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Equilibrium Labor Market Search and Health Insurance Reform*

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Abstract

We present and empirically implement an equilibrium labor market search model where risk averse workers facing medical expenditure shocks are matched with firms making health insurance coverage decisions. Our model delivers a rich set of predictions that can account for a wide variety of phenomenon observed in the data including the correlations among firm sizes, wages, employer-sponsored health insurance offering rates, turnover rates and workers' health compositions. We estimate our model by Generalized Method of Moments using a combination of micro datasets including the Survey of Income and Program Participation, the Medical Expenditure Panel Survey and the Kaiser Family Employer Health Insurance Benefits Survey. We use our estimated model to evaluate the equilibrium impact of the 2010 Affordable Care Act (ACA) and compare it with other health care reform proposals. We also use the estimates of the early impact of the ACA as a model validation. We find that the full implementation of the ACA would reduce the uninsured rate among the workers in our estimation sample from about 21.3% in the pre-ACA benchmark economy to 6.6%. We also find that income-based premium subsidies for health insurance purchases from the exchange play an important role for the sustainability of the ACA; without the premium subsidies, the uninsured rate would be around 15.8%. In contrast, as long as premium subsidies and health insurance exchanges with community ratings stay intact, ACA without the individual mandate, or without the employer mandate, or without both mandates, could still succeed in reducing the uninsured rates to 11.4%, 7.5% and 12.9% respectively.

Keywords: Health, Health Insurance, Health Care Reform, Labor Market Equilibrium
JEL Classification Number: G22, I11, I13, J32.

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1 Introduction

The Affordable Care Act (hereafter, ACA), signed into law by President Barack Obama in March 2010, represents the most significant reform to the U.S. health insurance and health care markets since the establishment of Medicare in 1965.[1] The health care reform in the U.S. was partly driven by two factors: first, a large fraction of the U.S. population does not have health insurance (close to 18% for 2009); second, the U.S. spends a much larger share of the national income on health care than the other OECD countries (health care accounts for about one sixth of the U.S. GDP in 2009).[2] There are many provisions in the ACA whose implementation were phased in over several years, and some of the most significant changes started taking effect from 2014. In particular, four of the most important pillars of the ACA are as follows:[3]

• **(Individual Mandate)** All individuals must have health insurance that meets the law's minimum standards or face a penalty when filing taxes for the year, which will be 2.5 percent of income or $695, whichever is higher.[4, 5]

• **(Employer Mandate)** Employers with 50 or more full-time employees will be required to provide health insurance or pay a fine of $2,000 per worker each year if they do not offer health insurance, where the fines would apply to the entire number of employees minus some allowances.

• **(Insurance Exchanges)** State-based health insurance exchanges will be established where the unemployed, the self-employed and workers who are not covered by employer-sponsored health insurance (ESHI) can purchase insurance. Importantly, the premiums for individuals who purchase their insurance from the insurance exchanges will be based on the average health expenditure of those in the exchange risk pool.[6] Insurance companies that want to participate in an exchange need to meet a series of statutory requirements in order for their plans to be designated as "qualified health plans."

• **(Premium Subsidies)** All adults in households with income under 138% of Federal poverty line (FPL) will be eligible for receiving Medicaid coverage with no cost sharing.[7] For individuals and families whose income is between the 138 percent and 400 percent of the FPL, subsidies will be provided toward the purchase of health insurance from the exchanges.[8]

[1]The Affordable Care Act refers to the Patient Protection and Affordable Care Act (PPACA) signed into law by President Obama on March 23, 2010, as well as the Amendment in the Health Care and Education Reconciliation Act of 2010.

[2]See OECD Health Data at `www.oecd.org/health/healthdata` for a comparison of the health care systems between the U.S. and the other OECD countries.

[3]Detailed formulas for the penalties associated with violating the individual and employer mandates, as well as for that for the permium subsidies, are provided in Section 8.2.

[4]These penalties were implemented fully from 2016. In 2014, the penalty is 1 percent of income or $95 and in 2015, it is 2 percent of income or $325, whichever is higher. Cost-of-living adjustments will be made annually after 2016. If the least inexpensive policy available would cost more than 8 percent of one's monthly income, no penalties apply and hardship exemptions will be permitted for those who cannot afford the cost.

[5]The individual mandate was controversial and there were numerous lawsuits challenging its constitutionality. The Tax Cut and Jobs Act of 2017 will repeal the individual mandate penalty for not having health insurance starting in 2019.

[6]States that opt not to establish their own exchanges will be pooled in a federal health insurance exchange.

[7]This represents a significant expansion of the current Medicaid system because many States currently cover adults with children only if their income is considerably lower, and do not cover childless adults at all. The U.S. Supreme Court's ruled on June 28, 2012 that the law's provision that, if a State does not comply with the ACA's new coverage requirements, it may lose not only the federal funding for those requirements, but all of its federal Medicaid funds, is unconstitutional. This ruling allows states to opt out of ACA's Medicaid expansion, leaving each state's decision to participate in the hands of the nation's governors and state leaders. As of June 2015, 30 states (including District of Columbia) expanded their Medicaid coverage (see `http://kff.org/health-reform`). In this paper, we will study both the full and the partial implementation of Medicaid expansion.

[8]Whether individuals in states that do not establish their own exchanges who purchase insurance from the federal health

There has been significant political activities ever since the enactment of the ACA. Some of policy proposals have considered to repeal and replace the ACA, such as the American Health Care Act (2017);[9] there are also other small scale policy changes, which modify a part of the ACA. An example is the eventually successful repeal of the individual mandate in the Tax Cuts and Jobs Act of 2017; another example is the attempt to reduce subsidies to the health insurance premiums. These policy proposals raise a number of questions about what are potential impacts of alternatives of the ACA: For example, how would the remainder of the ACA perform if its individual mandate penalty is repealed? Are the premium subsidies necessary for the insurance exchanges to overcome the adverse selection problem? Would the ACA be significantly impacted if the employer mandates were removed? What would happen if the current tax exemption status of employer-provided insurance premium is eliminated?

The goal of this paper is to present and empirically implement an equilibrium model that *integrates* the labor market with the major feature of U.S. health insurance system, and to use it to understand the *mechanisms* through which health insurance reform affects the labor market equilibrium, including the uninsured rate. An equilibrium model that integrates the labor and health insurance markets is necessary for us to understand the general equilibrium implications of the health insurance reform. First, the United States is unique among industrialized nations in that it lacks a national health insurance system and most of the working-age population obtain health insurance coverage through ESHI. According to Kaiser Family Foundation and Health Research and Educational Trust (2009), more than 60 percent of the non-elderly population received their health insurance sponsored by their employers, and about 10 percent of workers' total compensation was in the form of ESHI premiums.[10] Second, there have been many well-documented connections between firm sizes, wages, health insurance offerings and worker turnovers. For example, it is well known that firms that do not offer health insurance are more likely to be small firms, to offer low wages, and to experience higher rate of worker turnover. In the 1997 Robert Wood Johnson Foundation Employer Health Insurance Survey, we find that the average size was about 8.8 for employers that did not offer health insurance, in contrast to an average size of 33.9 for employers that offered health insurance; the average annual wage was $20,560 for workers at firms that did not offer health insurance, in contrast to an average wage of $29,077 at firms that did; also, annual separation rate of workers at firms that did not offer health insurance was 17.3%, while it was 15.8% at firms that did.[11] Moreover, in our data sets, workers in firms that offer health insurance are more likely to *self report* better health than those in firms that do not offer health insurance.

Our model is based on Burdett and Mortensen (1998) and Bontemps, Robin, and Van den Berg (1999, 2000).[12, 13] One of the most desirable features of these models is that they have a coherent notion of firm size which allows us to satisfactorily examine the effect of size-dependent employer mandate as stipulated in the ACA. We depart from these standard models by incorporating health and health insurance; thus

insurance exchange can receive the premium subsidies is being challenged in the U.S. Supreme Court case *King v. Burwell.* The Supreme Court ruled to allow all subsidies on June 25, 2015 on a 6-3 decision.

[9] It passed in the House of Representatives but did not pass in the Senate.

[10] Among those with private coverage from any source, about 95% obtained employment-related health insurance (see Selden and Gray (2006)).

[11] We used this dataset to estimate our model in previous versions of the paper (Aizawa and Fang (2013, 2015)).

[12] Their model theoretically explains both wage dispersion among *ex ante* homogeneous workers and the positive correlation between firm size and wage. Moscarini and Postel-Vinay (2013) demonstrate that the extended version of this model, which allows firm productivity heterogeneity and aggregate uncertainty, has very interesting but also empirically relevant properties about firm size and wage adjustment over the business cycles.

[13] Dizioli and Pinheiro (2016) also extended Burdett and Mortensen (1998) to incorporate health insurance as a productivity factor, and show that firms that offer health insurance are larger and pay higher wages in equilibrium.

we endogenize the distributions of wages and health insurance provisions, employer size, employment and worker's health. In our model workers, who differ by demographic types (gender, marital status, and the presence of children), observe their own health status which evolves stochastically. Workers' health consists of two components, one that is observable by all, including the firms and econometricians, and another that is observable to the worker but unobservable to firms and econometricians. Workers' health status affects both their medical expenditures and their labor productivity. Health insurance eliminates individuals' out-of-pocket medical expenditure risks and may affect the dynamics of their health status. Individuals may obtain health insurance through employers (ESHI), Medicaid if eligible, spousal insurance if available, or individual insurance. The uninsured individuals may be still partially insured through other social safety net programs modeled as a consumption floor. Both the unemployed and the employed workers randomly meet firms and decide whether to accept their job offer, compensation package of which consists of wage and ESHI (if offered). Firms, which are *heterogenous* in their productivity, post compensation packages, which includes wages (that are allowed to depend on workers' observable health component) and ESHI offerings, to attract workers. The cost of providing health insurance, which will be used to determine ESHI premiums, is determined by both the *demographic* and *health* composition of its workforce, in addition to a fixed administrative cost. When deciding on what compensation packages to offer, the firms anticipate that their choice of compensation packages will affect the demographic and health composition of their workforce as well as their sizes in the steady state.

We characterize the steady state equilibrium of the model in the spirit of Burdett and Mortensen (1998). We estimate the parameters of the baseline model using data from Survey of Income and Program Participation (SIPP, 2004 Panel), Medical Expenditure Panel Survey (MEPS, 2001-2007), and Kaiser Employer Health Benefit Survey (2004-2007).[14] The first two data sets are panels on worker-side labor market status, health and health insurance, while the third one is a cross-sectional firm level data set which contains information such as firm size and health insurance coverage. Because the data on the supply-side (i.e., workers) and demand-side (i.e. firms) of labor markets come from different sources, we estimate the model using GMM. We show that our baseline model delivers a rich set of predictions that can *qualitatively* and *quantitatively* account for a wide variety of the aforementioned phenomenon observed in the data including the correlations among firm sizes, wages, health insurance offering rates, turnover rates and workers' health compositions.

Our empirical analysis highlights the dynamic interactions between firm's health insurance provision and worker's health status, which helps to explain these correlations. While it is true that firms, by offering health insurance, can benefit from the tax exemption of the insurance premium, they also attract more unhealthy (in unobservable component) workers among their new hires, which leads to the standard adverse selection problem. We find that this adverse selection effect substantially reduces the incentive of low-productivity firms to offer ESHI because they tend to disproportionately attract more unhealthy workers. Interestingly, however, we find that the adverse selection problem is partially alleviated over time by the positive effect of health insurance on the dynamics of the observable health component; importantly, given our estimate of this effect on the observed health component, which is consistent with the estimates in the health economics literature reviewed in Section 7, we find that this positive effect from the improvement of health status of the workforce is captured more by high productivity firms due to what we term as "retention effect." This simply refers to the fact that high-productivity firms tend to offer more

[14]The full name of the data set is Kaiser Family Foundation and The Health Research and Educational Trust (KFF/HRET) Survey on Health Benefits. In earlier versions of the paper (Aizawa and Fang (2013, 2015)), we used data from Robert Wood Johnson Foundation Employer Health Insurance Survey from 1997, the last year it was available.

valuable compensation packages (through the combinations of higher wages and ESHI) and retain workers longer (see Fang and Gavazza (2011) for an evidence for this mechanism). These effects jointly allow our model to generate a positive correlation between wage, health insurance, and firm size; and they moreover explain why health status of employees covered by ESHI is better than that of uninsured employees on the observed health component in the data.

We use our estimated model to examine the impact of the previously-mentioned four key components of the ACA. We find that the full implementation of the ACA would significantly reduce the uninsured rate among the workers in our estimation sample from 21.3% in the pre-ACA benchmark economy to about 6.6%. This large reduction of the uninsured rate is mainly driven by an increase in the fraction of the population purchasing individual private health insurance; specifically, in the pre-ACA benchmark, only 3.4% purchased (unregulated) private individual health insurance; but under the ACA, 11.2% of the population will purchase private health insurance from the regulated health insurance exchanged established under the ACA with income-based premium subsidies from the government. The fraction of the population covered by Medicaid also increase from 5.0% from pre-ACA environment to 9.9% under the ACA. Also we find a small increase in the fraction of the population covered under own ESHI or spousal insurance, from 70.3% in the pre-ACA benchmark to 72.4% under the ACA. We find that, due to the employer mandate, the health insurance offering rate for firms with 50 or more workers increases from 93.5% in the benchmark to 98.9% under the ACA; however, the health insurance offering rate for firms with less than 50 workers decreases from 48.0% in the benchmark to 40.0% under the ACA. The reason for the reduction in small firms' ESHI offering rate is that the ACA reduces the value of ESHI for workers, particularly those with low income, because of the availability of premium-subsidized health insurance from the regulated health insurance exchange. This effect dominates the countervailing effect of the ACA that it reduces, and in fact, almost eliminates, the adverse selection for small firms to offer ESHI. We also find that the size-dependent employer mandate leads to a slight increase in the fraction of firms with less than 50 workers, with a small but noticeable clustering of firms with size just below the employer mandate threshold of 50.

For the purpose of model validation, we also investigate the model's ability to account for the early impact of the ACA in the data. We simulate the impact of the ACA implemented in 2015, which differs from the full implementation of the ACA regarding the policy scales for individual and employer mandates and Medicaid. We find that in general the model is able to account for the major features in the data, specifically the observed changes in the health insurance status of the U.S. population.

We further use the estimated model to evaluate a series of alternative policies which are currently considered in the policy debates. First, we investigate the effect of the ACA if its individual mandate component were removed, a scenario that the U.S. will face from 2019 due to the recent tax reform which repealed the individual mandate. We find that ACA sans the individual mandate would still achieve a significant reduction in the uninsured rate: in our simulation the uninsured rate under "ACA without individual mandate" would be 11.4%, significantly lower than the 21.3% under the benchmark. The premium subsidy component of the ACA would have in itself drawn all the unemployed (regardless of their health) and the low-wage employed (again regardless of their health) in the insurance exchange. In fact, if we were to remove the premium subsidies, instead of the individual mandate, from the ACA, we find that the insurance exchange will suffer from adverse selection problem so severe as to render it non-active at all. ACA without premium subsidies only leads to a small reduction of the uninsured rate to 15.7% from the 21.3% in the benchmark.

Interestingly, we find that, under a policy of "ACA without the employer mandate," the uninsured rate would be 7.5%, almost identical to that under the full ACA. We find that, although firms with 50 or more workers decrease their ESHI offering rate without the employer mandate penalty, many of their employees obtain other health insurance. Interestingly, this will create a general equilibrium effect that also affect small firms' ESHI offering rate. Overall, the effect of employer mandate under the ACA is likely to be very limited.

We also simulate the effects of eliminating the tax exemption for ESHI premium both under the benchmark and under the ACA. We find that, the elimination of the tax exemption for ESHI premium would reduce, but not eliminate, the incentives of firms, especially the larger ones, to offer health insurance to their workers; the overall effect on the uninsured rate is modest. We find that the uninsured rate would increase from 21.3% to 31.8% when the ESHI tax exemption is removed in the benchmark economy; and it will increase from 6.6% to 12.4% under the ACA. We also experimented with the effect of prohibiting firms from offering ESHI in the post-ACA environment. We find that it would lead to a large increase in the uninsured rate, which suggests that ESHI *complements*, instead of hinders, the smooth operations of the health insurance exchange.

The remainder of the paper is structured as follows. In Section 2, we review the related literature; in Section 3, we present the model of the labor market with endogenous determinations of wages and health insurance provisions; in Section 4, we present a qualitative assessment of the workings of the model; in Section 5, we describe the data sets used in our empirical analysis; in Section 6, we explain our identification and estimation strategy; in Section 7, we present our estimation results and the goodness-of-fit; in Section 8, we describe the results from several counterfactual experiments; and finally in Section 9, we conclude and discuss directions for future research.

2 Related Literature

This paper is related to three strands of the literature. First and foremost, it is related to a small structural empirical literature that examines the relationship between health insurance and labor market.[15] Rust and Phelan (1997) studies the interaction between Social Security, Medicare and employer-provided health insurance for retirement behavior in a world with incomplete markets. More closely related to our paper, Dey and Flinn (2005) propose and estimate an equilibrium model of the labor market in which firms and workers bargain over both wages and health insurance offerings to examine the question of whether the employer-provided health insurance system leads to inefficiencies in workers' mobility decisions (which are often referred to as "job lock" or "job push" effects).[16] Our primary contribution to this literature is to develop and estimate an equilibrium model of labor and health insurance markets, which explicitly incorporates firm size, health, medical expenditure, and realistic features of the U.S. health insurance system, such as the sizable presence of ESHI and Medicaid. To examine the effect of size-dependent employer mandate, it is crucial for us to endogenize firm size and quantitatively explain the dependence of ESHI offering on firm size, which is not considered in the literature including Dey and Flinn (2005). Moreover, incorporating health and medical expenditure will be crucial to understand equilibrium implications of health care reforms into health insurance markets.

The channel that worker turnover discourages firm's health insurance provision is related to Fang and Gavazza (2011). They argue that health is a form of general human capital, and labor turnover and labor-market frictions prevent an employer-employee pair from capturing the entire surplus from investment in

[15]See Currie and Madrian (1999) for a survey of the large reduced form literature on the interactions between health, health insurance and labor market.

[16]See Madrian (1994) and Gruber and Madrian (1994) for reduced-form evidence for job locks induced by ESHI.

an employee's health, generating under-investment in health during working years and increasing medical expenditures during retirement. In this paper, we develop an equilibrium framework that incorporates this channel, as well as other channels such as adverse selection, that are known to be important factors for health insurance coverage. We then investigate how these channels interact with each other to determine the general equilibrium impacts of health insurance system on insurance coverage and labor market outcomes. Moreover, our primary focus is about health insurance coverage provision and labor market outcomes, while theirs is about the life-cycle medical expenditure.

Second, there are a growing number of empirical analyses examining the likely impact of the ACA. Some of these papers study the Massachusetts Health Reform, implemented in 2006, which has similar features with the ACA. For example, Kolstad and Kowalski (2012); Hackmann, Kolstad, and Kowalski (2012); Kolstad and Kowalski (2016) use model-based "sufficient statistics" approach to study the effect on medical expenditure, selection in insurance markets, and labor markets. Courtemanche and Zapata (2014) found that Massachusetts reform improves the health status of individuals. They study these issues based on a "difference-in-difference" approach and require the availability of both pre- and post-reform data sets. These approaches are very informative to understand the overall and likely impact of reform. By structurally estimating an equilibrium model, we complement this literature by providing a quantitative assessment of the *mechanisms* generating such outcomes. Moreover, we provide the assessment of various other counterfactual policies such as health care reforms beyond the ACA and the removal of tax exclusion of ESHI premiums.

Pashchenko and Porapakkarm (2013) evaluates the ACA using a calibrated life-cycle incomplete market general equilibrium model. They consider several individual decisions such as health insurance, consumption, saving, and labor supply, but they do not model firms' decision of offering health insurance as well as firm size distribution. Therefore, their model is not designed to address the effects of ACA on firms' insurance coverage and wage offer decisions and the equilibrium effects of size-dependent employer mandate. Mulligan (2013), Gallen and Mulligan (2013) and Mulligan (2014) extensively investigated the various labor market impacts of the ACA via its effect on marginal tax rates. We differ from this set of papers by explicitly modeling health evolution and medical expenditures. Handel, Hendel, and Whinston (2015) studies how regulated but competitive health insurance exchanges may affect the welfare of participants, focusing on the trade-offs between the potential welfare loss from the adverse selection versus potential welfare gains from premium reclassification insurance. They find that welfare benefits from reclassification risk insurance is significantly larger than the loss from adverse selection when insurers can price based on some health status information. Their paper focuses on the functioning of the health insurance exchange and does not consider how the availability of the regulated exchange might impact the behavior of the firms and subsequently affect the risk pools of the exchange itself.

Third, this paper is related to a large literature estimating equilibrium labor market search models.[17] Van den Berg and Ridder (1998) and Bontemps, Robin, and Van den Berg (1999, 2000) empirically implement Burdett and Mortensen (1998)'s model. Hwang, Mortensen, and Reed (1998) investigates in a search model where workers have heterogenous preferences for non-wage amenities and firms endogenously decide upon wages and non-wage amenity bundles to compete for workers. They use their model to show that estimates of workers' marginal willingness to pay for amenities, derived from the conventional hedonic wage methodology, are biased in models with search frictions. These search-based empirical frameworks of labor market have been widely applied in subsequent studies investigating the impact of various labor

[17] See Eckstein and Wolpin (1990) for a seminal study that initiated the literature.

market policies on labor market outcomes. Among this literature, our study is mostly related to Shephard (2017) and Meghir, Narita, and Robin (2015), which also allow for multi-dimensional job characteristics as in our paper: wage and part-time/full-time in Shephard (2017), wage and formal/informal sector in Meghir, Narita, and Robin (2015), and wage and health insurance offering in our paper. However, in Shephard (2017) a firm's job characteristics is assumed to be exogenous, while in our paper employers endogenously choose job characteristics. In Meghir, Narita, and Robin (2015) firms choose whether to enter the formal or informal sectors so in some sense their job characteristics are also endogenously determined; however, in Meghir, Narita, and Robin (2015), workers are homogeneous so firms' decision about which sector to enter does not affect the composition of the types of workers they would attract. In contrast, in our model, workers are heterogenous in their health, thus employers endogenously choose job characteristics, namely wage and health insurance offering, by taking into account their influence on the initial composition of its workforce as well as the subsequent worker turnover.

3 An Equilibrium of Model of Wage Determination and Health Insurance Provision

3.1 The Environment

Consider a labor market with a continuum of firms with measure normalized to 1. There is a continuum of workers whose demographic type is denoted by $\chi \in \{1, 2, \ldots, N\}$. Let $M_\chi > 0$ denote the measures of workers with (permanent) demographic type χ, with $M \equiv \sum_{\chi=1}^{N} M_\chi$ denoting the total size of the workforce relative to firms.[18] Workers and firms are randomly matched in a frictional labor market. Time is discrete, and indexed by $t = 0, 1, ...$[19] We use $\beta \in (0, 1)$ to denote the discount factor for the workers.

Workers of demographic type χ have constant relative risk aversion (CARA) preferences:[20, 21]

$$u_\chi(c) = -\frac{\exp\left(-\gamma_\chi C\right)}{\gamma_\chi}, \tag{1}$$

where $\gamma_\chi > 0$ is the absolute risk aversion parameter for demographic type χ.[22]

Workers' Health. Workers differ in their health status, denoted by $\mathbf{h} = (h_1, h_2) \in \mathcal{H}$, where $h_1 \in \{H_1, U_1\}$ is the binary *observed* health status, and $h_2 \in \{H_2, U_2\}$ the binary *unobserved* health status, where $H.$ is interpreted to be healthier than $U.$ (see Footnote 54 for details on how we convert the five self-reported

[18]Throughout the paper, we use "workers" and "firms" interchangeably with "individuals" and "employers," respectively.

[19]In our empirical analysis, a "period" correponds to four months.

[20]Note that we assume that health states affect individual's utility only through their impact on consumption via medical expenditures. Considering the idenfication and estimation of a utility function specification that allows for the interaction of health states and marginal utility of consumption is an interesting and important area for future research.

[21]One can also specify the CRRA utility function, as opposed to the CARA utility function, which create additional income effect for the demand of health insurance. We also experimented with the CRRA utility function and found that the main results remain the same both qualitatively and quantitatively. The results are available upon request.

[22]In our model, we do not consider the joint labor supply decisions of couples (Dey and Flinn (2008)) as we assume that male and female workers make individual labor market decisions; however, male and female workers are integrated in the labor market because, as we will discuss in Section 3.3.4, firms consider their overall workforce including both male and female workers in deciding their compensation packages. Fang and Shephard (2018b) explicitly consider the joint labor supply decisions of couples.

health status to H_1 and U_1.)[23] In our model, a worker's health status has two effects. First, together with the worker's health insurance status, it affects the distribution of health expenditures. Specifically, we model an individual's distribution of medical expenditure m as follows. Let $x \in \{0, 1, 2, 3, 4\}$ denote an individual $i's$ health insurance status where

$$x = \begin{cases} 0 & \text{if} \quad i \text{ is uninsured,} \\ 1 & \text{if} \quad i \text{ is insured through his/her own ESHI,} \\ 2 & \text{if} \quad i \text{ is insured through an individual private insurance,} \\ 3 & \text{if} \quad i \text{ is insured through Medicaid,} \\ 4 & \text{if} \quad i \text{ is insured through spousal insurance.} \end{cases} \tag{2}$$

The probability that an individual of demographic type χ with health status $\mathbf{h} \in \mathcal{H}$ and health insurance status $x \in \{0, 1, 2, 3, 4\}$ will experience a positive medical shock is given by:

$$\Pr\left[m > 0 | \left(\chi, \mathbf{h}, x\right)\right]; \tag{3}$$

And conditional on a positive medical shock, his/her medical expenditure is represented by a random variable denoted by

$$m\,|(\chi, \mathbf{h}, x) \tag{4}$$

Note that in (3) and (4), we allow both the individual's health and health insurance status to affect the medical expenditure distributions. In subsequent analysis, we will use $\tilde{m}^x_{\chi\mathbf{h}}$ to denote the *random* medical expenditure for individuals with health status $\mathbf{h}$ and health insurance status x as described by (3) and (4), and use $m^x_{\chi\mathbf{h}}$ to denote the *expectation* of $\tilde{m}^x_{\chi\mathbf{h}}$.

Second, a worker's health status may affect his/her productivity. Specifically, if an individual works for a firm with productivity p, he/she produces $d_{\chi\mathbf{h}} \times p$ units of output under health status $\mathbf{h} \in \mathcal{H}$. [24]

In each period, a worker's health status changes stochastically according to a Markov Process. The period-to-period transition of an individual's health status depends on the demographic type χ, and his/her health insurance status x. Specifically, we use

$$\pi^x_{\chi\mathbf{h}\mathbf{h}'} \in (0, 1) \tag{5}$$

to denote the probability that a type-χ worker's health status changes from $\mathbf{h}' \in \mathcal{H}$ to $\mathbf{h} \in \mathcal{H}$ conditional on insurance status x; of course, $\sum_{\mathbf{h}\in\mathcal{H}} \pi^x_{\chi\mathbf{h}\mathbf{h}'} = 1$ for each $\mathbf{h}' \in \mathcal{H}$.

Firms. Firms are heterogeneous in their productivity. We assume that, in the population of firms, the distribution of productivity is denoted by $\Gamma(\cdot)$, and that it admits an everywhere continuous and positive density function. In our empirical application, we specify Γ to be log-normal with location parameter μ_p and scale parameter σ_p.

Firms, after observing their productivity, choose a *package* that consists of wage $w_{h_1^0} \in R_+$ and ESHI, denoted by $E \in \{0, 1\}$ where 1 (respectively, 0) denotes offering (not offering, respectively) ESHI. Note that we allow that wage offer can depend on worker's *observed* health status h_1 at the time of job entry,

[23] As should be clear from our analysis below, our theoretical framework can allow for any finite number of health status. The choice of having four health status is dictated by the sample size limitations.

[24] One can alternatively assume that the productivity loss only occurs if an individual experiences a bad health shock. Because an unhealthy worker is more likely to experience a bad health shock, such a formulation is equivalent to the one we adopt in the paper.

denoted by h_1^0. We assume that, even though the initial wage can depend on the observed health status at the time of job entry, wage must be constant over the course of the employment.

If a firm offers health insurance to its workers, it has to incur a *fixed* administrative cost $\tilde{C} = C + \sigma_f \epsilon_f$, where $C > 0$ and ϵ_f has a Type-I extreme value distribution with zero mean, and σ_f is a scale parameter. We assume that any firm that offers health insurance to its workers is self-insured, and it pays insurance premiums for all of its workforce each period to cover the necessary reimbursement of their expected health expenditures in addition to the administrative cost $\tilde{C}$.[25]

Remark 1. *We allow workers' wage to depend on their observable health at the time of job entry. While still restrictive, it nonetheless captures the idea that firms may want to screen workers based on workers' observable health status, which may affect firm productivity. Once workers are hired, however, firms will insure workers against their possible productivity changes, due to their health status change, by offering a constant wage within the employment relationship.*[26] *In practice, the extent to which firms can condition their wage offers to workers' health status is also limited by government regulations, such as Health Insurance Portability and Accountability Act (HIPAA) and Americans with Disabilities Act (ADA) as well as their amendments, which restrict firms' ability to condition hiring, firing, and compensation based on individuals health status. We capture these restrictions by assuming the presence of a component of* unobserved *health status h_2 which firms cannot use in the wage offers.*[27]

Labor Market. Firms and workers are randomly matched in the labor market.[28] We allow the matching rate to be dependent on the worker's demographic type χ and health status $\mathbf{h}$. In each period, an unemployed worker randomly meets a firm with probability $\lambda_u^{\chi\mathbf{h}} \in (0,1)$. He/She then decides whether to (1) accept the offer, or (2) to remain unemployed and search for jobs in next period. If an individual is employed, he/she meets randomly with another firm with probability $\lambda_e^{\chi\mathbf{h}} \in (0,1)$. If a currently employed worker receives an offer from another firm, he/she needs to decide whether to (1) accept the outside offer, or (2) to stay with the current firm. An employed worker can also decide to return to the unemployment pool.[29] Moreover, each match is destroyed exogenously with probability $\delta^{\chi\mathbf{h}} \in (0,1)$, upon which the worker will return to unemployment. As we discuss in Section 3.2, we assume that individual may experience both the exogenous job destruction and the arrival of the new job offer within in the same period.[30]

[25] As will be clear later, introducing a fixed administrative cost $\tilde{C}$ facilitates the model's ability to fit the empirical relationship between the firm size and health insurance offering rate. In principle, firms should also be able to choose the workers' contributions to the premium if they decide to offer ESHI. We abstract from this because we do not observe the premium payments by the workers from the data.

[26] Characterizing optimal wage contract, as in Burdett and Coles (2003) and Lentz and Roys (2015), is a very interesting extension. It is important to mention that, even without health dynamics, the optimal wage contract can be an upward wage-tenure profile, as highlighted by Burdett and Coles (2003). We decide to restrict the contract space as it is extremely challenging to estimate such a model, particularly because we lack data about details of the wage contracts.

[27] HIPAA is an amendment of Employee Retirement Security Act (ERISA), which is a federal law that regulates issues related to employee benefits in order to qualify for tax advantages. A description of HIPPA can be found at the Department of Labor website: http://www.dol.gov/dol/topic/health-plans/portability.htm

[28] We choose the random search framework over the directed search because the random search will naturally generate a pooling between healthy and unhealthy workers at each firm. This pooling feature is often considered as one of the rationalities of relying on ESHI.

[29] Returning to unemployment may be a better option for a currently employed worker if his/her heath status changed from when he/she accepted the current job offer, for example.

[30] This specification is used by Wolpin (1992) and more recently by Jolivet, Postel-Vinay, and Robin (2006). This allows us to account for transitions known as "job to unemployment, back to job" all occurring in a single period, as we observe in the

As we discuss below, in order to smooth the labor supply functions firms face, we assume that type-χ workers, whether unemployed or employed, receive preference shocks for working $\epsilon_{\chi w}$ each period. We assume that $\epsilon_{\chi w}$ is identically and independently distributed across periods, drawn from a Normal distribution $N\left(0, \sigma^2_{\chi w}\right)$. The introduction of preference shocks $\epsilon_{\chi w}$ plays several important roles. First, it smooths the labor supply functions as a function of wages, as will be clear below. Second, this in turn allows us to address the technical issue of mass points in the reservation wage distribution because of the discreteness of the health states and demographic types (see, e.g., Albrecht and Axell (1984)).[31] Third, it also implies that all firms, regardless of their productivity level, will be able to attract some positive measure of workers; together with the log-normal distributional assumption on the productivity distribution, this allows us to rationalize all the wages observed in the data without having to introduce measurement error.

