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 data sources including Survey of Income and Program Participation (SIPP), Medical Expenditure Panel Survey (MEPS) 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 20.12% to 7.27%. We also examine a variety of alternative policies to understand the roles of different components of the ACA in contributing to these equilibrium changes. Interestingly, we find that the uninsured rate will be even lower (at 6.44%) if the employer mandate in the ACA is eliminated.

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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 reforms to the U.S. health insurance and health care market 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 will take effect from 2014. In particular, four of the most important components 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 more than 50 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 risks of those in the exchange 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 the purchase of health insurance from the exchanges.

The goal of this paper is to understand how the health care reform will change the health insurance

[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 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.

and labor markets. Would the ACA significantly reduce the uninsured rate? Would more employers be offering health insurance to their employees? How would the reform affect workers' wages, health and productivity? How would it affect employment and firm size distributions? What is the impact on total health expenditures and on government budget? We are also interested in several counterfactual policies. For example, how would the remainder of the ACA perform if its individual mandate component had been struck down by the Supreme Court? What would happen if the current tax exemption status of employer-provided insurance premium is eliminated? Are the premium subsidies necessary for the insurance exchanges to overcome the adverse selection problem? Can we identify alternative reforms that can improve welfare relative to the ACA?

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.[8] 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 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 average wage of \$29,077 at firms that did; also, annual separation rate of workers at firms not offering 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.

In this paper we present and empirically implement an equilibrium labor market search model integrated with health insurance market. Our model is based on Burdett and Mortensen (1998) and Bontemps, Robin, and Van den Berg (1999, 2000).[9] But 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 observe their own health status which evolves stochastically. Workers' health status affects both their medical expenditures and their labor productivity. 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. 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 health

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

[9] 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 (2012) 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.

composition of its workforce and a fixed administrative cost. When deciding the compensation packages, the firms anticipate that their choice of compensation packages will affect the health composition of their worker 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). 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.

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 worked in firms that already offer insurance and thus are 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.

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.[10]

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 20.12% in the benchmark economy to 7.27%. This large reduction of the uninsured rate is mainly driven by the unemployed (3.2% of the population) and 9.65% 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 the employer mandate increases the

[10]In fact, we will show in Table 14 that, due to these effects, the incentives for firms, even the more productive ones, to offer health insurance is largely unaffected in a counterfactual environment where the tax exemption of ESHI premiums is eliminated.

health insurance offering rate for firms with 50 or more workers from 91.13% in the benchmark to 99.93% under the ACA; however, the health insurance offering rate is somewhat reduced for firms with less than 50 workers. Moreover, the 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, there is only a small increase in the fraction of employed workers receiving ESHI, from 82.53% in the benchmark to 82.84% under the ACA. We also find that the ACA would raise the health expenditure by about 8%, and lead to an increase in the fraction of healthy workers in the population.

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 12.18%, significantly lower than the 20.12% 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. 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. However, the presence of the exchange, though non-active, still changes the workers' outside option and thus affects the firms' decisions, which leads to a small reduction of the uninsured rate from 20.12% in the benchmark to 17.14-17.28% under "ACA without the subsidies."

Interestingly, we find that, under a policy of "ACA without the employer mandate," the uninsured rate would be 6.44%, lower than the uninsured rate under the full ACA. Without the employer mandate, the health composition of the workers in the health exchange pool is improved, which leads to a decrease in the premium in the exchange. This makes it less desirable for individuals to stay uninsured and subject to individual mandate penalty. We also find that the equilibrium under the policy of "ACA without employer mandate" achieves a higher average productivity, higher average wages and higher worker's average utility, without increasing the government spending.

We also simulate the effects of eliminating the tax exemption for ESHI premium both under the benchmark and under the ACA. We find that, while the elimination of the tax exemption for ESHI premium would reduce the probability of all firms, especially the larger ones, offering health insurance to their workers, the overall effect on the uninsured rate is rather modest. We find that the uninsured rate would increase from 20.12% to 23.39% when the ESHI tax exemption is removed in the benchmark economy; and it will increase from 7.27% to 9.15% under the ACA. We also experimented with the effect of prohibiting firms from offering ESHI. We find that it would lead to a large reduction in the fraction of active firms in the labor market, which suggests that ESHI allows low-productive firms to be active in the market because they can potentially extract the workers' risk premium.

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 describe the numerical algorithm to solve for the steady state equilibrium of the model, and present a qualitative assessment of the workings of the model; in Section 5, we describe the data sets used in our empirical analysis; in Section 6, we explain our 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 literature that examines the relationship between health insurance and labor market. 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). 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.

Bruegemann and Manovskii (2010) develop a search and matching model to study firms' health insurance coverage decision. In their model, firm sizes are discrete to highlight the effect of fluctuations in the health composition of employees on the dynamics of firm's coverage decision, and they argue that the insurance market for small firms suffers from adverse selection problem because those firms try to purchase health insurance when most of their employees are unhealthy. Our study provides a complementary channel which has received little attention in the literature: it is harder for small firms to overcome adverse selection problems because they cannot retain their workers long enough to capture the benefits from the advantageous dynamic effects of health insurance on health. This channel arises in our environment because we allow for on-the-job searches and explicitly model the dynamic effect of health insurance on health, both of which are absent in their model. Moreover, our model endogenously generates reasonable wage distributions, which are important to study the impact of income-based premium subsidies and individual mandates.

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, and 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 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 by focusing the Massachusetts Health Reform, implemented in 2006, which has similar features with the ACA. Kolstad and Kowalski (2012a); Hackmann, Kolstad, and Kowalski (2012); Kolstad and Kowalski (2012b) study the effect on medical expenditure, selection in insurance markets, and labor markets. Courtemanche and Zapata (2012) found that Massachusetts reform improves the health status of individuals. They study these issues based on a "difference-in-difference" approach. 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. In a recent paper, Pashchenko and Porapakkarm (2012) 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.

Third, this paper is related to a large literature estimating equilibrium labor market search models.[11] Van den Berg and Ridder (1998) and Bontemps, Robin, and Van den Berg (1999, 2000) empirically implement Burdett and Mortensen (1998)'s model. Their empirical frameworks 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 (2012), 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 (2012), 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 (2012) firms choose whether to enter the formal or informal sectors so in some sense their job characteristics are also endogenously determined; however, in Meghir, Narita, and Robin (2012), 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 and a continuum of workers with measure $M > 0$.[12] They 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.[13]

Workers have constant absolute risk aversion (CARA) preferences:[14]

$$u(c) = -\exp(-\gamma c), \tag{1}$$

where $\gamma > 0$ is the absolute risk aversion parameter.

Workers' Health. Workers differ in their health status, denoted by h, and they can either be **H**ealthy (H) or **U**nhealthy (U) . In our model, a worker's health status has two effects. First, it affects the distribution

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

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

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

[14] 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.

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 has health insurance. We assume that the probability that an individual will experience a medical shock is given by:

$$\Pr(m > 0|h, x) = \Phi(\alpha_0 + \beta_0 1\{h = U\} + \gamma_0 x), \tag{2}$$

and conditional on a medical shock, the realization of the medical expenditure is drawn from a log normal distribution:

$$m|(h, x) \sim \exp(\alpha_m + \beta_m 1\{h = U\} + \gamma_m x + \epsilon_{hx}), \tag{3}$$

where $\epsilon_{hx} \sim N(0, \sigma_{hx}^2)$ and is independently and identically distributed across time periods. Note that in (2) and (3) we allow both the individual's health and health insurance status to affect the medical expenditure distributions; moreover, in (3) we allow that the log normal medical expenditure distributions to be conditionally heteroskedastic.[15] In subsequent analysis, we will use $\tilde{m}_h^x$ 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_h^x to denote the expectation of $\tilde{m}_h^x$ which is given by:[16]

$$m_h^x \equiv \mathrm{E}\tilde{m}_h^x = \exp(\alpha_m + \beta_m 1\{h = U\} + \gamma_m x) \exp\left(\frac{\sigma_{hx}^2}{2}\right) \Phi(\alpha_0 + \beta_0 1\{h = U\} + \gamma_0 x). \tag{4}$$

Second, a worker's health status affects his productivity. Specifically, if an individual works for a firm with productivity p, he can produce p units of output if he is healthy, but he can produce only $d \times p$ units of output if he is unhealthy where $1 - d$ represents the productivity loss from being unhealthy.[17]

In each period, worker's health status changes stochastically according to a Markov Process. The period-to-period transition of an individual's health status depends on his health insurance status. We use $\pi_{h'h}^x \in (0, 1)$ to denote the probability that a worker's health status changes from $h \in \{H, U\}$ to $h' \in \{H, U\}$ conditional on insurance status $x \in \{0, 1\}$. The transition matrix is thus, for $x \in \{0, 1\}$,

$$\boldsymbol{\pi}^x = \begin{pmatrix} \pi_{HH}^x & \pi_{UH}^x \\ \pi_{HU}^x & \pi_{UU}^x \end{pmatrix}, \tag{5}$$

where $\pi_{UH}^x = 1 - \pi_{HH}^x$ and $\pi_{HU}^x = 1 - \pi_{UU}^x$.

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 lognormal with mean μ_p and variance σ_p^2, i.e., $p \sim \ln N(\mu_p, \sigma_p^2)$.

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

[15] 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. Similar specifications have been used in Einav, Finkelstein, Ryan, Schrimpf, and Cullen (2013).

[16] The conditional variances of the medical expenditures can also be analytically characterized:

$$Var(\tilde{m}_h^x|h, x) = \exp[2(\alpha_m + \beta_m 1\{h = U\} + \gamma_m x)] \exp(\sigma_{hx}^2)\left[\exp(\sigma_{hx}^2) - 1\right] \Phi(\alpha_0 + \beta_0 1\{h = U\} + \gamma_0 x)$$

We use these moments in our first-step estimation described in Section 6.1.

[17] 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.

to incur a fixed administrative cost $C > 0$. 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 C.[18]

Importantly, we assume, due to regulations in Health Insurance Portability and Accountability Act (HIPAA) which prohibits discrimination against employees and dependents based on their health status, that all the workers in a given firm will receive the *same* compensation package (wage and health insurance offering *regardless of* their health status.[19]

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. 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. In each period, an unemployed worker randomly meets a firm with probability $\lambda_u \in (0, 1)$. He then decides whether to accept the offer, or to remain unemployed and search for jobs in next period. We assume that all new-born workers are unemployed.

If an individual is employed, he meets randomly with another firm with probability $\lambda_e \in (0, 1)$. If a currently employed worker receives an offer from another firm, he 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.[20] Moreover, each match is destroyed exogenously with probability $\delta \in (0, 1)$, 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.[21]

To generate a steady state for the labor market, we assume that in each period any individual, regardless of health and employment status, will leave the labor market with probability $\rho \in (0, 1)$. An equal measure of newborns will enter the labor market unemployed and their initial health status with be healthy with probability $\mu_H \in (0, 1)$.

Income Taxes and Unemployment Benefit. 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

[18]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.

[19]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

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

[21]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.

specification in Kaplan (2012) which approximates the U.S. tax code by:[22]

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

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 but they are not crucial.

1. Any individual, whether employed or unemployed, and regardless of his health status, may leave the labor market with probability $\rho \in (0, 1)$;
2. If an employed worker stays in the labor market matched with a firm with productivity p, then:
   (a) he produces output p if healthy and $d \times p$ if unhealthy;
   (b) the firm pays wage and collects insurance premium if it offers health insurance;
   (c) he receives a medical expenditure shock, the distribution of which depends on his beginning-of-the-period health status;
   (d) he then observes the realization of the health status that will be applicable next period;
   (e) he randomly meets with new employers with probability λ_e;
   (f) the current match is destroyed with probability $\delta \in (0, 1)$, in which case the worker must decide whether to accept the outside offer, if any, or to enter unemployment pool;
   (g) if the current match is not destroyed, then he decides whether to accept the outside offer if any, to stay with the current firm, or to quit into unemployment.
3. Any unemployed worker experiences the following in a period:
   (a) he receives the unemployment benefit b;
   (b) he receives a medical expenditure shock, the distribution of which depends on his beginning-of-the-period health status;
   (c) he then observes the realization of the health status that will be applicable next period;
   (d) he randomly meets with employers with probability λ_u, and decides whether to accept the offer if any, or to stay unemployed.
4. Time moves to the next period.

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

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 $v_h(y,x)$ to denote the expected *flow* utility of workers with health status h from income y and insurance status $x \in \{0,1\}$; and it is give by:

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

where $T(y)$ is after-tax income as specified in (6) and $\tilde{m}_h^0$ is the random medical expenditure for uninsured individual as specified by (2) and (3). Note that when an individual is insured, i.e., $x = 1$, his medical expenditures are fully covered by the insurance. As long as $\tilde{m}_h^0$ is not always 0, $v_h(y,1) > v_h(y,0)$; i.e., regardless of workers' health, if wages are fixed, then all workers desire health insurance.

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

$$\frac{U_h}{1-\rho} = v_h(b,0) + \beta \mathrm{E}_{h'|(h,0)} \left[\lambda_u \int \max\{V_{h'}(w,x), U_{h'}\} dF(w,x) + (1-\lambda_u) U_{h'} \right], \tag{8}$$

where 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 the baseline model. (8) states that the value of being unemployed, normalized by the survival rate $1-\rho$, consists of the flow payoff $v_h(b,0)$, 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 $\pi_{h'h}^0$ as described in (5). The unemployed worker may be matched with a firm with probability λ_u 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 $V_{h'}(w,x)$, and the value of remaining unemployed $U_{h'}$; if no offer is received, which occurs with probability $1-\lambda_u$, the worker's continuation value is $U_{h'}$.

Similarly, $V_h(w,x)$ is given by

$$\begin{aligned} \frac{V_h(w,x)}{1-\rho} &= v_h(w,x) + \beta\lambda_e \left\{ \begin{array}{c} (1-\delta)\mathrm{E}_{h'|(h,x)} \left[\int \max\{V_{h'}(\tilde{w},\tilde{x}), V_{h'}(w,x), U_{h'}\} dF(\tilde{w},\tilde{x}) \right] \\ +\delta \mathrm{E}_{h'|(h,x)} \left[\int \max\{U_{h'}, V_{h'}(\tilde{w},\tilde{x})\} dF(\tilde{w},\tilde{x}) \right] \end{array} \right\} \\ &+ \beta(1-\lambda_e) \left\{ (1-\delta)\mathrm{E}_{h'|(h,x)} \left[\max\{U_{h'}, V_{h'}(w,x)\} \right] + \delta \mathrm{E}_{h'|(h,x)}[U_{h'}] \right\}. \end{aligned} \tag{9}$$

Note that in both (8) and (9), we used our timing assumption that a worker's health status next period depends on his insurance status this period even if he is separated from his job at the end of this period (see Section 3.2).

3.3.2 Workers' Optimal Strategies

Standard arguments can be used to show that a worker's decision about whether to accept a job offer is characterized by "generalized reservation wage" policies. Note that in our model, both unemployed and employed workers make decisions about whether to accept or reject an offer, and their reservation wages 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.

Optimal Strategies for Unemployed Workers. First, consider an unemployed worker. As the right hand side of (7) is increasing in w, $V_h(w, x)$ is increasing in w. On the other hand, U_h is independent of w. Therefore, the reservation wage for an unemployed worker with health status h satisfies:

$$U_h = V_h(\underline{w}_h^x, x), \tag{10}$$

so that if an unemployed worker meets a firm with offer (w, x), he will accept the offer if $w > \underline{w}_h^x$ and reject otherwise. Because a worker's expected flow utility $v_h(w, x)$ as described in (7) and the law of motion for health as described in (5) both depend on his current health and health insurance status, the reservation wages of the unemployed also differ across these statuses.

Optimal Strategies for Currently-Employed Workers: Job-to-Job Transitions. Now we consider the reservation wages for a currently-employed worker. Let (w, x) be the wage-insurance package offered by his current employer; and let (w', x') be the one offered by his potential employer. Then, the reservation wage for the employed worker with health status h to switch, denoted by $\underline{s}_h^{x'}(w, x)$, must satisfy

$$V_h(w, x) = V_h\left(\underline{s}_h^{x'}(w, x), x'\right). \tag{11}$$

A worker with health status h on a current job (w, x) will switch to a job (w', x') if and only if $w' > \underline{s}_h^{x'}(w, x)$. It is straightforward from (9) that

$$\underline{s}_h^{x'}(w, x) = w \text{ if } x = x'.$$

However, when $x \neq x'$, the exact value of $\underline{s}_h^{x'}(w, x)$ must be solved from (11); in particular, it will differ by worker's health and health insurance status. It can be easily shown that

$$\underline{s}_h^{x'}(w, x) > w \text{ if } x = 1 \text{ and } x' = 0; \ \underline{s}_h^{x'}(w, x) < w \text{ if } x = 0 \text{ and } x' = 1.$$

Once we solve $\underline{s}_h^{x}(\cdot, \cdot)$, we can use its definition as in (11) to obtain, for any new offer (w', x'),

$$V_h\left(w', x'\right) = V_h\left(\underline{s}_h^{x}(w', x'), x\right),$$

thus a worker with a current offer (w, x) will accept the new offer (w', x') if and only if

$$w < \underline{s}_h^{x}(w', x'). \tag{12}$$

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

Optimal Strategies for Currently-Employed Workers: Quitting-to-Unemployment. Finally, a worker with health status h who is currently on a job (w, x) may choose to quit into unemployment. This may happen because of the changes in workers' health condition since he last accepted the current job offer and the possibility that the offer arrival probability for unemployed worker, λ_u, may be higher than that for an employed worker, λ_e. Clearly a worker with health status h and health insurance status x will quit into unemployment only if the current wage w is below a threshold. Let us denote the threshold wages for quitting into unemployment by $\underline{q}_h^x$. Clearly, $\underline{q}_h^x$ must satisfy

$$V_h\left(\underline{q}_h^x, x\right) = U_h. \tag{13}$$

Comparing (13) with (10), it is clear that $\underline{q}_h^x = \underline{w}_h^x$. Thus we can conclude that employed workers will quit to unemployment only if his health status changed from when he first started on the current job. Moreover, if $\underline{w}_H^x < \underline{w}_U^x$, then a currently unhealthy worker who accepted a job (w, x) with wage $w \in (\underline{w}_H^x, \underline{w}_U^x)$ when his health status was H may now quit into unemployment; if $\underline{w}_H^x > \underline{w}_U^x$ instead, then a currently healthy worker who accepted a job (w, x) with wage $w \in (\underline{w}_U^x, \underline{w}_H^x)$ when his health status was U may now quit into unemployment.

