Labor Market Sorting and Health Insurance System Design*

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Abstract

This paper develops and estimates a life-cycle equilibrium labor search model in which heterogeneous firms determine health insurance provisions and heterogeneous workers sort themselves into jobs with different compensation packages over the life cycle. I study the optimal joint design of major policies in the Affordable Care Act (ACA) and the implications of targeting these policies to certain individuals. Compared with the health insurance system under the ACA, the optimal structure lowers the tax benefit of employer-sponsored health insurance and makes individual insurance more attractive to younger workers. Through changes in firms' insurance provisions, a greater number of younger workers sort into individual markets, which contributes to improving the risk pool in individual insurance and lowering the uninsured risk.

Key Words: Life-cycle Equilibrium Labor Search; Social Insurance; Joint Design of Policies

JEL Codes: J32, J60, H51, I13

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1 Introduction

Employer-sponsored health insurance (ESHI) has been the major source of health insurance coverage for the working-age population in the United States.[1] ESHI is offered as part of compensation by employers and covers two-thirds of the non-elderly.[2] As a result, an individual's coverage status is largely determined by labor supply (e.g., whether individuals work at a job offering ESHI) and labor demand (e.g., whether firms offer ESHI) decisions. This makes the labor market a key ingredient in evaluating the U.S. health insurance system.

The Patient Protection and Affordable Care Act of 2010 (ACA) and recent alternative reform proposals are designed to change access to health insurance coverage. These reforms have at least two important features. First, they consist of multiple policy instruments that directly intervene in the provisions of ESHI and other health insurance. For example, the ACA introduced both individual and employer mandates (penalties); it established regulated and subsidized individual insurance markets called health insurance exchanges (HIX); it expanded public insurance (Medicaid); and it will alter the tax treatment of ESHI.[3] Most recent reform proposals, such as the American Health Care Act, consider alternative mixtures of these policies compared with the ACA.[4] Second, these reforms are designed to target certain populations, by allowing that subsidies in HIX and individual mandate penalties may depend on income and age and by regulating premiums in HIX to vary only by age to a certain degree.[5]

These features of health insurance reforms raise two important questions about designing a social insurance system. First, how should the government choose a combination of these policy instruments? The economic rationale behind each policy instrument, which is used in a typical social insurance policy, is widely studied. However, very little is known about how to *jointly* design those policies. For example, how should subsidies in individual markets and individual mandates be jointly chosen? Do they have different impacts? What are the implications of changing the tax treatment of ESHI for individual market regulations? This knowledge will be central to the current debates that call for alternative mixtures of these policies. Second, how should these policies vary by individual characteristics (tagging)? Does the benefit of tagging arise by changing the insurance status of targeted groups, or does it also arise by changing the sorting patterns in health insurance or labor markets?

To address these questions in the context of the U.S. health insurance system, it is necessary to understand how firms' ESHI provision and workers' health insurance choices respond to these policies and how these decisions differ across both individuals and firms. Importantly, these decisions

[1]Based on the author's calculation from the American Community Survey, the fraction of working-age populations with ESHI was about 62% in 2012. 24% of working-age populations were uninsured. 8% of them were insured through Medicaid. Finally, only 6% of them owned privately purchased individual insurance.

[2]The value of ESHI premiums is 10% of overall compensation (Kaiser Family Foundation et al. (2009)).

[3]The ACA will introduce the Cadillac tax in 2022, which imposes a limit on the existing tax advantage of ESHI.

[4]The American Health Care Act proposed abolishing mandate requirements and altering subsidy structures.

[5]The ACA provides larger subsidies for low-income individuals and imposes larger penalties on high-income uninsured. The American Health Care Act, in contrasts, proposes age-dependent subsidies that are larger for older individuals.

are related to labor market equilibrium. For example, firms' ESHI provision is determined jointly by the composition of their employees, which are affected by sorting in the labor market. Given the dynamic nature of the labor market, how workers sort between jobs with and without ESHI and across employment status over the life cycle also determines the welfare impact of age- and income-dependent regulations for individual insurance. Moreover, it is important to understand whether there exist frictions, such as labor search frictions and selection in health insurance markets, which distort the sorting process from the socially optimal outcome. Although the coexistence of employer-based and private-individual insurance markets is common in many insurance products (e.g., disability insurance and pension and annuity), little is known about the optimal social insurance program designs in such environments. The goal of this paper is to derive insights on the optimal structure of the health insurance system by focusing on the efficiency of the sorting process in labor and health insurance markets.

In the first part of this paper, I develop a life-cycle equilibrium labor search model that incorporates the major features of the pre- and post-ACA health insurance system. The model builds on the standard and well-tested labor search model (Burdett and Mortensen (1998), Bontemps et al. (1999, 2000)), but its novel feature is that it jointly incorporates the following three ingredients. First, it incorporates individuals' life-cycle decision problems of labor supply, job mobility, private individual insurance take-up, and health care utilization, and characterizes rich individual heterogeneity, including age, health status, labor market skills, risk preference, and education. Second, the model considers heterogeneous productivity firms which determine both wage and ESHI offerings to maximize their profits. The ESHI offering decisions are made to take into account the impact on the composition of workers with different characteristics within the firm. Third, the model incorporates key features of the U.S. health insurance system, such as a tax exemption for the cost of ESHI premiums, implicit insurance through uncompensated care, and medical underwriting under the pre-ACA individual market. It also features the major ACA policies: individual and employer mandates (tax penalties on the uninsured and on large firms not offering ESHI); HIX as a competitive individual market where medical underwriting is prohibited; an age-adjusted community rating that requires that premiums can vary only by age and that sets the maximum premium ratio between the oldest and the youngest at 3; income-dependent subsidies in HIX; and public insurance expansion. By including these three ingredients, the model accounts for how the life-cycle decision processes of individuals determine the labor market sorting between workers and firms and the sorting of workers between employer-based and private-individual insurance markets. This *dynamic* sorting problem substantially differs from the one considered in the health insurance literature, which considers a *static* individual choice for an insurance plan in the same insurance market. This dynamic feature allows us to assess the lifetime welfare impacts of age- and income-dependent policies for individual insurance by accounting for the life-cycle evolution of the sorting process of workers.

The model is estimated by using data on labor market, health, and health insurance outcomes under the pre-ACA economy and is also subject to an external validation analysis based on the actual ACA impact. The data are from the Survey of Income and Program Participation, the Medical Expenditure Panel Survey, and the Kaiser Family Employer Health Insurance Benefit Survey. These data provide rich information about workers' health insurance, wage, employment, health, medical expenditure, and their transitions over age profiles and education status, as well as firms' characteristics and health insurance coverage. In the data, workers' ESHI coverage is positively correlated with wages, education status, and age, while large firms tend to offer ESHI. Although there are several mechanisms in the model which can explain above correlations, the model's estimates show that a main channel is *labor market sorting* in terms of worker age and skills and firm productivity. More experienced (and thus older) individuals sort into high-productivity firms that can offer greater compensation, simply because they are in the labor market longer and receive more job offers than the young throughout their life cycle. These workers will have a higher demand for health insurance because they tend to be older. Moreover, workers who are permanently more skilled are more efficient at searching on the job and have a high demand for health insurance. Sorting workers with a high demand for health insurance leads high-productivity firms, which tend to be large, to offer ESHI. Finally, I find that the simulated impact of the ACA implemented in 2015 on health insurance coverage and labor market outcomes is largely consistent with the data, which supports the model's ability to evaluate alternative health insurance systems.[6]

Using the estimated model, I study the optimal joint design of major health insurance policies that maximizes social welfare subject to the expected government revenue under the full implementation of the ACA. To understand the effectiveness of each policy instrument and its dependence on equilibrium sorting, I begin analyzing how the ACA policies lead to both aggregate and heterogeneous impacts. In the aggregate, the fully implemented ACA decreases the uninsured rate from 21% to 5%, whereas the partially implemented ACA (the 2015 version) reduces it to 12%. At an individual level, the remaining uninsured are mainly healthy, young individuals whereas individuals with HIX coverage are sicker, older individuals, indicating adverse selection in HIX. Moreover, the ACA's subsidies in HIX decrease the ESHI offer rate by small firms, which tend to hire low-skilled individuals because of *labor market sorting*, but employment mandates increase the ESHI offer rate by large firms. Interestingly, the individual mandate and subsidies in HIX are not perfect substitutes: although the individual mandate increases both HIX enrollees and the ESHI offer rate, the subsidies decrease the ESHI offer rate because firms let their employees obtain health insurance from HIX. Given these findings, I consider two sets of design problems: first, I study the optimal joint design of individual insurance regulations: the individual mandate (tax penalties on the uninsured), premium subsidies, and the age-based rating regulation, which determines the maximum premium ratio between the oldest and youngest individuals. I allow that both the mandate and subsidies can flexibly depend on individual characteristics such as age and income. Second, I study the optimal joint design of ESHI and individual insurance policies by proposing that the government replace the tax-deductible treatment

[6]The idea of holding out some data (i.e., the post-ACA data) for an out-of-sample validation follows Todd and Wolpin (2006) and French and Jones (2011).

of ESHI with a tax credit to ESHI and search for the optimal combination of subsidies in ESHI and HIX.

I find that the optimal joint design of individual insurance regulations makes purchasing health insurance from HIX less beneficial for old workers relative to young workers: under the optimal design. the maximum premium ratio to set to 4.9 (this is larger than ACA's ratio, which is 3) and subsidies decrease with age, contrary to ACA's age-independent subsidies. The individual mandate is instead flat across ages. The uninsured rate decreases to 3% and the ESHI offer rate decreases among less productive firms. The risk pool in HIX greatly improves by including more healthy enrollees. Overall, the optimal structure lowers the risk of being uninsured over the entire life cycle.

An interesting feature of the optimal joint design is that while premium subsidies are substantially decreasing in age, the individual mandate is not. This feature arises because they are not perfect substitutes in a model with HIX and ESHI: while subsidies give individuals an incentive to join HIX rather than ESHI, tax penalties do not directly provide such an incentive. Thus, while tax penalties mainly affect the uninsured rate, the subsidies affect both the uninsured rate and the sorting of workers between HIX and ESHI. This insight does not arise in models with HIX only, which makes the individual mandate and premium subsidies perfect substitutes. Therefore, accounting for the sorting between HIX and ESHI naturally allows us to understand how to *jointly* design individual insurance regulations.[7]

Another feature of the optimal structure is that it substantially exploits age-dependent policies. Intuitively, to maximize social welfare, the government wants to smooth access to and the premium for health insurance over individual life cycles. There are essentially three channels leading to this optimal structure. First, this optimal structure mitigates the uninsured risk generated by the age-dependence of the availability of ESHI in the labor market. Because older individuals have been in the labor market longer than the young, they are more likely to receive a job offer with ESHI at some point during their life cycle. Even if older individuals face a higher premium net of subsidies from HIX, they can still gain coverage from ESHI. On the other hand, the coverage status of young individuals is affected more by the cost of HIX because they may not find a job with ESHI. By reducing the net price of HIX coverage for young individuals, this optimal structure substantially lowers the risk of individuals becoming uninsured. Second, this optimal structure improves the risk pool of HIX by increasing the participation of young uninsured who are more likely to be healthy. Their participation can lower the insurance premium in HIX that even old individuals face. Third, this optimal structure changes the sorting of workers between HIX and ESHI by the endogenous responses of ESHI provisions. Low-productivity firms, which tend to have a greater number of younger workers because of labor market sorting, decrease their ESHI offer rate, which generates the endogenous sorting of younger workers from ESHI into HIX. This further lowers the insurance premium in HIX.

