by replacing the EHI system in the benchmark model with a universal health insurance financed by additional lump-sum taxes.[20] Then, we compare this counterfactual economy to the benchmark economy to identify the effects of different health insurance systems on labor supply and on other variables of interest. Table 7 displays the comparison of the key statistics in the two model economies. Figures 3 and 4 plot the key life-cycle profiles in the benchmark economy and the counterfactual economy.

As can be seen, aggregate labor supply decreases substantially after the EHI system is replaced with the universal government-financed health insurance. The average annual hours worked (aggregate labor supply) in the economy with the European system is only 91% of that in the benchmark economy. Since the data show that the average annual hours worked in four major European countries is, on average, 76% of that in the U.S., the quantitative result obtained here suggests that more than one third of the difference in aggregate labor supply between the U.S. and the four major European countries is due to the different health insurance systems.

The intuition for the labor supply effect of EHI is as follows. Since medical care expenses are large and extremely volatile, and there is no good alternative health insurance available for working-age Americans, EHI can be highly valuable to risk-averse individuals (much more than its actuarially fair cost). As a result, the EHI system provides working-age Americans extra incentive to work. Because the European system offers universal health insurance coverage to the entire working age population, and thus it does not provide such work incentives.

We conduct further analysis of some intermediate cases in the following section to provide more insights into the way the EHI system affects aggregate labor supply.

[20]Using additional lump-sum taxes to finance the universal health insurance implies that the labor supply effect obtained here does not include the labor supply distortions from income taxation, which helps us better identify the impact of employment-based health insurance on aggregate labor supply.

4.2. Intermediate Economies

In order to better understand the different labor supply results in the two economies-the benchmark versus the counterfactual with the European system-we analyze several intermediate economies in this section.

In the first intermediate economy, we remove the linkage between job status and availability of EHI but keep the rest of the economy the same as in the benchmark. That is, regardless of their labor supply choices, individuals are allowed to purchase EHI as long as $e_h = 1$. Table 7 presents the key statistics of the intermediate economy. As can be seen, aggregate labor supply decreases substantially after the linkage between EHI and labor supply choices is removed. The average annual hours worked (aggregate labor supply) in this intermediate case is only 96% of that in the benchmark economy. This result highlights the key mechanism of the paper, which is that many individuals in the U.S. economy work full-time primarily to secure health insurance. When the availability of health insurance is not tied to the job status, many of them stop working full-time.[21]

It is noteworthy that the cost of EHI is exempted from taxation in the U.S. What impact does this unique feature of the U.S. tax policy have on labor supply? To address this question, we consider the second intermediate case, in which we remove the tax exemption policy for EHI and keep the rest of the economy the same as in the benchmark. The key statistics of the second intermediate economy are also reported in Table 7, which shows that aggregate labor supply decreases substantially after the tax exemption policy is removed. The average annual hours worked (aggregate labor supply) in this intermediate case is only 96% of that in the benchmark economy. The removal of the tax exemption policy discourages labor supply because it reduces the attractiveness of EHI. Note that there are two channels through which the tax exemption policy affects the value of EHI. First, it provides tax benefits to individuals with EHI and, thus, implicitly increases its value. Second, the policy helps overcome the adverse selection problem in the group insurance market and, thus, increases the attractiveness of the insurance policy.[22] The adverse selec-

[21] Note that individuals in the benchmark economy face more risks than in the counterfactual economy. For instance, approximately over one third of the working-age population is without health insurance in the benchmark economy, and, thus, they face extra medical expense risks. The extra risk is the other important reason why agents work more in the benchmark economy.

[22] Note that EHI is group-rated, and, thus, it may suffer from adverse selection.

tion problem is very limited in the benchmark economy mainly due to the tax exemption policy. The take-up rate for EHI is near 100% (97%) in the benchmark, but it drops to 69% when the tax exemption policy is removed. As a result, the health insurance premium increases from $2918 to $4191, and the share of the working-age population with holding EHI drops from 55% to 34%.

It is interesting to compare the second intermediate case to Jeske and Kitao (2009) who analyze the impact of the tax exemption policy in a similar model. We find that our results from the second intermediate case are highly consistent with their findings. Jeske and Kitao (2009) found that if the tax exemption policy was abolished, the EHI take-up rate would drop substantially due to adverse selection, and meanwhile the EHI premium would jump up. However, they assume exogenous labor supply in their model, and thus cannot capture the labor supply implications of the tax exemption policy.

5. Further Discussion

5.1. Hours Worked By Age

In this section, we investigate the life-cycle patterns with regard to the hours worked in the model. As shown in Table 3, the U.S.-Europe difference in hours worked is larger for individuals at the beginning of their career and those near retirement. For instance, for individuals aged 15-24 and those aged 55-64, the hours worked in the four major European countries are only 73% and 57%, respectively, of those in the U.S., while the ratio is 87% for individuals aged 25-54.[23] We compare our model implications to these life-cycle patterns.

Table 8 presents the hours worked by different age groups in both the benchmark economy and the counterfactual economy. As can be seen, our model implications are also fairly consistent with the life-cycle patterns of hours worked documented in the data. The difference in hours worked between the two model economies is significantly smaller for the prime-age agents. In particular, the agents near retirement work substantially more in the benchmark economy than in the counterfactual economy. The intuition behind this

[23]The hours worked per person by different age groups are constructed by the authors based on OECD labor market data (2000). Note that since the hours worked per worker are not available for each age group in OECD labor market data, we construct them by using the distribution of employment by hour bands. In the calculations, we set the average hours worked for each hour band to its middle value.

result is simple. Medical expenses increase rapidly as agents approach retirement; therefore, the labor supply of agents near retirement is affected more by the EHI system.

5.2. Difference in Aggregate Effective Labor

Our quantitative results also provide an interesting implication for the difference in aggregate effective labor between the U.S. and Europe. It is well known that output per person in the U.S. is also significantly higher than in Europe. For instance, the average GDP per capita in four major Europeans countries is only approximately 71% of that in the US. This fact has led people wonder whether Americans are richer than Europeans simply because they work much more. We argue that this may not be the case according to our quantitative results.