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 workers of different health status h are allocated in their employment (w, x). Let u_h denote the measure of unemployed workers with health status $h \in \{U, H\}$; and let e_h^x denote the measure of employed workers with health insurance status $x \in \{0, 1\}$ and health status is $h \in \{U, H\}$. Of course, we have

$$\sum_{h \in \{U,H\}} (u_h + e_h^0 + e_h^1) = M. \tag{14}$$

Let $G_h^x(w)$ the *fraction* of employed workers with health status h working on jobs with insurance status x whose wage is below w, and let $g_h^x(w)$ be the corresponding density of $G_h^x(w)$. Thus, $e_h^x g_h^x(w)$ is the density of employed workers 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 into unemployment with health status h is given by

$$
\begin{aligned}
[u_h]^+ \quad \equiv \quad & (1-\rho)\left[\delta(1-\lambda_e) + \delta\lambda_e(F(\underline{w}_h^1, 1) + F(\underline{w}_h^0, 0))\right]\left[e_h^0\pi_{hh}^0 + e_h^1\pi_{hh}^1 + e_{h'}^0\pi_{hh'}^0 + e_{h'}^1\pi_{hh'}^1\right] && \text{(15a)}\\
& +(1-\rho)u_{h'}\pi_{hh'}^0[1-\lambda_u(1-F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0))] && \text{(15b)}\\
& +(1-\rho)(1-\delta)e_{h'}^1\pi_{hh'}^1 G_{h'}^1(\underline{w}_h^1)\left[1-\lambda_e(1-F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0))\right] && \text{(15c)}\\
& +(1-\rho)(1-\delta)e_{h'}^0\pi_{hh'}^0 G_{h'}^0(\underline{w}_h^0)\left[1-\lambda_e(1-F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0))\right] && \text{(15d)}\\
& +M\rho\mu_h. && \text{(15e)}
\end{aligned}
$$

In the above expression, the term on line (15a) is the measure of employed 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. The term on line (15b) is the measure of workers whose health status was h' last period but transitioned to h this period and who did not leave for employment. The terms on lines (15c) and (15d) are the measures of workers currently working on jobs with and without health insurance, respectively, quitting into unemployment. To understand these expressions, consider the term on line (15c). First, quitting into unemployment only applies to workers who did not leave the labor market and whose job did not get terminated (i.e., $(1-\rho)(1-\delta)$ measure of them). Second, note that quitting into unemployment at health status h this period is possible only if the worker's health status was h' in the previous period then transitioned to h this period, because otherwise the worker would have quit already in the previous period, and moreover only if his wage was lower than $\underline{w}_h^1$ defined in (10); these are captured by the term $e_{h'}^1 \pi_{hh'}^1 G_{h'}^1(\underline{w}_h^1)$. Third, those who quit into unemployment will remain in the unemployment pool only if the offer they may have received is not acceptable, which happens with probability $\left[1-\lambda_e(1-F(\underline{w}_h^1,1)-F(\underline{w}_h^0,0))\right]$. Finally, the term on line (15e) is the measure of new workers born into health status h.

The outflow from unemployment with health status h is given by:

$$[u_h]^- \equiv u_h \left\{\rho + (1-\rho)\left[\pi_{h'h}^0 + \pi_{hh}^0 \lambda_u (1-F(\underline{w}_h^1,1)-F(\underline{w}_h^0,0))\right]\right\}. \tag{16}$$

It states that a ρ fraction of the unemployed with health status h will die and the remainder $(1-\rho)$ will either change to health status h' (with probability $\pi_{h'h}^0$), or if their health does not change (with probability π_{hh}^0) they may become employed with probability $\lambda_u(1-F(\underline{w}_h^1,1)-F(\underline{w}_h^0,0))$. Then, in a steady-state we must have

$$[u_h]^+ = [u_h]^-, h \in \{U, H\}. \tag{17}$$

Now we provide the steady state equation for workers employed on jobs (w,x) with health status h. The inflow of workers with health status h to jobs $(w,1)$, denoted by $\left[e_h^1(w)\right]^+$, is given as follows. If $w > \underline{w}_h^1$,

$$\begin{aligned}
\left[e_h^1(w)\right]^+ \equiv\; & (1-\rho) f(w,1)\lambda_u\left(u_h \pi_{hh}^0 + u_{h'}\pi_{hh'}^0\right) && \text{(18a)}\\
& +(1-\rho) f(w,1)\delta\lambda_e\left(\pi_{hh}^0 e_h^0 + \pi_{hh'}^0 e_{h'}^0 + \pi_{hh}^1 e_h^1 + \pi_{hh'}^1 e_{h'}^1\right) && \text{(18b)}\\
& +(1-\rho) f(w,1)(1-\delta)\lambda_e\left[\begin{array}{c} \pi_{hh}^0 e_h^0 G_h^0\left(\underline{s}_h^0(w,1)\right) + \pi_{hh'}^0 e_{h'}^0 G_{h'}^0\left(\underline{s}_h^0(w,1)\right) \\ +\pi_{hh}^1 e_h^1 G_h^1(w) + \pi_{hh'}^1 e_{h'}^1 G_{h'}^1(w)\end{array}\right] && \text{(18c)}\\
& +(1-\rho)(1-\delta)\pi_{hh'}^1 e_{h'}^1 g_{h'}^1(w)\left[1-\lambda_e\left(1-\tilde{F}_h(w,1)\right)\right], && \text{(18d)}
\end{aligned}$$

where $h' \neq h$ and $\tilde{F}_h(w,1)$ is defined by

$$\tilde{F}_h(w,1) = F(w,1) + F(\underline{s}_h^0(w,1),0); \tag{19}$$

and $\left[e_h^1(w)\right]^+ = 0$ if $w < \underline{w}_h^1$. To understand expression (18), note that line (18a) presents the inflows from unemployed workers with health status h to job $(w,1)$; line (18b) represents the inflow from those whose current match was destroyed but transitions to job $(w,1)$ without experiencing an unemployment spell (recall our timing assumption 3(e) and 3(f) in Section 3.2); line (18c) represents inflows from workers who were employed on other jobs to job $(w,1)$; and finally line ((18d) is the inflow from workers who were employed on the same job but has experienced a health transition from h' to h and yet did not transition to other better jobs, which occurs with probability $\left[1-\lambda_e\left(1-\tilde{F}_h(w,1)\right)\right]$.

Denote the outflow of workers with health status h from jobs $(w,1)$ by $\left[e_h^1(w)\right]^-$, and it is given by

$$\left[e_h^1(w)\right]^- \equiv e_h^1 g_h^1(w)\left\{\left[\rho + (1-\rho)\pi_{hh}^1\delta\right] + (1-\rho)\pi_{h'h}^1 + (1-\rho)\pi_{hh}^1\lambda_e(1-\delta)\left[1-\tilde{F}_h(w,1)\right]\right\}. \tag{20}$$

The outflow consists of job losses due to death and exogenous termination represented by the term $e_h^1 g_h^1(w)\left[\rho + (1-\rho)\pi_{hh}^1 \delta\right]$, changes in current workers' health status represented by the term $e_h^1 g_h^1(w)(1-\rho)\pi_{h'h}^1$, and transitions to other jobs represented by the term $e_h^1 g_h^1(w)\,(1-\rho)\,\pi_{hh}^1 \lambda_e (1-\delta)\left[1 - \tilde{F}_h(w,1)\right]$. The steady state condition requires that

$$\left[e_h^1(w)\right]^+ = \left[e_h^1(w)\right]^- \text{ for } h \in \{U,H\} \text{ and for all } w \text{ in the support of } F(w,1). \tag{21}$$

Similarly, the inflow of workers with health status h into jobs $(w,0)$, denoted by $\left[e_h^0(w)\right]^+$, is as follows. If $w > \underline{w}_h^0$,

$$\begin{aligned}
\left[e_h^0(w)\right]^+ \;=\;& f(w,0)(1-\rho)\lambda_u\left(u_h \pi_{hh}^0 + u_{h'}\pi_{hh'}^0\right) \\
&+ f(w,0)(1-\rho)\delta\lambda_e\left(\pi_{hh}^1 e_h^1 + \pi_{hh'}^1 e_{h'}^1 + \pi_{hh}^0 e_h^0 + \pi_{hh'}^0 e_{h'}^0\right) \\
&+ f(w,0)(1-\rho)\lambda_e(1-\delta)\left[\begin{array}{c} \pi_{hh}^1 e_h^1 G_h^1\left(\underline{s}_h^1(w,0)\right) + \pi_{hh'}^1 e_{h'}^1 G_{h'}^1\left(\underline{s}_h^1(w,0)\right) \\ +\pi_{hh}^0 e_h^0 G_h^0(w) + \pi_{hh'}^0 e_{h'}^0 G_{h'}^0(w) \end{array}\right] \\
&+ (1-\rho)(1-\delta)\pi_{hh'}^0 e_{h'}^0 g_{h'}^0(w)\left[1 - \lambda_e\left(1 - \tilde{F}_h(w,0)\right)\right],
\end{aligned} \tag{22}$$

where $h \neq h'$ and $\tilde{F}_h(w,0)$ is defined by

$$\tilde{F}_h(w,0) = F(w,0) + F(\underline{s}_h^1(w,0),1); \tag{23}$$

and $\left[e_h^0(w)\right]^+ = 0$ if $w < \underline{w}_h^0$. The outflow of workers with health status h from jobs $(w,0)$, denoted by $\left[e_h^0(w)\right]^-$, is given by:

$$\left[e_h^0(w)\right]^- = e_h^0 g_h^0(w)\left\{\rho + (1-\rho)\left[\pi_{h'h}^0 + \pi_{hh}^0(\delta + (1-\delta)\lambda_e(1-\tilde{F}_h(w,0))\right]\right\}. \tag{24}$$

The steady state condition thus requires that

$$\left[e_h^0(w)\right]^+ = \left[e_h^0(w)\right]^- \text{ for } h \in \{H,U\} \text{ and for all } w \text{ in the support of } F(w,0). \tag{25}$$

From the four employment densities, $\langle e_h^x g_h^x(w) : h \in \{U,H\}, x \in \{0,1\}\rangle$, we can define a few important terms related to *firm size*. First, given $\langle e_h^x g_h^x(w) : h \in \{U,H\}, x \in \{0,1\}\rangle$, the number of employees with health status h if a firm offers (w,x) is simply given by

$$n_h(w,x) = \frac{e_h^x g_h^x(w)}{f(w,x)}, \tag{26}$$

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

$$n(w,x) = \sum_{h\in\{U,H\}} n_h(w,x) = \sum_{h\in\{U,H\}} \frac{e_h^x g_h^x(w)}{f(w,x)}. \tag{27}$$

Expressions (26) and (27) allow us to connect the firm sizes in steady state as a function of the entire distribution of employed workers $\langle e_h^x g_h^x(w) : h \in \{U,H\}, x \in \{0,1\}\rangle$.

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 $F(w, x)$. We assume that, before the firms make this decision, they each receive an i.i.d draw of $\sigma_f \epsilon$ where ϵ has a Type-I extreme value distribution and σ_f is a scale parameter. We interpret $\sigma_f \epsilon$ as an employer's idiosyncratic preference for offering health insurance. We assume that the $\sigma_f \epsilon$ shock a firm receives is persistent over time and it is separable from firm profits.[23]

Given the realization of ϵ, each firm chooses (w, x) to maximize the steady-state flow profit *inclusive* of the shocks. 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:

$$\max\{\Pi_0(p), \Pi_1(p) + \sigma_f \epsilon\}, \tag{28}$$

where

$$\Pi_0(p) = \max_{\{w_0\}} \Pi(w_0, 0) \equiv (p - w_0) n_H(w_0, 0) + (pd - w_0) n_U(w_0, 0); \tag{29}$$

$$\Pi_1(p) = \max_{\{w_1\}} \Pi(w_1, 1) \equiv \left[\left(p - w_1 - m_H^1\right) n_H(w_1, 1) + \left(pd - w_1 - m_U^1\right) n_U(w_1, 1)\right] - C. \tag{30}$$

To understand the expressions (29), note that $n_H(w_0, 0)$ and $n_U(w_0, 0)$ are respectively the measure of healthy and unhealthy workers the firm will have in the steady state as described by (26) if it offers compensation package $(w_0, 0)$. Thus, $(p - w_0) n_H(w_0, 0)$ is the firm's steady-state flow profit from the healthy workers and $(pd - w_0) n_U(w_0, 0)$ is the flow profit from the unhealthy workers. The expressions (30) can be similarly understood after recalling that m_h^1 is the expected medical expenditure of worker with health status h and health insurance as defined in (4). For future reference, we will denote the solutions to problems (29) and (30) respectively as $w_0(p)$ and $w_1(p)$.

Due to the assumption that ϵ is drawn from i.i.d. Type-I extreme value distribution, firms' optimization problem (28) thus implies that the probability that a firm with productivity p offers health insurance to its workers is

$$\Delta(p) = \frac{\exp(\frac{\Pi_1(p)}{\sigma_f})}{\exp(\frac{\Pi_1(p)}{\sigma_f}) + \exp(\frac{\Pi_0(p)}{\sigma_f})}, \tag{31}$$

where $\Pi_0(p)$ and $\Pi_1(p)$ are respectively defined in (29) and (30).

3.4 Steady State Equilibrium

A *steady state equilibrium* is a list $\left\langle \left(\underline{w}_h^x, \underline{s}_h^x(\cdot,\cdot), \underline{q}_h^x\right), \left(u_h, e_h^x, G_h^x(w)\right), \left(w_x(p), \Delta(p)\right), F(w, x) \right\rangle$ such that the following conditions hold:

- **(Worker Optimization)** Given $F(w, x)$, for each $(h, x) \in \{U, H\} \times \{0, 1\}$,
  - $\underline{w}_h^x$ solves the unemployed workers' problem as described by (10);
  - $\underline{s}_h^x(\cdot,\cdot)$ solves the job-to-job switching problem for currently employed workers as described by (11);

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

- $\underline{q}_h^x$ describes the optimal strategy for currently employed workers regarding whether to quit into unemployment as described by (13);

- **(Steady State Worker Distribution)** Given workers' optimizing behavior described by $\left(\underline{w}_h^x, \underline{s}_h^x(\cdot,\cdot), \underline{q}_h^x\right)$ and $F(w,x)$, $(u_h, e_h^x, G_h^x(w))$ satisfy the steady state conditions described by (14), (17), (21) and (25);

- **(Firm Optimization)** Given $F(w,x)$ and the steady state employee sizes implied by $(u_h, e_h^x, G_h^x(w))$, a firm with productivity p chooses to offer health insurance with probability $\Delta(p)$ where $\Delta(p)$ is given by (31). Moreover, conditional on insurance choice x, the firm offers a wage $w_x(p)$ that solves (29) and (30) 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:

$$F(w,1) = \int_0^\infty \mathbf{1}(w_1(p) < w)\Delta(p)d\Gamma(p), \tag{32}$$

$$F(w,0) = \int_0^\infty \mathbf{1}(w_0(p) < w)\left[1 - \Delta(p)\right]d\Gamma(p). \tag{33}$$

4 Numerical Algorithm and Qualitative Assessment of the Model

The complexity of the model precludes an analytical characterization of the equilibrium, thus we solve the equilibrium numerically.[24] 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. 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.

In Table 2, we use the estimates from Section 7 to shed light on the detailed mechanisms for why in our model more productive firms have stronger incentives to offer health insurance than less productive firms. For this purpose, we simulate the health composition of the workforce for the firms with the bottom 20 and the top 20 productivity levels in our discretized productivity distribution. 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 4.9% and 3.7%; in contrast, the fraction of unhealthy workers in low

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

Statistics	Benchmark	$\widehat{C}=0$	$\widehat{\pi^0_{hh'}=\pi^1_{hh'}}$	$\widehat{\gamma}=0.1$	$\widehat{d}=1.00$
	(1)	(2)	(3)	(4)	(5)
Fraction of Firms Offering Health Insurance	0.5581	0.5651	0.5081	0.5401	0.5198
... if firm size is less than 50	0.5200	0.5275	0.5021	0.5029	0.5015
...if firm size is at least 50	0.9113	0.9135	0.5623	0.8837	0.6947
Fraction of Firms with Less than 50 Workers	0.9026	0.9026	0.8999	0.9023	0.8868
Average (4-month) Wages of Employed Workers	0.8501	0.8502	0.8688	0.8532	0.8868
... for insured employees	0.8986	0.8977	0.8680	0.9074	0.9125
... for uninsured employees	0.6211	0.6206	0.8698	0.6437	0.8400
Fraction of Healthy Workers	0.9494	0.9497	0.9644	0.9471	0.9363
... among the uninsured workers	0.9017	0.9019	0.9646	0.8999	0.8967
... among the insured workers	0.9600	0.9600	0.9641	0.9599	0.9586

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.

and high productivity firms that do not offer health insurance are respectively 9.6% and 10.7%. 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 A-C, we disentangle the advantage of high-productivity firms relative to low-productivity firms in offering health insurance into three components.