[7]One can possibly incorporate additional channels (e.g., behavioral choice frictions) to mechanically differentiate each policy impact. An advantage of this model is that it naturally pins down the policy impact by explicitly accounting for multiple separate health insurance markets.

Quantitatively, I find that most of the welfare gain is due to changes in the sorting of workers between HIX and ESHI. Thus, the bottom line is that, given the presence of the labor market sorting, the age-dependent policies improve social welfare by inducing a better sorting of workers between HIX and ESHI and lowering the uninsured risk over the life cycle.

Finally, by jointly designing ESHI and individual insurance subsidies, I show that the optimal structure achieves a substantial welfare gain compared with the optimal combination of individual insurance regulations by transferring government spending from ESHI to HIX. It expands coverage through HIX while contracting ESHI coverage. This policy design is obtained by balancing two competing forces that arise from the differences between HIX and ESHI. First, because access to and health insurance premiums from HIX are independent of labor market dynamics, compared with ESHI, HIX offers protection against reclassification risks generated by labor market dynamics. Second, ESHI may be subject to adverse selection less significantly than HIX because labor market frictions make it difficult for individuals to switch jobs to change insurance status frequently. Quantitatively, the former channel dominates the latter, leading to expansion of HIX coverage. This design is in line with imposing a Cadillac tax on ESHI. Although the tax exclusion of ESHI has been justified to sustain ESHI coverage, this result suggests the scope for welfare gains from redesigning the tax treatment of ESHI and expanding individual markets, which stabilizes access to health insurance.

Related Literature This paper contributes to the large literature studying the link between health insurance systems and labor markets. A growing literature structurally estimates labor market models with health and health insurance. These papers estimate life-cycle models of labor supply and health (e.g., Rust and Phelan (1997); French and Jones (2011); Low and Pistaferri (2015); De Nardi et al. (2016)) to evaluate the welfare impacts of health risk and various public insurance policies. In particular, French et al. (2018) evaluate several components of the ACA within a life-cycle model. This literature considers labor supply margin as a key input to understanding the welfare impact of the health insurance system. In this paper, because the ACA policies are designed to affect firms' incentives to provide ESHI and equilibrium in health insurance markets, I substantially depart from this literature by investigating welfare effects of equilibrium responses in labor and health insurance markets.[8]

A few papers estimate labor search models with firms' ESHI provisions. Dey and Flinn (2005) develop and estimate a search-matching-bargaining model with endogenous ESHI provisions and quantify the labor market inefficiency generated by the ESHI system. Aizawa and Fang (2013, 2018) evaluate the impact of the ACA in an equilibrium labor search model in which firms decide whether to offer ESHI and workers are infinitely lived (i.e., no life cycle), possess homogeneous skills, and face exogenous medical spending risks. Although these papers contribute to a better understanding

[8]See also Jeske and Kitao (2009) on the welfare impact of the tax exemption of ESHI under the pre-ACA economy, and Fang and Gavazza (2011) on the link between ESHI systems and medical expenditure, as well as a new macro-health literature evaluating the ACA (e.g., Cole et al. (2012) and Pashchenko and Porapakkarm (2013)).

of firms' incentives to provide health insurance, they do not analyze *how* the government should design the health insurance system. Because most health insurance policies are targeted based on individual characteristics such as age and income, it is crucial to model rich individual heterogeneity and the life-cycle sorting process to address this question. To the best of my knowledge, this is the first paper to characterize the optimal social insurance program in an economy with employer-based and private-individual insurance markets. For this purpose, this paper proposes a tractable equilibrium model with the following new features: individual life cycle, human capital accumulation, observed and unobserved skill and (risk) preference heterogeneity, health care utilization decisions, and heterogeneity of plans and market regulations across individual insurance and ESHI, in both the pre- and post-ACA economy. With this new framework, the paper also advances the evaluation of the ACA policies by investigating their heterogeneous impacts and analyzing ACA's age-based pricing regulation. Finally, the optimal design analysis shows that the key source of the welfare gain is due to the introduction of age-dependent policies.

More broadly, this paper contributes to the new and growing literature evaluating the optimal public policy design using estimated labor market models, including Blundell and Shephard (2012), Haan and Prowse (2017), Gayle and Shephard (2019), and O'dea (2018). This literature emphasizes the importance of modeling micro-level heterogeneity, the role of tagging (Akerlof (1978)), and the study of the optimal mixture of different policy instruments. These papers either consider the market structure as exogenous or consider perfectly competitive markets and emphasize the trade-off between redistribution and incentive distortions. This paper adds to the literature by investigating how government policies should address the inefficiency generated by the interactions between health insurance and frictional labor markets.

Finally, this paper also contributes to the literature estimating equilibrium labor search models. Meghir et al. (2015) estimate an equilibrium search model with endogenous sector choice with homogeneous workers. This paper considers that the sector choice (ESHI or not) is affected by labor market sorting. Recently, Bagger et al. (2014) and Lise and Postel-Vinay (2018) estimate equilibrium search models with sorting and endogenous skill accumulation. This paper contributes to the literature by investigating how workers with different skills and health sort themselves into jobs with multidimensional compensation packages over the life cycle, its implications for firms' choice of compensation packages, and how to design public policies when labor market sorting is crucial.[9]

The paper proceeds as follows. Section 2 presents the model and illustrates its economic mechanisms. Section 3 presents the data sets, and Section 4 explains the estimation strategy. Section 5

[9] Several studies on market designs of HIX can also be found in the empirical industrial organization literature (Hackmann et al. (2015); Handel et al. (2015); Tebaldi (2017)). These papers focus on allocation *within* individual markets by modeling the health insurance plan choice with detailed plan-level data and abstracting from ESHI and the labor market. Because their models treat subsidies and mandates as perfect substitutes, they focus on a *single* policy design. By taking a modeling and empirical approach in the labor literature, along with detailed labor market data, an advantage of my approach is to allow the study of *joint* policy designs, including the optimal mix of subsidies and mandates as well as the optimal tax design for ESHI.

shows the estimation results, and Section 6 presents results about the ACA and optimal policy designs. Section 7 concludes.

2 Model

2.1 Environment

This section first presents a model of the pre-ACA economy and then later describes the extended model including the ACA policies. The model is partly designed to account for some of the key features in the data, as summarized in Section 3. For example, older workers tend to work at jobs offering ESHI; workers with a high level of education or, more generally, workers with high wages tend to have ESHI. On the labor demand side, large firms tend to offer ESHI. The model explains these empirical regularities by explicitly describing the dynamic sorting process between workers and firms in a frictional labor search model. Moreover, the model is also designed to capture the key equilibrium responses in health insurance policies, which is elaborated in Sections 2.3 and 2.4.

In the model, time is discrete and measured in periods of four months.[10] An economy is populated by a continuum of workers with a measure $M > 0$ and a continuum of firms with a measure normalized to 1. The workers and firms are randomly matched in a frictional labor market. Each worker lives for a finite horizon $t = t_0, \ldots, T$, while firms exist forever. Each worker, having the discount factor $\beta \in (0, 1)$, makes labor supply, job mobility, individual insurance take-up, and health care decisions up to period T. Then, workers exogenously retire from the labor market and are replaced by newborn workers. Upon entering the labor market, the new workers are initially heterogeneous with respect to their education status ed, which is either college graduate (C) or non-college graduate (NC), and with respect to their time-invariant type $\tau \in \{\tau_1, \ldots \tau_N\}$, the latter of which is a determinant of individual preference, labor market skills, medical expenditure, and health transitions. The distribution of τ varies by ed, allowing for their correlations.[11]

2.1.1 Individual preference and health

Let $U(C_t, P_t, h_t)$ be the period utility for individuals with type τ and age t, which is defined over consumption C_t; employment status $P_t \in \{0, 1\}$, which takes a value of 1 for employed and 0 for non-employed; and health status $h_t \in \{H, U\}$, which is H if individuals are healthy and U if they are unhealthy. It is specified as

$$U(C_t, P_t, h_t) = -\frac{\exp(-\gamma_\tau C_t)}{\gamma_\tau} - \eta_{pt} P_t - \eta_h^\tau \mathbf{1}(h_t = U) - \eta_{hpt} P_t \mathbf{1}(h_t = U), \tag{1}$$

[10] My choice of four months as a unit of time is motivated by the construction of data sets. See Section 3 for details.

[11] The permanent type will be treated as unobserved by the econometrician in the empirical part of this paper. In empirical section, I assume that the number of unobserved types is two, although one could choose any number of finite types.

where γ_τ is the constant absolute risk aversion (CARA) coefficient, η_{pt} is the disutility from working, which varies with individual age t;[12] η_h^τ is the disutility from being unhealthy U; and η_{hpt} is the disutility of work for an unhealthy individual, which varies with individual age.[13][14] I assume that individuals can neither save nor borrow. The budget constraint is given by

$$C_t = \max\left\{\tau_w(w_t)P_t + (1-P_t)b - OOP^{HI}(z_t m_t) - R^{HI}(\mathbf{x_t}), \underline{c}^{HI}\right\}, \tag{2}$$

where $\tau_w(w_t)$ is after-tax labor income, b is non-employed income, $OOP^{HI}(z_t m_t)$ is the out-of-pocket expenditure, and $R^{HI}(\mathbf{x_t})$ is the health insurance premium for an individual with characteristics $\mathbf{x_t}$. The out-of-pocket expenditure is a function of period t's medical expenditure and health insurance status: $z_t \in \{0,1\}$ is the health care utilization choice, m_t is the latent medical expenditure shock, and $HI \in \{0,1,2\}$ is health insurance status, where $HI = 0$ if the individual is uninsured, $HI = 1$ if the individual is insured through ESHI, and $HI = 2$ if the individual is insured through individual health insurance (IHI). Both ESHI and IHI are characterized by deductibles and coinsurance and provide partial insurance against medical expenses.[15] The uninsured is also partially insured against medical expenditure risks through implicit insurance. Specifically, they face a consumption floor, $\underline{c}^{HI}$ for $HI = 0$, which guarantees the minimum consumption for the uninsured when the realized medical expense is large. This captures the idea of informal care (or charity care) provision in the emergency room, which is an important source of health care provisions to the uninsured.

In each period, a worker may be hit by latent medical expenditure shock m_t, which is a function of health h_t, age (measured in four-month intervals) t, and idiosyncratic shock ϵ_t^m. I specify it as

$$\begin{aligned} m_t &= \max\{m_t^*(h_t, t, \epsilon_t^m), 0\} \\ m_t^* &= \exp(\omega_1^{h_t} + \omega_2^{h_t} t + \omega_3^{h_t} t^2 + \epsilon_t^m) - \kappa_{h_t},\ \epsilon_t^m | h_t \sim i.i.d.N(0, \sigma_{h_t}^2), \end{aligned} \tag{3}$$

where m_t^* is the latent health shock. It is determined by the log-normal distributed health shock, $\exp(\omega_1^{h_t} + \omega_2^{h_t} t + \omega_3^{h_t} t^2 + \epsilon_t^m)$, where ϵ_t^m is an i.i.d. idiosyncratic shock that is heteroskedastic with health h_t, and the health-specific constant term $\kappa_{h_t} > 0$, which rationalizes the possible presence of zero medical expenditures because of the lack of any negative health shocks.[16]

Conditional on the latent medical expenditure shock m_t, the worker chooses health care utilization $z_t \in \{0,1\}$, which affects the realization of the next period health status. The transition to next period health status is determined as a logistic function of (z_t, h_t, m_t, t, τ), $\Pr[h_{t+1} = k | z_t, h_t, m_t, t, \tau]$.