To generate a steady state for the labor market, we assume that in each period a type-χ individual, regardless of health and employment status, will leave the labor market with probability $\rho_\chi \in (0,1)$; an equal measure of type-χ newborns will enter the labor market as unemployed, and their initial health status is $\mathbf{h}$ with probability $\mu_{\chi\mathbf{h}} \in (0,1)$ for $\mathbf{h} \in \mathcal{H}$ so that $\sum_{\mathbf{h}\in\mathcal{H}} \mu_{\chi\mathbf{h}} = 1$.

Pre-ACA Health Insurance System. In the baseline model, which is intended to represent the pre-ACA U.S. health insurance system, we assume that workers can obtain health insurance from employers as ESHI, individual health insurance, spousal health insurance, or Medicaid, as we specified in (2). We now describe them in more details

For the *private individual health insurance* in the pre-ACA world, i.e., option 2 in (2), we assume that the premium is based on perfect risk rating; namely, the premium, denoted by $R^{II}(\mathbf{h},\chi)$, is equal to the expected medical expenditure, multiplied by a loading factor.[32] Analogous to the preference shock we introduced in the individuals' work decisions, we also introduce a preference shock, $\epsilon_{\chi II}$, to individuals' choice problem when they decide whether to purchase private individual health insurance. We assume that $\epsilon_{\chi II}$ follows a Normal distribution $N\left(0, \sigma^2_{\chi II}\right)$. This preference shock allows us to smooth the employment distribution over wage offers, which simplifies the characterization of the firms' problem, as we will show in Section 3.3.4.

We assume that *spousal health insurance* is offered with the probability $f_{SP}(\chi) \in [0,1]$ to a type-χ uninsured individual if he/she is married.[33] Note that it is not available to single individuals. Moreover, *Medicaid* is offered to individuals who do not have ESHI (whether from their own employer or from their spouse's) with probabilities $f^e_M(\chi, y) \in [0,1]$ and $f^u_M(\chi)$, respectively for employed and unemployed workers. This modeling assumption captures the essence that Medicaid eligibility depends crucially on income y and demographic type χ, especially the presence of children.[34]

Finally, we allow that the uninsured may be partially insured through uncompensated care or any other social safety net, which we model as *consumption floor* $\underline{c}_\chi$.[35] One important simplification is that, mainly

data.

[31] An alternative to induce smooth labor supply functions is to introduce permanent unobserved heterogeneity, e.g., value from leisure, drawn from a continuous distribution. Our formulation is simpler because it avoids the identification issues of heterogeneity vs. state dependence in the dynamic discrete choice models (see Heckman (1981)).

[32] See Aizawa (2017) which studies the role of various other features of pre-ACA individual health insurance markets and its interactions with the labor market.

[33] Note that we do not consider the joint household labor supply in this paper. See Fang and Shephard (2016) for such an analysis.

[34] Note that we do not model the asset testing of Medicaid. This is an important area for future research.

[35] We would like to point out that in our model the consumption floor applies only to the *uninsured* who experience large

due to the computational complexities, we do not model saving decisions, which may be a way to self insure against medical expenditure risks.[36]

Income Taxes. In the baseline model workers' wages are subject to a nonlinear tax schedule, but the ESHI premium is tax exempt. For the *after-tax income* $T(y)$, we follow the specification in Kaplan (2012) which approximates the U.S. tax code by:[37]

$$T(y) = \tau_0 + \tau_1 \frac{y^{1+\tau_2}}{1+\tau_2} \tag{6}$$

where $\tau_0 > 0, \tau_1 > 0$ and $\tau_2 < 0$.

3.2 Timing in a Period

At the beginning of each period, we should imagine that individuals, who are heterogeneous in their health status, are either unemployed or working for firms offering different combinations of wage and health insurance packages. We now describe the explicit timing assumptions in a period that we use in the derivation of the value functions in Section 3.3. Our particular timing assumptions simplify our derivation, but they are not crucial for the qualitative predictions of the model.

1. Type-χ individual, whether employed or unemployed, and regardless of his/her health status, exits the labor market (i.e., dies) with probability $\rho_\chi \in (0,1)$;

2. If a type-χ employed worker stays in the labor market and is matched with a firm with productivity p, then:

   (a) he/she produces output $pd_{\chi\mathbf{h}}$ if his/her health status is $\mathbf{h} \in \mathcal{H}$;

   (b) the firm pays the wage and pays for the expected health expenditure of its workers if it offers ESHI;

   (c) he/she receives a medical expenditure shock, the distribution of which depends on his/her beginning-of-the-period health status;

   (d) he/she randomly meets with new employers with probability $\lambda_e^{\chi\mathbf{h}}$;

   (e) he/she then observes the realization of the health status that will be applicable next period;

   (f) a labor supply preference shock $\epsilon_{\chi w}$ is drawn from $N\left(0, \sigma_{\chi w}^2\right)$;

   (g) the current match is destroyed with probability $\delta^{\chi\mathbf{h}} \in (0,1)$, in which case the worker must decide, given the realization of $\epsilon_{\chi w}$, whether to accept the outside offer, if any, or to enter the unemployment pool;

   (h) if the current match is not destroyed, then he/she decides, given the realization of $\epsilon_{\chi w}$, whether to accept the outside offer if any, to stay with the current firm, or to quit into unemployment.

medical expenses. In contrast, the consumption floor in Hubbard, Skinner, and Zeldes (1995) and French and Jones (2011) is available to *everyone*. See Footnote 80 for an extensive discussion.

[36] Lise (2013) is an exception in that it includes consumption and saving margin in a similar empirical on-the-job search model, although in his paper the firm-side is assumed to be exogenous. In a related work, French, Jones, and von Gaudecker (2017) studies the impact of the ACA on saving, retirement, and welfare through the life-cycle model. They find that changes in saving is modest, which may alleviate the concern about this omission, at least in our context.

[37] Robin and Roux (2002) also studied the impact of progressive income tax within the framework of Burdett and Mortensen (1998).

3. Any unemployed worker of type χ experiences the following sequence of events in a period:

   (a) he/she receives the "unemployment benefit" $\mathfrak{b}_\chi$;

   (b) he/she receives a medical expenditure shock, the distribution of which depends on his beginning-of-the-period health status;

   (c) he/she randomly meets with employers with probability $\lambda_u^{\chi\mathbf{h}}$;

   (d) he/she then observes the realization of the health status that will be applicable next period;

   (e) a labor supply preference shock $\epsilon_{\chi w}$ is drawn from $N\left(0, \sigma_{\chi w}^2\right)$;

   (f) he/she decides, given the realization of $\epsilon_{\chi w}$, whether to accept the offer if any, or to stay unemployed.

4. If a type-χ individual does not receive ESHI for the next period, then with probability $f_{SP}(\chi)$, he/she will obtain health insurance from spouse with premium R^{SP} (note, if individuals are single, $f_{SP}(\chi) = 0$). Note that he/she must take up this option.

5. If a type-χ individual does not receive ESHI for the next period and does not receive spousal insurance offers, then with probability $f_M^e(\chi, y)$ or $f_M^u(\chi)$ depending on whether the individual is employed, he/she receives the Medicaid coverage ($x = 3$).

6. If the individual is still uninsured, he/she will decide whether to purchase private individual health insurance with price $R^{II}(h, \chi)$. The decision to purchase private individual health insurance is affected by the health insurance preference shock $\epsilon_{\boldsymbol{\chi}II}$ which is drawn from $N(0, \sigma_{\boldsymbol{\chi}II}^2)$.

7. Time moves to the next period.

3.3 Analysis of the Model

In this section, we characterize the steady state equilibrium of the model. The analysis here is similar to but generalizes that in Burdett and Mortensen (1998). We first consider the decision problem faced by a worker with observable health status h_1^0 at the time of receiving a job offer $\left(\tilde{w}_{h_1^0}, E\right)$, drawn from a postulated distribution of wage and insurance packages by the firms, denoted by $F_{h_1^0}(\tilde{w}_{h_1^0}, E)$, and derive the steady state distribution of workers of different health status in unemployment and among firms with different offers of wage and health insurance packages. We then solve the firms' optimization problem and provide the conditions for the postulated $\left\langle F_{h_1^0}(\tilde{w}_{h_1^0}, E) : h_1^0 \in \{H_1, U_1\}\right\rangle$ to be consistent with equilibrium.

3.3.1 Value Functions

We first introduce the notation for several valuation functions. We use $v_{\chi\mathbf{h}}(y, x)$ to denote the expected *flow utility* of type-χ workers with health status $\mathbf{h}$ from income y and insurance status x; and it is given by:

$$v_{\chi\mathbf{h}}(y, x) = \begin{cases} \mathrm{E}_{\tilde{m}_{\chi\mathbf{h}}^0} u_{\boldsymbol{\chi}}\left(\max\left\{\left(T(y) - \tilde{m}_{\chi\mathbf{h}}^0\right), \underline{c}_\chi\right\}\right) & \text{if } x = 0 \\ u_\chi\left(T\left(y, \chi\right)\right) & \text{if } x \in \{1\,, 3\} \\ u_\chi\left(T\left(y, \chi\right) - R^{II}(\mathbf{h},\chi)\right) & \text{if } x = 2 \\ u_\chi\left(T\left(y - R^{SP}, \chi\right)\right) & \text{if } x = 4. \end{cases} \quad (7)$$

where $u_{\boldsymbol{\chi}}(\cdot)$ is specified in (1); $T(y)$ is after-tax income as specified in (6); and $\tilde{m}_{\chi h}^0$ is the random medical expenditure for uninsured type-χ individual as specified by (3) and (4). Note that in (7), we assume that when an individual is insured, i.e., $x \neq 0$, his/her medical expenditures are fully covered by the insurance.[38] However, if an individual is uninsured, i.e., $x = 0$, he/she is partially insured through the consumption floor $\underline{c}_\chi$ when he/she experiences an extremely large medical expenditure.

Let $U_{\chi\mathbf{h}}(x)$ denote the value for an unemployed worker of type χ with health status $\mathbf{h}$ and health insurance status $x \in \{0, 2, 3, 4\}$ at the beginning of a period; and let $V_{\chi\mathbf{h}}(w_{h_1^0}, x)$ denote the value function of a type-χ worker with current health status $\mathbf{h}$ who is employed on a job with wage $w_{h_1^0}$ (e.g., his/her observable health at the initial entry to the job is h_1^0) and whose insurance status is $x \in \{0, 1, 2, 3, 4\}$. $U_{\chi\mathbf{h}}(\cdot)$ and $V_{\chi\mathbf{h}}(\cdot, \cdot)$ are of course related recursively. $U_{\chi\mathbf{h}}$ is given by:

$$\frac{U_{\chi\mathbf{h}}(x)}{1-\rho_\chi} = v_{\chi\mathbf{h}}(\mathfrak{b}_\chi, x) + \beta \mathrm{E}_{\mathbf{h}'|(\mathbf{h},x,\chi)} \left[\begin{array}{l} \lambda_u^{\chi\mathbf{h}} \int\int \max\left\{\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E}), \tilde{U}_{\chi\mathbf{h}'} + \sigma_{\boldsymbol{\chi}w}\epsilon_w\right\} d\Phi(\epsilon_w)\, dF_{h_1'}(\tilde{w}_{h_1'}, \tilde{E}) \\ +(1-\lambda_u^{\chi\mathbf{h}})\tilde{U}_{\chi\mathbf{h}'} \end{array} \right]. \tag{8}$$

In (8), $\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E})$ is the value from accepting a job offer with the wage-ESHI package $(\tilde{w}_{h_0'}, \tilde{E})$, which is determined as:

$$\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E}) = \begin{cases} \left(\begin{array}{l} f_{SP}(\chi)V_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, 4) + \ [1 - f_{SP}(\chi)] \times \\ \left[\begin{array}{l} f_M^e(\chi, \tilde{w}_{h_1'})V_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, 3) + \left[1 - f_M^e(\chi, \tilde{w}_{h_1'})\right] \times \\ \max\left\{V_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, 2) + \sigma_{\boldsymbol{\chi}II}\epsilon_{\boldsymbol{\chi}II}, V_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, 0)\right\} \end{array} \right] \end{array} \right) & \text{if} \quad \tilde{E} = 0 \\ V_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, 1) & \text{if} \quad \tilde{E} = 1. \end{cases} \tag{9}$$

$\tilde{U}_{\chi\mathbf{h}'}$ is the value from being the unemployed, unconditional on insurance status, in the end of this period and it is given by:

$$\begin{aligned} \tilde{U}_{\chi\mathbf{h}'} \quad = \quad & f_{SP}(\chi)U_{\chi\mathbf{h}'}(4) + [1 - f_{SP}(\chi)] \times \\ & \left\{ \begin{array}{c} f_M^u(\chi)U_{\chi\mathbf{h}'}(3) + [1 - f_M^u(\chi)] \times \\ \max\left\{U_{\chi\mathbf{h}'}(2) + \sigma_{\boldsymbol{\chi}II}\epsilon_{\boldsymbol{\chi}II}, U_{\chi\mathbf{h}'}(0)\right\} \end{array} \right\}. \end{aligned} \tag{10}$$

Note that, in (8), $\Phi(\cdot)$ is the cumulative distribution function for a standard Normal distribution ϵ_w and the expectation $\mathrm{E}_{\mathbf{h}'|(\mathbf{h},x,\chi)}$ is taken with respect to the distribution of $\mathbf{h}'$ conditional on $(\mathbf{h}, x, \chi)$. (8) states that the value of being unemployed for a type-χ individual with insurance status x, normalized by the survival rate $1 - \rho_\chi$, consists of the flow payoff $v_{\chi h}(\mathfrak{b}_\chi, x)$, and the discounted expected continuation value where the expectation is taken with respect to the health status $\mathbf{h}'$ next period, whose transition is given by $\pi^x_{\chi\mathbf{h}'\mathbf{h}}$ as described in (5). The unemployed worker may be matched with a firm with probability $\lambda_u^{\chi\mathbf{h}}$ and the firm's offer $\left(\tilde{w}_{h_1'}, \tilde{E}\right)$ is drawn from the distribution $F_{h_1'}(\tilde{w}_{h_1'}, \tilde{E})$. If an offer is received, the worker will choose whether to accept the offer by comparing the value of being employed at that firm, $\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E})$, and the value of remaining unemployed $\tilde{U}_{\chi\mathbf{h}'} + \sigma_{\boldsymbol{\chi}w}\epsilon_w$; if no offer is received, which occurs with probability $1 - \lambda_u^{\chi\mathbf{h}}$, the worker's continuation value is $\tilde{U}_{\chi\mathbf{h}'}$. Thus, this formulation says that if the firm posts the contract $(\tilde{w}_{h_1'}, \tilde{E})$, then the value delivered to the worker is $\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E})$.

Similarly, $V_{\chi\mathbf{h}}(w_{h_1^0}, x)$ is given by:

$$\frac{V_{\chi\mathbf{h}}(w_{h_1^0}, x)}{1-\rho_\chi} = v_{\chi\mathbf{h}}(w_{h_1^0}, x) \tag{11a}$$

$$+ \quad \beta\lambda_e^{\chi\mathbf{h}} \left\{ \begin{array}{c} (1-\delta^{\chi\mathbf{h}})\, \mathrm{E}_{\mathbf{h}'|(\mathbf{h},x,\chi)} \left[\iint \max\left\{\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, \tilde{E}), \tilde{V}_{\chi\mathbf{h}'}(w_{h_1^0}, E(x)), \tilde{U}_{\chi\mathbf{h}'} + \sigma_{\boldsymbol{\chi}w}\epsilon_w\right\} d\Phi(\epsilon_w)\, dF_{h_1'}(\tilde{w}_{h_1'}, \tilde{E})\right] \\ +\delta^{\chi\mathbf{h}}\mathrm{E}_{\mathbf{h}'|(\mathbf{h},x,\chi)} \left[\int\int \max\left\{\tilde{V}_{\chi\mathbf{h}'}(\tilde{w}_{h_1'}, E), \tilde{U}_{\chi\mathbf{h}'} + \sigma_{\boldsymbol{\chi}w}\epsilon_w\right\} d\Phi(\epsilon_w)\, dF_{h_1'}(\tilde{w}_{h_1'}, E)\right] \end{array} \right\} \tag{11b}$$

$$+ \quad \beta(1-\lambda_e^{\chi\mathbf{h}})\mathrm{E}_{\mathbf{h}'|(\mathbf{h},x,\chi)} \left[\begin{array}{l} (1-\delta^{\chi\mathbf{h}}) \left[\int \max\left\{\tilde{V}_{\chi\mathbf{h}'}(w_{h_1^0}, E(x)), \tilde{U}_{\chi\mathbf{h}'} + \sigma_{\boldsymbol{\chi}w}\epsilon_w\right\} d\Phi(\epsilon_w)\right] \\ +\delta^{\chi\mathbf{h}}\tilde{U}_{\chi\mathbf{h}'} \end{array} \right]. \tag{11c}$$

[38] This assumption is necessitated by the fact that we have no information about the details of the health insurance policy in our main Survey of Income and Program Participation (SIPP) data.

Expression (11) consists of several components. The first component, (11a), is the flow utility. The second component, (11b), is the expected value when receiving an on-the-job offer package $\left(\tilde{w}_{h_1'}, \tilde{E}\right)$drawn from the distribution $F_{h_1'}(\tilde{w}_{h_1'}, \tilde{E})$. This component has two sub-components depending on whether or not the current job is destroyed. If it is not destroyed, which occurs with probability $1 - \delta^{\chi\mathbf{h}}$, the individual has the option of accepting the new offer, staying with the current job, or quit into unemployment; on the other hand, if the current job is destroyed, which occurs with probability $\delta^{\chi\mathbf{h}}$, the individual has the option of accepting the new offer, or quit into unemployment. Note that in the expression, $E(x)$ denotes the ESHI offering of the current employer for the employed worker whose insurance status is x, and it is determined simply by:

$$E(x) = \begin{cases} 0 & \text{if} \quad x \neq 1 \\ 1 & \text{if} \quad x = 1, \end{cases} \tag{12}$$

and $\tilde{V}_{\chi\mathbf{h}'}(w_{h_1^0}, E(x))$ and $\tilde{U}_{\chi\mathbf{h}'}$ are defined, respectively, in (9) and (10). The third component is the expected value when the worker does not receive an on-the-job offer. Note that in both (8) and (11), we used our timing assumption that a worker's next-period health status depends on his/her insurance status this period even if he/she is separated from the current job at the end of this period (see Section 3.2).

3.3.2 Workers' Optimal Strategies

In this subsection, we describe the workers' optimal strategies. Note that in our model, both unemployed and employed workers make decisions about whether to accept or reject an offer, and whether to purchase individual health insurance, by comparing the value from different options. Their optimal decisions will depend on their state variables, i.e., their employment status including the terms of their current offer $\left(w_{h_1^0}, E\right)$ if they are employed, and their health status $\mathbf{h}$, as well as the realized preference shocks $(\epsilon_{\chi w}, \epsilon_{\chi II})$.

Optimal Strategies for Unemployed Workers. From the value function for the unemployed worker, as given by (8), it is clear that a type-χ worker with health status $\mathbf{h}$ will accept an offer $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ if and only if

$$\begin{aligned} &\tilde{V}_{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}) \geq \tilde{U}_{\chi\mathbf{h}} + \sigma_{\boldsymbol{\chi} w}\epsilon_w \\ \Leftrightarrow \quad &\epsilon_w \leq \tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}) \equiv \frac{\tilde{V}_{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}) - \tilde{U}_{\chi\mathbf{h}}}{\sigma_{\boldsymbol{\chi} w}}. \end{aligned} \tag{13}$$

Thus, an unemployed worker with $(\chi, \mathbf{h})$ will accept an offer $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ with probability $\Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})\right)$.

If a worker remains unemployed at the end of the period with newly realized health status $\mathbf{h}$, conditional on not receiving spousal health insurance offering or Medicaid, his/her decision to purchase individual health insurance, as described in (10), is characterized by:

$$\begin{aligned} U_{\chi\mathbf{h}}(2) + \sigma_{\boldsymbol{\chi} II}\epsilon_{\chi II} \quad &\geq \quad U_{\chi\mathbf{h}}(0) \\ \Leftrightarrow \quad &\epsilon_{\chi II} \leq \tilde{v}_u^{\chi\mathbf{h}} \equiv \frac{U_{\chi\mathbf{h}}(2) - U_{\chi\mathbf{h}}(0)}{\sigma_{\chi II}}. \end{aligned} \tag{14}$$

Thus, an unemployed with $(\chi, \mathbf{h})$ will purchase individual private health insurance with probability $\Phi\left(\tilde{v}_u^{\chi\mathbf{h}}\right)$.

To summarize, let $\tilde{x}_{\chi\mathbf{h}}^u$ denote the health insurance status of a worker who is unemployed at the beginning of the next period. The probability that $\tilde{x}_{\chi\mathbf{h}}^u$ takes value $x \in \{0, 2, 3, 4\}$ can be expressed as:

$$\Pr\left[\tilde{x}_{\chi\mathbf{h}}^u = x\right] = \begin{cases} \left[1 - f_{SP}(\chi)\right]\left[1 - f_M^u(\chi)\right]\left(1 - \Phi\left(\tilde{v}_u^{\chi\mathbf{h}}\right)\right) & \text{if } x = 0 \\ \left[1 - f_{SP}(\chi)\right]\left[1 - f_M^u(\chi)\right]\Phi\left(\tilde{v}_u^{\chi\mathbf{h}}\right) & \text{if } x = 2 \\ \left(1 - f_{SP}(\chi)\right) f_M^u(\chi) & \text{if } x = 3 \\ f_{SP}(\chi) & \text{if } x = 4. \end{cases} \tag{15}$$

Optimal Strategies for Currently-Employed Workers. From the value function for a type-χ employed worker with health status $\mathbf{h}$ with insurance status x who is currently working on a job $(w_{h_1^0}, E(x))$, as given by (11), we see that he/she needs to decide whether to transition from the current job to a new job $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ if he/she receives such an on-the-job offer, or quit into unemployment.

We first consider the *job-to-job transition* decision, which is captured by the comparison of $\tilde{V}_{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})$ and $\tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))$ in (11). The solution to this comparison is in the form of a reservation wage strategy. A type-χ worker with health status $\mathbf{h}$ currently employed on a job $\left(w_{h_1^0}, E(x)\right)$ will switch to a job $(\tilde{w}_{h_1}, \tilde{E})$ *only if* $\tilde{w}_{h_1} > \underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0}, E(x)\right)$ where $\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0}, E(x)\right)$ satisfies:

$$\tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x)) = \tilde{V}_{\chi\mathbf{h}}\left(\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0}, E(x)\right), \tilde{E}\right). \tag{16}$$

Equation (16) implies that

$$\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0}, E(x)\right) \begin{cases} = w_{h_1^0} & \text{if} \quad \tilde{E} = E(x) \\ > w_{h_1^0} & \text{if} \quad \tilde{E} = 0 \;\&\; E(x) = 1 \\ < w_{\tilde{h}_0} & \text{if} \quad \tilde{E} = 1 \;\&\; E(x) = 0. \end{cases}$$

The reason that the above characterization of the employed workers' job-to-job transition decision is "only if" instead of "if and only if" is that they may choose to *quit into unemployment*, which we now consider. For workers receiving the offer $(\tilde{w}_{h_1}, \tilde{E})$, they will choose *not* to quit into unemployment if and only if

$$\begin{aligned} &\max\left\{\tilde{V}_{\chi\mathbf{h}}\left(\tilde{w}_{h_1}, \tilde{E}\right), \tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))\right\} \geq \tilde{U}_{\chi\mathbf{h}} + \sigma_{\boldsymbol{\chi}w}\epsilon_w \\ \Leftrightarrow\quad & \epsilon_w \leq \tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x)) \equiv \frac{\max\left\{\tilde{V}_{\chi\mathbf{h}}\left(\tilde{w}_{h_1}, \tilde{E}\right), \tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))\right\} - \tilde{U}_{\chi\mathbf{h}}}{\sigma_{\chi w}}. \end{aligned} \tag{17}$$

For individuals who do not received on-the-job offers, the decision to quit into unemployment is characterized analogously. A type-χ worker with health status $\mathbf{h}$ currently employed on a job $\left(w_{h_1^0}, E(x)\right)$, in the absence of an on-the-job offer, will not quit into unemployment if

$$\begin{aligned} &\tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x)) \geq U_{\chi\mathbf{h}} + \sigma_{\boldsymbol{\chi}w}\epsilon_w \\ \Leftrightarrow\quad & \epsilon_w \leq \tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E(x)) \equiv \frac{\tilde{V}_{\chi\mathbf{h}}(w_{h_1^0}, E(x)) - U_{\chi\mathbf{h}}}{\sigma_{\boldsymbol{\chi}w}}. \end{aligned} \tag{18}$$

Clearly, $\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E(x))$ is equal to $\tilde{z}_{u}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})\Big|_{\tilde{w}_{h_1}=w_{h_1^0}, \tilde{E}=E(x)}$ where $\tilde{z}_{u}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})$ is as given by (13).

It is useful to note that in our model, a worker may quit from a job that he/she previously accepted for two reasons. First, quitting into unemployment could be due to a change in the worker's health status; for example, he/she may have accepted a job without health insurance previously when he/she was healthy, but now he/she may prefer to be in unemployment waiting for a job with health insurance if his/her health status changed to be unhealthy. Second, quitting into unemployment could also be induced by a labor supply preference shock.

Next, we characterize the decision to purchase private individual health insurance for an employed worker without ESHI, spousal health insurance or Medicaid, as described in (9). It is clear that the worker will purchase a private individual health insurance if and only if

$$\begin{aligned} V_{\chi\mathbf{h}}(w_{h_1}, 2) + \sigma_{\boldsymbol{\chi}II}\epsilon_{\chi II} \quad &\geq \quad V_{\chi\mathbf{h}}(w_{h_1}, 0) \\ &\Leftrightarrow\quad \epsilon_{\chi II} \leq \tilde{v}_{e}^{\chi\mathbf{h}}(w_{h_1}) \equiv \frac{V_{\chi\mathbf{h}}(w_{h_1}, 2) - V_{\chi\mathbf{h}}(w_{h_1}, 0)}{\sigma_{\chi II}} \end{aligned} \tag{19}$$

This implies that an employed worker with $(\chi, \mathbf{h})$ without access to ESHI, spousal insurance and Medicaid will purchase individual private health insurance probability $\Phi\left(\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})\right)$.

To summarize, let us use $\tilde{x}_{\chi\mathbf{h}}^e(w_{h_1^0}, E)$ to denote the health insurance status of a worker who is employed on a job with compensation package $\left(w_{h_1^0}, E\right)$ at the beginning of the next period. If $E = 1$, then his/her health insurance status next period stays will be $\tilde{x}_{\chi\mathbf{h}}^e(w_{h_1^0}, 1) = 1$ with probability 1; if $E = 0$, then the probability that $\tilde{x}_{\chi\mathbf{h}}^e(w_{h_1^0}, 0)$ takes value $x \in \{0, 1, 2, 3, 4\}$ can be expressed as:

$$\Pr\left[\tilde{x}_{\chi\mathbf{h}}^e(w_{h_1^0}, 0) = x\right] = \begin{cases} [1 - f_{SP}(\chi)]\left[1 - f_M^e(\chi, w_{h_1^0})\right]\left(1 - \Phi\left(\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1^0})\right)\right) & \text{if } x = 0 \\ [1 - f_{SP}(\chi)]\left[1 - f_M^e(\chi, w_{h_1^0})\right]\Phi\left(\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1^0})\right) & \text{if } x = 2 \\ (1 - f_{SP}(\chi))\, f_M^e(\chi, w_{h_1^0}) & \text{if } x = 3 \\ f_{SP}(\chi) & \text{if } x = 4 \end{cases}. \tag{20}$$

3.3.3 Steady State Condition

We now focus on the steady state of the dynamic equilibrium of the labor market described above. We first describe the steady state equilibrium objects that we need to characterize and then provide the steady state conditions.

In the steady state, we need to describe how workers with different demographic types χ and health status $\mathbf{h}$ are allocated in different employment status $\left(w_{h_1^0}, E\right)$ or in unemployment. Let $u_{\chi\mathbf{h}}(x)$ denote the measure of unemployed type-χ workers with health status $\mathbf{h} \in \mathcal{H}$ and health insurance status $x \in \{0, 2, 3, 4\}$; and let $e_{\chi\mathbf{h}}^x$ denote the measure of employed type-χ workers with health insurance status x and health status $\mathbf{h} \in \mathcal{H}$. Of course, for each χ, we have

$$\sum_{\mathbf{h}\in\mathcal{H}}\left(\sum_{x\in\{0,2,3,4\}} u_{\chi\mathbf{h}}(x) + \sum_{x=0}^{4} e_{\chi\mathbf{h}}^x\right) = M_\chi \tag{21}$$

Let $S_{\chi\mathbf{h}}^x(w)$ be the *fraction* of employed type-χ workers with health status $\mathbf{h}$ working on jobs with wage *no more than* w and with insurance status $x \in \{0, 1, 2, 3, 4\}$; and let $s_{\chi\mathbf{h}}^x(w)$ be the corresponding density of $S_{\chi\mathbf{h}}^x(w)$. Thus, $e_{\chi\mathbf{h}}^x s_{\chi\mathbf{h}}^x(w)$ is the density of type-χ employed workers with health status $\mathbf{h}$ whose compensation package is (w, E).

These objects would have to satisfy the steady state conditions for unemployment and for the allocations of workers across firms with different productivity. First, let us consider the steady state condition for unemployment. To do so, it is convenient to start with the characterization of the steady state unemployment of type-χ workers with health status $\mathbf{h}$, unconditional on health insurance status, that is,

$$\tilde{u}_{\chi\mathbf{h}} = \sum_{x\in\{0,2,3,4\}} u_{\chi\mathbf{h}}(x).$$

The inflow into $\tilde{u}_{\chi\mathbf{h}}$, denoted by $[\tilde{u}_{\chi\mathbf{h}}]^+$, is given by:

$$[\tilde{u}_{\chi\mathbf{h}}]^+ \equiv M_\chi \rho_\chi \mu_{\chi\mathbf{h}} \tag{22a}$$

$$+ (1-\rho_\chi) \sum_{\mathbf{h}'\in\mathcal{H}} \left\{ \sum_{x=0}^{4} e^x_{\chi\mathbf{h}'} \pi^x_{\chi\mathbf{h}\mathbf{h}'} \delta^{\chi\mathbf{h}'} \left[(1-\lambda_e^{\chi\mathbf{h}'}) + \lambda_e^{\chi\mathbf{h}'} \int \left[1 - \Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}) \right) \right] dF_{h_1}(\tilde{w}_{h_1}, \tilde{E}) \right] \right\} \tag{22b}$$

$$+(1-\rho_\chi) \sum_{\mathbf{h}'\neq\mathbf{h}} \left\{ \tilde{u}_{\chi\mathbf{h}'} \sum_{x\in\{0,2,3,4\}} \pi^x_{\chi\mathbf{h}\mathbf{h}'} \Pr\left[\tilde{x}^u_{\chi\mathbf{h}'} = x \right] \left[1 - \lambda_u^{\chi\mathbf{h}'} \int \Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}) \right) dF_{h_1}(\tilde{w}_{h_1}, \tilde{E}) \right] \right\} \tag{22c}$$

$$+(1-\rho_\chi) \sum_{x=0}^{4} \sum_{h_1^0\in\mathcal{H}_1} \sum_{\mathbf{h}'\in\mathcal{H}} e^x_{\chi\mathbf{h}'} \pi^x_{\chi\mathbf{h}\mathbf{h}'} (1-\delta^{\chi\mathbf{h}'}) \lambda_e^{\chi\mathbf{h}'} \int\int \left[1 - \Phi\left(\tilde{z}_{e1}^{\chi\mathbf{h}}\left(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x) \right) \right) \right] dF_{h_1}(\tilde{w}_{h_1}, \tilde{E}) dS^x_{\chi\mathbf{h}'}(w_{h_1^0}) \tag{22d}$$

$$+(1-\rho_\chi) \sum_{x=0}^{4} \sum_{h_1^0\in\mathcal{H}_1} \sum_{\mathbf{h}'\in\mathcal{H}} e^x_{\chi\mathbf{h}'} \pi^x_{\chi\mathbf{h}\mathbf{h}'} (1-\delta^{\chi\mathbf{h}'})(1-\lambda_e^{\chi\mathbf{h}'}) \int \left[1 - \Phi\left(\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E(x)) \right) \right] dS^x_{\chi\mathbf{h}'}(w_{h_1^0}). \tag{22e}$$

In the above expression, the term on line (22a) is the measure of new type-χ workers born into health status $\mathbf{h}$; the term on line (22b) is the measure of employed type-χ workers whose health status transitioned from $\mathbf{h}'$ to $\mathbf{h}$ this period, did not leave the labor market but had their jobs terminated exogenously, and did not subsequently find a job that was better than being unemployed (either because he/she did not receive an offer, or received an offer but it was not accepted). The term on line (22c) is the measure of type-χ unemployed workers whose health status was $\mathbf{h}'$ last period but transitioned to $\mathbf{h}$ this period and did not leave for employment. The terms on lines (22d) and (22e) are the measures of type-χ workers currently working on jobs with and without an on-the-job offer, respectively, quitting into unemployment. To understand these expressions, consider the term on line (22d). First, quitting into unemployment by workers with an on-the-job offer occur only to those who actually received an on-the-job offer, denoted by $\left(\tilde{w}_{h_1}, \tilde{E}\right)$, which occurs with probability $\lambda_e^{\chi\mathbf{h}'}$. Second, since the on-the-job offer $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ is drawn from $F_{\mathbf{h}}(\cdot,\cdot)$, and the worker will quit into unemployment when he/she has the option of both the current job $\left(w_{h_1^0}, E(x)\right)$ and the new offer $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ if and only if the labor supply preference shock ϵ_w exceeds $\tilde{z}_{e1}^{\chi\mathbf{h}}\left(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x)\right)$ as defined in (17). The term (22e) is similarly constructed.