We find that most of the decrease in aggregate hours worked is from low-productivity agents who choose to work primarily to secure health insurance.[24] This result suggests that the extra hours that Americans work may not add much to aggregate effective labor in the US. As shown in Table 7, when the EHI system is replaced by a universal health insurance system, aggregate raw labor (aggregate hours worked) decreases by 9%, but aggregate effective labor drops by only 4%, and, thus, the output per person also drops by 4%. These quantitative results suggest that though Americans work much more, the difference in effective labor supply between the U.S. and Europe may be much smaller. Therefore, the difference in output per capita between the U.S. and Europe may not be mainly due to the different hours worked between the two areas.

The different implications for effective labor supply or labor productivity is also related to the existing literature emphasizing the negative aspect of the EHI system such as the job-lock effect.[25] This literature finds that the EHI system reduces the job mobility and thus is bad for labor productivity.

[24]Chivers, Feng and Villamil (2015) study the impact of EHI on entrepreneurship. Similarly, they find that EHI induces more agents with mediocre managerial ability enter entrepreneurship, which reduces the aggregate productivity.

[25]See Madrian (1994), Gruber and Madrian (1994, 2002), etc.

5.3. Relating to the Empirical Literature

There exists an extensive empirical literature that examine the labor supply impact of health insurance. The main findings from this literature suggest that the impacts of health insurance on individual's labor supply decisions are significant, and these effects vary with income level, age groups and other idiosyncratic characteristics.[26] These empirical studies usually focus on only one specific subgroup of the population. In contrast, we build up a large-scale general equilibrium life-cycle model featuring rich individual heterogeneities, such as age, education, persistent and transitory earning shocks and health risk. Hence, our analysis complements the existing empirical literature by providing an aggregate analysis of the labor market effects of the EHI system. In addition, as we argued previously, the EHI system may affect aggregate labor supply via several margins/mechanisms, such as labor participation decision, full-time/part-time choice, the job lock effect, and these mechanisms often times overlap and interact with each other. Most of the existing empirical studies only focus on a subset of the mechanisms, and thus their findings cannot provide direct evidence on the aggregate impact of the EHI system. We capture all these mechanisms, and furthermore our general equilibrium model allows factor prices and the price of health insurance to be endogenously determined and thus also captures the general equilibrium effects of the EHI system on labor market decisions. Moreover, our research provides the first evidence that EHI is an important factor to explain the cross-Atlantic labor supply difference.

5.4. Difference in Aggregate Hours Worked Over Time

Some recent studies in the literature on the U.S.-Europe difference in aggregate labor supply have focused on a closely related empirical observation: the different trends on hours worked over time (e.g., Rogerson, 2008, McDaniel, 2011). That is, the U.S.-Europe difference in aggregate hours worked was small before the 1970s, and this difference has gradually increased over the last several decades.[27] It is worth noting that while this paper

[26]Rust and Phelan (1997), Olson (1998), Buchmueller and Valletta (1999), Schone and Vistnes (2000), Wellington and Cobb-Clark (2000), Blau and Gilleskie (2006, 2008), French and Jones (2011), Garthwaite, Gross and Notowidigdo (2014), etc.

[27]This is mainly due to that in the U.S. the hours worked have remained roughly constant since 1970s, whereas the hours worked in Europe have gradually declined ever since.

is mainly concerned with the current level difference in hours worked between the U.S. and Europe, our theory also has the potential to be consistent with the different trends on hours worked over the last half-century. The intuition for that is as follows. The quantitative importance of our mechanisms is largely dependent on the magnitude of the medical expense shocks, and it is well known that U.S. medical expenditures have risen dramatically over the last half-century.[28] Therefore, while the health insurance systems in the U.S. and Europe have not dramatically changed over time, the rising medical expenditures would generate a widening gap in aggregate labor supply between the two areas according to our hypothesis.

To shed some lights on this hypothesis, we replicate our comparison of the two health insurance systems in model economies with different levels of health expenditures. As shown in Zhao (2014), the U.S. aggregate health expenditure has increased dramatically since WWII, i.e., from below 4% of GDP in 1950 to over 6% of GDP in 1970, and then to about 13% of GDP in 2000. The health expenditure level in 1970 was approximately half of that in 2000. Therefore, here we consider an alternative case in which we exogenously scale down the health expenditures by 50%. In addition, we consider another case in which health expenditures are completely assumed away. The results from these two cases are reported in Table 9. As can be seen clearly, the level of health expenditures matters for the magnitude of the impact of the EHI system on aggregate labor supply. When health expenditures are scaled down by 50%, the difference in aggregate hours worked shrinks substantially, from 9% to 4%. If health expenditures are completely assumed away, the difference between the aggregate hours worked in the two health insurance systems disappear. These results suggest that our theory (together with the rising health expenditure in the U.S.) is not inconsistent with the times series data on aggregate hours worked. However, to account for the different trends in hours worked, we would need to extend our model to incorporate additional forces that are relevant for the times paths of aggregate hours worked in the U.S. and Europe. For instance, the different labor market regulations implemented over this period in the two areas, that influence work hours differentially.[29]

[28]Please see Zhao (2014) for the details of the rising medical expenditure in developed countries over the last half century and its causes.

[29]See Siebert (2006) for a discussion of the details of some labor market regulations in a group of OECD countries.

Clearly the different trends in hours worked are important for understanding the determinants of aggregate labor supply. We leave this issue for future research and concentrate on the contemporary cross-country comparisons in this paper.[30]

5.5. The Taxation Hypothesis

In this section, we extend our analysis to include the taxation hypothesis-the main existing explanation for the difference between aggregate labor supply in the U.S. and Europe. This hypothesis argues that different tax rates on labor income can account for the difference in hours worked in the U.S. and Europe (see Prescott, 2004; Rogerson, 2006). The tax rate on labor income discourages work because it reduces the after-tax wage rate. In the rest of this section, we consider the following quantitative question: Can the model account for the entire difference between aggregate hours worked in the U.S. and the four major European countries when different tax rates are also included?