[12] Its precise functional form specification is reported in Section 5.

[13] The last term is incorporated to fit the relationship between health and employment status.

[14] Note that the model permits the rich preference heterogeneity in health insurance choices by allowing that the unobserved characteristics may affect risk aversion and the disutility from bad health. These heterogeneity will be helpful in generating the possibility of both adverse and advantageous selections in health insurance markets.

[15] In practice, the health insurance plan is also characterized by the out-of-pocket maximum, which can be added to the model. Moreover, although it is plausible to allow multiple plans in each market, I assume that there is a single plan for ESHI and IHI in the economy because of the data limitations.

[16] The realization of the large ϵ_t^m captures the idea of a catastrophic shock in this context.

2.1.2 Individual health insurance market

Under the pre-ACA economy, an individual with characteristics $\mathbf{x_t}$ can purchase IHI at the premium $R^{IHI}(\mathbf{x_t})$ subject to medical underwriting. Specifically, individuals who decide to apply for IHI are denied from purchasing with probability $\delta^D(\mathbf{x_t})$. When individuals decide to apply for IHI, they also face an additively separable preference shock on obtaining individual insurance ϵ_t^{IHI}, which follows the Normal distribution $N(0, \sigma_{IHI}^2)$. As discussed later in Section 2.5, this preference shock smooths the decision of the individual insurance choice, which will dramatically simplify the characterization of equilibrium.[17] In the pre-ACA economy, the premium $R^{IHI}(\mathbf{x_t})$ is determined exogenously in the model; however, it will be endogenously determined in an equilibrium in post-ACA economy analyses.

2.1.3 Individual labor productivity

Each individual possesses labor productivity that affects the size of their compensation. Let $y_{\mathbf{x_t}}(p)$ denote the output that each individual produces, which depends on (1) a vector of individual characteristics $\mathbf{x_t} = (ed, \tau, E_t, h_t)$ where E_t is labor market experience and (2) the permanent productivity of the firm the individual is currently matched with, denoted by p. The log of output is specified as

$$\begin{aligned} \ln(y_{\mathbf{x_t}}(p)) &= y_w^*(ed, \tau, E_t) + y_h^*(h_t) + p \\ &= \alpha_1^{ed} + \alpha_1^{\tau} + (\alpha_2^{ed} + \alpha_2^{\tau})E_t + (\alpha_3^{ed} + \alpha_3^{\tau})E_t^2 + \alpha_4^{h_t} + p, \end{aligned} \tag{4}$$

where $y_w^*(ed, \tau, E_t)$ is the worker skill explained by (ed, τ, E_t) and $y_h^*(h_t)$ is the worker skill explained by h_t. This specification imposes that output is multiplicatively separable in (ed, τ, E_t) and h_t. The separability of health in the log of output helps to simplify a characterization of the firm's optimal wage policy in the analysis.

Individual labor market experience E_t is accumulated as long as the individual is employed ($P_t = 1$). That is, $E_{t+1} = E_t + 1$ if $P_t = 1$ and $E_{t+1} = E_t$ otherwise.

2.1.4 Firm

The firm-side environment is based on Burdett and Mortensen (1998) with productivity heterogeneity (Bontemps et al. (1999, 2000)) and an ESHI provision (Aizawa and Fang (2013, 2018)), but is extended to incorporate workers' skill heterogeneity and their life cycles.

Firms are heterogeneous with respect to their permanent productivity. In the population of firms, the distribution of productivity is denoted by $\Gamma(\cdot)$, which has a density function $d\Gamma$ that is continuous and positive everywhere. In my empirical application, I specify Γ to be log-normal with location μ_p and scale σ_p^2, that is, $p \sim \ln N(\mu_p, \sigma_p^2)$.

[17] It also helps to produce richer individual responses to policy designs in individual markets and makes optimal design analyses more tractable (see footnote 54).

Firms have access to a constant returns to scale production function. They offer a package that includes a wage offer and an ESHI provision to maximize their steady-state profit flow. If they offer ESHI, they incur the cost of a health insurance provision, which is equal to the sum of the total expected medical expenditure of their workforce and a fixed administrative cost ξ_{ESHI}, the latter being independent of firm size. Importantly, the cost for ESHI premiums is exempt from both employee income and payroll tax as well as employer payroll tax, whereas wage payments are not.

To make the analysis tractable, I consider that (1) firms post a skill price θ_O^{ed} for each skill group ed subject to the constraint that health h_t cannot be priced, which determines wage, and (2) they decide whether to offer ESHI to all of their workforce $O \in \{0, 1\}$. The assumption of skill price posting follows the literature of empirical search models with worker heterogeneity (e.g., Barlevy (2008), Bagger et al. (2014) and Taber and Vejlin (2016)), which discuss its empirical plausibility.[18][19] The assumption that firms cannot condition on individual health is made either because worker health status is not observed by firms or because many labor regulations limit firm's ability to condition on hiring, firing, and compensation based on an individual's health status.[20,21,22] Then, a wage offer for a worker with $\mathbf{x_t} = (ed, \tau, E_t, h_t, t)$ in a firm offering a compensation package (θ, O) is equal to

$$w^O_{\mathbf{x_t}}(\theta) = \theta^{ed}_O \exp(y^*_w(ed, \tau, E_t)). \tag{5}$$

2.1.5 Labor market

Workers and firms randomly meet in the frictional labor market. A non-employed worker with characteristics $\mathbf{x_t}$ receives a job offer from a firm with probability $\lambda_u^{\mathbf{x_t}}$, and an employed worker receives a new job offer with probability $\lambda_e^{\mathbf{x_t}}$. The compensation is drawn from the offer distribution $F^{ed}(\theta, O)$. Upon receiving the job offer, the worker decides whether to accept it.

In addition to changing jobs, employed workers are allowed to quit and become non-employed. Furthermore, they are hit by an exogenous job destruction shock with probability $\delta^{\mathbf{x_t}}$, upon which workers lose their current jobs. Because the model period is relatively long (four-months), the model allows the simultaneous occurrence of the exogenous job destruction shock and the arrival of a new

[18] An interesting extension is to allow firms to offer an optimal screening contract (i.e., a menu of wage and ESHI combinations). Because most employers offer only a few plans, and the welfare loss from selection for ESHI plans within an employer has consistently been estimated to be very small in the literature of health insurance, this omission is not likely to change the main results in this paper.

[19] I also experimented with a specification that firms can allow skill price to depend on labor market experience, (i.e., $\theta_O^{ed,E}$) and found that the main results are robust. Those results are available upon request.

[20] Existing anti-discrimination laws prohibit compensation packages from being based on age and health (e.g., Health Insurance Portability and Accountability Act and Americans with Disabilities Act and its amendments). Starting in 2014, firms are also prohibited from offering different sets of health plans to full-time employees with different income levels. Also, if ESHI is offered, workers cannot obtain premium subsidies from HIX unless the premium contribution of the ESHI plan exceeds 9.5% of annual income.

[21] I assume that the employer's premium contribution is 100% so that workers cannot receive an additional wage even if they decline coverage. This is not unrealistic because the current U.S. average is 85% for a single worker's premium.

[22] The education-specific skill price is motivated by the view that labor markets may be segmented by education status. A similar assumption is made in the literature (e.g., Bagger et al. (2014)).

job offer within the same period with probability $\delta^{\mathbf{x_t}}\lambda_e^{\mathbf{x_t}} > 0$. Moreover, in every period, individuals draw an additively separable preference shock to being non-employed ϵ_t^n, which follows a Normal distribution $N(0, \sigma_n^2)$. As discussed later in Section 2.2.4, introducing this preference shock will dramatically simplify the characterization of equilibrium.

2.1.6 Timing in a period

At the beginning of each period, individuals are heterogeneous in their characteristics $\mathbf{x_t} = (ed, \tau, E_t, h_t, t)$, employment status P_t, and compensation package (θ, O) if working. Then, the order of events within a period is as follows:[23] (i) individuals without ESHI decide whether to purchase IHI; (ii) the employed produce output and accumulate labor market experience; (iii) the idiosyncratic health shock ϵ_t^m is realized; (iv) an individual makes a health care utilization decision z_t; (v) the next period health status is realized; (vi) the employed are hit by an exogenous job destruction shock with probability $\delta^{\mathbf{x_t}}$; (vii) individuals draw a preference shock for being non-employed ϵ_t^n; (viii) the non-employed receive a job offer with probability $\lambda_u^{\mathbf{x_t}}$ and decide whether to accept the job offer; the employed receive a job offer with probability $\lambda_e^{\mathbf{x_t}}$ and choose to accept the offer, stay at the current job, or quit into being non-employed; the employed who do not receive the offer decide whether to stay at the current job or quit into being non-employed. Finally, once individuals reach the terminal age T, they receive the utility that is a function of health status, $\upsilon_T^{h_T}$.

The initial condition of individuals is specified as follows. I assume that all newborn individuals are healthy, have no labor market experience, and start their career as non-employed.[24] Finally, I assume that the population of individuals and firms grows at the constant rate n in each period. Thus, the fraction of a cohort size of age t in the total population is constant over time in a steady state.

2.2 Analysis of the Model

This section first characterizes the individual life-cycle optimization and steady-state worker distribution. Next, it characterizes the firm optimization problem. Then a steady-state equilibrium is defined.

2.2.1 Individual optimization problem

At the beginning of a period, the state space of individuals is $(\mathbf{x_t}, \theta, O)$: individual characteristics $\mathbf{x_t}$ and the compensation package (θ, O) if working. They face the offer distribution $F^{ed}(\theta, O)$. To characterize the individual optimal decision, the analysis starts by characterizing individual value functions. Let $V_0(\mathbf{x_t})$ and $V_1(\mathbf{x_t}, \theta, O)$ denote the value functions for the non-employed and employed, respectively. Importantly, they are defined as the values at the beginning of period t.

[23] Note that these particular timing assumptions simplify our derivation, but they are not crucial.

[24] However, their health evolution is affected by their permanent type, and therefore they face different health risks.