The *outflow* from unemployment of type-χ workers with health status $\mathbf{h}$, denoted by $[\tilde{u}_{\chi\mathbf{h}}]^-$, is given by:

$$[\tilde{u}_{\chi\mathbf{h}}]^- \equiv \tilde{u}_{\chi\mathbf{h}} \sum_{x\in\{0,2,3,4\}} \Pr\left[\tilde{x}^u_{\chi\mathbf{h}} = x\right] \left\{ \begin{array}{c} \rho_\chi + (1-\rho_\chi)\sum_{\mathbf{h}'\neq\mathbf{h}} \pi^x_{\chi\mathbf{h}'\mathbf{h}} \\ +(1-\rho_\chi)\pi^x_{\chi\mathbf{h}\mathbf{h}} \lambda_u^{\chi\mathbf{h}} \int \Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})\right) dF_{h_1}(\tilde{w}_{h_1}, \tilde{E}) \end{array} \right\}. \tag{23}$$

It states that a ρ_χ fraction of the type χ unemployed with health status $\mathbf{h}$ will die and the remainder $\left(1-\rho_\chi\right)$ will either change to health status $\mathbf{h}' \neq \mathbf{h}$ (with probability $\pi^x_{\chi\mathbf{h}'\mathbf{h}}$), or if their health does not change (with probability $\pi^x_{\chi\mathbf{h}\mathbf{h}}$) they may become employed with probability $\lambda_u^{\chi\mathbf{h}} \int \Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E})\right) dF_{h_1}(\tilde{w}_{h_1}, \tilde{E})$. Then, in a steady-state we must have

$$[\tilde{u}_{\chi\mathbf{h}}]^+ = [\tilde{u}_{\chi\mathbf{h}}]^-, \text{ for } \chi \in \{1,\ldots,N\}, \mathbf{h} \in \mathcal{H}. \tag{24}$$

Then, one can characterize $u_{\chi\mathbf{h}}(x)$ simply by

$$u_{\chi\mathbf{h}}(x) = \tilde{u}_{\chi\mathbf{h}} \Pr\left[\tilde{x}^u_{\chi\mathbf{h}} = x\right] \tag{25}$$

where $\Pr\left[\tilde{x}^u_{\chi\mathbf{h}} = x\right]$ is given by (15).

Now we provide the steady state equation for employed workers. We first characterize the inflow and outflow of the employment density with the compensation package $(w_{h_1^0}, E)$, denoted by $\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)$ where $E \in \{0,1\}$ is ESHI offering. We will show later that we can easily derive $e_{\chi\mathbf{h}}\left(w_{h_1^0}, x\right)$ from $\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)$.

We first consider the case in which workers' current observable health status h_1 (of $\mathbf{h}$) is *the same as* that at the time of job entry, namely, $h_1 = h_1^0$. Denote the *inflow by* $\left[\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]^+$, and it is given by:

$$\left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^+ \equiv (1-\rho_\chi) \sum_{\mathbf{h}'\in\mathcal{H}} \sum_{x=0}^{4} u_{\chi\mathbf{h}'}(x)\pi^x_{\chi\mathbf{h}\mathbf{h}'}\lambda_u^{\chi\mathbf{h}'} f_{h_1}(w_{h_1^0}, E)\Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(w_{h_1^0}, E)\right) \tag{26a}$$

$$+(1-\rho_\chi)\left[\sum_{\mathbf{h}'\in\mathcal{H}}\sum_{x=0}^{4} e^x_{\chi\mathbf{h}'}\pi^x_{\chi\mathbf{h}\mathbf{h}'}\right]\delta^{\chi\mathbf{h}'}\lambda_e^{\chi\mathbf{h}'} f_{h_1}(w_{h_1^0}, E)\Phi\left(\tilde{z}_u^{\chi\mathbf{h}}(w_{h_1^0}, E)\right) \tag{26b}$$

$$+(1-\rho_\chi)\sum_{x=0}^{4}\sum_{h_1^{0''}\in\mathcal{H}_1}\sum_{\mathbf{h}'\in\mathcal{H}}\left[\begin{array}{c}(1-\delta^{\chi\mathbf{h}'})e^x_{\chi\mathbf{h}'}\pi^x_{\chi\mathbf{h}\mathbf{h}'}\lambda_e^{\chi\mathbf{h}'} f_{h_1}(w_{h_1^0}, E) \\ \times\int_{\tilde{w}_{h_1^{0''}}\le \underline{w}_{\chi\mathbf{h}}^{E(x)}\left(w_{h_1^0},\ E\right)}\Phi\left(\tilde{z}_{e1}^{\chi\mathbf{h}}\left(\tilde{w}_{h_1^{0''}}, E(x), w_{h_1^0}, E\right)\right)dS^x_{\chi\mathbf{h}'}(\tilde{w}_{h_1^{0''}})\end{array}\right] \tag{26c}$$

$$+(1-\rho_\chi)\sum_{x\in\{\tilde{x}:E(\tilde{x})=E\}}\sum_{\mathbf{h}'\neq\mathbf{h}}(1-\delta^{\chi\mathbf{h}'})e^x_{\chi\mathbf{h}'}\pi^x_{\chi\mathbf{h}\mathbf{h}'}s^x_{\chi\mathbf{h}'}\left(w_{h_1^0}\right)\Phi\left(\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E)\right)\left[1-\lambda_e^{\chi\mathbf{h}'}\left[1-\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]\right], \tag{26d}$$

where $\underline{w}_{\chi h}^E(\cdot,\cdot)$ in line (26c) is as defined by (16), and $\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E)$ in line (26d) denotes that probability that a received offer is less preferred than $(w_{h_1^0}, E)$ for a type-χ worker with health status $\mathbf{h}$, and it is defined as:

$$\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E) \equiv F_{h_1}(w_{h_1^0}, E) + F_{h_1}(\underline{w}_{\chi\mathbf{h}}^{1-E}(w_{h_1^0}, E), 1-E). \tag{27}$$

To understand expression $\left[\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]^+$, note that line (26a) presents the inflows from unemployed type-χ workers with health status $\mathbf{h}$ to the job $(w_{h_1^0}, E)$; line (26b) represents the inflow from those whose current matches were destroyed but transition to the job $(w_{h_1^0}, E)$ without experiencing an unemployment spell (recall our timing assumption 2(d) and 2(g) in Section 3.2); line (26c) represents the inflows from type-χ workers who were employed on jobs $\left(\tilde{w}_{h_1^{0''}}, E(x')\right)$ where $h_1^{0''}$ was the observable health at the time of entry into that job, but switched to the job $\left(w_{h_1^0}, E\right)$ as the health transitioned from $\mathbf{h}'$ to $\mathbf{h}$; and finally line (26d) is the inflow from workers who were employed on the same job but experienced a health transition from $\mathbf{h}'$ to $\mathbf{h}$ and yet did not transition to other better jobs, which occurs with probability $1-\lambda_e^{\chi\mathbf{h}}\left[1-\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]$, and did not quit into unemployment which occurs with probability $\Phi\left(\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E)\right)$.

Now denote the *outflow* of type-χ workers with health status $\mathbf{h}$ from jobs $\left(w_{h_1^0}, E\right)$ by $\left[\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]^-$, and it is given by:

$$\begin{aligned}&\left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^- \\ \equiv\ & \tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\sum_{x\in\{\tilde{x}:E(\tilde{x})=E\}}\Pr\left[\tilde{x}^e_{\chi\mathbf{h}}(w_{h_1^0}, E)=x\right] \\ \times\ & \left\{\begin{array}{l}\left[\rho_\chi+(1-\rho_\chi)\pi^x_{\chi\mathbf{h}\mathbf{h}}\delta^{\chi\mathbf{h}}\right]+(1-\rho_\chi)\sum_{\mathbf{h}'\neq\mathbf{h}}\pi^x_{\chi\mathbf{h}'\mathbf{h}} \\ +\left(1-\rho_\chi\right)\pi^x_{\chi\mathbf{h}\mathbf{h}}\lambda_e^{\chi\mathbf{h}}(1-\delta^{\chi\mathbf{h}})\left[1-\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))\right] \\ +\left(1-\rho_\chi\right)\pi^x_{\chi\mathbf{h}\mathbf{h}}(1-\delta^{\chi\mathbf{h}})\left[\lambda_e^{\chi\mathbf{h}}\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))+\left(1-\lambda_e^{\chi\mathbf{h}}\right)\right]\left[1-\Phi\left(\tilde{z}_u^{\chi\mathbf{h}}\left(w_{h_1^0}, E(x)\right)\right)\right]\end{array}\right\}.\end{aligned} \tag{28}$$

The outflow consists of (1) job losses due to death and exogenous job termination, as represented by the term $\rho_\chi+(1-\rho_\chi)\pi^x_{\chi\mathbf{h}\mathbf{h}}\delta^{\chi\mathbf{h}}$; (2) changes in current workers' health status as represented by the term $(1-\rho_\chi)\sum_{\mathbf{h}'\neq\mathbf{h}}\pi^x_{\chi\mathbf{h}'\mathbf{h}}$; (3) transitions to other jobs, as represented by the term $\left(1-\rho_\chi\right)\pi^x_{\chi\mathbf{h}\mathbf{h}}\lambda_e^{\chi\mathbf{h}}(1-\delta^{\chi\mathbf{h}})\left[1-\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E(x))\right]$; and (4) quitting into unemployment (the last term in the curly bracket).

Next we provide the steady state equations for employed workers whose current observable health status h_1 is *not the same* as that at the time of job entry, namely, $h_1 \neq h_1^0$. In this case, the inflow can only come from the workers who is previously employed at a job with compensation package $\left(w_{h_1^0}, E\right)$ whose health status transitioned from $\mathbf{h}'(\neq\mathbf{h})$ to $\mathbf{h}$ and is at the same time not lured away to another job or quit into unemployment; thus the inflow of $\left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^+$ is given by:

$$\left[\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right]^+ \equiv (1-\rho_\chi)\sum_{\mathbf{h}'\neq\mathbf{h}}\sum_{x\in\{\tilde{x}:E(\tilde{x})=E\}}\left\{\begin{array}{c}\pi^x_{\chi\mathbf{h}\mathbf{h}'}\tilde{e}'_{\chi\mathbf{h}'}(w_{h_1^0}, E)\Pr\left[\tilde{x}^e_{\chi\mathbf{h}'}(w_{h_1^0}, E)=x\right] \\ \times\left[1-\lambda_e^{\chi\mathbf{h}'}\left(1-\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E)\right)\right]\left(1-\delta^{\chi\mathbf{h}'}\right)\Phi\left(\tilde{z}^{\chi\mathbf{h}}_{e2}(w_{h_1^0}, E)\right)\end{array}\right\} \tag{29a}$$

where $\tilde{F}_{\chi\mathbf{h}}(w_{h_1^0}, E)$ is defined as in (27). The outflow equation, $\left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^-$, however, is identical when $h_1 \neq h_1^0$ as when $h_1 = h_1^0$, thus is still represented by (28).

The steady state condition requires that, for all $\left(w_{h_1^0}, E\right)$ in the support of $F_{h_1}(\cdot,\cdot)$, and for all χ and $\mathbf{h}\in\mathcal{H}$, we have:

$$\left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^+ = \left[\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)\right]^-. \tag{30}$$

From the steady state values of $\tilde{e}_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right)$, we can recover the steady state values of $e_{\chi\mathbf{h}}\left(w_{h_1^0}, x\right)$ using the following relationship:

$$e_{\chi\mathbf{h}}\left(w_{h_1^0}, x\right) = \Pr\left[\tilde{x}^e_{\chi\mathbf{h}}(w_{h_1^0}, E)=x\right]\tilde{e}_{\chi\mathbf{h}}(w_{h_1^0}, E), \tag{31}$$

where $\Pr\left[\tilde{x}^e_{\chi\mathbf{h}}(w_{h_1^0}, E)=x\right]$ is defined in (20) and the text surrounding it.

From the employment densities, $\left\langle e^x_{\chi\mathbf{h}}s^x_{\chi\mathbf{h}}(w_{h_1^0})\right\rangle$, we can define a few important terms related to *firm size*. First, given $\left\langle e^x_{\chi\mathbf{h}}s^x_{\chi\mathbf{h}}(w_{h_1^0})\right\rangle$, the number of type-$\chi$ employees with health status $\mathbf{h}$ who joined the firm with a compensation package $\left(w_{h_1^0}, E\right)$ is simply given by

$$n_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right) = \frac{\sum_{x\in\{\tilde{x}:E(\tilde{x})=E\}} e^x_{\chi\mathbf{h}}s^x_{\chi\mathbf{h}}(w_{h_1^0})}{f_{h_1}(w_{h_1^0}, E)}, \tag{32}$$

where the numerator is the total density of workers with health status $\mathbf{h}$ on the job $\left(w_{h_1^0}, E\right)$ and the denominator is the total density of firms offering compensation package $(w_{h_1^0}, E)$.

Thus, if a firm offers a compensation package $(\mathbf{w}_{h_1^0}, E) \equiv (w_{H_1}, w_{U_1}, E)$, its total size in the steady state will be given by:

$$n(\mathbf{w}_{h_1^0}, E) = \sum_\chi\sum_{h_1^0\in\mathcal{H}_1}\sum_{\mathbf{h}\in\mathcal{H}} n_{\chi\mathbf{h}}\left(w_{h_1^0}, E\right) = \sum_\chi\sum_{h_1^0\in\mathcal{H}_1}\sum_{\mathbf{h}\in\mathcal{H}}\frac{\sum_{x\in\{\tilde{x}:E(\tilde{x})=E\}} e^x_{\chi\mathbf{h}}s^x_{\chi\mathbf{h}}(w_{h_1^0})}{f_{h_1}(w_{h_1^0}, E)}. \tag{33}$$

Expressions (32) and (33) allow us to connect the firm sizes in steady state as a function of the entire distribution of employed workers $\left\langle e_{\chi\mathbf{h}}\left(w_{h_1^0}, x\right) : \chi\in\{1,2,\ldots,N\}, h_1^0\in\mathcal{H}_1, \mathbf{h}\in\mathcal{H}, x\in\{0,1,\ldots,4\}\right\rangle$. Notice that the preference shocks $\epsilon_{\chi w}$ in workers' labor supply decisions we introduced in our model smooth the labor supply functions $n(\cdot, E)$ as a function of wages $\mathbf{w}_{h_1^0}$.

3.3.4 Firm's Optimization Problem

A firm with a given productivity p decides what compensation package $(\mathbf{w}^E_{h_1}, E) \equiv \left(w^E_{H_1}, w^E_{U_1}, E\right)$ to offer, taken as given the *aggregate* distribution of compensation packages $\mathbf{F}_{h_1}(w_{h_1}, E) \equiv (F_{H_1}(w_{H_1}, E), F_{U_1}(w_{U_1}, E))$. As we discussed in Section 3, we assume that, before the firms make this decision, they each receive an i.i.d draw of a *fixed* administrative cost $\tilde{C} = C + \sigma_f\epsilon_f$ where $C > 0$ and ϵ_f has a Type-I Extreme Value distribution with zero mean and σ_f is a scale parameter.[39] We assume that the $\sigma_f\epsilon$ shock a firm receives is permanent and it is separable from firm profits.[40]

Given the realization of $\tilde{C}$, each firm chooses $(\mathbf{w}_{h_1^0}, E)$ to maximize the steady-state flow profit *inclusive* of the administrative costs. It is useful to think of the firm's problem as a two-stage problem. First, it decides on the wage

[39] Alternatively, we can interpret C as a fixed administrative cost and $\sigma_f\epsilon_f$ as an employer's idiosyncratic preference for offering health insurance.

[40] These shocks allow us to smooth the insurance provision decision of the firms.

that maximizes the deterministic part of the profits for a given insurance choice; and second, it maximizes over the insurance choices by comparing the shock-inclusive profits with or without offering health insurance. Specifically, the firm's problem is as follows:

$$\max\{\Pi_0(p), \Pi_1(p) - \sigma_f \epsilon_f\}, \tag{34}$$

where $\Pi_0(p)$ and $\Pi_1(p)$ are the firm's expected steady state profit flow with $E = 0$ and $E = 1$ respectively, and they are given by:

$$\Pi_0(p) = \max_{\left\{w^0_{H_1}, w^0_{U_1}\right\}} \Pi\left(w^0_{H_1}, w^0_{U_1}, E = 0\right) \equiv \sum_{\chi} \sum_{h^0_1 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} \left[pd_{\chi\mathbf{h}} - (1 + \tau_p)\, w^0_{h^0_1}\right] n_{\chi\mathbf{h}}\left(w^0_{h^0_1}, 0\right); \tag{35}$$

$$\Pi_1(p) = \max_{\left\{w^1_{H_1}, w^1_{U_1}\right\}} \Pi\left(w^1_{H_1}, w^1_{U_1}, E = 1\right) \equiv \sum_{\chi} \sum_{h^0_1 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} \left[pd_{\chi\mathbf{h}} - (1 + \tau_p)\, w^1_{h^0_1} - m^1_{\chi\mathbf{h}}\right] n_{\chi\mathbf{h}}\left(w^1_{h^0_1}, 1\right) - C, \tag{36}$$

where τ_p is the payroll tax rate imposed on firms. To understand the expressions (35), note that $n_{\chi\mathbf{h}}\left(w^0_{h^0_1}, 0\right)$ is the measure of type-χ employees with health status $\mathbf{h}$ who joined the firm with initial compensation package $\left(w^0_{h^0_1}, E = 0\right)$ that the firm will have in the steady state, as described by (32). Thus, $\left[pd_{\chi\mathbf{h}} - (1 + \tau_p)\, w^0_{h^0_1}\right] n_{\chi\mathbf{h}}\left(w^0_{h^0_1}, 0\right)$ is the firm's steady-state after-tax flow profit from type-χ employees with health status $\mathbf{h}$ who joined the firm with initial compensation package $\left(w^0_{h^0_1}, E = 0\right)$. The expressions (36) can be similarly understood after recalling that $m^1_{\chi\mathbf{h}}$ is the expected medical expenditure of type-χ worker with health status $\mathbf{h}$ and health insurance as defined by (3) and (4). Note that in (36), the payroll tax is only assessed on wages, but not on the ESHI premium $m^1_{\chi\mathbf{h}}$, reflecting the tax exemption status of ESHI premium in the benchmark economy.[41, 42] For future reference, we will denote the solutions to problems (35) and (36) respectively as $\mathbf{w}^{*0}_{h^0_1}(p)$ and $\mathbf{w}^{*1}_{h^0_1}(p)$.[43] Note that in problems (35) and (36), the firms are restricted to offer compensation packages that do not depend on workers' family characteristics or the unobservable component of their health status, a restriction that we discussed and motivated in Section 3.

Due to the assumption that ϵ_f is drawn from i.i.d. Type-I Extreme Value distribution with zero mean, firms' optimization problem (34) thus implies that the probability that a firm with productivity p offers health insurance to its workers is

$$\Delta(p) = \frac{\exp(\frac{\Pi_1(p)}{\sigma_f})}{\exp(\frac{\Pi_1(p)}{\sigma_f}) + \exp(\frac{\Pi_0(p)}{\sigma_f})}, \tag{37}$$

where $\Pi_0(p)$ and $\Pi_1(p)$ are respectively defined in (35) and (36).

Equations (35), (36) and (37) clarifies the determinants of ESHI provisions in our model. Importantly, the cost of ESHI provision is endogenous, depending on the type of workers firms will be able to attract and retain. Moreover, the ESHI provision affects workers' composition by influencing their health status, which in turn affects the productivity of workers. We will further clarify these interactions in Section 4.

[41] In reality, there is a cap on the social security portion of the payroll tax. The linear specification ignores this, but we believe this simplification will have little impact to our results because our focus on relatively les-skilled workers in this paper.

[42] In Section 8.3.4, we will study the impact of removing the tax exemption status of ESHI premiums from the U.S. tax code.

[43] Note that Bontemps, Robin, and Van den Berg (1999, 2000) prove theoretically that firms use pure strategy wage offers in Burdett and Mortensen (1998) model with continuous firm heterogeneiy, in stead of the mixed strategy in their model with homogenous or discrete productivity type.

3.4 Steady State Equilibrium

A *steady state equilibrium* is a list of objects, for all χ and $\mathbf{h}\in\mathcal{H}$,

$$\left\langle \begin{array}{c}\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E}),\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(\tilde{w}_{h_1},E(x)\right),\tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E},w_{h_1^0},E(x)),\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0},E\left(x\right)),\tilde{v}_u^{\chi\mathbf{h}},\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})\right),\\ \left(u_{\chi\mathbf{h}}\left(x\right),e_{\chi\mathbf{h}}^x,S_{\chi\mathbf{h}}^x(w_{h_1})\right),\left(\mathbf{w}_{h_1^0}^{*0}\left(p\right),\mathbf{w}_{h_1^0}^{*1}\left(p\right),\Delta\left(p\right)\right),\mathbf{F}_{h_1}\left(w_{h_1},E\right)\end{array}\right\rangle,$$

such that the following conditions hold:

- **(Worker Optimization)** Given $\mathbf{F}_{h_1}\left(w_{h_1},E\right)$, for each χ and $\mathbf{h}\in\mathcal{H}$,
  - an unemployed type-χ worker with health status $\mathbf{h}$ will
    - accept a job offer (w_{h_1},E) if and only if $\epsilon_{\chi w}\leq\tilde{z}_u^{\chi\mathbf{h}}(w_{h_1^0},E)$, as described by (13);
    - purchase individual health insurance if and only if $\epsilon_{\chi II}\leq\tilde{v}_u^{\chi\mathbf{h}}$, as described by (14), if he/she does not receive spousal health insurance and Medicaid.
  - if a type-χ worker with health status $\mathbf{h}$ who is currently employed at a job $\left(w_{h_1^0},E\right)$ receives an on-the-job offer $\left(\tilde{w}_{h_1},\tilde{E}\right)$, he/she will:
    - switch to job $\left(\tilde{w}_{h_1},\tilde{E}\right)$ if and only if $\tilde{w}_{h_1}>\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0},E(x)\right)$ and $\epsilon_{\chi w}\leq\tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E},w_{h_1^0},E(x))$, as described by (16) and (17);
    - quit into unemployment if $\epsilon_{\chi w}>\tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E},w_{h_1^0},E(x))$, as described by (17);
    - stay at the current job $\left(w_{h_1^0},E\right)$, otherwise.
  - if a type-χ worker with health status $\mathbf{h}$ who is currently employed at a job $\left(w_{h_1^0},E\right)$ does not receive an on-the-job offer, he/she will stay at the current job instead of quitting into unemployment if and only if $\epsilon_w\leq\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0},E\left(x\right))$, as described by (18).
  - A type-χ worker with health status $\mathbf{h}$ employed on a job $(w_{h_1},E=0)$ will purchase private individual health insurance if and only if $\epsilon_{\chi II}\leq\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})$, as described by (19), if he/she does not receive spousal health insurance and Medicaid.

- **(Steady State Worker Distribution)** Given $\mathbf{F}_{h_1}\left(w_{h_1},E\right)$ and workers' optimizing behavior described by $\left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E}),\underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(\tilde{w}_{h_1},E(x)\right),\tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1},\tilde{E},w_{h_1^0},E(x)),\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0},E\left(x\right)),\tilde{v}_u^{\chi\mathbf{h}},\tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})\right)$, $\left(u_{\chi\mathbf{h}}\left(x\right),e_{\chi\mathbf{h}}^x,S_{\chi\mathbf{h}}^x(w_{h_1})\right)$ satisfy the steady state conditions described by (21), (25), and (31);

- **(Firm Optimization)** Given $\mathbf{F}_{h_1}\left(w_{h_1},E\right)$ and the steady state employee sizes implied by $\left(u_{\chi\mathbf{h}}\left(x\right),e_{\chi\mathbf{h}}^x,S_{\chi\mathbf{h}}^x(w_{h_1})\right)$, a firm with productivity p chooses to offer health insurance with probability $\Delta\left(p\right)$ where $\Delta\left(p\right)$ is given by (37). Moreover, conditional on insurance choice E, the firm offers a wage $\mathbf{w}_{h_1^0}^{*E}\left(p\right)$ that solves (35) and (36) respectively for $E\in\{0,1\}$.

- **(Equilibrium Consistency)** The postulated distributions of offered compensation packages are consistent with the firms' optimizing behavior $\left(\mathbf{w}_{h_1}^{*E}\left(p\right),\Delta\left(p\right)\right)$. Specifically, $\mathbf{F}_{h_1}\left(w_{h_1},E\right)$ must satisfy, for each $h_1\in\{H_1,U_1\}$,

$$F_{h_1}\left(w_{h_1},1\right)=\int_0^\infty\mathbf{1}(w_{h_1}^{*1}\left(p\right)<w)\Delta(p)d\Gamma(p),\tag{38}$$

$$F_{h_1}\left(w_{h_1},0\right)=\int_0^\infty\mathbf{1}(w_{h_1}^{*0}\left(p\right)<w)\left[1-\Delta(p)\right]d\Gamma(p).\tag{39}$$

To discuss the existence and the uniqueness of equilibrium, first we refer to Bontemps, Robin, and Van den Berg (1999, 2000), which is an extension of Burdett and Mortensen (1998) with continuous firm productivity and continuous worker heterogeneity. They show equilibrium existence under some parametric assumptions; they moreover show that, as long as worker's reservation wage is uniquely determined, equilibrium wage offer distribution is uniquely determined. Our model has two additional complexities relative to theirs. First, because of the introduction of multi-dimensional compensation package and the heterogenous worker preference on the contract, we cannot analytically characterize the steady state worker distribution. Second, allowing health insurance effect on health can be thought as a form of general human capital training, and provisions of ESHI by one firm may lower the cost of providing ESHI by other firms. This externality effect can be a potential source of equilibrium multiplicity. However, as we show below, most of the workers in our sample are healthy; as a result, the impact of this externality will be limited. Because of these complexities, we need to rely on numerical approaches to discuss the existence and the uniqueness. Throughout extensive numerical simulations, we always find a unique equilibrium for our baseline empirical model using our solution algorithm.

3.5 Empirical Specifications

So far, we described our model in as much generality as possible. The empirical model we implement requires some additional parametric assumptions.

First, in the empirical model, the demographic vector χ we consider is based on gender (Male vs. Female), marital status (Married vs. Single), and children status (Has Children vs. No Children); specifically, the demographic vector χ belongs to one of the following seven types: (i) single men; (ii) married men without children; (iii) married men with children; (iv) single women without children; (v) single women with children; (vi) married women without children; (vii) married women with children.[44]

Second, we will proxy the observable component of the health status by the individual's self-reported health status. We interpret the unobserved health component as a persistent characteristic that affects medical expenditures. We provide the details of how we estimate the unobserved health component h_2 in Section 6. Moreover, in the empirical model, we restrict the health insurance to affect only the transition of the observed health component h_1, with the transition described by (5), and that the unobserved component of health is time invariant.

Remark 2. *To estimate the health transition, we assume that the observed health component follows the equation (51) while the unobserved health component is the time invariant. As we will discuss in Section 7.1, the health economics literature tends to find that the health insurance status affects the dynamics of self-reported health status, which is the measure underlying our observed health component. They also report that the impact of health insurance on certain health measures (e.g., blood pressure and cholesterol) are not statistically significant. Based on these findings in the literature, we take a conservative approach that only observed health component is affected by the health insurance status. In addition, it is important to note that one can relax the assumption that the unobserved health component is time invariant as long as we have a long panel data. We believe that this assumption is less crucial given that the literature estimating the unobserved medical expenditure shocks tends to find that it is very persistent.*[45]

[44] We do not condition on the presence of children for single men mainly because the sample size of single men with children is very small.

[45] See French and Jones (2011); French, Jones, and von Gaudecker (2017) and references there in.

Third, in our general model (see (2)), the insurance status x can take values from $\{0,1,2,3,4\}$ where 0 indicates no insurance, and the other values indicate different sources of insurance. We will define the insurance indicator $\hat{x}$ as:

$$\hat{x}(x) = \begin{cases} 0 & \text{if} \quad x = 0 \\ 1 & \text{if} \quad x \in \{1,2,3,4\} \end{cases} \tag{40}$$

where $\hat{x} = 0$ indicates "uninsured" and $\hat{x} = 1$ indicates "insured." In the empirical specification, we assume that medical expenditure distributions and the health improvement effect depend on x only through $\hat{x}$. Moreover, we parametrize the medical expenditure process specified by (3) and (4) as:

$$\Pr\left[m > 0 | (\chi, \mathbf{h}, \hat{x})\right] = \frac{\exp\left(\sum_{\tilde{h}_1 \in \{H_1, U_1\}, \tilde{x} \in \{0,1\}} \alpha_{m\chi}^{\tilde{h}_1, \tilde{x}} 1\left\{h_1 = \tilde{h}_1, \hat{x} = \tilde{x}\right\} + \zeta_{1m\chi} 1\{h_2 = U_2\}\right)}{1 + \exp\left(\sum_{\tilde{h}_1 \in \{H_1, U_1\}, \tilde{x} \in \{0,1\}} \alpha_{m\chi}^{\tilde{h}, \tilde{x}} 1\left\{h_1 = \tilde{h}_1, \hat{x} = \tilde{x}\right\} + \zeta_{1m\chi} 1\{h_2 = U_2\}\right)}; \tag{41}$$

And conditional on a positive medical shock, we assume that the realization of his/her medical expenditure is drawn from a log-normal distribution specified as follows:

$$m | (\chi, \mathbf{h}, \hat{x}) \sim \exp\left(\sum_{\tilde{h}_1 \in \{H_1, U_1\}, \tilde{x} \in \{0,1\}} \beta_{m\chi}^{\tilde{h}_1, \tilde{x}} 1\left\{h_1 = \tilde{h}_1, \hat{x} = \tilde{x}\right\} + \zeta_{2m\chi} 1\{h_2 = U_2\} + \epsilon_{\chi h_1}^{\hat{x}}\right) \tag{42}$$

where $\epsilon_{\chi h_1}^{\hat{x}} \sim N(0, \sigma_{\chi h_1}^{\hat{x}2})$. We report our estimates of the medical expenditure process for adults in Table 6. We also treat the medical expenditure process for the adult and the child separately. We assume that the medical expenditure process of the child just depends on insurance status.[46]

Due to data limitations, we also assume that the health insurance effect on health, $\pi_{\chi \mathbf{hh}'}^{x}$, is identical for any insured status (i.e., $x = 1,2,3,4$), i.e., it only depends on $\hat{x}(x)$; moreover, it depends on demographic type χ only via gender. We henceforth denote it by $\pi_{\chi \mathbf{hh}'}^{\hat{x}}$ for $\hat{x} \in \{0,1\}$.

