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, 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 Survey of Income and Program Participation, Medical Expenditure Panel Survey and Robert Wood Johnson Foundation Employer Health Insurance Survey. We use our estimated model to evaluate the equilibrium impact of the 2010 Affordable Care Act (ACA) and find that it would reduce the uninsured rate among the workers in our estimation sample from about 22.34% in the pre-ACA benchmark economy to about 3.67-3.93%. 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 18.19%. 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 7.34%, 4.63% and 9.22% respectively.

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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 will be 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 133% 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 133 percent and 400 percent of the FPL, subsidies will be provided toward

[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 would be 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]This component of the ACA was one of the core issues in the U.S. Supreme Course case 567 U.S. 2012 where twenty-six States, several individuals and the National Federation of Independent Business challenged the constitutionality of the individual mandate and the Medicaid expansion. The U.S. Supreme Court ruled on June 28, 2012 to uphold the constitutioniality of the individual mandate on a 5-to-4 decision.

[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 assume that Medicaid expansion will eventually implemented in all states under the ACA.

the purchase of health insurance from the exchanges.[8]

The goal of this paper is to present and empirically implement an equilibrium model that *integrates* the labor and health insurance markets to *quantitatively evaluate* how much the ACA will reduce the uninsured rate and understand the *mechanisms* through which health insurance reform affects the labor market equilibrium. We are also interested in using our estimated model to evaluate several variations of the ACA, some of which are of particular interests due to the legal challenges to the ACA. For example, how would the remainder of the ACA perform if its individual mandate component had been struck down by the Supreme Court? 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?

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 their employers. 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.[9] 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 which we use later in our empirical analysis, 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. 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).[10, 11] 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 we endogenize the distributions of wages and health insurance provisions, employer size, employment and worker's health. In our model workers, both males and females, observe their own health status which evolves stochastically. Workers' health status affects both their medical expenditures and their labor pro-

[8]Whether individuals in states that do not establish their own exchanges who purchase insurance from the federal health 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]Among those with private coverage from any source, about 95% obtained employment-related health insurance (see Selden and Gray (2006)).

[10]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.

[11]Dizioli and Pinheiro (2014) 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.

ductivity. Health insurance eliminates workers' out-of-pocket medical expenditure risks and affects the dynamics of their health status. In the benchmark model, we assume that workers can obtain health insurance only through employers. Both unemployed and 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 to attract workers. The cost of providing health insurance, which will be used to determine ESHI premiums, is determined by both the *gender and health* composition of its workforce and a fixed administrative cost. When deciding on what compensation packages to offer, the firms anticipate that their choice of compensation packages will affect the health composition of their workerforce 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, 1996 Panel), Medical Expenditure Panel Survey (MEPS, 1997-1999), and Robert Wood Johnson Foundation Employer Health Insurance Survey (RWJ-EHI, 1997).[12] 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 establishment level data set which contains information such as establishment 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 for the case of combinations of data sets, as proposed by Imbens and Lancaster (1994) and Petrin (2002). 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. We also use the model which is estimated using the data sets from 1996-1999 to conduct an out-of-sample prediction of the ESHI offering rate for the U.S. economy in 2004-2006 assuming that the only changes during this period was the medical expenditure processes, which we estimated using the MEPS data from 2004-2006, and the productivity distribution which we adjust using data from the Bureau of Labor Statistics. Our model is able to successfully predict a significant drop in the ESHI offering rate, which is consistent with the data.

In our empirical analysis, we find that a critical driver to explain these correlations is the positive effect of health insurance on the dynamics of health status. While it is true that firms by offering health insurance can benefit from the tax exemption of the insurance premium, they also attract unhealthy workers who both increase their health insurance costs and decrease their labor productivity – this is the standard *adverse selection* problem. This creates a potential disincentive for firms to offer health insurance. In Section 4.1, we show that in the presence of the positive effect of health insurance on health, the degree of the adverse selection problem faced by high-productivity firms offering health insurance is *less severe* than that for low-productivity firms. The reason is that, a high-productivity firm offering health insurance can poach workers from a much wider range of firms, including a larger fraction of workers who work in firms that already offer insurance and are thus healthier; in contrast, a low-productivity firm offering health insurance can only poach workers from firms with even lower productivity, many of which do not offer health insurance and thus have less healthy workers. We also show that an important effect of the ACA is that it lessens the degree of adverse selection for less productive, and thus small firms, to offer health

[12] We did not use data from more recent years because 1997 was the last year of RWJ-EHI data. Kaiser Family Foundation and The Health Research and Educational Trust (KFF/HRET) Survey on Health Benefits started in 1999, but it had very little information on incomes which is critical for our employer-side moments used in estimation (see Section 6.2.2). Nonetheless, we use our estimated model for an out-of-sample validation exercise to predict the ESHI offering rates in more recent years of 2004-2006 (see Section 7.3).

insurance to their workers.

Moreover, the adverse selection problem that firms offering health insurance suffer is attenuated over time by the *positive effect of health insurance on health*. Importantly, however, this 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*," which simply refers to the fact that high-productivity firms tend to offer higher wages 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 in the data.[13]

We use our estimated model to examine the impact of the previously-mentioned four key components of the ACA. We find that the implementation of the ACA would significantly reduce the uninsured rate among the workers in our estimation sample from 22.34% in the pre-ACA benchmark economy to about 3.67% or 3.93%, depending on whether the expanded Medicaid rolls are included in the risk pool of health insurance exchange. This large reduction of the uninsured rate is mainly driven by the unemployed (5.13% of the population) receiving Medicaid coverage due to its expansion and around 17% of the employed workers with relatively low wages participating in the insurance exchange with their premium supported by the income-based subsidies. We find that, due to the employer mandate the health insurance offering rate for firms with 50 or more workers increases from 92.03% in the benchmark to 98.67% under the ACA; however, the health insurance offering rate for firms with less than 50 workers decreases from 55.40% in the benchmark to 46.05% 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, 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. Overall, we find that there is a small reduction in the fraction of employed workers receiving ESHI, from 82.17% in the benchmark to 79.15% under the ACA.

We also investigate the effect of the ACA if its individual mandate component were removed, a scenario that would have resulted had the Supreme Court ruled the individual mandate unconstitutional (see Footnote 5). We find that a significant reduction in the uninsured rate would also have been achieved: the uninsured rate in our simulation under "ACA without individual mandate" would be 7.34%, significantly lower than the 22.34% 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 18.19% from the 22.34% in the benchmark.

Interestingly, we find that, under a policy of "ACA without the employer mandate," the uninsured rate would be 4.63%, just slightly higher than the uninsured rate under the full ACA. Without the employer mandate on firms with 50 or more workers, small firms increase their ESHI offering rate, and individuals

[13] In fact, we will show in Table 19 that, due to these effects, the incentives for firms, even the more productive ones, to offer health insurance is only slightly reduced in a counterfactual environment where the tax exemption of ESHI premiums is eliminated.

without ESHI also have stronger incentives to purchase insurance from the exchange.

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 22.34% to 35.10% when the ESHI tax exemption is removed in the benchmark economy; and it will increase from 3.67% to 6.05% 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 and discuss sources of identification of some of the key model parameters; in Section 5, we describe the data sets used in our empirical analysis; in Section 6, we explain our 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.[14] 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).[15] However, because a worker/vacancy match is the unit of analysis in Dey and Flinn (2005), their model is not designed to address the relationship between firm size and wage/health insurance provisions, which is important to understand the size-dependent employer mandate in the ACA. Moreover, in Dey and Flinn (2005), workers' health status and health expenditures are not explicitly modeled, and firms' heterogenous costs of offering health insurance are also exogenous. In our paper, we explicitly incorporate workers' health and health expenditures, and endogenize health insurance costs and premium. We believe these features are essential to assess the general equilibrium effects of the ACA on population health, health expenditures and health insurance premiums.

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 an employee's health, generating under-investment in health during working years and increasing medical expenditures during retirement. We advance their insights by showing that in an equilibrium model of labor market, it also reduces the adverse selection problem for high-productivity firms relative to low-productivity firms, which helps explain why high-productivity firms have a stronger incentives to provide health insurance to their workers. Moreover, our primary focus is about health insurance coverage provision

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

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

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 (2012a); Hackmann, Kolstad, and Kowalski (2012); Kolstad and Kowalski (2012b) 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 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.[16] 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 market policies on labor market outcomes. Among this literature, our study is mostly related to Shephard (2012) 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 (2012), wage and formal/informal sector in Meghir, Narita, and Robin (2015), and wage and health insurance offering in our paper. However, in Shephard (2012) 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,

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

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 gender is denoted by $g \in \{1, 2\}$ where $g = 1$ and 2 respectively stands for "male" and "female." Let $M_1 > 0$ and $M_2 > 0$ denote the measures of male and female workers respectively and $M \equiv M_1 + M_2$.[17] Workers and firms are randomly matched in a frictional labor market. Time is discrete, and indexed by $t = 0, 1, ...,$ and we use $\beta \in (0, 1)$ to denote the discount factor for the workers.[18]

Workers of gender g have constant absolute risk aversion (CARA) preferences:[19]

$$u_g(c) = -\exp(-\gamma_g c), \tag{1}$$

where $\gamma_g > 0$ is the absolute risk aversion parameter for gender $g \in \{1, 2\}$.[20, 21]

Workers' Health. Workers differ in their health status, denoted by h, which can take on three categories: **E**xcellent (E) **,** **H**ealthy (H) and **U**nhealthy (U) .[22] In our model, a worker's health status has two effects. First, it affects the distribution of health expenditures. Specifically, we model an individual's health expenditure distributions as follows. Let $x \in \{0, 1\}$ denote an individual's health insurance status, where $x = 1$ means that he/she has health insurance. We assume that the probability that an individual of gender $g \in \{1, 2\}$ with health status $h \in \mathcal{H} \equiv \{\mathrm{E}, \mathrm{H}, \mathrm{U}\}$ and health insurance status $x \in \{0, 1\}$ will experience a medical shock is given by:

$$\Pr[m > 0 | (g, h, x)] = \gamma^{+}_{ghx}. \tag{2}$$

Following Fang and Shephard (2015b), we assume that, conditional on a positive medical shock, the realization of his/her medical expenditure is drawn from a Gamma-Gompertz distribution (see also Bemmaor

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

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

[19]Alternatively we can assume constant relative risk aversion (CRRA) preferences as in Rust and Phelan (1997), but then would have to deal with the issue of possible negative consumption. Also, 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.

[20]We only allow the risk aversion to depend on gender of the individual, not on the individual's health status. We do not have clear sources of identification if risk aversion depends on health status.

[21]In our model, we do not consider the joint labor supply decisions of couples as we assume that male and female workers make individual labor market decisions, but they are integrated in the labor market because, as we will discuss in Section 3.3.4, firms consider its overall workforce including both male and female workers in deciding its compensation packages. Fang and Shephard (2015b) explicitly consider the *joint* labor supply decisions of *couples*.

[22]As should be clear from our analysis below, our theoretical framework can allow for any finite number of health states. We choose three health states due to the limitations imposed by sample size.

and Glady (2012)), which is a three-parameter distribution $\langle b_{ghx}, s_{ghx}, \beta_{ghx} \rangle$ with the following probability density function:[23]

$$m \,|(g,h,x) \sim \frac{b_{ghx} \cdot s_{ghx} \cdot \beta_{ghx}^{s_{ghx}}}{\left[\beta_{ghx} - 1 + \exp(b_{ghx} \cdot m)\right]^{s_{ghx}+1}}. \tag{3}$$

Note that in (2) and (3) we allow both the individual's health and health insurance status to affect the medical expenditure distributions. Gamma-Gompertz distribution is a flexible family of continuous distributions with positive support that in practice provides excellent fit to empirical medical expenditure distributions. In subsequent analysis, we will use $\tilde{m}_{gh}^x$ to denote the *random* medical expenditure for individuals with health status h and health insurance status x as described by (2) and (3), and use m_{gh}^x to denote the *expectation* of $\tilde{m}_h^x$.[24]

Second, a worker's health status affects his/her productivity. Specifically, if an individual works for a firm with productivity p, he can produce $d_{gh} \times p$ units of output for the health status $h \in \mathcal{H}$. We normalize $d_{gE} = 1$ and assume that $d_{gE} \geq d_{gH} \geq d_{gU}$.[25]

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 gender, and his/her health insurance status. We use $\pi_{gh'h}^x \in (0,1)$ to denote the probability that a gender-g worker's health status changes from $h \in \mathcal{H}$ to $h' \in \mathcal{H}$ conditional on insurance status $x \in \{0,1\}$. The transition matrix is thus, for $g \in \{1,2\}$ and $x \in \{0,1\}$,

$$\boldsymbol{\pi}_g^x = \begin{pmatrix} \pi_{gEE}^x & \pi_{gHE}^x & \pi_{gUE}^x \\ \pi_{gEH}^x & \pi_{gHH}^x & \pi_{gUH}^x \\ \pi_{gEU}^x & \pi_{gHU}^x & \pi_{gUU}^x \end{pmatrix}, \tag{5}$$

where $\sum_{h' \in \mathcal{H}} \pi_{gh'h}^x = 1$ for each $h \in \mathcal{H}$ and $g \in \{1,2\}$.

Firms. Firms are heterogeneous in their productivity. In the population of firms, the distribution of productivity is denoted by $\Gamma(\cdot)$ which we assume to admit 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, decide a package of wage and health insurance provision, denoted by (w,x) where $w \in R_+$ and $x \in \{0,1\}$. 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 Logistic distribution with zero

[23]Our specification allows us to capture two of the most salient features of the medical expenditure distributions: they are heavily skewed to the right and there is a sizable fraction of individuals with zero medical expenditure. It is common in the literature, e.g., Einav, Finkelstein, Ryan, Schrimpf, and Cullen (2013), to use log-normal specifications for the continuous distribution of positive medical expenditure. However, the relatively fat tail of log-normal distribution would lead to a prediction of an unbounded value from insurance under the CARA utility function. In a previous version of this paper, Aizawa and Fang (2013), we also used a log-normal distribution for the positive medical expenditures, but approximated it with a finite-support discrete distribution.

[24]The Gamma-Gompertz distributions admit a moment generating function, which provides analytical forms for different moments. For example, its mean is given by

$$m_{gh}^x \equiv \mathrm{E}\tilde{m}_{gh}^x = \frac{\gamma_{ghx}^+}{b_{ghx} s_{ghx}} \; {}_2F_1\left(s_{ghx}, 1; s_{ghx}+1; \left(\beta_{ghx} - 1\right)/\beta_{ghx}\right). \tag{4}$$

where ${}_2F_1$ is the Gaussian hypergeometric function (see, Chapter 15 Abramowitz and Stegun, 1964).

[25]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.

mean and σ_f is a scale parameter. We assume that any firm that offers health insurance to its workers is self-insured, and will charge an insurance premium from its workers each period to cover the necessary reimbursement of all the realized health expenditures in addition to the administrative cost $\tilde{C}$.[26]

Importantly, we assume, *either* because workers' health status is not observed by the firms when firms and workers first meet, *or* because of regulations in Health Insurance Portability and Accountability Act (HIPAA) and Americans with Disabilities Act (ADA) as well as its amendments which restrict firms' ability to condition hiring, firing, and compensation based on individuals' gender and health status, that all the workers in a given firm will receive the *same* compensation package (wage and health insurance offering *regardless of* their gender and health status.[27, 28]

Health Insurance Market. In the baseline model, which is intended to represent the pre-ACA U.S. health insurance market, we assume that workers can obtain health insurance only if their employers offer them. This is a simplifying assumption meant to capture the fact that the individual private insurance market is rather small in the U.S. (see Footnote 9). In our counterfactual experiment, we will consider the case of competitive private insurance market to mimic the health insurance exchanges that would be established under the ACA.

Labor Market. Firms and workers are randomly matched in the labor market. We allow the meeting rate to be dependent on the worker's gender g. In each period, an unemployed worker randomly meets a firm with probability $\lambda_{gu} \in (0,1)$ for $g \in \{1,2\}$. He/She then decides whether to accept the offer, or to remain unemployed and search for jobs in next period. If an individual is employed, he/she meets randomly with another firm with probability $\lambda_{ge} \in (0,1)$. If a currently employed worker receives an offer from another firm, he/she needs to decide whether to accept the outside offer or 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 $\delta_g \in (0,1)$, 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]

As we discuss below, in order to smooth the labor supply functions firms face, we assume that gender-g workers, whether unemployed or employed, receive preference shocks for working ϵ_{gw} each period. We assume that ϵ_{gw} is identically and independently distributed across periods, drawn from a Normal distribution $N\left(0, \sigma_{gw}^2\right)$. The introduction of preference shocks ϵ_{gw} plays several important roles. First, it smooths the labor supply functions as a function of wages as it will be clear below. Second, this in turn

[26] As will be clear later, introducing a fixed administrative cost $\tilde{C}$ facilitates the model's ability to fit the empirical relationship firm size and health insurance offering rate. In principle, firms should also be able to decide on the premium if they decide to offer health insurance. However, because we require that firms be self-insured, the insurance premium will be determined in equilibrium by the health composition of workers in steady state.

[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] Cole, Kim, and Krueger (2014) made similar assumptions and provided extensive discussions about other regulations restricting firm's choices of compensation packages.

[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 data.

allows us to address the technical issue of mass points in the reservation wage distribution because of the discreteness of the health states and gender (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 gender-g individual, regardless of health and employment status, will leave the labor market with probability $\rho_g \in (0,1)$. An equal measure of newborns will enter the labor market unemployed and their initial health status with be healthy with probability $\mu_{gh} \in (0,1)$ for $h \in \mathcal{H}$ so that $\sum_{h\in\mathcal{H}} \mu_{gh} = 1$. We assume that all new-born workers are unemployed.

Income Taxes. Workers' wages are subject to a nonlinear tax schedule, but the ESHI premium is tax exempt in the baseline model. For the *after-tax income* $T(y)$, we follow the specification in Kaplan (2012) which approximates the U.S. tax code by:[32]

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

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. We believe that our particular timing assumptions simplify our derivation and provide an easy way of avoiding a degenerate likelihood function (see Section 6.2.1 below), but they are not crucial.

1. A gender-g individual, whether employed or unemployed, and regardless of his/her health status, may leave the labor market with probability $\rho_g \in (0,1)$;
2. If a gender-g employed worker stays in the labor market matched with a firm with productivity p, then:
   (a) he/she produces output pd_{gh} if his/her health status is $h \in \mathcal{H}$;
   (b) the firm pays wage and collects insurance premium if it offers health insurance;
   (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 then observes the realization of the health status that will be applicable next period;
   (e) he/she randomly meets with new employers with probability λ_{ge};

[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 dynamic discrete choice models (see Heckman (1981)).

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

(f) a preference shock ϵ_{gw} is drawn from $N\left(0, \sigma_{gw}^2\right)$;

(g) the current match is destroyed with probability $\delta_g \in (0,1)$, in which case the worker must decide, given the realization of ϵ_{gw}, whether to accept the outside offer, if any, or to enter unemployment pool;

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

3. Any unemployed worker of gender g experiences the following in a period:

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

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

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

   (d) he/she randomly meets with employers with probability λ_{gu};

   (e) a preference shock ϵ_{gw} is drawn from $N\left(0, \sigma_{gw}^2\right)$;

   (f) he/she decides, given the realization of ϵ_{gw}, whether to accept the offer if any, or to stay unemployed.

4. 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, for a postulated distribution of wage and insurance packages by the firms, denoted by $F(w,x)$, 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 (w,x). We then solve the firms' optimization problem and provide the conditions for the postulated $F(w,x)$ to be consistent with equilibrium.

3.3.1 Value Functions

We first introduce the notation for several valuation functions. We use $v_{gh}(y,x)$ to denote the expected *flow* utility of gender-g workers with health status h from income y and insurance status $x \in \{0,1\}$; and it is given by:

$$v_{gh}(y,x) = \begin{cases} u_g\left(T\left(y\right)\right) & \text{if } x = 1 \\ \mathrm{E}_{\tilde{m}_{gh}^0} u\left(T(y) - \tilde{m}_{gh}^0\right) & \text{if } x = 0, \end{cases} \tag{7}$$

where $u_g(\cdot)$ is specified in (1); $T(y)$ is after-tax income as specified in (6); and $\tilde{m}_{gh}^0$ is the random medical expenditure for uninsured gender-g individual as specified by (2) and (3). Note that in (7), we assume that when an individual is insured, i.e., $x = 1$, his/her medical expenditures are fully covered by the insurance.[33] As long as $\tilde{m}_{gh}^0$ is not always 0, $v_{gh}(y,1) > v_{gh}(y,0)$; that is, regardless of workers' health, *if* wages are fixed, then all workers desire health insurance.