Value Function of Non-employed. The value function for the non-employed at the beginning of the period t, $V_0\left(\mathbf{x_t}\right)$, is expressed as

$$V_0(\mathbf{x_t}) = \mathbb{E}_{\epsilon_t^{IHI}}\left[\max\left\{\underbrace{\left(1-\delta^D(\mathbf{x_t})\right)\left(\bar{V}_0(\mathbf{x_t}_t,2)+\epsilon_t^{IHI}\right)+\delta^D(\mathbf{x_t})\bar{V}_0(\mathbf{x_t},0)}_{\text{value from applying to IHI}}, \underbrace{\bar{V}_0(\mathbf{x_t},0)}_{\text{value from staying uninsured}}\right\}\right] \tag{6}$$

where $\bar{V}_0(\mathbf{x_t}, HI_t)$ is the health insurance choice-specific value function of the non-employed, determined as

$$\bar{V}_0(\mathbf{x_t}, HI_t) = \mathbb{E}_{\epsilon_t^m}\left[\max_{z_t} u_t(C_t, 0, h_t; \mathbf{x_t}, HI_t) + \beta\mathbb{E}_{\hat{h}}\left[\underbrace{\lambda_u^{\mathbf{x_t}} V_0^R(\mathbf{x_{t+1}})}_{\text{value from receiving a job offer}} + \underbrace{(1-\lambda_u^{\mathbf{x_t}})V_0(\mathbf{x_{t+1}})}_{\text{value from not receiving a job offer}}\right]\right] \tag{7}$$

where consumption C_t is subject to the budget constraint (2), $\mathbf{x_{t+1}} = (ed, \tau, E_t, \hat{h}, t+1)$, and V_0^R represents the value of receiving a job offer, determined as

$$V_0^R(\mathbf{x_{t+1}}) = \int \mathbb{E}_{\epsilon_t^n}\left[\max\{\underbrace{V_0(\mathbf{x_{t+1}})+\epsilon_t^n}_{\text{value from staying non-employed}}, \underbrace{V_1(\mathbf{x_{t+1}},\theta,O)}_{\text{value from accepting the job offer}}\}\right] dF^{ed}(\theta, O). \tag{8}$$

Equation (6) shows that the value of being non-employed at the beginning of each period, $V_0(\mathbf{x_t})$, is determined by the individual optimal choice of the IHI application based on the choice-specific value function defined in equation (7). Given the insurance status, individuals determine health care utilization z_t and labor supply decisions, which leads to value $\bar{V}_0$, as in equation (7). The first term is the flow utility this period, and the second term in (7) consists of the expected future value from receiving a job offer, $V_0^R(\mathbf{x_{t+1}})$, and the expected future value from not receiving a job offer, denoted by $V_0(\mathbf{x_{t+1}})$. As seen from equation (8), the value from receiving a job offer depends on the individual optimal choice of the job accepting decision, which essentially compares the value from accepting a job offer with (θ, O), $V_1(\mathbf{x_{t+1}}, \theta, O)$ with the value from staying non-employed next period, $V_0(\mathbf{x_{t+1}}) + \epsilon_t^n$, where ϵ_t^n is the preference shock to work.

Value Function of Employed. Similarly, the value for being employed at the beginning of the period t, $V_1\left(\mathbf{x_t}, \theta, O\right)$, is given by

$$V_1(\mathbf{x_t},\theta,O) = \begin{cases} \mathbb{E}_{\epsilon_t^{IHI}}\left[\max\left\{\left(1-\delta^D(\mathbf{x_t})\right)\left(\bar{V}_1(\mathbf{x_t},\theta,2)+\epsilon_t^{IHI}\right)+\delta^D(\mathbf{x_t})\bar{V}(\mathbf{x_t},\theta,0), \bar{V}_1(\mathbf{x_t},\theta,0)\right\}\right] & \text{if} \quad O=0 \\ \bar{V}_1(\mathbf{x_t},\theta,1) & \text{if} \quad O=1 \end{cases} \tag{9}$$

where $\bar{V}_1(\mathbf{x_t}, \theta, HI_t)$ represents the insurance choice-specific value function:

$$\bar{V}_1(\mathbf{x_t},\theta,HI_t)=\mathbb{E}_{\epsilon_t^m}\left[\max_{z_t} u_t(C_t,0,h_t;\mathbf{x_t},HI_t)+\beta\mathbb{E}_{\hat{h}}\left[\underbrace{\lambda_e^{\mathbf{x_t}}V_1^R(\mathbf{x_{t+1}},\theta,O)}_{\text{value from receiving a job offer}}+\underbrace{(1-\lambda_e^{\mathbf{x_t}})V_1^{NR}(\mathbf{x_{t+1}},\theta,O)}_{\text{value from not receiving a job offer}}\right]\right] \tag{10}$$

Here, consumption C_t is subject to the budget constraint (2), $\mathbf{x_{t+1}}=(ed,\tau,E_t+1,\hat{h},t+1)$, and V_1^R and V_0^{NR} represent the value of receiving a job offer and not receiving a job offer, respectively,

$$\begin{aligned} V_1^R(\mathbf{x_{t+1}},\theta,O) &= (1-\delta^{\mathbf{x_t}})\int \mathbb{E}_{\epsilon_t^n}\left[\max\{V_1(\mathbf{x_{t+1}},\theta',O'),V_1(\mathbf{x_{t+1}},\theta,O),V_0(\mathbf{x_{t+1}})+\epsilon_t^n\}\right]dF^{ed}(\theta',O') \\ &+ \delta^{\lambda_e^{\mathbf{x_t}}}\int \mathbb{E}_{\epsilon_t^n}\left[\max\{V_0(\mathbf{x_{t+1}})+\epsilon_t^n,V_1(\mathbf{x_{t+1}},\theta',O')\}\right]]\,dF^{ed}(\theta',O') \end{aligned} \tag{11}$$

$$V_1^{NR}(\mathbf{x_{t+1}},\theta,O)=\delta^{\mathbf{x_t}}V_0(\mathbf{x_{t+1}})+(1-\delta^{\mathbf{x_t}})\mathbb{E}_{\epsilon_t^n}\left[\max\{V_0(\mathbf{x_{t+1}})+\epsilon_t^n,V_1(\mathbf{x_{t+1}},\theta,O)\}\right]. \tag{12}$$

Equation (9) determines health insurance status. The IHI take-up decision is made only if individuals are not offered ESHI ($O=1$). Then, health care utilization and labor supply decisions are determined in equation (10). The second term is the expected value from receiving a job offer, $V_1^R(\mathbf{x_{t+1}},\theta,O)$. If individuals are not hit by job destruction shocks, then they choose whether to switch to a new job with (θ',O'), stay at the current job, or quit into non-employment. If they are hit by job destruction shocks, they choose whether to accept a new job or become non-employed.

Optimal Choice of Individuals. Now, one can characterize individual optimal choices as follows. From equations (6) and (9), *health insurance choice probabilities* for non-employed $hi_0\left(HI_t|\mathbf{x_t}\right)$ and for the employed $hi_1\left(HI_t|\mathbf{x_t},\theta,O\right)$ are given by

$$hi_0\left(2|\mathbf{x_t}\right)=\Pr\left(HI_t=2|\mathbf{x_t}\right)=\left(1-\delta^D(\mathbf{x_t})\right)\Phi\left(\frac{\bar{V}_0(\mathbf{x_t},2)-\bar{V}_0(\mathbf{x_t},0)}{\sigma_{IHI}}\right) \tag{13}$$

$$hi_1\left(2|\mathbf{x_t},\theta,0\right)=\Pr\left(HI_t=2|\mathbf{x_t},\theta,0\right)=\left(1-\delta^D(\mathbf{x_t})\right)\Phi\left(\frac{\bar{V}_1(\mathbf{x_t},\theta,2)-\bar{V}_1(\mathbf{x_t},\theta,0)}{\sigma_{IHI}}\right), \tag{14}$$

where σ_{IHI} is a standard deviation for the preference shock to purchase IHI, and $hi_0\left(0|\mathbf{x_t}\right)=1-hi_0\left(2|\mathbf{x_t}\right)$,$hi_1\left(0|\mathbf{x_t},\theta,0\right)=1-hi_1\left(2|\mathbf{x_t},\theta,0\right)$, and $hi_1\left(1|\mathbf{x_t},\theta,1\right)=1$. Moreover, from (8), a non-employed worker accepts a job offer with (θ,O) (over the non-employed) with the probability

$$A(\mathbf{x_{t+1}},\theta,O)=\Phi\left(\frac{V_1(\mathbf{x_{t+1}},\theta,O)-V_0(\mathbf{x_{t+1}})}{\sigma_n}\right). \tag{15}$$

One can characterize employed workers' job acceptance decisions as being similar to the standard on-the-job search model (e.g., Burdett and Mortensen (1998)). The model also permits endogenous decisions to quit into non-employment by introducing a preference shock to work and by introducing changes in individual characteristics (e.g., health). Finally, the optimal health care utilization z_t^* leads to the expected next period health transition rates $H_u(\hat{h}|\mathbf{x_t},HI_t)$ and $H_e(\hat{h}|\mathbf{x_t},\theta,HI_t)$:

$$H_u(\hat{h}|\mathbf{x_t},HI_t)=\int \Pr[h_{t+1}=\hat{h}|z_t^*(\mathbf{x_t},m_t,HI_t),h_t,m_t,t,\tau]dF(m_t) \tag{16}$$

$$H_e(\hat{h}|\mathbf{x_t},\theta,HI_t)=\int \Pr[h_{t+1}=\hat{h}|z_t^*(\mathbf{x_t},m_t,\theta,HI),h_t,m_t,t,\tau]dF(m_t). \tag{17}$$

2.2.2 Steady-state worker distribution

The steady-state distribution of workers is characterized by two objects: $g(\mathbf{x_t},\theta,O)$, a steady-state density of the employed with characteristics $\mathbf{x_t}=(ed,type,E,\hat{h},t)$ receiving compensation packages (θ,O), and $u(\mathbf{x_t})$, a steady-state measure of the non-employed with characteristics $\mathbf{x_t}$.

The distinct feature of the steady-state distribution under the finite horizon life-cycle model, contrary to the standard infinite horizon search model (e.g., Burdett and Mortensen (1998)), is that it includes age as a state variable. As a result, g and u at age t are fully determined by the inflow from the steady-state distribution with age $t-1$, while the standard model determines the distribution as a result of both inflows into and outflows from the distribution. The density of employed $g(\mathbf{x_t},\theta,O)$ is determined as

$$\begin{aligned}
\frac{g(\mathbf{x_t},\theta,O)}{1+n} &= \underbrace{\sum_{h_{t-1}} g\left(\mathbf{x^A_{t-1}},\theta,O\right)\sum_{HI_t} hi_1\left(HI_t|\mathbf{x^A_{t-1}},\theta,O\right)H_1(\hat{h}|\mathbf{x^A_{t-1}},\theta,HI_t)EE(\mathbf{x_t},\theta,O)}_{\text{the inflow from employed staying at the same job}}\\
&+ \underbrace{\sum_{h_{t-1}} u\left(\mathbf{x^B_{t-1}}\right)\sum_{HI_t} hi_0\left(HI_t|\mathbf{x^B_{t-1}}\right)H_0(\hat{h}|\mathbf{x^B_{t-1}},HI_t)NE(\mathbf{x_t},\theta,O)}_{\text{the inflow from non-employed}}\\
&+ \underbrace{\sum_{h_{t-1}}\sum_{O'}\int\left[g\left(\mathbf{x^A_{t-1}},\theta',O'\right)\sum_{HI_t} hi_1\left(HI_t|\mathbf{x^A_{t-1}},\theta',O'\right)H_1(\hat{h}|\mathbf{x^A_{t-1}},\theta',HI_t)JJ(\mathbf{x_t},\theta,O;\theta',O')\right]d\theta'}_{\text{the inflow from employed in other firms making job-to-job transitions}}
\end{aligned} \tag{18}$$