Remark 3. *Note that these specifications assume that the source of insurance coverage does not affect medical expenditure distribution or the health insurance transition. These assumptions are necessitated by the sample size limitations. Some sources of coverage, particularly, individual private insurance, have a very small sample size. In principle with larger samples one can relax this assumption and estimate the processes separately by insurance status.*

Fourth, in the general model we describe above, we allowed several structural parameters, such as the offer arrival rates $\lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}$ and job destruction rates $\delta^{\chi\mathbf{h}}$, to be $(\chi, \mathbf{h})$ specific; in the empirical model we impose the following parsimonious specifications on these parameters:

$$\lambda_u^{\chi\mathbf{h}} = \frac{\exp\left[\lambda_{u0} + \lambda_{u1} 1(h_1 = U_1) + \lambda_{u2} 1(\text{Female}) + \lambda_{u3} 1(\text{HasChildren}) + \lambda_{u4} 1(\text{Married})\right]}{1 + \exp\left[\lambda_{u0} + \lambda_{u1} 1(h_1 = U_1) + \lambda_{u2} 1(\text{Female}) + \lambda_{u3} 1(\text{HasChildren}) + \lambda_{u4} 1(\text{Married})\right]}, \tag{43}$$

$$\lambda_e^{\chi\mathbf{h}} = \frac{\exp\left[\lambda_{e0} + \lambda_{e1} 1(h_1 = U_1) + \lambda_{e2} 1(\text{Female}) + \lambda_{e3} 1(\text{HasChildren}) + \lambda_{e4} 1(\text{Married})\right]}{1 + \exp\left[\lambda_{e0} + \lambda_{e1} 1(h_1 = U_1) + \lambda_{e2} 1(\text{Female}) + \lambda_{e3} 1(\text{HasChildren}) + \lambda_{e4} 1(\text{Married})\right]}, \tag{44}$$

$$\delta^{\chi\mathbf{h}} = \frac{\exp\left[\delta_0 + \delta_1 1(h_1 = U_1) + \delta_2 1(\text{Female}) + \delta_3 1(\text{HasChildren}) + \delta_4 1(\text{Married})\right]}{1 + \exp\left[\delta_0 + \delta_1 1(h_1 = U_1) + \delta_2 1(\text{Female}) + \delta_3 1(\text{HasChildren}) + \delta_4 1(\text{Married})\right]}. \tag{45}$$

The above specifications allow the possibility that the observed health component impacts the labor market frictions, possibly capturing the idea that the unhealthy individuals can spend less time looking for jobs or exert less efforts to retain the current jobs.

[46]We assume that the total medical expenditure of individual with child is the sum of the adult's own medical expenditure and the children's medical expenditure. If individuals are married, we assume that they need to pay just a half of medical expenditure (and the health insurance premium) of their children.

Fifth, we similarly assume that the productivity effect of health is channeled through observed health component and constant for all demographic types χ; that is, we specify that

$$d_{\chi\mathbf{h}} = \begin{cases} d_{U_1} \text{ if } h_1 = U_1 \\ 1 \text{ if } h_1 = H_1. \end{cases} \tag{46}$$

Specifications (43), (44), (45) and (46) assume that the unobserved health component does not directly affect the worker's labor market parameters, even though it affects their medical expenditures. One reason for these restrictions is the difficulty of identifying these parameters if they are unrestricted. In addition, we also believe that these restrictions are plausible, at least in our context, given the recent finding by Blundell, Britton, Dias, and French (2017) that self-reported health status is the single most important indicator of individual health status to predict his/her labor market outcomes (e.g., employment).

Sixth, in our empirical model we allow that the "unemployment benefits" $\mathfrak{b}_\chi$ to freely vary by demographic type χ. However, we assume that risk aversion γ_χ vary only by gender. Also, for simplicity we assume that $(\sigma_{\chi w}, \sigma_{\chi II}, \underline{c}_\chi)$ do not vary by demographic type χ. We also model, if a worker does not have access to his/her own or spousal ESHI, the probabilities of Medicaid eligibility $f_M^e(\chi, y)$ for employed workers and $f_M^u(\chi)$ for unemployed workers, take the following forms respectively:

$$f_M^e(\chi, y) = \frac{\exp\left[\alpha_{m0}^e 1(\text{HasChildren}) + \alpha_{m1}^e 1(\text{NoChildren}) + \alpha_{m2}^e y + \alpha_{m3}^e y^2\right]}{1 + \exp\left[\alpha_{m0}^e 1(\text{HasChildren}) + \alpha_{m1}^e 1(\text{NoChildren}) + \alpha_{m2}^e y + \alpha_{m3}^e y^2\right]}, \tag{47}$$

$$f_M^u(\chi) = \frac{\exp\left[\alpha_{m0}^u 1(\text{HasChildren}) + \alpha_{m1}^u 1(\text{NoChildren})\right]}{1 + \exp\left[\alpha_{m0}^u 1(\text{HasChildren}) + \alpha_{m1}^u 1(\text{NoChildren})\right]}. \tag{48}$$

Finally, we specify that in the pre-ACA benchmark the individual private insurance premium is perfectly risk-rated by individuals demographic χ and health type $\mathbf{h}$, and it is determined by

$$R^{II}(\mathbf{h}, \chi) = (1 + \xi_{II}) m_{\chi\mathbf{h}}^2, \tag{49}$$

where $\xi_{II} > 0$ is the loading factor in the pre-ACA individual private insurance market.

4 Qualitative Assessment of the Model

We present numerical simulation results using parameter estimates that we will report in Section 7 to illustrate how our model can generate the positive correlations among wage, health insurance and firm size we discussed in the introduction.

4.1 Numerical Simulations

In Column (1) of Table 1, labeled "Benchmark", we report the main implications obtained from our benchmark model using parameter estimates that we report in Section 7. It shows that our baseline model is able to replicate the positive correlations among health insurance coverage rate, average wage, and employer size. It shows that 48.0% of the firms with fewer than 50 workers will offer ESHI, which is lower than the 93.5% ESHI offering rate for firms with 50 or more workers; and the average four-month wages for workers with own ESHI is \$10,700 in contrast to \$7,980 for workers without their own ESHI. Moreover, it also generates the empirically consistent prediction that the average observed health status of the employees with ESHI is relatively better than that of the uninsured: the fraction that are observably unhealthy is 5.5% and 5.8%, respectively, for those with ESHI and those who are uninsured.[47]

[47] Note that individuals with unhealthy observed health component among the employed without ESHI tend to obtain other insurances. This selection improves the observed health composition of the uninsured.

[Insert Table 1 About Here]

In Table 2, we use the estimates from Section 7 to shed light on the detailed mechanisms for why in our model more productive firms have stronger incentives to offer health insurance than less productive firms. For this purpose, we simulate the health composition of the workforce for the firms with the bottom 20% and the top 20% of productivity in our discretized (with 150 grid points) productivity distribution. Panel A (i.e., Row 1) of Table 2 shows that, *in the steady state*, the fraction of unhealthy workers based on the observed health in low and high productivity firms that offer ESHI are respectively 5.58% and 5.11%; in contrast, the fraction of unhealthy workers in low and high productivity firms that do not offer ESHI are respectively 7.03% and 5.70%.[48] Thus, high productivity firms tend to have more observably healthy workers, regardless of whether or not they provide health insurance. This arises in our model partly because observably healthy workers, both employed and unemployed, receive offers at a higher probability than unhealthy workers, thus they are more likely to climb up to the job ladder toward high productivity firms. In contrast, we observe a substantial degree of adverse selection on the unobserved component of the health: for any level of firm productivity, the fraction of workers who are unhealthy in unobservable health component is higher if a firm offers ESHI than if it does not, though the difference is much more modest for high productivity firms. This result occurs because in our model we do not allow firms to post wage offers conditional on their unobservable health component and that the unobservable health component is a permanent health type. In Panels B-D, we disentangle the advantage of high-productivity firms relative to low-productivity firms in offering health insurance into three components: (1). the *adverse selection* effect among new hires; (2). the *health improvement effect* of health insurance; (3). the *retention* effect.

In Panel B (i.e., Row 2), we illustrate that the adverse selection from offering health insurance in terms of the fraction of unhealthy on unobserved health component among the new hires is less severe for high-productivity firms than for low-productivity firms. Specifically, we show that, in the low-productivity firms, the fraction of unobservably unhealthy among the new hires – including those hired directly from the unemployment pool and those poached from other firms (i.e., job-to-job switchers) – is 45.30% if they offer health insurance and 42.40% if they do not; in contrast, in the high-productivity firms the fraction of unhealthy is 39.53% if they offer health insurance, which is virtually identical to the case if they do not offer health insurance (40.32%).[49] Thus, the new hires attracted to low-productivity firms that offer health insurance are indeed somewhat unhealthier, which is manifestation of adverse selection; but importantly, the new hires to high-productivity firms are significantly healthier than those to the low-productivity firms. This reflects the following facts: high-productivity firms offering health insurance can at the same time offer higher wages; in contrast, low-productivity firms can only offer low wages if they were to offer health insurance. As a result, high productivity firms can poach a larger fraction of healthy workers from a much wider range of firms. Note that in this model the initial selection based on observed health component is not a crucial source of adverse selection because firms are allowed to condition their wage offers on workers' observed health component.

[Insert Table 2 About Here]

In Panel C, we show that the adverse selection effect that a firm offering health insurance suffers in terms of the unobserved health component of their new hires can be mitigated by the positive effect of

[48] The same patterns hold conditional on the demographic type χ. They are available upon request from the authors.

[49] Using estimates in Panel C of Table 6, we can calculate the fraction with unhealthy unobserved component in the population to be about 48.46%, which is much higher than the fraction with unhealthy observed component in the population, which is 7.7% (see Panel B of Table 3).

health insurance on the improvement of observed health component. In Row 3, we show that, if those new hires stay at the same firms for nine-periods (3 years), those hired at firms offering ESHI would be significantly healthier than those in firms not offering ESHI. Then, in Panel D we show that the positive effect of health insurance on health, which leads to increased productivity of the workers, is better captured by high productivity firms.[50] It shows that the job-to-job transition rate for workers in high-productivity firms, regardless of their health status, is significantly lower than that in low-productivity firms. Thus in our model, high-productivity firms enjoy several advantages in offering health insurance to their workers relative to low-productivity firms: first, they face less severe adverse selection problem among the new hires; second, they are more likely to retain their workers as their observable health component is improved by insurance, which allows them to capture the increased productivity from the health improvement effect of health insurance as well as the reduction in the expected health care cost.

4.2 Comparative Statics

In Columns (2)-(5) of Table 1 we also present some comparative statics result to shed light on the effects of different parameters on the equilibrium features of our model. These also provide some insights on how different parameters may be identified in our empirical estimation.

Fixed Administrative Cost of Offering Health Insurance. In Column (2) of Table 1, we investigate the effect of the fixed administrative cost C on health insurance offering rate, by setting it to 0 as supposed to the estimated value of $C = 0.275$ (i.e., \$2,750 per 4 months) as reported in Table 8. Comparing the results in Column (2) with the benchmark results in Column (1), we find that lowering the fixed administrative cost of offering health insurance affects mainly the coverage rate for small firms; and its effect on the insurance offering rate of large firms is much smaller. Moreover, it does not affect much of the other outcomes. Although we still have a positive correlation between firm size and health insurance offering rate (due to other effects we illustrated in Table 2) when $C = 0$ instead of the estimated value, the ESHI offering rate for firms with fewer than 50 workers will increase from 48.0% to 51.6%.

Health Insurance Effect on Health. In Column (3), we shut down the effect of health insurance on the dynamics of the observed health status by assuming that health transition process for the insured, i.e. when $x \in \{1, 2, 3, 4\}$, is the same as that of the uninsured, $\widehat{\pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}} = \pi^0_{\chi\mathbf{h}'\mathbf{h}}$ for all $(\mathbf{h}, \mathbf{h}')$ and for all demographic type χ.[51] Column (3) of Table 1 shows that the fraction of large firms offering health insurance decrease significantly when $\widehat{\pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}}$ is set to be equal to $\pi^0_{\chi\mathbf{h}'\mathbf{h}}$: the fraction of firms with 50 or more workers that offer health insurance decreases from 93.5% in the benchmark to 61.9% when $\widehat{\pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}} = \pi^0_{\chi\mathbf{h}'\mathbf{h}}$. Moreover, this change significantly reduces the positive correlation between wage and health insurance. Therefore, the health insurance effect on health substantially affects the relationship among insurance offering rates, wages, and employer size in our model. Absent the health improvement effect of health insurance, the overall uninsured rate in the economy also significantly increases to 31.5%, from 21.3% in the benchmark.

[50] Note that if the arrival rate of job offer for the employed for the healthy individuals are significantly higher than healthy individuals, then having more healthy individuals may lead to the higher turnover. However, this effect will work mainly for the low productivity firms, as workers in high productivity firms are less likley to find a better job.

[51] We also obtain similar qualitative result in the opposite scenario, where health transition of the uninsured is set to be equal to that estimated for the insured, i.e., $\widehat{\pi^0_{\chi\mathbf{h}'\mathbf{h}}} = \pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}$.

The reason why large firms are more likely not to offer health insurance when $\widehat{\pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}} = \pi^0_{\chi\mathbf{h}'\mathbf{h}}$ can be understood as follows. When $\widehat{\pi^{\hat{x}(x)}_{\chi\mathbf{h}'\mathbf{h}}} = \pi^0_{\chi\mathbf{h}'\mathbf{h}}$, i.e., when health insurance provision does not influence the dynamics of worker's observable health status (which affects worker productivity), the health composition of a firm's workforce is fully determined by health composition of the workers at the time they accept the offer. The high productivity firms no longer enjoys the extra benefit from the increase in worker productivity resulting from their advantage in retaining their workers (see Panel D of Table 2).

Risk Aversion. In Column (4) of Table 1 we simulate the effect on the equilibrium when we reduce the CARA coefficient from the estimated values of 3.71E-4 for male and 4.88E-4 for females in Table 8 to *half* of their respective estimated values. A 50 percent reduction in CARA coefficients lead to a significant reduction in the health insurance offering rate for both small and large firms, but particularly so for firms with more than 50 workers. The health insurance offering rate on average decreases from 52.5% in the benchmark to 40.9%; it decreases from 48.0% to 37.9% for firms with less than 50 workers, and it decreases from 93.5% to 62.6% for firms with 50 or more workers. Not surprisingly, the overall uninsured rate goes up substantially to 34.9%, in contrast to 21.3% in the benchmark. Interestingly, when workers have lower risk aversion, the average wages firms will pay in equilibrium increase substantially, and particularly so for firms that do not offer health insurance. The average four-month wage for workers with own ESHI increases by 2.5 percent from \$10,700 to \$10,970, while it increases by 20 percent from \$7,980 to \$9,580 for employed workers without own ESHI. The reason is that, when workers are less risk averse, it is less effective for firms to compete for workers by offering health insurance (which allows the firms to capture the risk premium), and as a result wages become the more important instrument for firms to attract workers.

Effects of Health on Productivity and Labor Market Frictions. In Column (5) of Table 1 we investigate the productivity effect of health by changing d_{U_1} from their estimated values reported in Table 8 to 1.00; This eliminates the negative productivity effect of bad health. In Column (6) we additionally set the labor market friction parameters $(\lambda_u^{\chi\mathbf{h}'}, \lambda_e^{\chi\mathbf{h}'}, \delta^{\chi\mathbf{h}'})$ for the workers with unhealthy observable component to be the same as those with healthy observable component. Columns (5) and (6) show that the absence of the negative productivity effect of bad health leads to a substantial reduction in the ESHI offering rates of large firms relative to that in the benchmark. The fraction of firms with 50 or more workers offering ESHI decreases from 93.5% in the benchmark to 63.6% when the effects of health on productivity and labor market frictions are removed. The reason is that, in the benchmark when bad health reduces productivity, the large firms, which tend to retain workers longer as shown in Panel D of Table 2, have stronger incentive than smaller firms to improve the health of their workforce in order to raise the expected flow profit.[52] We also find that an increase in d_{U_1} to 1 increases firms' wage offers in general due to the overall productivity improvement.

Eliminating Adverse Selection In Column (7) of Table 1, we investigate the impact of shutting down the adverse selection effect. In this column we report simulation results for an environment in which the unobservable health component of all workers is set to be healthy; i.e., there is no heterogeneity in the

[52]In addition, note that firms' productivity and the productivity effect of health are complementary in the production function. This gives high productivity firms additional incentives to offer ESHI to maintain their workers' health. This supermodularity feature of the production function *amplifies* the retention effect and health insurance effect of health discussed in the text.

unobserved health component. This essentially eliminates the adverse selection effect. We find that the eliminating adverse selection substantially increases the firm's provision of health insurance offering rate, particularly among small firms, from 48.0% in the benchmark to 54.3%. Thus, the adverse selection channel can be important to understand why small firms do not offer health insurance.

5 Data Sets

In this section, we describe our data sets and sample selection. In order to estimate the model, it is ideal to use employee-employer matched dataset which contains information about worker's labor market outcome and its dynamics, health, medical expenditure, and health insurance, and firm's insurance coverage rate and size. Unfortunately, such a data set does not exist in the U.S. Instead, we combine three separate data sets for our estimation: (1) Survey of Income and Program participation (2004 Panel); (2) Medical Expenditure Panel Survey (2001-2007); and (3) Kaiser Family Employer Health Insurance Benefit Survey (2004-2007).

5.1 Survey of Income and Program Participation

Our main dataset for individual labor market outcome, health, and health insurance is 2004 Panel of Survey of Income Program Participation (hereafter, SIPP 2004).[53] SIPP 2004 interviews individuals *every four months* up to twelve times, so that an individual may be interviewed over a four-year period. It consists of two parts: (1) core module, and (2) topical module. The core module, which is based on interviews in each wave, contains detailed *monthly* information regarding individuals' demographic characteristics and labor force activity, including earnings, number of weeks worked, average hours worked, employment status, as well as whether the individual changed jobs during each month of the survey period. In addition, information for health insurance status is recorded in each wave; it also specifies the source of insurance so we know whether it is an employment-based insurance, a private individual insurance, or Medicaid, and we also know whether it is obtained through the individual's own or the spouse's employer. The topical module contains *yearly* information about the worker and his/her family member's self reported health status and *out-of-pocket* medical expenditure at interview waves 3 and 6.[54]

Sample Selection Criterion. In order to have an estimation sample that is somewhat homogeneous in skills as we assume in our model, we restrict our sample to individuals whose ages are between 26-46. In addition, we only keep individuals who are not in school, not self-employed, do not work in the public sector, do not currently receive Social Security income, do not engage in the military, and have health insurance status that belongs to one of those categories defined in our model. We restrict our samples to individuals who are at most high school graduates. Finally we drop top and bottom 3% of salaried workers. Our final estimation sample that meets all of the above selection criterion consists of a total of 11,271 individuals.

[53] SIPP 2004 Panel is available at: `https://www.census.gov/programs-surveys/sipp/data/2004-panel.html`

[54] In both SIPP and MEPS, we use the self-reported health status to construct whether the individual is Healthy or Unhealthy based on the observed health. The self-reported health status has five categories. We categorize "Excellent", "Very Good", and "Good" as *Healthy,* and "Fair" and "Poor" as *Unhealthy.*

5.2 Medical Expenditure Panel Survey (MEPS)

The weakness of using SIPP data for our research is the lack of information for total medical expenditure. To obtain the information, we use Medical Expenditure Panel Survey (hereafter, MEPS). We use its Household Component (HC), which interviews individuals *every half year* up to five times, so that an individual may be interviewed over a two-and-a-half-year period.[55] Medical expenditure is recorded at annual frequency. Several health status related variables are recorded in each wave. Moreover, health insurance status is recorded at monthly level. We use the same sample selection criteria as SIPP 2004. As discussed later, we need to exploit the panel structure of the data to estimate the medical expenditure process. For this purpose, we use years of MEPS data between 2001 and 2007 to maintain enough samples. The sample size is 23,840.

5.3 Kaiser Family Employer Health Insurance Benefit Survey

In addition, we also need information for employer size and associated health insurance offering rate, which is not available from the worker-side data. The data source we use is 2004-2007 Kaiser Family Employer Health Insurance Benefit Survey (hereafter, Kaiser). It is a national survey of public and private firms, containing information about firm's characteristics such as industry, firm size, and employees' demographics, as well as information about health insurance offering, health insurance plans, employees' eligibility and enrollment in health plans, and the plan type. We restrict the sample to firms which belong to the private sector and have at least three employees. The final sample size is 18,782.

5.4 Summary Statistics

Table 3 reports the summary statistics of the key variables in the 2004 SIPP data. In Panel A, we report the distribution of health insurance status for the overall sample, and for subsamples defined by gender, marital status and whether the individual has children. In the overall sample, 24.7% of individuals are uninsured; roughly 65% have ESHI, either through own (51%) or through their spouses' (13.7%). The fraction of individuals with individual insurance is remarkably small: only 2% of individuals own individual coverage. This fact reflects that most individuals owning individual health insurance coverage under the pre-ACA economy are self-employed, who are excluded from our analysis. This pattern of insurance status distribution holds in the subsamples; the only exception is the singles subsample where the fraction of uninsured is much higher at 32.5%, mostly because they do not have the option of obtaining spousal ESHI. In Panel B, we report the fraction of individuals with healthy observed health component in each insurance status. It shows that the fraction of individuals with healthy observed health component among those with either own or spousal ESHI is higher than that among the uninsured or among those with Medicaid. In Panel C, we report the average four-month wage (in $10,000) of individuals in each health insurance status.[56] It shows, as we described in the introduction, that individuals who have ESHI tend to receive higher wages than those who are uninsured or are insured by Medicaid. The last row of Table 3 reports the employment rates. The employment rates are quite high: 94% for the overall sample, but there are small variations across the subsamples. These descriptive statistics suggest that there is a systematic pattern regarding health, health insurance status, and labor market status.

[Insert Table 3 About Here]

[55] MEPS HC is publicly available at http://www.meps.ahrq.gov.

[56] We normalize the wages and medical expenditures to 2007 dollars.

In Table 4, we report the comparison of summary statistics for the individuals in MEPS 2001-2007 and those in SIPP 2004. The fractions of workers with healthy observables are somewhat lower in MEPS than in SIPP. The fractions of uninsured are higher in MEPS than in SIPP. We also report the average medical expenditure by insurance status and observed health component in the MEPS data. It shows that the average medical expenditure is about $2,180 for the overall sample; but the average medical expenditure is much higher among those with insurance and with unhealthy observed health component at $7,080, and much lower among those without insurance and with healthy observed health component at $680. Our estimates of the medical expenditure process in Section 6.1 will confirm these differences.[57]

[Insert Table 4 About Here]

In Table 5, we provide the summary statistics for our firm-side data set, Kaiser 2004-2007. It shows that large firms are much more likely to offer ESHI than smaller firms. 56% of the firms with less than 50 workers offer health insurance, in contrast to 93% of the firms with 50 or more workers. Firms that offer ESHI average about 30 workers, while those that do not offer ESHI average about 8 workers. Although Kaiser does not provide the detailed wage information, they report the quantile of wages among employed workers. It is shown that firms offering health insurance consist of a larger portion of higher wage workers.[58] Therefore, although we restrict samples to relatively unskilled workers in SIPP, the compensation patterns seem to be quite consistent between the worker-side and firm-side data sets.

[Insert Table 5 About Here]

6 Estimation Strategy

In this section we present our strategy to structurally estimate our baseline model using the datasets we described above. We estimate parameters regarding health transitions and medical expenditure distribution without using the model. The remaining parameters are estimated via a generalized method of moments where moments come from different data sources. We construct worker-side moments such as the cross-sectional distribution of health insurance coverages and wages, as well as individuals' labor market transitions from the SIPP data; and we construct firm-side moments such as the firm size distribution and firms' ESHI offering rates conditional on their size from the Kaiser data. Loosely speaking, the parameters are chosen to best fit the data from *both* sides of labor markets. This is the main difference from the existing estimation procedure for related models used in Bontemps, Robin, and Van den Berg (1999, 2000) and Shephard (2017), where model parameters are chosen to fit worker-side data alone.[59] As a result, we

[57] We do not observe total medical expenditures in the SIPP data, thus preventing us from comparing the MEPS and SIPP sample on the statistics related to the medical expenditures.

[58] This pattern is also confirmed in other data sets, such as 1996 Robert Wood Johnson Employer Based Health Insurance Survey. See our previous working papers (Aizawa and Fang (2013, 2015)) which used this dataset.

[59] Consequently they can estimate productivity distribution nonparametrically so that the model's prediction of workers' wage distribution perfectly fits with the data. Specifically, in Bontemps, Robin, and Van den Berg (1999, 2000) and Shephard (2017), worker-side parameters are estimated from the likelihood function of individual labor market transitions. Then, firm productivity distribution is estimated to perfectly fit wage distribution observed from the worker side by utilizing the theoretical relationship between wage offer and firm productivity implied from the model. Note that one can still apply semiparametric multi-step estimation to fit both worker and employer side moments if one has access to employee-employer matched panel data. For example, Postel-Vinay and Robin (2002) and Cahuc, Postel-Vinay, and Robin (2006) nonparametrically estimate worker's sampling distribution of job offer from each firm to match observed wage distribution. Given the estimated sampling distribution, they then estimate productivity distribution of firms to perfectly fit the employer-size distribution.

assume a parametric specification of the productivity distribution and it is estimated, jointly with other parameters, to fit both the wage and firm size distributions. Specifically, as we mentioned in Section 3.1, we specify that the productivity distribution is given by a lognormal distribution with location and scale parameters μ_p and σ_p respectively.

In our empirical application, the model period is set to be four months, driven by the fact that we can only observe the transition of health insurance status at four-month intervals in the SIPP data. In this paper, we do not try to estimate β but set $\beta = 0.99$ so that annual interest rate is about 3%.[60] Moreover, we set the exogenous death rate ρ_χ to be 0.001 for any demographic type.[61] We also set the distribution of demographic type M_χ/M directly from the SIPP data.[62]

We assume that all new-born workers have the healthy observed health component.[63] However, we set the distribution of the new-born workers' unobserved health component to be equal to the steady state distribution of the unobserved health types, which we calculate based on the estimates of our first-step (see below for details) based on medical expenditure distributions. In the estimation, we also set the spousal insurance premium R^{SP} to be equal to the average medical expenditure of individuals who have spousal insurance in the data, and set the probability of being offered spousal insurance, $f_{SP}(\chi)$, to be the proportion of the married opposite gender who have ESHI in the data.[64] Finally, the after-tax income schedule (6) is estimated by using the same approach as Kaplan (2012), i.e., $\tau_0 = 565.584$, $\tau_1 = 2.863$ and $\tau_2 = -0.153$.[65] We also set that firm's payroll tax rate as $\tau_p = 0.0765$.

6.1 First Step

In Step 1 we estimate parameters determining individuals' medical expenditure distributions and health transitions. The parameters related to the health expenditure distributions include, for each $h_1 \in \{H_1, U_1\}, \hat{x} \in \{0,1\}, \chi$ (only by gender), of the parameters $\left(\alpha_{m\chi}^{h_1,\hat{x}}, \zeta_{1m\chi}\right)$ which characterize the probability of receiving a medical shock in (41), and the parameters $\left(\beta_{m\chi}^{h_1,\hat{x}}, \zeta_{2m\chi}, \sigma_{\chi\mathbf{h}}^{\hat{x}2}\right)$ for the log-normal distribution of medical expenditures as specified in (42). They are estimated by GMM using the MEPS data. We also estimate the health transitions $\pi_{\chi\mathbf{hh}'}^{\hat{x}}$ as in (5) without explicitly using the model.

Specifically, for each $h_1 \in \{H_1, U_1\}, \hat{x} \in \{0,1\}$ and χ, we construct five moments, namely, the mean and variance of the medical expenditures, the fraction of individuals with zero medical expenditure, the fraction of individuals with zero medical expenditures in both years, and the covariance of the medical expenditures over the two years. We include the latter two dynamic moments to identify the effect of the time invariant unobserved health status $h_2 \in \{H_2, U_2\}$ on medical expenditures.[66] We classify individuals into four categories based on observed health component, $h_1 \in \{H_1, U_1\}$, and observed insurance coverage

[60] It is known from Flinn and Heckman (1982) that it is difficult to separately identify the discount factor β from the flow unemployed income b in standard search models.

[61] This roughly matches the average 4-month death rate in the age range of 26-46, which is the sample of individuals we include in our estimation.

[62] The magnitude of M, the measure of workers relative to firms, will be estimated and it is reported in Table 8.

[63] In the previous versions of this paper, we estimated the model allowing that the proportion of new born healthy individuals may be less than 1. We always find that it is very close to 1, which leads us to choose this normalization.

[64] Although these number are fixed in the estimation, we allow them to be endogenously adjusted when we solve the new equilibrium in our *counterfactrual analyses* in Section 8.

[65] We estimate the after-tax income schedule parameters based on annual income, and then adjust the schedule appropriately to apply to four-month incomes in our model environemnt (see Online Appendix E for details).

[66] Note that we cannot directly implement the standard linear fixed effect panel regression because the unobserved type affects the overall medical expenditure nonlinearly: it affects the probability of positive expenditure and the realization of positive medical expenditure.

status $\hat{x} \in \{0,1\}$.[67, 68] Then, we fit the theoretical moments, which are derived from our model with periods consisting of *four-months*, with empirical moments at the *annual* level.[69] Importantly, equation (4) includes the unobserved health component $h_2 \in \{H_2, U_2\}$ that econometrician does not observe from the data. In estimating the medical expenditure process (4), we deal with the selection of the unobserved health component as follows. We let $\Pr(h_2 = U_2 | \langle h_{1t}, \hat{x}_t \rangle_{t=1,2}, \chi)$ depend on the individual's observed characteristics $\left\{ \langle h_{1t}, \hat{x}_t \rangle_{t=1,2}, \chi \right\}$ such that it varies by both first- and second-year insurance and health status in the panel as well as the observed demographic types. In particular, we specify that the the probability of $h_2 = U_2$ takes the following Logit form, by demographic type χ (which we only include gender due to data limitations):

$$\begin{aligned} \Pr(h_2 &= U_2 | \{h_{1t}, \hat{x}_t\}_{t=1}^2, \chi) \\ &= \frac{\exp\left(\alpha_{s0\chi} + \alpha_{s1\chi} \sum_t 1\left(h_{1t} = H_1\right) + \alpha_{s2\chi} \sum_t 1\left(\hat{x}_t = 1\right) + \alpha_{s3\chi} \sum_t 1\left(\hat{x}_t = 1 \wedge h_{1t} = H_1\right)\right)}{1 + \exp\left(\alpha_{s0\chi} + \alpha_{s1\chi} \sum_t 1\left(h_{1t} = H_1\right) + \alpha_{s2\chi} \sum_t 1\left(\hat{x}_t = 1\right) + \alpha_{s3\chi} \sum_t 1\left(\hat{x}_t = 1 \wedge h_{1t} = H_1\right)\right)} \end{aligned} \quad (50)$$

where $\{h_{1t}, \hat{x}_t\}_{t=1}^2$ are respectively the individual's first- and second-year annual-level observed health component and the health insurance status. We estimate the parameters in (50) jointly with all the other medical expenditure parameters.[70]

Note that, we do not directly use the estimate of $\Pr(h_2 = U_2 | \langle h_{1t}, x_t \rangle_{t=1,2}, \chi)$ in the later estimation. Instead, from this estimate, we calculate the *unconditional* proportion of the population with unhealthy unobserved component, $\Pr(h_2 = U_2)$, by integrating over the joint distribution of $\left(\langle h_{1t}, x_t \rangle_{t=1,2}, \chi \right)$ observed in the data. The unconditional distribution is used as an input to calculate the steady-state worker distribution in our equilibrium model.[71] We then verify how well our model is able to account for the selection based on the unobserved health component.[72]

We estimate the parameters in health transition matrix $\pi^{\hat{x}}_{\chi h_1 h_1'}$, as described in (5) and further parametrized in Section 3.5, using the 2004 SIPP data based on maximum likelihood. The key issue we need to deal with is that our model period is four-months; and while we can observe health insurance status each period (every four months), we observe health status only every *three* periods (a year). We deal with this issues as follows, separately by demographic type χ. Let $\hat{x}_t \in \{0,1\}$ be a type-χ worker's insurance status at period t, and let $h_{1t} \in \mathcal{H}_1$ and $h_{1t+3} \in \mathcal{H}_1$ denote respectively the worker's observed health component in period t and $t+3$ (when it is next measured), the likelihood of observing $h_{1t+3} \in \mathcal{H}_1$ conditional on $\hat{x}_t, \hat{x}_{t+1}, \hat{x}_{t+2}$

[67] The details of the classification are provided in Appendix B.