[33] 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.

Let U_{gh} denote the value for an unemployed worker of gender g with health status h at the beginning of a period; and let $V_{gh}(w, x)$ denote the value function for an employed worker of gender g with health status h working for a job characterized by wage-insurance package (w, x) at the beginning of a period. U_{gh} and $V_{gh}(\cdot, \cdot)$ are of course related recursively. U_{gh} is given by:

$$\frac{U_{gh}}{1-\rho_g} = v_{gh}(\mathfrak{b}_g, 0) + \beta \mathrm{E}_{h'|(h,0,g)} \left[\lambda_{gu} \int \int \max\{V_{gh'}(w, x), U_{gh'} + \sigma_{gw}\epsilon_w\} d\Phi(\epsilon_w) \, dF(w, x) + (1-\lambda_{gu}) U_{gh'} \right], \quad (8)$$

where $\Phi(\cdot)$ is the cumulative distribution function for a standard Normal distribution ϵ_w and the expectation $\mathrm{E}_{h'}$ is taken with respect to the distribution of h' conditional on the current health status h and insurance status $x = 0$ because unemployed workers are uninsured in this baseline model. (8) states that the value of being unemployed for a gender-g individual, normalized by the survival rate $1 - \rho_g$, consists of the flow payoff $v_{gh}(\mathfrak{b}_g, 0)$, and the discounted expected continuation value where the expectation is taken with respect to the health status h' next period, whose transition is given by $\pi^0_{gh'h}$ as described in (5). The unemployed worker may be matched with a firm with probability λ_{gu} and the firm's offer (w, x) is drawn from the distribution $F(w, x)$. If an offer is received, the worker will choose whether to accept the offer by comparing the value of being employed at that firm $V_{gh'}(w, x)$, and the value of remaining unemployed $U_{gh'} + \sigma_{gw}\epsilon_w$; if no offer is received, which occurs with probability $1 - \lambda_{gu}$, the worker's continuation value is $U_{gh'}$.

Similarly, $V_{gh}(w, x)$ is given by

$$\begin{aligned}
&\frac{V_{gh}(w, x)}{1-\rho_g} = v_{gh}(w, x) \\
&+\beta\lambda_{ge} \left\{ \begin{array}{l} (1-\delta_g)\mathrm{E}_{h'|(h,x,g)} \left[\int \int \max\{V_{gh'}(\tilde{w}, \tilde{x}), V_{gh'}(w, x), U_{gh'} + \sigma_{gw}\epsilon_w\} d\Phi(\epsilon_w) \, dF(\tilde{w}, \tilde{x}) \right] \\ +\delta_g \mathrm{E}_{h'|(h,x,g)} \left[\int \int \max\{U_{gh'} + \sigma_{gw}\epsilon_w, V_{gh'}(\tilde{w}, \tilde{x})\} d\Phi(\epsilon_w) \, dF(\tilde{w}, \tilde{x}) \right] \end{array} \right\} \\
&+\beta(1-\lambda_{ge}) \left\{ (1-\delta_g)\mathrm{E}_{h'|(h,x,g)} \left[\int \max\{U_{gh'} + \sigma_{gw}\epsilon_w, V_{gh'}(w, x)\} d\Phi(\epsilon_w) \right] + \delta_g \mathrm{E}_{h'|(h,x,g)}[U_{gh'}] \right\}. \quad (9)
\end{aligned}$$

Note that in both (8) and (9), we used our timing assumption that a worker's health status next period depends on his/her insurance status this period even if he/she is separated from his 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 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 (w, x) if they are employed, and their health status h, as well as the period's preference shock ϵ_{gw}.

Optimal Strategies for Unemployed Workers. From the value function for the unemployed worker, as given by (8), it is clear that a gender-g worker with health status will accept an offer (w, x) if and only if

$$\begin{aligned}
& V_{gh}(w, x) \geq U_{gh} + \sigma_{gw}\epsilon_w \\
\Leftrightarrow \quad & \epsilon_w \leq \tilde{z}_{gu}(w, x, h) \equiv \frac{V_{gh}(w, x) - U_{gh}}{\sigma_{gw}}. \quad (10)
\end{aligned}$$

This implies that a gender-g unemployed worker with health status h will accept an offer (w, x) with probability $\Phi(\tilde{z}_{gu}(w, x, h))$. Using (10), we can re-write (8) as:

$$\frac{U_{gh}}{1-\rho_g}=v_{gh}(\mathfrak{b}_g,0)+\beta \mathrm{E}_{h'|(h,0,g)}\left[\begin{array}{l}\lambda_{gu}\int\left\{\begin{array}{l}\Phi\left(\tilde{z}_{gu}(w,x,h')\right)V_{gh'}(w,x)\\+\left[1-\Phi\left(\tilde{z}_{gu}(w,x,h')\right)\right]U_{gh'}+\sigma_{gw}\phi\left(\tilde{z}_{gu}(w,x,h')\right)\end{array}\right\}dF(w,x)\\+(1-\lambda_{gu})U_{gh'}\end{array}\right]. \quad (11)$$

Optimal Strategies for Currently-Employed Workers. From the value function for a gender-g employed worker with health status h who is currently working on a job (w,x), as given by (9), we see that he/she needs to decide whether to transition to a new job $(\tilde{w},\tilde{x})$ 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 $V_{gh}(\tilde{w},\tilde{x})$ and $V_{gh}(w,x)$ in (9). The solution to this comparison is reservation strategy: the reservation wage for the employed gender-g worker with health status h to switch from job (w,x) to a job $(\tilde{w},\tilde{x})$ *only if* $\tilde{w}>\underline{w}^{\tilde{x}}_{gh}(w,x)$ where $\underline{w}^{\tilde{x}}_{gh}(w,x)$ satisfies:

$$V_{gh}(w,x)=V_{gh}\left(\underline{w}^{\tilde{x}}_{gh}\left(w,x\right),\tilde{x}\right). \quad (12)$$

Equation (12) implies that

$$\underline{w}^{\tilde{x}}_{gh}(w,x)\begin{cases}=w & \text{if} \quad \tilde{x}=x\\ >w & \text{if} \quad \tilde{x}=0 \ \& \ x=1\\ <w & \text{if} \quad \tilde{x}=1 \ \& \ x=0.\end{cases}$$

It is useful to note that the definition of $\underline{w}^{\tilde{x}}_{gh}(w,x)$ as given in (12) implies the following identity:

$$V_{gh}\left(\tilde{w},\tilde{x}\right)=V_{gh}\left(\underline{w}^{x}_{gh}(\tilde{w},\tilde{x}),x\right),$$

which yields a simple characterization of an employed gender-g worker's job-to-job transition decision: a worker with a current offer (w,x) will accept the new offer $(\tilde{w},\tilde{x})$ *only if*

$$w<\underline{w}^{x}_{gh}(\tilde{w},\tilde{x}). \quad (13)$$

We will use this characterization in the expressions for steady steady conditions in Section 3.3.3.

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. From value function (9), we know that if the worker has the option to choose from staying in the current job (w,x), the new on-the-job offer $(\tilde{w},\tilde{x})$ and quitting into unemployment, he/she will choose *not* to quit into unemployment if and only if

$$\begin{aligned}&\max\left\{V_{gh}(\tilde{w},\tilde{x}),V_{gh}(w,x)\right\}\geq U_{gh}+\sigma_{gw}\epsilon_w\\ \Leftrightarrow\quad &\epsilon_w\leq\tilde{z}^1_{ge}(\tilde{w},\tilde{x},w,x,h)\equiv\frac{\max\left\{V_{gh}(\tilde{w},\tilde{x}),V_{gh}(w,x)\right\}-U_{gh}}{\sigma_{gw}}.\end{aligned} \quad (14)$$

Now we are ready to provide a full characterization of the job-to-job transition decision of an employed worker: a worker with a current offer (w,x) will accept the new offer $(\tilde{w},\tilde{x})$ if and only if both (13) and (14) hold.

Similarly, if the worker only has the option between his/her current job (w,x) and quitting into unemployment, he/she will choose to stay employed if and only if

$$\begin{aligned}&V_{gh}(w,x)\geq U_{gh}+\sigma_{gw}\epsilon_w,\\ \Leftrightarrow\quad &\epsilon_w\leq\tilde{z}^2_{ge}(w,x,h)\equiv\frac{V_{gh}(w,x)-U_{gh}}{\sigma_{gw}}.\end{aligned} \quad (15)$$

Clearly, $\tilde{z}_{ge}^{2}(w,x,h)$ is equal to $\tilde{z}_{gu}(w,x,h)$ as given by (10). 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, the quit 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 his/her health was excellent, but now he/she may prefer to be in unemployment waiting for a job with health insurance if his/her health status changed to unhealthy. Second, the quit could be induced by a preference shock.

Using (14) and (15), we can rewrite (9) as:

$$
\begin{aligned}
&\frac{V_{gh}(w,x)}{1-\rho_g} = v_{gh}(w,x) \\
&+\beta\lambda_{ge}\left\{\begin{array}{l}
(1-\delta_g)\mathrm{E}_{h'|(h,x,g)}\left[\int\left\{\begin{array}{l}\Phi\left(\tilde{z}_{ge}^{1}(\tilde{w},\tilde{x},w,x,h')\right)\max\left\{V_{gh'}(\tilde{w},\tilde{x}),V_{gh'}(w,x)\right\} \\ +\left[1-\Phi\left(\tilde{z}_{ge}^{1}(\tilde{w},\tilde{x},w,x,h')\right)\right]U_{gh'}+\sigma_w^s\phi\left(\tilde{z}_{ge}^{1}(\tilde{w},\tilde{x},w,x,h')\right)\end{array}\right\}dF(\tilde{w},\tilde{x})\right] \\
+\delta_g\mathrm{E}_{h'|(h,x)}\left[\int\left\{\begin{array}{l}\Phi\left(\tilde{z}_{ge}^{2}(\tilde{w},\tilde{x},h')\right)V_{gh'}(\tilde{w},\tilde{x}) \\ +\left[1-\Phi\left(\tilde{z}_{ge}^{2}(\tilde{w},\tilde{x},h')\right)\right]U_{gh'}+\sigma_{gw}\phi\left(\tilde{z}_{ge}^{2}(\tilde{w},\tilde{x},h')\right)\end{array}\right\}dF(\tilde{w},\tilde{x})\right]
\end{array}\right\} \\
&+\beta(1-\lambda_{ge})\left\{\begin{array}{l}
(1-\delta_g)\mathrm{E}_{h'|(h,x)}\left[\begin{array}{l}\Phi\left(\tilde{z}_{ge}^{2}(w,x,h)\right)V_{gh'}(w,x) \\ +\left[1-\Phi\left(\tilde{z}_{ge}^{2}(w,x,h)\right)\right]U_{gh'}+\sigma_{gw}\phi\left(\tilde{z}_{ge}^{2}(w,x,h)\right)\end{array}\right] \\
+\delta_g\mathrm{E}_{h'|(h,x,g)}[U_{gh'}]
\end{array}\right\}.
\end{aligned} \tag{16}
$$

3.3.3 Steady State Condition

We will 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 the male and female workers of different health status h are allocated in their employment (w,x). Let u_{gh} denote the measure of unemployed gender-g workers with health status $h\in\mathcal{H}$; and let e_{gh}^{x} denote the measure of employed gender-g workers with health insurance status $x\in\{0,1\}$ and health status is $h\in\mathcal{H}$. Of course, we have

$$\sum_{h\in\mathcal{H}}(u_{gh}+e_{gh}^{0}+e_{gh}^{1}) = M_g \text{ for each } g\in\{1,2\} \tag{17}$$

Let $S_{gh}^{x}(w)$ the *fraction* of employed gender-g workers with health status h working on jobs with insurance status x whose wage is below w, and let $s_{gh}^{x}(w)$ be the corresponding density of $S_{gh}^{x}(w)$. Thus, $e_{gh}^{x}s_{gh}^{x}(w)$ is the density of employed workers of gender g with health status h whose compensation package is (w,x).

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. The *inflow* of gender-g workers into unemployment with health status h is given by

$$[u_{gh}]^{+} \equiv M_g\rho_g\mu_{gh} \tag{18a}$$

$$+\ (1-\rho_g)\left[\sum_{h'\in\mathcal{H}}\left(e_{gh'}^{0}\pi_{ghh'}^{0}+e_{gh'}^{1}\pi_{ghh'}^{1}\right)\right]\delta_g\left[\begin{array}{l}(1-\lambda_{ge}) \\ +\lambda_{ge}\int\left[1-\Phi\left(\tilde{z}_{gu}(\tilde{w},\tilde{x},h)\right)\right]dF(\tilde{w},\tilde{x})\end{array}\right] \tag{18b}$$

$$+(1-\rho_g)\sum_{h'\neq h}u_{gh'}\pi_{ghh'}^{0}\left[1-\lambda_{gu}\int\Phi\left(\tilde{z}_{gu}(\tilde{w},\tilde{x},h)\right)dF(\tilde{w},\tilde{x})\right] \tag{18c}$$

$$+(1-\rho_g)(1-\delta_g)\sum_{x\in\{0,1\}}\sum_{h'\in\mathcal{H}}e_{gh'}^{x}\pi_{ghh'}^{x}\lambda_{ge}\int\int\left(1-\Phi\left(\tilde{z}_{ge}^{1}(\tilde{w},\tilde{x},w,x,h)\right)\right)dF(\tilde{w},\tilde{x})dS_{gh}^{x}(w) \tag{18d}$$

$$+(1-\rho_g)(1-\delta_g)\sum_{x\in\{0,1\}}\sum_{h'\in\mathcal{H}}e_{gh'}^{x}\pi_{ghh'}^{x}(1-\lambda_{ge})\int\left[1-\Phi\left(\tilde{z}_{ge}^{2}(w,x,h)\right)\right]dS_{gh}^{x}(w). \tag{18e}$$

In the above expression, the term on line (18a) is the measure of new gender-g workers born into health status h; the term on line (18b) is the measure of employed gender-g workers who had health status 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 (18c) is the measure of gender-g unemployed workers whose health status was h' last period but transitioned to h this period and did not leave for employment. The terms on lines (18d) and (18e) are the measures of gender-g 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 (18d). 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 $(\tilde{w}, \tilde{x})$), which occurs with probability λ_{ge}. Second, since the on-the-job offer $(\tilde{w}, \tilde{x})$ is drawn from $F(\cdot, \cdot)$, and the worker will quit into unemployment with the job options of the current job (w, x) and the new offer $(\tilde{w}, \tilde{x})$ if and only if the preference shock ϵ_w exceeds $\tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h)$ as defined in (14).

The *outflow* from unemployment of gender-g workers with health status h is given by:

$$[u_{gh}]^- \equiv u_{gh} \left\{ \rho_g + (1-\rho_g) \left[\sum_{h' \neq h} \pi^0_{gh'h} + \pi^0_{ghh} \lambda_{gu} \int \Phi\left(\tilde{z}_{gu}(\tilde{w}, \tilde{x}, h)\right) dF(\tilde{w}, \tilde{x}) \right] \right\}. \tag{19}$$

It states that a ρ_g fraction of the gender-g unemployed with health status h will die and the remainder $\left(1-\rho_g\right)$ will either change to health status $h' \neq h$ (with probability $\pi^0_{gh'h}$), or if their health does not change (with probability π^0_{ghh}) they may become employed with probability $\lambda_{gu} \int \Phi\left(\tilde{z}_{gu}(\tilde{w}, \tilde{x}, h)\right) dF(\tilde{w}, \tilde{x})$. Then, in a steady-state we must have

$$[u_{gh}]^+ = [u_{gh}]^-, \text{ for } g \in \{1, 2\}, h \in \mathcal{H}. \tag{20}$$

Now we provide the steady state equation for gender-g workers employed on jobs (w, x) with health status h. The *inflow* of gender-g workers with health status h to jobs (w, x), denoted by $\left[e^x_{gh}(w)\right]^+$, is given as follows:

$$\left[e^x_{gh}(w)\right]^+ \equiv (1-\rho_g) f(w, x) \Phi\left(\tilde{z}_{gu}(w, x, h)\right) \lambda_{gu} \sum_{h' \in \mathcal{H}} u_{gh} \pi^0_{ghh'} \tag{21a}$$

$$+(1-\rho_g) f(w, x) \delta_g \lambda_{ge} \Phi\left(\tilde{z}^2_{ge}(w, x, h)\right) \left[\sum_{h' \in \mathcal{H}} \left(e^0_{gh} \pi^0_{ghh'} + e^1_{gh'} \pi^1_{ghh'} \right) \right] \tag{21b}$$

$$+(1-\rho_g) f(w, x)(1-\delta_g) \lambda_{ge} \sum_{\tilde{x} \in \{0,1\}} \sum_{h' \in \mathcal{H}} e^{\tilde{x}}_{gh'} \pi^{\tilde{x}}_{ghh'} \int_{\tilde{w} \leq \underline{w}^{\tilde{x}}_{gh}(w,x)} \Phi\left(\tilde{z}^1_{ge}(w, x, \tilde{w}, \tilde{x}, h)\right) dS^{\tilde{x}}_{gh'}(\tilde{w}) \tag{21c}$$

$$+(1-\rho_g)(1-\delta_g) \sum_{h' \neq h} \pi^x_{ghh'} e^x_{gh'} s^x_{gh'}(w) \Phi\left(\tilde{z}^2_{ge}(w, x, h)\right) \left[1 - \lambda_{ge}\left[1 - \tilde{F}_{gh}(w, x)\right]\right], \tag{21d}$$

where $\underline{w}^{\tilde{x}}_{gh}(\cdot, \cdot)$ is as defined by (12), and

$$\tilde{F}_{gh}(w, x) \equiv F(w, x) + F(\underline{w}^{1-x}_{gh}(w, x), 1-x). \tag{22}$$

To understand expression (21), note that line (21a) presents the inflows from unemployed gender-g workers with health status h to the job (w, x); line (21b) represents the inflow from those whose current matches were destroyed but transition to the job (w, x) without experiencing an unemployment spell (recall our timing assumption 3(e) and 3(g) in Section 3.2); line (21c) represents inflows from gender-g workers who were employed on other jobs $(\tilde{w}, \tilde{x})$ to the job (w, x); and finally line ((21d) is the inflow from workers who were employed on the same job but experienced a health transition from h' to h and yet did not transition to other better jobs, which occurs with probability $1 - \lambda_{ge}\left\{1 - \left[F(w,x) + F(\underline{w}_{gh}^{1-x}(w,x), 1-x)\right]\right\}$, and did not quit into unemployment which occurs with probability $\Phi\left(\tilde{z}_{ge}^2(w,x,h)\right)$.

Denote the *outflow* of gender-g workers with health status h from jobs (w,x) by $\left[e_h^x(w)\right]^-$, and it is given by

$$\left[e_{gh}^x(w)\right]^- \equiv e_{gh}^x s_{gh}^x(w) \left\{ \begin{array}{l} \left[\rho_g + (1-\rho_g)\pi_{ghh}^x \delta_g\right] + (1-\rho_g)\sum_{h' \neq h} \pi_{gh'h}^x \\ + \left(1-\rho_g\right)\pi_{ghh}^x \lambda_{ge}(1-\delta_g)\left[1 - \tilde{F}_{gh}(w,x)\right] \\ + \left(1-\rho_g\right)\pi_{ghh}^x(1-\delta_g)\left[\lambda_{ge}\tilde{F}_{gh}(w,x) + (1-\lambda_{ge})\right]\left[1 - \Phi\left(\tilde{z}_{ge}^2(w,x,h)\right)\right] \end{array} \right\}. \tag{23}$$

The outflow consists of job losses due to death and exogenous termination represented by the term $e_{gh}^x s_{gh}^x(w) \times \left[\rho_g + (1-\rho_g)\pi_{ghh}^x \delta_g\right]$, changes in current workers' health status represented by the term $e_{gh}^x s_{gh}^x(w)(1-\rho_g)\sum_{h' \neq h} \pi_{gh'h}^x$, and transitions to other jobs represented by the term $e_{gh}^x s_{gh}^x(w)\left(1-\rho_g\right) \times \pi_{ghh}^x \lambda_{ge}(1-\delta_g)\left[1 - \tilde{F}_{gh}(w,x)\right]$, and quitting into unemployment (the last term). The steady state condition requires that, for $x \in \{1,2\}$,

$$\left[e_{gh}^x(w)\right]^+ = \left[e_{gh}^x(w)\right]^- \text{ for } g \in \{1,2\}, h \in \mathcal{H} \text{ and for all } w \text{ in the support of } F(w,x). \tag{24}$$

From the employment densities, $\left\langle e_{gh}^x s_{gh}^x(w) : g \in \{1,2\}, h \in \mathcal{H}, x \in \{0,1\}\right\rangle$, we can define a few important terms related to *firm size*. First, given $\left\langle e_{gh}^x s_{gh}^x(w) : g \in \{1,2\}, h \in \mathcal{H}, x \in \{0,1\}\right\rangle$, the number of employees with health status h and gender g if a firm offers (w,x) is simply given by

$$n_{gh}(w,x) = \frac{e_{gh}^x s_{gh}^x(w)}{f(w,x)}, \tag{25}$$

where the numerator is the total density of workers with health status h on the job (w,x) and the denominator is the total density of firms offering compensation package (w,x). Of course, the total size of a firm that offers compensation package (w,x) is

$$n(w,x) = \sum_{g \in \{1,2\}} \sum_{h \in \mathcal{H}} n_{gh}(w,x) = \sum_{g \in \{1,2\}} \sum_{h \in \mathcal{H}} \frac{e_{gh}^x s_{gh}^x(w)}{f(w,x)}. \tag{26}$$

Expressions (25) and (26) allow us to connect the firm sizes in steady state as a function of the entire distribution of employed workers $\left\langle e_{gh}^x s_{gh}^x(w) : g \in \{1,2\}, h \in \mathcal{H}, x \in \{0,1\}\right\rangle$. Notice that the preference shocks ϵ_{gw} in workers' labor supply decisions we introduced smooth the labor supply functions $n_{gh}(\cdot, x)$ as a function of wages.