where health insurance choice probabilities $hi_0(\cdot)$and $hi_1(\cdot)$ are defined in (13) and (14), respectively; health transition functions $hi_0(\cdot)$ and $hi_1(\cdot)$ are defined in (16) and (17), respectively; and $\mathbf{x^A_{t-1}}=(ed,\tau,E_{t-1},h_{t-1},t-1)$ and $\mathbf{x^B_{t-1}}=(ed,\tau,E_t,h_{t-1},t-1)$ are individual characteristics in the last period for the employed and non-employed, respectively, which can turn into $\mathbf{x_t}$ in this period. Three transition terms are defined in the equation: $EE(\mathbf{x_t},\theta,O)$ is the *probability* of staying at the same firm among workers with $\mathbf{x_t}$ and compensation (θ,O); $NE(\mathbf{x_t};\theta,O)$ is the *probability* that non-employed individuals with $\mathbf{x_t}$ will transition into being employed with compensation package (θ,O); and $JJ(\mathbf{x_t},\theta,O;\theta,O')$ is the *probability* that employed workers receiving compensation (θ',O') will switch to the job with (θ,O):

$$\begin{aligned}
EE(\mathbf{x_t},\theta,O) &= (1-\delta^{\mathbf{x_t}})\left(1-\lambda_e^{\mathbf{x_t}}+\lambda_e^{\mathbf{x_t}}\int \mathbf{1}(V_1(\mathbf{x_t},\theta,O)>V_1(\mathbf{x_t},\theta',O'))dF(\theta'O')\right)A(\mathbf{x_t},\theta,O)\\
NE(\mathbf{x_t},\theta,O) &= \lambda_u^{\mathbf{x_t}}f^{ed}(\theta,O)A(\mathbf{x_t},\theta,O)\\
JJ(\mathbf{x_t},\theta,O;\theta',O') &= \lambda_e^{\mathbf{x_t}}f^{ed}(\theta,O)\left((1-\delta^{\mathbf{x_t}})\mathbf{1}(V_1(\mathbf{x_t},\theta,O)>V_1(\mathbf{x_t},\theta',O'))+\delta^{\mathbf{x_t}}\right)A(\mathbf{x_t},\theta,O)
\end{aligned}$$

where $A(\mathbf{x_t},\theta,O)$is the probability of accepting a job offer with (θ,O) (over the non-employed) defined in (15). Essentially, (18) describes that the inflows into $g\left(\mathbf{x_t},\theta,O\right)$ consist of three components: the inflow from the employed workers who receive the same compensation package (the first line in (18)); the inflow from non-employed workers (the second line in (18)); and the inflow from employed workers who switch from other firms through job-to-job transitions (the third line in (18)).

One can characterize $u(\mathbf{x_t})$ in a similar way, which is done by equation (25) in Appendix B. Although the determinants of the distribution are complicated objects, one can analytically (and fairly quickly) calculate the distribution starting from the period 1 distribution (g,u) by forward induction, given the value function and the offer distribution.

Finally, the steady state requires that the total sum of workers must be equal to M:

$$\sum_{\mathbf{x_t}} u(\mathbf{x_t}) + \sum_{\mathbf{x_t}}\sum_{O}\int g\left(\mathbf{x_t},\theta,O\right)d\theta = M. \tag{19}$$

As in Burdett and Mortensen (1998) and Postel-Vinay and Robin (2002), one can define the terms related to firm size. The density of employees with characteristics $\mathbf{x_t}$ for firms offering compensation package (θ,O) is $g\left(\mathbf{x_t},\theta,O\right)$ divided by the density of those firms $f^{ed}(\theta,O)$, which is the density of the offer distribution F^{ed}:

$$l\left(\mathbf{x_t},\theta,O\right) = \frac{g\left(\mathbf{x_t},\theta,O\right)}{f^{ed}(\theta,O)}.$$

2.2.3 Firm optimization problem

Firms choose wage offers and health insurance offerings to maximize steady-state profit flow. I assume that the firm draws a (permanent) shock, ϵ^O, in each period, which is specific to its choice of whether to offer health insurance. The shock is additively separable from the deterministic component of the steady-state profit flow conditional on the ESHI provision. The choice-specific shock is introduced so that the model can generate the smooth relationship between the fraction of firms offering ESHI and their productivity. This problem can be formulated as

$$\Pi(p,\epsilon^O) = \max\left\{\Pi_1(p)+\epsilon^O, \Pi_0(p)\right\}.$$

The conditional profit under the ESHI offer status $O\in\{0,1\}$, Π_O, consists of the flow output net of wage and ESHI costs (if ESHI is offered):

$$\Pi_O(p) = \max_{\theta_O^{ed}}\sum_{\mathbf{x_t}}\left(y_{\mathbf{x_t}}(p) - (1+\tau_f)w^O_{\mathbf{x_t}}(\theta_O^{ed}) - \mathbb{E}[\tilde{m}_O^{\mathbf{x_t}}]O\right) l\left(\mathbf{x_t},\theta_O^{ed},O\right) - \xi_{ESHI}O, \tag{20}$$

where the ESHI costs consist of the total expected medical expenditure of the firm's own employees and the fixed cost. Note that wage payments are subject to the constant payroll tax τ_f, while the costs for ESHI are not. Appendix C shows how to further characterize the optimal skill price.

I assume that ϵ^O follows an i.i.d. Type I extreme value distribution with scale parameter σ_f. Then, the fraction of firms with productivity p offering health insurance is characterized by

$$\Delta(p) = \frac{\exp(\frac{\Pi_1(p)}{\sigma_f})}{\exp(\frac{\Pi_0(p)}{\sigma_f}) + \exp(\frac{\Pi_1(p)}{\sigma_f})}. \tag{21}$$

2.2.4 Equilibrium

Finally, one can characterize the equilibrium offer distribution $F^{ed}(\theta, O)$. It is determined to be consistent with the firms' optimization behavior $\{\theta_O^{ed}(p), \Delta(p)\}$ so that it must satisfy

$$F^{ed}(\theta, O) = \int_0^\infty \mathbf{1}(\theta_O^{ed}(p) < \theta^{ed}) \left(O\Delta(p) + (1-O)\left[1 - \Delta(p)\right]\right) d\Gamma(p). \tag{22}$$

A steady-state equilibrium consists of $\{V_0, V_1\}$ and corresponding policy functions, $g(\mathbf{x_t}, \theta, O)$ and $u(\mathbf{x_t})$, $\{\theta_O^{ed}(p), \Delta(p)\}$ for all p, and $F^{ed}(\theta, O)$ such that (i) given $F^{ed}(\theta, O)$, $\{V_0, V_1\}$ and corresponding policy functions solve (7) and (10); (ii) given $\{V_0, V_1\}$, corresponding policy functions and $F^{ed}(\theta, O)$, $g(\mathbf{x_t}, \theta, O)$ and $u(\mathbf{x_t})$ must satisfy (18), (25) (in Appendix B) and (19); (iii) given $F^{ed}(\theta, O)$, $g(\mathbf{x_t}, \theta, O)$ and $u(\mathbf{x_t})$, $\{\theta_O^{ed}(p), \Delta(p)\}$ solves (20); (iv) $F^{ed}(\theta, O)$ satisfies (22).

Note that this model is an extension of Burdett and Mortensen (1998) with firm heterogeneity, for which Bontemps et al. (1999, 2000) discuss conditions for the existence and uniqueness of the equilibrium. It is very difficult to derive such conditions in this model because of the sorting mechanism that heterogeneous workers have different preferences for different employment contracts, which complicates the steady-state distribution. Moreover, ESHI can possibly be used as a screening device, which generates a concern about the possibility of the non-existence of equilibria, as in many insurance market models. However, as shown by Guerrieri et al. (2010) and Lester et al. (2019) theoretically, introducing search frictions often guarantees the existence and uniqueness of equilibrium in these models. In this paper, I numerically solve the equilibrium using the algorithm described in Appendix D. Through extensive numerical simulations, I always find a unique solution.

It is also important to note that the model includes various preference shocks on the individual side (preference shocks to the individual decision to obtain individual insurance and the decision to work). Without the individual preference shock to work, because of the life-cycle and skill heterogeneity in a discrete fashion, the model produces a finite number of reservation wages. As a consequence, the labor supply function that the firm faces may be discontinuous, generating the possibility of mass points in the wage offer distribution. Thus, incorporating the preference shock brings an important technical advantage to smooth the labor supply function and guarantee a *continuous* equilibrium offer distribution.[25] Moreover, the exogenous *permanent* cost shock of ESHI (ϵ^O) is introduced to generate the smooth relationship between firm size and the ESHI offer rate.

[25] See Shephard (2017) for a discussion of smoothing the labor supply function in wage posting models (Burdett and Mortensen (1998)).

2.3 Illustrating Mechanisms

The model characterizes various mechanisms that determine the demand for health insurance and the supply of ESHI. In order to understand how each mechanism works and the interactions between them, this section performs numerical simulations based on the estimated parameter values reported in Section 5. As discussed by Bontemps et al. (1999, 2000), this class of models predicts that high-productivity firms tend to be larger because they offer larger compensation packages to attract more workers. The current model has three features: (a) individual life cycle and heterogeneity; (b) health and ESHI provisions (as in Aizawa and Fang (2013, 2018)); and (c) the decisions of IHI take-up and health care utilization, allowing plan heterogeneity between ESHI and IHI. I conduct comparative statics to understand their effects.

2.3.1 Individual Heterogeneity and Incentive of ESHI Provisions

First, I analyze which features of the model affect the incentive of ESHI offerings. In the data, positive correlations can be found among workers' age, wage, education status, and ESHI coverage, and between firm size and the ESHI offering rate (see Section 5.2). A new channel introduced in this paper that qualitatively accounts for those correlations is labor market sorting in terms of a worker's age and skills and the firm's productivity. More experienced (and thus older) individuals will sort into high-productivity firms because they have been in the labor market longer and have received more job offers than the young throughout their life cycle.[26] High-skilled workers, defined by education or by permanent type, may climb the job ladder toward high-productivity firms faster because they may be more efficient at job searching (i.e., $\lambda_e^{\mathbf{x_t}}$ is large) than low-skilled workers. These channels, which demonstrate that the differences in the arrival rate of job offers induce labor market sorting, are shown to be empirically important by existing frictional labor market sorting models such as Bagger and Lentz (2017) and Bagger et al. (2014). Importantly, workers in high-productivity firms may have a higher demand for health insurance. Older workers may have a higher demand because they are more likely than younger workers to transition to being unhealthy. Moreover, the presence of a consumption floor makes health insurance demand by low-skilled (and therefore low-income) individuals much less than the demand by high-skilled (or high-income) individuals. As found in Handel (2013), they may also be more risk averse, which increases their demand for health insurance. This mechanism gives high-productivity firms the incentive to offer ESHI to minimize their total compensation.

Columns (2) and (3) in Table 1 report the quantitative importance of this channel. They show that the not considering the effect of age in the health transition and medical expenditure processes greatly decreases the ESHI offer rate, particularly among large firms, by lowering the demand for health

[26]Note that worker skills and firm productivity are complements in the production function. In a frictional sorting model where firms have a capacity constraint (e.g., one-to-one matching model such as Shimer and Smith (2000)), the supermodularity of production function leads to the assortative matching between workers and firms. On the other hand, in this model, firms face no capacity constraint and therefore want to hire any productive workers. Thus, the supermodularity of production function will have a limited effect on this sorting pattern.