[68] We assume that the observed health component and health insurance status stay fixed in the year, which is necessitated by the difficulty in measuring the exact timing of the health care spending as related to the health and health insurance status. An alternative strategy is to use the subsample of individuals whose health and insurance status are unchanged within each year. One drawback of this alternative approach is that it will result in an extremely small estimation sample; in particular, this approach significantly reduces the samples whose health and insurance status change across years, which is the key source of variation to construct the covariance moments.

[69] The weighting matrix we use is the diagonal elements of inverse of variance-covariance matrix of sample moments.

[70] Instead of relying on exclusion restrictions to address the selection on unobserved health component, our identification of the distribution of the unobserved health component relies on the panel structure of the data, akin to the fixed effect regression.

[71] The medical expenditure process of the children is estimated with three conditional moments, the mean and variance of the medical expenditures conditional on the expenditures being positive, and the fraction of children with zero medical expenditure for each $\hat{x} \in \{0,1\}$.

[72] As we will discuss in Section 7.2, an important reason that we do not directly use the estimates of $\Pr(h_2 = U_2 | \{h_{1t}, \hat{x}_t\}_{t=1}^2, \chi)$ in the second-step estimation is is that they are not directly comparable to the steady-state distribution in our equilibrium.

and $h_{1t} \in \mathcal{H}_1$ can be written out explicitly using the Law of Total Probability:

$$\Pr(h_{1t+3}|\hat{x}_t, \hat{x}_{t+1}, \hat{x}_{t+2}, h_{1t}, \chi) = \sum_{h_{1t+2}\in\mathcal{H}} \sum_{h_{1t+1}\in\mathcal{H}} \pi^{\hat{x}_t}_{\chi h_{1t+1} h_{1t}} \pi^{\hat{x}_{t+1}}_{\chi h_{1t+2} h_{1t+1}} \pi^{\hat{x}_{t+2}}_{\chi h_{1t+3} h_{1t+2}}. \quad (51)$$

We use them to formulate the log-likelihood of observed data, which records the health transition every three periods, as a function of one-period health transition parameters as captured by $\pi^{\hat{x}}_{\chi h_1 h_1'}$, for $\hat{x} \in \{0, 1\}$, as in (5) in our model.[73]

6.2 Second Step

In the second step, we estimate the remaining parameters $\boldsymbol{\theta} \equiv (\theta_1, \theta_2)$ where $\theta_1 \equiv \left\langle \gamma_\chi, \mathfrak{b}_\chi, \lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}, \delta^{\chi\mathbf{h}}, f_M^e(\chi, y), f_M^u(\chi), \sigma_{\chi II}, \xi_{II}, \sigma_{\chi w}, \underline{c}_\chi \right\rangle$ are parameters that affect worker-side dynamics, and $\theta_2 \equiv \left\langle C, d_{U_1}, M, \mu_p, \sigma_p, \sigma_f \right\rangle$ are the additional parameters that are mostly relevant to the firm-side moments. First, we discuss the identification of these parameters. Then, we explain how to use the actual data variation to estimate these parameters.

6.2.1 Identification

Our model is an extension of the standard Burdett and Mortensen (1998) model whose identification is extensively discussed in the literature (e.g., Bontemps, Robin, and Van den Berg (1999, 2000)). In this section, we heuristically discuss the identification of the additional parameters related to health and health insurance, both on the worker and firm sides, that are not present in Burdett and Mortensen (1998).

We first discuss the sources of variations in the data that can identify the worker-side parameters related to the health insurance choices of workers, which include the CARA risk aversion parameters γ_χ, the consumption floor $\underline{c}_\chi$, the loading factor for individual insurance ξ_{II} [as in (49)], the standard deviation of preference shock to obtaining individual insurance $\sigma_{\chi II}$, and the Medicaid eligibility probabilities $\langle f_M^e(\chi, y), f_M^u(\chi)\rangle$. First, the CARA risk aversion parameter γ_χ determines the value of health insurance, which will determine the *overall* uninsured rate. The consumption floor $\underline{c}_\chi$ will also affect the demand for insurance, but mainly for low income individuals. Thus, the insurance coverage rates *by income* (e.g., wage variations between insured and insured) and *employment* provide the source of variation to separately identify γ_χ and $\underline{c}_\chi$. The loading factor parameter ξ_{II} mainly affects the demand of the pre-ACA individual private insurance relative to other insurance options, for a given level of risk aversion. Thus, the fraction of individuals holding individual private insurance among the overall insured population is informative about ξ_{II}. For the standard deviation of the preference shock on having individual insurance $\sigma_{\chi II}$, note that it regulates the smoothness of the relationship between income and individual insurance coverage, which provides the source of variation to identify $\sigma_{\chi II}$. Finally, the function of Medicaid offer rates $f_M^e(\chi, y)$ and $f_M^u(\chi)$ are identified off the proportions of Medicaid enrollees across demographic types, income, and employment status.

The firm-side parameters related to the health and health insurance provisions include the parameter that measure productivity effect of health $d_{\chi h_1}$, firms' mean administrative cost of offering health insurance C together with the scale parameter of the administrative cost shock σ_f [as in (34)]. The identification of the productivity effect of health $d_{\chi h_1}$ is mainly due to the fact that it is directly related to firms' wage offer:

[73] Although our estimation procedure for the health impact of health insurance is more restrictive than randomized or quasi-randomized experiments used in some of the recent health literature, our estimates turn out to be largely consistent with those in the literature, as we will review in Section 7.1.

as can be seen from firm's profit function in (35) and (36), wage offers depend on the workers' observed health component at the initial entry. Thus, if workers' observed health component were persistent and unhealthy individuals are less productive, they would receive lower wages. The variation of wages across observed health status is therefore informative about the productivity effect of health. The parameters C and σ_f are mainly identified off the relationship between the firm size and health insurance offering probability from the firm-side data. Specifically, the mean of the administrative cost C is identified from the the probability (in *level*) of small firms offering health insurance; the scale parameter σ_f is identified off the relationship between the probability of offering health insurance and firm productivity (and thus firm size).

Finally, we discuss the identification of remaining parameters, which include the parameters measuring the labor market friction $(\lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}, \delta^{\chi\mathbf{h}})$, the variance of the preference shock to work $(\sigma_{\chi w})$, flow "income" when in unemployment $(\mathfrak{b}_\chi)$, and firm productivity distribution parameters $\left(\mu_p, \sigma_p\right)$. First, the labor market friction parameters, $\lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}$ and $\delta^{\chi\mathbf{h}}$, are identified off the the labor market transitions from the worker-side data. Note that, compared with the standard labor search model, we additionally have preference shock to work, which also affect the worker transition. The exclusion restriction to separately identify $\sigma_{\chi w}$ from $\left(\lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}, \delta^{\chi\mathbf{h}}\right)$ is the assumption that the preference shock to work is independent of firms' characteristics. To see this, note from Eqs. (17)-(18), endogenous quits induced by the preference shock depend on employee's current wage and ESHI status. Thus, by using the variation of labor market transition by previous employers' contract, one can separately identify these parameters. Finally, similar to other labor search models, the flow "income" in unemployment $(\mathfrak{b}_\chi)$ and the firm productivity distribution parameters $\left(\mu_p, \sigma_p\right)$ are identified off the observed wage and firm size distributions.

6.2.2 Estimation

Our objective function is based on the GMM which consists of the worker-side data from the SIPP and the firm-side data from Kaiser. Specifically, let the targeted moments be

$$\mathcal{M}(\boldsymbol{\theta}) = \begin{bmatrix} \mathbf{m}_w - \mathrm{E}[\mathbf{m}_w; \boldsymbol{\theta}] \\ \mathbf{m}_f - \mathrm{E}[\mathbf{m}_f; \boldsymbol{\theta}] \end{bmatrix}, \tag{52}$$

where $\mathbf{m}_w$ is a vector of worker-side moments and $\mathbf{m}_f$ is a vector of firm-side moments, details of which are described below.

Then, we construct an objective function as

$$\min_{\{\theta\}} \mathcal{M}(\boldsymbol{\theta})' \mathbf{W} \mathcal{M}(\boldsymbol{\theta}), \tag{53}$$

where the weighting matrix $\mathbf{W}$ is a diagonal matrix of inverse of variance of corresponding moment.[74] Let $\mathbb{M}(\boldsymbol{\theta}) = \mathrm{E}[\frac{\partial \mathcal{M}(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}'}]$, the gradient matrix of the moment conditions with respect to the parameters evaluated at the true parameter values and $\Omega = \mathrm{E}[\mathcal{M}(\boldsymbol{\theta})\mathcal{M}(\boldsymbol{\theta})']$, the variance-covariance matrix of the moment condition. As in Petrin (2002), we first assume that Ω takes block diagonal matrix because different moments come from different sampling processes. The asymptotic variance of $\sqrt{n}\left(\hat{\boldsymbol{\theta}} - \boldsymbol{\theta}\right)$ is then given by

$$\left[\mathbb{M}(\boldsymbol{\theta})' \mathbf{W} \mathbb{M}(\boldsymbol{\theta})\right]^{-1} \mathbb{M}(\boldsymbol{\theta})' \mathbf{W} \Omega \mathbf{W} \mathbb{M}(\boldsymbol{\theta}) \left[\mathbb{M}(\boldsymbol{\theta})' \mathbf{W} \mathbb{M}(\boldsymbol{\theta})\right]^{-1},$$

which we use to calculate the standard errors of the parameter estimates.

[74] We do not use the optimal weight matrix because of its potentially poor small-sample properties, as suggested by Altonji and Segal (1996).

Worker-Side Moments. Motivated by our discussion about identification in the beginning of this subsection, we incorporate the following worker-side moments $\mathbf{m}_w$ constructed from SIPP:

- Mean wages among the employed jointly by health insurance status, observed health status, and demographic types;
- Variances of wages among the employed by health insurance status, observed health status and demographic types;
- Distribution of health insurance status among the employed by observed health status and demographic types;
- Distribution of health insurance status among the unemployed by observed health status and demographic types;
- Unemployment-employment transition rates by observed health status;[75]
- Unemployment-employment transition rates by ESHI/No-ESHI status of new jobs;
- Unemployment-employment transition rates by demographic types;
- Employment-unemployment transition rates by observed health status and ESHI/No-ESHI jobs
- Employment-unemployment transition rates by demographic types;
- Job–to-job transition rates by observed health status and the ESHI/No-ESHI status of previous and new jobs;
- Job–to-job transition rates by demographic types and the ESHI/No-ESHI of the previous jobs.

Employer-Side Moments. In our estimation, we also require that our model's predictions match the following employer-side moments $\mathbf{m}_f$ constructed from the Kaiser data:

- Mean firm size;
- Fraction of firms with less than 50 workers;
- Health insurance coverage rate among firms with less than 10 workers;
- Health insurance coverage rate among firms with 10-30 workers;
- Health insurance coverage rate among firms with 30-50 workers;
- Health insurance coverage rate among firms with more than 50 workers.

[75]Note that we do not condition on the finer cells of ESHI offering status-health-demographic types. The reason is that the number of observably unheathy individuals can be too small if we also condition on other individual characteristics.

7 Estimation Results

7.1 Parameter Estimates

Parameters Estimated in the First Step. Tables 6 and 7 respectively report the step 1 parameter estimates for the medical expenditure processes as described by (41) and (42), and the health transitions as described by (5). The estimated coefficients imply that unhealthy individuals and individuals with health insurance tend to be more likely to experience medical shocks. Moreover, conditional on experiencing medical shocks, the medical expenditure realizations for the unhealthy individuals and individuals with health insurance tend to have higher means and higher variances. Quantitatively, both the observed and unobserved health components significantly impact the means and variances of medical expenditures.

[Insert Table 6 About Here]

In Table 7, we report the parameter estimate for the transition matrix for the observed health component, by gender and health insurance status. For the most part, the parameter estimates for the health transitions are consistent with the notion that there is a significant health insurance effect on the dynamics of observable health component. Specifically, our estimates indicate that $\pi^1_{\chi H_1 H_1} > \pi^0_{\chi H_1 H_1}$, which implies that workers with health insurance is more likely to stay in the observable healthy component than those without health insurance. Similarly, we find that $\pi^1_{\chi U_1 U_1} < \pi^0_{\chi U_1 U_1}$, which implies that workers with health insurance are more likely to transition out of the observed unhealthy status to healthy.

[Insert Table 7 About Here]

It is useful to note that our estimates of the effect of health insurance on observed (self-reported) health are consistent with the experimental evidence found in Finkelstein, Taubman, Wright, Bernstein, Gruber, Newhouse, Allen, Baicker, and the Oregon Health Study Group (2012), where they use the randomized control design as a result of the allocation of Medicaid insurance by lottery to over-subscribers in Oregon in 2008. They found that one year after being randomly allocated Medicaid insurance increases the probability that people *self report* “Good” or “Excellent” health (compared with “Fair” or “Poor” health) by 25 percent, and increases the probability of not screening positive for depression by 10 percent. The findings about the positive effect of insurance on *self-reported* physical and mental health persist after two years despite the finding in Baicker, Taubman, Allen, Bernstein, Gruber, Newhouse, Schneider, Wright, Zaslavsky, Finkelstein, and the Oregon Health Study Group (2013) that Medicaid has no statistically significant effect on *measured* blood pressure and cholesterol approximately two years after the experiment.[76]

Parameters Estimated in the Second Step. Table 8 reports the parameter estimates from step 2, which consist of $\theta_1 \equiv \left\langle \gamma_\chi, \mathfrak{b}_\chi, \lambda_u^{\chi\mathbf{h}}, \lambda_e^{\chi\mathbf{h}}, \delta^{\chi\mathbf{h}}, f_M^e(\chi, y), f_M^u(\chi), \sigma_{\chi II}, \xi_{II}, \sigma_{\chi w}, \underline{c}_\chi \right\rangle$ and $\theta_2 \equiv \left\langle d_{\chi\mathbf{h}}, C, M, \mu_p, \sigma_p, \sigma_f \right\rangle$. Panel A reports the parameters that are related to the labor market frictions. We find that the offer arrival rate for an unemployed worker $\lambda_u^{\chi\mathbf{h}}$ is 0.504 $(= \exp(0.016)/[1+\exp(0.016)])$ for single men without children who is observably healthy. This estimate implies that on average it takes about 7.9 months for such an unemployed individual to receive an offer. However, we also find that there is a large heterogeneity of arrival rates. Specifically, we find that individuals whose observed health component is unhealthy or who is female tend to have much lower arrival rate of job offers; on the other hand,

[76] Also see Courtemanche and Zapata (2014) for similar evidence from Massachusetts health reform. Levy and Meltzer (2008) provides a comprehensive survey on the previous literature that examined the health effect of health insurance.

married individuals, and individuals with children tend to have somewhat higher offer arrival rate while unemployed. We also find that the offer arrival rates for employed workers, $\lambda_e^{\chi\mathbf{h}}$, are about 0.20 for single men without children who is observably healthy. This implies that on average it takes about 19 months for such a currently employed worker to receive an outside offer.[77] We also find that the on-the-job offer arrival rate tends to be lower for workers whose observable health component is unhealthy or who is female, and somewhat higher for married individuals and individuals with children. Also in Panel A, our estimates for the probability of exogenous job destruction, $\delta^{\chi\mathbf{h}}$ imply that there is a 5.4% probability in a four-month period for a job to be exogenously terminated for single men without children who is observably healthy. But we also find that unhealthy individuals have a higher job destruction rate, indicating that bad health significantly lowers the worker's ability to continue working the job. The exogenous job destruction rates are lower for females, the married and those with children.

[Insert Table 8 About Here]

In Panel B, we report our estimate of CARA coefficients γ_χ. Note that we only allow the risk aversion to vary by gender. We estimate that the CARA coefficient is about 3.71E-4 (recalling that our unit is in $10,000) for males and 4.88E-4 for females. Using the four-month average wages for employed workers reported in Table 3, which is about $10,610 for males and $8,050 for females, our estimated CARA coefficients imply relative risk aversions of about 3.50 for males and 6.06 for females. These are squarely in the range of estimates of CARA and Relative Risk Aversion coefficients in the literature (see Cohen and Einav (2007) for a summary of such estimates), and they are also consistent with the findings by others that women tend to be more risk averse than men in the western economies (see, e.g., Barsky, Juster, Kimball, and Shapiro (1997) for survey evidence, and Levin, Snyder, and Chapman (1988) and Borghans, Golsteyn, Heckman, and Meijers (2009) for experimental evidence that women are more risk averse than men).

In Panel C, we report our estimated values for the "monetary income" received while in unemployment $\mathfrak{b}_\chi$ for demographic group χ. We find that the magnitude of $\mathfrak{b}_\chi$ is small overall for all groups, and it ranges from $170 to $220 for four months. The relatively small estimates of $\mathfrak{b}_\chi$ suggests that a large fraction of the UI benefits is probably expensed for job search or other psychological costs associated with being unemployed.

In Panel D, we report our estimates of the standard deviations of the preference shocks to work, $\sigma_{\chi w}$, and the preference shocks to private insurance, $\sigma_{\chi II}$. Our estimates indicate that there is a substantial variation in the preference shock to work, and that the standard deviation of the preference shock to purchase private insurance is much smaller.

In Panel E, we report our estimates of what we will refer to as the firm-side parameters. We find that there is substantial productivity loss for workers with unhealthy observable component: the productivity of an unhealthy worker (those who self-reported health is "Poor" or "Fair"), d_{U_1}, is about 0.40, which implies

[77] Dey and Flinn (2005) estimated that the mean wait between contacts for the unemployed is about 3.25 months, while the a contact between a new potential employer and a currently employed individual occurs about every 19 months. The differences for the contact rate for the unemployed between our paper and Dey and Flinn (2005) could be due to the fact that a period is four months in our paper while it is a week in Dey and Flinn (2005). An unemployed individual in both the first month and the fifth month will be considered as being in a continuous unemployment spell, though at weekly frequency he could have been matched with some firms inbetween. This may lead us to a lower estimate for the contact rate for the unemployed. Another possibility is the differences in the sample selection: our sample includes only individuals with no more than high school degree, while Dey and Flinn (2005)'s sample has at least a high school degree.

that there is a 60 percent productivity loss for unhealthy workers relative to healthy workers.[78] Moreover, we find that the mean of the administration cost for firms to offer ESHI, C, is about \$2,750 per four month, i.e., about \$13,200 per year. We estimate that the smoothing parameter of the fixed cost of offering ESHI, σ_f, as specified in (34), is estimated to be about \$1,500, which is of a similar magnitude as the estimate of C. We estimate that the scale and shape parameters of the lognormal productivity distribution are respectively -0.288 and 0.579, which implies that the mean (4-month) productivity of firms is about $\$8,864$. The fact that the mean accepted four-month wages in our sample are on average $\$9,530$ (see Table 3) is largely due to the fact that more productive firms attract more workers in the steady state as our model implies. Our estimate of the loading factor in individual insurance market is $\xi_{II} = 0.69$, which implies that the predicted medical loss ratio, the ratio of the claim cost over the premium, is about to 0.60.[79]

Finally in Panel F, we report the estimates of remaining parameters. In order to fit the average firm size, our estimate of M, the ratio between workers and firms, is about 21.44. This estimate is about the same as the average establishment size of 21.02 reported in Table 5. Because of the preference shock to work we introduced in our model, all firms in our model regardless of their productivity will attract some workers in equilibrium. Our estimate of the consumption floor $\underline{c}_\chi$ is very modest at about \$50 for four-months.[80] We also estimate that, for both the employed and the unemployed, individuals with children are more likely to be eligible for Medicaid; and in addition, for the employed, individuals with lower income are more likely to be eligible for Medicaid.

7.2 Within-Sample Goodness of Fit

In this section, we examine the within-sample goodness of fit of our estimates by comparing the model predictions with their data counterparts. Tables 9-10 report the model fits for medical expenditure in the first step. Table 9 focuses on the cross-sectional fit for medical expenditures, for adults by gender, and by observable health status and health insurance status, and for children by health insurance status. The table shows that our parameter estimates fit the data on the conditional means and variances very well; we also accurately replicate the fraction of individuals with zero medical expenditures conditional, both for adults and for children. Table 10 focuses on the within-individual dynamics of medical expenditures. For this exercise, we exploit the panel feature of MEPS data. For different combinations of observable health component and health insurance status in the two year panel, we present the model fit for the covariance of positive medical expenditure across the two years and the fraction of individuals with zero expenditure

[78] There is a vast literature examining whether healthy workers have higher productivity using different methods and different data. Most papers share the findings that healthier individuals are more productive. For a thorough survey on the relationships between health and productivity, see Tompa (2002).

[79] Quantitatively, this prediction is consistent with the finding in Cicala, Lieber, and Marone (2017) that the median medical loss ratio in the individual health insurance markets between 2005-2009 was close to 0.70. They also find that the median medical loss ratio threshold among states with some regulation was only 0.65.

[80] The estimates of consumption floor is clearly model specific, and depend on what goverment programs are already included in the analysis. For example, De Nardi, French, and Jones (2010) estimate a consumption floor of \$2,663 (in 1998 dollars) per year in their life-cycle model of elderly savings, but they argue that this includes the value of the Medicaid coverage for the elderly. We explicitly include Medicaid in our analysis so our estimate of the "consumption floor" for the uninsured is more narrowly focused on emergency care, for example, and thus lower. Similarly, French, Jones, and von Gaudecker (2017) argued that their estimate of the consumption floor likely captures "the medically needy pathway for Medicaid, debt removal through bankruptcy, or debt forgiveness by hospitals."

in both years. It is shown that we fit all the conditional moments well.[81]

Table 11 reports the fit for the annual transitions of the observable health component, by gender and health insurance status. Recall that, in the SIPP data the self-reported health is surveyed annually and the insurance status is surveyed every four months. For simplicity, in Table 11 we show the model fit for individuals who were either continuously insured or continuously uninsured throughout the year. It shows that our model fits the data very well. For both males and females, it captured the pattern that insured workers are more likely to transition to be healthy (in observed health component); but the effect of health insurance in improving health is much more pronounced for females than for males.

[Insert Table 11 About Here]

Tables 12 and 13 report the model fit for the worker-side moments. In Table 12, we show that the model fits reasonably well the cross-sectional distribution of the employed (Panel A) and the unemployed (Panel B) by demographic types, observable health and health insurance status; in 13 we show that the model fits well the mean wages conditional on demographic types, observable health and health insurance status.

[Insert Table 12 About Here]
[Insert Table 13 About Here]

In Table 14, we report the model fit for the one-period transition of workers' labor market transitions, by their observed health status. Although the fit is not perfect, in general the model is able to explain the significant effect of health status on labor market transitions. Our model over-predicts the probability that an employed workers with unhealthy observed health component transitions from a job with ESHI to unemployment, and under-predicts the probability that unhealthy employed workers transition from a job without ESHI to another job without ESHI.

[Insert Table 14 About Here]

In Table 15 we compare the model's predictions of the targeted employer-side moments listed in Section 6.2.2 with those in the data. In general, our model fits reasonably well on average, including mean firm size, fraction of firms with less than 50 workers, and health insurance coverage rate by firm size. Our model captures the pattern that larger firms are more likely to offer ESHI, as consistent with the data: our model predicts that the ESHI offering rate for firms with less than 10 workers is about 44.6%, but will rise to 93.5% for firms with more than 50 workers. However, our model under-predicts the ESHI offering rates for firms with 10-30 and 30-50 workers.

[Insert Table 15 About Here]

Finally, it is useful to point out that, in a sense to be described below, our model also predict well the distribution of unobserved health components in the population. Note that in the MEPS data, the unobserved health components are recovered as a function of the individuals combination of observed health components and health insurance status over the two years at the annual frequency, but in our model the steady state distribution of the unobserved health components are defined over the four-month

[81] From the twelve potential health and health insurance combinations in the two years, we choose 6 targeted moments with sufficiently large sample size.

model period. For this reason, we cannot directly compare the distribution of the unobserved health component in the steady state of the model with the distribution of the unobserved health components recovered from the MEPS. Instead, we examine the model's implication on medical expenditure in the steady state equilibrium, which is un-targeted in our second step estimation.[82] Because the unobserved health components affect the medical expenditure, the model should be able to predict well about the average medical expenditure as long as it generates the selection patterns consistent with the data. Table 16 compares the mean medical expenditure in the model with the mean medical expenditure in the MEPS data. It shows that the model prediction matches the data reasonably well.

[Insert Table 16 About Here]

8 Counterfactual Experiments

In this section, we use our estimated model to examine the impact of the Affordable Care Act, its key components, and various alternative policy designs. For the ACA, we consider a stylized version which incorporates its main components as mentioned in the introduction: first, all individuals are required to have health insurance or have to pay a penalty; second, all firms with more than 50 workers are required to offer health insurance, or have to pay a penalty; third, we consider that the individual health insurance market is replaced by a health insurance exchange where individuals can purchase health insurance at community rated premium; fourth, the participants in the health insurance exchange can obtain income-based subsidies; fifth, individuals whose income is below 138% of the Federal Poverty Level is eligible for the Medicaid regardless of their demographic status. Note that the ACA's Medicaid expansion is state-specific and about 30 states expanded Medicaid in 2014, although in our analysis we consider it as the national expansion. In Section 8.3.1, we argue that the main qualitative findings will remain valid when the Medicaid is only partially expanded.

The introduction of health insurance exchange represents a substantial departure from our benchmark model because the premium in the health insurance exchange needs to be endogenously determined in equilibrium. As a result, we will first describe how we extend and analyze our benchmark model to incorporate the health insurance exchange.

8.1 Model for the Counterfactual Experiments

We provide a brief explanation of the main changes in the economic environment for the model used in our counterfactual experiments. First, an introduction of individual mandate and premium subsidies changes the budget constraint of individuals, as a result, the expected flow utility $v_{\chi\mathbf{h}}(y,x)$ in the counterfactual differs from (7) in the benchmark and is now defined as:

$$v_{\chi\mathbf{h}}(y,x)=\begin{cases}\mathrm{E}_{\tilde{m}^0_{\chi\mathbf{h}}}u_{\boldsymbol{\chi}}\left(T(y,\chi)-\tilde{m}^0_{\chi\mathbf{h}}-P_W(y)\right) & \text{if } x=0\\ u_\chi\left(T\left(y,\chi\right)\right) & \text{if } x\in\{1\,,3\}\\ u_\chi\left(T\left(y,\chi\right)+SUB\left(y,R^{EX}\right)-R^{EX}\right) & \text{if } x=2\\ u_\chi\left(T\left(y-R^{SP},\chi\right)\right) & \text{if } x=4,\end{cases} \tag{54}$$

where $x=2$ now indicates health insurance obtained from the health insurance exchange in place of the private individual insurance market in the benchmark; $P_W(y)$ denotes the penalty to individuals who

[82] This validation approach is very similar to Low and Pistaferri (2015) who also estimate their model in two steps.

remain uninsured under the ACA, which depends on income level and will be parameterized below in (60) for the ACA; and $SUB\left(y, R^{EX}\right)$ denotes income based subsidies to an individual with income y who purchase health insurance from the exchange, where R^{EX} is the premium in exchange determined in (57) below which due to community-rating regulations does not depend on health status $\mathbf{h}$ or gender; and R^{SP} is the spousal insurance premium (to be determined in equilibrium, as described in (59) below). With this modification, individual optimization problem can be characterized and solved as in the benchmark model.

The introduction of employer mandate penalty, however, makes firm's problem much more complicated. Firms with more than 50 workers now face a penalty if they do not offer health insurance. Let $P_E(n)$ denote the the amount of the penalty, which depends on the firm size n. We parameterize $P_E(n)$ in (61) for the employer mandate penalty under the ACA. Firm's profit maximization problem will now change to:

$$\max\{\Pi_0(p), \Pi_1(p) - \sigma_f \epsilon\},$$

where

$$\Pi_0(p) = \max_{\{w_H^0, w_U^0\}} \Pi\left(w_H^0, w_U^0, E=0\right) \equiv \sum_{\chi} \sum_{h_1^0 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} \left(p d_{\chi \mathbf{h}} - w_{h_1^0}^0\right) n_{\chi \mathbf{h}}\left(w_{h_1^0}^0, 0\right) - P_E\left(n\left(\mathbf{w}_{h_1^0}^0, 0\right)\right), \quad (55)$$

$$\Pi_1(p) = \max_{\{w_H^1, w_U^1\}} \Pi\left(w_H^1, w_U^1, E=1\right) \equiv \sum_{\chi} \sum_{h_1^0 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} \left[\left(p d_{\chi \mathbf{h}} - w_{h_1^0}^1 - m_{\chi \mathbf{h}}^1\right) n_{\chi \mathbf{h}}\left(\mathbf{w}_{h_1^0}^1, 1\right)\right] - C. \quad (56)$$

where $n\left(\mathbf{w}_{h_1^0}^0, 0\right) = \sum_{\chi} \sum_{h_1^0 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} n_{\chi \mathbf{h}}\left(w_{h_1^0}^0, 0\right)$ is the total number of workers in the steady state for a firm that offers contract $\left(\mathbf{w}_{h_1^0}^0, 0\right)$ and the term $P_E\left(n\left(\mathbf{w}_{h_1^0}^0, 0\right)\right)$ in the expression for $\Pi_0(p)$ is the penalty to employers for not offering ESHI to their workers.

The premium in the insurance exchange, R^{EX}, is determined based on the average medical expenditures of all participants in the health insurance exchange, multiplied by $1+\xi_{EX}$, where $\xi_{EX} > 0$ is loading factor for health insurance exchange; specifically,

$$R^{EX} = (1+\xi_{EX}) \frac{\sum_{\chi} \sum_{\mathbf{h} \in \mathcal{H}} m_{\chi \mathbf{h}}^2 \left[u_{\chi \mathbf{h}}(2) + \int e_{\chi \mathbf{h}}^2 s_{\chi \mathbf{h}}^2(w) dw\right]}{\sum_{\chi} \sum_{\mathbf{h} \in \mathcal{H}} \left[u_{\chi \mathbf{h}}(2) + \int e_{\chi \mathbf{h}}^2 s_{\chi \mathbf{h}}^2(w) dw\right]} \quad (57)$$

where $m_{\chi \mathbf{h}}^2$ is expected medical expenditure of type-χ individual with health status $\mathbf{h}$ for individuals with insurances purchased from the exchange.

In our counterfactual experiments, we recognize that the changes in the firms' ESHI offering decisions will affect the availability and the premium of spousal health insurance option. Specifically, as in the benchmark economy, we let the probability of being offered spousal health insurance for married male (female, respectively) be equal to the proportion of the married female (male, respectively) being offered ESHI, i.e., for each χ_g, which is either married male or married female,

$$f_{SP}(\chi_g) = \frac{\sum_{\chi = \chi_g'} \sum_{\mathbf{h} \in \mathcal{H}} \int e_{\chi \mathbf{h}}^1 s_{\chi \mathbf{h}}^1(w) dw}{\sum_x \sum_{\chi = \chi_{g'}} \sum_{\mathbf{h} \in \mathcal{H}} \left[u_{\chi \mathbf{h}}(x) + \int e_{\chi \mathbf{h}}^x s_{\chi \mathbf{h}}^x(w) dw\right]} \quad (58)$$

where $\chi_{g'}$ denotes married individuals of opposite gender. In (58), the numerator is the measure of workers of type $\chi_{g'}$ who have own ESHI $(x=1)$, and the denominator is the total measure of type-$\chi_{g'}$ workers in the economy. In addition, the spousal insurance premium is equated to the average medical expenditure of the individuals with spousal health insurance, given by:

$$R^{SP} = \frac{\sum_{\chi} \sum_{\mathbf{h} \in \mathcal{H}} m_{\chi \mathbf{h}}^4 \left[u_{\chi \mathbf{h}}(4) + \int e_{\chi \mathbf{h}}^4 s_{\chi \mathbf{h}}^4(w) dw\right]}{\sum_{\chi} \sum_{\mathbf{h} \in \mathcal{H}} \left[u_{\chi \mathbf{h}}(4) + \int e_{\chi \mathbf{h}}^4 s_{\chi \mathbf{h}}^4(w) dw\right]}. \quad (59)$$

The steady state equilibrium for the post-reform economy can be defined analogous to that for our benchmark model in Section 3.4 and is provided in Online Appendix C.