In Panel A (or Row 2), we show that, in the low-productivity firms, the fraction of unhealthy among the new hires – including those hired directly from unemployment pool and those poached from other firms (i.e., job-to-job switchers) – is 8.0% if they offer health insurance and 7.4% if they do not; in contrast, in the high-productivity firms the fraction of unhealthy is 5.06% if they offer health insurance and 5.05% if they do not. 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 thus are 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.

In Panel B, 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 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 6.7% and 8.4% respectively in those offering health insurance and those not offering health insurance. Similarly, for high-productivity firms, the fraction of unhealthy workers among those hired a period ago is 4.6% and 6.7% 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 3.807% in low-productivity firms that offer health insurance, but it would be 10.9% 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 3.7%

Statistics	Low-Productivity Firms HI	Low-Productivity Firms No HI	High-Productivity Firms HI	High-Productivity Firms No HI
[1] Fraction of Unhealthy Workers in Steady State	0.049	0.096	0.037	0.107
	Panel A: Adverse Selection Effect			
[2] Fraction of Unhealthy Among New Hires	0.080	0.074	0.0506	0.0505
	Panel B: Health Insurance Effect on Health			
[3] One-Period Ahead Fraction of Unhealthy Among New Hires	0.067	0.084	0.046	0.067
[4] Nine-Period Ahead Fraction of Unhealthy Among New Hires	0.038	0.109	0.037	0.107
	Panel C: Retention Effect			
[5] Job-to-Job Transition Rate for Healthy Workers	0.109	0.126	8.29E-9	4.03E-14
[6] Job-to-Job Transition Rate for Unhealthy Workers	0.104	0.126	8.29E-9	5.91E-5

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

Notes: For the simulations reported in this table, the low-productivity and high productivity firms are the firms with the bottom 20 and top 20 values of productivity in our discretized productivity support. See Footnote 1 in Online Appendix A.

and 10.7% respectively in those offering health insurance and those not offering health insurance.

Finally, in Panel C 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 rates 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 $C = 0.0730$ (i.e., \$730 per 4 months) as reported in Table 8. Comparing the results in Column (2) with the benchmark results in Column (1), we find that lowering the fixed administrative cost of offering health insurance affects mainly the coverage rate for small firms; and its effect on the insurance offering rate of large firms is much smaller. Moreover, it does not affect much of the other outcomes. Although we still have a positive correlation between firm size and health insurance offering rate, the offering rate for small firms is around 52.75% if $C = 0$.

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 uninsured is the same as that of the insured, $\widehat{\pi^0_{h'h}} = \pi^1_{h'h}$.[25] Column (3) of Table 1 shows that the fraction of large firms offering health insurance decrease significantly when $\widehat{\pi^0_{h'h}}$ is set to be equal to $\pi^1_{h'h}$. 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.

The reason why large firms decide not to offer health insurance when $\widehat{\pi^0_{h'h}} = \pi^1_{h'h}$ can be understood as follows. When $\widehat{\pi^0_{h'h}} = \pi^1_{h'h}$, 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 is worse than that of firms who do not, 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 decrease the CARA coefficient from the estimated value of 0.4915 in Table 8 to 0.1. A reduction in CARA coefficient leads to a modest reduction in the health insurance offering rate for the large firms. It also increases the average wages in firms without health insurance.

Productivity Effect of Health. In Column (5) of Table 1 we investigate the productivity effect of health by changing d from 0.3386 in Table 8 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 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 increases firms' wage offers in general due to the productivity improvement.

4.3 Identification of γ, d, C and σ_f

As shown in Columns (2) and (4)-(5) in Table 1, the CARA coefficient γ, the productivity effect of health d, and the fixed 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 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 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. These effects are

[25] We also obtain similar qualitative result in the opposite scenario, where health transition of the insured is set to be equal to that estimated for the uninsured, i.e., $\widehat{\pi^1_{h'h}} = \pi^0_{h'h}$.

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 and risk aversion γ affect the relationship between the probability of offering health insurance and firm size. Of course, the scale parameter σ_f in (31) 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 is disciplined by the worker-side job-to-job transition information as we described above; second, even though the parameter d 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 has an additional effect on the differences in wages for firms depending on whether they offer health insurance. Finally, the administrative cost C is identified from the the probability (in *level*) of small firms offering health insurance.

5 Data Sets

In this section, we describe our data sets and sample selection. In order to estimate the model, it is ideal to use employee-employer matched dataset which contains information about worker's labor market outcome and its dynamics, health, medical expenditure, and health insurance, and firm's insurance coverage rate and size. Unfortunately, such a data set does not exist in the U.S. Instead, we combine three separate data sets for our estimation: (1) Survey of Income and Program participation; (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).[26] 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.[27]

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 men (dropping 59,846 female individuals) whose ages are between 26-46 (dropping an additional 38,016 individuals). In addition, we only keep individuals who are

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

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

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 6,995 individuals in total). We also require that our sample be covered either by an employer-based health insurance in his own name or is uninsured (dropping an additional 1,948 individuals). We restrict our samples to individuals who are at most high school graduates (dropping 3,060 individuals). Finally we drop top and bottom 3% of salaried workers (dropping an additional 817 individuals). Our final estimation sample that meets all of the above selection criterion consists of a total of 5,309 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.[28] 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 4,815.

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 Foundation Employer Health Insurance Survey (hereafter, RWJ-EHI).[29] 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 workers receive health insurance from their employers; the average 4-month wage for employed workers with health insurance is about $9,240, higher than that for those without health insurance which is about $6,187. The unemployment rate for our selected sample is about 3.18%, lower than the overall unemployment rate in the U.S. in 1996 (which was about 5.4%).[30] About 95.11% of our sample reported their health to be healthy (i.e. either "Good", "Very Good", or "Excellent"). Moreover, it is important to note that 95.36% of the workers with insurance and 93.89% of those without insurance reported healthy.

In Table 4 we report the comparison of summary statistics for the individuals in MEPS 1997-1999 and those in SIPP 1996. Both the fraction of healthy workers and the fraction of employed workers who own health insurance are somewhat lower in MEPS than in SIPP. By using the mean expenditure given health and health insurance in MEPS, we also impute the annual average medical expenditure based on SIPP's

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

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

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

Variable	Mean	Std. Dev.
Fraction of Insured Among Employed Workers	0.7619	0.4260
Average (4-Month) Wages for Employed Workers	0.8538	0.3532
... for insured employees	0.9240	0.3462
... for uninsured employees	0.6187	0.2750
Fraction of Unemployed Workers	0.0318	0.1758
Fraction of Healthy Workers	0.9511	0.2177
... among insured workers	0.9536	0.2103
... among uninsured workers	0.9389	0.2398

Table 3: Summary Statistics: SIPP 1996.

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

Variable	MEPS (1)	SIPP (2)
Fraction of Healthy Workers	0.912 (0.284)	0.951 (0.218)
Fraction of Insured Among Employed Workers	0.651 (0.477)	0.762 (0.426)
Annual Medical Expenditure	0.077 (0.337)	0.079*
... for those with health insurance and who are healthy	0.078 (0.265)	-
... for those without health insurance and who are healthy	0.043 (0.366)	-
... for those with health insurance and who are unhealthy	0.293 (0.603)	-
... for those without health insurance and who are unhealthy	0.133 (0.451)	-

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

Notes: (1). The average wages are in units of $10,000. (2). Standard deviations are in parentheses. (3). The annual medical expenditure for SIPP is 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.

health and health insurance composition for the SIPP sample. It shows that annual medical expenditures are similar in the two samples.

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 large size in employment and provide higher wage. Moreover, wages, both unconditional and conditional on insurance status, are very close to the one reported for the 1996 SIPP sample. 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.

6 Estimation Strategy

In this section we present our strategy to structurally estimate our baseline model using the datasets we described above.[31] 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,

[31]The details of the numerical estimation procecure are available in Online Appendix D.

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
Health Insurance Coverage Rate	0.56	0.50
... for those with less than 50 workers	0.53	0.50
... for those with 50 or more workers	0.95	0.23
Average Annual Wage Compensation, in $10,000	2.53	2.44
... for those that offer health insurance	2.92	2.50
... for those that do not offer health insurance	2.03	2.27

Table 5: Summary Statistics: RWJ-EHI 1997.
Note: Standard deviations are in parentheses.

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.[32] 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 mean μ_p and variance σ_p^2.

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%.[33] Moreover, we set the exogenous death rate ρ to be 0.001.[34] Finally, the after-tax income schedule (6) is set to be that estimated in Kaplan (2012), i.e., $\tau_0 = 0.0056$, $\tau_1 = 0.6377$ and $\tau_2 = -0.1362$.

6.1 First Step

In Step 1 we estimate parameters $(\alpha_0, \beta_0, \gamma_0)$ in the probability of receiving a medical shock in (2) and the parameters $(\alpha_m, \beta_m, \gamma_m, \sigma_{hx} : h \in \{H, U\}, x \in \{0, 1\})$ in the distribution of medical expenditures as specified in (3), as well as the health transitions $\boldsymbol{\pi}^x$ as in (5) without explicitly using the model. They are estimated by GMM using the MEPS data. A total of twelve sample target moments are used, including the mean and variance of the medical expenditure conditional on health and health insurance status

[32] 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.

[33] 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.

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

Variable	Mean	Std. Dev.
Fraction of Healthy Workers	0.9723	0.1640
Fraction of Insured Among Employed Workers	0.6677	0.4711
Annual Medical Expenditure, in $10,000	0.0621	0.3033
... for those with health insurance and who are healthy *throughout the year*	0.0675	0.1987
... for those without health insurance and who are healthy *throughout the year*	0.0365	0.4003
... for those with health insurance and who are unhealthy *throughout the year*	0.4804	0.9299
... for those without health Insurance and who are unhealthy *throughout the year*	0.1249	0.2955

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

(eight moments) and the fraction of individuals with zero medical expenditures conditional on health and health insurance status (four moments). 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 from parameters which are defined for our model with a four-month period.[35]

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.[36] 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.

We estimate the parameters in health transition matrix $\left(\pi^1_{HH}, \pi^1_{UU}, \pi^0_{HH}, \pi^0_{UU}\right)$ 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. Let $x_t \in \{0,1\}$ be worker's insurance status at period t, and let $h_t \in \{H,U\}$ and $h_{t+3} \in \{H,U\}$ denote respectively the worker's health status in period t and $t+3$ (when it is next measured), the likelihood of observing $h_{t+3} \in \{H,U\}$ conditional on x_t, x_{t+1}, x_{t+2} and $h_t \in \{H,U\}$ can be written out explicitly using the Law of Total Probability. For example, if $h_{t+3} = H$ and $h_t = H$, we have:[37]

$$\begin{aligned}\Pr(h_{t+3} = H | x_t, x_{t+1}, x_{t+2}, h_t = H) &= \pi^{x_t}_{HH}\pi^{x_{t+1}}_{HH}\pi^{x_{t+2}}_{HH} + \pi^{x_t}_{HH}(1-\pi^{x_{t+1}}_{HH})(1-\pi^{x_{t+2}}_{UU}) \\ &\quad + (1-\pi^{x_t}_{HH})(1-\pi^{x_{t+1}}_{UU})\pi^{x+2}_{HH} + (1-\pi^{x_t}_{HH})\pi^{x_{t+1}}_{UU}(1-\pi^{x_{t+2}}_{UU}).\end{aligned}$$

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

6.2 Second Step

In the second step, we estimate the remaining parameters $\theta = (\theta_1, \theta_2)$ where $\theta_1 = (\lambda_u, \lambda_e, \delta, \gamma, \mu, b)$ are parameters that affect worker-side dynamics, and $\theta_2 = (C, d, M, \mu_p, \sigma_p)$ are the additional parameters that

[35] We use the identity weighting matrix for simplicity.

[36] The sample size is 2,892.

[37] The formulae for the other cases are analogous and are available in Online Appendix B.

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

$$g(\theta) = \begin{bmatrix} \frac{\sum_i \partial \log(L_i(\theta))}{\partial \theta} \\ \mathbf{s} - \mathrm{E}[\mathbf{s}; \theta] \end{bmatrix}, \tag{34}$$

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 $\mathbf{s}$ is a vector of firm-side moments we describe in Section 6.2.2. Then, we construct an objective function as

$$\min_{\{\theta\}} g(\theta)'\Omega g(\theta), \tag{35}$$

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

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

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 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 $(\tilde{w}, x)$. 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:

$$\frac{u_{h_1}}{M} \times \Pi_{j=2}^{l} \left\{ \Pr(h_j | h_{j-1}, x_{j-1} = 0) \times \left[(1 - \lambda_u) + \lambda_u \left(F\left(\underline{w}_{h_j}^1, 1\right) + F\left(\underline{w}_{h_j}^0, 0\right) \right) \right] \right\} \tag{36a}$$

$$\times \ \Pr(h_{l+1} | h_l, x_l = 0) \times [\lambda_u f(\tilde{w}, 1)]^{\mathbf{1}(x=1)} \times [\lambda_u f(\tilde{w}, 0)]^{\mathbf{1}(x=0)} \tag{36b}$$

where $\mathbf{1}(x = 1)$ is an indicator function taking value one if we observe a transition to employment with $(\tilde{w}, 1)$ at period $l+1$, and similarly $\mathbf{1}(x = 0)$ is an indicator function taking value one if we observe a transition to employment with $(\tilde{w}, 0)$ at period $l+1$. To understand (36), note that the first term in line (36a), u_h/M, reflects the assumption that the initial condition of individuals is drawn from the steady state worker distribution because u_h/M the probability that an unemployed worker with health status h is sampled. The second term in line (36a) 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 $\left[(1 - \lambda_u) + \lambda_u(F(\underline{w}_{h_j}^1, 1) + F(\underline{w}_{h_j}^0, 0)\right]$ is the probability that the individual does not receive an offer or receives an offer that is lower than the relevant reservation wages $\underline{w}^1_{h_j}$ or $\underline{w}^0_{h_j}$. The term on line (36b) is the probability that his health transitions from h_l to h_{l+1} in period $l+1$ and receive an acceptable offer $(\tilde{w}, x)$ from the relevant density function $f(\tilde{w}, x)$.

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.[38]

We can similarly derive the likelihood contribution of the job dynamics of *employed workers.* Consider an employed 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 Loss"*]: The individual experienced a job loss at period $l+1$;
- [Event *"Switch 1"*]: The individual transitioned to a job $(\tilde{w}, x')$ such that $x' = x$ and the accepted wage is $\tilde{w} > w$;
- [Event *"Switch 2"*]: The individual transitioned to a job $(\tilde{w}, x')$ such that $x' = x$ and the accepted wage is $\tilde{w} < w$;
- [Event *"Switch 3"*]: The individual transitioned to a job $(\tilde{w}, x')$ such that $x' \neq x$ 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:

$$\frac{e^x_h g^x_h(w)}{M} \times \Pi^l_{j=2} \left\{ \Pr(h_j|h_{j-1}, x)(1-\delta)\left[(1-\lambda_e) + \lambda_e\left(F(w,x) + F\left(\underline{s}^{x'}_{h_j}(w,x), x'\right)\right)\right]\right\} \tag{37a}$$

$$\times \Pr(h_{l+1}|h_l, x) \times \begin{cases} \delta\left[(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}^{\tilde{x}}_{h_{l+1}}, \tilde{x})\right] & \text{if Event is "Job Loss"} \\ \lambda_e f(\tilde{w}, x) & \text{if Event is "Switch 1"} \\ \delta\lambda_e f(\tilde{w}, x) & \text{if Event is "Switch 2"} \\ (1-\delta)\lambda_e f(\tilde{w}, x') + \delta\lambda_e f(\tilde{w}, x') & \text{if Event is "Switch 3"}, \end{cases} \tag{37b}$$

To understand (37), note that similar to that in (36), the first term in line (37a), $e^x_h g^x_h(w)/M$, is the probability of sampling an employed worker with health status h working on a job (w, x); the second term in line (37a) 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 (37b) expresses the likelihood of observing health transition from h_l to h_{l+1} in period $l+1$ and one of the four job status change events. For example, the event "Job Loss" is observed in period $l+1$ with probability $\delta\left[(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}^{\tilde{x}}_{h_{l+1}}, \tilde{x})\right]$ because in order for a job loss to occur, the worker has to experience an exogenous shock that destroys the current match (which occurs with probability δ), and then he does not get matched to another acceptable job (which occurs with probability $(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}^{\tilde{x}}_{h_{l+1}}, \tilde{x})$). To understand the probability of event "Switch 2", we note that in order for a worker to switch to a job $(\tilde{w}, x')$ with $x' = x$ but $\tilde{w} < w$, the worker must have experienced a job separation (which occurs with probability δ), but is then lucky enough to find an acceptable job immediately, which happens with probability $\lambda_e f(\tilde{w}, x)$. The probability of the other job switch events are derived similarly.