	(1)	(2)	(3)	(4)	(5)	(6)
	Benchmark	no age effect on health transition & med. exp.	lowering risk aversion for the high skilled	removal of ESHI tax deduction	no productivity effect of health	no fixed cost of ESHI
ESHI offer rate: firm size≥50	0.91	0.70	0.89	0.80	0.90	0.92
ESHI offer rate: firm size<50	0.51	0.50	0.51	0.48	0.51	0.53
ESHI offer rate (average)	0.56	0.52	0.55	0.52	0.56	0.57
Uninsured rate	0.21	0.32	0.234	0.29	0.22	0.20
The frac. ind. with ESHI	0.77	0.66	0.76	0.69	0.76	0.78
The frac. ind. with IHI	0.01	0.02	0.006	0.03	0.01	0.01
Non-employment rate	0.07	0.05	0.07	0.07	0.07	0.07

Table 1: Assessment of mechanisms affecting the demand and provisions of ESHI

Notes: (a) Column (1) reports the main aggregate outcomes under the benchmark model (pre-ACA). (b) Column (2) considers that the coefficients of age terms in health transitions and latent medical expenditure are set to be zero. (c) Column (3) considers that the CARA coefficients of type 1 (more risk averse) individuals decrease from 1.4 to 0.5. (d) Column (4) considers that ESHI costs are also subject to income and payroll taxes. (e) Column (5) considers that the productivity loss from bad health is set at zero. (f) Column (6) considers that the fixed cost of ESHI is zero.

insurance by older individuals, relative to the ESHI offer rate under the benchmark case (Column (1)). Column (3) shows that lowering risk aversion by skilled individuals also contributes to lowering the ESHI offer rate among large (high-productivity) firms, although its impact is much more modest. Overall, sorting channels play an important role in affecting the incentive of ESHI provisions.

Other channels may also affect ESHI offer decisions. First, the tax exemption of ESHI, together with a progressive income tax code, gives high-productivity firms more incentive to offer ESHI because those firms tend to post higher skill prices, and high-income workers want to minimize their tax payments. Second, the fixed cost of offering ESHI, ξ_{ESHI}, also lowers the ESHI offer rate, particularly among small firms, because they need to spread the fixed cost among a small number of employees. Third, by offering ESHI, firms may suffer from an (initial) adverse selection problem by attracting more unhealthy individuals, which increases health insurance costs and decreases labor productivity, lowering the incentives to offer ESHI. Fourth, the cost of the initial adverse selection to firms may be mitigated if health insurance will improve worker health over time by allowing them greater access to health care. Columns (4)-(6) in Table 1 provide a quantitative assessment of those channels. Overall, those channels account for much less than the sorting mechanism.

2.3.2 Interaction between ESHI Provisions and Individual Insurance Market

Next, I examine how features of the IHI market affect various outcomes through three exercises: (a) lowering the net price of IHI; (b) prohibition of insurer rejections; (c) changes in the financial characteristics of IHI. I conduct these analyses taking the insurance premium in IHI as $exogenous$.

Column (2) in Table 2 shows that the reduction of the net premium in IHI substantially increases IHI coverage. It lowers the uninsured rate modestly, whereas the ESHI offer rate decreases substantially. By making the IHI market more attractive to the worker, firms cannot extract many rents from workers by offering ESHI. Thus, firms drop ESHI coverage, which leads their workers to obtain IHI. As a result, lowering the net price in IHI increases coverage not only by lowering the uninsured rate but also by generating an inflow of workers with ESHI. Column (3) shows the impact of prohibiting insurer rejections, and Column (4) shows the impact of making the financial characteristics of IHI more generous. In both cases, the uninsured rate changes little. The coverage of IHI increases modestly, whereas the coverage of ESHI decreases.

Thus, changes in the IHI market affect not only the uninsured rate but also the sorting of workers between IHI and ESHI through endogenous ESHI provisions. Section 6 studies the importance of this channel for the optimal design of the health insurance system. Note that changes in sorting can affect the insurance premium in IHI. Moreover, other policy instruments (e.g., employer mandate) may affect the response of ESHI in the post-ACA economy. These channels are modeled below.

	(1)	(2)	(3)	(4)
	Benchmark	lowering the net price of IHI	prohibition of insurer rejections	changes in financial characteristics
ESHI offer rate: firm size≥50	0.91	0.78	0.90	0.82
ESHI offer rate: firm size<50	0.51	0.48	0.51	0.49
ESHI offer rate (average)	0.56	0.52	0.56	0.53
Uninsured rate	0.21	0.18	0.205	0.22
The frac. ind. with ESHI	0.77	0.67	0.76	0.69
The frac. ind. with IHI	0.01	0.15	0.025	0.08
Non-employment rate	0.07	0.07	0.07	0.07

Table 2: The impact of individual insurance market regulations in the model

Notes: (a) Column (1) reports the main aggregate outcomes under the benchmark model (pre-ACA). (b) Column (2) considers that the premium subsidies are offered so that the effective premium individuals face is 10% of the original price. (c) Column (3) considers that insurers cannot reject any individuals. (d) Column (4) considers that the deductible and the coinsurance rate of IHI are set to zero.

2.4 Modeling ACA Policies

In order to study the design of the health insurance system, I extend the model to include the six main ACA policy instruments: the creation of HIX; the age-based rating regulations in HIX; income-based coinsurance and premium subsidies in HIX, which are larger for lower-income individuals; a tax penalty on the uninsured (individual mandate), which is larger for higher-income individuals; a tax penalty on firms with more than 50 workers not offering ESHI (employer mandate); and free public insurance through Medicaid for poor individuals. This environment is considered as the benchmark in the optimal design analysis in Section 6.

These policy components are modeled as follows. First, the IHI market is regulated as HIX implemented under the ACA where there is a single plan offered in the HIX, the generosity of which is the same as the "silver plan" specified under the ACA.[27] There is no medical underwriting in HIX so that $\delta^D(\mathbf{x_t}) = 0$. The premium in HIX is regulated as a modified community rating so that it can vary

[27] Although there are also bronze, gold, and platinum plans, which differ in generosity, currently most enrollees in HIX choose silver plans because cost-sharing subsidies are offered only for silver plans. Extending to multiple plans (e.g., Handel et al. (2015)) is left to future research.

only based on individual age. Finally, assume that HIX is a competitive individual health insurance market.[28] In equilibrium, the premium is determined so as to satisfy the break-even condition:

$$\sum_{\mathbf{x_t}} R^{HI}(t) \int g\left(\mathbf{x_t}, \theta, 0\right) hi_1\left(2|\mathbf{x_t}, \theta, 0\right) d\theta = \left(1+\xi_{HIX}\right) \sum_{\mathbf{x_t}} \mathbb{E}[\tilde{m}_0^{\mathbf{x_t}}|HI_t=2] \int g\left(\mathbf{x_t}, \theta, 0\right) hi_1\left(2|\mathbf{x_t}, \theta, 0\right) d\theta, \quad (23)$$

where the left-hand side is the total premium paid by individuals purchasing health insurance from HIX, and the right-hand side is the total expected medical expenditure by those individuals multiplied by the loading factor ξ_{HIX}.[29] Age-based regulation determines the maximum premium ratio (MPR) between the oldest and the youngest ω_{AGE} so that $\omega_{AGE} R^{HI}(1) = R^{HI}(T)$.

Subsidies in HIX and the individual mandate affect individuals by changing the budget constraint:

$$C_t = \max\left\{\tau_w(w_t)P_t + (1-P_t)b - OOP^{HI}(z_t m_t, y) - \mathbf{1}(HI=0)IM(y) - R^{HI}(t) + \mathbf{1}(HI=2)S^{HIX}\left(y, R^{HI}(t)\right), \underline{c}^{HI}\right\},$$

where $S^{HIX}\left(y, R^{HI}(t)\right)$ is income-based premium subsidies to an individual with income y purchasing health insurance from HIX at premium $R^{HI}(t)$ and $IM(y)$ is the penalty to individuals who remain uninsured, which just depends on income under the ACA. The out-of pocket-expenditure becomes a function of income because of coinsurance subsidies in HIX. Moreover, I assume that individuals may also be eligible for Medicaid ($HI = 3$), which provides full insurance with no premium, depending on their incomes. It is important to note that, under the pre-ACA economy, the model considers the members of population who do not have access to Medicaid. Thus, this policy change captures the effect of the Medicaid expansion, which makes more people eligible under the ACA.[30]

For the firm side, the introduction of an employer mandate changes the profit function to

$$\Pi_O(p) = \max_{\theta_O^{ed}} \sum_{\mathbf{x_t}} \left(y_{\mathbf{x_t}}(p) - (1+\tau_f) w_{\mathbf{x_t}}^O(\theta_O^{ed}) - \mathbb{E}[\tilde{m}_O^{\mathbf{x_t}}]O\right) l\left(\mathbf{x_t}, \theta_O^{ed}, O\right) - \xi_{ESHI} O - EM\left(\sum_{\mathbf{x_t}} l\left(\mathbf{x_t}, \theta_0^{ed}, 0\right)\right)(1-O)$$

where $EM(l)$ is the tax penalty amount, which depends on firm size l.

The definition of the steady-state equilibrium is a straightforward extension of the equilibrium under the pre-ACA economy. Specifically, it includes premiums in HIX $\left\{R^{HI}(t)\right\}$ as equilibrium objects. Insurance premiums must satisfy equation (23).[31] Note that it is assumed that the ACA is

[28] See Hackmann et al. (2015) and Handel et al. (2015) for similar assumptions. Although I do not consider imperfect competition, I calibrate the loading factor in HIX to bind to the minimum loss ratio regulation, which is the premium under the maximum markup rate in an economy with imperfect competition.

[29] Note that the non-employed are not included in this calculation because they are covered by Medicaid.

[30] In practice, public disability insurance also provides health insurance coverage via Medicare. Studying the implications of health care reforms on disability insurance is an interesting future topic.

[31] Because the insurance market structure is similar to that in Akerlof (1970), there are concerns about the presence of multiple equilibria. Given the numerical algorithm I discussed in the Appendix D, numerically I always find one equilibrium given the policy parameters partly because the model includes rich dimensions of individual heterogeneity. Such an approach leads to a reasonable prediction for the impact of the ACA (see Section 5.3).

not budget neutral with respect to the pre-ACA government budget. Although it is not difficult to model it as a budget-neutral policy by adjusting the income tax, I believe this choice is appropriate in my setting because the major revenues for financing the current ACA likely come from populations outside of this model economy: the elderly through changes in Medicare reimbursement rates and families making more than $250,000 through the Medicare payroll tax on investment income.

I consider two versions the ACA: the "partial ACA" or "ACA 2015" in Section 5.3 where policy parameters are chosen according to the ACA implemented in 2015, which is used for the model validation; and the "full ACA" in Section 6.2 where all the policy parameters are chosen at the full implementation of the ACA, which is used as a benchmark to explore the optimal policy designs. Appendix G explains in detail the choice of functional form and the parameterization of those ACA policies.

2.5 Discussion about Modeling Assumptions

Several comments about modeling assumptions are in order. First, although the model is much richer along many dimensions than existing characterizations in the literature, it also has certain limitations. The model abstracts from various insurance channels possibly available under the pre-ACA economy to individuals, such as saving, borrowing, or spousal insurance coverage, mainly because of computational complexities.[32][33] These omissions may overpredict the value of ESHI or IHI, which may bias estimates of structural parameters such as risk aversion. In Section 5.3, I show that the impact of the ACA in the model is largely consistent with the early impact of the ACA seen in the data. Section 6.3 also discusses that the key mechanisms determining the welfare impacts of policy designs are not affected by the presence of saving and borrowing options. Thus, although these assumptions are important limitations, I believe that they will not be crucial, at least for the qualitative conclusion from my analysis.