3.3.4 Firm's Optimization Problem

A firm with a given productivity p decides what compensation package (w,x) to offer, taken as given the *aggregate* distribution of compensation packages $F(w,x)$. 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 Logistic distribution with zero mean and σ_f is a scale parameter.[34] We assume that the $\sigma_f \epsilon$ shock a firm receives is persistent over time and it is separable from firm profits.[35]

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

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

Given the realization of $\tilde{C}$, each firm chooses (w, x) 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 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:

$$\max\{\Pi_0(p), \Pi_1(p) - \sigma_f \epsilon_f\}, \tag{27}$$

where

$$\Pi_0(p) = \max_{\{w_0\}} \Pi(w_0, 0) \equiv \sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} (pd_{gh} - w_0)\, n_{gh}(w_0, 0); \tag{28}$$

$$\Pi_1(p) = \max_{\{w_1\}} \Pi(w_1, 1) \equiv \sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} \left[(pd_{gh} - w_1)\, n_{gh}(w_1, 1) - m^1_{gh}\right] - C. \tag{29}$$

To understand the expressions (28), note that $n_{gh}(w_0, 0)$ is the measure of gender-g employees with health status h the firm will have in the steady state as described by (25) if it offers compensation package $(w_0, 0)$. Thus, $(pd_{gh} - w_0)\, n_{gh}(w_0, 0)$ is the firm's steady-state flow profit from gender-g workers with health status h. The expressions (29) can be similarly understood after recalling that m^1_{gh} is the expected medical expenditure of gender-g worker with health status h and health insurance as defined in (4). For future reference, we will denote the solutions to problems (28) and (29) respectively as $w_0^*(p)$ and $w_1^*(p)$. Note that in problems (28) and (29), the firms are restricted to offer compensation packages that do not depend on gender and health status of the workers, a restriction that we discussed and motivated in Section 3.

Due to the assumption that ϵ_f is drawn from i.i.d. Logistic distribution with zero mean, firms' optimization problem (27) thus implies that the probability that a firm with productivity p offers health insurance to its workers is

$$\Delta(p) = \frac{\exp(\frac{\Pi_1(p)}{\sigma_f})}{\exp(\frac{\Pi_1(p)}{\sigma_f}) + \exp(\frac{\Pi_0(p)}{\sigma_f})}, \tag{30}$$

where $\Pi_0(p)$ and $\Pi_1(p)$ are respectively defined in (28) and (29).

3.4 Steady State Equilibrium

A *steady state equilibrium* is a list of objects, for $g \in \{1, 2\}$ and $h \in \mathcal{H}$,

$$\left\langle \left(\tilde{z}_{gu}(w, x, h), \underline{w}^{\tilde{x}}_{gh}(w, x), \tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h), \tilde{z}^2_{ge}(w, x, h)\right), \left(u_{gh}, e^x_{gh}, S^x_{gh}(w)\right), \left(w^*_x(p), \Delta(p)\right), F(w, x) \right\rangle,$$

such that the following conditions hold:

- **(Worker Optimization)** Given $F(w, x)$, for each $g \in \{1, 2\}$, $h \in \mathcal{H}$,
  - an unemployed gender-g worker with health status h will accept a job offer (w, x) if and only if $\epsilon_w \le \tilde{z}_{gu}(w, x, h)$, as described by (10);
  - if a gender-g worker with health status h who is currently employed at a job (w, x) receives an on-the-job offer $(\tilde{w}, \tilde{x})$, he/she will:
    - switch to job $(\tilde{w}, \tilde{x})$ if and only if $\tilde{w} > \underline{w}^{\tilde{x}}_{gh}(w, x)$ and $\epsilon_w \le \tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h)$, as described by (13) and (14);

* $*$ quit into unemployment if $\epsilon_w > \tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h)$, as described by (14);
* $*$ stay at the current job (w, x), otherwise.

– if a gender-g worker with health status h who is currently employed or has the only job option of (w, x) will stay at or accept the job if and only if $\epsilon_w \leq \tilde{z}^2_{ge}(w, x, h)$, as described by (15).

- **(Steady State Worker Distribution)** Given $F(w, x)$ and workers' optimizing behavior described by $\left(\tilde{z}_{gu}(w, x, h), \underline{w}^{\tilde{x}}_{gh}(w, x), \tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h), \tilde{z}^2_{ge}(w, x, h)\right)$, $\left(u_{gh}, e^x_{gh}, S^x_{gh}(w)\right)$ satisfy the steady state conditions described by (17), (20) and (24);

- **(Firm Optimization)** Given $F(w, x)$ and the steady state employee sizes implied by $\left(u_{gh}, e^x_{gh}, S^x_{gh}(w)\right)$, a firm with productivity p chooses to offer health insurance with probability $\Delta(p)$ where $\Delta(p)$ is given by (30). Moreover, conditional on insurance choice x, the firm offers a wage $w^*_x(p)$ that solves (28) and (29) respectively for $x \in \{0, 1\}$.

- **(Equilibrium Consistency)** The postulated distributions of offered compensation packages are consistent with the firms' optimizing behavior $(w^*_x(p), \Delta(p))$. Specifically, $F(w, x)$ must satisfy:

$$F(w, 1) = \int_0^\infty \mathbf{1}(w^*_1(p) < w)\Delta(p)d\Gamma(p), \tag{31}$$

$$F(w, 0) = \int_0^\infty \mathbf{1}(w^*_0(p) < w)\left[1 - \Delta(p)\right]d\Gamma(p). \tag{32}$$

4 Qualitative Assessment of the Model

The complexity of the model precludes an analytical characterization of the equilibrium, thus we solve the equilibrium numerically.[36] The complexity of our model also prevents us from proving the existence and uniqueness of the equilibrium, but, throughout extensive numerical simulations, we always find a unique equilibrium for our baseline model based on our algorithm. We then 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. We also use the numerical simulations to provide informal arguments about how some of key parameters of model are identified.

4.1 Numerical Simulations

In Column (1), labeled "Benchmark," of Table 1, 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 on average 47.72% of firms with less than 10 workers offer health insurance, lower than the average of 51.14% if firms have fewer than 50 workers, which is in turn lower than the average of 92.03% for firms with 50 or more workers; and the average four-month wages for workers with health insurance is \$9,754 in contrast to \$5,526 for uninsured workers. Moreover, it also generates the empirically consistent prediction that the average health status of employees at firms offering health insurance is relatively better that those at firms not offering health insurance: the fraction of workers that are unhealthy is 5.03% among insured workers, which is lower than the 7.27% of unhealthy among uninsured workers.

[36] The details of our numerical algorithm are provided in Online Appendix A.

[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 5% and the top 5% of productivity in our discretized (with 200 grid points) productivity distribution. Panel A (i.e., Row 1) of Table 2 shows that, *in the steady state*, the fraction of unhealthy workers in low and high productivity firms that offer health insurance are respectively 5.61% and 4.88%; in contrast, the fraction of unhealthy workers in low and high productivity firms that do not offer health insurance are respectively 6.74% and 9.27%.[37] Offering health insurance seems to improve the health composition of workers over not offering health insurance for high-productivity firms, more so than for the low productivity firms. 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 among 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 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 6.28% if they offer health insurance and 5.98% if they do not; in contrast, in the high-productivity firms the fraction of unhealthy is 5.64% if they offer health insurance, which is virtually identical to the case if they do not offer health insurance (the difference appears in the fifth decimal point). Thus, the new hires attracted to 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 fact that, a high-productivity firm offering health insurance can poach workers from a much wider range of firms, including a larger fraction of workers from firms that already offer insurance and are thus healthier; in contrast, a low-productivity firm offering health insurance can only poach workers from firms with even lower productivity, most of which do not offer health insurance and thus have less healthy workers. Notice that the adverse selection effect operates not only at the aggregate level for the low productivity firms, but also at the gender specific level.

[Insert Table 2 About Here]

In Panel C, we show that any adverse selection effect that a firm offering health insurance suffers in terms of the health composition of their new hires is quickly remedied by the positive effect of health insurance on the improvement of health. In Row 3, we show that, just one-period later, the new hires' health composition is already in favor of firms that offer health insurance. For low-productivity firms, the fraction of unhealthy workers among those hired a period (4-months) ago, *were they not to leave*, is 5.49% and 6.62% respectively in those offering health insurance and those not offering health insurance. The health improvement of health insurance operates also at the gender specific level. Similarly, for high-productivity firms, the fraction of unhealthy workers among those hired a period ago is 5.40% and 6.59% respectively in those offering health insurance and those not offering health insurance. In Row 4 we show that if the new hires from nine-periods (3 years) ago *were not to leave*, the fraction of unhealthy among them would be only 4.85% in low-productivity firms that offer health insurance, but it would be 8.52%

[37] The same patterns hold true by gender of the workers. They are available upon request from the authors.

in low-productivity firms that do not offer health insurance. Similarly, among high-productivity firms, the fraction of unhealthy workers among those hired nine periods ago, if they were not to leave, would be 4.85% and 9.07% respectively in those offering health insurance and those not offering health insurance. Notice that the overall fraction of unhealthy workers when health insurance is offered among those hired nine periods ago, if they were not to leave, is higher for high-productivity firms than for low-productivity firms. The reason is that the high productivity firms attract more male workers than low productivity firms (because, as we will show in Section 7, the on-the-job offer arrival rate is higher for males than for females) and there is a higher fraction of unhealthy among male workers than among female workers.

Finally, 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. 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 healthy workers, which allows them to capture the increased productivity from the health improvement effect of health insurance as well as reduce the 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 shed light 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 $C = 0.160$ (i.e., \$1,600 per 4 months) as reported in Table 9. 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 offering rate for firms with fewer than 10 workers will increase from 47.72% to 50.01% and the health insurance offering rate for firms with fewer than 50 workers will increase from 51.14% to 53.77%.

Health Insurance Effect on Health. In Column (3), we shut down the effect of health insurance on the dynamics of health status by assuming that health transition process for the insured is the same as that of the uninsured, $\widehat{\pi^1_{h'h}} = \pi^0_{h'h}$ for all h, h'.[38] Column (3) of Table 1 shows that the fraction of large firms offering health insurance decrease significantly when $\widehat{\pi^1_{h'h}}$ is set to be equal to $\pi^0_{h'h}$: the fraction of firms with 50 or more workers that offer health insurance decreases from 92.03% in the benchmark to 79.63% when $\widehat{\pi^1_{h'h}} = \pi^0_{h'h}$. 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

[38] 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., $\widehat{\pi^0_{h'h}} = \pi^1_{h'h}$.

effect of health insurance, the overall uninsured rate in the economy also significantly increases to 29.69%, from 22.34% in the benchmark.

The reason why large firms decide not to offer health insurance when $\widehat{\pi^1_{gh'h}} = \pi^0_{gh'h}$ can be understood as follows. When $\widehat{\pi^1_{gh'h}} = \pi^0_{gh'h}$, i.e., when health insurance provision does not influence the dynamics of worker's health status, 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 bottom two cells in Column (3) show that health composition of firms offering health insurance (8.89% of workers being unhealthy) is worse than that of firms who do not (8.83% being unhealthy), because health insurance provision attract more unhealthy workers. This creates an adverse selection problem which is not subsequently overcome as in Panel B of Table 2, thus leading to some firms not to provide coverage.

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 0.2415 for male and 0.8878 for females in Table 9 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 decreases from 51.14% on average in the benchmark to 45.96% for firms with less than 50 workers, and it decreases from 92.03% to 63.72% for firms with 50 or more workers. Not surprisingly, the overall uninsured rate goes up substantially to 44.27%, in contrast to 22.34% 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 insured workers increases by 6.5 percent from $9,754 to $10,387, while it increases by 37.8 percent from $5,526 to $7,615 for uninsured workers. 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.

Productivity Effect of Health. In Column (5) of Table 1 we investigate the productivity effect of health by changing $d_{gh}, h \in \{H, U\}$ from their estimated values reported in Table 9 to 1.00. This eliminates the negative productivity effect of bad health. Column (5) shows that the absence of the negative productivity effect of bad health leads to a substantial reduction of the coverage rate for the large employers relative to the benchmark. The fraction of firms with 50 or more workers offering health insurance decreases from 92.03% in the benchmark to 83.2% when the productivity effect of health were 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 C of Table 2, have stronger incentive than smaller firms to improve the health of their workforce in order to raise the expected flow profit. Moreover, an increase in d_{gh} increases firms' wage offers in general due to the overall productivity improvement.

4.3 Identification of γ_g, d_{gh}, C, σ_f and σ_{gw}

As shown in Columns (2) and (4)-(5) in Table 1, the CARA coefficient γ_g, the productivity effect of health $d_{gh}, h \in \{H, U\}$, and the mean of the administrative cost of offering health insurance C, all have important effects on the firms' incentives to provide health insurance. How are they separately identified? Here we provide some "heuristic" discussion.

As we detail in Section 6, in our estimation we use both *worker-side* data which has information about workers' labor market dynamics and *firm-side* data that has information about firm size, wages and health insurance offering. While it is true that the CARA coefficient γ_g affects the firms' incentives to provide insurance as shown in Column (4) of Table 1, it also affects the workers' job-to-job transitions. In particular, if γ_g is larger (i.e. when workers are more risk averse), we would expect to observe *more frequent* transitions of workers from jobs *without* health insurance to a job *with* health insurance, especially after a deterioration of health status, and even if the transition involves a reduction in wages. Moreover, the magnitude of the wage cut a worker is willing to tolerate in order to switch from a job without health insurance to a job with health insurance increases with the risk aversion parameter γ_g. These effects are not shown in Table 1, but will be incorporated in our estimation via the likelihood function of the workers' labor market transition dynamics.

As shown in Columns (4) and (5) in Table 1, both the productivity effect of health d_{gh} and risk aversion γ_g affect the relationship between the probability of offering health insurance and firm size. Of course, the scale parameter σ_f in (30) also affects the relationship between the probability of offering health insurance and firm productivity (and thus firm size). These three parameters are separately identified for the following reasons. First, the risk aversion parameter γ_g is disciplined by the worker-side job-to-job transition information as we described above; second, even though the parameter d_{gh} and the scale parameter σ_f both affect the *slope* between the firm size and insurance offering probability from the firm-side data, the parameter d_{gh} has an additional effect on the differences in wages for firms depending on whether they offer health insurance. It is important to note that the identification for d_{gh}, the parameter that measure the productivity effect of health, crucially relies on the firm side information on firm sizes, wages and health insurance offering; without the firm-side data, d_{gh} can not be identified from the worker-side data alone because workers' decisions are only affected by offer distributions, not by how the distributions arise in equilibrium (i.e., whether it is partly due to the productivity effect of health). Finally, the mean of the administrative cost C is identified from the the probability (in *level*) of small firms offering health insurance.

Finally, we explain how σ_{gw}, the standard deviations of gender-g workers' preference shocks, is identified. Note that σ_{gw}, together with the exogenous job destruction rate δ_g, affects the relationship between the rate of transition of employed workers at a given compensation to unemployment (EU transition). A higher σ_{gw} implies that a higher rate of EU transition by workers at low wage jobs; and it also decreases the rate of UE transition to low wage jobs. Thus, σ_{gw} is estimated to balance these two effects to achieve the best overall fit.

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; (2) Medical Expenditure Panel Survey; and (3) Robert Wood Johnson Employer Health Insurance Survey.

5.1 Survey of Income and Program Participation

Our main dataset for individual labor market outcome, health, and health insurance is 1996 Panel of Survey of Income Program Participation (hereafter, SIPP 1996).[39] SIPP 1996 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, 6, 9 and 12.[40]

Sample Selection Criterion. The total sample size after matching the topical module and the core module is 115,981. 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 (dropping 69,858 individuals). In addition, we only keep individuals who are not in school, not self-employed, do not work in the public sector, are not engage in the military, and do not participate in any government welfare program (dropping an additional 20,435 individuals in total). We also require that our sample be covered either by an employer-based health insurance in *his or her own name* or *is uninsured* (dropping an additional 4,670 individuals). We restrict our samples to individuals who are at most high school graduates (dropping 8,063 individuals). Finally we drop top and bottom 3% of salaried workers (dropping an additional 2,003 individuals). Our final estimation sample that meets all of the above selection criterion consists of a total of 10,952 individuals.

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) 1997-1999. 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.[41] 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 1996. The sample size is 9,759.

5.3 Robert Wood Johnson Foundation Employer Health Insurance 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 1997 Robert Wood Johnson

[39] SIPP 1996 Panel is available at: `http://www.census.gov/sipp/core_content/1996/1996.html`

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

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

Foundation Employer Health Insurance Survey (hereafter, RWJ-EHI).[42] It is a nationally representative survey of public and private establishments conducted in 1996 and 1997. It contains information about employer'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 establishments which belong to the private sector and have at least three employees. The final sample size is 19,089.

5.4 Summary Statistics

Table 3 reports the summary statistics of the key variables in the 1996 SIPP data. About 76% of the employed male workers, and 85.6% of female workers, receive health insurance from their employers. The average 4-month wage for employed male workers with health insurance is about $9,050, higher than that for those without health insurance which is about $6,090; the average 4-month wage for employed female workers is about $7,370 for those with health insurance and $5,360 for those without health insurance. The unemployment rate for our selected sample is about 4.1% among males and 4.8% among females, both lower than the overall unemployment rate in the U.S. in 1996 (which was about 5.4%).[43] About 30.3% and 26.6% of our male and female sample respectively have excellent health (i.e., self-reported health status is "Excellent"), 63.8% and 67.4% of male and female samples are healthy (i.e., self-reported health status is either "Good" or "Very Good") and about 5.9% of them are unhealthy (i.e., self-reported health status is either "Fair" or "Poor"). Moreover, it is important to note that about 5.3% of male (5.4% of female, respectively) workers with insurance and 7.3% of male (7.8% of females, respectively) workers without insurance reported unhealthy.

[Insert Table 3 About Here]

In Table 4 we report the comparison of summary statistics for the individuals in MEPS 1997-1999 and those in SIPP 1996. Among both males and females, the fractions of excellent health and healthy workers are somewhat lower, and the fraction of unhealthy are higher, in MEPS than in SIPP. The fractions of employed workers who own health insurance are also lower in MEPS than in SIPP, for both males and females. By using the mean expenditure given health and health insurance in MEPS, we also impute the annual average medical expenditure based on SIPP's health and health insurance composition for the SIPP sample. It shows that annual medical expenditures are similar in the two samples: the imputed annual average medical expenditures for our SIPP sample is about $800 for males and $1,364 for females, which are very close to the observed average annual expenditures of $790 and $1,230 for males and females respectively in the MEPS sample.