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

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 **s** in expression (34):

- 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 more than 50 workers;
- Health insurance coverage rate among firms with less than 50 workers;
- Average wages of firms with less than 50 workers;
- Average wages of firms with more than 50 workers.

7 Estimation Results

7.1 Parameter Estimates

Parameters Estimated in the First Step. Table 7 reports the parameter estimates from step 1. The estimated coefficients imply that unhealthy individuals and individuals with health insurance are more likely to experience medical shocks; moreover, conditional on experiencing medical shocks, unhealthy and insured individuals are more likely to incur larger medical expenditures. The finding that health insurance increases both the incidence and magnitude of medical expenditures captures the moral hazard effect of health insurance. As we report in Table 9, our model fits the means and variances of medical expenditures by health and healthy insurance status in the data well.

In Panel B of Table 7, we find that there is a significant health insurance effect on the dynamics of health since $\pi^1_{HH} > \pi^0_{HH}$ and $\pi^1_{UU} < \pi^0_{UU}$, implying that not having health insurance increases the probability that the next period health status is unhealthy. It is also interesting to note that our estimates indicate that health insurance has a higher marginal effect on health for a currently unhealthy worker than for a currently healthy worker, that is, $\pi^1_{HU} - \pi^0_{HU} > \pi^1_{HH} - \pi^0_{HH}$.

Parameters Estimated in the Second Step. Table 8 reports the parameter estimates from step 2. Panel A shows that our estimate of CARA coefficient is about 0.4915E-4 (recalling that our unit is in \$10,000). Using the four-month average wages for employed workers reported in Table 3, which is about \$8,538, our estimated CARA coefficient implies a relative risk aversion of about 0.42. 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).

We find that the offer arrival rate for an employed worker, λ_e, is about 0.268, which implies that on average it takes about 15 months for a currently employed worker to receive an outside offer; we also find that the offer arrival rate for an unemployed worker, λ_u, is 0.434, implying that on average it takes about 9 months for an unemployed to receive an offer.[39] Our estimate of the unemployment income b is small,

[39]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

Parameter	Estimate	Std. Err.
Panel A: Medical Expenditure Parameters in Eq. (4)		
α_0	-1.0909	(0.0446)
β_0	0.5247	(0.0723)
γ_0	0.5787	(0.0747)
α_m	-4.4222	(0.3099)
β_m	1.6262	(0.3268)
γ_m	0.7227	(0.3867)
α_p	-1.0909	(0.0446)
σ_{H1}	1.4783	(0.0662)
σ_{H0}	1.9895	(0.1235)
σ_{U1}	1.3584	(0.0919)
σ_{U0}	1.3193	(0.0173)
Panel B: Health Transition Parameters in Eq. (5)		
π^1_{HH}	0.9865	(0.0023)
π^0_{HH}	0.9689	(0.0058)
π^1_{UU}	0.7294	(0.0310)
π^0_{UU}	0.7587	(0.0365)

Table 7: Parameter Estimate from Step 1.

Note: Standard errors are in parentheses. The unit of medical expenditure is $10,000.

about $137, reflecting that a large fraction of the UI benefits are probably expensed for job search costs. In Panel A, we also report that our estimate of the probability of exogenous job destruction, δ, is about 1.79% in a four-month period; and the fraction of newly arrived workers who are healthy is about 99.30%.

Panel B reports our estimates of parameters $\theta_2 \equiv (C, d, M, \mu_p, \sigma_p)$. We find that the productivity of a worker in bad health, d, is only 0.3386, implying that there is a significant amount of productivity loss from bad health. This seems plausible because we categorize only those whose self-reported health is “Poor” or “Fair” as unhealthy. Moreover, we find that the fixed administration cost of offering health insurance is about $730 per four month, i.e., about $2,190 per year.

In order to fit the average firm size, our estimate of M, the ratio between workers and firms, is about 18.892. This estimate is smaller than the average establishment size of 19.92 reported in Table 5 because in our model some low-productivity firms do not attract any workers in equilibrium. We also estimated that the scale and shape parameters of the lognormal productivity distribution are respectively -0.5860 and 0.4043, which implies that the mean (4-month) productivity of firms is about 0.6149 (i.e. $6149). The fact that the mean accepted four-month wage in our sample is 0.8538 (see Table 3) is largely due to the fact more productive firms attract more workers in the steady state as our model implies, but also due to the fact that a fraction of the low-productivity firms are not able to attract any workers in equilibrium i.e., they are inactive.

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.

Parameter	Estimates	Std. Err.
Panel A: Parameters in $\theta_1 \equiv (\lambda_u, \lambda_e, \delta, \gamma, \mu, b)$		
CARA Coefficient (γ)	0.4915	(0.0051)
Unemployment Income (b)	0.0137	(0.0002)
Offer Arrival Rate for the Unemployed (λ_u)	0.4340	(0.0112)
Offer Arrival Rate for the Employed (λ_e)	0.2680	(0.0038)
Probability of Exogenous Match Destruction (δ)	0.0179	(0.0003)
Fraction of New Born Workers that are Healthy (μ_H)	0.9930	(0.0156)
Panel B: Parameters in $\theta_2 \equiv (C, d, M, \mu_p, \sigma_p, \sigma_f)$		
Productivity of a Worker in Bad Health (d)	0.3386	(0.0063)
Fixed Administrative Cost of Insurance in \$10,000 (C)	0.0730	(0.0063)
Total Measure of Workers Relative to Firms (M)	18.8920	(8.7940)
Scale Parameter of Firms' Lognormal Productivity Distribution $\left(\mu_p\right)$	-0.5680	(0.0031)
Shape Parameter of Firms' Lognormal Productivity Distribution (σ_p)	0.4043	(0.0036)
Scale Parameter of Choice Specific Shock to ESHI offering (σ_f)	0.2397	(0.0025)

Table 8: Parameter Estimate from Step 2.

7.2 Within-Sample Goodness of Fit

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

Worker-Side Goodness of Fit. Table 9 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) and variances (in Panel B) of medical expenditure conditional on health and health insurance status very well; moreover, in Panel C we show that we accurately replicate the fraction of individuals with zero medical expenditures conditional on health and health insurance status.

Table 10 reports the model fit for the worker-side moments. It shows that the model fits really well for cross section worker distribution in terms of health, health status, health insurance, wage, and employment distribution. Note that these moments are not directly targeted in our estimation.

Figure 1 plots the distribution of workers' accepted wages by health insurance status. It shows that our model is able to capture the overall patterns reasonably well, but it predicts a much more concentrated wage distribution than what is in the data, especially among workers who have health insurance from their employers.

Employer-Side Goodness of Fit. Table 11 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).

Figure 2 plots the size distribution of the firms both in the data and that implied by our model estimates. Figure 3 shows the size distributions of firms by health insurance offering status. Both figures show that our model is able to capture the size distribution of firms overall and by health insurance status reasonably well.

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.

	Data	Model
Panel A: Mean Annual Medical Expenditure		
Healthy & insured	0.0672	0.0673
Healthy & uninsured	0.0365	0.0359
Unhealthy & insured	0.4804	0.4794
Unhealthy & uninsured	0.1249	0.1249
Panel B: Variance of Annual Medical Expenditure		
Healthy & insured	0.0393	0.0392
Healthy & uninsured	0.1601	0.1601
Unhealthy & insured	0.8084	0.8084
Unhealthy & uninsured	0.0856	0.0856
Panel C: Fraction with Zero Medical Expenditure		
Healthy & insured	0.3324	0.3368
Healthy & uninsured	0.6458	0.6413
Unhealthy & insured	0.1290	0.1213
Unhealthy & uninsured	0.3600	0.3646

Table 9: Fit for Medical Expenditure Distributions: Model vs. Data.

Moreover, as we showed in Figure 1, our fit of workers' wage distribution conditional on health insurance status is still not ideal. 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 worker's sampling distribution of firms and firm's productivity distribution.[40]

8 Counterfactual Experiments

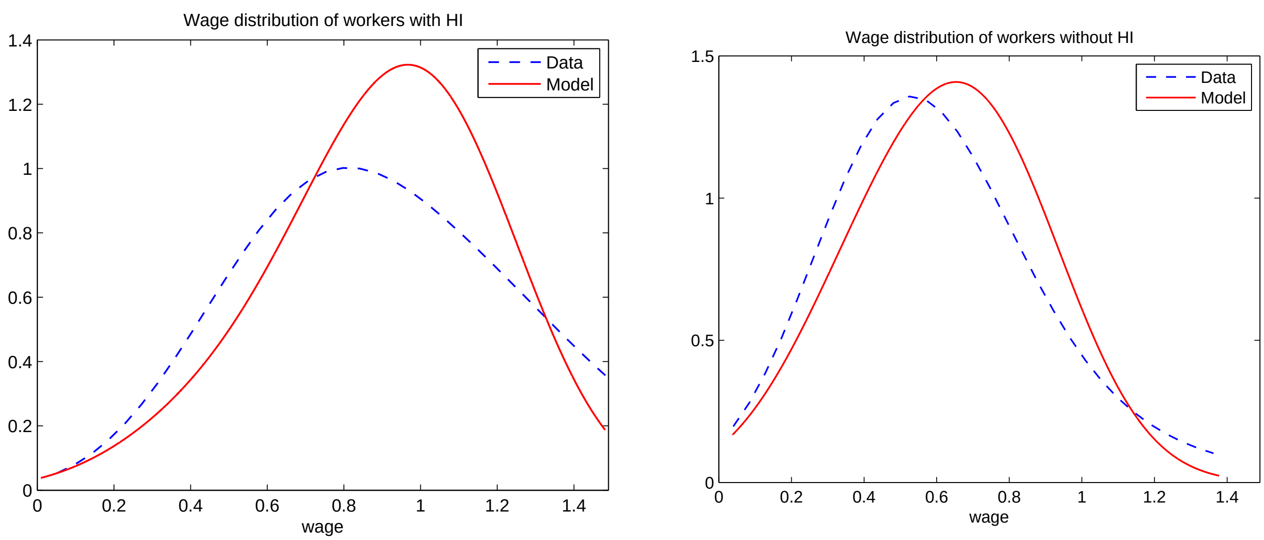
In this section, we use our estimated model to examine the impact of the Affordable Care Act, its various components, and alternative policy designs. For the ACA, we consider a stylized version which incorporates its main components as mentioned in the introduction: first, all individuals are required 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.

[40]We believe that incorporating richer worker heterogeneity in their productivity, beside health status, may be a more important direction for further research.

Moments	Data	Model
Fraction of individuals who are unemployed and healthy	0.0314	0.0301
Fraction of individuals who are unemployed and unhealthy	0.0040	0.0021
Fraction of individuals who are employed, healthy and have health insurance	0.7009	0.7667
Fraction of individuals who are employed, unhealthy and have health insurance	0.0340	0.0319
Fraction of individuals who are employed, healthy and do not have health insurance	0.2156	0.1525
Fraction of individuals who are employed, unhealthy and do not have health insurance	0.0140	0.0167
Mean wage ($10,000)	0.8538	0.8501
Mean wage with health insurance ($10,000)	0.9240	0.8986
Mean wage without health insurance ($10,000)	0.6187	0.6211
Mean medical expenditure ($10,000)	0.0266	0.0253

Table 10: Worker-Side Moments in the Labor Market: Model vs. Data.



(a) With Health Insurance (b) Without Health Insurance

Figure 1: The Distributions of Workers' Accepted Wages by Health Insurance Status: Model vs. Data.

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

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

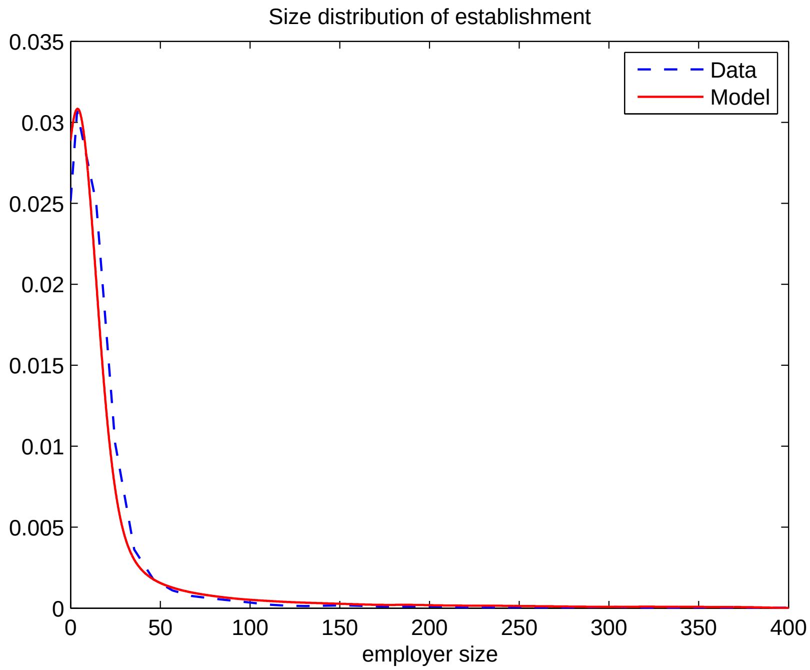
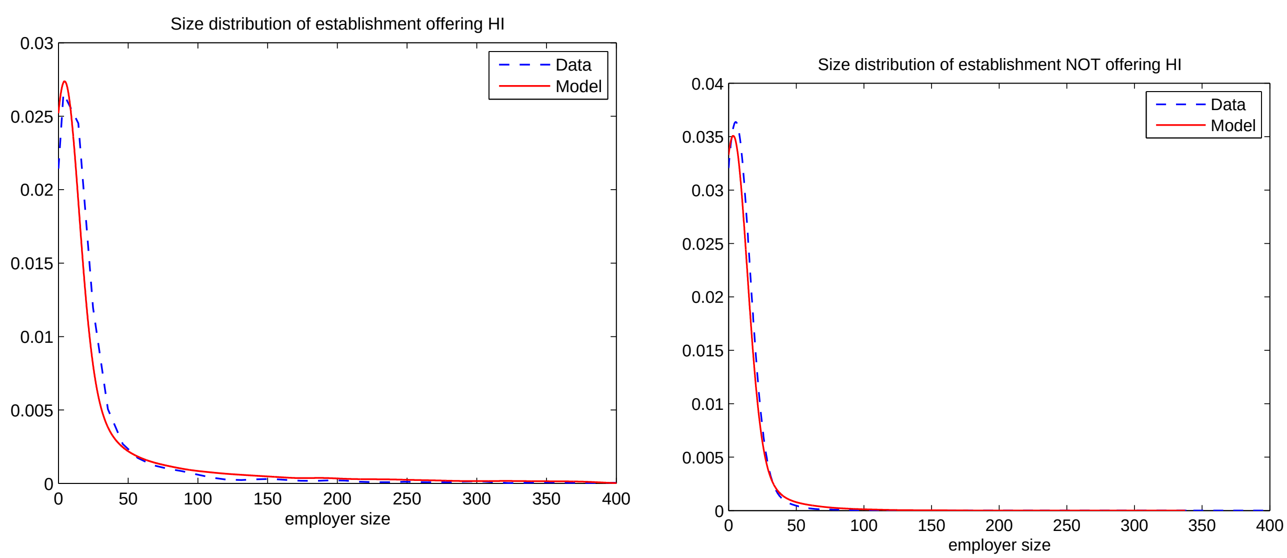


Figure 2: Size Distribution of Firms: Model vs. Data.



(a) With Health Insurance

(b) Without Health Insurance

Figure 3: Size Distribution of Firms by Insurance Offering Status: Model vs. Data.

Moments	Data	Model
Mean firm size	19.92	18.5239
Fraction of firms less than 50 workers	0.93	0.9026
Mean size of firms that offer health insurance	30.08	27.0368
Mean size of firms that do not offer health insurance	6.95	7.2363
Health insurance coverage rate	0.56	0.5581
Health insurance coverage rate among firms with less than 50 workers	0.53	0.5200
Health insurance coverage rate among firms with more than 50 workers	0.95	0.9113
Average wages of firms with less than 50 workers	0.84	0.4129
Average wages of firms with more than 50 workers	0.92	0.9563

Table 11: Employer-Side Moments: Model vs. Data.