Moreover, several labor market channels are not captured in this paper. Although I explicitly incorporate public insurance as implicit insurance through the consumption floor, I do not consider the segment of the population who were already eligible and enrolled in Medicaid under the pre-ACA economy.[34] Thus, the model captures the impact of ACA's Medicaid expansion on those populations who were ineligible for Medicaid before. Assessing the ACA may be problematic if the pre-ACA Medicaid population, who are mostly non-employed, start working after the ACA and affect the equi-

[32] In ongoing work, Fang and Shephard (2018) extend the work of Aizawa and Fang (2013, 2018) to incorporate joint household search and study the impact of the ACA on spousal health insurance provisions.

[33] As an additional robustness exercise, I also experimented with the specification that the consumption floor is age-dependent so that older individuals may have access to other means to insure medical expenditure risks. Overall, this specification does not alter the main implications of the paper. Those results are available upon request.

[34] I made this choice because modeling Medicaid eligibility is rather complicated under the pre-ACA: it substantially varies by state. It is still possible to add these samples by modeling a simple approximated eligibility rule. In a recent work, Aizawa and Fu (2019) study the efficiency of Medicaid designs by exploiting pre- and post-ACA variations of Medicaid eligibility across states.

librium wage and ESHI offers. Also, the model does not make a distinction between full-time and part-time jobs, which may be important in understanding the labor market effects of the ACA. At this stage, several studies find little impact of the ACA on the flow from the pre-Medicaid eligible individuals to other coverage (Frean et al. (2016)) and on full-time/part-time compositions (Pinkovskiy (2015), Moriya et al. (2016)). Given the focus on interactions between ESHI and HIX, as a first step, I believe that this omission will not be crucial for my analysis.[35]

3 Data

The estimation of the model requires rich information about labor markets, health, and health insurance. This paper exploits three data sets: (1) the 2004 Survey of Income and Program Participation (SIPP); (2) the 2004-2007 Medical Expenditure Panel Survey (MEPS); and (3) the Kaiser Family 2004-2007 Employer Health Benefit Survey (Kaiser). I choose the data period 2004-2007 because estimating the model using data after 2008 is not ideal for several reasons. First, the Great Recession generated dramatic changes in the labor market. Second, possibly because of the ACA's policy announcement effect, there was a sharp jump in the ESHI offer rate in 2010, which disappears after 2011. It is difficult to capture these short-term fluctuations with the model characterizing only a steady state.

I use the SIPP for individual-level labor market outcome and associated health status, health insurance coverage status, and demographic information. The SIPP interviews individuals every four months up to twelve times, so that an individual may be interviewed over a four-year period. Thus, it can measure the dynamics of insurance coverage driven by labor market mobility, a key driver determining insurance status under the pre-ACA economy. I merge the core module with the topical module that contains health status information. The self-reported health status is used as the health measure in this paper.[36] Although it is not a perfect measure of true health status, it still accounts for significant variation in medical expenditure (Section 5.2).

A problem with using the SIPP data for my estimation is the lack of information about total medical expenditure. To obtain this information, I use the household component of MEPS, a set of large-scale annual rotating panel surveys. This component collects detailed information about an individual's demographic characteristics, use of medical services, charges and source of payments, access to care, satisfaction with care, health conditions, health insurance coverage, income, and employment.

Firm-side information about the ESHI offering status and associated firm characteristics was obtained from Kaiser. Kaiser is an annual survey of the nation's private and public firms with three or more workers. The survey contains information about firm characteristics (e.g., firm size and industry), categorical information about employee demographics (e.g., age and annual wage), and health

[35] Of course, understanding why this impact is small is itself a very interesting research question.

[36] In both SIPP and MEPS, the self-reported health status has five categories. I categorize "Excellent," "Very Good," and "Good" as Healthy (H) and "Fair" and "Poor" as Unhealthy (U).

insurance (e.g., ESHI offering status, plan type, employee eligibility, and enrollment).

I construct the estimation sample for the individual side as follows. I first match samples in the core module with the topical module. I restrict the sample to men between 25 and 59 years old. I keep individuals who are not in school, are not self-employed, do not work in the public sector, do not engage in military service, and do not receive any government welfare benefits or social security income. I restrict the sample to individuals who are uninsured, covered by IHI or ESHI in their own name. To reduce the impact of outliers, I drop the observations with wages above the top 1% or below the bottom 1%. Finally, I drop the observations with missing health insurance and labor market information. As a result, the sample size for the SIPP data is 8,794. Similarly, the sample size for the MEPS data is 17,952. For the firm-side data of Kaiser, I restrict the sample to firms that belong to the private sector and have at least three employees, leaving 18,593 observations.[37]

	Mean	Std. Dev
SIPP 2004		
Fraction of workers who are college graduates	0.45	0.50
Average worker age	40.76	9.31
Fraction of insured through ESHI	0.77	0.42
Fraction of insured through IHI	0.02	0.16
Fraction of uninsured	0.20	0.40
Average four-month wage for employed workers, in $\$10,000$	1.75	1.14
... for employees with ESHI	1.92	1.14
... for employees with IHI	1.64	1.34
... for employees without HI	0.87	0.54
Employment rate	0.92	0.27
Fraction of healthy individuals	0.93	0.24
.... among insured	0.95	0.21
... among uninsured	0.88	0.33
MEPS 2004-2007		
Average worker age	41.03	9.82
Fraction of healthy individuals	0.91	0.28
Fraction of uninsured	0.22	0.41
Annual medical expenditure, in $\$10,000$	0.25	0.91

Table 3: Summary statistics: SIPP 2004 and MEPS 2004-2007

Table 3 reports the descriptive statistics of worker-side data from SIPP 2004 and MEPS 2004-2007. In the data, 77% of the population have ESHI coverage, whereas only 2% have IHI. The magnitude of IHI enrollees is very small because most IHI enrollees in the pre-ACA economy were self-employed, who are outside of the estimation sample. The average wage of workers with ESHI is higher than those with IHI and the uninsured. Moreover, insured workers are healthier than the uninsured. Many demographic variables in SIPP and MEPS look very similar. Table 4 provides descriptive statistics for the firm-side data from Kaiser 2004-2007. In general, large firms tend to

[37]The data also show that 90% of firms consist of a single establishment in the estimation sample.

	all firms		firms offering ESHI		firms not offering ESHI	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Average firm size	20.82	53.87	29.64	67.73	7.89	12.30
ESHI offer rate	0.59	0.49	0.57	0.50	0.93	0.25
Average frac. workers more than age 26	0.84	0.21	0.86	0.15	0.80	0.27
Average frac. workers annual wages $\leqq$ \$21,000 or less	0.21	0.31	0.12	0.23	0.33	0.36
Average frac. workers annual wages \$50,000 or more	0.23	0.28	0.27	0.29	0.18	0.26

Table 4: Summary statistics: Kaiser 2004-2007

offer ESHI. Moreover, firms offering health insurance tend to employ a larger share of high-income employees and a larger share of older workers.

4 Estimation

4.1 Identification and Empirical Specification

This section starts by discussing the identification of key parameters. Given the focus on the interaction between health insurance and labor markets, the main elements for my analysis are the demand for health insurance by individuals and the cost of providing health insurance by firms. Although every parameter can possibly affect all of them, the key parameters are risk aversion, γ_τ, the consumption floor, $\underline{c}^{HI}$, the standard deviation of IHI preference shock σ_{IHI}, productivity loss due to bad health, α_h, and parameters related to ESHI costs (σ_f, ξ_{ESHI}). The parameters $\left(\gamma_\tau, \underline{c}^{HI}, \sigma_{IHI}\right)$ mainly affect the demand for health insurance, while the parameters $(\alpha_h, \sigma_f, \xi_{ESHI})$ mainly affect the incentives of offering ESHI.

To gain intuition for how we separately identify those parameters, it is important to recognize that $\left(\gamma_\tau, \underline{c}^{HI}, \sigma_{IHI}\right)$ affect worker-side moments differently in the model. First, note that the consumption floor $\underline{c}^{HI}$ largely affects the demand of health insurance among low income population, who are likely to bind to the consumption floor when incurring large medical expenditures. Thus, the fraction of uninsured among low-income employed (e.g., wage difference between insured and uninsured) helps us to identify $\underline{c}^{HI}$. Next, note that the preference shock parameter σ_{IHI} helps us to generate the smooth relationship between wages and IHI status; otherwise, the model will have a stark prediction. Thus, this parameter is identified by the slope between the wage and IHI take-up rate in the data (e.g., wage difference between uninsured and insured with IHI by education and age cohort). Finally, the risk aversion γ_τ determines the value of health insurance. Thus, it is identified by the overall insured rate, as well as the rate of worker's labor market transitions which involve change in insurance status and the wage variations behind these worker transitions.[38] The parameters $(\alpha_h, \sigma_f, \xi_{ESHI})$ will be identified by the data variation related to the ESHI offer rate and wages. First, α_h has an additional

[38]Note that fitting various moments of the joint distribution of the IHI take-up and wage (e.g., higher-order moments or by education) helps us to identify the heterogeneity of risk aversion across types, which is correlated with education.

effect on the differences in wages offered by firms, depending on ESHI offerings, which affects the health composition. This motivates us to target the wage difference between jobs with ESHI and jobs without ESHI to identify α_h. The other two parameters (σ_f, ξ_{ESHI}) are identified through the variation in the relationship between the ESHI offer rate and firm size. Specifically, the firm-size independent fixed cost ξ_{ESHI} is identified from the proportion of small firms offering health insurance; the scale parameter σ_f is identified by the slope of increasing ESHI offering probability by firm sizes.[39]

The identification of the remaining parameters follows the approach in the existing literature. The labor market structure in the model follows labor search and life-cycle labor supply models, and the identification of those models with similar data settings is surveyed by French and Taber (2011). The specification of health and medical expenditure largely follows empirical life-cycle models with health (e.g., Blau and Gilleskie (2008), Khwaja (2010) and De Nardi et al. (2016)). Labor market friction parameters $(\lambda_u^{\mathbf{x_t}}, \lambda_e^{\mathbf{x_t}}, \delta^{\mathbf{x_t}})$ are identified by fitting worker transition data.[40] By following Bagger et al. (2014), I make the restriction that friction parameters are only education and type specific: $\lambda_u^{\mathbf{x_t}} = \lambda_u^{ed,\tau}$, $\lambda_e^{\mathbf{x_t}} = \lambda_e^{ed,\tau}$, and $\delta^{\mathbf{x_t}} = \delta^{ed}$.[41] Individual skill characteristics are identified by fitting the level of and changes in wages. I normalize the mean of firm productivity distribution μ_p as zero because it is difficult to separately identify from constant terms in the individual skill function. The standard deviation of the firm productivity distribution σ_p is disciplined to fit both the cross-sectional wage and firm size distribution. The parameters for the latent medical expenditure shock, health transition process, and disutility from bad health, η_h^τ, are identified by the medical expenditure and health transition rate. An identification approach for η_h^τ is similar to De Nardi et al. (2016) when they identify medically needy parameters. I exploit the variation in the fraction of positive medical expenditure by insurance status conditional on the current health status: it will be informative to identify η_h^τ because health care utilization is a choice variable that may affect future health status. By conditioning on current health, it controls the standard reverse causality that it affects the medical expenditure to a large extent. As discussed in Section 6.2, the model predicts a relationship between health status and insurance coverage, consistent with Oregon experimental studies.[42]

As discussed in the literature, estimating parametric models causes concerns about the credibility of counterfactual analyses via the possibility of model misspecification. To address this issue, Section

[39] In Online Appendix A.2, I conduct the sensitivity analysis following Andrews et al. (2017) to show that different moments have different influences on estimates of model parameters.