[Insert Table 4 About Here]

Finally, in Table 5 we provide the summary statistics for our firm side data based on RWJ-EHI 1997. In general, firms that tend to offer health insurance have larger size in employment and provide higher wage. The average establishment size in the RWJ-EHI 1997 is about 20 workers, but the average size is more than 30 among those that offer health insurance and slightly less than 7 among those that do not offer health insurance. 53% of the firms with less than 50 workers offer health insurance, in contrast to 95% of the

[42] It is publicly available at `http://www.icpsr.umich.edu/icpsrweb/HMCA/studies/2935`

[43] See U.S. Department of Labor, Bureau of Labor Statistics at website: `http://stats.bls.gov`.

firms with 50 or more workers. Moreover, wages, both unconditional and conditional on insurance status, are very close to the one reported for the 1996 SIPP sample. The average annual wages are calculated in two ways, either using the firm or using the worker as a unit of observation. They show that firms that offer insurance on average pay more than firms that do not offer health insurance; and on average workers with health insurance earn more than those without health insurance. Therefore, although we restrict samples to relatively unskilled workers in SIPP, the compensation patterns seem to be quite consistent in the worker-side and employer-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.[44] We estimate parameters regarding health transitions and medical expenditure distribution without using the model. The remaining parameters are estimated via a minimum-distance estimator which follows Imbens and Lancaster (1994) and Petrin (2002). They consider the situation where moments come from different data sources. In this study we construct worker-side moments from the likelihood of individuals' labor market transition, as in Bontemps, Robin, and Van den Berg (1999, 2000) and Shephard (2012). Then, we construct firm-side moments such as firm size distribution and firm's coverage rate conditional on their size from employer-side 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 used in Bontemps, Robin, and Van den Berg (1999, 2000) and Shephard (2012), where model parameters are chosen to fit worker side data alone.[45] As a result, we 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%.[46] Moreover, we set the exogenous death rate ρ_g to be 0.001 for both $g = 1$ and 2.[47] We also set the fraction of male workers in the population M_1/M to be 0.543, which is the fraction of males workers in our selected SIPP

[44] The details of the numerical estimation procecure are available in Online Appendix C.

[45] 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 (2012), 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.

[46] 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.

[47] 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.

sample.[48] 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 $\tau_2 = -0.153$.[49]

6.1 First Step

In Step 1 we estimate parameters determining individuals' medical expenditure distribution, including for each $h \in \mathcal{H}, x \in \{0,1\}, g \in \{1,2\}$, γ^{+}_{ghx}, which characterize the probability of receiving a medical shock in (2), and the parameters $\left(b_{ghx}, s_{ghx}, \beta_{ghx}\right)$ for the Gamma-Gompertz the distribution of medical expenditures as specified in (3), as well as the health transitions π^x as in (5) without explicitly using the model. They are estimated by GMM using the MEPS data. For *each* h, x, g, we construct four moments (mean, variance, and skewness of annual medical expenditure and the fraction of individuals with zero medical expenditure). For simplicity, we estimate these parameters using a subsample of individuals whose health and health insurance status are *unchanged* throughout the year. The *annual* theoretical moments conditional on health insurance and health status are constructed or simulated from parameters which are defined for our model with a four-month period.[50]

Because we are assuming that the effect of health insurance and health status on medical shocks and medical expenditures are exogenous, our restriction to the subsample of individuals whose health and health insurance status are *unchanged* throughout the year does not create a biased sample for our estimation purpose. However, it is useful to recognize that this subsample differs from the overall MEPS sample. Table 6 provides the analogous summary statistics of the MEPS subsample we used in our first step estimation. The comparison of Tables 6 and 4 shows that, not surprisingly, the magnitudes of medical expenditure are substantially lower in this subsample than those in the overall sample.

[Insert Tables 6 About Here]

We estimate the parameters in health transition matrix $\pi^x_{ghh'}$ as described in (5) using the 1996 SIPP data based on maximum likelihood. The key issue we need to deal with is that our model period is 4 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 gender. Let $x_t \in \{0,1\}$ be a gender-g worker's insurance status at period t, and let $h_t \in \mathcal{H}$ and $h_{t+3} \in \mathcal{H}$ denote respectively the worker's health status in period t and $t+3$ (when it is next measured), the likelihood of observing $h_{t+3} \in \mathcal{H}$ conditional on x_t, x_{t+1}, x_{t+2} and $h_t \in \mathcal{H}$ can be written out explicitly using the Law of Total Probability:

$$\Pr(h_{t+3}|x_t, x_{t+1}, x_{t+2}, h_t, g) = \sum_{h_{t+2}\in\mathcal{H}} \sum_{h_{t+1}\in\mathcal{H}} \pi^{x_t}_{gh_{t+1}h_t} \pi^{x_{t+1}}_{gh_{t+2}h_{t+1}} \pi^{x_{t+2}}_{gh_{t+3}h_{t+2}}.$$

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 $\boldsymbol{\pi}^x_g$, for $x \in \{0,1\}$, as in (5) in our model.

[48] The magnitude of M, the measure of workers relative to firms, will be estimated and it is reported in Table 9.

[49] 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 F for details).

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

6.2 Second Step

In the second step, we estimate the remaining parameters $\boldsymbol{\theta} \equiv (\theta_1, \theta_2)$ where $\theta_1 \equiv \langle \gamma_g, \mathfrak{b}_g, \lambda_{gu}, \lambda_{ge}, \delta_g, \mu_{gE}, \mu_{gH}, \sigma_{gw} : g \in \{1,2\} \rangle$ are parameters that affect worker-side dynamics, and $\theta_2 \equiv \langle C, d_{gh}, M, \mu_p, \sigma_p, \sigma_f : g \in \{1,2\}, h \in \{H, U\} \rangle$ are the additional parameters that are mostly relevant to the firm-side moments. Our objective function is based on the optimal GMM which consists of two types of moments. The first set of moments are derived from the worker-side data in SIPP in the form of the log-likelihood of the observed labor market dynamics of the workers, which we aim to maximize by requiring that the first derivatives should be equal to zero, following Imbens and Lancaster (1994). The second set of moments come from the firm-side data RWJ-EHI.

Specifically, let the targeted moments be

$$\mathcal{M}(\boldsymbol{\theta}) = \begin{bmatrix} \frac{\sum_i \partial \log(L_i(\boldsymbol{\theta}))}{\partial \theta} \\ \mathbf{m} - \mathrm{E}[\mathbf{m}; \boldsymbol{\theta}] \end{bmatrix}, \tag{33}$$

where $L_i(\theta)$ is individual i's contribution to the labor market dynamics likelihood, which we discuss in details in Section 6.2.1; and $\mathbf{m}$ is a vector of firm-side moments we describe in Section 6.2.2. Then, we construct an objective function as

$$\min_{\{\theta\}} \mathcal{M}(\boldsymbol{\theta})' \Omega \mathcal{M}(\boldsymbol{\theta}), \tag{34}$$

where the weighting matrix Ω is chosen as a consistent estimator of $\mathrm{E}[\mathcal{M}(\boldsymbol{\theta})'\mathcal{M}(\boldsymbol{\theta})]^{-1}$, which is obtained using $\tilde{\boldsymbol{\theta}}$, a preliminary consistent estimate of $\boldsymbol{\theta}$. As in Petrin (2002), we first assume that $\mathrm{E}[\mathcal{M}(\boldsymbol{\theta})'\mathcal{M}(\boldsymbol{\theta})]$ takes block diagonal matrix because different moments come from different sampling processes. Let $\mathbb{M}(\boldsymbol{\theta}) = \mathrm{E}[\frac{\partial \mathcal{M}(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}'}]$, the gradient of the moments with respect to the parameters evaluated at the true parameter values. The asymptotic variance of $\sqrt{n}\left(\hat{\boldsymbol{\theta}} - \boldsymbol{\theta}\right)$ is then given by

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

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

6.2.1 Deriving the Likelihood Functions of Workers' Labor Market Dynamics

Here we derive the likelihood functions of workers' labor market dynamics similar to those in Bontemps, Robin, and Van den Berg (1999, 2000). Let $F(w, x)$ denote the distribution of (w, x) in the labor market.

We will first derive the likelihood contribution of the labor market transitions of *unemployed workers.* Consider an unemployed gender-g worker at period 1 with health status is h_1, who experiences an unemployment spell of duration l and in period $l+1$ transitions to a job $(\tilde{w}, \tilde{x})$.[51] To ease exposition, let us first *suppose* that health history between $j = 1$ to $l+1$ for this worker, $(h_1, h_2, ..., h_{l+1})$, is observed. The likelihood contribution of observing such a transition is:

$$\frac{u_{gh_1}}{M} \times \Pi_{j=2}^{l} \left\{ \Pr(h_j | h_{j-1}, x_{j-1} = 0, g) \times \left[1 - \lambda_{gu} \int \Phi\left(\tilde{z}_{gu}(w', x', h_j)\right) dF(w', x') \right] \right\} \tag{35a}$$

$$\times \Pr(h_{l+1} | h_l, x_l = 0, g) \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 1, h_{l+1})\right) f(\tilde{w}, 1)\right]^{\mathbf{1}(\tilde{x}=1)} \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 0, h_{l+1})\right) f(\tilde{w}, 0)\right]^{\mathbf{1}(\tilde{x}=0)} \tag{35b}$$

where $\mathbf{1}(\tilde{x} = 1)$ is an indicator function taking value one if we observe a transition to employment with $(\tilde{w}, 1)$ at period $l+1$, and similarly $\mathbf{1}(\tilde{x} = 0)$ is an indicator function taking value one if we observe

[51] Note that we do not explicitly incorporate measurement error in wages in our estimation. We mitigated the impact of potential measurement errors in wages by dropping the top and bottom 3% of wage observations from our estimated samples (see the description of sample selection in Section 5).

a transition to employment with $(\tilde{w}, 0)$ at period $l+1$. To understand (35), note that the first term in line (35a), u_{gh}/M, reflects the assumption that the initial condition of individuals is drawn from the steady state worker distribution because u_{gh}/M the probability that an unemployed gender-g worker with health status h is sampled. The second term in line (35a) is the probability that individual experiences l periods of unemployment with health status transitions $(h_2, ..., h_l)$ during the process; note that the term $\left[1-\lambda_{gu} \int \Phi\left(\tilde{z}_{gu}\left(w', x', h_j\right)\right) dF(w', x')\right]$ is the probability that the individual does not receive an offer or receives an offer whose value is less than staying as an unemployed (see the definition of $\tilde{z}_{gu}\left(w', x', h_j\right)$ as given by (10)). The term on line (35b) is the probability that his health transitions from h_l to h_{l+1} in period $l+1$ and receive an acceptable offer $(\tilde{w}, \tilde{x})$ from the relevant density function $f(\tilde{w}, \tilde{x})$.

Now as we described earlier in Section 5, SIPP data we observe the workers' self-reported health status only annually (at interview waves 3, 6, 9 and 12); as a result, we do not always observe workers' health history in-between labor market transitions. However, since we already estimated the health transitions conditional on health insurance in Step 1, we can integrate out the unobserved health status.[52]

We can similarly derive the likelihood contribution of the job dynamics of *employed workers.* Consider an employed gender-g worker in period 1 with health status h_1 working on a job with compensation package (w, x). Suppose that the worker experiences a job status changes in period $l+1$. For an employed worker, there are four possible job status changes:

• [Event *"Job Separation"*]: The individual experienced a job separation at period $l+1$, which can be a result of exogenous destruction of the job or a voluntary quit into unemployment (due to changes in health and the preference shocks);

• [Event *"Switch 1"*]: The individual transitioned to a job $(\tilde{w}, \tilde{x})$ such that $\tilde{x} = x$ and the accepted wage is $\tilde{w} > w$;

• [Event *"Switch 2"*]: The individual transitioned to a job $(\tilde{w}, \tilde{x})$ such that $\tilde{x} = x$ and the accepted wage is $\tilde{w} < w$;

• [Event *"Switch 3"*]: The individual transitioned to a job $(\tilde{w}, \tilde{x})$ such that $\tilde{x} \neq x$ and the accepted wage is $\tilde{w}$.

Again, suppose that the health history between $j = 1$ to $l+1$ for this worker, $(h_1, h_2, ..., h_{l+1})$, is observed, then the likelihood contribution is given by:

$$\frac{e^x_{gh_1} s^x_{gh_1}(w)}{M} \tag{36a}$$

$$\times \Pi_{j=2}^{l} \left\{ \Pr(h_j | h_{j-1}, x, g)(1-\delta_g) \left[\left((1-\lambda_{ge}) + \lambda_{ge} \begin{pmatrix} F(w, x) \\ +F\left(\underline{w}^{1-x}_{gh_j}(w, x), 1-x\right) \end{pmatrix} \right) \Phi\left(\tilde{z}^2_{ge}(w, x, h_j)\right) \right] \right\} \tag{36b}$$

$$\times \Pr(h_{l+1} | h_l, x, g) \tag{36c}$$

$$\times \begin{cases} \begin{array}{l} \delta_g \left[(1-\lambda_{ge}) + \lambda_{ge} \int \left[1-\Phi\left(\tilde{z}_{gu}(w', x', h_{l+1})\right)\right] dF(w', x')\right] \\ +(1-\delta_g) \left\{ \begin{array}{l} \lambda_{ge} \int \left[1-\Phi\left(\tilde{z}^1_{ge}(w', x', w, x, h_{l+1})\right)\right] dF(w', x') \\ +(1-\lambda_{ge})\left[1-\Phi\left(\tilde{z}_{gu}(w, x, h_{l+1})\right)\right] \end{array} \right\}, \end{array} & \text{if Event is "Job Separation"} \\ \lambda_{ge} f(\tilde{w}, \tilde{x}) \Phi\left(\tilde{z}^2_{ge}(\tilde{w}, \tilde{x}, h_{l+1})\right), & \text{if Event is "Switch 1"} \\ \delta_g \lambda_{ge} f(\tilde{w}, \tilde{x}) \Phi\left(\tilde{z}^2_{ge}(\tilde{w}, \tilde{x}, h_{l+1})\right), & \text{if Event is "Switch 2"} \\ \left[\begin{array}{l} (1-\delta_g)\lambda_{ge} f(\tilde{w}, \tilde{x}) \mathbf{1}\left\{\tilde{w} \geq \underline{w}^{\tilde{x}}_{gh_{l+1}}(w, x), \tilde{x}\right\} \Phi\left(\tilde{z}^1_{ge}(\tilde{w}, \tilde{x}, w, x, h_{l+1})\right) \\ +\delta_g \lambda_{ge} f(\tilde{w}, \tilde{x}) \Phi\left(\tilde{z}^2_{ge}(\tilde{w}, \tilde{x}, h_{l+1})\right), \end{array} \right] & \text{if Event is "Switch 3".} \end{cases} \tag{36d}$$

To understand (36), note that similar to that in (35), the term in line (36a), $e^x_{gh} s^x_{gh}(w)/M$, is the probability of sampling an employed gender-g worker with health status h_1 working on a job (w, x); the term in

[52] Details for the likelihood functions when the health history in-between labor market transitions are not observable are provided in Online Appendix B.

line (36b) is the probability that individual stays with the job (w, x) for l periods with health status transitions $(h_2, ..., h_l)$ during the process. Line (36c) expresses the likelihood of observing health transition from h_l to h_{l+1} in period $l+1$. Line (36d) expresses the likelihood of observing one of the four job status change events. For example, the event "Job Separation" is observed in period $l+1$ because the individual experiences an exogenous shock that destroys the current match (which occurs with probability δ_g), and then he/she does not get matched to another acceptable job (which occurs with probability $(1-\lambda_{ge}) + \lambda_{ge} \int [1 - \Phi(\tilde{z}_{gu}(w', x', h_{l+1}))] \, dF(w', x')$ or he/she voluntarily quits into unemployment which may happen due to changes in health status or preference shocks to employment. To understand the probability of event "Switch 2", we note that in order for a worker to switch to a job $(\tilde{w}, \tilde{x})$ with $\tilde{x} = x$ but $\tilde{w} < w$, the worker must have experienced a job separation (which occurs with probability δ_g), but is then lucky enough to receive the offer $(\tilde{w}, \tilde{x})$ immediately and moreover the preference shock ϵ_w is less than $\tilde{z}^2_{ge}(\tilde{w}, \tilde{x}, h_{l+1})$, which happens with probability $\lambda_{ge} f(\tilde{w}, \tilde{x}) \Phi\left(\tilde{z}^2_{ge}(\tilde{w}, \tilde{x}, h_{l+1})\right)$. The probability of the other job switch events are derived similarly.

6.2.2 Employer-Side Moments

In our estimation, we also require that our model's predictions match the following employer-side moments calculated from the RWJ-EHI data. These moments correspond to the vector $\mathbf{m}$ in expression (33):

- Mean firm size;
- Fraction of firms less than 50 workers;
- Mean size of firms that offer health insurance;
- Mean size of firms that do not offer health insurance;
- Health insurance coverage rate;
- 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;
- Average wages of workers in firms offering health insurance;
- Average wages of workers in firms not offering health insurance;
- Average wages of workers in firms with less than 50 workers;
- Average wages of workers in firms with more than 50 workers.
- Fraction of female workers in firms offering health insurance;
- Fraction of female workers in firms not offering health insurance.

7 Estimation Results

7.1 Parameter Estimates

Parameters Estimated in the First Step. Tables 7 and 8 respectively report the step 1 parameter estimates for the medical expenditure processes as described by (2) and (3), 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. The parameter estimates for the Gamma-Gompertz distributions are hard to interpret directly, but as we will show in Table 10 below, 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. Table 10 will show that our estimated medical expenditure processes fit the mean, variance, skewness of medical expenditures by health and healthy insurance status in the data well.

[Insert Table 7 About Here]

In Table 8, we report the parameter estimate for the health transitions, 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 health. Specifically, our estimates indicate that $\pi^1_{gEE} > \pi^0_{gEE}$ for both genders, which implies that workers of both genders with health insurance is more likely to stay in excellent health than those without health insurance. Similarly, we find that $\pi^1_{gEU} > \pi^0_{gEU}$ and $\pi^1_{gHU} > \pi^0_{gHU}$ for both genders, which implies that workers with health insurance are more likely to transition out of the unhealthy status to either excellent health or healthy.

[Insert Table 8 About Here]

It is useful to note that our estimates of the effect of health insurance on 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.[53]

Parameters Estimated in the Second Step. Table 9 reports the parameter estimates from step 2. The gender-specific parameters are indicated by the subscript g. Panel A provides the estimates for the model parameters that are related to workers, namely $\theta_1 \equiv \left\langle \lambda_{gu}, \lambda_{ge}, \delta_g, \gamma_g, \mu_{gE}, \mu_{gH}, \mathfrak{b}_g, \sigma_{gw} \right\rangle$. Our estimate of CARA coefficient is about 0.2415E-4 (recalling that our unit is in $10,000) for males and 0.8878E-4 for females. Using the four-month average wages for employed workers reported in Table 3, which is about $8,350 for males and $7,080 for females, our estimated CARA coefficients imply relative risk aversions of about 0.2017 for males and 0.6286 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).

[Insert Table 9 About Here]

[53] 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.

We find that the "monetary income" received while in unemployment $\mathfrak{b}_g$ is similar for men and women at about \$170 for four months for men and \$134 for women respectively. The relatively small estimates of b_g suggests that a large fraction of the UI benefits are probably expensed for job search costs. We also find that the offer arrival rates for an unemployed worker λ_{gu} are 0.4345 for males and 0.3540 for females, which imply that on average it takes about 9 months and 11 months for an unemployed male and female, respectively, to receive an offer. We also find that the offer arrival rates for employed workers, λ_{ge}, are respectively about 0.3745 for males and 0.2780 for females, which imply that on average it takes about 10.7 and 14.4 months for for a currently male and female employed worker respectively to receive an outside offer.[54]

In Panel A, we also report that our estimates of the probability of exogenous job destruction, δ_g, are about 2.09% and 2.58% in a four-month period for males and female respectively. Also, we estimate that the fraction of newly arrived workers who have excellent health is about 36.3% and 33% for males and females respectively, and the fractions that are healthy are 62.5% and 63.37% for males and females respectively. Finally, we found that there is substantial variation in the preference shock to work for both males and females.

Panel B reports our estimates of parameters $\theta_2 \equiv \left\langle d_{gh}, C, M, \mu_p, \sigma_p, \sigma_f \right\rangle$. We find that there is very little productivity loss for healthy workers relative to workers with excellent health, with the estimates of d_{gH} to be 0.9979 and 1.00 for males and females respectively (recall that the productivity of workers with excellent health is normalized to 1); however, we find that there is substantial productivity loss for unhealthy workers: the productivity of an unhealthy worker (those who self-reported health is "Poor" or "Fair"), d_{gU}, is 0.7665 and 0.7946 respectively for male and female workers, implying between 21-24% productivity loss for unhealthy workers relative to workers with excellent health.[55] Moreover, we find that the mean of the administration cost of offering health insurance, C, is about \$1,601 per four month, i.e., about \$6,400 per year.