As Prescott (2004) estimates, the U.S. tax rate is approximately 40%, while the average tax rate in Europe is 60%. To include the taxation mechanism, we construct another counterfactual economy (experiment II) by changing both the health insurance system and the labor income tax rate. That is, we replace the EHI system with a universal government-financed health insurance, and raise the tax rate on labor income, τ, from 40% to 60%.[31] We compare this counterfactual economy to the benchmark economy to identify the joint effect of different health insurance systems and different tax rates on labor supply, as well as other variables of interest. The key statistics in this counterfactual economy are reported in Table 10. As shown in the table, aggregate labor supply decreases further after the taxation mechanism is incorporated. The average annual hours worked in this counterfactual is only 77% of that in the benchmark economy. This quantitative result suggests that different health insurance systems together with the taxation hypothesis can account

[30]Specifically, to account for the different trends in hours worked observed in the data, we would need to extend our model to incorporate additional forces that would drive labor supply down over time in both areas. That is, while these downward forces reduce the hours worked in Europe over time, they are offset by the interaction of employment-based health insurance and the rising medical expenditures in the U.S.. We leave these ideas for future research as they are out of the scope of this paper.

[31]We achieve the tax rate change by exogenously increasing the proportional part of the income tax, $\overline{\tau}$. In addition, we assume that part of the extra tax revenues from the tax increase is used to finance the universal health insurance. As for the remaining part of the extra tax revenues, we follow the tradition in the literature (e.g., Prescott,2004), and equally redistribute them back to the working-age population.

for most of the difference in aggregate labor supply between the U.S. and these European countries.

6. Sensitivity Analysis

6.1. Individual Health Insurance

We assume for simplicity that there is no individual health insurance available in the benchmark model because only a tiny fraction of working-age Americans purchase individual health insurance from the private market. The availability of individual health insurance may weaken the impact of EHI as individuals without EHI can buy insurance from the private market as the substitute. However, we argue that this effect is quantitatively less important because the individual health insurance market in the U.S. does not function well. It features high premiums, and in addition, it mainly offers one-year contracts and thus offers very limited risk-sharing. That is, people with individual health insurance are still subjected to significant re-classification risk, i.e., insurance premiums will go up after a health shock (Pashchenko and Porapakkarm, 2014). In response to these issues, most working-age Americans without EHI do not buy individual health insurance as a substitute.

To assess the sensitivity of our results to the availability of individual health insurance, we conduct an additional computational experiment in which we introduce a private market for individual health insurance in the same fashion as in Pashchenko and Porapakkarm (2014) and Zhao (2016). That is, the individual health insurance premium is conditioned on age j and the current health shock m. In addition, the health insurance companies are operating competitively with some administrative costs covered by a markup, λ_{ih}, to the premium. The individual health insurance premium, p_{ih}, can be specified as follows:

$$p_{ih}(j,m) = (1+\lambda_{ih})\frac{\kappa_{ih} P_j E[m'|j,m]}{1+r}, \forall m, j. \tag{13}$$

Here we assume that the individual health insurance provides the same coinsurance rate as the EHI, that is, $\kappa_{ih} = 0.8$. We consider two values for λ_{ih}: zero and 11 percentages. The first value represents the case with no administrative costs, and the second value is based on the estimation of Kahn et al.(2005) in the data. As shown in Table 11, when we introduce individual health insurance into the model, aggregate hours worked decreases but the size of the decrease is negligible (i.e. 0.1%). This confirms our intuition that the availability of individual health insurance may weaken our results, but its quantitative importance should be small.[32]

6.2. Alternative Options for Uninsured Americans

It is worth noting that uninsured Americans may reduce their out of pocket medical expenses by postponing treatments, using cheaper but low-quality services, or defaulting. However, these options are not cost-free. By using them, agents may also suffer significant utility loss, either because of their negative impacts on health or due to the loss of access to future financial markets. Though they are relatively extreme, the availability of these options may provide implicit insurance against medical expense risks.

To assess the sensitivity of our results to the availability of these alternative options, we conduct another computational experiment in which the uninsured agents are given an additional option that allows them to pay a utility cost instead of paying the medical bill. We calibrate the value of the utility cost to match the personal bankruptcy rate in the U.S., which is slightly below 1% of the whole population, according to Livshits, et al. (2007). The results from this experiment are also reported in Table 11. We find that the aggregate hours worked in this experiment is approximately 1% lower than that in the benchmark economy, which suggests that our main quantitative results remain after incorporating these alternative extreme options in the model.

6.3. Spousal Insurance

Thus far, we have assumed that EHI is available only through the agent's own employer. However, working-age Americans may also receive health insurance through their spouse's employer. In the benchmark economy, we do not model spousal coverage due to its complexity and the lack of information on its dynamics in the data. To shed some light on

[32]It is worth noting that the individual health insurance market would become relevant after the creation of health insurance exchanges with the passage of the Patient Protection and Affordable Care Act(ACA), which prohibits price discrimination.

the importance of spousal coverage in understanding the labor supply effect of EHI, we conduct the following robustness check. Specifically, we introduce one more individual state variable, e_s, to indicate whether spousal insurance is available to the agent. We assume that the spousal coverage is as generous as the insurance through the agent's own employer. Note that spousal coverage is not conditional on job status; therefore, agents with spousal coverage do not have the incentive to work for health insurance.