Numerical Algorithm to Solve the Equilibrium. We use numerical methods to solve the equilibrium. The basic iteration procedure to solve the equilibrium for the counterfactual environment remains the same as the one used to solve the benchmark model, but an important change is that now we need to find the fixed point of not only $\left(\mathbf{w}^{*0}_{h^0_1}(p), \mathbf{w}^{*1}_{h^0_1}(p), \Delta(p)\right)$ but also R^{EX}, R^{SP}, and $f_{SP}(\chi_g)$, respectively the premiums in insurance exchange, the premium for spousal insurance, and the offer probability of spousal insurance. A technical complication is that, the size dependent employer mandate may lead to the presence of a mass point in the wage offer distribution: firms not offering ESHI may not want to hire slightly more than 50 workers in order to avoid paying the employer-mandate penalty $P_E(n)$. In the Online Appendix C, we discuss how we can address this issue numerically to solve for the equilibrium in this environment.

8.2 Parameterization of the Counterfactual Policies

Before we conduct counterfactual experiments to evaluate the effect of ACA and its components, we need to address several issues regarding how to introduce the specifics of the ACA provisions, such as the penalties associated with the individual and the employer mandates and the premium subsidies, into our model. First, we estimated our model using data sets in 2004-2007, while the ACA policy parameters are chosen to suit the economy in 2011. However, the U.S. health care sector has very different growth rate than that of the overall GDP; in particular, there have been substantial increases in medical care costs relative to GDP. Thus we need to appropriately adjust the policy parameters in the ACA to make them more in line with the U.S. economy around 2007. Second, the amount of penalties and subsidies are defined as annual level, while our model period is four months. We simply divide all monetary units in the ACA by three to obtain the applicable number for a four-month period. Third, we need to decide on the magnitude of the loading factor ξ_{EX} that appeared in (57) that is applicable in the insurance exchange. We calibrate ξ_{EX} based on the ACA requirement that all insurance sold in the exchange must satisfy the ACA regulation that the medical loss ratio must be at least 80%. This implies that $\xi_{EX} = 0.25$, which is lower than our estimate about pre-ACA individual insurance loading factor $\xi_{II} = 0.69$.[83]

Below we present the ACA provisions for penalties associated with the individual and the employer mandates, and the income-based premium subsidies. In Online Appendix D, we describe how we translate the ACA provisions for 2011 into applicable formulas for our 2007 economy.

Penalties Associated with Individual Mandate. The exact stipulation of the penalty in ACA if an individual does not show proof of insurance (from 2016 onward when the law is fully implemented) is that individuals without health insurance coverage pay a tax penalty of the greater of \$695 per year or 2.5% of the taxable income above the Tax Filing Threshold (TFT), which can be written as:

$$P_W^{ACA}(y) = \max\{0.025 \times (y - \text{TFT\_2011}), \$695\} \tag{60}$$

where y is annual income.

[83]The medical loss ratio is the ratio of the total claim costs the insurance company incurs to total insurance premium collected from participants. The medical loss ratio implied by (57) is simply $1/(1+\xi_{EX})$, thus an 80% medical loss ratio corresponds to $\xi_{EX} = 0.25$. ACA requires that $\xi_{EX} \leq 0.25$.

Penalties Associated with Employer Mandate. ACA stipulates that employers with 50 or more full-time employees that do not offer health insurance coverage will be assessed each year a penalty of \$2,000 per full-time employee, excluding the first 30 employees from the assessment. That is,

$$P_E^{ACA}(n) = \begin{cases} (n-30) \times \$2,000, & \text{if } n \geq 50 \\ 0, & \text{otherwise.} \end{cases} \tag{61}$$

Income-Based Premium Subsidies. ACA stipulates that premium subsidies for purchasing health insurance from the exchange are available if an individual's income is less than 400% of Federal Poverty Level (FPL), denoted by FPL400.[84] The premium subsidies are set on a sliding scale such that the premium contributions are limited to a certain percentage of income for specified income levels. If an individual's income is at 138% of the FPL, denoted by FPL138, premium subsidies will be provided so that the individual's contribution to the premium is equal to 3.5% of his income; when an individual's income is at FPL400, his premium contribution is set to be 9.5% of the income. When his/her income is below FPL138, he/she will receive insurance with zero premium contribution through Medicaid. If his/her income is above FPL400, he/she is no longer eligible for premium subsidies. Note that the premium subsidy rule as described in the ACA creates a discontinuity at FPL138: individuals with income below FPL138 receives free Medicaid, but those at or slightly above FPL138 have to contribute at least 3.5% of their income to health insurance purchase from the exchange. To avoid this discontinuity issue, we instead adopt a slightly modified premium support formula as follows:

$$SUB^{ACA}\left(y, R^{EX}\right) = \begin{cases} \max\left\{R^{EX} - \left[0.035\Phi\left(\frac{y-\text{FPL140}}{\sigma_{SUB}}\right) + 0.06\frac{(y-\text{FPL138})}{\text{FPL400}-\text{FPL138}}\right] y,\ 0\right\}, & \text{if } y \in (\text{FPL138, FPL400}) \\ 0, & \text{otherwise,} \end{cases} \tag{62}$$

when y is the *annual* income and R^{EX} is the annual premium for health insurance in the exchange. According to (62), the individual contribution to insurance premium will be close to 0 when his/her income is close to 138 % of the FPL, similar to those who receive free Medicaid, as long as the smoothing parameter σ_{SUB} is small.[85] Then, as income rises, the individual's maximum premium contribution increases toward 3.5% quickly and then the individual contribution to insurance premium increases up to 9.5% when his income is at 400% of the FPL.

Finally, we capture the Medicaid expansion under the ACA to modify the Medicaid eligibility probabilities for the employed and the unemployed to be as follows:

$$\begin{aligned} f_M^{e,ACA}(\chi, y) &= 1 \text{ if } y \leq \text{FPL138} \\ f_M^{u,ACA}(\chi) &= 1. \end{aligned}$$

That is, the employed will be eligible for Medicaid if their income is below FPL138, and all the unemployed is eligible for Medicaid with probability 1.[86]

[84] We assume that FPL is defined as single person. In 2007, it is \$10,210 annually.

[85] Note that in (62),0.035 is multiplied by $\Phi\left(\frac{y-\text{FPL140}}{\sigma_{SUB}}\right)$, which will be close to zero when y is close to FPL138 and σ_{SUB} is sufficiently small. We need to set σ_{SUB} to ensure that it will not create convexity to the firm's problem. Eventually, we chose $\sigma_{SUB} = 0.01$ but we find that our main results are robust for a range of reasonable choices of σ_{SUB}. One can also specify the subsidies as the polynomial function of premium and income (e.g., Aizawa (2017)).

[86] We will also analyze the partial Medicaid expansion in Section 8.3.1.

8.3 Results from Counterfactual Experiments[87]

In this section, we reports results from several counterfactual experiments. First, we report results from the steady state equilibrium when the ACA is fully implemented. We note that, even though components of the ACA was implemented from 2013, the full version of the ACA was never fully implemented, and it is unlikely that the early impact of the ACA would completely resemble the steady state results of the ACA. We also compare our model's steady state prediction with the ACA's early impact. Second, we evaluate several reform proposals to the ACA. In particular, we evaluate the "ACA without individual mandate", and the "ACA without the employer mandate". The "ACA without individual mandate" is an important variation of the ACA because the individual mandate of the Affordable Care Act was repealed by the Tax Cuts and Jobs Act of 2017, even though the full ACA was not. The "ACA without the employer mandate" is important because the employer mandate was actually never fully implemented. Third, we conduct a series of additional counterfactual experiments to understand the effects of the various components of the ACA. In the last two counterfactual experiments, we consider the role of the ESHI itself and the role of the tax exemption of ESHI premiums in the US health insurance system.

8.3.1 Evaluating the Full Implementation of the ACA

One of the main goals for the ACA is to reduce the fraction of the U.S. population that do not have insurance, i.e., the uninsured rate. In Columns 1 and 2 in Table 17, we respectively report results from the pre-ACA economy, which we refer to as the benchmark economy, and the ACA. For the ease of reading Table 17, we divide the statistics into two subgroups. The first subgroup is referred to as the "key labor market statistics", including as ESHI offering rates, unemployment rate, and average wages; and the second subgroup is the distribution of the population in different health insurance categories; and the third group reports the equilibrium premium in the health insurance exchange.

[Insert Table 17 About Here]

Benchmark. In Column (1), we show that the steady state of our estimated benchmark economy, i.e., the pre-ACA environment, exhibits the patterns we discuss in the introduction. It shows that 93.5% of the firms with more than 50 workers offer ESHI to their workers, in contrast to 48.0% of the firms with fewer than 50 workers. Overall, 52.5% of the firms will offer ESHI to their workers. The average four-month wage of the employed workers working in firms offering ESHI is about $10,700, while that for workers in firms not offering ESHI is 7,980. The steady state unemployment rate is 7.9%. It also shows that, the uninsured rate among the population we study is about 21.3% overall; the fractions of individuals who have own ESHI, private individual insurance, Medicaid, and spousal coverage are respectively, 59.5%, 3.4%, 5.0%, and 10.8%. These patterns match those in the data.

The Full Implementation of the ACA. Column (2) reports the counterfactual results from the ACA. We find that the overall fraction of firms offering ESHI declines from 52.5% under the benchmark to about 45.9% under the ACA. Of course, due to the employer mandate for firms with 50 or more workers, the ESHI offering rates for these large firms increase from 93.5% in the benchmark to over 98.9% under the

[87] We focus on reporting the results related to the uninsured rate. Additional results on the effect of the ACA and its variations on other interesting statistics such as overall productivity, average health, profits, health expenditures, etc. are available upon request.

ACA; however, the ESHI offering rate for firms with less than 50 workers decreases significantly from 48.0% under the benchmark to 40.0% under the ACA. The steady state unemployment rate stays about the same under the ACA as that under the benchmark. The average four-month wage of the workers in firms offering ESHI has a slight increase from $1,0700 to $11,100, while that for workers in firms not offering ESHI experiences slight decrease from $7,980 to $7,660; overall, the average wage of the employed worker has a slight increase from $9,890 to $9,920.

Importantly, we find that the uninsured rate under the ACA will be significantly reduced when all features of the ACA are fully phased in. The uninsured rate is predicted to be 6.6%. Notably the fraction of the population with individual insurance increased from 3.4% in the pre-ACA benchmark to 11.2% under the ACA.[88] This represents the biggest source of the drop in the uninsured rate under the ACA. The second important source for the reduction in the uninsured rate is Medicaid, as the fraction of the population covered by Medicaid increase from 5.0% in the benchmark to 9.90% under the ACA. Notably, the fraction of individuals covered by their own ESHI slightly dropped from 59.5% in the benchmark to 58.5% under the ACA. The sizable drop of ESHI offer rate among small firms shifts insurance status of their married employees from their own ESHI coverage toward the spousal coverage, contributing to an increase in the overall spousal coverage from 10.8% in the benchmark to 14.3% under the ACA. Thus, the overall impact on the ESHI coverage is very small: it is 72.4% under the ACA while it is 70.3% in the benchmark.

To understand the reasons for the decline of ESHI offering rate of the small firms, it is useful to study how the ACA affects the adverse selection differentially for firms of different productivities when they decide whether to offer ESHI. Table 18 reports the simulation results similar to those in Table 2. In Table 2 we showed that, in the pre-ACA environment, low-productivity firms would experience an adverse selection effect if they offer health insurance in the sense that they will attract a higher fraction of unhealthy (on unobservable component) workers among their new hires than if they do not offer health insurance; in contrast, high-productivity firms do not experience adverse selection among their new hires. In Table 18, we conduct the same type of numerical exercise under the ACA, and it shows that low-productivity firms no longer suffer from adverse selection in the health of their new hires if they were to offer health insurance. The reason is very simple: because of the expansion of Medicaid and the generous premium subsidies to low-income individuals for purchasing insurance from the exchange, low productivity firms are no longer attracting new hires from a pool with worse unobservable health under the ACA, which is in stark contrast to the pre-ACA case. Thus, the ACA levels the playing field for low- and high-productivity firms to offer health insurance in terms of the adverse selection problem. However, this effect is dwarfed by a countervailing effect: because of the availability of subsidized health insurance from the exchange, workers' willingness to pay for ESHI and the firms' benefit in terms of increased productivity from offering ESHI are significantly reduced under the ACA, and the reduction is much more pronounced for the low-productivity firms.

[Insert Table 18 About Here]

The Early Impact of the ACA: Model vs. Data. Column (2) in Table 17 presents the steady state results when the ACA is fully implemented, including the full expansion of Medicaid at the national level.

[88] Note that, even though both are called "Individual Insurance", the individual insurance in the pre-ACA world differs from that under the ACA in how they are priced: pre-ACA individual insurance is individually priced according to health, while under the ACA, it is community-rated.

Due to the Supreme Court ruling described in Footnote 7, the actual implementation of the Medicaid expansion of the ACA is only partial. In order to examine how well the model is able to account for the early impact of the ACA, we report results from a counterfactual experiment with only partial Medicaid expansion.

Specifically, we evaluate the ACA as implemented in 2015 (which we refer to as "ACA 2015") and compare the model's counterfactual predictions with the data. The main differences between "ACA 2015" and the full implementation of the ACA are as follows: (a) only 30 states expanded Medicaid in "ACA 2015"; (b) the magnitude of the individual mandate tax penalties is lower than when it is fully phased in under "ACA 2015"; specifically, instead of $P_W^{ACA}(y)$ specified in (60), the individual mandate penalty in 2015 is given by:

$$P_W^{ACA2015}(y) = \max\left\{0.02 \times (y - \text{TFT\_2011}), \$325\right\}; \tag{63}$$

(c) only firms with more than 100 workers are subject to employer mandate requirements under "ACA 2015"; specifically, instead of $P_E^{ACA}(n)$ specified in (61), the employer mandate penalty in 2015 is given by:

$$P_E^{ACA2015}(n) = \begin{cases} (n-30) \times \$2,000, & \text{if } n \geq 100 \\ 0, & \text{otherwise.} \end{cases} \tag{64}$$

It is straightforward to incorporate (b) and (c). To incorporate (a) without significantly complicating our framework, we modify the Medicaid eligibility probability under "ACA 2015" as follows. Let f_M^{30} be the proportion of the U.S. population in the thirty states who expanded Medicaid in 2015, and the Medicaid offer probability in "ACA 2015" is specified as:

$$f_M^{e,ACA2015}(\chi, y) = \max\left\{f_M^e(\chi, y), f_M^{30}\right\} \text{ if } y \leq \text{FPL138}; \tag{65a}$$

$$f_M^{u,ACA2015}(\chi) = \max\left\{f_M^u(\chi), f_M^{30}\right\}, \tag{65b}$$

where $f_M^e(\chi, y)$ and $f_M^u(\chi)$ are the probabilities of Medicaid eligibility in the pre-ACA benchmark environment as specified in (47) and (48). We simulate the steady state of our estimated model of the 2004-2007 economy under "ACA 2015" using the policies of (63), (64) and (65).[89] To compare our counterfactual prediction of the impact of "ACA 2015" with the early impact of the ACA in the data, we focus on the predicted changes from the baseline. Focusing on the changes instead of the levels is important because, around the implementation of the ACA, the US economy was just recovering from the Great Recession. For the early impact of the ACA in the data, we obtain the statistics of the distribution of the insurance status in the population in 2012 and 2015 from the American Community Survey (ACS) through IPUMS. Note that ACS does not distinguish individuals' own ESHI from spousal ESHI, thus we aggregate both the own and spousal ESHI into "ESHI" category.

The result is reported in Table 19. We find that our model predicts that the uninsured rate under "ACA 2015" decreases by 9.4 percentage points, from 21.3% to 11.9%; this magnitude of change is largely consistent with that in the data, where the uninsured rate decreases by 10.6 percentage points, from 38.6% to 28.0%. Note that the reduction of uninsured rate in the data is attributed to an increase in all other

[89] Note that under the "ACA 2015", the individuals whose income is below 138% of FPL cannot obtain subsidies if they buy insurance from the exchange, a situation that is referred to as the "coverage gap." This coverage gap creates the possible discontinuities of the worker's value function in the sense that there may be the possible jump of the value of employed workers without ESHI around 138% of FPL. Again, one can deal with this discontinuty by adjusting the smoothing paramter σ_{SUB} and check the robustness of the results. Based on our extensive investigation, we do not find that this will create a significant numerical error.

insurance options. Consistent with the data, our model also finds the substantial increase in both individual and Medicaid coverages. The only difference is that in the data, ESHI rate increased, while our model predicts a slight decrease of ESHI from 70.3% to 68.5%. This discrepancy, however, likely reflects the impact of the fact that the unemployment rate (shown in the last row of Table 19) decreased in the data from 11.6% in 2012 to 8.0% in 2015. Overall, we think our model captures the major changes resulting from the early impact of the ACA as it is implemented in 2015.

[Insert Table 19 About Here]

8.3.2 Evaluating Health Care Reform Proposals

In this section, we present counterfactual simulation results from several proposals to reform the ACA.

ACA without the Individual Mandate. The first reform proposal, which we refer to as "ACA without the Individual Mandate" (or, "ACA w/o IM"), corresponds to the actual case after the Tax Cut and Jobs Act of 2017, which repeals the individual mandate penalty but keeps the other components of the ACA intact, is implemented.

In Column (3) of Table 17, we report simulation results from this reform proposal, in a hypothetical environment of ACA without the individual mandate (IM), i.e. only health insurance exchange (EX), premium subsidy (Sub) and employer mandate (EM) components of ACA are implemented.

We find that, surprisingly, we find that ACA without the individual mandate would also have still significantly reduced the uninsured rate to be about 11.4%, which is about 4.8 percentage points higher than under the ACA, but still represent close to 9.9 percentage points reduction from the 21.3% uninsured rate predicted in the benchmark.

The reason for the sizeable reduction in the uninsured rate despite the absence of individual mandate is the generous premium subsides stipulated under the ACA. Individuals are risk averse so they would like to purchase insurance if the amount of premium they need to pay out of pocket is sufficiently small, which is true for workers in low-wage firms that do not offer health insurance. Thus, even in the absence of the individual mandate penalty, low-wage workers in firms not offering ESHI will continue to buy insurance from the exchange with premium subsidy. In unreported results, we know that the workers who decide to forego health insurance when the individual mandate is repealed, tend to be those who work in firms with medium-wages and who are healthy. These account for the 1.4 percentage points decline in the individual insurance coverage under "ACA w/o IM" relative to the full ACA. Because those who decided to go uninsured when there is no individual mandate are precisely those who are healthy, their absence in the exchange exacerbates the adverse selection problem, leading to a substantial increases in the premium in the exchange (from $1,500 under the ACA to $1,750 in "ACA w/o IM").

Column (3) also shows that repealing the individual mandate of the ACA will result in a substantial reduction of the fraction of firms who offer ESHI, especially for firms with fewer than 50 workers. The reason is very simple: in our model firms are trying to attract workers by offering compensation packages that are valuable to the workers; in the absence of individual mandate, offering ESHI becomes less valuable to the workers than under the full ACA. Note, however, the average wages of workers increase when there is no individual mandate penalty, particularly in firms not offering ESHI.

ACA without Employer Mandate. The second reform proposal is ACA without the employer mandate ("ACA w/o EM"). The employer mandate in the ACA has been very contentious. The Obama

Administration has twice delayed its implementation. The first delays exempted all firms from the employer mandate penalty in 2014; the second delay exempts all employers with 50 to 99 workers from the employer mandate penalty in 2015.[90] What would happen if the employer mandate component is eliminated from the ACA? This would roughly correspond to a health care system in the spirit of what is implemented in Netherlands and Switzerland where individuals are mandated to purchase insurance from the private insurance market, employers are not required to offer health insurance to their workers, and government subsides health care for the poor on a graduated basis.[91]

In Column (4) of Table 17, we report the results from the counterfactual experiment "ACA w/o EM". We find that, surprisingly, such a system without employer mandate only slightly increases the uninsured rate relative to the full version of ACA. We find that the uninsured rate under this "ACA w/o EM" system would be about 7.5%, just 0.9 percentage point higher than the 6.6% uninsured rate predicted under the full ACA. The reasons for the somewhat surprising finding are as follows. First, eliminating the employer mandate decreases the ESHI offer rate of large firms and the large firms tend to be the firms paying higher wages. Since the willingness to pay for health insurance is higher for high income individuals, partly because of the individual mandate penalty, the employees in large firms that do not offer ESHI are likely to purchase health insurance from the exchange, thus offsetting the effect from the reduction of ESHI offering rate on the uninsured rate. Note that, when the large firms reduce their ESHI offering rate in the absence of employer mandate penalty, it has a ripple effect on the small firms' incentives to offer ESHI as well. There are two reasons for this. First, the adverse selection problem faced by the smaller firms offering ESHI is somewhat exacerbated when the larger firms offer ESHI at a lower rate. Second, the workers in the larger firms tend to be healthier, so their purchase of insurance from the exchange tends to lower the premium in the exchange, everything else equal. Because of these forces, the smaller firms' ESHI offering rate is also slightly reduced under "ACA w/o EM." However, the reduction in the ESHI offering rate is nearly compensated by the increase in the insurance purchase from the exchange – which likely will result in more premium subsidy by the government – and increase in the utilization of spousal insurance. In equilibrium, the premium in the exchange stays almost identical to that under the full ACA.

ACA without Premium Subsidy. The issue of whether the U.S. Internal Revenue Service may permissibly promulgate regulations to extend tax-credit subsidies to insurance coverage purchased through exchanges established by the federal government under Section 1321 of the Patient Protection and Affordable Care Act is the focus of the U.S. Supreme Court case, *King v. Burwell*. More recently, there has been many political activities, which in principle lower the subsidies through the exchange and Medicaid. Whether subsidies matter also depend on how employers may respond: whether they increase the coverage, which may depend on the choice of individual or employer mandate.

In Column (5) of Table 17, we report the results when we evaluate the ACA *sans* the income-based premium subsidies, dropping both subsidies in EX and Medicaid expansion. Relative to the full ACA results reported in Columns (2), the uninsured rate is much larger, at 15.7%. Essentially no one participates in the health insurance exchange without premium subsidy due to adverse selection.[92] These results demonstrate that the proposed premium subsidies are *crucial* to solve adverse selection problem in the insurance

[90]See http://obamacarefacts.com/obamacare-employer-mandate/

[91]Strictly speaking, the Swiss health care system expressly forbids employers from providing basic social health insurance as a benefit of employment, though employers can provide supplemental health insurance to their workers. See Fijolek (2012, p.8) for a descriptioin.

[92]Note that the fraction of the population in individual insurance market is tiny, thought it is not literally zero, due to the preference shock for insurance purchase (see Section 3.1).

exchange and contribute importantly to the substantial reduction of uninsured rate achieved under the full ACA. Moreover, we find that employers respond to the non-functioning of the health insurance exchange by offering ESHI at a much higher rate, both for large and small firms.

8.3.3 Assessing the Effects of the Components of the ACA and the ESHI

In Table 20 we report several counterfactual experiments that would allow us to understand the effects of the various components of the ACA. We also investigate the role of the ESHI under the ACA by completely shutting down the ESHI.

[Insert Table 20 About Here]

Health Insurance Exchange Only. In Columns (1) of Table 20, we report the equilibrium of the economy which differs from the benchmark economy only in that we replace the individual health insurance market in the benchmark with the ACA-style health insurance exchange (EX). The ACA-style health insurance exchange differs from the individual insurance market in the benchmark in terms of pricing regulation, so that it is community rating under EX, and the loading factor is now 0.25 instead of 0.69 as estimated in the benchmark economy. It turns out, having an ACA-style exchange alone does little to the uninsured rate in equilibrium: the equilibrium uninsured rate under this counterfactual is only slightly lower relative to the benchmark economy (19.1% vs. 21.3% in the benchmark as in Column 1 of Table 17). Interestingly, EX will have almost no participants at all due to the adverse selection problem; the four-month premium in the exchange is $4,250, more than 2.8 times the premium level under the full ACA. In other words, only replacing the risk-rated individual health insurance market in the pre-ACA benchmark by a community rated health insurance exchange (albeit one with a much lower loading cost) essentially eliminates the private individual insurance option for those who do not receive ESHI. This effect, somewhat perversely, incentivizes larger firms to offer ESHI at a much higher rate: the ESHI offering rate for firms with more than 50 workers increase from 93.5% in the benchmark to 98.0% in the "EX" counterfactual. As a result, more workers obtain ESHI either from their own or their spouses' employers, resulting in a slight reduction in the overall uninsured rate.

Health Insurance Exchange with Premium Subsidy. In Column (2) of Table 20, we report the results when we introduce health insurance exchange (EX) *and* health insurance premium subsidies (Sub). It shows that the introduction of premium subsidies and exchange leads to a sizable reduction in the uninsured rate to about 12.9%. The exchange is quite active that 10.7% of individuals now obtain health insurance from there. However, without employer mandate, the introduction of exchange and premium subsides also lead to a reduction in the probabilities of firms, particularly the large firms, offering ESHI to their workers: the fraction of firms with 50 or more workers offering ESHI is now 82.8% in contrast to 98.9% under the full ACA as reported in Column (2) of Table 17. Without the individual mandate, the health insurance exchange is also subject to more severe adverse selection with healthy individuals who are not eligible for much of premium subsidy opting to be uninsured. This drives up the equilibrium four-month premium in the exchange to $1,747, which represents a 16 percent increase from the $1,502 premium predicted under the full ACA (again, reported in Column (2) of Table 17).

Health Insurance Exchange with Individual Mandate. In Column (3) of Table 20, we report the equilibrium results when we introduce health insurance exchange and individual mandate. As in the

"EX only" case in Column (1), adding individual mandate but no premium subsidy, the health insurance exchange will almost have no participants: the equilibrium premium in the EX is even higher than the willingness to pay for insurance for the unhealthy individuals. This indicates that the proposed individual mandate alone, at least at the current levels of penalty, is not large enough to solve the adverse selection problem in the insurance exchange. Instead, the individual mandate leads more employers to offer health insurance: the ESHI offering rate for firms with less than 50 workers increases from 46.9% under "EX" to 51.3% under "EX+IM", and that for firms with 50 or more workers rises from 98.0% to 99.0%. As a result, uninsured rate is 15.8% in Column (3), which represents a 3.3 percentage point decrease from Column (1). The fact that the ESHI offering rates increase in this experiment, which imposes individual mandate but not employer mandate, is interesting in itself; and it is a result of the fact that competition among firms for workers will result in an internalization of workers' higher demand for insurance due to individual mandate in firms' behavior in equilibrium models. Here individual mandate increases the value of ESHI to workers, which makes ESHI offering a more effective instrument to compete for workers, and in turns leading more firms to offer ESHI in equilibrium.

Health Insurance Exchange with Employer Mandate. In Column (4) of Table 20, we report the results when we introduce the health insurance exchange and employer mandate into the benchmark economy. We again find that the exchange is essentially not active. There is a reduction of the uninsured rate, from 21.3% in the benchmark to 18.6% in Column (4), but the declines of the uninsured rate are mostly due to the increased probability of offering ESHI by firms with 50 or more workers.

No Employer Sponsored Health Insurance Market. Finally, in Column (6) of Table 20, we investigate the effects of *eliminating* employer sponsored health insurance market. This is an interesting exercise as U.S. is the only industrialized nation in which employers are the main source of health insurance for the working age population. In Column (6), we report the results from an experiment where we *prohibit* firms from offering ESHI, but instead we introduce the health insurance exchange, individual mandate and premium subsidies as stipulated in the ACA.[93] We find that disallowing ESHI would lead to drastic increases of uninsured rate; in fact, our model predicts that the uninsured rate would reach 38.7%, which is roughly more than 50% as large as the one in the benchmark economy. Insurance premium in exchange is $1,596 per four months, about 6 percent higher than the $1,502 level under the full ACA. It thus indicates that if there is no employer sponsored health insurance market, the proposed subsidies and individual mandate penalty under the ACA are not large enough to induce individuals to participate in insurance exchange. Our result also suggests that, interestingly, ESHI in fact complements, instead of hinders, the smooth operations of the health insurance exchange.

8.3.4 Role of Tax Exemption of ESHI Premium

Given the growing federal deficits in the United States, reducing tax expenditures - tax exemption for ESHI premium being one of the major tax expenditure categories – has been mentioned in several prominent reports.[94] In this section, we describe the results from counterfactual experiments where the tax exemption status of employer-sponsored health insurance premium is eliminated, both under the benchmark model and under the ACA. We implement this counterfactual as follows. Suppose that a worker works for a firm

[93] Of course, as a result of disallowing employer sponsored health insurance, we have to drop the employer mandate of the ACA.

[94] See, for example, National Commission on Fiscal Responsibility and Reform (2010).

that pays wage w and incurs an actuarially fair health insurance premium R, we let the after-tax income of the worker to be $T(w+R)-R$ when R is not exempted from personal income tax. In contrast, with tax exemption of ESHI premium, the worker's after tax income would have been $T(w)$, where $T(\cdot)$ is as specified in (6). In addition, firms' payroll tax τ_p in (36) will also be applied to the health insurance premium $m^1_{\chi\mathbf{h}}$.[95]

[Insert Table 21 About Here]

Columns (1) and (3) of Table 21 report the same simulation results for the benchmark and the ACA as reported in Columns (1) and (2), respectively, of Table 17 under the current tax exemption status for ESHI premium. In Column (2), we remove the tax exemption for ESHI under the benchmark economy. We find that removing the tax exemption increase the uninsured rate from 21.3% to 31.8%. The removal of ESHI premium exemption does significantly reduce the fraction of firms that offer ESHI; this effect is particularly strong for firms with 50 or more workers, whose ESHI offering rate decreases from 93.5% under the benchmark with tax exemption to 61.7% under no exemption. This, of course, is a result of the fact that workers in large firms are in higher income tax brackets.[96]

In Column (4), we remove the tax exemption for ESHI under the ACA. We find that removing the tax exemption increase the uninsured rate from 6.6% to 12.4%. Eliminating tax exemption for ESHI again has strong negative effect on the ESHI offering rates, both for small and large firms. Notice that as firms decrease ESHI offering, more workers purchase insurance from the exchange.[97]

Overall, our findings show that eliminating the tax exemption status for ESHI premium will increase the uninsured rate, both under the benchmark and under the ACA, but the elimination of the tax exemption of ESHI premium does *not* lead to the collapse of the ESHI. In fact, in Table 21, we report that even without the tax exemption for ESHI premium, a substantial fraction of the firms will choose to offer health insurance to their workers, both in the benchmark economy and under the ACA. In the benchmark economy, we find that 32.6% of the firms will still offer health insurance to their workers when ESHI premium is no longer exempt from income taxation. Similarly, 34.2% of the firms will offer health insurance to their workers under the ACA when ESHI premium is not exempt from income taxation. There are several reasons that firms have strong incentives to offer health insurance to their workers in our economy. First, workers are risk averse and firms are risk neutral; thus firms can enjoy the risk premium by offering health insurance to their workers. Second, health insurance improves health and healthy workers are more productive. Thus firms, particularly those with higher productivity, will have incentives to offer health insurance to their workers so that their workforce will be healthier and thus more productive. This mechanism is illustrated in Table 2.

In Panel C of Table 21, we also report the implications of removing tax exemption on government expenditures. Under the ACA with exemption, we find that the *net per capita government expenditure*,

[95] The analogous expression for (36) in this counterfactual is now:

$$\Pi_1(p) = \max_{\left\{w^1_H, w^1_U\right\}} \Pi\left(w^1_H, w^1_U, E=1\right) \equiv \sum_{\chi} \sum_{h^0_1 \in \mathcal{H}_1} \sum_{\mathbf{h} \in \mathcal{H}} \left[p d_{\chi\mathbf{h}} - (1+t_p)\left(w^1_{h^0_1} + m^1_{\chi\mathbf{h}}\right)\right] n_{\chi\mathbf{h}}\left(\mathbf{w}^1_{h^0_1}, 1\right) - C,$$

[96] It is important to note that this analysis is carried out by assuming that the spousal insurance premium and insurance offer rate is fixed as in the benchmark economy. As in the post-ACA analysis, we can endogenize them. However, the result is largely unchanged. These results are available from the authors upon request.

[97] Note that the model predicts the fraction of individuals with their own ESHI decreases, while the fraction with spousal ESHI coverage increases. As firms' ESHI offering rate is reduced, the supply for spousal ESHI is lowered, but the take-up rate of spousal ESHI increases. The latter effect dominates the former in the counterfactual experiment.

which includes the tax expenditure due to the exemption, the premium subsidy and individual/employer mandate penalties, is about \$500 (\$200 + \$310 − \$10 = \$500); under the ACA without tax exemption, it is reduced to about \$450 (\$470 − \$20 = \$450). This is a decline of \$50 per capita per four months, which translates to about \$150 per capita per year. Also, note that average worker utility under the ACA without tax exemption is actually *higher* that under the benchmark economy with tax exemption. Removing tax exemption does have a negative effect of firms' average profit, around 0.3% $[(1.227 - 1.223)/1.223 \approx 0.3\%]$ in the benchmark; and around 0.89% $[(1.241 - 1.230)/1.241 \approx 0.89\%]$ under the ACA.