In order to fit the average firm size, our estimate of M, the ratio between workers and firms, is about 20.39. This estimate is about the same as the average establishment size of 19.92 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 be able to attract some workers in equilibrium. We also estimated that the scale and shape parameters of the lognormal productivity distribution are respectively -1.092 and 0.7183, which implies that the mean (4-month) productivity of firms is about \$4,343. The fact that the mean accepted four-month wages in our sample are \$8,350 and \$7,080 respectively for males and females (see Table 3) is largely due to the fact more productive firms attract more workers in the steady state as our model implies. Lastly, we estimated that the scale parameter of the random cost of ESHI offering, σ_f, as specified in (27) is estimated to be about \$1,703, which is of a similar magnitude as the estimate of C.

[54] 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.

[55] 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).

7.2 Within-Sample Goodness of Fit

In this section, we examine the within-sample goodness of fit of our estimates by numerically solving the equilibrium of our estimated model and compare the model predictions with their data counterparts.

Worker-Side Goodness of Fit. Table 10 reports the model fits for medical expenditure in the first step. It shows that our parameter estimates fit the data on the means (in Panel A), variances (in Panel B) and skewnesses (in Panel C) of the medical expenditure processes conditional on gender, health and health insurance status very well; moreover, in Panel D, we show that we accurately replicate the fraction of individuals with zero medical expenditures conditional on gender, health and health insurance status. Table 11 shows that our model provides excellent fits for annual health transitions by gender and health insurance status.

[Insert Table 10 About Here]
[Insert Table 11 About Here]

Table 12 reports the model fit for the worker-side moments. It shows that the model fits reasonably well the cross section worker distribution, by gender, in terms of health, health status, health insurance, wage, and employment distribution. It also shows the estimated model provides a reasonably well fit for mean wages, with and without health insurance, as well as the mean medical expenditures, for both genders. Note that these worker-side moments are not directly targeted in our estimation, as we were using the score of the log likelihood of the workers' labor market transitions in our estimation (see 6.2).

[Insert Table 12 About Here]

In Table 13, we report the model fit for the one-period transition of workers' labor market status, by gender and health status. The fits are reasonable, but not perfect. In particular, the model seems to over-predict the unemployment to employment transition for unhealthy male workers, and under-predict the employment to unemployment transitions for unhealth workers. These are likely to be related to the small sample sizes for unhealthy workers, once breaking down by gender and health status.[56, 57]

[Insert Table 13 About Here]

Employer-Side Goodness of Fit. Table 14 compares the model's predictions of the targeted employer-side moments listed in Section 6.2.2 with those in the data. With the exception of the average wage of firms with less than 50 workers, our model fits all the other moments, including mean firm size, fraction of firms with less than 50 workers, and health insurance coverage rate (overall and by firm size).

[Insert Table 14 About Here]

Figure 1 shows the size distributions of firms by health insurance offering status, both in the data and that implied by our model estimates. It shows that our model is able to capture the size distribution of firms by health insurance offering status reasonably well.

[56] In other words, in the data the transition rates of the unhealthy workers have relatively large standard errors, so the optimal weighting matrix puts less weight on fitting these transitions.

[57] In general, our model does not generate sufficient differentiations in the one-period labor market transition rates by health status. We could have allowed the offer arrival rates, both when unemployed and on the job, to differ by health status.

[Insert Figure 1 About Here]

We should point out that even though our model qualitatively predicts the positive correlation between wage and firm size, it generates a much steeper relationship between them than what is in the data. Because firm productivity is positively correlated with wage offer in our model, in order to fit worker's wage distribution which is very dispersed, we need to have a relatively large variance of firm productivity. However, since firm size and wage are positively correlated in our model, a larger variance of firm productivity distribution leads to a steeper relationship between wage and firm size. The difficulty of simultaneously fitting firm size distribution from firm-side data and wage distribution from the worker-side data is known from Postel-Vinay and Robin (2002) and Cahuc, Postel-Vinay, and Robin (2006), who proposed to address the issue by introducing a wedge between workers' sampling distribution of firms and firms' productivity distribution.

7.3 Out-of-Sample Validation

We also attempted an out-of-sample validation of our model. Recall that we estimated our model using the data sets from 1996-1999. One way to provide some suggestive evidence of validation of our model is to use it to predict the ESHI offering rate for another period. Specifically, we use the estimated model to predict the changes of the ESHI offering rate from 1996-1999 to 2004-2006.[58] We conduct two version of the out of sample predictions. In both versions, we use the 2004-2006 MEPS data to re-estimate the medical expenditure processes for the period of 2004-2006. In the first version, we shift up the mean of the productivity distribution for this period to be commensurate with the increase in the consumer price index, which is about 30% from 1996 to 2006 from Bureau of Labor Statistics) by changing the location parameter of the Log Normal productivity distribution, μ_p, from the estimated value of -1.092 for 1996-1999 to -0.85. In the second version, we further shift up the mean of the productivity distribution to reflect the 20% increase in real wages from 1996 to 2006, by changing μ_p to -0.65 for 2004-2006.[59] The results from these two versions are reported in Table 15 respectively under "Inflation Adjustment Only" and "Inflation and Productivity Adjustment". We find that our model predicts that the fraction of firms that would offer ESHI to their workers would decrease from 55.40% in 1996-1997 to about 47.73% or 48.36% in 2004-2006 under the two versions, and it predicts that the unemployment rate would be about 4.97% and 4.84%, and also the fraction of unhealthy workers in the population would slightly increase from 5.53% in 1996-1997 to 6.27% or 6.17% in 2004-2006. Our model's prediction of about 13.8 percent or 12.7 percent decline in ESHI offering rates is largely consistent with the pattern reported in Kaiser Family Foundation and Health Research and Educational Trust (2009), where it found that the fraction of firms offering ESHI declined by about 9 percent from 66% in 1999 to about 60% in the period of 2004-2006.[60]

[Insert Table 15 About Here]

[58] We chose this period because there were substantial increases in healthcare costs during this period, yet the overall unemployment rate was similar to the 1996-1997 level.

[59] From the TFP data series available at Federal Reserve Bank of San Francisco, `http://www.frbsf.org/economic-research/total-factor-productivity-tfp/`, the TFP growth between 1996 and 2006 is about 20%.

[60] The earliest Kaiser/HRET Survey of Employer Benefits was in year 1999.

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 introduce a health insurance exchange where individuals can purchase health insurance at community rated premium; fourth, the participants in health insurance exchange can obtain income-based subsidies.

The introduction of health insurance exchange represents a substantial departure from our benchmark model because premium in exchange needs to be endogenously determined. 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.

The Main Change in Individuals' Environment. We now assume individuals who are not offered health insurance by their employers and those who are unemployed can purchase individual health insurance from the health insurance exchange. We assume that the insurance purchased from the exchange is identical to those offered by the employers in that it also fully insures medical expenditure risk. Thus in the extended model, an individual's insurance status x is defined as

$$x = \begin{cases} 0 & \text{if uninsured} \\ 1 & \text{if insured through employer} \\ 2 & \text{if insured through exchange.} \end{cases}$$

We assume that the effect on health for health insurance purchased from the exchange for gender-g workers, denoted by $\boldsymbol{\pi}_g^2$ analogously defined as (5), is identical to that for employer-sponsored health insurance, i.e., $\boldsymbol{\pi}_g^2 = \boldsymbol{\pi}_g^1$ for $g \in \{1, 2\}$.

We also incorporate the premium subsidies to the individuals and penalties if uninsured into the model. Let $SUB\left(y, R^{EX}\right)$ denote income based subsidies to an individual with income y who purchase health insurance from the exchange where R^{EX} is the premium in exchange, which is to be determined in equilibrium. Similarly, let $P_W(y)$ denote the penalty to individuals who remain uninsured, which also depends on income level.

Worker's problem. Under this extension, the expected flow utility $v_{gh}(y, x)$ in the counterfactual is defined as:

$$v_{gh}(y, x) = \begin{cases} \mathrm{E}_{\tilde{m}_{gh}^0} u_g\left(T(y) - \tilde{m}_{gh}^0 - P_W(y)\right) & \text{if } x = 0 \\ u_g\left(T\left(y\right)\right) & \text{if } x = 1 \\ u_g\left(T\left(y\right) + SUB\left(y, R^{EX}\right) - R^{EX}\right) & \text{if } x = 2 \end{cases} \tag{37}$$

The value function of a gender-g unemployed individual with health insurance status $x \in \{0, 2\}$ becomes

$$\frac{U_{gh}(x)}{1-\rho_g} = v_{gh}(\mathfrak{b}_g, 0) + \beta \mathrm{E}_{h'|(h,x,g)} \left[\begin{array}{l} \lambda_{gu} \int\int \max\left\{V_{gh'}(\tilde{w}, 1), U_{gh'}(x_{gh'}^*) + \sigma_{gw}\epsilon_w\right\} d\Phi\left(\epsilon_w\right) dF(\tilde{w}, 1) \\ +\lambda_{gu} \int\int \max\left\{V_{gh'}(\tilde{w}, x_{gh'}^*\left(\tilde{w}\right)), U_{h'}(x_{gh'}^*) + \sigma_{gw}\epsilon_w\right\} d\Phi\left(\epsilon_w\right) dF(\tilde{w}, 0) \\ +(1-\lambda_{gu}) U_{gh'}(x_{gh'}^*), \end{array} \right] \tag{38}$$

where

$$x^*_{gh'} = \arg\max_{x' \in \{0,2\}} U_{gh'}(x'), \tag{39}$$

$$x^*_{gh'}(\tilde{w}) = \arg\max_{x \in \{0,2\}} V_{gh'}(\tilde{w}, x). \tag{40}$$

Similarly, the value function of a gender-g employed worker with health status h working on a job with insurance status (w, x), $V_{gh}(w, x)$, is as follows. If $x = 1$,

$$\begin{aligned}
& \frac{V_{gh}(w,1)}{1-\rho_g} = v_{gh}(w,1) \\
+ \quad & \beta\lambda_{ge}\left\{(1-\delta_g)\,\mathrm{E}_{h'|(h,1,g)}\left[\begin{array}{l} \int\int \max\{V_{gh'}(\tilde{w},1), V_{gh'}(w,1), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\}d\Phi(\epsilon_w)\,dF(\tilde{w},1) \\ +\int\int \max\{V_{gh'}(\tilde{w}, x^*_{gh'}(\tilde{w})), V_{gh'}(w,1), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\}d\Phi(\epsilon_w)\,dF(\tilde{w},0) \end{array}\right]\right. \\
+ \quad & \left.\delta_g \mathrm{E}_{h'|(h,1,g)}\left[\begin{array}{l} \int\int \max\left\{V_{gh'}(\tilde{w},1), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\,dF(\tilde{w},1) \\ +\int\int \max\left\{V_{gh'}(\tilde{w}, x^*_{gh'}(\tilde{w})), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\,dF(\tilde{w},0) \end{array}\right]\right\} \\
+ \quad & \beta(1-\lambda_{ge})\left\{\begin{array}{l} (1-\delta_g)\mathrm{E}_{h'|(h,1,g)}\left[\int \max\left\{V_{gh'}(w,1), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\right] \\ +\delta_g \mathrm{E}_{h'|(h,1,g)} U_{gh'}(x^*_{gh'}) \end{array}\right\},
\end{aligned} \tag{41}$$

and if $x \in \{0, 2\}$,

$$\begin{aligned}
& \frac{V_{gh}(w,x)}{1-\rho_g} = v_{gh}(w,x) \\
& +\beta\lambda_{ge}\left\{(1-\delta_g)\mathrm{E}_{h'|(h,x,g)}\left[\begin{array}{l} \int\int \max\{V_{gh'}(\tilde{w},1), V_{gh'}(w, x^*_{gh'}(w)), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\}d\Phi(\epsilon_w)\,dF(\tilde{w},1) \\ +\int\int \max\{V_{gh'}(\tilde{w}, x^*_{gh'}(\tilde{w})), V_{gh'}(w, x^*_{gh'}(w)), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\}d\Phi(\epsilon_w)\,dF(\tilde{w},0) \end{array}\right]\right. \\
& \left.+\,\delta_g \mathrm{E}_{h'|(h,x,g)}\left[\begin{array}{l} \int\int \max\left\{V_{gh'}(\tilde{w},1), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\,dF(\tilde{w},1) \\ +\int\int \max\left\{V_{gh'}(\tilde{w}, x^*_{gh'}(\tilde{w})), U_{gh'}(x^*_{h'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\,dF(\tilde{w},0) \end{array}\right]\right\} \\
& +\beta(1-\lambda_{ge})\left\{\begin{array}{l} (1-\delta_g)\mathrm{E}_{h'|(h,x,g)}\left[\int \max\left\{V_{gh'}(w, x^*_{gh'}(w)), U_{gh'}(x^*_{gh'}) + \sigma_{gw}\epsilon_w\right\} d\Phi(\epsilon_w)\right] \\ +\delta_g \mathrm{E}_{h'|(h,x,g)} U_{gh'}(x^*_{gh'}) \end{array}\right\},
\end{aligned} \tag{42}$$

where in both (41) and (42), $x^*_{gh'}$ is as given by (39) and $x^*_{gh'}(\cdot)$ is as given by (40).

We characterize the individuals' optimal job acceptance strategies, and their optimal decision regarding whether to purchase insurance from the exchanges when they are unemployed or when their employers do not offer health insurance similar to those for the benchmark model. We also characterize the steady state worker distribution among firms $\left\langle e^x_{gh}, S^x_{gh}(w)\right\rangle$ for $x \in \{0, 1, 2\}$ when the two additional terms, e^2_{gh} and $S^2_h(w)$, are now respectively the measure of employed gender-g workers with health status h who purchase insurance from the exchange, and the distribution of wages among them.

Firms' Problem. 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 specify $P_E(n)$ in the next subsection when we parameterize the employer mandate of the Affordable Care Act.

There are two important changes to the firms' problem. The first one is how firm size is determined. Because of the insurance exchange, some of their workforce may be insured even if they do not offer health insurance. Specifically, $n(w, 0)$, the size of firms not offering health insurance, becomes

$$n(w,0) = \sum_{g\in\{1,2\}}\sum_{h\in\mathcal{H}} n_{gh}(w,0) = \sum_{g\in\{1,2\}}\sum_{h\in\mathcal{H}} \frac{e^0_{gh}s^0_{gh}(w) + e^2_{gh}s^2_{gh}(w)}{f(w,0)},$$

and the expression for $n(w,1)$ remains the same as before.

Second, because of the employer mandate, firm's profit maximization problem will change. It now becomes

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

where:

$$\Pi_0(p) = \max_{\{w_0\}} \Pi(w_0, 0) \equiv \sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} (pd_{gh} - w_0)\, n_{gh}(w_0, 0) - P_E(n(w,0)), \tag{43}$$

$$\Pi_1(p) = \max_{\{w_1\}} \Pi(w_1, 1) \equiv \sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} \left[(pd_{gh} - w_1)\, n_{gh}(w_0, 1) - m^1_{gh}\right] - C \tag{44}$$

where the term $P_E(n(w,0))$ in the expression for $\Pi_0(p)$ reflects the possible penalty to employers for not offering employer-sponsored health insurance to their workers.

Insurance Exchange. 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 $1+\xi$, where $\xi > 0$ is loading factor for health insurance exchange; specifically,

$$R^{EX} = (1+\xi)\frac{\sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} m^2_{gh}\left[u^2_{gh} + \int e^2_{gh} s^2_{gh}(w)\, dw\right]}{\sum_{g\in\{1,2\}} \sum_{h\in\mathcal{H}} \left[u^2_{gh} + \int e^2_{gh} s^2_{gh}(w)\, dw\right]} \tag{45}$$

where m^2_{gh} is expected medical expenditure of gender-g individual with health status h for individuals with insurances purchased from the exchange which, due to our assumption that the insurances in the exchange are identical to those from the firms, is exactly the same as m^1_{gh} described by (4); u^2_{gh} is the measure of gender-g unemployed workers participating insurance exchange with health status h; and $e^2_{gh}s^2_{gh}(w)$ is the density for gender-g employed workers not being offered health insurance from employers but participating insurance exchange with health status h.

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 D.

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 thatthat described in the Online Appendix A, but an important change is that now we need to find the fixed point of not only $(w_0(p), w_1(p), \Delta(p))$ but also R^{EX}, the premium in insurance exchange.

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 ACA provisions, such as penalty associated with individual mandate, employer mandate and the premium subsidies, into our model. First, we estimated our model using data sets in 1996, 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 are substantial increases in medical care costs relative to GDP in the last 15 years. Thus we need to appropriately adjust the policy parameters in the ACA to make them more in line with the U.S. economy around 1996. 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 that appeared in (45) that is applicable in the insurance exchange. We calibrate ξ 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 $\xi = 0.25$.[61]

Below we present the ACA provisions for penalties associated with individual mandate, employer mandate and the income-based premium subsidies. In Online Appendix E, we describe how we translate the ACA provisions for 2011 into applicable formulas for our 1996 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 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:

$$P_W^{ACA}(y) = \max\{0.025 \times (y - \text{TFT\_2011}), \$695\} \tag{46}$$

where y is annual income.

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,

$$P_E^{ACA}(n) = \begin{cases} (n-30) \times \$2,000 \text{ if } n \geq 50 \\ 0 \text{ otherwise.} \end{cases} . \tag{47}$$

We follow the idea of smoothing of marginal tax rates in MaCurdy, Green, and Paarsch (1990) and adopt the following formulation as a smooth approximation of the above discontinuous employer-mandate penalty function:[62]

$$\tilde{P}_E^{ACA}(n) = \Phi\left(\frac{n-50}{\sigma_E}\right)(n-30) \times \$2,000, \tag{48}$$

where $\Phi(\cdot)$ is the Normal cumulative density function and σ_E is a smoothing parameter, which is chosen to be 0.01.[63]

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.[64] The premium subsidies are set on a sliding scale such that the

[61]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 (45) is simply $1/(1+\xi)$, thus an 80% medical loss ratio corresponds to $\xi = 0.25$. ACA requires that $\xi \leq 0.25$.

[62]We experimented with different values of σ_E, which governs the curvature of the penalty function. In order to ensure that, for firms with a given productivity level that do not offer health insurance, the profit net of the employer mandate penalty remains a concave function of wage level, σ_E can not be too small. This smoothed formulation of the employer mandate penalty avoids the issue of mass point at size just below 50. We also implemented the ACA with a discontinuous formulation of the employer mandate penalty, as in our earlier version Aizawa and Fang (2013), and the results are quantitatively similar and available upon request.

[63]Clearly, if the closer the smoothing parameter σ_E is to 0, the more $\tilde{P}_E^{ACA}(n)$ will resemble the discontinuousstep function of (47).

[64]We assume that FPL is defined as single person. In 1996, it is \$7,730 annually.

premium contributions are limited to a certain percentage of income for specified income levels. If an individual's income is at 133% of the FPL, denoted by FPL133, 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 income is below FPL133, he will receive insurance with zero premium contribution. If his income is above FPL400, he is no longer eligible for premium subsidies. Note that the premium support rule as described in the ACA creates a discontinuity at FPL133: individuals with income below FPL133 receives free Medicaid, but those at or slightly above FPL133 have to contribute at least 3.5% of his income to health insurance purchase from the exchange. To avoid this discontinuity issue, we instead adopt a slightly modified premium support formula as follows:

$$SUB\left(y, R^{EX}\right) = \begin{cases} \max\left\{R^{EX} - \left[0.0350 + 0.060\frac{(y-\text{FPL133})}{\text{FPL400}-\text{FPL133}}\right]y,\ 0\right\} \text{ if } y < \text{FPL400} \\ R^{EX} \text{ if unemployed} \\ 0, \text{ otherwise,} \end{cases} \tag{49}$$

when y is the *annual* income and R^{EX} is the annual premium for health insurance in the exchange. According to (49) the individual contribution to insurance premium increases linearly from 3.5% of his income when his income is at 133% of the FPL to 9.5% when his income is at 400% of the FPL.

8.3 Results from Counterfactual Experiments[65]

8.3.1 Uninsured Rates Under the ACA and its Variations

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 Table 16, we report results from several counterfactual policy experiments and contrast the outcomes under these counterfactual policies with the benchmark.