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

We also incorporate the premium subsidies to the individuals and penalties if uninsured into the model. Let $S\left(y, R^{EX}\right)$ 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 $v_h(y,x)$ in the counterfactual is defined as:

$$v_h(y,x) = \begin{cases} \mathrm{E}_{\tilde{m}_h^0} u\left(T(y) - \tilde{m}_h^0 - P_W(y)\right) & \text{if } x = 0 \\ u\left(T\left(y\right)\right) & \text{if } x = 1 \\ u\left(T\left(y\right) + S\left(y, R^{EX}\right) - R^{EX}\right) & \text{if } x = 2 \end{cases} \tag{38}$$

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

$$\frac{U_h(x)}{1-\rho} = v_h(b,x) + \beta \mathrm{E}_{h'|(h,x)} \left[\begin{array}{c} \lambda_u \int \max\left\{V_{h'}(w,1), U_{h'}(x_{h'}^*)\right\} dF(w,1) \\ +\lambda_u \int \max_{x' \in \{0,2\}} \left\{V_{h'}(w,x'), U_{h'}(x_{h'}^*)\right\} dF(w,0) \\ +(1-\lambda_u) U_{h'}(x_{h'}^*), \end{array} \right] \tag{39}$$

where

$$x_{h'}^* = \arg\max_{x' \in \{0,2\}} U_{h'}(x'). \tag{40}$$

Similarly, the value function of an employed worker with health status h working on a job with insurance status (w,x), $V_h\left(w,x\right)$, is as follows. If $x=1$,

$$\begin{aligned} \frac{V_h(w,1)}{1-\rho} = v_h(w,1) \qquad & +\beta\lambda_e \left\{ (1-\delta)\, \mathrm{E}_{h'|(h,1)} \left[\begin{array}{c} \int \max\{V_{h'}(\tilde{w},1), V_{h'}(w,1), U_{h'}(x_{h'}^*)\} dF(\tilde{w},1) \\ + \int \max\{V_{h'}^0(\tilde{w}, x_{h'}^*(\tilde{w})), V_{h'}(w,1), U_{h'}(x_{h'}^*)\} dF(\tilde{w},0) \end{array} \right] \right. \\ & \left. + \,\delta \mathrm{E}_{h'|(h,1)} \left[\begin{array}{c} \int \max\left\{U_{h'}(x_{h'}^*), V_{h'}(\tilde{w},1)\right\} dF(\tilde{w},1) \\ + \int \max\left\{U_{h'}(x_{h'}^*), V_{h'}(\tilde{w}, x_{h'}^*(\tilde{w}))\right\} dF(\tilde{w},0) \end{array} \right] \right\} \\ & +\beta(1-\lambda_e)\left\{(1-\delta)\mathrm{E}_{h'|(h,1)} \max\left\{U_{h'}(x_{h'}^*), V_{h'}(w,1)\right\} + \delta \mathrm{E}_{h'|(h,1)} U_{h'}(x_{h'}^*)\right\}, \end{aligned} \tag{41}$$

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

$$\frac{V_h(w,x)}{1-\rho} = v_h(w,x) + \beta\lambda_e \left\{ (1-\delta)\mathrm{E}_{h'|(h,1)} \left[\begin{array}{c} \int \max\{V_{h'}(\tilde{w},1), V_{h'}(w, x^*_{h'}(\tilde{w})), U_{h'}(x^*_{h'})\} dF(\tilde{w},1) \\ + \int \max\{V_{h'}(\tilde{w}, x^*_{h'}(\tilde{w})), V_{h'}(w, x^*_{h'}(\tilde{w})), U_{h'}(x^*_{h'})\} dF(\tilde{w},0) \end{array} \right] \right.$$
$$\left. + \delta \mathrm{E}_{h'|(h,1)} \left[\begin{array}{c} \int \max\{U_{h'}(x^*_{h'}), V_{h'}(\tilde{w},1)\} dF(\tilde{w},1) \\ + \int \max\{U_{h'}(x^*_{h'}), V_{h'}(\tilde{w}, x^*_{h'}(\tilde{w}))\} dF(\tilde{w},0) \end{array} \right] \right\} \tag{42}$$
$$+ \beta(1-\lambda_e)\left\{(1-\delta)\mathrm{E}_{h'|(h,1)} \max\left\{U_{h'}(x^*_{h'}), V^0_{h'}(w, x^*_{h'}(\tilde{w}))\right\} + \delta \mathrm{E}_{h'|(h,1)} U_{h'}(x^*_{h'})\right\},$$

where in both (41) and (42),

$$x^*_{h'}(\tilde{w}) = \arg\max_{x \in \{0,2\}} V_{h'}(\tilde{w}, x). \tag{43}$$

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 $\langle e^x_h, G^x_h(w)\rangle$ for $x \in \{0,1,2\}$ when the two additional terms, e^2_h and $G^2_h(w)$, are now respectively the measure of employed workers with health status h who purchase insurance from the exchange, and the distribution of wages among them.[41]

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.

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

$$n(w,0) = \sum_{h \in \{U,H\}} n_h(w,0) = \sum_{h \in \{U,H\}} \frac{e^0_h g^0_h(w) + e^2_h g^2_h(w)}{f(w,0)},$$

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:

$$\Pi_0(p) = \max_{w_0} \Pi(w_0,0) \equiv (p - w_0)\, n_H(w_0,0) + (pd - w_0)\, n_U(w_0,0) - P_E(n(w,0)), \tag{44}$$
$$\Pi_1(p) = \max_{w_1} \Pi(w_1,1) \equiv ((p - w_1 - m_H)\, n_H(w_1,1) + (pd - w_1 - m_U)\, n_U(w_1,1)) - C \tag{45}$$

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,

$$R^{EX} = (1+\xi) \frac{\sum_{h \in \{H,U\}} m^2_h \left[u^2_h + \int e^2_h(w) g^2_h(w)\, dw\right]}{\sum_{h \in \{H,U\}} \left[u^2_h + \int e^2_h(w) g^2_h(w)\, dw\right]} \tag{46}$$

[41]Details for the derivation of steady state employment distribution used in our counterfactual policy experiments are provided in Online Appendix E.3.

where m_h^2 is expected medical expenditure of 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_h^1 described by (4); u_h^2 is the measure of unemployed workers participating insurance exchange with health status h; and $e_h^2(w)g_h^2(w)$ is the density for 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 E.1.

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 that described in the online appendix A, but there are two important changes. First, 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. Second, because the penalty associated with employer mandate depends on size of the firm, for example, the threshold under the ACA for firms to pay penalty if they do not offer health insurance is 50; as a result we need to modify the algorithm to allow for a potential mass point of employers just to the left of 50 when we derive optimal wage policy $w_0(p)$.[42]

Finally, the establishment of the health insurance exchange with community rating may result in multiple equilibria under some counterfactual policy experiments. In our numerical simulations, we sometimes find multiple equilibria and we will report them.

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 (46) 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 $\xi = 0.25$.[43]

We now 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

[42] The details of the modified numerical algorithm are provided in Online Appendix E.2.

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

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:

$$P_W^{ACA}(y) = \max\{0.025 \times (y - \text{TFT\_2011}), \$695\} \tag{47}$$

where y is annual income.

We adjust the above formula 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.[44] 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:

$$\begin{aligned} P_W(y) &= \max\left\{ \begin{array}{c} 0.025 \times \left(\frac{\text{CPI\_Med\_1996}}{\text{CPI\_All\_1996}}\right) / \left(\frac{\text{CPI\_Med\_2011}}{\text{CPI\_All\_2011}}\right) \times \left(y - \frac{1}{3}\text{TFT\_2011} \times \frac{\text{CPI\_All\_1996}}{\text{CPI\_All\_2011}}\right), \\ \frac{1}{3} \times \$695 \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}} \end{array} \right\} \\ &\approx \max\left\{\frac{0.025}{1.42} \times (y - 2,323),\ \$119\right\}, \end{aligned} \tag{48}$$

where y is four-month income in dollars.

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,

$$P_E^{ACA}(n) = (n - 30) \times \$2,000. \tag{49}$$

We adjust the above formula 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.,

$$\begin{aligned} P_E(n) &= \frac{1}{3}\left[(n-30) \times \$2,000 \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}}\right] \\ &= 342.45\,(n - 30). \end{aligned} \tag{50}$$

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.[45] The premium subsidies are set on a sliding scale such that the premium contributions are limited to a certain percentage of income for specified income levels. If an individual's income is at 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 ACA creates

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

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

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:

$$S\left(y, R^{EX}\right) = \begin{cases} \max\left\{R^{EX} - \left[0.0350 + 0.060\frac{(3y-\text{FPL133})}{\text{FPL400}-\text{FPL133}}\right] y \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}},\ 0\right\} \text{ if } y < \frac{\text{FPL400}}{3} \\ R^{EX} \text{ if unemployed} \\ 0, \text{ otherwise,} \end{cases} \tag{51}$$

when y is four-month income. According to (51) 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 Main Result

In Table 12, we report results from several counterfactual policy experiments and contrast the outcomes under these counterfactual policies with the benchmark.

Benchmark. In Column (1) of Table 12, we report in Panel A predictions related to the firm side using our baseline model using the parameter estimates reported in Tables 7 and 8. It shows that our benchmark model predicts that 55.81% of the *active* firms offer health insurance to their workers, but the health insurance offering rate is 91.13% if the firm size is more than 50 and only 52.00% if it has fewer than 50 workers; moreover, our model predicts that 90.26% of the firms have fewer than 50 workers. We find that 98.72% of the firms are active in the benchmark environment; and the average labor productivity, taking into account the productivity loss from unhealthy workers, is $11,300 per four months.[46]

In Panel B, we report predictions related to worker side. We find that our model predicts that in the benchmark environment, 20.12% of the population would have no health insurance; 3.22% would be unemployed. We also find that the average wage of all workers is about $8,501 per four months, but it is about $8,986 for workers with health insurance from their employers and $6,211 for those without. We find that the fraction of healthy workers in the economy overall is 94.94%, but it is 96% among those insured by ESHI is 96.00% in contrast to 90.17% among those who are uninsured. We find that 61.42% of the employed workers work in firms with 50 or more workers. Finally, we find that the consumption equivalent valuation (CEV) of workers' lifetime welfare is about $6,152 in the benchmark economy.

In Panel C, we report statistics related to expenditures. We find that the tax exemption of ESHI premium leads to a tax expenditure of about $84 *per capita* every four months. We also find that the per capita four-month medical expenditure is about $253; and the average insurance premium *among those insured* by ESHI is about $306 every four months.

Affordable Care Act. In Column (2), we report the simulation results when we introduce the ACA, including insurance exchange (EX), Individual Mandate (IM), Employer Mandate (EM) and Premium Subsidies (Sub), as parameterized in Section 8.2.

The important finding from Column (2) is that, under the ACA, our model predicts that there would be significant reduction in the uninsured rate relative to the benchmark: the uninsured rate under ACA

[46] Recall that in our model, some low-productivity firms would not be able to attract any workers and they are considered *non-active* firms. The set of non-active firms is affected by the counterfactual policies. Thus our model allows for an extensive margin on the firm side.

	Benchmark	ACA	EX+Sub+EM	EX+Sub+IM
	(1)	(2)	(3)	(4)
	Panel A: Effects on the Firm Side			
Frac. of firms offering HI	0.5581	0.5486	0.5494	0.5531
...if firm size is less than 50	0.5200	0.5039	0.5012	0.5111
...if firm size is 50 or more	0.9113	0.9993	0.9988	0.9506
Frac. of firms with less than 50 workers	0.9026	0.9097	0.9031	0.9043
Average labor productivity	1.1300	1.1299	1.1309	1.1349
Firm's profit	0.4717	0.4937	0.4809	0.4765
Frac. of firms in operation	0.9872	0.9872	0.9872	0.9872
	Panel B: Effects on the Worker Side			
Uninsured rate	0.2012	0.0727	0.1218	0.0644
Frac. of emp. workers with HI from ESHI	0.8253	0.8284	0.8259	0.8364
Frac. of emp. workers with HI from EX	-	0.0965	0.0482	0.0971
Average wage	0.8501	0.8449	0.8482	0.8526
... with health insurance	0.8986	0.8934	0.9002	0.9019
... without health insurance	0.6211	0.6132	0.6021	0.6014
Unemployment rate	0.0322	0.0320	0.0322	0.0322
Frac. of healthy workers	0.9494	0.9592	0.9558	0.9598
... among uninsured	0.9017	1.0000	1.0000	1.0000
... among insured through ESHI	0.9600	0.9636	0.9628	0.9636
... among insured through EX	-	0.8890	0.7170	0.8984
Frac. of emp. workers in firms with 50+ workers	0.6142	0.5940	0.6129	0.6096
Average worker utility (CEV)	0.6152	0.6133	0.6164	0.6184
	Panel C: Effects on Expenditures			
Average tax expenditure to ESHI	0.0084	0.0083	0.0083	0.0084
Subsidies to exchange purchases	-	0.0034	0.0038	0.0032
Revenue from penalties	-	0.0010	0.00002	0.0009
Average health expenditure	0.0253	0.0273	0.0272	0.0273
Average premium in ESHI	0.0306	0.0301	0.0302	0.0300
Premium in exchange	-	0.0439	0.0595	0.0427

Table 12: Counterfactual Policy Experiments: Evaluation of the ACA and its Two Variations.

is predicted to be about 7.27% in contrast to 20.12% under the benchmark. While this is certainly a significant reduction in the uninsured rate, it should be noted that it is still far from universal coverage. It is also interesting to note that the 7.27% uninsured population are all healthy and are employed workers who belong to middle income level so that premium subsidies to them are relatively small. They apparently prefers paying the penalty associated with not meeting the individual mandate than purchasing insurance from the exchange.

A major reason for the reduction of uninsured rate under the ACA is that 9.65% of the employed workers purchase insurance from the exchange. This, coupled with the fact that in our counterfactual model all unemployed workers (3.20%) will purchase from the exchange as well because they will receive the insurance for free due to their low income at unemployment, accounts for almost all the reductions in the uninsured rate. Interestingly, we find in Panel A that the ACA would slightly *reduce* the fraction of active firms that offer health insurance from 55.81% to 54.86%. However, we find that, as a result of employer mandate penalty for firms with more than 50 workers, such firms significantly increase the probability that they offer health insurance to their workers from 91.13% in the benchmark to 99.93% under the ACA; in contrast, the probability that firms with less than 50 workers offer health insurance is reduced from 52% in the benchmark to 50.39% under the ACA.

We find that ACA leads to a reduction in average labor productivity and worker wages. This is related to the changes in the size distribution of firms: fewer workers are employed in larger, more productive, firms under the ACA. In Panel B we also report that ACA improves the health of the workers overall: the fraction of healthy workers increases from 94.94% to 95.92%. We find that the fraction of employed workers in firms with 50 or more workers decreases from 61.42% in the benchmark to 59.4% under the ACA. We also find that workers' CEV is $6,133 under the ACA, lower than the benchmark of $6,152.

In Panel C, we report the effect of ACA on expenditure related variables. First, because a smaller fraction of firms offer health insurance under the ACA, and because health insurance premium is not subject to income taxation, the tax expenditure due to ESHI premium exemption is reduced somewhat from $84 per capita in the benchmark to $83 under ACA. The government also incurs on average $34 per capita subsidies to health insurance purchases from the exchange; however, the revenue from penalties from individuals who decide to go without insurance or firms with 50 or more workers which do not offer health insurance is also about $10 per capita. Because of the reduction in the uninsured rate, there is about a 8% increase in the average medical expenditure.

Interestingly, the average four-month premium in ESHI is slightly reduced from $306 in the benchmark to $301 under the ACA; this reduction is partly due to the improved health of the population under the ACA. We also find that the four-month premium in the exchange is about $439, which is significantly higher than the average ESHI premium due to the severe adverse selection problem in the exchange.

ACA without the Individual Mandate. In Column (3), we report simulation results from a hypothetical environment of ACA without the individual mandate, 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 achieved significant reduction in the uninsured rate. In Panel B, we show that the uninsured rate under "EX+Sub+EM" would be about 12.18%, which is 4.91 percentage points higher than under the ACA, but still represent close to 39% reduction from the 20.12% uninsured rate predicted in the benchmark. The reason for the sizeable reduction in the uninsured rate despite the absence of individual mandate is the premium subsides.

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. 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 are healthy. Notice that the fraction of employed workers who purchase health insurance from the exchange is significantly lower in "EX+Sub+EM" (Column 3) than under the full ACA (Column 2): only 4.82% of the employed workers have insurance from the exchange in "EX+Sub+EM" while 9.65% do so under the ACA. This further intensifies the adverse selection problem in the exchange, leading to a substantial increases in the premium in the exchange (from $439 under the ACA to $595 in "EX+Sub+EM"). Interestingly, because of the premium increase, the per capita premium subsidy is $38, higher than the $34 per capita amount under the ACA, despite the decrease in the number of participants in exchange.

Note that the average worker lifetime utility in CEV is $6,164 under ACA without individual mandate, which is higher than that under the full ACA and that under the benchmark.

ACA without Employer Mandate. In Column (4), 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.[47]

We find that, surprisingly, such a system without employer mandate would actually lead to an even lower uninsured rate than the full version of ACA. We find that the uninsured rate under this "EX+Sub+IM" system would be about 6.44%, lower than the 7.27% uninsured rate predicted under the full ACA. Because there is no size-dependent employer mandates, firms do not have to reduce their size to less than 50 in order to avoid paying penalties.[48] Indeed, the fraction of employed workers in firms with 50 or more workers is 60.96% under this "EX+Sub+IM" system, somewhat higher than 59.40% under the ACA.

We also find that more individuals obtain health insurance from insurance exchange. The premium in the exchange decreases from $439 under the full ACA to $427 under this "EX+Sub+IM" system. Furthermore, the workers' average lifetime utility measured by CEV is higher than under the full ACA.

To understand why the employer mandate on large firms might increase the uninsured rate, it is important to recognize that the employer mandate has the following two effects. First, since the mandate increases the health insurance offer rate of large firms, it improves the overall health composition of the population. However, through labor market transitions, the workers hired at large firms may return to unemployment (due to exogenous separation) and subsequently find jobs at small firms that may not offer health insurance. Since these workers are healthier, the health composition of potential entrants in insurance exchange improves, which alleviates the adverse selection problem in the insurance exchange. This externality from employer mandate contributes to an increase of the participants in exchange, lowering uninsured rate.

However, there is a second countervailing effect. The size-dependent employer mandate indeed increases the health insurance offering by large and high-productivity firms. However, small firms' incentive to offer

[47]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.

[48]Indeed, we find a probability mass of firms (2.12%) with size just below the mandate threshold of 50 under the ACA. The probability mass disappears under the "EX+Sub+IM" system.