9 Conclusion

We present and empirically implement an equilibrium labor market search model where risk averse workers facing medical expenditure shocks are matched with employers making health insurance coverage decisions. The distributions of wages, health insurance provisions, employer size, employment and worker's health are all endogenously determined in equilibrium. We estimate our model using various micro data sources including the panel of the Survey of Income and Program Participation, the Medical Expenditure Panel Survey and the Kaiser Family Employer Health Insurance Benefit Survey. The equilibrium of our estimated model is largely consistent with the dynamics of the workers' labor market experience, health, health insurance and medical expenditure, as well as the distributions of employer sizes in the data.

We use our estimated model to examine the impact of the key components of the 2010 Affordable Care Act (ACA), including the individual mandate, the employer mandate, the insurance exchange and the income-based insurance premium subsidy, as well as various alternative designs which are central to the current policy debates. We also demonstrate that our model is able to quantitatively account for an early impact of the ACA seen in the data.

We find that the implementation of the full version of the ACA would significantly reduced the uninsured rate from about 21.3% in the pre-ACA benchmark economy to 6.6% under the ACA. This large reduction of the uninsured rate is mainly driven by low-wage workers participating in Medicaid or in the insurance exchange with their premium supported by the income-based subsidies. We find that income-based premium subsidies for health insurance purchases from the exchange and Medicaid expansion play an important role for the sustainability of the ACA; if the subsidies were removed from the ACA, the insurance exchange will suffer from severe adverse selection problem so it is not active at all, and the uninsured rate would be around 15.8%.

We find that the ACA would also have achieved significant reduction in the uninsured rate if its individual mandate component were removed. We find in our simulation that under "ACA without individual mandate", the uninsured rate would be 11.4%, significantly lower than the 21.3% under the benchmark. The Medicaid expansion and the exchange premium subsidy component of the ACA would covered all the unemployed (healthy or unhealthy) and the low-wage employed (again both healthy and unhealthy). Interestingly, we find that employer mandate does not seem to be an essential feature of the ACA; under ACA *without* employer mandate, the uninsured rate would be about 7.5%, just slightly higher than that under the full ACA. If both individual and employer mandates were removed from the ACA, the uninsured rate would be around 12.9% as long as the ACA components of Medicaid expansion, premium subsidies and health insurance exchanges with community rating stayed intact.

We also simulate the effects of removing the tax exemption for employer-sponsored health insurance (ESHI) premium both under the benchmark and under the ACA. We find that, while the removal of the tax exemption for ESHI premium would reduce, but not eliminate the incentives of firms, especially the larger ones, offering health insurance to their workers; the overall effect on the uninsured rate is modest: we find that the uninsured rate would increase from 21.3% to 31.8% when the ESHI tax exemption is removed in the benchmark economy; and it will increase from 6.6% to 12.4% under the ACA. Finally, we find that prohibiting firms from offering ESHI in the post-ACA environment would lead to a large increase in the uninsured rate, which suggests that ESHI complements, instead of hinders, smooth operations of the health insurance exchange.

We should emphasize that our paper is only a first step toward understanding the mechanism through which the ACA, and more generally any health insurance reform, may influence labor market equilibrium. We estimated our model using a selected sample of individuals with relatively homogeneous skills (with no more than high school graduation between ages 26-46), and thus our quantitative findings may only be valid for this population. Thus the quantitative results we present in this paper should be understood with these qualifications in mind. However, we believe that the various channels we uncovered in this paper through which components of ACA interact with the labor market and with each other are of importance even in richer models.

There are many areas for future research. First, it will be important to introduce richer worker heterogeneity in the equilibrium labor market model; it is also important to endogenize health care decisions, and incorporate workers' life-cycle considerations (see Aizawa (2017) for an attempt in these directions where he studies the optimal design of health insurance system in the labor market sorting equilibrium). Second, while our paper characterizes rich demographic heterogeneity, we do not fully characterize the joint household labor supply decisions. Fang and Shephard (2018b) consider how the ACA may change the behavior of both workers and firms, takings into account the joint labor supply. Third, there are many additional channels through which firms and workers might have responded to individual mandates and employer mandates that we abstracted in this paper; for example, firms may change their choices of production technology in response to the ACA, which could be interpreted as a form of labor market regulations (see Fang and Shephard (2018a) for an attempt). Similarly, firms may change the composition of part-time and full-time workers in response to the ACA. Finally, in this paper we partially incorporated Medicaid by modeling its availability probabilistically, but did not model the endogenous asset accumulation. Incorporating endogenous asset accumulation to model Medicaid eligibility more realistically will be an important but challenging area of research.

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	Benchmark	$\widehat{C}=0$	$\widehat{\pi^1_{\chi\mathbf{h'h}}=\pi^0_{\chi\mathbf{h'h}}}$	$\widehat{\gamma_\chi}=0.5\gamma_\chi$	$\widehat{d_{U_1}}=1.00$	$\widehat{d_{U_1}}=1.00$ & Same Labor Market Frictions	No Adverse Selection
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Labor Market Statistics							
Fraction of Firms Offering ESHI	0.525	0.558	0.395	0.409	0.404	0.401	0.575
... if firm size is at least 50	0.935	0.953	0.619	0.626	0.844	0.636	0.864
...if firm size is less than 50	0.480	0.516	0.370	0.379	0.356	0.373	0.543
unemployment rate	0.079	0.079	0.082	0.084	0.079	0.074	0.078
Average Wages of Employed	0.989	0.988	0.977	1.026	1.025	1.052	1.029
... among firms offering ESHI	1.070	1.061	1.028	1.097	1.136	1.115	1.085
... among firms not offering ESHI	0.798	0.792	0.928	0.958	0.864	0.985	0.864
B. Distribution of Health Insurance Status							
Uninsured	0.213	0.200	0.315	0.349	0.258	0.298	0.151
ESHI	0.595	0.620	0.433	0.410	0.504	0.456	0.639
Individual insurance	0.034	0.031	0.040	0.028	0.049	0.047	0.070
Medicaid	0.050	0.048	0.056	0.050	0.053	0.049	0.045
Spousal insurance	0.108	0.101	0.156	0.164	0.135	0.150	0.095
C. Fraction of Individuals with Healthy Observable Component in Each Insurance Status							
Uninsured	0.942	0.942	0.892	0.947	0.941	0.919	0.973
ESHI	0.945	0.945	0.898	0.945	0.945	0.942	0.945
Individual insurance	0.821	0.819	0.928	0.634	0.841	0.933	0.853
Medicaid	0.914	0.914	0.852	0.905	0.914	0.929	0.921
Spousal Insurance	0.928	0.928	0.883	0.927	0.928	0.928	0.934
D. Fraction of Workers with Healthy Unobservable Component in Each Insurance Status							
Uninsured	0.495	0.498	0.506	0.511	0.491	0.506	1.000
ESHI	0.519	0.518	0.508	0.513	0.516	0.506	1.000
Individual insurance	0.981	0.982	0.961	1.000	0.957	0.927	1.000
Medicaid	0.407	0.407	0.410	0.409	0.406	0.409	1.000
Spousal Insurance	0.461	0.461	0.476	0.471	0.464	0.474	1.000

Table 1: Predictions of the Baseline Model: Benchmark and Comparative Statistics.

Notes: (1). The benchmark (Column (1)) predictions are based on the parameter estimates reported in Section 7. (2). The average wages (4 month) are in units of \$10,000. (3). In Column (2), we assume that the fixed administrative cost of offering health insurance is zero. (4). In Column (3), we assume that the health transition process for the insured is the same as that of the uninsured. (4). In Column (4), we assume that the CARA coefficients are half of their gender-specific estimated value. (5). In Column (5), we assume that health does not affect productivity. In Column (6), we assume that health does not affect productivity and the labor market friction parameters, i.e., the labor market friction parameters for unhealthy workers are the same as those for healthy workers. In Column (7), we assume that there is no adverse selection, by setting all workers' unobserved health component as healthy.

Statistics	Low Productivity Firms		High Productivity Firms	
	ESHI	No ESHI	ESHI	No ESHI
A. Steady-State Distribution of Health Status				
[1] Fraction Observed Unhealthy in Steady State	0.0558	0.0703	0.0511	0.0570
[2] Fraction Unobserved Unhealthy in Steady State	0.5061	0.4557	0.4074	0.3920
B. Adverse Selection Effect				
[3] Fraction of Unobserved Unhealthy Among New Hires	0.4530	0.4240	0.3953	0.4032
C. Health Improvement of Health Insurance (Observed Health Status)				
[4] One-Period Ahead Fraction of Unhealthy Among New Hires	0.0576	0.0629	0.0543	0.0570
[5] Nine-Period Ahead Fraction of Unhealthy Among New Hires	0.0536	0.0786	0.0518	0.0638
D. Retention Effect				
[6] Job-to-Job Transition Rate for Observed Healthy Workers	0.01884	0.02038	0.00021	0.00039
[7] Job-to-Job Transition Rate for Observed Unhealthy Workers	0.00081	0.01512	0.00001	0.00057

Table 2: Understanding Why High-Productivity Firms Are More Likely to Offer Health Insurance than Low Productivity Firms.

Notes: For the simulations reported in this table, the low-productivity and high productivity firms are the firms with the bottom 20% and top 20% of productivity in our discretized productivity distribution support.

Variable	All		Male		Female		Single		Married		Without Child		With Child	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
A. Distribution of Insurance Status														
Uninsured	0.257	0.437	0.294	0.456	0.212	0.409	0.325	0.469	0.214	0.410	0.299	0.458	0.237	0.425
ESHI	0.510	0.500	0.558	0.497	0.451	0.498	0.543	0.498	0.489	0.500	0.572	0.495	0.480	0.500
Individual Insurance	0.019	0.138	0.018	0.131	0.022	0.145	0.018	0.132	0.020	0.141	0.025	0.155	0.017	0.129
Medicaid	0.077	0.266	0.045	0.208	0.115	0.319	0.114	0.318	0.053	0.224	0.035	0.184	0.096	0.295
Spousal Insurance	0.137	0.344	0.085	0.279	0.202	0.401	0.000	0.000	0.223	0.416	0.069	0.253	0.170	0.376
B. Fraction of Individuals with Healthy Observed Component in Each Insurance Status														
Average	0.923	0.267	0.925	0.263	0.920	0.272	0.905	0.293	0.933	0.249	0.919	0.273	0.924	0.265
Uninsured	0.911	0.284	0.917	0.276	0.901	0.299	0.900	0.300	0.922	0.268	0.897	0.304	0.920	0.271
ESHI	0.942	0.234	0.943	0.233	0.941	0.236	0.925	0.263	0.954	0.210	0.935	0.246	0.946	0.227
Individual Insurance	0.926	0.263	0.971	0.171	0.882	0.327	0.917	0.282	0.932	0.255	0.893	0.315	0.950	0.221
Medicaid	0.810	0.393	0.773	0.421	0.882	0.327	0.825	0.381	0.791	0.408	0.775	0.423	0.817	0.388
Spousal Insurance	0.934	0.249	0.909	0.289	0.947	0.225	n/a	n/a	0.934	0.249	0.962	0.194	0.928	0.258
C. Average Income (4 month) in Each Insurance Status (in $10,000)														
Average	0.953	0.452	1.061	0.468	0.805	0.383	0.868	0.420	1.006	0.463	0.949	0.433	0.955	0.461
Uninsured	0.731	0.343	0.813	0.359	0.561	0.226	0.698	0.331	0.763	0.351	0.739	0.338	0.727	0.346
ESHI	1.088	0.449	1.182	0.466	0.945	0.378	0.996	0.421	1.151	0.457	1.047	0.428	1.112	0.459
Individual Insurance	0.903	0.534	1.049	0.560	0.735	0.456	0.770	0.551	0.978	0.516	0.877	0.566	0.923	0.516
Medicaid	0.595	0.304	0.736	0.368	0.512	0.221	0.552	0.252	0.653	0.356	0.601	0.307	0.594	0.304
Spousal Insurance	0.915	0.429	1.152	0.425	0.772	0.363	n/a	n/a	0.915	0.429	0.986	0.450	0.901	0.423
Fraction Employed	0.940	0.238	0.962	0.191	0.912	0.284	0.930	0.254	0.945	0.227	0.940	0.237	0.939	0.239

Table 3: Summary Statistics: SIPP 2004.

Variable Names	All				Male				Female			
	MEPS (1)		SIPP (2)		MEPS (1)		SIPP (2)		MEPS (1)		SIPP (2)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Fraction of Healthy (Observed) Workers	0.879	0.326	0.923	0.267	0.894	0.307	0.925	0.263	0.862	0.345	0.920	0.272
Fraction of Uninsured	0.322	0.467	0.257	0.437	0.345	0.476	0.294	0.456	0.294	0.456	0.212	0.409
Average Annual Medical Expenditure ($10,000)	0.218	0.851			0.168	0.831			0.277	0.871		
... among insured and (observed) healthy	0.221	0.614			0.161	0.521			0.289	0.697		
... among uninsured and (observed) healthy	0.068	0.320			0.055	0.363			0.088	0.245		
... among insured and (observed) unhealthy	0.708	2.284			0.710	2.515			0.707	2.074		
... among uninsured and (observed) unhealthy	0.249	0.982			0.242	1.149			0.256	0.781		

Table 4: Summary Statistics: Comparison between MEPS 2001-2007 and SIPP 2004.

Variable Names	Mean	Std. Dev.
Average Firm Size	21.020	54.542
... for those that offer ESHI	29.961	68.577
... for those that do not offer ESHI	7.909	12.325
Fraction of Firms Offering ESHI	0.595	0.491
... among firms with less than 50 workers	0.569	0.495
... among firms with more than 50 workers	0.934	0.247
Fraction of employees with annual salaries $21,000 or less	0.21	0.31
... for those that offer ESHI	0.12	0.23
... for those that do not offer ESHI	0.32	0.36
Fraction of employees with annual salaries $50,000 or more	0.23	0.28
... for those that offer ESHI	0.27	0.29
... for those that do not offer ESHI	0.18	0.26

Table 5: Summary Statistics: Kaiser 2004-2007.

		Male		Female		Children		
	Parameter	Estimate	Std. Err.	Estimate	Std Err.	Parameter	Estimate	Std. Err.
	Panel A: Parameters in Equation (41)							
$\alpha_{m\chi}^{\tilde{h}_1,\tilde{x}}$:	$\tilde{h}_1 = H_1, \tilde{x} = 1$	-1.3404	(0.0218)	-0.9179	(0.0156)	$1(\tilde{x} = 1)$	-0.8280	(0.4762)
	$\tilde{h}_1 = U_1, \tilde{x} = 1$	-1.6405	(0.0751)	-0.3487	(0.0336)			
	$\tilde{h}_1 = H_1, \tilde{x} = 0$	-2.5369	(0.0375)	-2.0467	(0.0288)	$1(\tilde{x} = 0)$	0.0971	(1.5698)
	$\tilde{h}_1 = U_1, \tilde{x} = 0$	-1.1457	(0.0261)	-1.0000	(0.0346)			
$\zeta_{1m\chi}$	$1\left(\tilde{h}_2 = U_2\right)$	1.9504	(0.0857)	1.5498	(0.0483)			
	Panel B: Parameters in Equation (42)							
$\beta_{m\chi}^{\tilde{h}_1,\tilde{x}}$:	$\tilde{h}_1 = H_1, \tilde{x} = 1$	-4.2380	(0.0197)	-4.9455	(0.0103)	$1(\tilde{x} = 1)$	-4.4614	(0.909)
	$\tilde{h}_1 = U_1, \tilde{x} = 1$	-3.6970	(0.0356)	-5.3239	(0.013)			
	$\tilde{h}_1 = H_1, \tilde{x} = 0$	-5.4492	(0.0258)	-6.2975	(0.0139)	$1(\tilde{x} = 0)$	-4.5638	(2.2295)
	$\tilde{h}_1 = U_1, \tilde{x} = 0$	-4.1777	(0.0258)	-5.6968	(0.0235)			
$\sigma_{\chi\mathbf{h}}^{\hat{x}}$:	$\tilde{h}_1 = H_1, \tilde{x} = 1$	1.7462	(0.0028)	1.4918	(0.0033)	$1(\tilde{x} = 1)$	1.8996	(0.3721)
	$\tilde{h}_1 = U_1, \tilde{x} = 1$	1.9167	(0.0015)	1.9679	(0.0015)			
	$\tilde{h}_1 = H_1, \tilde{x} = 0$	1.9511	(0.0055)	1.7363	(0.0047)	$1(\tilde{x} = 0)$	2.0716	(1.1646)
	$\tilde{h}_1 = U_1, \tilde{x} = 0$	1.5823	(0.0054)	1.7712	(0.0133)			
$\zeta_{2m\chi}$	$1\left(\tilde{h}_2 = U_2\right)$	1.5423	(0.0398)	2.5641	(0.0143)			
	Panel C: Parameters in Equation (50)							
$\alpha_{s0\chi}$	Constant	-1.4243	(0.0073)	-1.2362	(0.0102)			
$\alpha_{s1\chi}$	$1(h_{1t} = H_1)$	0.2416	(0.0152)	0.7439	(0.0188)			
$\alpha_{s2\chi}$	$1(\hat{x}_t = 1)$	2.5631	(0.0224)	1.5718	(0.0189)			
$\alpha_{s3\chi}$	$1(\hat{x}_t = 1 \wedge h_{1t} = H_1)$	-2.6907	(0.042)	-1.1935	(0.0324)			

Table 6: Step 1 Parameter Estimates for the Medical Expenditure Processes for Adults.
Note: See Eqs. (3) and (4) for details of the medical expenditure processes. The unit of medical expenditure is $10,000.

Parameter	Male		Female	
	Estimate	Std. Err.	Estimate	Std. Err.
Panel A: Health Transition Parameters in $\pi^1_{\chi h_1 h'_1}$				
$\pi^1_{\chi H_1 H_1}$	0.9788	(0.0231)	0.9799	(0.0217)
$\pi^1_{\chi U_1 U_1}$	0.5696	(0.1671)	0.7142	(0.1813)
Panel B: Health Transition Parameters in $\pi^0_{\chi h_1 h'_1}$				
$\pi^0_{\chi H_1 H_1}$	0.9740	(0.0350)	0.9673	(0.0494)
$\pi^0_{\chi U_1 U1}$	0.7018	(0.2040)	0.7983	(0.1999)

Table 7: First Step Parameter Estimate for the Health Transitions (5), by Gender and Health Insurance Status.

Parameter Descriptions	Estimate	Std. Err.
Panel A: Labor Market Frictions		
Job Offer Arrival Rate for Unemployed $\lambda_u^{\chi\mathbf{h}}$ *[Eq. 43]:*		
Constant: λ_{u0}	0.016	(0.0041)
$1(h_1 = U_1)$: λ_{u1}	-0.200	(0.0097)
1(Female):λ_{u2}	-0.646	(0.0024)
1(HasChildren): λ_{u3}	0.018	(0.0021)
1(Married): λ_{u4}	0.033	(0.002)
Job Offer Arrival Rate for Employed $\lambda_e^{\chi\mathbf{h}}$ *[Eq. 44]:*		
Constant: λ_{e0}	-1.370	(0.0098)
$1(h_1 = U_1)$: λ_{e1}	-0.173	(0.0204)
1(Female): λ_{e2}	-1.297	(0.0064)
1(HasChildren): λ_{e3}	-0.348	(0.003)
1(Married): λ_{e4}	0.102	(0.0041)
Job Destruction Rate $\delta^{\chi\mathbf{h}}$ *[Eq. 45]*:		
Constant: δ_0	-2.851	(0.0011)
$1(h_1 = U_1)$: δ_1	0.806	(0.0054)
1(Female): δ_2	-0.031	(0.0092)
1(HasChildren): δ_3	-0.101	(0.0032)
1(Married): δ_4	-0.698	(0.0052)
Panel B: Risk Aversion Parameters γ_χ [E-4]		
Male	3.708	(0.0292)
Female	4.878	(0.0017)
Panel C: Flow Consumption of Unemployed b_χ		
Single Man	0.017	(0.0022)
Married Man without Children	0.018	(0.0053)
Married Man with Children	0.017	(0.0026)
Single Women without Children	0.019	(0.001)
Single Women with Children	0.018	(0.0012)
Married Women without Children	0.022	(0.0009)
Married Women with Children	0.018	(0.0005)

Table 8: Parameter Estimate from Step 2.

Parameter Descriptions	Estimate	Std. Err.
Panel D: Preference Shocks		
Standard Deviation of Preference Shock to Work: $\sigma_{\chi w}$	0.165	(0.0067)
Standard Deviation of Preference Shock to Private Insurance: $\sigma_{\chi II}$	0.002	(0.01)
Panel E: Firm-Side Parameters		
Productivity Effect of Bad Health: d_{U_1}	0.401	(0.0117)
Location Parameter of Firm Productivity Distribution: μ_p	-0.288	(0.0035)
Scale Parameter of Firm Productivity Distribution: σ_p	0.579	(0.0006)
Mean of Fixed Cost of Offering ESHI: C	0.275	(0.7469)
Smoothing Parameter of the Fixed Cost of Offering ESHI: σ_f	0.150	(0.0192)
Panel F: Other Parameters		
Worker Size: M	21.436	(0.2267)
Loading Factor in Pre-ACA Individual Insurance Market: ξ_{II}	0.690	(0.0046)
Consumption Floor: $\underline{c}_\chi$	0.005	(0.0022)
Medicaid Eligibility Probability for the Employed $f_M^e(\chi, y)$ [Eq. 47]:		
1(HasChildren): α_{m0}^e	1.010	(0.0174)
1(NoChildren): α_{m1}^e	-2.947	(0.7771)
Income: α_{m2}^e	2.528	(0.0142)
Income^2: α_{m3}^e	1.325	(0.0124)
Medicaid Eligibility Probability for the Unemployed $f_M^u(\chi)$ [Eq. 48]:		
1(HasChildren): α_{m0}^u	1.391	(0.049)
1(NoChildren): α_{m1}^u	-3.466	(0.1699)

Table 8: Parameter Estimate from Step 2, Continued.

Obs. Health/HI	Mean of Expenditure		Variance of Expenditure		Fraction with Zero Expenditure	
	Data	Model	Data	Model	Data	Model
			A. Male			
$(h_1 = U_1, \hat{x} = 0)$	0.174	0.171	0.352	0.352	0.337	0.333
$(h_1 = U_1, \hat{x} = 1)$	1.093	1.117	11.707	11.707	0.109	0.108
$(h_1 = H_1, \hat{x} = 0)$	0.048	0.044	0.091	0.091	0.608	0.612
$(h_1 = H_1, \hat{x} = 1)$	0.153	0.155	0.149	0.149	0.273	0.276
			B. Female			
$(h_1 = U_1, \hat{x} = 0)$	0.196	0.198	0.179	0.179	0.211	0.209
$(h_1 = U_1, \hat{x} = 1)$	0.860	0.846	6.519	6.519	0.023	0.025
$(h_1 = H_1, \hat{x} = 0)$	0.080	0.073	0.058	0.058	0.384	0.391
$(h_1 = H_1, \hat{x} = 1)$	0.286	0.294	0.515	0.515	0.107	0.101
			C. Children			
$(\hat{x} = 0)$	0.064	0.064	0.061	0.061	0.337	0.337
$(\hat{x} = 1)$	0.140	0.140	0.336	0.336	0.108	0.108

Table 9: Cross-Sectional Fit for Medical Expenditure: Model vs. Data.

Note: The unit of medical expenditure is $10,000 at the annual level.

Obs. Health/HI in Years t and t'	Covariance of Medical Expenditure Over Two Years		Fraction of Zero Medical Expenditures Over Two Years	
	Data	Model	Data	Model
A. Male				
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 0 \\ h_{1t'} = U_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.050	0.049	0.211	0.200
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.012	0.014	0.284	0.306
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 1 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.161	0.098	0.057	0.059
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.004	0.004	0.484	0.475
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.015	0.013	0.270	0.261
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 1 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.037	0.041	0.144	0.147
B. Female				
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 0 \\ h_{1t'} = U_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.055	0.049	0.099	0.104
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.014	0.015	0.167	0.161
$\begin{pmatrix} h_{1t} = U_1, \hat{x}_{1t} = 1 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.025	0.057	0.021	0.015
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 0 \end{pmatrix}$	0.003	0.004	0.248	0.244
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 0 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.000	0.010	0.104	0.102
$\begin{pmatrix} h_{1t} = H_1, \hat{x}_{1t} = 1 \\ h_{1t'} = H_1, \hat{x}_{2t'} = 1 \end{pmatrix}$	0.046	0.029	0.035	0.043

Table 10: Time Series Fit for Medical Expenditure: Model vs. Data.

Note: The unit of medical expenditure is $10,000 at the annual level.

	Male		Female	
	Data	Model	Data	Model
Panel A: Insured Throughout the Year				
Healthy to Healthy	0.963	0.938	0.956	0.941
Unhealthy to Unhealthy	0.172	0.185	0.386	0.364
Panel B: Uninsured Throughout the Year				
Healthy to Healthy	0.949	0.924	0.943	0.905
Unhealthy to Unhealthy	0.222	0.346	0.556	0.509

Table 11: Fit for Annual Health Transitions of Observed Health Component by Gender and Insurance Status: Model vs. Data.

Demographic Type	Obs. Health	Uninsured		ESHI		Ind. Private HI		Medicaid		Spousal Ins.	
		Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
A: Employed Individuals											
Single Men	Healthy	0.061	0.056	0.110	0.110	0.004	0.008	0.004	0.000	0.000	0.000
	Unhealthy	0.005	0.001	0.007	0.006	0.000	0.003	0.001	0.000	0.000	0.000
Married Men w/o Child	Healthy	0.010	0.007	0.029	0.035	0.001	0.001	0.001	0.000	0.008	0.005
	Unhealthy	0.000	0.000	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Married Men w/ Child	Healthy	0.066	0.037	0.164	0.188	0.004	0.004	0.010	0.007	0.032	0.031
	Unhealthy	0.004	0.001	0.008	0.009	0.000	0.001	0.002	0.000	0.004	0.002
Single Women w/o Child	Healthy	0.013	0.016	0.039	0.030	0.001	0.004	0.002	0.000	0.000	0.000
	Unhealthy	0.002	0.002	0.004	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Single Women w/ Child	Healthy	0.023	0.027	0.052	0.054	0.001	0.005	0.019	0.008	0.000	0.000
	Unhealthy	0.002	0.003	0.005	0.004	0.000	0.001	0.002	0.001	0.000	0.000
Married Women w/o Child	Healthy	0.005	0.005	0.027	0.027	0.001	0.001	0.000	0.000	0.011	0.008
	Unhealthy	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.001
Married Women w/ Child	Healthy	0.024	0.021	0.080	0.117	0.005	0.004	0.006	0.006	0.059	0.040
	Unhealthy	0.003	0.002	0.003	0.008	0.000	0.001	0.002	0.001	0.003	0.003
Panel B: Unemployed Individuals											
Single Men	Healthy	0.008	0.017			0.000	0.000	0.001	0.001	0.000	0.000
	Unhealthy	0.002	0.001			0.000	0.000	0.000	0.000	0.000	0.000
Married Men w/o Child	Healthy	0.002	0.001			0.000	0.000	0.000	0.000	0.001	0.001
	Unhealthy	0.001	0.000			0.000	0.000	0.000	0.000	0.000	0.000
Married Men w/ Child	Healthy	0.003	0.002			0.000	0.000	0.001	0.006	0.001	0.005
	Unhealthy	0.001	0.000			0.000	0.000	0.002	0.000	0.001	0.000
Single Women w/o Child	Healthy	0.002	0.008			0.000	0.000	0.001	0.000	0.000	0.000
	Unhealthy	0.001	0.001			0.000	0.000	0.001	0.000	0.000	0.000
Single Women w/ Child	Healthy	0.004	0.003			0.000	0.000	0.006	0.012	0.000	0.000
	Unhealthy	0.000	0.000			0.000	0.000	0.002	0.001	0.000	0.000
Married Women w/o Child	Healthy	0.001	0.001			0.000	0.000	0.001	0.000	0.002	0.002
	Unhealthy	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000
Married Women w/ Child	Healthy	0.007	0.001			0.000	0.000	0.002	0.005	0.011	0.008
	Unhealthy	0.000	0.000			0.000	0.000	0.001	0.001	0.001	0.001

Table 12: Cross-Sectional Distribution of the Employed (Panel A) and the Unemployed (Panel B) by Demographic Types, Observed Health and Health Insurance Status: Model vs. Data.

		Uninsured		ESHI		Ind. Private HI		Medicaid		Spousal Ins.	
Demographic Type	Obs. Health	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
Single Men	Healthy	0.785	0.770	1.082	1.076	0.939	0.979	0.566	0.607	N/A	N/A
	Unhealthy	0.746	0.729	1.000	1.036	0.856	0.793	0.813	0.571	N/A	N/A
Married Men w/o Child	Healthy	0.756	0.823	1.247	1.177	1.061	1.026	0.568	0.632	1.105	0.850
	Unhealthy	1.065	0.759	1.047	1.155	N/A	0.867	0.823	0.595	1.698	0.826
Married Men w/ Child	Healthy	0.844	0.846	1.245	1.159	1.170	1.098	0.804	0.664	1.168	0.841
	Unhealthy	0.920	0.766	1.244	1.144	N/A	0.936	0.745	0.643	1.075	0.825
Single Women w/o Child	Healthy	0.598	0.719	0.920	0.921	0.446	0.785	0.528	0.580	N/A	N/A
	Unhealthy	0.604	0.718	0.692	0.872	0.608	0.710	0.356	0.557	N/A	N/A
Single Women w/ Child	Healthy	0.541	0.736	0.915	0.936	0.403	0.905	0.547	0.606	N/A	N/A
	Unhealthy	0.429	0.750	0.765	0.907	N/A	0.791	0.481	0.596	N/A	N/A
Married Women w/o Child	Healthy	0.641	0.754	0.970	0.989	0.878	0.829	0.351	0.598	0.891	0.768
	Unhealthy	0.406	0.747	0.886	0.963	0.486	0.761	N/A	0.574	0.237	0.749
Married Women w/ Child	Healthy	0.551	0.770	0.993	0.969	0.873	0.892	0.460	0.623	0.757	0.758
	Unhealthy	0.615	0.774	0.874	0.950	0.522	0.811	0.403	0.610	0.706	0.749

Table 13: Cross-Sectional Wage Distribution by Demographic Types and Health Insurance Status: Model vs. Data.

Note: The unit of wage is $10,000 at the 4-month level.

	Obs. Health	Data	Model
Panel A: Unemployment to Employment Transition			
	Healthy	0.48	0.41
	Unhealthy	0.38	0.34
Panel B: Employment to Unemployment Transition			
From Jobs without ESHI to Unemp.	Healthy	0.03	0.04
	Unhealthy	0.10	0.08
From Jobs with ESHI to Unemp.	Healthy	0.01	0.03
	Unhealthy	0.01	0.07
Panel C: Job-to-Job Transition			
From Jobs w/o ESHI to Jobs w/ ESHI	Healthy	0.07	0.02
	Unhealthy	0.01	0.02
From Jobs w/o ESHI to Jobs w/o ESHI	Healthy	0.07	0.02
	Unhealthy	0.09	0.01
From Jobs w/ ESHI to Jobs w/ ESHI	Healthy	0.01	0.01
	Unhealthy	0.00	0.01
From Jobs w/ ESHI to Jobs w/o ESHI	Healthy	0.05	0.01
	Unhealthy	0.04	0.01

Table 14: Workers' Labor Market Transitions by Observed Health Status: Model vs. Data.

	Data	Model
Average Firm Size	21.020	20.748
Fraction of Firms with Fewer than 50 Workers	0.929	0.903
ESHI Offering Rate for Firms with Fewer than 10 Workers	0.467	0.446
ESHI Offering Rate for Firms with 10-30 Workers	0.744	0.452
ESHI Offering Rate for Firms with 30-50 Workers	0.862	0.678
ESHI Offering Rate for Firms with More than 50 Workers	0.934	0.935

Table 15: Employer-Side Moments: Model vs. Data.

	Data	Model
All Population	0.074	0.072
Male Only	0.054	0.063
Female Only	0.092	0.096

Table 16: Mean Four-Month Medical Expenditure: Model (predicted in the steady-state equilibrium) vs. Data (MEPS)

The unit of medical expenditure is $10,000 at the 4-month level.