[Insert Table 16 About Here]

Benchmark. In Column (1), we report that under the benchmark economy, i.e., the pre-ACA environment, the uninsured rate among the population we study would be about 22.34% overall; when breaking down by gender, the uninsured rates are 20.67% and 23.67% respectively for males and females.

Two Versions of the ACA. We report the counterfactual results from two versions of the ACA, which differs in whether those who receive the free Medicaid insurance, as a result of the Medicaid expansion as stipulated under the ACA, will be included in the health insurance exchange risk pool. ACA*, reported in Column (2), assumes that the expanded Medicaid roll is part of the health insurance exchange risk pool, while ACA**, reported in Column (3), assumes that it is not. Our results in Columns (2) and (3) show that, regardless of the distinction of whether Medicaid rolls are part of the health insurance exchange , 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 between 3.67% (under ACA*) and 3.93% (under ACA**). Under both version of the ACA, the uninsured rate is lower for females than for males, even though females started off in the benchmark with higher uninsured rate than males.

It is also interesting to note that the fraction of firms offering ESHI declines from 55.4% under the benchmark to about 51.4% under either version of the ACA. Of course, due to the employer mandate for

[65]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 wages, profits, health expenditures, etc. are available upon request.

firms with 50 or more workers, the ESHI offering rates for these large firms increase from 92.03% in the benchmark to over 98% under the ACA; however, the ESHI offering rate for firms with less than 50 workers decreases significantly from 51.15% under the benchmark to 46% under the ACA.

To understand the *reasons* for the decline of ESHI offering rate of the small firms, it is useful to understand how the ACA affects the adverse selection. Table 17 reports 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 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 17, 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 that covers all unemployed 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 health under the ACA, which is in stark contrast to the pre-ACA case. If anything, the low productivity firms are actually attracting less unhealthy workers among their new hires than high-productivity firms. The reason is that the pool of workers attracted to high productivity firms include more uninsured workers whose used to work in firms that do not offer ESHI and whose income is in the medium level that prevents them from receiving government subsidies. 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 17 About Here]

ACA without the Individual Mandate. In Column (4), we report simulation results from a hypothetical environment of ACA without the individual mandate (IM), i.e. only EX, Sub and EM components of ACA are implemented. This would correspond to the case had the Supreme Court ruled against the constitutionality of the individual mandate. Surprisingly, we find that ACA without the individual mandate would also have still significantly reduced the uninsured rate to be about 7.34%, which is about 3.6 percentage points higher than under the ACA, but still represent close to 67% reduction from the 22.34% 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 many workers in low-wage firms that do not offer health insurance. In unreported results, we know that those workers who work in firms with medium-wages but do not offer health insurance turn out to be those workers who decide to pay the penalty and go without health insurance, if they have excellent health or are healthy. Notice that the fraction of employed workers who purchase health insurance from the exchange is about 2.7 percentage points lower under ACA without the individual mandate than under the full ACA. Because those who decided to go uninsured when there is no individual mandate are precisely those who are healthy or have excellent health, their absence in the exchange exacerbates the adverse selection problem, leading to a substantial increases in the premium in the exchange (from $535 under the ACA* to $591 in "ACA* w/o IM").

ACA without Employer Mandate. The employer mandate (EM) in the ACA has been very contentious. The Obama Administration has twice delayed its implementation. The first delays exempts 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.[66] What would happen if the employer mandate component is eliminated from the ACA? In Column (5), we report the result from a hypothetical environment of ACA *without* the employer mandate. 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.[67]

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 4.63%, just less than 1 percentage point higher than the 3.67% uninsured rate predicted under the full ACA. This somewhat surprising finding results from two forces. First, eliminating the employer mandate decreases the health insurance 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, the workers working in large firms that do not offer ESHI are likely to purchase health insurance from the exchange, thus offseting the effect from the reduction of ESHI offering rate on the uninsured rate.

The second effect is that eliminating the employer mandate on large firms may actually increase the ESHI offering rate of small firms. As shown in Columns (2) and (5), eliminating employer mandate on firms with 50 or more workers does decrease the ESHI offering rate of these large firms from 98.67% under the full ACA to 93.40% under "ACA w/o EM"; however, this is compensated by the increase of the ESHI offering rate of firms with less than 50 workers, which increased from 46.05% under the full ACA to 46.44% under "ACA w/o EM."

To understand why the employer mandate on large firms may dampen the incentives of the small firms to offer ESHI, it is important to recognize that as the size-dependent employer mandate increases the health insurance offering by large and high-productivity firms, small firms' incentive to offer health insurance may be reduced. The reason is that small firms anticipate that their workers will benefit less from being offered health insurance. In our model, workers demand health insurance because it not only provides insurance against the health expenditure shocks in the current period, but also it reduces future health expenditure risks since health insurance improves the realization of future health. If these workers anticipate that they will move to high-productivity firms offering health insurance with higher probability, the incentives to purchase health insurance in the current period may be lower. This channel may also reduce the incentives of healthy uninsured workers to participate in insurance exchange. This phenomena, known as *dynamic inefficiency* in the literature of insurance markets, may therefore lead small firms not to offer health insurance (see Fang and Gavazza (2011)), and also lead workers not offered insurance by their employers to forgo purchasing health insurance from the exchange.

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

[67]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.

8.3.2 Assessing the Effects of the Components of the ACA

The issue of whether the U.S. Internal Revenue Service may permissibly promulgate regulations to extend tax-credit subsidies to 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*. In Table 18 we report several counterfactual experiments that would allow us to understand the likely consequence if the premium subsidies in the ACA were disallowed.

[Insert Table 18 About Here]

Health Insurance Exchange Only. In Columns (1), we report the equilibrium of the economy when we introduce only the health insurance exchange (EX) to the benchmark economy. It turns out, having an exchange that mandates community rating 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 (22.27% vs. 22.34% in the benchmark as in Column 1 of Table 16). In fact, the exchange will not have any participants at all due to the adverse selection problem. However, the presence of the exchange still causes small changes to the labor market, both on the firm side and on the worker side, because the exchange affects the outside options of the workers' and thus affects the firms' decisions regarding wage and health insurance offering decisions in equilibrium.

Health Insurance Exchange with Premium Subsidy. In Column (2), 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 9.22%. The exchange is quite active with all the unemployed and 15.36% of the employed workers purchasing insurance from the exchange. 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 87.58% in contrast to 98.67% under the full ACA as reported in Column (2) of Table 16. Without 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 HIX to $601, which represents a 12.3 percent increase from the $535 premium predicted under the full ACA (again, reported in Column (2) of Table 16).

Health Insurance Exchange with Individual Mandate. In Column (3), 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 not have any participants: the equilibrium premium in the EX is even higher than the willingness to pay for insurance for the unhealthy type, let alone the healthy type. This indicates that the proposed individual mandate alone, at least at the current levels of penalty, is not large enough to solve adverse selection problem in the insurance exchange. Instead, the individuals mandate leads more employers to offer health insurance: the ESHI offering rate for firms with less than 50 workers increases from 50.84% under "EX" to 52.59% under "EX+IM", and that for firms with 50 or more workers rises from 92.11% to 96.50%. As a result, uninsured rate is 18.85% in Column (3), which represents a 3.4 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' demands 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), 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 not active. There is a reduction of the uninsured rate, from 22.34% in the benchmark to 20.79% in Column (4), but the declines of the uninsured rate are mostly due to the increased probability of offering health insurance by firms with 50 or more workers.

ACA without Premium Subsidy. In Column (5), we report the results when we introduce the ACA *sans* the income-based premium subsidies. Relative to the full ACA results reported in Columns (2) and (3) of Table 16, the uninsured rate is about much larger, at 18.19%. No one participates in the health insurance exchange due to adverse selection.

These results demonstrate that the proposed premium subsidies are *crucial* to solve adverse selection problem in the insurance exchange and contribute importantly to the substantial reduction of uninsured rate achieved under the full ACA.

8.3.3 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.[68] 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 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 $T(w)$.

[Insert Table 19 About Here]

Columns (1) and (3) of Table 19 report the same simulation results for the benchmark and the ACA as reported in Columns (1) and (2), respectively, of Table 16 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 22.34% to 35.10%. 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 92.03% under the benchmark with tax exemption to 72.86% under no exemption. This, of course, is a result of the fact that workers in large firms are in higher income tax brackets.

In Column (4), we remove the tax exemption for ESHI under ACA. We find that removing the tax exemption increase the uninsured rate from 3.67% to 6.05%. 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.

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

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 19, 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 51.72% of the firms will offer health insurance to their workers when ESHI premium is no longer exempt from income taxation; this is only slightly lower than 55.40% when ESHI premium is exempt from income taxation. Similarly, 48.52% of the firms will offer health insurance to their workers under the ACA when ESHI premium is not exempt from income taxation, which is again only slightly lower than 51.48% with exemption. 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 Table 19, 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*, which includes the tax expenditure due to the exemption, the premium subsidy and individual/employer mandate penalties, is about \$203 (\$127 + \$80 − \$6 = \$201); under the ACA without tax exemption, it is reduced to about \$80 (\$93 − \$13 = \$80). This is a decline of \$123 per capita per four months, which translates to about \$1,000 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 slightly negative effect of firms' average profit, but the impact is very small at around 0.1% $[(0.9538 - 0.9547)/0.9547 \approx 0.1\%]$.

8.3.4 ACA vs. the Massachusetts Health Care Reform

Next, we examine Massachusetts (MA) Health Care Reform implemented in 2006. It is well known that the ACA is based on the MA reform and there are strong similarities between them. However, employer mandate is implemented somewhat differently from the ACA, so is the premium subsidy. In this section, we investigate what happens if the federal government follows exactly the same reform as that in the MA.

To parametrize the MA reform, we consider the following stylized version of the reform as described in Kolstad and Kowalski (2012b). For individual mandate penalty, we assume that it is the same as the ACA.[69] In terms of employer mandate under the MA reform, firms with more than 10 workers are subject to the penalty tax if they do not offer health insurance. The amount of penalty is equal to \$295 times the number of full time employees. By using the same argument for the parameterization in the ACA, we parameterize it as follows:[70] for firms with more than 10 workers, the annual amount of penalty, $P_E^{MA}(n)$, is

$$P_E^{MA}(n) = \Phi(\frac{n-10}{\sigma_E}) \times n \times \$295. \tag{50}$$

Finally, as in the ACA, the income based subsidies in the MA reform are available to individuals partici-

[69]Note that the actual policy taken in MA was that penalty is equal to a half of premium of the least generous qualifying plan.

[70]Of course, we apply the same adjustments as those for the ACA described in Online Appendix E for account for the CPI differences between 1996 and 2011, as well as the fact that we use four-month income instead of annual income.

pating in insurance exchange. However, it is available to individuals whose income is less than 300% FPL (FPL300). Therefore, we parameterize it as:

$$SUB^{MA}\left(y,R^{EX}\right)=\begin{cases}\max\left\{R^{EX}-\left[0.0350+0.060\frac{(y-\text{FPL133})}{\text{FPL300}-\text{FPL133}}\right]y,\ 0\right\} & \text{if } y<\text{FPL300}\\ R^{EX} & \text{if unemployed}\\ 0, & \text{otherwise,}\end{cases} \tag{51}$$

The result is reported in Column (2) of Table 20, where we also reproduced the previous results about ACA from Table 16. We find that the uninsured rate is 4.21% under the MA reform, which is slightly higher than the 3.67% under the ACA. Recall that the MA reform has a somewhat lower income eligibility threshold for premium subsidy than the ACA, but the employer mandate is imposed more uniformly across firms. It seems that the less generous premium subsidy under the MA reform leads less to participate in the health insurance exchange, particularly those with good health and medium level incomes. As a result, the premium in the exchange is somewhat higher under the MA reform ($544 per four months under the MA reform vs. $535 under the ACA). Our prediction of the uninsured rate under the MA reform is qualitatively consistent with, and remarkably close to, the findings from the ex post evaluations of the MA reform as in Kolstad and Kowalski (2012b).

[Insert Table 20 About Here]

8.3.5 No Employer Sponsored Health Insurance Market

Finally, in Column (3) 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 (3), 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.[71] We find that disallowing ESHI would lead to drastic increases of uninsured rate; in fact, our model predicts that the uninsured rate would reach 51.69%, which is more than twice as large as the one in the benchmark economy. Insurance premium in exchange is $756 per four months, about 41 percent higher than the $535 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 solve adverse selection problem in insurance exchange. Our result also suggests that ESHI in fact complements, instead of hinders, the smooth operations of the health insurance exchange.

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 1996 panel of the Survey of Income and Program Participation (SIPP), the Medical Expenditure Panel Survey (MEPS, 1997-1999) and the 1997 Robert Wood Johnson Foundation Employer

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

Health Insurance 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 combinations of these ACA components.

We find that the implementation of the full version of the ACA would significantly reduced the uninsured rate from about 22% in the pre-ACA benchmark economy to less than 4% under the ACA. This large reduction of the uninsured rate is mainly driven by low-wage workers participating 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 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 18%.

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 7.34%, significantly lower than the 22% under the benchmark. The premium subsidy component of the ACA would have in itself drawn all the unemployed (healthy or unhealthy) and the low-wage employed (again both healthy and unhealthy) in the insurance exchange. 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 4.63%, 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 9.22% as long as the ACA components of 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 22.34% to 35.10% when the ESHI tax exemption is removed in the benchmark economy; and it will increase from 3.67% to 6.05% 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 markets equilibrium. We estimated our model using a selected sample of male and female 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 (2014) for an attempt in these directions where he evaluates the optimal designs of the health insurance exchanges). Second, while our paper includes both males and females in our analysis, they are treated as individuals, not as potential spouses. Fang and Shephard (2015b) consider how the ACA may change the behavior of both workers and firms, takings into account the jointness of the labor supply decisions of couples. 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 (2015a) for an attempt). Finally, incorporating Medicaid, the free public health insurance for the poor, into a model with endogenous asset accumulation is also an important direction.

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Tables and Figures

Statistics	Benchmark	$\widehat{C}= 0$	$\widehat{\pi^1_{gh'h}= \pi^0_{gh'h}}$	$\widehat{\gamma_g}= 0.5\gamma_g$	$\widehat{d_{gh}}= 1.00$
	(1)	(2)	(3)	(4)	(5)
Fraction of Firms Offering Health Insurance	0.5540	0.5769	0.5326	0.4779	0.5385
... if firm size is less than 10	0.4772	0.5001	0.4749	0.4692	0.4764
... if firm size is less than 50	0.5114	0.5377	0.5032	0.4596	0.5041
...if firm size is at least 50	0.9203	0.9230	0.7963	0.6372	0.8320
Uninsured rate	0.2234	0.2132	0.2969	0.4427	0.2745
Average (4-month) Wages of Employed Workers	0.8993	0.9011	0.8833	0.9307	0.9168
... for insured employees	0.9754	0.9705	0.9643	1.0387	0.9944
... for uninsured employees	0.5526	0.5544	0.6854	0.7615	0.6603
Fraction of Unhealthy Workers	0.0553	0.0550	0.0873	0.0623	0.0576
... among insured workers	0.0503	0.0502	0.0889	0.0509	0.0506
... among uninsured workers	0.0727	0.0722	0.0833	0.0761	0.0757

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

Notes: (1). The benchmark predictions are based on the parameter estimates reported in Section 7. (2). The average wages 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.

Statistics	Low-Productivity Firms		High-Productivity Firms	
	HI	No HI	HI	No HI
Panel A: Steady State				
[1] Fraction of Unhealthy Workers in Steady State	0.0561	0.0674	0.0488	0.0927
Panel B: Adverse Selection Effect				
[2] Fraction of Unhealthy Among New Hires	0.0628	0.0598	0.0564	0.0564
... among Male Workers	0.0743	0.0683	0.0608	0.0608
... among Female Workers	0.0524	0.0507	0.0494	0.0494
Panel C: Health Improvement of Health Insurance				
[3] One-Period Ahead Fraction of Unhealthy Among New Hires	0.0549	0.0662	0.0540	0.0659
... among Male Workers	0.0644	0.0787	0.0575	0.0745
... among Female Workers	0.0464	0.0531	0.0485	0.0522
[4] Nine-Period Ahead Fraction of Unhealthy Among New Hires	0.0485	0.0852	0.0485	0.0907
... among Male Workers	0.0500	0.1118	0.0494	0.1116
... among Female Workers	0.0472	0.0573	0.0470	0.0572
Panel D: Retention Effect				
[5] Job-to-Job Transition Rate for Excellent Health Workers	0.1913	0.1974	3.90E-3	3.11E-3
[6] Job-to-Job Transition Rate for Healthy Workers	0.1804	0.1991	3.96E-3	3.12E-3
[7] Job-to-Job Transition Rate for Unhealthy Workers	0.1845	0.2079	4.01E-3	3.12E-3

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 5% and top 5 % of productivity in our discretized productivity distribution support.

Variable	Male		Female	
	Mean	Std. Dev.	Mean	Std. Dev.
Fraction of Insured Among Employed Workers	0.763	0.425	0.857	0.350
Average (4-Month) Wages for Employed Workers	0.835	0.336	0.708	0.285
... for insured employees	0.905	0.327	0.737	0.283
... for uninsured employees	0.609	0.253	0.536	0.230
Fraction of Unemployed Workers	0.041	0.200	0.048	0.214
Fraction of Excellent Health Workers	0.303	0.459	0.266	0.442
... among insured workers	0.304	0.460	0.272	0.445
... among uninsured workers	0.299	0.459	0.245	0.431
Fraction of Healthy Workers	0.638	0.480	0.674	0.468
... among insured workers	0.642	0.479	0.674	0.469
... among uninsured workers	0.628	0.484	0.676	0.469
Fraction of Unhealthy Workers	0.059	0.235	0.059	0.236
... among insured workers	0.053	0.225	0.054	0.225
... among uninsured workers	0.073	0.259	0.078	0.269

Table 3: Summary Statistics: SIPP 1996.

Notes: The average wages are in units of $10,000.

Variable	Male		Female	
	MEPS	SIPP	MEPS	SIPP
	(1)	(2)	(1)	(2)
Fraction of Workers with Excellent Health	0.293 (0.455)	0.303 (0.459)	0.225 (0.418)	0.266 (0.442)
Fraction of Healthy Workers	0.618 (0.486)	0.638 (0.480)	0.641 (0.480)	0674 (0.468)
Fraction of Unhealthy Workers	0.089 (0.285)	0.059 (0.235)	0.134 (0.340)	0.059 (0.236)
Fraction of Insured Among Employed Workers	0.685 (0.465)	0.763 (0.425)	0.764 (0.425)	0.857 (0.350)
Annual Medical Expenditure	0.079 (0.346)	0.080*	0.123 (0.406)	0.1364*
... for those with health insurance and excellent health	0.051 (0.174)	-	0.121 (0.267)	
... for those without health insurance, but with excellent health	0.021 (0.086)	-	0.038 (0.123)	
... for those with health insurance and who are healthy	0.091 (0.459)	-	0.145 (0.262)	
... for those without health insurance and who are healthy	0.053 (0.432)	-	0.088 (0.489)	
... for those with health insurance and who are unhealthy	0.332 (0.718)	-	0.343 (0.936)	
... for those without health insurance and who are unhealthy	0.147 (0.460)	-	0.142 (0.654)	

Table 4: Summary Statistics: Comparison between MEPS 1997-1999 and SIPP 1996.

Notes: (1). The average medical expeditures are in units of $10,000. (2). Standard deviations are in parentheses. (3). The annual medical expenditures for SIPP are imputed based on the average annual medical expenditures for workers of different health insurance and health status combinations computed from MEPS, reported in Column (1), using the factions of the workers of the four health insurance and health status combinations that can be calculated from Table 3.

Variable Name	Mean	Std. Dev.
Average Establishment Size	19.92	133.40
... for those that offer health insurance	30.08	177.24
... for those that do not offer health insurance	6.95	11.03
Fraction of Firms Offering Health Insurance	0.56	0.50
... among firms with less than 50 workers	0.53	0.50
... among firms with 50 or more workers	0.95	0.23
Average Annual Wages (in $10,000) [over Firms]	2.53	2.44
... among firms that offer health insurance	2.92	2.50
... among firms that do not offer health insurance	2.03	2.27
Average Annual Wages (in $10,000) [over Workers]	2.65	2.27
... among workers with health insurance	2.69	2.07
... among workers without health insurance	1.96	2.26
Average Fraction of Female Employees [over Firms]	0.44	0.32
... among firms that offer health insurance	0.44	0.31
... among firms that do not offer health insurance	0.45	0.34
Fraction of Female Employees [over Workers]	0.48	0.26
... among workers with health insurance	0.48	0.76
... among workers without health insurance	0.46	0.69

Table 5: Summary Statistics: RWJ-EHI 1997.