To assess quantitatively how spousal coverage affects labor supply, we simply recompute the stationary equilibrium in this extended model with spousal coverage, and compare it to the benchmark economy.[33] We use the MEPS dataset to estimate the probability of getting spousal coverage in each period. In the data, approximately 34% of working-age males who receive EHI are both married and working full-time. In one experiment, we set the probability of getting spousal coverage to match this fraction. We find that the aggregate hours worked in this extended model is only 1% lower than that in the benchmark economy, and the fraction of working-age population with EHI increases to 68%. Note that this result provides the upper bound for the impact of spousal coverage on labor supply. The actual impact of spousal coverage may be even smaller because (1) not all employers offer spousal coverage, and (2) the spousal coverage is usually not as generous as the coverage through the agents' own employers. Overall, this robustness check exercise suggests that our main results are not sensitive to this modeling choice.

6.4. Medicaid Eligibility

Before the Affordable Care Act reform, the eligibility requirements for Medicaid differed substantially across the states. According to Pashchenko and Porapakkarm (2013), the income thresholds vary from below 50% to over 100% of the Federal Poverty Line (FPL). In the benchmark calibration, we set the income threshold, Θ_{income}, to 100% of the FPL, a value probably on the up side. Here we explore alternative values for Θ_{income}, and assess the sensitivity of our results to this value. These sensitivity results are reported in Table 12. As can be seen, the main results remain similar to the benchmark case as the Medicaid income eligibility varies.

[33]We do not describe the individual's problem again for the extended model with spousal coverage because it is the same as the problem in the benchmark model except for the extra state variable e_s.

6.5. Utility Function Parameters

In this section, we investigate the sensitivity of our main results to some key parameter values in the utility function. In the benchmark calibration, we set the risk aversion parameter, σ, to two, which is in the middle of the range of values used in the existing literature. We also explore two alternative values for σ, one (log utility) and three, as robustness check. In each case, we recalibrate the model to match the same moments as in the benchmark calibration. The results from these robustness check exercises are reported in Table 13 in the appendix. As can be seen, our main results remain fairly similar to the benchmark case as the value σ varies.

We also explore the sensitivity of our main quantitative results to the value of another key parameter, γ. According to Chetty (2012), we set its value to two in the benchmark calibration. Here we consider two alternative values, one and three, for this parameter. The sensitivity analysis results are also reported in Table 13 in the appendix. We find that our main quantitative results are not sensitive to this parameter value.

7. Conclusion

In this paper, we study the impact of the employment-based health insurance system on aggregate labor supply. We find that the unique EHI system in the U.S. and uncertain medical expenses are important reasons why Americans work more than Europeans. In contrast to Europeans, who get universal health insurance from the government, most working-age Americans get health insurance through their employers. In a quantitative dynamic general equilibrium model with endogenous labor supply and uncertain medical expenses, we quantitatively assess the extent to which different health insurance systems account for the labor supply difference between the U.S. and Europe. Our quantitative results suggest that different health insurance systems can account for more than one third of the difference in average hours worked in the U.S. and Europe. In addition, our model implications are consistent with the different employment rates and the different shares of full-time/part-time workers in the two areas as well. When our model is extended to include the different tax rates in the U.S. and Europe, a main existing explanation for the difference in aggregate labor supply, the extended model accounts for most of the difference in aggregate hours that Americans and Europeans work.

References

ALONSO-ORTIZ, J., AND R. ROGERSON (2010): "Taxes, transfers and employment in an incomplete markets model," *Journal of Monetary Economics*, 57, 949–958.

ATTANASIO, O., S. KITAO, AND G. L. VIOLANTE (2008): "Financing Medicare: A General Equilibrium Analysis," in Demography and Economics, edited by J. Shoven, NBER.

BLAU, D. M., AND D. GILLESKIE (2006): "Health Insurance and Retirement of Married Couples," *Journal of Applied Econometrics*, 21, 935–953.

——— (2008): "The Role of Retiree Health Insurance in the Employment Behavior of Older Men," *International Economic Review*, 49(2), 475–514.

BUCHMUELLER, T. C., AND R. G.VALLETTA (1999): "The Effect of Health Insurance on Married Female Labor Supply," *Journal of Human Resources*, 34(1), 42–70.

CHAKRABORTY, I., H. HOLTER, AND S. STEPANCHUK (2014): "Marriage Stability, Taxation and Aggregate Labor Supply in the U.S. vs. Europe," unpublished manuscript.

CHETTY, R. (2012): "Bounds on Elasticities with Optimization Frictions: A Synthesis of Micro and Macro Evidence on Labor Supply," *Econometrica*, 80(3), 969–1018.

DE NARDI, M., E. FRENCH, AND J. B. JONES (2010): "Why do the Elderly Save? The Role of Medical Expenses," *Journal of Political Economy*, 118 (1), 37–75.

EROSA, A., L. FUSTER, AND G. KAMBOUROV (2012): "Labor Supply and Government Programs: A Cross-Country Analysis," *Journal of Monetary Economics*, 59(1), 84–107.

FEENBERG, D., AND J. SKINNER (1994): "The Risk and Duration of Catastrophic Health Care Expenditure," *Review of Economics and Statistics*, 76(4), 633–47.

FRENCH, E., AND J. B. JONES (2011): "The Effects of Health Insurance and Self-Insurance on Retirement Behavior," *Econometrica*, 79(3), 693–732.

FUSTER, L., A. IMROHOROGLU, AND S. IMROHOROGLU (2007): "Elimination of Social Security in a Dynastic Framework," *Review of Economic Studies*, 74(1), 113–145.

GARTHWAITE, C., T. GROSS, AND M. NOTOWIDIGDO (2014): "Public Health Insurance, Labor Supply, and Employment Lock," *Quarterly Journal of Economics*, forthcoming.

GOLDMAN, L., E. VITTINGHOFF, AND R. DUDLEY (2007): "Quality of care in hospitals with a high percent of Medicaid patients," *Medical Care*, 45(6), 579–583.

GOURINCHAS, P.-O., AND J. A. PARKER (2002): "Consumption over the Life Cycle," *Econometrica*, 70(1), 47–89.

GRUBER, J. (2003): "Medicaid," in *Means-Tested Transfer Programs in the United States*, ed. by R. Moffitt. University of Chicago Press.