	Benchmark	ACA	ACA w/o IM	ACA w/o EM	ACA w/o Premium Subsidy
	(1)	(2)	(3)	(4)	(5)
Labor Market Statistics:					
Fraction of Firms Offering ESHI	0.525	0.459	0.419	0.438	0.564
... if firm size is at least 50	0.935	0.989	0.965	0.918	0.998
...if firm size is less than 50	0.480	0.400	0.357	0.383	0.515
Unemployment Rate	0.079	0.079	0.079	0.079	0.078
Average Wages of the Employed	0.989	0.992	0.997	0.995	0.969
... among firms offering ESHI	1.070	1.110	1.126	1.109	1.045
... among firms not offering ESHI	0.798	0.766	0.798	0.797	0.701
Distribution of Health Insurance Status:					
Uninsured	0.213	0.066	0.114	0.075	0.157
ESHI	0.595	0.580	0.536	0.555	0.681
Individual Insurance	0.034	0.112	0.098	0.121	0.000
Medicaid	0.050	0.099	0.102	0.101	0.037
Spousal Insurance	0.108	0.143	0.150	0.147	0.125
Premium in EX ($10,000)	N/A	0.150	0.175	0.151	0.419

Table 17: Counterfactual Policy Experiments: Key Statistics under the Benchmark Model, the ACA and Other Health Care Reform Proposals.

	Low-Productivity Firms		High-Productivity Firms	
	ESHI	No ESHI	ESHI	No ESHI
Fraction of Unhealthy (Unobserved) among New Hires	0.443	0.434	0.400	0.402

Table 18: Adverse Selection Effect under the ACA: Low Productivity vs. High Productivity Firms.

	Data		Model	
	Pre-ACA (2012)	ACA (2015)	Pre-ACA (2004-2007)	ACA (2015)
Uninsured	0.386	0.280	0.213	0.119
ESHI	0.480	0.521	0.703	0.685
Individual Insurance	0.037	0.071	0.034	0.118
Medicaid	0.097	0.127	0.050	0.078
Unemployment Rate	0.116	0.080	0.079	0.079

Table 19: The Early Impact of the ACA: Model vs Data.

Note: In this table, we define the ESHI as the fraction of individuals who have ESHI either through their own employers or through their spouses. We make this choice because the ACS data does not distinguish whether the source of ESHI coverage is one's own or spousal ESHI.

	EX	EX+Sub	EX+IM	EX+EM	No ESHI EX+Sub+IM
	(1)	(2)	(3)	(4)	(5)
Labor Market Statistics:					
Fraction of Firms Offering ESHI	0.521	0.410	0.562	0.523	0.000
... if firm size is at least 50	0.980	0.828	0.990	0.996	0.000
...if firm size is less than 50	0.469	0.362	0.513	0.469	0.000
Unemployment Rate	0.080	0.079	0.078	0.080	0.080
Average Wages of the Employed	0.986	1.001	0.969	0.986	1.045
... among firms offering ESHI	1.077	1.116	1.046	1.078	N/A
... among firms not offering ESHI	0.745	0.845	0.707	0.733	1.045
Distribution of Health Insurance Status:					
Uninsured	0.191	0.129	0.158	0.186	0.387
ESHI	0.632	0.507	0.680	0.639	0.000
Individual Insurance	0.000	0.107	0.000	0.000	0.427
Medicaid	0.041	0.104	0.037	0.040	0.184
Spousal Insurance	0.136	0.153	0.126	0.135	0.002
Premium in EX ($10,000)	0.425	0.175	0.426	0.414	0.160

Table 20: Counterfactual Policy Experiments: Evaluation of Various Components of the ACA, and No ESHI.

	Benchmark		ACA	
	Exempt	No exempt	Exempt	No exempt
	(1)	(2)	(3)	(4)
A. Labor Market Statistics				
Fraction of Firms Offering ESHI	0.525	0.326	0.459	0.342
... if firm size is at least 50	0.935	0.617	0.989	0.842
...if firm size is less than 50	0.480	0.290	0.400	0.278
Unemployment Rate	0.079	0.081	0.079	0.080
Average Wages of the Employed	0.989	1.013	0.992	1.014
... among firms offering ESHI	1.070	1.130	1.110	1.186
... among firms not offering ESHI	0.798	0.919	0.766	0.839
B. Distribution of Health Insurance Status				
Uninsured	0.213	0.318	0.066	0.124
ESHI	0.595	0.383	0.580	0.429
Individual Insurance	0.034	0.072	0.112	0.182
Medicaid	0.050	0.057	0.099	0.115
Spousal insurance	0.108	0.169	0.143	0.150
C. Worker's Utility, Government Expenditure and Revenues				
Average Worker Utility (CEV, $10,000)	0.597	0.598	0.611	0.603
Average Firm Profit ($10,000)	1.227	1.223	1.241	1.230
Average Tax Subsidies to ESHI	0.021	0.000	0.020	0.000
Average Exchange/Medicaid subsidies	0.003	0.004	0.031	0.047
Revenue from Penalties	0.000	0.000	0.001	0.002

Table 21: Counterfactual Policy Experiments: Evaluating the Effects of Eliminating the Tax Exemption for EHI Premium under the Benchmark and the ACA.

Online Appendix
(Not Intended for Publication)

A Numerical Algorithm to Solve the Equilibrium of the Benchmark Model

In this appendix, we describe the numerical algorithm used to solve the equilibrium of the benchmark model in Section 4.

1. **(Discretization of Productivity).** Discretize the support of productivity $[\underline{p}, \overline{p}]$ into N finite points $\{p_1, ..., p_N\}$, and calculate the probability weight of each $p \in \{p_1, ..., p_N\}$ using $\Gamma(p)$.[1]

2. **(Initialization).** Provide an initial guess of the wage policy functions and the health insurance offer probability $\left(\mathbf{w}^{0,0}_{h_1^0}(p), \mathbf{w}^{1,0}_{h_1^0}(p), \Delta^0(p)\right)$ for all $p \in \{p_1, ..., p_N\}$.

3. **(Iterations).** At iteration $\iota = 0, 1, ...$, do the following sequentially, where we index the objects in iteration ι by superscript ι :

   (a) Given the current guess of the wage policy function and the health insurance offer probability $\left(\mathbf{w}^{0,\iota}_{h_1}(p), \mathbf{w}^{1,\iota}_{h_1}(p), \Delta^\iota(p)\right)$, use (38) and (39) to construct the offer distributions $\mathbf{F}^\iota_{h_1}(w_{h_1}, E)$.

   (b) Using $\mathbf{F}^\iota_{h_1}(w_{h_1}, E)$, numerically solve for the worker's optimal strategy $\left\langle \tilde{z}^{\chi\mathbf{h}}_u(\tilde{w}_{h_1}, \tilde{E}), \underline{w}^{\tilde{E}}_{\chi\mathbf{h}}(\tilde{w}_{h_1}, E(x)), \tilde{z}^{\chi\mathbf{h}}_{e1}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x)), \tilde{z}^{\chi\mathbf{h}}_{e2}(w_{h_1^0}, E(x), \mathbf{h}), \tilde{v}^{\chi\mathbf{h}}_u, \tilde{v}^{\chi\mathbf{h}}_e(w_{h_1}) \right\rangle$ as described in Section 3.3.2; calculate the value functions $\tilde{U}_{\chi\mathbf{h}}$ and $V_{\chi\mathbf{h}}(w_{h_1}, E)$. Moreover, calculate $V_{\chi\mathbf{h}}(w, E)$ for $w \in \mathcal{W}$, where $\mathcal{W}$ is the discrete set of potential wage choices.

   (c) For different insurance source $x \in \{0, 1, ..., 4\}$, calculate the unemployment rate $u^\iota_{\chi\mathbf{h}}(x)$ and the employment distribution $e^{x,\iota}_{\chi\mathbf{h}} s^{x,\iota}_{\chi\mathbf{h}}(w^{E(x),\iota}_{h_1}(p))$ for all $p \in \{p_1, ..., p_N\}$ by solving functional fixed point equations (21), (25) and (31);[2]

   (d) Calculate $n^\iota_{\chi\mathbf{h}}\left(w^{E,\iota}_{h_1^0}(p), E\right)$ and $n^\iota\left(w^{E,\iota}_{h_1^0}(p), E\right)$ for all p by respectively using (32) and (33). Moreover, calculate $n^\iota_{\chi\mathbf{h}}(w, E)$ and $n^\iota(w, E)$ for all $w \in \mathcal{W}$;

   (e) Update the firm's optimal policy $\left(\mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{1,*\iota}_{h_1^0}(p)\right)$ for all p using (35) and (36);[3]

   (f) Given $\left(\mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{1,*\iota}_{h_1^0}(p)\right)$, calculate $\Pi^{*\iota}_0(p)$ and $\Pi^{*\iota}_1(p)$ from (35) and (36) and obtain $\Delta^{*\iota}(p)$ by using (37).

4. **(Convergence Criterion)**

[1] See Kennan (2006) for a discussion about the discrete approximation of the continuous distributions. In our empirical application, we set $N = 150$; and set $p_1 = 0.5$ and $p_N = 6$. Although this choice should be arbtitrary, we choose it so that the profit from hiring a worker who are initially unhealthy net of the health insurance cost for the lowest productivity firm remains the positive. Otherwise, one must consider the threshold firm productivity where the firms with the productivity belows the threshold may only hire initially healthy workers. This creates additional technical complications which may not be central issues for our focus. We also experimented with $N = 200$, 250 and the results are similar.

[2] Although we do not have a proof that the unique fixed point exists, we always find a unique solution regardless of the initial guesses of $u_{\chi\mathbf{h}}(x)$ and $e^x_{\chi\mathbf{h}} s^x_{\chi\mathbf{h}}(w^{E(x)}_{h_1}(p))$.

[3] For firms with the lowest productivity, we utilize the grid search to find the optimal wage policy. For other firms, we use the numerical shortcut in the updating of $\left\langle \mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{1,*\iota}_{h_1^0}(p) \right\rangle$ using the equations derived in Proposition 4.

(a) If $(\mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{1,*\iota}_{h_1^0}(p), \Delta^{*\iota}(p))$ satisfies $\mathrm{d}(\mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{0,\iota}_{h_1^0}(p)) < \epsilon_{tol}$, $\mathrm{d}(\mathbf{w}^{1,*\iota}_{h_1^0}(p), \mathbf{w}^{1,\iota}_{h_1^0}(p)) < \epsilon_{tol}$ and $\mathrm{d}(\Delta^{*\iota}(p), \Delta^{\iota}(p)) < \epsilon_{tol}$, where ϵ_{tol} is a pre-specified tolerance level of convergence and $\mathrm{d}(\cdot,\cdot)$ is a distance metric, then firm's optimal policy converges and we have an equilibrium.

(b) Otherwise, update $(\mathbf{w}^{0,\iota+1}_{h_1^0}(p), \mathbf{w}^{1,\iota+1}_{h_1^0}(p), \Delta^{\iota+1}(p))$ as follows:

$$\begin{aligned} \mathbf{w}^{0,\iota+1}_{h_1^0}(p) &= \omega \mathbf{w}^{0,\iota}_{h_1^0}(p) + (1-\omega)\mathbf{w}^{0,*\iota}_{h_1^0}(p), \\ \mathbf{w}^{1,\iota+1}_{h_1^0}(p) &= \omega \mathbf{w}^{1,\iota}_{h_1^0}(p) + (1-\omega)\mathbf{w}^{1,*\iota}_{h_1^0}(p), \\ \Delta^{\iota+1}(p) &= \omega \Delta^{\iota}(p) + (1-\omega)\Delta^{*\iota}(p), \end{aligned} \tag{A1}$$

for $\omega \in (0,1)$ and continue Step 3 at iteration $\iota' = \iota + 1$.

Given our convergence criterion, it is clear that the convergence point of our numerical algorithm will correspond to a steady state equilibrium of our model.

The numerical shortcut we use for the updating in Step (3e) is the following:

Proposition 4. *For each p, optimal wage policy must satisfy*

$$w^{1*}_{h_1^0}(p) = \frac{\sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[\left(pd_{\chi\mathbf{h}} - m^1_{\chi\mathbf{h}}\right) n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(\underline{p}), 1 \right) \right] - \int_{\underline{p}}^{p} \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[d_{\chi\mathbf{h}} n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(\tilde{p}), 1 \right) \right] d\tilde{p} - \Pi_{1,h_1^0}\left(\underline{p}\right)}{(1+\tau_p) \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(\underline{p}), 1 \right)} \tag{A2}$$

$$w^{0*}_{h_1^0}(p) = \frac{\sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[pd_{\chi\mathbf{h}} n_{\chi\mathbf{h}} \left(w^{0*}_{h_1^0}(\underline{p}), 0 \right) \right] - \int_{\underline{p}}^{p} \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[d_{\chi\mathbf{h}} n_{\chi\mathbf{h}} \left(w^{0*}_{h_1^0}(\tilde{p}), 0 \right) \right] d\tilde{p} - \Pi_{0,h_1^0}(\underline{p})}{(1+\tau_p) \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} n_{\chi\mathbf{h}} \left(w^{0*}_{h_1^0}(\underline{p}), 0 \right)}. \tag{A3}$$

where $\underline{p}$ is the lower bound of the productivity distribution support, and

$$\Pi_{1,h_1^0}(p) = \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[pd_{\chi\mathbf{h}} - (1+\tau_p) w^{1*}_{h_1^0}(p) - m^1_{\chi\mathbf{h}} \right] n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(p), 1 \right), \tag{A4}$$

$$\Pi_{0,h_1^0}(p) = \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[pd_{\chi\mathbf{h}} - (1+\tau_p) w^{0*}_{h_1^0}(p) \right] n_{\chi\mathbf{h}} \left(w^{0*}_{h_1^0}(p), 0 \right). \tag{A5}$$

Proposition 4 is similar to that in Bontemps, Robin, and Van den Berg (2000). To prove (A2), we use the definition of $\Pi_{1,h_1^0}(p)$ as defined by (A4) and apply the Envelope Theorem to get:

$$\Pi'_{1,h_1^0}(p) = \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[d_{\chi\mathbf{h}} n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(p), 1 \right) \right]$$

for $p > \underline{p}$. Taking integral over $[\underline{p}, p]$ and applying the boundary condition $\Pi_{1,h_1^0}\left(\underline{p}\right)$, we have the following expression for $\Pi_{1,h_1^0}(p)$:

$$\Pi_{1,h_1^0}(p) = \int_{\underline{p}}^{p} \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[d_{\chi\mathbf{h}} n_{\chi\mathbf{h}} \left(w^{1*}_{h_1^0}(\tilde{p}), 1 \right) \right] d\tilde{p} + \Pi_{1,h_1^0}\left(\underline{p}\right). \tag{A6}$$

Now equating the right hand sides of (A4) and (A6), we obtain (A2). Analogously, (A3) is obtained by applying the Envelope Theorem on $\Pi_{0,h_1^0}(p)$.

In Step (3e), we obtain the $\left(\mathbf{w}^{0,*\iota}_{h_1^0}(p), \mathbf{w}^{1,*\iota}_{h_1^0}(p))\right)$ by plugging $\left(\mathbf{w}^{0,\iota-1}_{h_1^0}(p), \mathbf{w}^{1,\iota-1}_{h_1^0}(p)\right)$ on the left hand sides of (A2) and (A3) respectively.

B Sample Classification in MEPS

To construct the data moments for medical expenditure, we need to classify each individual into different health and health insurance categories. In the MEPS data, we observe individuals' health insurance status at the monthly frequency, and the observable component of the health status at the semi-annual frequency, and the medical expenditure is observed at the annual frequency.

While there are several alternative approaches to classify the data in order to estimate the medical expenditure processes described by (41) and (42), we decide to conduct the analysis at the annual frequency because of the fact that the medical expenditure is observed at the annual frequency in the data. We classify the observed health status at the semi-annual frequency and health insurance at the monthly frequency at the annual level. We adopt the following classification scheme.

For observed component of the health status, which is recorded semi-annually in the data, we let the observed health component of period 1 of the year (the first four-months) corresponds to the observed health status at the first month of the year; that of period 2 of the year (the second four-months) corresponds to the observed health status at the seventh month of the year; and that of period 3 of the year (the third four-months) corresponds to the observed health status at the first month of the next year. With is classification at the period level, we then classify that an individual has healthy (or unhealthy) observed health component in the year if he/she is healthy (or unhealthy, respectively) in at least two out of the three periods of the year.

Similarly, for health insurance status, which is observed at the monthly frequency. we first construct the insurance status at each four-month period. We assume that an individual's health insurance status and source in the first period of the year corresponds to that recorded for January; second period corresponds to May; third period corresponds to September. With this classification at the period level, we then classify that an individual is insured in this year if he/she has health insurance in least two out of three periods of the year. Otherwise, he/she is considered uninsured in the year.

C Steady State Equilibrium of the Counterfactual Economy

The steady state equilibrium for the post-ACA economy is somewhat more involved in the sense that we need to describe the equilibrium premium in health insurance exchange, as well as the equilibrium spousal insurance offer rate and premium. Formally, a *steady state equilibrium in the post-ACA economy* is a list of objects, for all χ and $\mathbf{h} \in \mathcal{H}$,

$$\left\langle \begin{array}{c} \left(\tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}), \underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(\tilde{w}_{h_1}, E(x)\right), \tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x)), \tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E\left(x\right)), \tilde{v}_u^{\chi\mathbf{h}}, \tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})\right), \\ \left(u_{\chi\mathbf{h}}\left(x\right), e_{\chi\mathbf{h}}^x, S_{\chi\mathbf{h}}^x(w_{h_1})\right), \left(\mathbf{w}_{h_1^0}^{*0}\left(p\right), \mathbf{w}_{h_1^0}^{*1}\left(p\right), \Delta\left(p\right)\right), \mathbf{F}_{h_1}\left(w_{h_1}, E\right), R^{EX}, R^{SP}, f_{SP}(\chi_g) \end{array} \right\rangle,$$

such that the following conditions hold:

- **(Worker Optimization)** Given $\mathbf{F}_{h_1}\left(w_{h_1}, E\right)$ and the flow utility function updated in (54), for each χ and $\mathbf{h} \in \mathcal{H}$,
  - an unemployed type-χ worker with health status $\mathbf{h}$ will
    - accept a job offer (w_{h_1}, E) if and only if $\epsilon_{\chi w} \leq \tilde{z}_u^{\chi\mathbf{h}}(w_{h_1^0}, E)$, as described by (13);
    - purchase individual health insurance if and only if $\epsilon_{\chi II} \leq \tilde{v}_u^{\chi\mathbf{h}}$, as described by (14), if he/she does not receive spousal health insurance and Medicaid.

– if a type-χ worker with health status $\mathbf{h}$ who is currently employed at a job $\left(w_{h_1^0}, E\right)$ receives an on-the-job offer $\left(\tilde{w}_{h_1}, \tilde{E}\right)$, he/she will:

  * switch to job $\left(\tilde{w}_{h_1}, \tilde{E}\right)$ if and only if $\tilde{w}_{h_1} > \underline{w}_{\chi\mathbf{h}}^{\tilde{E}}\left(w_{h_1^0}, E(x)\right)$ and $\epsilon_{\chi w} \leq \tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x))$, as described by (16) and (17);
  * quit into unemployment if $\epsilon_{\chi w} > \tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x))$, as described by (17);
  * stay at the current job $\left(w_{h_1^0}, E\right)$, otherwise.

– if a type-χ worker with health status $\mathbf{h}$ who is currently employed at a job $\left(w_{h_1^0}, E\right)$ does not receive an on-the-job offer, he/she will stay at the current job instead of quitting into unemployment if and only if $\epsilon_w \leq \tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E(x))$, as described by (18).

– A type-χ worker with health status $\mathbf{h}$ employed on a job $(w_{h_1}, E = 0)$ will purchase private individual health insurance if and only if $\epsilon_{\chi II} \leq \tilde{v}_e^{\chi\mathbf{h}}(w_{h_1})$, as described by (19), if he/she does not receive spousal health insurance and Medicaid.

- **(Steady State Worker Distribution)** Given $\mathbf{F}_{h_1}(w_{h_1}, E)$ and workers' optimizing behavior described by $\Big\langle \tilde{z}_u^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}), \underline{w}_{\chi\mathbf{h}}^{\tilde{E}}(\tilde{w}_{h_1}, E(x)), \tilde{z}_{e1}^{\chi\mathbf{h}}(\tilde{w}_{h_1}, \tilde{E}, w_{h_1^0}, E(x))$ $\tilde{z}_{e2}^{\chi\mathbf{h}}(w_{h_1^0}, E(x)), \tilde{v}_u^{\chi\mathbf{h}}, \tilde{v}_e^{\chi\mathbf{h}}(w_{h_1}), \left(u_{\chi\mathbf{h}}(x), e_{\chi\mathbf{h}}^x, S_{\chi\mathbf{h}}^x(w_{h_1})\right)\Big\rangle$, satisfy the steady state conditions described by (21), (25), and (31);

- **(Firm Optimization)** Given $\mathbf{F}_{h_1}(w_{h_1}, E)$ and the steady state employee sizes implied by $\left(u_{\chi\mathbf{h}}, e_{\chi\mathbf{h}}^x, S_{\chi\mathbf{h}}^x(w_{h_1})\right)$, a firm with productivity p chooses to offer health insurance with probability $\Delta(p)$ where $\Delta(p)$ is given by (37). Moreover, conditional on insurance choice E, the firm offers a wage $\mathbf{w}_{h_1^0}^{*E}(p)$ that solves (55) and (56) respectively for $E \in \{0, 1\}$.

- **(Equilibrium Consistency)** The postulated distributions of offered compensation packages are consistent with the firms' optimizing behavior $\left(\mathbf{w}_{h_1}^{*E}(p), \Delta(p)\right)$. Specifically, $\mathbf{F}_{h_1}(w_{h_1}, E)$ must satisfy:

$$F_{h_1}(w_{h_1}, 1) = \int_0^\infty \mathbf{1}(w_{h_1}^{*1}(p) < w)\Delta(p)d\Gamma(p), \tag{C7}$$

$$F_{h_1}(w_{h_1}, 0) = \int_0^\infty \mathbf{1}(w_{h_1}^{*0}(p) < w)\left[1 - \Delta(p)\right]d\Gamma(p). \tag{C8}$$

- **(Equilibrium Condition in Insurance Exchange)** The premium in exchange is determined so as to satisfy (57).

- **(Equilibrium Spousal Insurance)** The premium and the offer rate of spousal health insurance are given by in exchange is determined so as to satisfy (59) and (58).

C.1 Numerical Algorithm for Counterfactual Experiments

We now briefly explain how to numerically solve the steady state equilibrium of the post-ACA economy. There are two necessary adjustments from the numerical algorithm described in Appendix A for the benchmark economy. First, we need to solve the equilibrium insurance premiums: R^{EX} for the insurance exchange and R^{SP} for the spousal insurance, as well as the equilibrium spousal insurance offer probabilities of $f_{SP}(\chi_g)$. In each iteration, we also update $\left(R^{EX}, R^{SP}, f_{SP}(\chi_g)\right)$ based on the break-even conditions (57) and (59) and the employment distribution (58).

The second necessary adjustment is to account for the size-dependent employer mandate. We need to modify Step 3(e) of the numerical algorithm described in Appendix A for the benchmark economy, in particular, the iteration of the wage policies, $\mathbf{w}^{0,*\iota}_{h_1^0}(p)$, for firms not offering ESHI, to account for the presence of size-dependent employer mandate penalties.

The modified Step 3(e) is as follows:[4] For iteration $\iota = 0, 1, 2, \ldots.$

(3e-i). For the wage policies $\mathbf{w}^{0,*\iota}_{h_1^0}(\underline{p})$ of the firms with lowest productivity $\underline{p}$, we solve the profit maximization based on the grid search as in the benchmark model.

(3e-ii). For firms whose size predicted in Step 3 (d) is below 50, we solve the wage policy utilizing (A3) as in the benchmark model, because they are not subject to the employer mandate penalty.

(3e-iii). For firms whose size predicted in Step 3(d) is at least 50, we now need to deal with the employer mandate penalty. Consider the firms with the *lowest* productivity among them. We solve this firm's problem as follow:

1. First, we consider the potential profit if this firm chooses $\hat{\mathbf{w}}^{0,\iota}_{h_1^0}(p) = \left(\hat{w}^{0,\iota}_{H_1}(p), \hat{w}^{0,\iota}_{U_1}(p)\right)$ to obtain a firm size precisely below 50 (in practice, we set 49.9) so as to avoid paying the penalty. We use the grid search algorithm to choose $\hat{\mathbf{w}}^{*0,\iota}_{h_1^0}(p)$ that generates the highest profit.
2. Next, we consider the potential profit if this firm chooses $\hat{\mathbf{w}}^{0,\iota}_{h_1^0}(p) = \left(\hat{w}^{0,\iota}_{H_1}(p), \hat{w}^{0,\iota}_{U_1}(p)\right)$ that leads to a firm size more than 50 and pay employer mandate tax penalty. We use the grid search algorithm to solve the the profit maximization problem described by (55).
3. Compare the profits from (3e-iii-1) with (e-iii-2). If the former is higher, then we conclude that this firm chooses to stay below size 50; we then solve the problem for the firm with the *next* productivity level by repeating the step (3e-iii-1) and (3e-iii-2); if the latter is higher, we conclude that this firm chooses to pay the tax penalty, and we then move to the step (3e-iv) below, and record the productivity level as p^{**}.

(3e-iv). For other firms, we solve the optimal wage using the modified wage policy function, which now takes into account the employer mandate penalty:

$$w^{0*}_{h_1^0}(p) = \frac{\sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[p d_{\chi\mathbf{h}} n_{\chi\mathbf{h}}\left(w^{0*}_{h_1^0}(p^{**}), 0\right)\right] - \int_{p^{**}}^{p} \sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} \left[d_{\chi\mathbf{h}} n_{\chi\mathbf{h}}\left(w^{0*}_{h_1^0}(\tilde{p}), 0\right)\right] d\tilde{p} - \Pi_{0,h_1^0}(p^{**}) - c_{EM}}{(1+\tau_p)\sum_\chi \sum_{\mathbf{h}\in\mathcal{H}} n_{\chi\mathbf{h}}\left(w^{0*}_{h_1^0}(p^{**}), 0\right)}, \tag{C9}$$

where c_{EM} is the marginal employer mandate tax penalty and p^{**} is the maximum productivity level obtained at the step (3e-iii). The derivation of this equation is similar to the one without employer mandate penalty.

Remark 5. *One issue of having an equilibrium model with a mass point is that the prediction of the model may be affected by the number of grid points for firm productivity. We address this issue by having a fine grid for productivity levels. As in the previous version of the paper (Aizawa and Fang (2015)), one can also approximate the employer mandate as a smooth function of firm size. This could avoid removing the*

[4] This algorithm is originally developed in Aizawa (2017).

mass point around the threshold of 50. The cost of using this approximation is that, when firms choose a menu of wages contingent on observed health component, one can no longer apply the wage policy iterations (A2)-(A3) derived from the envelope conditions. The reason is that, because the employer mandate is not linear in firm size, the choice of wage policy for each observed health type should be determined jointly, as highlighted in Step (3e) above.

D Adjusting the ACA Provisions for 2011 into Applicable Formulas for the 2007 Economy

Individual Mandate Penalties. We adjust formula (60) in several dimensions. First, the \$695 amount is adjusted by the ratio of the 2007 Medical Care CPI (CPI_Med_2007) relative to the 2011 Medical Care CPI (CPI_Med_2011); this is appropriate if we believe that the amount \$695 is chosen to be proportional to the 2011 medical expenditures. We then multiply it by 1/3 to reflect the fact that the period length of our model is fourth months instead of a year. Second, we need to adjust the TFT_2011 by the ratio of 1996 CPI of all goods (CPI_All_2007) relative to the 2011 CPI of all goods (CPI_All_2011) and also multiply it by 1/3 to reflect that our income is the four-month income.[5] Finally, we need to adjust the percentage 2.5% by the differential growth rate of medical care and GDP, i.e., multiply it by the relative ratio of $\frac{\text{CPI\_Med\_2007}}{\text{CPI\_All\_2007}}$ and $\frac{\text{CPI\_Med\_2011}}{\text{CPI\_All\_2011}}$. With these adjustments, we specify the adjusted penalty associated with individual mandate appropriate for the 2007 economy as:

$$\begin{aligned} P_W(y) &= \max\left\{ \begin{array}{c} 0.025 \times \left(\frac{\text{CPI\_Med\_2007}}{\text{CPI\_All\_2007}}\right) / \left(\frac{\text{CPI\_Med\_2011}}{\text{CPI\_All\_2011}}\right) \times \left(y - \frac{1}{3}\text{TFT\_2011} \times \frac{\text{CPI\_All\_2007}}{\text{CPI\_All\_2011}}\right), \\ \frac{1}{3} \times \$695 \times \frac{\text{CPI\_Med\_2007}}{\text{CPI\_Med\_2011}} \end{array} \right\} \\ &\approx \max\left\{ \frac{0.025}{1.03} \times (y - 2,919),\ \$207 \right\}, \end{aligned} \tag{D10}$$

where y is four-month income in 2007 dollars.

Employer Mandate Penalties. We adjust formula (61) by first scaling the \$2,000 per-worker penalty using the ratio of the 2007 Medical Care CPI relative to the 2011 Medical Care CPI, and then multiply it by 1/3 to reflect our period-length of four months instead of a year, i.e.,

$$P_E(n) = \frac{1}{3} P_E^{ACA}(n) \times \frac{\text{CPI\_Med\_2007}}{\text{CPI\_Med\_2011}}, \tag{D11}$$

where $P_E^{ACA}(n)$ is given by (61).

Income-Based Premium Subsidies. We adjust the income-based premium subsidies (62) to account for the fact that in our analysis y is measured as four-month income at 2007 as follows:

$$SUB\left(y, R^{EX}\right) = \begin{cases} \max\left\{ R^{EX} - \left[0.035\Phi\left(\frac{y - \text{FPL140}}{\sigma_{SUB}}\right) + 0.06 \frac{(3y - \text{FPL138})}{\text{FPL400} - \text{FPL138}}\right] y \times \frac{\text{CPI\_Med\_2007}}{\text{CPI\_Med\_2011}},\ 0 \right\} & \text{if } y \in \left(\frac{\text{FPL138}}{3}, \frac{\text{FPL400}}{3}\right) \\ 0, & \text{otherwise.} \end{cases} \tag{D12}$$

E Tax Function Estimation

In this section, we describe how we estimate the tax function using Kaplan (2012)'s specification with our estimation samples. We restrict our samples to be those who are employed. First, we multiply the

[5] We obtain CPI data for medical care and all goods both from Bureau of Labor Statistics website: `http://www.bls.gov/cpi/data.htm`.

four-month wages y,which we directly observed in our data used in the estimation, by 3 to convert them to annual income, i.e., $Y = 3y$. Using our *after-tax income* formula $T(\cdot)$ as specified in (6), the tax payment at annual income Y is simply:

$$TAX(Y) = Y - T(Y) = Y - \tau_0 - \tau_1 \frac{Y^{(1+\tau_2)}}{1+\tau_2}.$$

In order to estimate τ_1 and τ_2, we note that

$$1 - TAX'(Y) = \tau_1 Y^{\tau_2}$$

where $TAX'(Y)$ is marginal income tax rate. Taking the logarithm, we have

$$\ln\left[1 - TAX'(Y)\right] = \ln \tau_1 + \tau_2 \ln Y.$$

To estimate τ_1 and τ_2, we regress logarithm of 1 minus the marginal tax rates for each individual in the sample on annual labor earnings. Individuals' marginal tax rates are calculated using the National Bureau of Economic Research's TAXSIM program, which includes federal income tax, state income tax, and the employee-portion of the payroll income tax. Once we obtain τ_1 and τ_2 from the above regression, we set τ_0 to the value that equates the actual average tax rate in the sample (as computed by TAXSIM) to that implied by the above equation.

After obtaining those parameter estimates $(\tau_0^*, \tau_1^*, \tau_2^*)$, we feed them in the model by adjusting the magnitude to fit the four-month income level y; specifically, the adjustment yields the following after-tax income schedule:[6]

$$T(y) = \frac{1}{3}\left[\tau_0^* + \tau_1^* \frac{(3y)^{1+\tau_2^*}}{1+\tau_2^*}\right].$$

[6]Based on the same approach, we also adjust the scale of tax function so that the unit of income is $10,000.