Variable	Male	Female
Fraction of Workers with Excellent Health	0.231 (0.422)	0.150 (0.357)
Fraction of Healthy Workers	0.722 (0.448)	0.787 (0.409)
Fraction of Unhealthy Workers	0.047 (0.212)	0.063 (0.243)
Fraction of Insured Among Employed Workers	0.678 (0.468)	0.718 (0.450)
Annual Medical Expenditure, in $10,000	0.075 (0.366)	0.101 (0.233)
... for those with health insurance and who are excellent *throughout the year*	0.050 (0.145)	0.091 (0.186)
... for those without health insurance and who are excellent *throughout the year*	0.030 (0.122)	0.014 (0.028)
... for those with health insurance and who are healthy *throughout the year*	0.087 (0.231)	0.125 (0.200)
... for those without health insurance and who are healthy *throughout the year*	0.048 (0.569)	0.051 (0.173)
... for those with health insurance and who are unhealthy *throughout the year*	0.479 (0.914)	0.639 (0.833)
... for those without health Insurance and who are unhealthy *throughout the year*	0.125 (0.295)	0.139 (0.225)

Table 6: Summary Statistics of the Subsample of the MEPS 1997-1999 Used in the Estimation of Medical Expenditure Distributions in the First Step.

	Male		Female			Male		Female	
Parameter	Est.	Std. Err.	Est.	Std. Err.	Parameter	Est.	Std. Err.	Est.	Std. Err.
Panel A: Excellent Health, with Insurance					Panel B: Excellent Health, without Insurance				
b_{gE1}	1.2015	(0.0025)	2.0217	(0.0036)	b_{gE0}	1.3888	(0.0730)	4.2742	(0.0036)
s_{gE1}	1.1915	(0.0009)	1.5211	(0.0187)	s_{gE0}	1.1228	(0.0089)	3.6755	(0.0187)
β_{gE1}	0.0314	(0.0001)	0.1945	(0.0007)	β_{gE0}	0.0243	(0.0012)	0.3787	(0.0007)
γ^{+}_{gE1}	0.2628	(3.5E-6)	0.3844	(0.0005)	γ^{+}_{gE0}	0.2359	(0.0101)	0.1921	(0.0005)
Panel C: Healthy, with Insurance					Panel D: Healthy, without Insurance				
b_{gH1}	1.0582	(0.0064)	2.0159	(0.0106)	b_{gH0}	0.3745	(0.0275)	0.9017	(0.0048)
s_{gH1}	1.0609	(0.0019)	1.6276	(0.0031)	s_{gH0}	0.7530	(0.0905)	1.0283	(0.0013)
β_{gH1}	0.0281	(0.0004)	0.2334	(0.0014)	β_{gH0}	0.0010	(0.0002)	0.0130	(0.0002)
γ^{+}_{gH1}	0.3381	(1.4E-6)	0.4623	(0.0017)	γ^{+}_{gH0}	0.1510	(2.9E-6)	0.2499	(7.2E-6)
Panel E: Unhealthy, with Insurance					Panel F: Unhealthy, without Insurance				
b_{gU1}	1.1340	(0.0065)	1.3847	(0.0125)	b_{gU0}	1.4849	(0.0023)	1.8614	(0.0207)
s_{gU1}	0.8409	(0.0014)	1.0750	(0.0040)	s_{gU0}	1.1834	(0.0016)	1.4696	(0.0092)
β_{gU1}	0.1830	(0.0030)	0.4184	(0.0104)	β_{gU0}	0.1748	(0.0019)	0.1422	(0.0037)
γ^{+}_{gU1}	0.4947	(3.5E-6)	0.6624	(9.1E-6)	γ^{+}_{gU0}	0.2707	(0.0025)	0.6147	(0.0008)

Table 7: Step 1 Parameter Estimates for the Medical Expenditure Processes, by Gender, Health and Health Insurance Status.

Note: See Eqs. (2) and (3) for details of the medical expenditure processes. Standard errors are in parentheses. The unit of medical expenditure is $10,000.

Parameter	Male		Female	
	Estimate	Std. Err.	Estimate	Std. Err.
Panel A: Health Transition Parameters in $\boldsymbol{\pi}_g^1$				
π_{gEE}^1	0.7764	(0.0108)	0.7934	(0.0156)
π_{gHE}^1	0.2230	(0.0110)	0.2066	(0.0166)
π_{gEH}^1	0.0946	(0.0052)	0.0734	(0.0065)
π_{gHH}^1	0.8857	(0.0061)	0.9008	(0.0089)
π_{gEU}^1	0.0261	(0.0184)	0.0250	(0.0271)
π_{gHU}^1	0.2458	(0.0308)	0.3592	(0.0571)
Panel B: Health Transition Parameters in $\boldsymbol{\pi}_g^0$				
π_{gEE}^0	0.7296	(0.0238)	0.7400	(0.0301)
π_{gHE}^0	0.2699	(0.0250)	0.2397	(0.0306)
π_{gEH}^0	0.0914	(0.0099)	0.0687	(0.0093)
π_{gHH}^0	0.8652	(0.0122)	0.9111	(0.0114)
π_{gEU}^0	0.0140	(0.0152)	0.00001	(0.0167)
π_{gHU}^0	0.2338	(0.0344)	0.3324	(0.0511)

Table 8: First Step Parameter Estimate for the Health Transitions, by Gender and Health Insurance Status.

Note: See Eq. (5) for details of the health transition process. Standard errors are in parentheses.

Parameters	Male		Female	
Panel A: Parameters in $\theta_1 \equiv \langle \gamma_g, \mathfrak{b}_g, \lambda_{gu}, \lambda_{ge}, \delta_g, \mu_{gE}, \mu_{gH}, \sigma_{gw} \rangle$				
CARA Coefficient (γ_g)	0.2415	(0.0080)	0.8878	(0.0064)
Unemployment Income $(\mathfrak{b}_g)$	0.0170	(0.0004)	0.0134	(0.0009)
Offer Arrival Rate for the Unemployed (λ_{gu})	0.4345	(0.0169)	0.3540	(0.0187)
Offer Arrival Rate for the Employed (λ_{ge})	0.3745	(0.0272)	0.2780	(0.0194)
Probability of Exogenous Match Destruction (δ_g)	0.0209	(0.0004)	0.0258	(0.0013)
Fraction of New Born Workers with Excellent Health (μ_{gE})	0.3630	(0.0064)	0.3300	(0.0057)
Fraction of New Born Workers who are Healthy (μ_{gH})	0.6250	(0.0029)	0.6337	(0.0036)
Standard Deviation of Preference Shock to Work in \$10,000 (σ_{gw})	0.0540	(0.0027)	0.0840	(0.0037)
Panel B: Parameters in $\theta_2 \equiv \langle d_{gh}, C, M, \mu_p, \sigma_p, \sigma_f \rangle$				
Productivity of a Worker in Healthy (d_{gH})	0.9979	(0.0591)	1.0000	(0.0341)
Productivity of a Worker in Unhealthy (d_{gU})	0.7665	(0.0155)	0.7946	(0.0312)
Four-Month Fixed Administrative Cost of Insurance in \$10,000 (C)	0.1601 (0.0111)			
Total Measure of Workers Relative to Firms (M)	20.392 (0.1803)			
Scale Parameter of Firms' Lognormal Productivity Distribution (μ_p)	-1.0920 (0.0250)			
Shape Parameter of Firms' Lognormal Productivity Distribution (σ_p)	0.7183 (0.0389)			
Scale Parameter of Random Cost of ESHI offering (σ_f)	0.1703 (0.0242)			

Table 9: Parameter Estimate from Step 2.

	Male		Female	
	Data	Model	Data	Model
Panel A: Mean of Annual Medical Expenditure				
Excellent Health & Insured	0.0503	0.0503	0.0919	0.0919
Excellent Health & Uninsured	0.0296	0.0294	0.0140	0.0137
Healthy & Insured	0.0871	0.0871	0.1245	0.1244
Healthy & Uninsured	0.0475	0.0503	0.5054	0.5062
Unhealthy & Insured	0.4791	0.4792	0.6386	0.6385
Unhealthy & Uninsured	0.1249	0.1248	0.1386	0.1386
Panel B: Variance of Annual Medical Expenditure				
Excellent Health & Insured	0.0209	0.0209	0.0342	0.0342
Excellent Health & Uninsured	0.0148	0.0149	0.0007	0.0007
Healthy & Insured	0.0531	0.0532	0.0400	0.0400
Healthy & Uninsured	0.3229	0.0743	0.0297	0.0297
Unhealthy & Insured	0.8084	0.8085	0.6665	0.6666
Unhealthy & Uninsured	0.0855	0.0854	0.0498	0.0498
Panel C: Skewness of Annual Medical Expenditure				
Excellent Health & Insured	5.9419	6.0766	3.6021	3.2956
Excellent Health & Uninsured	6.5943	6.9319	3.2085	3.1846
Healthy & Insured	8.0489	7.2455	3.0113	2.8610
Healthy & Uninsured	20.536	16.912	7.4523	7.9405
Unhealthy & Insured	2.7762	2.7097	1.9566	1.8671
Unhealthy & Uninsured	3.6395	3.6032	3.0789	3.3427
Panel D: Fraction with Zero Medical Expenditure				
Excellent Health & Insured	0.4007	0.4006	0.2333	0.2054
Excellent Health & Uninsured	0.6457	0.4661	0.5185	0.5273
Healthy & Insured	0.2900	0.2900	0.1209	0.1555
Healthy & Uninsured	0.6119	0.6119	0.4220	0.4221
Unhealthy & Insured	0.1290	0.1290	0.0385	0.0385
Unhealthy & Uninsured	0.3600	0.3879	0.0545	0.0572

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

Statistics	Male		Female	
	Data	Model	Data	Model
Panel A: Annual Health Transition for Workers Insured Throughout the Year				
Excellent Health →Excellent Health	0.5150	0.5196	0.5028	0.5373
Excellent Health→Healthy	0.4659	0.4668	0.4783	0.4504
Excellent Health→Unhealthy	0.0191	0.0115	0.0189	0.0123
Healthy→Excellent Health	0.1984	0.2000	0.1675	0.1615
Healthy→Healthy	0.7560	0.7608	0.7808	0.7928
Healthy→Unhealthy	0.0456	0.0392	0.0517	0.0457
Unhealthy→Excellent Health	0.0935	0.1006	0.1121	0.0989
Unhealthy→Healthy	0.5280	0.5019	0.6168	0.6476
Unhealthy→Unhealthy	0.3785	0.3975	0.2710	0.2534
Panel B: Annual Health Transition for Workers Uninsured Throughout the Year				
Excellent Health→Excellent Health	0.4704	0.4459	0.4198	0.4451
Excellent Health→Healthy	0.5078	0.5258	0.5309	0.5130
Excellent Health→Unhealthy	0.0218	0.0283	0.0494	0.0419
Healthy→Excellent Health	0.1800	0.1794	0.1559	0.1426
Healthy→Healthy	0.7429	0.7337	0.7834	0.8157
Healthy→Unhealthy	0.0771	0.0869	0.0607	0.0418
Unhealthy→Excellent Health	0.0847	0.0737	0.0541	0.0513
Unhealthy→Healthy	0.4661	0.4765	0.4595	0.6340
Unhealthy→Unhealthy	0.4492	0.4498	0.4865	0.3131

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

Moments	Male		Female	
	Data	Model	Data	Model
Fraction of individuals who are unemployed and have excellent health	0.010	0.017	0.017	0.017
Fraction of individuals who are unemployed and healthy	0.030	0.025	0.039	0.039
Fraction of individuals who are unemployed and unhealthy	0.006	0.003	0.008	0.003
Fraction of individuals who are employed, have excellent health and have HI	0.219	0.226	0.215	0.190
Fraction of individuals who are employed, healthy and have HI	0.461	0.526	0.534	0.537
Fraction of individuals who are employed, unhealthy and have HI	0.038	0.041	0.042	0.036
Fraction of individuals who are employed, have excellent health and do not have HI	0.074	0.040	0.033	0.038
Fraction of individuals who are employed, healthy and do not have HI	0.146	0.106	0.102	0.129
Fraction of individuals who are employed, unhealthy and do not have HI	0.015	0.016	0.007	0.009
Mean wage ($10,000)	0.835	0.954	0.708	0.836
Mean wage with health insurance ($10,000)	0.905	1.031	0.737	0.907
Mean wage without health insurance ($10,000)	0.609	0.581	0.536	0.532
Mean medical expenditure ($10,000)	0.026	0.029	0.041	0.040

Table 12: Worker-Side Moments in the Labor Market: Model vs. Data.

Moments	Male		Female	
	Data	Model	Data	Model
Unemployment to Employment Transition for Workers with Excellent Health	0.440	0.392	0.200	0.332
Unemployment to Employment Transition for Healthy Workers	0.430	0.394	0.310	0.337
Unemployment to Employment Transition for Unhealthy Workers	0.250	0.397	0.330	0.338
Job to Job Transition for Workers with Excellent Health	0.048	0.048	0.038	0.040
Job to Job Transition for Healthy Workers	0.053	0.048	0.039	0.042
Job to Job Transition for Unhealthy Workers	0.052	0.057	0.018	0.047
Employment to Unemployment Transition for Workers with Excellent Health	0.015	0.017	0.025	0.020
Employment to Unemployment Transition for Healthy Workers	0.016	0.017	0.026	0.020
Employment to Unemployment Transition for Unhealthy Workers	0.054	0.018	0.058	0.021

Table 13: Workers' Labor Market Transitions: Model vs. Data.

Moments	Data	Model
Mean firm size	19.92	19.34
Fraction of firms less than 50 workers	0.93	0.90
Mean size of firms that offer health insurance	30.08	28.70
Mean size of firms that do not offer health insurance	6.95	7.73
Health insurance coverage rate	0.56	0.55
Health insurance coverage rate among firms with less than 10 workers	0.45	0.47
Health insurance coverage rate among firms with 10 to 30 workers	0.72	0.58
Health insurance coverage rate among firms with 30 to 50 workers	0.85	0.74
Health insurance coverage rate among firms with more than 50 workers	0.95	0.92
Average wages of workers in firms offering health insurance	0.90	0.97
Average wages of workers in firms not offering health insurance	0.65	0.56
Average wages of workers in firms with less than 50 workers	0.85	0.47
Average wages of workers in firms with more than 50 workers	0.91	1.15
Fraction of female employees among firms that offer health insurance	0.48	0.45
Fraction of female employees among firms that do not offer health insurance	0.46	0.48

Table 14: Employer-Side Moments: Model vs. Data.

	1996-1997	2004-2006	
		Inflation Adj. Only	Inflation & Productivity Adj.
Fraction of Firms Offering ESHI	0.5540	0.4773	0.4836
Unemployment Rate	0.0513	0.0497	0.0484
Fraction of Unhealthy Workers	0.0553	0.0627	0.0617

Table 15: Out of Sample Predictions for 2004-2006.

	Benchmark	ACA*	ACA**	ACA* w/o IM	ACA* w/o EM
	(1)	(2)	(3)	(4)	(5)
Uninsured rate	0.2234	0.0367	0.0393	0.0734	0.0463
... male	0.2067	0.0419	0.0465	0.0925	0.0574
... female	0.2367	0.0306	0.0308	0.0507	0.0332
Frac. of firms offering HI	0.5540	0.5148	0.5143	0.5085	0.5119
...if firm size is less than 50	0.5115	0.4605	0.4604	0.4581	0.4644
...if firm size is 50 or more	0.9203	0.9867	0.9805	0.9611	0.9340
Frac. of firms with less than 50 workers	0.8959	0.8968	0.8963	0.8997	0.8989
Frac. of emp. workers with HI from ESHI	0.8217	0.7915	0.7905	0.7800	0.7784
Frac. of emp. workers with HI from EX	-	0.1697	0.1679	0.1425	0.1727
Unemployment rate	0.0513	0.0531	0.0532	0.0533	0.0532
Premium in EX ($10,000)	-	0.0535	0.0561	0.0591	0.0545

Table 16: Counterfactual Policy Experiments: Uninsured Rates Under the Benchmark Model, the ACA and its Two Variations.

Notes: In ACA*, we assume that the expanded Medicaid roll under the ACA is included in the health insurance exchange risk pool, while in ACA**, we assume that it is not.

	Low-Productivity Firms		High-Productivity Firms	
Statistics	HI	No HI	HI	No HI
Fraction of Unhealthy Among New Hires	0.0439	0.0439	0.0489	0.0489
... among Male Workers	0.0431	0.0432	0.0494	0.0494
... among Female Workers	0.0446	0.0447	0.0481	0.0481

Table 17: Adverse Selection Effect under the ACA: Low Productivity vs. High Productivity Firms.

	EX	EX+Sub	EX+IM	EX+EM	EX+IM+EM
	(1)	(2)	(3)	(4)	(5)
Uninsured rate	0.2227	0.0922	0.1885	0.2079	0.1819
... male	0.2085	0.1222	0.1741	0.1921	0.1668
... female	0.2396	0.0566	0.2055	0.2266	0.1999
Frac. of firms offering HI	0.5514	0.5018	0.5715	0.5544	0.5730
...if firm size is less than 50	0.5084	0.4593	0.5259	0.5078	0.5256
...if firm size is 50 or more	0.9211	0.8758	0.9650	0.9611	0.9844
Frac. of firms with less than 50 workers	0.8959	0.8979	0.8960	0.8970	0.8966
Frac. of emp. workers with HI from ESHI	0.8191	0.7490	0.8547	0.8347	0.8616
Frac. of emp. workers with HI from EX	0.0000	0.1536	0.0000	0.0000	0.0000
Unemployment rate	0.0510	0.0533	0.0505	0.0510	0.0504
Premium in EX ($10,000)	0.2661	0.0601	0.2661	0.2661	0.2661

Table 18: Counterfactual Policy Experiments: Evaluation of Various Components of the ACA.

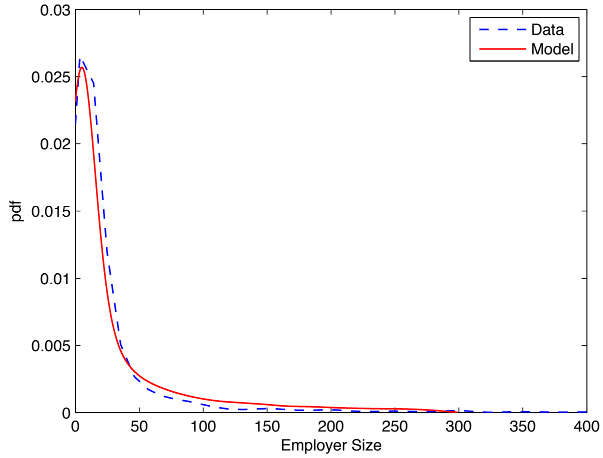
	Benchmark		ACA	
	Exempt	No Exempt	Exempt	No Exempt
	(1)	(2)	(3)	(3)
Uninsured rate	0.2234	0.3510	0.0367	0.0605
... male	0.2067	0.3323	0.0419	0.0761
... female	0.2367	0.3454	0.0306	0.0420
Frac. of firms offering HI	0.5540	0.5172	0.5148	0.4852
...if firm size is less than 50	0.5115	0.4936	0.4605	0.4366
...if firm size is 50 or more	0.9203	0.7286	0.9867	0.9149
Frac. of firms with less than 50 workers	0.8959	0.8996	0.8968	0.8984
Frac. of emp. workers with HI from ESHI	0.8217	0.6978	0.7915	0.7336
Frac. of emp. workers with HI from EX	-	-	0.1697	0.2025
Unemployment rate	0.0513	0.0518	0.0531	0.0538
Premium in EX (in $10,000)	-	-	0.0535	0.0556
Average tax expenditure to ESHI	0.0133	0.0000	0.0127	0.0000
Subsidies to exchange purchases	-	-	0.0080	0.0093
Revenue from penalties	-	-	0.0006	0.0013
Average worker utility (CEV, in $10,000)	0.5942	0.5835	0.6059	0.5959
Average firm profit (in $10,000)	0.9547	0.9480	0.9546	0.9538

Table 19: Counterfactual Policy Experiments: Evaluating the Effects of Eliminating the Tax Exemption for EHI Premium under the Benchmark and the ACA.