GRUBER, J., AND B. C. MADRIAN (1994): "Health Insurance and Job Mobility: The Effects of Public Policy on Job-Lock," *Industrial and Labor Relations Review*, 48(1), 86–102.

——— (2002): "Health Insurance, Labor Supply, and Job Mobility: A Critical Review of the Literature," *NBER WP 8817*.

GUNNER, N., R. KAYGUSUZ, AND G. VENTURA (2012): "Taxation and Household Labour Supply," *Review of Economic Studies*, 79(3), 1113–1149.

HANSEN, G. D., M. HSU, AND J. LEE (2012): "Health Insurance Reform: The impact of a Medicare Buy-In," unpublished manuscript.

HSIAO, W., AND P. S. HELLER (2007): "What Should Macroeconomists Know about Health Care Policy," IMF working paper.

HUANG, K. X., AND G. HUFFMAN (2010): "A Defense of the Current US Tax Treatment of Employer-Provided Medical Insurance," unpublished manuscript, Vanderbilt University.

IMROHOROGLU, S. (2012): "Discussion of Erosa, Fuster, and Kambourov," *Journal of Monetary Economics*, 59(1), 108110.

JANICKI, H. P. (2014): "The role of asset testing in public health insurance reform," *Journal of Economic Dynamics and Control*, 44.

JESKE, K., AND S. KITAO (2009): "U.S. tax policy and health insurance demand: Can a regressive policy improve welfare?," *Journal of Monetary Economics*, 56(2).

KAHN, J., R. KRONICK, M. KREGER, AND D. GANS (2005): "The cost of health insurance administration in California: Estimates for insurers, physicians, and hospitals," *Health Affairs*, 24, 1629–1639.

KOPECKY, K. A., AND T. KORESHKOVA (2011): "The Impact of Medical and Nursing Home Expenses on Savings," unpublished manucript, University of Western Ontario.

KRUEGER, D., K. MITMAN, AND F. PERRI (2016): "Macroeconomics and Household Heterogeneity," University of Pennsylvania, unpublished manuscript.

LAUN, T., AND J. WALLENIUS (2013): "Social Insurance and Retirement: A Cross-Country Perspective," unpublished manuscript.

LIVSHITS, I., J. MACGEE, AND M. TERTILT (2007): "Consumer Bankruptcy: A Fresh Start," *American Economic Review*, 97(1), 402–418.

MADRIAN, B. C. (1994): "Employment-Based Health Insurance and Job Mobility: Is There Evidence of Job-Lock?," *The Quarterly Journal of Economics*, 109(1), 27–54.

OHANIAN, L., A. RAFFO, AND R. ROGERSON (2008): "Long-Term Changes in Labor Supply and Taxes: Evidence from OECD Countries," *Journal of Monetary Economics*, 55(8), 1353–1362.

OLSON, C. A. (1998): "A Comparison of Parametric and Semiparametric Estimates of the Effect of Spousal Health Insurance Coverage on Weekly Hours Worked by Wives," *Journal of Applied Econometrics*, 13(5), 543–565.

PASHCHENKO, S., AND P. PORAPAKKARM (2013): "Quantitative Analysis of Health Insurance Reform: Separating Regulation from Redistribution," *Review of Economic Dynamics*, 16(3), 383–404.

——— (2014): "Welfare Costs of Reclassification Risk in the Health Insurance Market," unpublished manuscript.

PRESCOTT, E. C. (2004): "Why Do Americans Work So Much More Than Europeans?," *Federal Reserve Bank of Minneapolis Quarterly Review*, 28(1).

ROGERSON, R. (2006): "Understanding Differences in Hours Worked," *Review of Economic Dynamics*, 9, 365–409.

——— (2007): "Taxation and Market Work: Is Scandinavia an Outlier?," *Economic Theory*, 32(1), 59–85.

ROGERSON, R., AND J. WALLENIUS (2009): "Micro and Macro Elasticities in a Life Cycle Model with Taxes," *Journal of Economic Theory*, 144(6), 2277–2292.

——— (2013): "Nonconvexities, Retirement and the Elasticity of Labor Supply," *American Economic Review*, 103(4), 1445–1462.

RUST, J., AND C. PHELAN (1997): "How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets," *Econometrica*, 65(4), 781–831.

SCHONE, B. S., AND J. P. VISTNES (2000): "The Relationship Between Health Insurance and Labor Force Decisions: An Analysis of Married Women," unpublished Paper (Agency for Healthcare Research and Quality).

SIEBERT, W. S. (2006): "Labour Market Regulation in the EU-15: Causes and Consequences - A Survey," IZA Discussion Paper No. 2430.

STUBER, J., AND K. KRONEBUSCH (2004): "Stigma and other determinants of participation in TANF and Medicaid," *Journal of Policy Analysis and Management*, 23(3), 509530.

WALLENIUS, J. (2013): "Social Security and Cross-Countries Differences in Hours: A General Equilibrium Analysis," *Journal of Economic Dynamics and Control*, pp. 2466–2482.

WELLINGTON, A. J., AND D. A. COBB-CLARK (2000): "The Labor-Supply Effects of Universal Health Coverage: What Can We Learn From Individuals with Spousal Coverage?," in Simon W. Polachek, ed., Worker Well-Being: Research in Labor Economics, Volume 19 (Elsevier Science: Amsterdam).

ZHAO, K. (2014): "Social Security and the Rise in Health Spending," *Journal of Monetary Economics*, 64, 21–37.

——— (2016): "Social Insurance, Private Health Insurance and Individual Welfare," University of Connecticut, unpublished manuscript.

Table 1: Aggregate Labor Supply: U.S. vs. Four Major European Countries

	Annual Hours Worked per person (age 15-64)	Compared to the US (U.S.=1)
U.S.	1360	1
France	940	0.69
Germany	965	0.71
Italy	980	0.72
UK	1227	0.90
Average (Major 4)	1028	0.76

Data source: OECD Labor Market Data (2000).