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, and also lead workers not offered insurance by their employers to forgo purchasing health insurance from the exchange. Both can lead to higher uninsured rate. Therefore, the quantitative impact of the size-dependent employer mandate on overall uninsured rate is nontrivial and can be highly dependent on policy parameters.

Finally, workers' lifetime utility is higher under "EX+Sub+IM" system than under the full ACA for the following reason. Because of the employer mandate in the ACA, large firms not offering health insurance need to pay penalty. One option to finance the penalties is to reduce its wage offer. It then has an equilibrium impact on firms offering health insurance so that they can reduce wage offer to attract workers. Indeed, in Columns (3) and (4) we see that the average wages of workers with and without health insurance are both lower under the ACA than under the "EX+Sub+IM" system. This overall wage decline under the ACA is responsible for the lower worker utility relative to the "EX+Sub+IM" system.

8.4 Assessing the Effects of Components of the ACA

In Table 13, we report the results from several counterfactual experiments that are aimed to understand the effects of several components of the ACA. In Columns (1) and (2), we report two equilibria when we introduce only the insurance exchange to the benchmark economy. In both equilibria, having an exchange alone does little to the uninsured rate in equilibrium: the equilibrium uninsured rate under this counterfactual is only slightly lower relative to the benchmark economy. 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.

In Column (3), we report the results when we introduce health insurance exchange *and* health insurance premium subsidies. It shows that the introduction of premium subsidies and exchange leads to a sizable reduction in the uninsured rate to about 13.20%. The exchange is quite active with all the unemployed and 5.54% 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 offering health insurance to their workers.

In Columns (4) and (5), we report the two equilibria when we introduce health insurance exchange and individual mandate. As in the case of Columns (1) and (2), the exchange will not have any participants. This indicates that the proposed individual mandate alone is not sufficiently large enough to solve adverse selection problem in the insurance exchange. Instead, the individuals mandate leads more employers to offer health insurance. As a result, uninsured rate is 18.06% in Column (4) and 16.90% in Column (5). Because there still exists the sizable fraction of uninsured, introducing individual mandate lowers worker utility relative to an economy with insurance exchange only.

	EX		EX+Sub	EX+IM		EX+EM		EX+IM+EM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Effects on the Firm Side									
Frac. of firms offering HI	0.5591	0.5610	0.5476	0.5683	0.5721	0.5613	0.5618	0.5708	0.5704
...if firm size is less than 50	0.5210	0.5202	0.5105	0.5272	0.5294	0.5139	0.5143	0.5236	0.5233
...if firm size is 50 or more	0.9146	0.9498	0.8919	0.9568	0.9795	0.9996	0.9996	0.9999	0.9999
Frac. of firms with less than 50 workers	0.9031	0.9049	0.9028	0.9044	0.9052	0.9024	0.9021	0.9010	0.9012
Average labor productivity	1.1297	1.1300	1.1323	1.1308	1.1312	1.1279	1.1280	1.1282	1.1283
Firm's profit	0.4702	0.4712	0.4725	0.4717	0.4732	0.4781	0.4783	0.4802	0.4799
Frac. of firms in operation	0.9919	0.9919	0.9872	0.9919	0.9919	0.9919	0.9919	0.9919	0.9919
Panel B: Effects on the Worker Side									
Uninsured rate	0.2002	0.1919	0.1320	0.1806	0.1690	0.1882	0.1867	0.1714	0.1728
Frac. of emp. workers with HI from ESHI	0.8261	0.8347	0.8082	0.8464	0.8583	0.8383	0.8402	0.8559	0.8543
Frac. of emp. workers with HI from EX	0.0000	0.0000	0.0554	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Average wage	0.8495	0.8490	0.8529	0.8490	0.8483	0.8453	0.8453	0.8448	0.8449
... with health insurance	0.8989	0.8983	0.9037	0.8950	0.8930	0.8940	0.8937	0.8885	0.8887
... without health insurance	0.6151	0.6011	0.6391	0.5952	0.5769	0.5943	0.5919	0.5869	0.5898
Unemployment rate	0.0320	0.0320	0.0322	0.0318	0.0318	0.0320	0.0320	0.0318	0.0318
Frac. of healthy workers	0.9495	0.9500	0.9550	0.9509	0.9518	0.9504	0.9505	0.9516	0.9515
... among uninsured	0.9020	0.9022	1.0000	0.9030	0.9037	0.9021	0.9021	0.9030	0.9032
... among insured through ESHI	0.9600	0.9601	0.9628	0.9602	0.9603	0.9602	0.9602	0.9604	0.9603
... among insured through exchange	-	-	0.7280	-	-	-	-	-	-
Frac. of emp. workers in firms with 50+ workers	0.6139	0.6091	0.6136	0.6102	0.6081	0.6160	0.6167	0.6194	0.6188
Average worker utility (CEV)	0.6149	0.6149	0.6188	0.6127	0.6127	0.6127	0.6128	0.6106	0.6106
Panel C: Effects on Expenditures									
Tax expenditure to ESHI	0.0084	0.0085	0.0082	0.0086	0.0087	0.0085	0.0085	0.0087	0.0087
Subsidies to exchange purchases	-	-	0.0042	-	-	-	-	-	-
Tax revenue from penalties	-	-	-	0.0023	0.0021	6.4330E-6	6.9414E-6	0.0021	0.0022
Average health expenditure	0.0253	0.0254	0.0272	0.0255	0.0257	0.0254	0.0254	0.0256	0.0256
Average premium in ESHI	0.0306	0.0306	0.0302	0.0306	0.0305	0.0306	0.0306	0.0305	0.0305
Premium in exchange	0.1156	0.1997	0.0598	0.1156	0.1997	0.0900	0.1997	0.1208	0.1997

Table 13: Counterfactual Policy Experiments: Evaluation of Various Components of the ACA.

In Columns (6) and (7), 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 20.12% in the benchmark to 18.82% in Column (6) and to 18.67% in Column (7), 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.

In Columns (8) and (9), we report the results when we introduce the ACA without that the income-based premium subsidies. Relative to the full ACA results reported in Column 2 of Table 12, the uninsured rate is about twice as large, 17.14% in Column (8) and 17.28% in Column (9). Moreover, worker utility is much lower than the experiments described from Column (1) to Column (7). 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.

8.5 Role of Tax Exemption for ESHI Premium

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 are interested in these counterfactual experiments because, 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.[49]

Columns (1) and (3) of Table 14 report the same simulation results for the benchmark and the ACA as reported in Table 12 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 20.12% to 23.39%. It leads to an increase in average wage for workers, and a deterioration of workers' health.

In Column (4), we remove the tax exemption for ESHI under ACA. We find that removing the tax exemption increase the uninsured rate from 7.27% to 9.15%. These differences are driven by the fact that under the ACA, workers who do not receive health insurance from their employers would have to purchase health insurance from the exchange or pay a penalty. 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 impact is not sufficient to lead to the collapse of the ESHI.

In fact, in Table 14, 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 54.19% 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 55.58% when ESHI premium is exempt from income taxation. Similarly, 52.90% 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 54.86% 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.

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

	Benchmark		ACA	
	Exempt	No Exempt	Exempt	No Exempt
	(1)	(2)	(3)	(4)
	Panel A: Effects on the Firm Side			
Frac. of firms offering HI	0.5581	0.5419	0.5486	0.5290
...if firm size is less than 50	0.5200	0.5053	0.5039	0.4889
...if firm size is 50 or more	0.9113	0.8834	0.9993	0.9837
Frac. of firms with less than 50 workers	0.9026	0.9031	0.9097	0.9188
Average labor productivity	1.1300	1.1287	1.1299	1.1133
Firm's profit	0.4717	0.4692	0.4937	0.4995
Frac. of firms in operation	0.9872	0.9872	0.9872	0.9919
	Panel B: Effects on the Worker Side			
Uninsured rate	0.2012	0.2339	0.0727	0.0915
Frac. of emp. workers with HI from ESHI	0.8253	0.7916	0.8284	0.7871
Frac. of emp. workers with HI from EX	-	-	0.0965	0.1170
Average wage	0.8501	0.8510	0.8449	0.8401
... with health insurance	0.8986	0.9072	0.8934	0.8983
... without health insurance	0.6211	0.6374	0.6132	0.6336
Unemployment rate	0.0322	0.0320	0.0320	0.0353
Frac. of healthy workers	0.9494	0.9470	0.9592	0.9557
... among uninsured	0.9017	0.9007	1.0000	1.0000
... among insured through ESHI	0.9600	0.9597	0.9636	0.9627
... among insured through exchange	-	-	0.8890	0.8798
Frac. of emp. workers in firms with 50+ workers	0.6142	0.6127	0.5940	0.5698
Average worker utility (CEV)	0.6152	0.6077	0.6133	0.6028
	Panel C: Effects on Expenditures			
Tax expenditure to ESHI	0.0084	-	0.0083	-
Subsidies to exchange purchases	-	-	0.0034	0.0044
Tax revenue from penalties	-	-	0.0010	0.0014
Average health expenditure	0.0253	0.0249	0.0273	0.0275
Average premium in ESHI	0.0306	0.0307	0.0301	0.0302
Premium in Exchange	-	-	0.0439	0.0466

Table 14: Counterfactual Policy Experiments: Evaluating the Effects of Eliminating the Tax Exemption for EHI Premium under the Benchmark and the ACA.

8.6 Other Counterfactual Experiments

In this section, we describe the results from several additional counterfactual policy experiments.

8.6.1 The Role of Individual Mandate Penalty

Recall that in Columns (4) and (5) in Table 13 we considered a counterfactual economy where we introduce only insurance exchange and individual mandate to the benchmark economy and we found that the uninsured rate would be 16.90% or 18.82% depending on equilibrium selection. Here we investigate how high the penalties for not having health insurance need to be in order to achieve universal coverage with only exchange and individual mandate. This experiment allows us to understand the impact of the strictness of individual mandate on the uninsured rate. To do so, we modify the formula of individual mandate to:

$$P_W(y) = \max\left\{0.025 \times \left(\frac{\text{CPI\_Med\_1996}}{\text{CPI\_All\_1996}}\right) / \left(\frac{\text{CPI\_Med\_2011}}{\text{CPI\_All\_2011}}\right) \times \left(y - \frac{1}{3}\text{TFT\_2011} \times \frac{\text{CPI\_All\_1996}}{\text{CPI\_All\_2011}}\right),\ P^*\right\}$$

where P^* is the amount of penalty under which the economy achieves universal coverage. Note that in this economy we might encounter multiple equilibria; and in this exercise, we search for the minimum level of P^* that yields a *unique* equilibrium with full coverage.

We find that if P^* is set to

$$\begin{aligned} P^* &= 15 \times \frac{1}{3} \times \$695 \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}} \\ &\approx \$1785, \end{aligned}$$

which is 15 times as large as the proposed penalty in the ACA, the economy achieves the universal coverage.

The main results for this counterfactual economy (IM + EX) with an individual mandate penalty 15 times as large as in the ACA are reported in Column (1) of Table 15. We find a substantial reduction of coverage rate by large firms relative to the benchmark economy; instead, 30.52% of employed workers obtain health insurance from insurance exchange, which is much higher than under the full ACA. While the premium in the exchange is still higher than the average ESHI premium, some firms choose not offer health insurance because the strong presence of the insurance exchange increases the workers' outside option and thus limits the degree in which firms can extract the risk premium from workers' wages by offering health insurance. Moreover, because all individuals are insured, the fraction of healthy workers increases, and as a result the average labor productivity increases. Also, because workers are now all insured and their wages are higher, worker utility increases relative to the benchmark economy.

8.6.2 ACA without the Individual Mandate: How Much Additional Subsidies Are Needed?

One of the major criticisms to the ACA has been the presence of individual mandate. As we demonstrate in Columns (2) and (3) of Table 12, eliminating the individual mandate from the ACA leads to an uninsured rate that is 4.91 percentage points higher than that under the ACA. An interesting question is, how much additional premium subsidies are needed to achieve the uninsured rate similar to under the ACA? To answer the question, we consider that, in addition to the proposed premium subsidies, the government provides a flat subsidy to any employed workers who choose to participate in the insurance exchange.

We find that if the government offers a four-month subsidy of \$135, the uninsured rate decreases to 7.52%, close to that under the full ACA. However, the per capita subsidies to exchange purchases increase from \$38 to \$51, which is higher than the \$34 amount under the ACA. All the results are in Column (2) of Table 15.

				No ESHI	
	EX+ IM[1]	Sub[2]+EX +EM	MA Reform[3]	Sub+EX +IM	Sub+EX +IM[4]
	(1)	(2)	(3)	(4)	(5)
			Panel A: Effects on the Firm Side		
Frac. of firms offering HI	0.5293	0.5286	0.5509	-	-
...if firm size is less than 50	0.5071	0.4779	0.5083	-	-
...if firm size is 50 or more	0.7400	0.9972	0.9529	-	-
Frac. of firms with less than 50 workers	0.9047	0.9025	0.9041	0.5192	0.6958
Average labor productivity	1.1388	1.1212	1.1280	1.2185	1.2169
Firm's profit	0.4689	0.4995	0.4893	3.0564	1.6809
Frac. of firms in operation	0.9919	0.9898	0.9872	0.2065	0.3264
			Panel B: Effects on the Worker Side		
Uninsured rate	0.0000	0.0752	0.0529	0.5896	0.0000
Frac. of emp. workers with HI from ESHI	0.6948	0.8061	0.8470	-	-
Frac. of emp. workers with HI from EX	0.3052	0.1162	0.0983	0.2929	1.0000
Average wage	0.8633	0.8426	0.8449	0.8179	0.8909
... with health insurance	0.9019	0.9006	0.8949	-	-
... without health insurance	0.7755	0.6121	0.5787	-	0.8909
Unemployment rate	0.0318	0.0320	0.0322	0.1662	0.1090
Frac. of healthy workers	0.9644	0.9591	0.9606	0.9229	0.9644
... among uninsured	-	1.0000	1.0000	1.0000	-
... among insured through ESHI	0.9643	0.9636	0.9638	-	-
... among insured through EX	0.9644	0.8994	0.9106	0.7146	0.9643
Frac. of emp. workers in firms with 50+ workers	0.6093	0.6150	0.6103	0.7827	0.7080
Average worker utility (CEV)	0.6175	0.6142	0.6146	0.4866	0.5630
			Panel C: Effects on Expenditures		
Average tax expenditure to ESHI	0.0070	0.0081	0.0085	-	-
Subsidies to exchange purchases	-	0.0051	0.0029	0.0179	0.0057
Revenue from penalties	0.00000	0.00004	0.0011	0.0096	0.00000
Average health expenditure	0.0273	0.0273	0.0273	0.0269	0.0273
Average premium in ESHI	0.0304	0.0300	0.0300	-	-
Premium in exchange	0.0341	0.0429	0.0411	0.0603	0.0342

Table 15: Counterfactual Policy Experiments: Evaluation of Alternative Policy Arrangements.

Notes: (1). Individual mandate penalty in Column (1) is set to be 15 times as large as the $695 specified in the ACA; (2). In Column (2), the individual mandate is eliminated, but besides the income based premium subsidies as specified under the ACA, any employed worker who chooses to purchase health insurance from the exchange receives a $135 flat subsidy; (3). In Column (3) we assume that the individual mandate penalty is the same as that in the ACA; the rest follows the MA reform rules; (4). In Column (5), the individual mandate penalty is assumed to be 2.5% of income, or $1,390, whichever is higher.

8.6.3 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 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).

Individual Mandates. We assume that it is the same as the ACA.[50]

Employer Mandates. 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: for firms with more than 10 workers, the amount of penalty, $P_E^{MA}(n)$, is

$$P_E^{MA}(n) = \frac{1}{3}\left[n \times \$295 \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}}\right].$$

Premium Subsidies to Exchange Participants. As in the ACA, the income based subsidies are available to individuals participating in insurance exchange. However, it is available to individuals whose income is less than 300% FPL (FPL300). Therefore, we parameterize it as:

$$S\left(y, R^{EX}\right) = \begin{cases} \max\left\{R^{EX} - \left[0.0350 + 0.060\frac{(3y-\text{FPL133})}{\text{FPL300}-\text{FPL133}}\right] y \times \frac{\text{CPI\_Med\_1996}}{\text{CPI\_Med\_2011}},\ 0\right\} \text{ if } y < \frac{\text{FPL300}}{3} \\ R^{EX} \text{ if unemployed} \\ 0, \text{ otherwise,} \end{cases} \tag{52}$$

Findings. The main result is Column (3) in Table 15. We find that the uninsured rate is 5.29% under the MA reform, which is lower than the 7.27% under the ACA. Because employer mandate is imposed more uniformly across firms, the positive externalities from the health improvement of workers insured by their firms are larger than under the ACA, which leads to lower premium in the exchange (\$411 under the MA reform vs. \$439 under the ACA), as well as that in the ESHI market. Both contributed to a lower uninsured rate. Worker utility in CEV is \$6,146, again higher than under the ACA. These findings are qualitatively consistent with Kolstad and Kowalski (2012b).