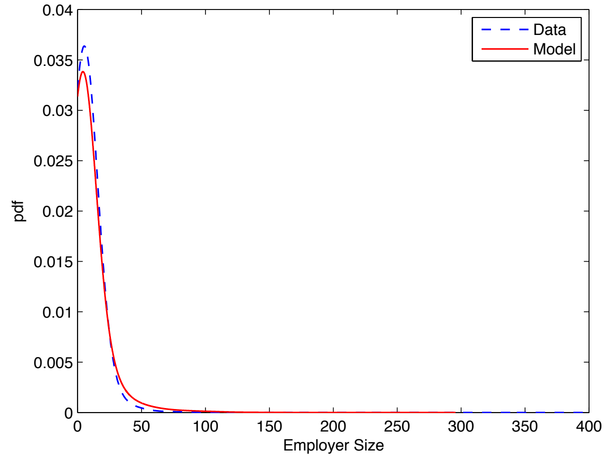
	ACA*	MA Reform[1]	No ESHI EX+Sub+IM
	(1)	(2)	(3)
Uninsured rate	0.0367	0.0421	0.5169
... male	0.0419	0.0519	0.8102
... female	0.0306	0.0304	0.1679
Frac. of firms offering HI	0.5148	0.5258	-
...if firm size is less than 50	0.4605	0.4764	-
...if firm size is 50 or more	0.9867	0.9566	-
Frac. of firms with less than 50 workers	0.8968	0.8971	0.8996
Frac. of emp. workers with HI from ESHI	0.7915	0.8072	-
Frac. of emp. workers with HI from EX	0.1697	0.1483	0.4552
Unemployment rate	0.0531	0.0533	0.0512
Premium in EX (in $10,000)	0.0535	0.0544	0.0756

Table 20: Counterfactual Policy Experiments: MA Reform and the Elimination of ESHI.

Notes: (1). In Column (2) we assume that the individual mandate penalty is the same as that in the ACA; the rest follows the MA reform rules.



(a) With Health Insurance



(b) Without Health Insurance

Figure 1: Size Distribution of Firms by Insurance Offering Status: Model vs. Data.

Note: The empirical distributions are calculated using a Gaussian kernel.

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 function and the health insurance offer probability $(w_0^0(p), w_1^0(p), \Delta^0(p))$ 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 $(w_0^\iota(p), w_1^\iota(p), \Delta^\iota(p))$, construct the offer distribution $F^\iota(w, x)$ by using (32) and (31).

   (b) By using $F^\iota(w, x)$, numerically solve worker's optimal strategy $\left\langle \tilde{z}_{gu}(w, x, h), \underline{w}_{gh}^{\tilde{x}}(w, x), \tilde{z}_{ge}^1(\tilde{w}, \tilde{x}, w, x, h), \tilde{z}_{ge}^2(w, x, h) \right\rangle$ and calculate U_{gh} and $V_{gh}(w_x^\iota(p), x)$ for $g \in \{1, 2\}, h \in \{E, H, U\}$, $x \in \{0, 1\}$, and p on on support $[\underline{p}, \overline{p}]$. Moreover, calculate $V_{gh}(w, x)$ for $w \in \mathcal{W}$, where $\mathcal{W}$ is the discrete set of potential wage choices.

   (c) Calculate unemployment u_{gh}^ι and employment distribution $e_{gh}^{x,\iota} S_{gh}^{x,\iota}(w_x^\iota(p))$ for all $p \in \{p_1, ..., p_N\}$ by solving functional fixed point equations (17), (20) and (24);[2]

   (d) Calculate $n_{gh}^\iota(w^\iota(p), x)$ and $n^\iota(w^\iota(p), x)$ for all p by respectively using (25) and (26). Moreover, calculate $n^\iota(w, x)$ for $w \in \mathcal{W}$;

   (e) Update the firm's optimal policy $(w_0^{*\iota}(p), w_1^{*\iota}(p), \Delta^{*\iota}(p))$ for all p using (28) and (29);[3]

   (f) Given $(w_0^{*\iota}(p), w_1^{*\iota}(p))$, calculate $\pi_0^{*\iota}(p)$ and $\pi_1^{*\iota}(p)$ from (28) and (29) and obtain $\Delta^{*\iota}(p)$ by using (30).

4. **(Convergence Criterion)**

   (a) If $(w_0^{*\iota}(p), w_1^{*\iota}(p), \Delta^{*\iota}(p))$ satisfies $d(w_0^{*\iota}(p), w_0^\iota(p)) < \epsilon_{tol}$, $d(w_1^{*\iota}(p), w_1^\iota(p)) < \epsilon_{tol}$ and $d(\Delta^{*\iota}(p), \Delta^\iota(p)) < \epsilon_{tol}$ where ϵ_{tol} is a pre-specified tolerance level of convergence and $d(\cdot, \cdot)$ is a distance metric, then firm's optimal policy converges and we have an equilibrium.

[1] See Kennan (2006) for a discussion about the discrete approximation of the continuous distributions. In our empirical application, we set $N = 200$; and set $p_1 = 0.1$ and $p_N = 6$. We also experimented with $N = 800$. The results are similar.

[2] Although we do not have a proof that the unique fixed point exists, we always find the unique solution regardless of initial guess of u_{gh} and $e_{gh}^x S_{gh}^x(w(p))$.

[3] See Proposition 1 below for a numerical shortcut in the updating of $w_0^{\iota+1}(p)$ and $w_1^{\iota+1}(p)$.

(b) Otherwise, update $(w_0^{\iota+1}(p), w_1^{\iota+1}(p), \Delta^{\iota+1}(p))$ as follows:

$$\begin{aligned} w_0^{\iota+1}(p) &= \omega w_0^{\iota}(p) + (1-\omega) w_0^{*\iota}(p), \\ w_1^{\iota+1}(p) &= \omega w_1^{\iota}(p) + (1-\omega) w_1^{*\iota}(p), \\ \Delta^{\iota+1}(p) &= \omega \Delta^{\iota}(p) + (1-\omega) \Delta^{*\iota}(p), \end{aligned}$$

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 steady state equilibrium of our model.

Proposition 1. *For each p, optimal wage policy must satisfy*

$$w_1^*(p) = \frac{\sum_g \sum_h \left(p d_{gh} - m_{gh}^1\right) n_{gh}(w_1^*(p), 1) - \int_{\underline{p}}^{p} \sum_g \sum_h \left[d_{gh} n_{gh}(w_1^*(\tilde{p}), 1)\right] d\tilde{p} - \Pi_1(\underline{p})}{\sum_g \sum_h n_{gh}(w_1(p), 1)} \tag{A1}$$

$$w_0^*(p) = \frac{\sum_g \sum_h p d_{gh} n_{gh}(w_0^*(p), 0) - \int_{\underline{p}}^{p} \sum_g \sum_h \left[d_{gh} n_{gh}(w_0^*(\tilde{p}), 0)\right] d\tilde{p} - \Pi_0(\underline{p})}{\sum_g \sum_h n_{gh}(w_0^*(p), 0)}. \tag{A2}$$

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

$$\begin{aligned} \Pi_1(\underline{p}) &= \sum_g \sum_h \left(\underline{p} d_{gh} - w_1^*\left(\underline{p}\right) - m_{gh}^1\right) n_{gh}(w_1^*(\underline{p}), 1) - C, \\ \Pi_0(\underline{p}) &= \sum_g \sum_h \left(\underline{p} d_{gh} - w_0^*\left(\underline{p}\right)\right) n_{gh}(w_0^*(\underline{p}), 0). \end{aligned}$$

Proof. To prove Proposition 1, we first establish a lemma that:

Lemma 2. *For any distribution $F(w,x)$, $w_x^*(p), x \in \{0,1\}$, that respectively solves (28) and (29), is increasing in p.*

Proof. The proof is based on revealed preference argument. Choose any p and p' in $[\underline{p}, \overline{p}]$ such that $p > p'$ and fix $x \in \{0,1\}$. Notice that

$$\begin{aligned} \pi_x(p) &= \sum_g \sum_h \left(p d_{gh} - w_x^*(p) - x m_{gh}^x\right) n_{gh}(w_x^*(p), x) - xC \\ &\geq \sum_g \sum_h \left(p d_{gh} - w_x^*(p') - x m_{gh}^x\right) n_{gh}(w_x^*(p'), x) - xC \\ &\geq \sum_g \sum_h \left(p' d_{gh} - w_x^*(p') - x m_{gh}^x\right) n_{gh}(w_x^*(p'), x) - xC \\ &= \pi_x(p') \\ &\geq \sum_g \sum_h \left(p' d_{gh} - w_x^*(p) - x m_{gh}^x\right) n_{gh}(w_x^*(p), x) - xC, \end{aligned}$$

where the second line comes from the fact that $w_x^*(p)$ is the optimal wage policy, for a given x, of a firm with productivity p and third line is implied by the assumption that $p > p'$. The fifth line is implied by the fact that $w_x^*(p)$ is the optimal policy for a firm with productivity p, not p'. Therefore, we have

$$(p - p') \sum_g \sum_h \left[d_{gh} n_{gh}(w_x^*(p), x)\right] \geq (p - p') \sum_g \sum_h \left[d_{gh} n_{gh}(w_x^*(p), x)\right].$$

Since $n_{gh}(w,x)$ is increasing in w, this inequality holds if and only if $w_x^*(p) \geq w_x^*(p')$. □

Now we complete the proof of Proposition 1. From Lemma 2, $w_x^*(p)$ is increasing in p. Using the definition of $\Pi_0(p)$ and $\Pi_1(p)$ as given in (28) and (29), we can apply the Envelope Theorem and obtain

$$\Pi_x'(p) = \sum_g \sum_h d_{gh} n_{gh}(w_x^*(p), x)$$

for $p > \underline{p}$. By taking integral over $[\underline{p}, p]$, we then obtain

$$\Pi_x(p) = \int_{\underline{p}}^{p} \sum_g \sum_h d_{gh} n_{gh}(w_x^*(\tilde{p}), x) d\tilde{p} + \Pi_x(\underline{p}).$$

By equating it with (28) and (29), we obtain (A1) and (A2). This is a form of wage policy which we utilize in our numerical algorithm. $\square$

B Derivation of Likelihood Function for Labor Market Transitions When Health Status is Not Always Observed

In this appendix, we provide the details of how we formulate the likelihood function for workers' labor market transitions when the health history in-between job transitions are not observed.

First, consider the labor market transitions of *unemployed workers.* In Section 6.2.1, we derived the likelihood function for an unemployed worker at period 1 with health status is h_1, who experiences an unemployment spells l and in period $l+1$ transitions to a job $(\tilde{w}, \tilde{x})$, *assuming* that the health history between $j = 1$ to $l+1$ for this worker, $(h_1, h_2, ..., h_{l+1})$, is completely observed. The likelihood function is reproduced here for convenience:

$$\frac{u_{gh_1}}{M} \times \left\{ \begin{array}{l} \Pi_{j=2}^{l} \left\{ \Pr(h_j | h_{j-1}, x_{j-1} = 0, g) \times \left[1 - \lambda_{gu} \int \Phi\left(\tilde{z}_{gu}(w', x', h_j) \right) dF(w', x') \right] \right\} \\ \times \ \Pr(h_{l+1} | h_l, x_l = 0, g) \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 1, h_{l+1}) \right) f(\tilde{w}, 1) \right]^{\mathbf{1}(\tilde{x}=1)} \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 0, h_{l+1}) \right) f(\tilde{w}, 0) \right]^{\mathbf{1}(\tilde{x}=0)} \end{array} \right\}$$

Now consider the data scenario that we only observe h_1, not $\mathbf{h}^l = (h_2, ..., h_{l+1})$. The only modification we need is to integrate over all the possible health history $\mathbf{h}^l \in \mathcal{H}^l$, i.e.,

$$\frac{u_{gh_1}}{M} \times \sum_{\mathbf{h}^l \in \mathcal{H}^l} \left\{ \begin{array}{l} \Pi_{j=2}^{l} \left\{ \Pr(h_j | h_{j-1}, x_{j-1} = 0, g) \times \left[1 - \lambda_{gu} \int \Phi\left(\tilde{z}_{gu}(w', x', h_j) \right) dF(w', x') \right] \right\} \\ \times \ \Pr(h_{l+1} | h_l, x_l = 0, g) \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 1, h_{l+1}) \right) f(\tilde{w}, 1) \right]^{\mathbf{1}(\tilde{x}=1)} \\ \times \left[\lambda_{gu} \Phi\left(\tilde{z}_{gu}(\tilde{w}, 0, h_{l+1}) \right) f(\tilde{w}, 0) \right]^{\mathbf{1}(\tilde{x}=0)} \end{array} \right\}$$

where the integration is represented by the summation $\sum_{\mathbf{h}^l \in \mathcal{H}^l}$. The case where we do not observe a subset of the health history is handled analogously by integrating over all possible realization of the subset of health history that is unobserved.

The likelihood contribution of the job dynamics of *employed workers* when part of the health history in-between job transitions is unobserved can be handled analogously. For example, if a subset $\mathbf{h}^l$ containing l periods is unobserved. Then we will integrate over $\mathbf{h}^l \in \mathcal{H}^l$ in the expression (36).

C Estimation Procedure

The following is the procedure we use to implement the GMM estimator in Section 6:

1. **(Initialization)** Initialize a guess of the parameter values θ;

2. **(Solving for Equilibrium Offer Distribution)** Given the guess, solve equilibrium numerically using the algorithm we provided in Section A. Obtain the offer distribution $\hat{F}(w,x)$ from the equilibrium;

3. **(Calculating the Worker-Side Moments)** Use $\hat{F}(w,x)$ in place of $F(w,x)$ in the likelihood functions of the observed worker-side data based on (35) and (36), and obtain the numerical derivative of likelihood with respect to parameters $\boldsymbol{\theta}$ and use them as a subset of the moments in (33);

4. **(Calculating the Employer-Side Moments)** Use $\hat{F}(w,x)$ and other equilibrium elements obtained in (2) to calculate the employer-side moments listed in Section 6.2.2;

5. **(Iteration)** Evaluate the GMM objective (34) and iterate until it converges.

D Steady State Equilibrium of the Counterfactual Economy

The steady state equilibrium for the post-ACA economy is somewhat more involved in the sense that the unemployed *and* those employed workers who do not receive insurance from their employers need to decide whether to purchase insurance from the exchange; moreover, we need to determine the equilibrium premium in the health insurance exchange. Formally, a *steady state equilibrium for the post-ACA economy* is a list of objects, for $g \in \{1,2\}$ and $h \in \mathcal{H}$,

$$\left\langle \left(\tilde{z}^{x}_{gu}(\tilde{w},\tilde{x},h), \underline{w}^{\tilde{x}}_{gh}(w,x), \tilde{z}^{1}_{ge}(\tilde{w},\tilde{x},w,x,h), \tilde{z}^{2}_{ge}(w,x,h), x^{*}_{gh}, x^{*}_{gh}(w)\right), \left(u^{x}_{gh}, e^{x}_{gh}, S^{x}_{gh}(w)\right), \left(w^{*}_{x}(p), \Delta(p)\right), F(w,x), R^{EX} \right\rangle,$$

such that the following conditions hold:

- **(Worker Optimization)** Given $F(w,x)$ and R^{EX},

  - $\tilde{z}^{x}_{gu}(\tilde{w},\tilde{x},h)$ solves the job acceptance decision problem (38) for a gender-g unemployed worker with health status $h \in \mathcal{H}$,insurance status $x \in \{0,2\}$;
  - x^{*}_{gh} solves the insurance purchase problem (39) for a gender-g unemployed worker with health status $h \in \mathcal{H}$;
  - $\left\langle \underline{w}^{\tilde{x}}_{gh}(w,x), \tilde{z}^{1}_{ge}(\tilde{w},\tilde{x},w,x,h), \tilde{z}^{2}_{ge}(w,x,h) \right\rangle$ solves the job transition problems (41) and (42) for a gender-g worker employed on a job (w,x) with health $h \in \mathcal{H}$;
  - $x^{*}_{gh}(w)$ solves the insurance purchase problem (40) for a gender-g worker with health status $h \in \mathcal{H}$ when he/she is employed on a job $(w,0)$;

- **(Steady State Worker Distribution)** Given workers' optimizing behavior described by $\langle \tilde{z}^{x}_{gu}(\tilde{w},\tilde{x},h)$, $\underline{w}^{\tilde{x}}_{gh}(w,x), \tilde{z}^{1}_{ge}(\tilde{w},\tilde{x},w,x,h), \tilde{z}^{2}_{ge}(w,x,h), x^{*}_{gh}, x^{*}_{gh}(w) \rangle$, $F(w,x)$ and R^{EX}, the objects describing worker distributions $\left(u^{x}_{gh}, e^{x}_{gh}, S^{x}_{gh}(w)\right)$, $x \in \{0,1,2\}$, satisfy the steady state conditions for worker distribution (details are omitted but available upon request);

- **(Firm Optimization)** Given $F(w,x)$, R^{EX} and the steady state employee sizes implied by $\left(u^{x}_{gh}, e^{x}_{gh}, S^{x}_{gh}(w)\right)$, a firm with productivity p chooses to offer health insurance, i.e., $x=1$, with probability $\Delta(p)$ and chooses not to offer health insurance with probability $1-\Delta(p)$, where $\Delta(p)$ is given by (30). Moreover, conditional on insurance choice x, the firm offers a wage $w^{*}_{x}(p)$ that solves (43) and (44) respectively for $x=0$ and 1.

- **(Equilibrium Consistency)** The postulated distributions of offered compensation packages are consistent with the firms' optimizing behavior $(w_x^*(p), \Delta(p))$. Specifically, $F(w,x)$ must satisfy:

$$
\begin{aligned}
F(w,1) &= \int_0^\infty \mathbf{1}(w_1(p) < w)\Delta(p)d\Gamma(p), \\
F(w,0) &= \int_0^\infty \mathbf{1}(w_0(p) < w)\left[1-\Delta(p)\right]d\Gamma(p).
\end{aligned}
$$

- **(Equilibrium Condition in Insurance Exchange)** The premium in exchange is determined by (45).

E Adjusting the ACA Provisions for 2011 into Applicable Formulas for the 1996 Economy

Penalties Associated with Individual Mandate Penalty. We adjust formula (46) in several dimensions. First, the \$695 amount is adjusted by the ratio of the 1996 Medical Care CPI (CPI_Med_1996) 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 our period-length of 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_1996) 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.[4] 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 $\frac{\text{CPI\_Med\_1996}}{\text{CPI\_All\_1996}}$ 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 1996 economy as:

$$
\begin{aligned}
P_W(y) &= \max\left\{ \begin{array}{c} 0.025 \times \left(\frac{\text{CPI\_Med\_1996}}{\text{CPI\_All\_1996}}\right) / \left(\frac{\text{CPI\_Med\_2011}}{\text{CPI\_All\_2011}}\right) \times \left(y - \frac{1}{3}\text{TFT\_2011} \times \frac{\text{CPI\_All\_1996}}{\text{CPI\_All\_2011}}\right), \\ \frac{1}{3} \times \$695 \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}} \end{array} \right\} \\
&\approx \max\left\{\frac{0.025}{1.42} \times (y - 2{,}323),\ \$119\right\},
\end{aligned}
\tag{E4}
$$

where y is four-month income in dollars.

Penalties Associated with Employer Mandate. We adjust formula (47) by first scaling the \$2,000 per-worker penalty using the ratio of the 1996 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.,

$$
P_E(n) = \frac{1}{3}\tilde{P}_E^{ACA}(n) \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}}, \tag{E5}
$$

where $\tilde{P}_E^{ACA}(n)$ is given by (48).

Income-Based Premium Subsidies. We adjust the income-based premium subsidies (49) to accout for the fact that in our analysis, y is measured as four-month income at 1996 as follows:

$$
SUB\left(y, R^{EX}\right) = \begin{cases} \max\left\{R^{EX} - \left[0.0350 + 0.060\frac{(3y - \text{FPL133})}{\text{FPL400} - \text{FPL133}}\right] y \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}},\ 0\right\} \text{ if } y < \frac{\text{FPL400}}{3} \\ R^{EX} \text{ if unemployed} \\ 0, \text{ otherwise,} \end{cases} \tag{E6}
$$

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

F 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 four month wages,which we observed in our data used in the estimation, by 3 to convert them to annual income. Using our *after-tax income* formula $T(y)$ as specified in (6), the tax payment at 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 marginal tax rates for each individual in the baseline sample on labor earnings. 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 parameters, we feed them in the model by adjusting the magnitude to fit the four-month income level. Specifically, the adjustment yields the following after-tax income schedule:

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

where y is the four-month income level, and τ_0, τ_1 and τ_2 are estimated above using the annual income data.