Table 2: Full-time Workers: U.S. vs. Four Major European Countries

	Employment Rate	FT Share (% of All Workers)	FT Employment Rate(relative to the U.S.)	Annual Hours Worked (relative to the U.S.)
U.S.	74.1%	88.1%	65.31%(1)	1
France	61.7%	85.9%	53.0%(0.81)	0.69
Germany	65.6%	82.8%	54.3%(0.83)	0.71
Italy	53.9%	87.9	47.4%(0.73)	0.72
UK	72.2%	77.8%	56.2%(0.86)	0.90
Average(Major 4)	63.4%	83.6%	53.0%(0.81)	0.76

Data source: OECD Labor Market Data (2000).

Table 3: Annual Hours Worked By Age: U.S. vs. Four Major European Countries

	Ages 15-24 (relative to the U.S.)	Ages 25-54 ..	Ages 55-64 ..
U.S.	1	1	1
France	0.51	0.89	0.46
Germany	0.88	0.89	0.59
Italy	0.54	0.80	0.47
UK	0.98	0.89	0.76
Average(Major 4)	0.73	0.87	0.57

Data source: Authors' own calculations based on OECD Labor Market Data.

Table 4: Health Expenditure Grids

Health exp. shock	1	2	3	4	5	6
Ages 21-35	0	143	775	2696	6755	17862
Ages 36-45	5	298	1223	4202	9644	29249
Ages 46-55	46	684	2338	6139	12596	33930
Ages 56-65	204	1491	3890	9625	20769	58932
Ages 66-75	509	2373	5290	11997	21542	50068
Ages 76-80	750	2967	7023	16182	30115	53549

Data Source: MEPS.

Table 5: The Benchmark Calibration

Parameter	Value	Source/Moment to match
σ	2	Macro literature
α	0.36	Macro literature
δ	0.06	Macro literature
γ	2	Chetty (2012)
A	1100	U.S. GDP per capita: $36467
$\{a_0, a_1\}$	$\{0.258, 0.768\}$	Gouveia and Stauss (1994)
τ_s	12.4%	U.S. Social Security tax rate
κ_h, κ_m	0.8	U.S. data
β	0.98	Annual interest rate: 4.0%
π	0.2	Sommers(2002)
$\underline{c}$	$3700	EHI take-up rate: 96%
ζ	0.9-E04	Employment rate: 74.1%
θ	0.37	Full-time worker share: 88.1%
ρ	0.9695	Krueger, Mitman and Perri (2016)
σ^2_μ	0.0384	Krueger, Mitman and Perri (2016)
σ^2_ν	0.0522	Krueger, Mitman and Perri (2016)

Table 6: Key Statistics of the Benchmark Economy

Statistics	Model	Data
Output per person	$35833	$36467
Interest rate	3.9%	4.0%
Aggregate hours worked	0.29 (appr. 1450 hours)	1360 hours
Employment rate	78.1%	74.1%
Full-time worker share	86.1%	88.1%
% of working-age popu. with EHI	55.1%	59.4%
EHI take-up rate	97%	96%

Table 7: The Main Quantitative Results

Statistics	Benchmark (U.S. HI)	Experiment I (Eur HI)	Inter. I (no link to job)	Inter. II (no tax exemp.)
Output per person	$35833	$34285	$34859	$34105
Interest rate	3.9%	3.9%	3.9%	4.4%
Aggregate hours worked	0.291	0.265	0.279	0.279
(relative to the benchmark)	(1)	(91.1%)	(96.0%)	(95.9%)
Employment rate	78.1%	73.2%	81.5%	79.2%
Full-time worker share	86.1%	81.2%	71.4%	76.2%
Aggregate effective labor	0.420	0.402	0.408	0.410
% of working-age popu. (with EHI)	55.1%	..	65.7%	34.1%
EHI take-up rate	97%	..	80%	69%
EHI premium	$3010	..	$2918	$4191

Table 8: Aggregate Hours Worked By Age: Model vs. Data

	Age 15-24	Age 25-54	Age 55-64
Data			
Four major European countries (relative to the U.S.)	0.73	0.87	0.57
Model			
Counterfactual (with Eur HI) (relative to the benchmark)	0.92	0.93	0.84

Table 9: Diff Health Expenditures and Aggregate Hours Worked Over Time

	Benchmark (with EHI)	Counterfactual (with universal HI)
2000 Health expenditures(13% of GDP)	0.291	0.265
(relative to benchmark)		(91%)
1970 Health expenditures(6% of GDP)	0.284	0.272
(relative to benchmark)		(96%)
No Health expenditures	0.272	0.272
(relative to benchmark)		(100%)

Table 10: The Taxation Hypothesis

Statistics	Benchmark	Experiment I (Eur HI)	Experiment II (Eur HI+ Eur tax)
Output per person	$35833	$34285	$31210
Interest rate	3.9%	3.9%	3.9%
Aggregate hours worked	0.291	0.265	0.225
(relative to the benchmark)		(91%)	(77%)
Employment rate	78.1%	73.2%	68.8%
Full-time worker share	86.1%	81.2%	63.7%
Aggregate effective labor	0.420	0.402	0.367

Table 11: Sensitivity Analysis: Alternative Options

Statistics	Benchmark	Sens. I (IH, $\lambda_{ih} = 0.11$)	Sens.II (IH, $\lambda_{ih} = 0$)	Sens.III (default)	Sens.IV (Spousal HI)
Hours worked	0.291	0.291	0.290	0.288	0.289
(% of benchmark)		(100.0%)	(99.9%)	(99.0%)	(98.6%)
% of popu.	55.1%	55.1%	54.9%	54.1%	67.9%
(with EHI)					
% of popu.	..	2.6%	29.0%	..	..
(with IHI)					
EHI take-up rate	97%	97%	97%	96%	97%