8.6.4 No Employer Sponsored Health Insurance Market

In Columns (4) and (5), we investigate the effects of *eliminating* employer sponsored health insurance market. In Column (4), 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. We find a rather drastic change in the outcomes. Only 20.65% of firms are in operation, compared with 98.72% in the benchmark economy. Unemployment rate also increase to 16.62% from 3.22% in the benchmark economy. Uninsured rate is 58.96%, which is more than twice as large as the one in the benchmark economy. Insurance premium in exchange is \$603, higher than under the full ACA. It thus indicates that if there is no employer sponsored health insurance market, the proposed subsidies

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

and individual mandate are not large enough to solve adverse selection problem in insurance exchange. This result suggests that ESHI allows low productive firms to be active in the market because they can exploit the workers' risk premium.

The next question we investigate is, is it possible to achieve universal coverage when ESHI is eliminated by increasing the individual mandate penalty amount? The results are reported in Column (5). We find that, if we set the penalty of not having insurance to be 2.5% of income, or $1,390 (i.e. twice the amount of penalty in the ACA), it leads to the full coverage. The main outcomes are reported in Column (5) of 15. Relative to Column (4), it achieves much lower unemployment rate and higher worker utility. Labor productivity decreases because less productive firms enter more into the labor market. More interestingly, it also achieves the substantial reduction in premium subsidies. This is due to the reduction of the unemployed who receive the full premium subsidies, and the decrease of premium itself.

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 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 20.12% in the benchmark economy to 7.27%. 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, 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, though the presence of the exchange still leads to a small reduction of the uninsured rate from 20.12% in the benchmark to 17.14-17.28% under "ACA without the subsidies."

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 12.18%, significantly lower than the 20.12% 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 the current version of ACA *without* employer mandate may be more efficient than the one with employer mandate. The latter achieves higher average productivity, higher worker's average utility, higher average wage, and similar government spending.

We also simulate the effects of eliminating the tax exemption for employer-sponsored health insurance (ESHI) premium both under the benchmark and under the ACA. We find that, while the elimination of the tax exemption for ESHI premium would reduce the probability of all firms, especially the larger ones, offering health insurance to their workers, the overall effect on the uninsured rate is rather modest. We find that in the benchmark economy the uninsured rate would increase from 20.12% to 23.39% when the ESHI tax exemption is removed; and it will increase from 7.27% to 9.15% under the ACA.

Finally, we find that prohibiting firms from ESHI would lead to a huge reduction on the fraction of active firms in the labor market. This result suggests that ESHI allows low productive firms to be active in the market because they can exploit the workers' risk premium.

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 individuals with relatively homogeneous skills (men 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 and foremost, 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. Incorporating Medicaid, the free public health insurance for the poor, into a model with endogenous asset accumulation decisions is also an important direction. Finally, 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. We plan to address those issues in our future research.

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Online Appendix

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 (33) and (32).

   (b) By using $F^\iota(w, x)$, numerically solve worker's optimal strategy $\left(\underline{w}_h^x, \underline{s}_h^x(\cdot, \cdot), \underline{q}_h^x\right)$ and calculate U_h and $V_h(w_x^\iota(p), x)$ for $h \in \{U, H\}$, $x \in \{0, 1\}$, and p on on support $[\underline{p}, \overline{p}]$. Moreover, calculate $V_h(w, x)$ for $w \in \mathcal{W}$, where $\mathcal{W}$ is the discrete set of potential wage choices.[2]

   (c) Calculate unemployment u_h^ι and employment distribution $e_h^{x,\iota} G_h^{x,\iota}(w_x^\iota(p))$ for all $p \in \{p_1, ..., p_N\}$ by solving functional fixed point equations (14), (17), (21) and (25);[3]

   (d) Calculate $n_h^\iota(w^\iota(p), x)$ and $n^\iota(w^\iota(p), x)$ for all p by respectively using (26) and (27). 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 (29) and (30);[4]

   (f) Given $(w_0^{*\iota}(p), w_1^{*\iota}(p))$, calculate $\pi_0^{*\iota}(p)$ and $\pi_1^{*\iota}(p)$ from (29) and (30) and obtain $\Delta^{*\iota}(p)$ by using (31).

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.[5]

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

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

[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] The number discrete values of potential wage choices is set to 400 in our empirical application.

[3] 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_h and $e_h^x G_h^x(w(p))$.

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

[5] In solving for the equilibrium we set ϵ_{tol} to 1.0e-6.

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*

$$w_1(p) = \frac{\left(p - m_H^1\right) n_H(w_1(p),1) + \left(pd - m_U^1\right) n_U(w_1(p),1) - \int_{p_1^*}^{p} \left[n_H(w_1(\tilde{p}),1) + dn_U(w_1(\tilde{p}),1)\right] d\tilde{p} - \pi_1(p_1^*)}{n_H(w_1(p),1) + n_U(w_1(p),1)} \quad \text{(A1)}$$

$$w_0(p) = \frac{pn_H(w_0(p),0) + pdn_U(w_0(p),0) - \int_{p_0^*}^{p} \left[n_H(w_0(\tilde{p}),0) + dn_U(w_0(\tilde{p}),0)\right] d\tilde{p} - \pi_0(p_0^*)}{n_H(w_0(p),0) + n_U(w_0(p),0)}. \quad \text{(A2)}$$

where $p_x^* = \inf\{p \in [\underline{p}, \overline{p}] : n_H(w_x(p),x) > 0$ *and* $n_U(w_x(p),x) > 0\}$ *and*

$$\begin{aligned} \pi_1(p_1^*) &= \left[p_1^* - w_1^*(p_1^*) - m_H^1\right] n_H(w_1^t(p_1^*),1) + \left[p_1^* d - w_1(p_1^*) - m_U^1\right] n_U(w_1^t(p_1^*),1) \\ \pi_0(p_0^*) &= \left[p_0^* - w_0(p_0^*)\right] n_H(w_0(p_0^*),0) + \left[p_0^* d - w_0\left(p_0^*\right)\right] n_U(w_0(p_0^*),0). \end{aligned}$$

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

Lemma 2. *For any distribution $F(w,x)$, $w_x(p)$ is increasing in p for each x.*

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

$$\begin{aligned} \pi_x(p) &= \left[(p - w_x(p) - xm_H^x) n_H(w_x(p),x) + (pd - w_x(p) - xm_U^x) n_U(w_x(p),x)\right] - xC \\ &\geq \left[\left(p - w_x(p') - xm_H^x\right) n_H(w_x(p'),x) + \left(pd - w_x(p') - xm_U^x\right) n_U(w_x(p'),x)\right] - xC \\ &\geq \left[\left(p' - w_x(p') - xm_H^x\right) n_H(w_x(p'),x) + \left(p'd - w_x(p') - xm_U^x\right) n_U(w_x(p'),x)\right] - xC \\ &= \pi_x\left(p', k\right) \\ &\geq \left[\left(p' - w_x(p) - xm_H^x\right) n_H(w_x(p),x) + \left(p'd - w_x(p) - xm_U^x\right) n_U(w_x(p),x)\right] - xC, \end{aligned}$$

where the second line comes from the fact that $w_x(p)$ is the optimal wage policy for 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

$$(p - p')\left[n_H(w_x(p),x) + n_U(w_x(p),x)\right] \geq (p - p')\left[n_H(w_x(p'),x) + n_U(w_x(p'),x)\right].$$

Since $n_h(w,x)$ 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. Define p_x^* =inf$\{p \in [\underline{p}, \overline{p}] : n_H(w_x(p),x) > 0$ and $n_U(w_x(p),x) > 0\}$ for $x = 0,1$. From Lemma 2, $w_x(p)$ is increasing in p; also $n_h(w,x)$ is increasing in w; thus we have $n_H(w_x(p),x) > 0$ and $n_U(w_x(p),x) > 0$ for $p > p_x^*$. Define

$$\tilde{\pi}\left(w_x, x\right) \equiv \max_x \left(p - w_x - xm_H^x\right) n_H(w_x,x) + \left(pd - w_x - xm_U^x\right) n_U(w_x,x).$$

Notice that the solution $w_x(p)$ is equal to the one defined in (29) and (30) and be independent of C. By applying envelope condition, we have

$$\tilde{\pi}_x'(p) = n_H(w_x(p),x) + dn_U(w_x(p),x)$$

for $p > p_x^*$. By taking integral over $[p_x^*, p]$, we then obtain

$$\tilde{\pi}_x(p) = \int_{p_x^*}^{p} n\left[{}_H(w_x(\tilde{p}),x) + dn_U(w_x(\tilde{p}),x)\right] d\tilde{p} + \tilde{\pi}_x(p_x^*).$$

By equating it with (29) and (30), we obtain (A1) and (A2). This is a form of wage policy which we utilize in our numerical algorithm. □

B Omitted Formula in Section 6.1

In this appendix, we provide the formula omitted in Section 6.1:

$$\begin{aligned}
\Pr(h_{t+3} &= U|x_t, x_{t+1}, x_{t+2}, h_t = H) = \pi_{HH}^{x_t}\pi_{HH}^{x_{t+1}}(1-\pi_{HH}^{x_{t+2}}) + \pi_{HH}^{x_t}(1-\pi_{HH}^{x_{t+1}})\pi_{UU}^{x_{t+2}} \\
&+(1-\pi_{HH}^{x_t})(1-\pi_{UU}^{x_{t+1}})(1-\pi_{HH}^{x_{t+2}}) + (1-\pi_{HH}^{x_t})\pi_{UU}^{x_{t+1}}\pi_{UU}^{x_{t+2}}; \\
\Pr(h_{t+3} &= H|x_t, x_{t+1}, x_{t+2}, h_t = U) = (1-\pi_{UU}^{x_t})\pi_{HH}^{x_{t+1}}\pi_{HH}^{x_{t+2}} + (1-\pi_{UU}^{x_t})(1-\pi_{HH}^{x_{t+1}})(1-\pi_{UU}^{x_{t+2}}) \\
&+\pi_{UU}^{x_t}(1-\pi_{UU}^{x_{t+1}})\pi_{HH}^{x_{t+2}} + \pi_{UU}^{x_t}\pi_{UU}^{x_{t+1}}(1-\pi_{UU}^{x_{t+2}}); \\
\Pr(h_{t+3} &= U|x_t, x_{t+1}, x_{t+2}, h_t = U) = (1-\pi_{UU}^{x_t})\pi_{HH}^{x_{t+1}}(1-\pi_{HH}^{x_{t+2}}) + (1-\pi_{UU}^{x_t})(1-\pi_{HH}^{x_{t+1}})\pi_{UU}^{x_{t+2}} \\
&+\pi_{UU}^{x_t}(1-\pi_{UU}^{x_{t+1}})(1-\pi_{HH}^{x_{t+2}}) + \pi_{UU}^{x_t}\pi_{UU}^{x_{t+1}}\pi_{UU}^{x_{t+2}}.
\end{aligned}$$

C Derivation of Likelihood Function

We will first derive the likelihood contribution of the labor market transitions of *unemployed workers.* Consider 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 $(\tilde{w}, x)$. Moreover, denote $h^l \equiv (h_1, h_2, ..., h_l)$ be the realized history of health status between $j = 1$ to l. In our data scenario, we assume that the initial h_1 but we do not observe $h_2, ..., h_l$. The likelihood contribution of observing such a transition is:

$$\frac{u_{h_1}}{M} \times \sum_{h^l \in \{H,L\}^l} \Pr(s_u(h^l)) \times \sum_{h_{l+1} \in \{H,L\}} \Pr(h_{l+1}|h_l) \times [\lambda_u f(\tilde{w}, 1)]^{\mathbf{1}(x=1)} \times [\lambda_u f(\tilde{w}, 0)]^{\mathbf{1}(x=0)} \tag{C3}$$

where

$$\Pr(s(h^l)) = \Pi_{j=2}^{l} \left\{ \Pr(h_j|h_{j-1}) \times \left[(1-\lambda_u) + \lambda_u \left(F\left(\underline{w}_{h_j}^1, 1\right) + F\left(\underline{w}_{h_j}^0, 0\right) \right) \right] \right\}$$

and $\mathbf{1}(x = 1)$ is an indicator function such that it takes one if we observe a transition to employment with $(\tilde{w}, 1)$ at period $l+1$, and similarly $\mathbf{1}(x = 0)$ is an indicator function such that it takes one if we observe a transition to employment with $(\tilde{w}, 0)$ at period $l+1$. To understand (C3), note that the first term in (C3), u_h/M, reflects the assumption that the initial condition of individuals is drawn from steady state worker distribution because u_h/M the probability that an unemployed worker with health status h is sampled. The second term in (C3) 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 $\left[(1-\lambda_u) + \lambda_u(F(\underline{w}_{h_j}^1, 1) + F(\underline{w}_{h_j}^0, 0)\right]$ is the probability that the individual does not receive an offer or receives an offer that is lower than the relevant reservation wages $\underline{w}_{h_j}^1$ or $\underline{w}_{h_j}^0$. The third to fifth terms in (C3) are the probability that his health transitions from h_l to h_{l+1} in period $l+1$ and receive an acceptable offer $(\tilde{w}, x)$ from the relevant density function $f(\tilde{w}, x)$.

We can similarly derive the likelihood contribution of the job dynamics of *employed workers.* Consider an employed 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 $l+1$, and denote h^l be the realized history of health status between $j = 1$ to l $(h_1, h_2, ..., h_l)$. We again assume that we observe h_1 but do not for $h_2 \ldots, h_l$. For an employed worker, there are four possible changes in job status:

- [Event *"Job Loss"*] the individual experienced a job loss at period $l+1$;
- [Event *"Switch 1"*] the individual transitioned to a job $(\tilde{w}, x')$ such that $x' = x$ and the accepted wage is $\tilde{w} > w$;

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

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

The likelihood contribution is given by:

$$\frac{e_h^x g_h^x(w)}{M} \times \sum_{h^l \in \{H,L\}^l} \Pr(s_e(h^l)) \tag{C4a}$$

$$\times \sum_{h_{l+1} \in \{H,L\}} \Pr(h_{l+1}|h_l) \times \begin{cases} \delta \left[(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}_{h_{l+1}}^{\tilde{x}}, \tilde{x})\right] & \text{if Event is "Job Loss"} \\ \lambda_e f(\tilde{w}, x) & \text{if Event is "Switch 1"} \\ \delta\lambda_e f(\tilde{w}, x) & \text{if Event is "Switch 2"} \\ (1-\delta)\lambda_e f(\tilde{w}, x') + \delta\lambda_e f(\tilde{w}, x') & \text{if Event is "Switch 3",} \end{cases} \tag{C4b}$$

where

$$\Pr(s_e(h^l)) = \Pi_{j=2}^{l} \left\{ \Pr(h_{j+1}|h_{j-1})(1-\delta) \left[(1-\lambda_e) + \lambda_e \left(F(w,x) + F\left(\underline{s}_{h_j}^{x'}(w,x), x'\right)\right)\right]\right\}$$

and $x' \neq x$. To understand (C4a), note that similar to that in (36a), the first term in (C4a), $e_h^x g_h^x(w)/M$, is the probability of sampling an employed worker with health status h working on a job (w, x); the second term in (C4a) is the probability that individual stays with the job (w, x) for l periods of unemployment with health status transitions $(h_2, ..., h_l)$ during the process. The remaining two terms in (C4b) express the likelihood of observing health transition from h_l to h_{l+1} in period $l+1$ and one of the four job status change events. For example, the event "Job Loss" is observed in period $l+1$ with probability $\delta \left[(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}_{h_{l+1}}^{\tilde{x}}, \tilde{x})\right]$ because in order for a job loss to occur, the worker has to experience an exogenous shock that destroys the current match (which occurs with probability δ), and then does not get matched to another accepted job (which occurs with probability $(1-\lambda_e) + \lambda_e \sum_{\tilde{x}} F(\underline{w}_{h_{l+1}}^{\tilde{x}}, \tilde{x})$). To understand the probability of event "Switch 2", we note that in order for a worker to switch to a job $(\tilde{w}, x')$ with $x' = x$ but $\tilde{w} < w$, the worker must have experienced a job separation (which occurs with probability δ), but is then lucky enough to find an acceptable job immediately, which happens with probability $\lambda_e f(\tilde{w}, x)$. The probability of the other job switch events are derived similarly.

D 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 (36) and (37), and obtain the numerical derivative of likelihood with respect to parameters $\theta_1 \equiv (\lambda_u, \lambda_e, \delta, \gamma, \mu_h, b)$ and use them as a subset of the moments in (34);[6]

[6]Note from (36) and (37), the likelihood function of the worker labor market transitions depends only on θ_1, given $F(w, x)$.

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 (35) and iterate until it converges.

E Equilibrium of the Counterfactual Economy

E.1 Steady State Equilibrium for the Post-Reform Economy

A *steady state equilibrium for the post-reform economy* is a list $\left\langle \left(\underline{w}_h^x, \underline{s}_h^x(\cdot,\cdot), \underline{q}_h^x, x_h^*, x_h^*(\cdot)\right), \left(u_h^x, e_h^x, G_h^x(w)\right), \left(w_x(p), \Delta(p), F(w,x)\right), R^{EX} \right\rangle$ such that the following conditions hold:

- **(Worker Optimization)** Given $F(w,x)$ and R^{EX},
  - $\underline{w}_h^x$ solves the unemployed workers' job acceptance decision problem for each $(h,x) \in \{U,H\} \times \{0,1\}$;
  - $\underline{s}_h^x(\cdot,\cdot)$ solves the job-to-job switching problem for currently employed workers for each $(h,x) \in \{U,H\} \times \{0,1\}$
  - $\underline{q}_h^x$ describes the optimal strategy for currently employed workers regarding whether to quit into unemployment for each $(h,x) \in \{U,H\} \times \{0,1\}$;
  - x_h^* and $x_h^*(\cdot)$ respectively solve (40) and (43) for $h \in \{H,U\}$.