Table 12: Sensitivity Analysis: Medicaid Eligibility

Statistics	Benchmark (US)	Counterfactual (Eur.)
$\Theta_{income} = 75\%$ of FPL		
Aggregate hours worked	0.290	0.264
Employment rate	78.0%	72.9%
Full-time share	86.0%	81.1%
$\Theta_{income} = 50\%$ of FPL		
Aggregate hours worked	0.289	0.264
Employment rate	77.7%	72.9%
Full-time share	85.9%	81.0%

Figure 1: Life-Cycle Profile in the Benchmark Economy: Saving

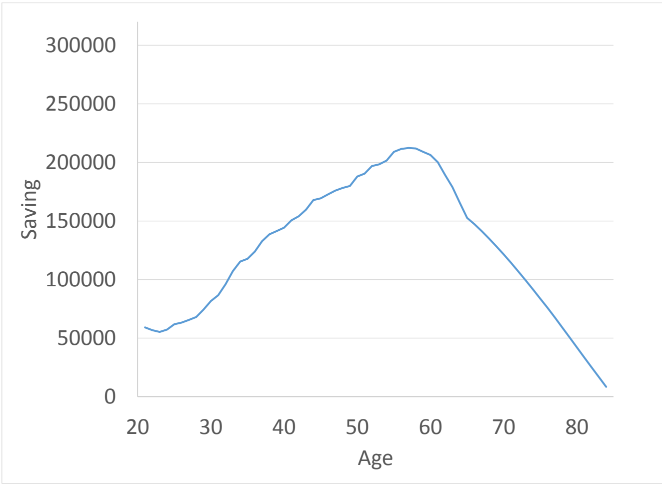
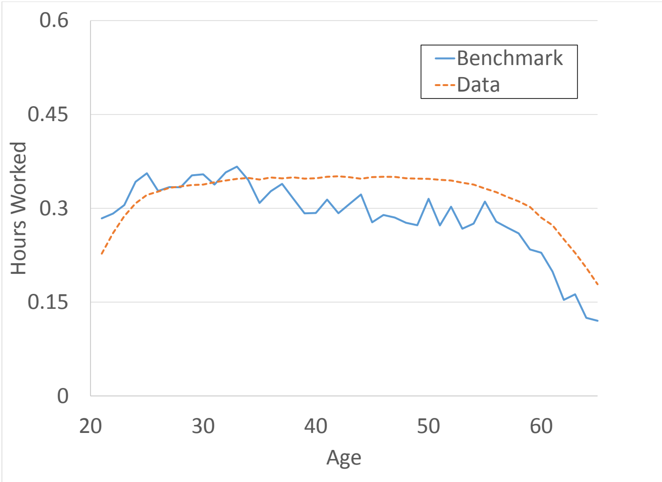


Figure 2: Life-Cycle Profile in the Benchmark Economy: Labor Supply (hours worked)



Data source: 2008 Survey of Income and Program Participation (SIPP) Panel Data.

Figure 3: Benchmark vs. Counterfactual (U.S. vs. EUR): Saving

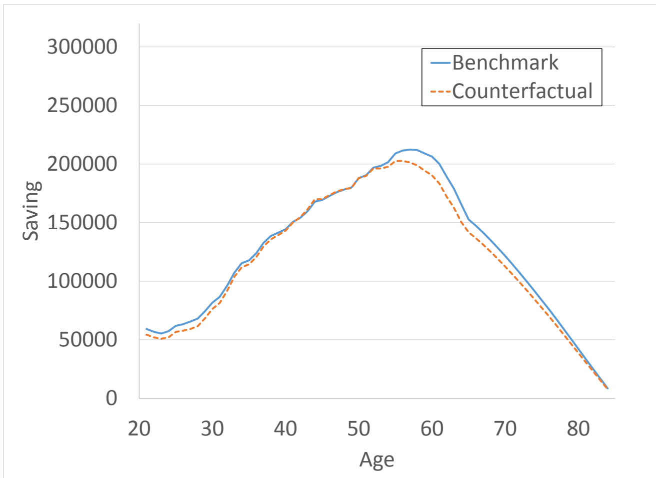
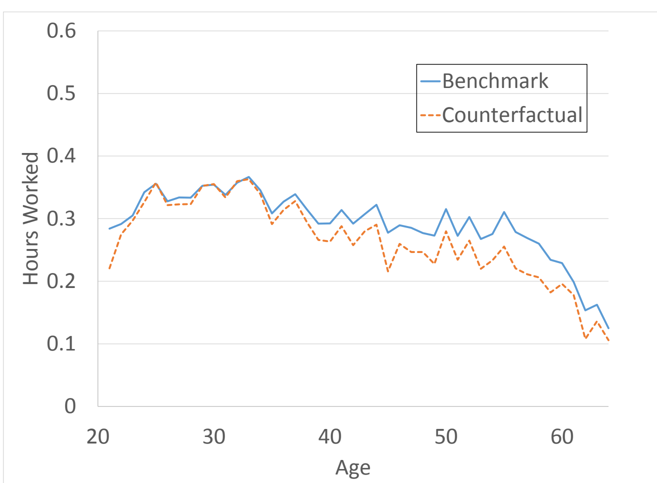


Figure 4: Benchmark vs. Counterfactual (U.S. vs. EUR): Labor Supply (hours worked)



8. Appendix (not for publication)

8.1. A Simple Decomposition Calculation

To further understand the causes of the difference between average annual hours worked in the U.S. and Europe, we conduct the following simple decomposition calculation. By definition, the average hours worked per person can be calculated as follows:

$$h = e[s_f h_f + (1 - s_f)h_p],$$

where h_f and h_f are the average hours worked per full-time worker and part-time worker, respectively. e is the employment rate and s_f is the share of the workers that are working full-time. This equation shows that the difference in average hours worked comes from two sources: (1) the difference in employment rate and full-time worker share, and (2) the difference in average hours worked per full-time and part-time worker. To assess the contribution from the first source, we construct a counterfactual measure $\widehat{h}$ for each country by plugging in the country-specific employment rates and full-time worker shares but the same h_f and h_p.[34] The results are reported in Table 14. As can be seen, using this counterfactual measure, the difference between annual hours worked in the U.S. and Europe are very similar to that in the data. More specifically, the annual hours worked in the four major European countries is, on average, 0.83 of that in the U.S. This suggests that over two thirds of the aggregate labor supply difference between the U.S. and these European countries is due to the differences in employment rate and full-time worker share.

8.2. Data and Calibration Details

Here we provide additional information regarding the MEPS panel dataset used in the calibration. we make use of the 2006-2007 wave of the MEPS dataset, which provides a good measure of the total health expenditure, i.e., “totexpy1” and “totexpy2”. We calibrate the six states for m by breaking down the total health expenditure distribution into four bins of sizes (0-25%; 25-50%; 50-75%; 75-90%; 90-95%; 95%-100%). We do so for each of the fol-

[34]Here, we assume that average hours worked per full-time worker is 2000 hours, and the number is 1000 hours for part-time workers. These numbers are approximately consistent with the averages of all countries in the data.

lowing age groups, 21-35, 36-45, 46-55, 56-65, 66-75, and 76-80. The results are reported in Table 4. Then, we compute the corresponding transition matrix for the health expense shock directly from the panel data.[35] In addition, since the MEPS dataset also contains information on whether the EHI is offered and information on education level, we can simply compute the transition matrix for the EHI offer for each education level directly from the data as well. These transition matrices are reported in Table 18.

Table 13: Sensitivity Analysis: Some Key Parameters

Statistics	Benchmark (US)	Counterfactual (Eur.)
$\sigma = 1$ (log utility)		
Aggregate hours worked	0.293	0.270
Employment rate	76.8%	72.4%
Full-time share	90.0%	86.3%
$\sigma = 3$		
Aggregate hours worked	0.290	0.269
Employment rate	77.2%	72.3%
Full-time share	87.7%	85.8%
$\gamma = 1$		
Aggregate hours worked	0.291	0.265
Employment rate	78.3%	72.8%
Full-time share	86.1%	82.3%
$\gamma = 3$		
Aggregate hours worked	0.288	0.262
Employment rate	77.4%	72.4%
Full-time share	86.0%	81.0%

[35]These transition matrices are available upon request from the authors.

Table 14: Aggregate Labor Supply: Decomposition

	Actual Annual Hours Worked: h (relative to the U.S.)	Constructed annual hours worked: $\widehat{h}$ (relative to the U.S.)
U.S.	1	1
France	0.69	0.82
Germany	0.71	0.86
Italy	0.72	0.73
UK	0.90	0.92
Average (Major four)	0.76	0.83

Data source: OECD Labor Market Data (2000).

Table 15: Aggregate Hours Worked and Full-time Workers: U.S. vs. Europe

	Employment Rate	FT Worker (% of All Workers)	FT Employment Rate (relative to the U.S.)	Annual Hours Worked (relative to the U.S.)
U.S.	74.1%	88.1%	65.31%(1)	1360(1)
France	61.7%	85.9%	53.0%(0.81)	940(0.69)
Germany	65.6%	82.8%	54.3%(0.83)	965(0.71)
Italy	53.9%	87.9%	47.4%(0.73)	980 (0.72)
UK	72.2%	77.8%	56.2%(0.86)	1227(0.90)
Average(Major 4)	63.4%	83.6%	53.0%(0.81)	1028(0.76)
Austria	68.3%	87.8%	60.0%(0.92)	1258(0.92)
Belgium	60.9%	81.0%	49.3%(0.76)	941(0.69)
Ireland	65.1%	81.9%	53.3%(0.82)	1119(0.82)
Netherlands	72.1%	67.9%	48.9%(0.75)	1035(0.76)
Spain	57.4%	92.3%	53.0%(0.81)	994(0.73)
Switzerland	78.4%	75.6%	59.3% (0.91)	1323(0.97)
Portugal	68.3%	90.6%	61.9% (0.95)	1223(0.90)
Greece	55.9%	94.6%	52.9% (0.81)	1191(0.88)
Norway	77.9%	79.8%	62.2% (0.95)	1133(0.83)
Sweden	74.3%	86.0%	63.9% (0.98)	1220(0.90)
Finland	67.5%	89.6%	60.5%(0.93)	1182(0.87)
Denmark	76.4%	83.9%	64.1%(0.98)	1208(0.89)
Average(exclude Scan.)	65%	84%	54%(0.83)	1100(0.81)
Average(all)	67%	84%	56%(0.86)	1121(0.82)

Data source: OECD Labor Market Data (2000).

Table 16: Labor Supply by Health Insurance Status in the Baseline Economy

	Model	
Health insurance status	$h = 0$	$h = 1$
Hours worked	0.226	0.343
Employment rate	64.1%	89.5%
	Data	
Health insurance status	No EHI	With EHI
Hours worked	20.0	37.5
Employment rate	61.5%	93.1%

Data source: SIPP (2008)

Table 17: Labor Supply by Other Characteristics in the Baseline Economy

EHI offer	$e_h = 0$	$e_h = 1$				
Hours worked	0.273	0.294				
Medical expense grid	1	2	3	4	5	6
Hours worked	0.268	0.283	0.298	0.313	0.322	0.332
Transitory shock grid	1	2				
Hours worked	0.222	0.359				
Permanent shock grid	1	2	3			
Hours worked	0.324	0.325	0.194			

Table 18: Transition Matrices for e_h by Education Level

High-school dropouts($e = 1$)	$e_h = 0$	$e_h = 1$
$e_h = 0$	0.8583	0.1417
$e_h = 1$	0.0848	0.9152
High-school graduates($e = 2$)	$e_h = 0$	$e_h = 1$
$e_h = 0$	0.7865	0.2135
$e_h = 1$	0.0415	0.9585
College graduates ($e = 3$)	$e_h = 0$	$e_h = 1$
$e_h = 0$	0.7717	0.2283
$e_h = 1$	0.0207	0.9793