- **(Steady State Worker Distribution)** Given workers' optimizing behavior described by $\left(\underline{w}_h^x, \underline{s}_h^x(\cdot,\cdot), \underline{q}_h^x, x_h^*, x_h^*(\cdot)\right)$ and $F(w,x)$ and R^{EX}, $\left(u_h^x, e_h^x, G_h^x(w)\right)$ satisfy the steady state conditions for worker distribution (details are provided in Section E.3).

- **(Firm Optimization)** Given $F(w,x)$, R^{EX} and the steady state employee sizes implied by $\left(u_h^x, e_h^x, G_h^x(w)\right)$, 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 (31). Moreover, conditional on insurance choice x, the firm offers a wage $w_x(p)$ that solves (44) and (45) 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 (46).

E.2 Numerical Algorithm for the Counterfactual Policy Experiments

We use numerical methods to solve the equilibrium. The basic iteration procedure to solve the equilibrium for the counterfactual environment remains the same as that described in Section A, but there are two important changes. First, 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. Second, because the penalty associated with employer mandate depends on size of the firm, for example, the threshold under the ACA for firms to pay penalty if they do not offer health insurance is 50; as a result we need to modify the algorithm to allow for a potential mass point of employer size just to the left of 50 (say, 49 workers) when we derive optimal wage policy $w_0(p)$.

Finally, the establishment of the health insurance exchange with community rating may result in multiple equilibria under some counterfactual policy experiments. In our numerical simulations, we sometimes find multiple equilibria and we will discuss their implication.

Because of the size dependent employer mandate, there may exist a mass point of wage offer w_{49} under which firm size is equal to 49 if $x = 0$:

$$n_H(w_{49}, 0) + n_U(w_{49}, 0) = 49.$$

Note that w_{49} is endogenously determined in equilibrium. We now provide our numerical algorithm:

1. Guess $(w_0(p), w_1(p), \Delta(p))$ for $p = p_1, \ldots, p_N$ and R^{EX}.

2. Solve value function and employment distribution as before. Notice that there may exist an interval of productivity $[p^*, p^{**}]$ such that there is a mass point of wage offer $w_{49} = w_0(p) = w_0(p')$, for $p, p' \in [p^*, p^{**}]$.

3. Once we solve employment distribution, find w_{49} by linear interpolation of firm size distribution.

4. Update $w_1(p)$ as in the benchmark case. $w_0(p)$ is updated in the following way:

   (a) From p_1, solve $w_0(p)$ by maximizing $(p-w)(n_H(w,0)+n_U(w,0))$. If $n_H(w,0) > 0$ and $n_U(w,0) > 0$, then solve it by using the equation implied from the envelope condition, as before. Repeat this for $p_2, p_3 \ldots$ as long as $w_0(p) < w_{49}$.

   (b) If we find p^* such that $w(p^*) > w_{49}$ where $w(p^*) = \arg\max(p^* - w)(n_H(w, 0) + n_U(w, 0))$, then from p^*, solve firm's problem by
   $$\max \{\Pi_{49}(p), \Pi_{pe}(p)\}$$
   where
   $$\begin{aligned} \Pi_{49}(p) &= (p - w_{49})(n_H(w_{49}, 0) + n_U(w_{49}, 0)); \\ \Pi_{pe}(p) &= \max_w (p - w)(n_H(w, 0) + n_U(w, 0)) - P_E\left(n_H(w, 0) + n_U(w_0, 0)\right). \end{aligned}$$

   (c) If we find p^{**} such that $\Pi_{49}(p^{**}) < \pi_{pe}(p^{**})$, then for the remaining $p > p^{**}$, evaluate $w_0(p)$ by
   $$\begin{aligned} w_0(p) &= \frac{p n_H(w_0(p), 0) + p d n_U(w_0(p), 0) - \int_{p^{**}}^{p} \left[n_H(w_0(\tilde{p}), 0) + d n_U(w_0(\tilde{p}), 0)\right] d\tilde{p} - \pi_0(p^{**})}{n_H(w_0(p), 0) + n_U(w_0(p), 0)} \\ &\quad - P_E(n_H(w_0(p), 0) + n_U(w_0(p), 0)), \end{aligned}$$
   the derivation of which basically follows Proposition 1 in benchmark case but reflects the existence of employer mandate.

5. Update R^{EX} using (46). Continue it until it converges.

In Step 4 (c) we utilize the following lemma.

Lemma 3. *Suppose that there exists a p^{**} such that $\Pi_{49}(p^{**}) < \Pi_{pe}(p^{**})$. Then, for any $p > p^{**}$, $\Pi_{49}(p) < \Pi_{pe}(p)$.*

Proof. Proof is by contradiction. Suppose that there exists $p' > p^{**}$ such that $\Pi_{49}(p') \geq \Pi_{pe}(p')$. Then, notice that

$$\Pi_{49}(p') \geq \Pi_{pe}(p') \geq \Pi_{pe}(p^{**}) > \Pi_{49}(p^{**})$$

where the second inequality is from the revealed preference argument. Therefore, we must have:

$$\Pi_{49}(p') - \Pi_{49}(p^{**}) > \Pi_{pe}(p') - \Pi_{pe}(p^{**}). \tag{E5}$$

The left hand side of (E5) is:

$$\Pi_{49}(p') - \Pi_{49}(p^{**}) = (p - p^{**})\left(n_H(w_{49}, 0) + n_U(w_{49}, 0)\right).$$

The right hand side of (E5) is:

$$\begin{aligned}
& \Pi_{pe}(p') - \Pi_{pe}(p^{**}) \\
= \; & \left\{\left(p' - w(p')\right)\left[n_H(w(p'), 0) + n_U(w(p'), 0)\right] - P_E(n(w(p')))\right\} \\
& - \left\{(p^{**} - w(p^{**}))\left[n_H(w(p^{**}), 0) + n_U(w(p^{**}), 0)\right] - P_E(n(w(p^{**})))\right\} \\
\geq \; & (p' - w(p^{**}))\left[n_H(w(p^{**}), 0) + n_U(w(p^{**}), 0)\right] - P_E(n(w(p^{**}))) \\
& - \left\{(p^{**} - w(p^{**}))\left[n_H(w(p^{**}), 0) + n_U(w(p^{**}), 0)\right] - P_E(n(w(p^{**})))\right\} \\
= \; & (p - p^{**})\left[n_H(w(p^{**}), 0) + n_U(w(p^{**}), 0)\right].
\end{aligned}$$

Since $w(p^{**}) > w_{49}$, we must have $\Pi_{pe}(p') - \Pi_{pe}(p^{**}) > \Pi_{49}(p') - \Pi_{49}(p^{**})$. A contradiction. □

E.3 Steady State Distribution of Employment in Counterfactual Experiments

We provide a derivation of steady state employment distribution used in our counterfactual policy experiments. Note that worker's insurance status can be $x \in \{0, 2\}$ for the unemployed and $x \in \{0, 1, 2\}$ for the employed, because of the insurance exchange.

First, we define the resource constraints of the economy:

$$\sum_{h \in \{U, H\}} (u_h^0 + u_h^2 + e_h^0 + e_h^1 + e_h^2) = M. \tag{E6}$$

Next, we provide the determination of the unemployment. The inflow into unemployment with health status h and insurance status x is given by: if $x = x_h^*$,

$$\begin{aligned}
[u_h^x]^+ \;\equiv\; & (1-\rho)\left[\delta(1-\lambda_e) + \delta\lambda_e(F(\underline{w}_h^1, 1) + F(\underline{w}_h^0, 0)\right]\left[e_h^0\pi_{hh}^0 + e_h^1\pi_{hh}^1 + e_{h'}^0\pi_{hh'}^0 + e_{h'}^1\pi_{hh'}^1 + e_h^2\pi_{hh}^2 + e_{h'}^2\pi_{hh'}^2\right] \\
& + (1-\rho)\sum_{x=0,2} u_{h'}^x \pi_{hh'}^x [1 - \lambda_u\left(1 - F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0)\right)] + M\rho\mu_h \\
& + (1-\rho)(1-\delta)e_{h'}^1 G_{h'}^1(\underline{w}_h^1)\pi_{hh'}^1\left[1 - \lambda_e\left(1 - F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0)\right)\right] \\
& + (1-\rho)(1-\delta)\left(e_{h'}^0 G_{h'}^0(\underline{w}_h^0)\pi_{hh'}^0 + e_{h'}^2 G_{h'}^2(\underline{w}_h^0)\pi_{hh'}^2\right)\left[1 - \lambda_e\left(1 - F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0)\right)\right];
\end{aligned}$$

otherwise, $[u_h^x]^+ = 0$.

The outflow from unemployment with health status h and insurance status x is described as follows. If $x = x_h^*$ where x_h^* is defined in (40),

$$[u_h^x]^- \equiv u_h^x \left\{\rho + (1-\rho)\left[\pi_{h'h}^x + \pi_{hh}^x \lambda_u \left(1 - F(\underline{w}_h^1, 1) - F(\underline{w}_h^0, 0)\right)\right]\right\};$$

otherwise, $[u_h^x]^- = 0$. Then, in a steady-state we must have

$$[u_h^x]^+ = [u_h^x]^-, h \in \{U, H\}.$$

Now we provide the steady state equation for workers employed on jobs (w, x) with health status h. Note that the inflow of workers with health status h on jobs $(w, 1)$, denoted by $\left[e_h^1(w)\right]^+$, is given by:

$$\begin{aligned}\left[e_h^1(w)\right]^+ \equiv\ & (1-\rho) f(w,1) \left\{ \begin{array}{c} \lambda_u \left(u_h^0 \pi_{hh}^0 + u_{h'}^0 \pi_{hh'}^0 + u_h^2 \pi_{hh}^2 + u_{h'}^2 \pi_{hh'}^2\right) \\ +(1-\delta)\lambda_e \left[\begin{array}{c} \sum_{x'=0,2} e_h^{x'} G_h^{x'}\left(s_h^0(w,1)\right) \pi_{hh}^{x'} + \sum_{x'=0,2} e_{h'}^{x'} G_h^{x'}\left(s_{h'}^0(w,1)\right) \pi_{hh'}^{x'} \\ +\pi_{hh}^1 e_h^1 G_h^1(w) + \pi_{hh'}^1 e_{h'}^1 G_{h'}^1(w) \end{array} \right] \\ +\delta\lambda_e \left(e_h^0 \pi_{hh}^0 + e_{h'}^0 \pi_{hh'}^0 + e_h^1 \pi_{hh}^1 + e_{h'}^1 \pi_{hh'}^1 + e_h^2 \pi_{hh}^2 + e_{h'}^2 \pi_{hh'}^2\right) \end{array} \right\} \\ & +(1-\rho)(1-\delta) e_{h'}^1 g_{h'}^1(w) \pi_{hh'}^1 \left[1 - \lambda_e \left(1 - \tilde{F}_h(w,1)\right)\right],\end{aligned}$$

where $h' \neq h$ and $\tilde{F}_h(w, 1)$ is defined by

$$\tilde{F}_h(w,1) = F(w,1) + F\left(s_h^0(w,1), 0\right).$$

Denote the outflow of workers with health status h from jobs $(w, 1)$ by $\left[e_h^1(w)\right]^-$, and it is given by

$$\left[e_h^1(w)\right]^- \equiv e_h^1 g_h^1(w) \left\{\rho + (1-\rho)\left[\pi_{h'h}^1 + \pi_{hh}^1 \left(\delta + \lambda_e(1-\delta)\left(1 - \tilde{F}_h(w,1)\right)\right)\right]\right\}. \tag{E7}$$

The steady state condition requires that

$$\left[e_h^1(w)\right]^+ = \left[e_h^1(w)\right]^- \text{ for } h \in \{U, H\} \text{ and for all } w \text{ in the support of } F(w,1). \tag{E8}$$

Similarly, the inflows of workers with health status h into jobs $(w, 0)$, denoted by $\left[e_h^0(w)\right]^+$, are given as follows. If $x_h^*(w) = 0$, where $x_h^*(w)$ is defined in (43),

$$\begin{aligned}\left[e_h^0(w)\right]^+ =\ & f(w,0)(1-\rho) \left\{ \begin{array}{c} \lambda_u \left[u_h \pi_{hh}^0 + u_{h'} \pi_{hh'}^0 + u_h^2 \pi_{hh}^2 + u_{h'}^2 \pi_{hh'}^2\right] \\ +\lambda_e(1-\delta) \left[\begin{array}{c} e_h^1 G_h^1\left(\underline{s}_h^1(w,0)\right) \pi_{hh}^1 + e_{h'}^1 G_{h'}^1(\underline{s}_{h'}^1(w,0)) \pi_{hh'}^1 \\ e_h^0 G_h^0(w) \pi_{hh}^0 + e_{h'}^0 G_{h'}^0(w) \pi_{hh'}^0 \\ +e_h^2 G_h^2(w) \pi_{hh}^2 + e_{h'}^2 G_{h'}^2(w) \pi_{hh'}^2 \end{array} \right] \\ +\delta\lambda_e \left(e_h^1 \pi_{hh}^1 + e_{h'}^1 \pi_{hh'}^1 + e_h^0 \pi_{hh}^0 + e_{h'}^0 \pi_{hh'}^0 + e_h^2 \pi_{hh}^2 + e_{h'}^2 \pi_{hh'}^2\right) \end{array} \right\} \\ & +(1-\rho)(1-\delta) \sum_{x=0,2} e_{h'}^x g_{h'}^x(w) \pi_{hh'}^x \left[1 - \lambda_e \left(1 - \tilde{F}_h(w,0)\right)\right],\end{aligned}$$

where $h \neq h'$ and $\tilde{F}_h(w, 0)$ is defined by

$$\tilde{F}_h(w,0) = F(w,0) + F(\underline{s}_h^1(w,0), 1);$$

and $\left[e_h^0(w)\right]^+ = 0$ otherwise. The outflows of workers with health status h from jobs $(w, 0)$, denoted by $\left[e_h^0(w)\right]^-$, are given by:

$$\left[e_h^0(w)\right]^- = e_h^0 g_h^0(w) \left\{\rho + (1-\rho)\left[\pi_{h'h}^0 + \pi_{hh}^0(\delta + (1-\delta)\lambda_e(1 - \tilde{F}_h(w,0))\right]\right\}.$$

The steady state condition thus requires that

$$\left[e_h^0\left(w\right)\right]^+ = \left[e_h^0\left(w\right)\right]^- \text{ for } h \in \{H, U\} \text{ and for all } w \text{ in the support of } F\left(w, 0\right).$$

Similarly, the inflows of workers with health status h into jobs $(w, 2)$ with health insurance through exchange, denoted by $\left[e_h^2\left(w\right)\right]^+$, are given as follows. If $x_h^*(w) = 2$, where $x_h^*(w)$ is defined in (43),

$$\begin{aligned} \left[e_h^2\left(w\right)\right]^+ &= f(w,0)(1-\rho)\left\{\begin{array}{c} \lambda_u\left[u_h\pi_{hh}^0 + u_{h'}\pi_{hh'}^0 + u_h^2\pi_{hh}^2 + u_{h'}^2\pi_{hh'}^2\right] \\ +\lambda_e(1-\delta)\left[\begin{array}{c} e_h^1 G_h^1\left(\underline{s}_h^1(w,0)\right)\pi_{hh}^1 + e_{h'}^1 G_{h'}^1(\underline{s}_{h'}^1(w,0))\pi_{hh'}^1 \\ e_h^0 G_h^0(w)\pi_{hh}^0 + e_{h'}^0 G_{h'}^0(w)\pi_{hh'}^0 \\ +e_h^2 G_h^2(w)\pi_{hh}^2 + e_{h'}^2 G_{h'}^2(w)\pi_{hh'}^2 \end{array}\right] \\ +\delta\lambda_e\left(e_h^1\pi_{hh}^1 + e_{h'}^1\pi_{hh'}^1 + e_h^0\pi_{hh}^0 + e_{h'}^0\pi_{hh'}^0 + e_h^2\pi_{hh}^2 + e_{h'}^2\pi_{hh'}^2\right) \end{array}\right\} \\ &\quad +(1-\rho)(1-\delta)\sum_{x=0,2} e_{h'}^x g_{h'}^x(w)\pi_{hh'}^2\left[1-\lambda_e\left(1-\tilde{F}_h(w,0)\right)\right], \end{aligned}$$

where $h \neq h'$ and $\tilde{F}_h(w,0)$ is defined by

$$\tilde{F}_h(w,0) = F(w,0) + F(\underline{s}_h^1(w,0),1);$$

and $\left[e_h^2\left(w\right)\right]^+ = 0$ otherwise. The outflows of workers with health status h from jobs $(w, 0)$, denoted by $\left[e_h^0\left(w\right)\right]^-$, are given by:

$$\left[e_h^2\left(w\right)\right]^- = e_h^2 g_h^2(w)\left\{\rho + (1-\rho)\left[\pi_{h'h}^2 + \pi_{hh}^2(\delta + (1-\delta)\lambda_e(1-\tilde{F}_h(w,0))\right]\right\}.$$

The steady state condition thus requires that

$$\left[e_h^2\left(w\right)\right]^+ = \left[e_h^2\left(w\right)\right]^- \text{ for } h \in \{H, U\} \text{ and for all } w \text{ in the support of } F\left(w, 0\right).$$

These steady state conditions pin down the distribution of employment and are used to calculate firm size distribution as in the benchmark case.