[40] Note that, as discussed in Section 2.5, the model also incorporates the preference shock to work to guarantee the continuous offer distribution. This preference shock may also affect worker transitions. As in many labor supply models, the identification of the preference shock parameter relies on exclusion restriction. Note that labor market friction parameters do not depend on wage or ESHI provisions. On the other hand, the labor market transitions induced by the preference shock depend on the previous job's wage and ESHI: as seen from equations (11) and (12), workers in low-value jobs are more likely to quit into non-employment. Thus, the preference shock parameter can be identified by the variation of labor market transitions across employment contracts in the previous job.

[41] Although allowing more flexible labor market transition parameters can improve the model fit, it also requires much more time for the estimation. I believe these restrictions will not be crucial for my counterfactual analyses.

[42] Note that this variation is different from the Rand experiment, which shows that changes in the medical expenditure generated by the variation in health insurance plan generosity among the insured is not associated with future health.

5.3 conducts an out-of-sample validation test by utilizing the early impact of the ACA in the data.

4.2 Estimation Strategy

Estimation is by the method of simulated moments (MSM). Specifically, a weighted average distance between sample moments and simulated moments from the model is minimized with respect to the model's parameters. The weights are the inverses of the estimated variances of the moments. The details of the estimation algorithm are in Appendix F.

The choice of moments is guided by the identification discussion in Section 4.1 and is summarized as follows. Each worker-side moment is a conditional moment by education and age cohort: (M1) labor market status and its dynamics: (a) employment rate; (b) transition rate from non-employment to employment with ESHI or no-ESHI jobs; (c) job-to-job (JJ) transition rate conditional on before-after ESHI status (ESHI or no-ESHI); (d) transition rate from employment with ESHI or no-ESHI jobs to non-employment; (M2) wage and health insurance: (a) the distribution of insurance status among both employed and non-employed; (b) mean and standard deviation of wage change through JJ conditional on before-after ESHI status; (c) mean and standard deviation of wage by health insurance status; (d) mean and standard deviation of wage change of job stayers by job's ESHI offering status; (e) mean and standard deviation of wage among previously unemployed workers, conditional on job's ESHI offering status; (M3) health and medical expenditure: (a) health status conditional on employment and health insurance status; (b) annual health transition conditional on health; (c) annual health transition conditional on health and health insurance status; (d) annual medical expenditure conditional on health; (e) annual medical expenditure conditional on health and health insurance; (f) the fraction of zero medical expenditure conditional on health and health insurance; (M4) firm-side moment: (a) the fraction of firms with less than 50 workers; (b) ESHI offer rate by whether firm size is less than 50 workers; (c) mean firm size conditional on ESHI offering status.[43]

Certain model parameters are selected without using the model. I set the discount factor $\beta = 0.99$ because the annual interest rate is about 3%.[44] The population growth rate n is estimated using the SIPP 2004 sample by running a regression of cohort size on age and $n = 1.0005$ per four-month period. The after-tax income schedule is specified by following Kaplan (2012), who approximates the U.S. income tax code as $\tau_w(w) = \tau_0 + \tau_1 \frac{w^{(1+\tau_2)}}{1+\tau_2}$. I estimate the parameters using NBER TAXSIM with SIPP 2004-2007 samples. The details of the procedure and the estimate are in the Appendix E. The firm's payroll tax τ_f is approximated as linear in wage and is set as 7.65%, which is the average employer contribution of Social Security (OASDI) and Medicare tax.[45] I specify that the age of the

[43] The interval of the age cohort for moments in (i) and (ii) is 7 years. Regarding (iii), I aggregate several cohorts into one group to have enough sample sizes without losing much interesting data variation, as shown in Section 5.2. Also, moments in (iii) related to health insurance status are by ESHI coverage because of the small sample size for IHI.

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

[45] See Social Security Administration, "OASDI and SSI Program Rates & Limits, 2007," https://www.ssa.gov/policy/docs/quickfacts/prog_highlights/RatesLimits2007.html. I ignore the presence of the

terminal period is 61, although it is possible to extend it to older ages. I assume that wages are subject to classical measurement error, with errors following a log-normal distribution with zero mean.

I parameterize the financial characteristics of insurance plans as follows. From Sommers and Crimmel (2008), who report the financial characteristics of representative ESHI plans for MEPS samples, I assume that the annual deductible for ESHI is \$700 and the coinsurance rate for ESHI is 18%. The financial characteristics of IHI are based on AHIP (2007): I parameterize that the deductible for IHI is \$750 and the coinsurance rate is 25%, which is the median value of the most popular PPO options. Moreover, I parameterize that the rejection rate is a function of age only, $\delta^D(\mathbf{x_t})$=$\delta^D(t)$. Although one could model it to depend on current health, this specification will be a reasonable first-order approximation because medical underwriting is in practice based on the entire health history, not only on the current health condition, so that older individuals are likely to be rejected because they have a longer medical history. Indeed, AHIP (2007) shows that the rejection rate around age 22 is 9.3% but increases to 28.7% around age 60.[46] Using the data from the age-based rejection rate from AHIP (2007), I assume that the rejection rate is monotonically increasing so that it is 9.3% at age 22 and then increases 0.5 percentage point every year. Finally, the premium for IHI is estimated with MEPS 2004-2007 as a flexible function of age and health. The details are in Appendix E.

5 Estimation Results

5.1 Parameter Estimates

Table 5 shows selected structural parameter estimates. All the estimated parameters are reported in Tables A1-A3 in Appendix A.1. Table 5 shows that the CARA coefficient is very heterogeneous across different types.[47] For example, if we convert this coefficient into relative risk aversion (RRA) by multiplying it by income, it will be around 0.5 for low-income type 2 workers and 4.2 for high-income type 1 workers. The magnitude of estimates falls into the standard estimates in the consumption/saving literature as well as the health insurance literature.[48] The consumption floor available to the uninsured is estimated to be \$100 per four months.[49] I also find a large disutility from bad health for type 1 individuals. The coefficient of the interaction between the disutility from working and bad health is strongly positive, implying that old, unhealthy individuals suffer higher disutility

cap for maximum taxable wages for simplicity in this analysis.

[46]Note that the proportion of the unhealthy does not increase as drastically over ages, indicating that current health alone is a poor proxy for the insurance rejection.

[47]Note that I do not impose any restrictions in terms of the correlation of risk type with other characteristics such as labor market skills, health transition, and disutility from bad health. These correlations are estimated to fit the data.

[48]See, for example, Attanasio et al. (1999) and Cohen and Einav (2007).

[49]Note that this estimate is much lower than the estimates of the consumption floor in the literature, which tend to be around \$2,000-80,000 (see, e.g., De Nardi et al. (2016)). This is because consumption floor is very context specific: many life-cycle models of the elderly, such as De Nardi et al. (2016), consider that this captures payments from Medicaid and other welfare payments. In this model, it captures uncompensated care, such as charity care, which is only available to the uninsured. This contributes to the substantially small estimate of this parameter.

from working than the young. The proportion of type 1 individuals among college graduates is much larger than that among non-college graduates. Table 5 also reports some key firm-side parameters. It is shown that the fixed cost of offering ESHI is estimated to be $1,800 per four months. Moreover, the productivity loss of being unhealthy, α_h, is -0.37, which means that unhealthy workers produce around 70% of the output of healthy workers.

Parameter	Estimates	Std. Error
individual-side parameters		
CARA coeff. for type 1: γ_{τ_1}	1.40	(0.008)
CARA coeff. for type 2: γ_{τ_2}	0.85	(0.005)
consumption floor: $\underline{c}^0$	0.01	(0.0004)
disutility from bad health for type 1: $\eta_h^{\tau_1}$	0.27	(0.006)
disutility from bad health for type 2: $\eta_h^{\tau_2}$	0.08	(0.001)
disutility from work: $\tilde{\eta}_p$	0.0005	(3.5E-06)
disutility from work for unhealthy: $\tilde{\eta}_{hp}$	0.003	(2.4E-05)
standard deviation of preference shock to purchase IHI: σ_{IHI}	0.01	(0.0002)
frac. of type 1 among college graduates: $\Pr(\tau_1 \mid C)$	0.74	(0.008)
frac. of type 1 among non-college graduates: $\Pr(\tau_1 \mid NC)$	0.19	(0.007)
firm-side parameters		
fixed cost of providing ESHI (in $10,000): ξ_{ESHI}	0.18	(0.0005)
scale parameter for the cost of providing ESHI: σ_f	0.30	(0.001)
productivity effect of bad health : α_4^U	-0.37	(0.005)

Table 5: Selected structural parameters estimates
Note: (a) the unit of time t is four months. (b) the disutility from work and the disutility from work for the unhealthy are specified as ($\eta_{pt} = \tilde{\eta}_p \max\{t - \bar{t}, 0\}$) and $\eta_{hpt} = \tilde{\eta}_{hp} \max\{t - \bar{t}, 0\}$, where $\bar{t}$ is fixed as age 45.

The parameter estimates for labor market skill, health transition, labor market frictions, and latent medical expenditure shocks are reported in Appendix A.1. I summarize some of the important features as follows. First, the health transition process differs substantially between type 1 and type 2 workers: type 1 workers are more likely to transition to being healthy in the next period relative to type 2 workers. Moreover, it has a significant age dependence in that older individuals are likely to be unhealthy. Regarding labor market skill, an important finding is that type 1 workers, who are more risk averse and are more likely to be healthy, are more productive than type 2 workers. Furthermore, particularly among college graduates, type 1 individuals have much higher job offer arrival rates than type 2 individuals, which helps to account for the degree of wage differences between jobs with ESHI and jobs without ESHI across education status, as seen in Table 7.[50]

Therefore, our estimates imply that older and thus more experienced workers will have a higher demand for health insurance because they are more likely to transition to being unhealthy. Moreover, higher-skilled individuals (in terms of both education and unobserved type) will also have a higher

[50] On average, the magnitude of labor market friction parameters is lower than that in Low et al. (2010), who estimate a similar life-cycle on-the-job search model. This is because our model period is longer than their model period, which misses high frequent labor turnover. However, the ratio of the job arrival rate for the employed to the job destruction rate, which is often considered as an important source of labor market frictions, is very similar.

demand for health insurance given their risk preferences. Finally, they are more likely to end up working at high-productivity firms because they have received more job offers over time. This gives an incentive to those high-productivity firms to offer ESHI, as discussed in Section 2.3.1.

5.2 Model Fit

This section discusses the model fit for most salient features of the data. Table 6 shows the pattern of health insurance coverage status over ages. The model is able to account for their life cycle features in the data, such as a positive correlation between the ESHI coverage rate and age, regardless of education group and the flat IHI coverage rate over ages. Table 7 is the average wage conditional on health insurance status, age, and education group. In the data, there is a positive correlation between wage and age for individuals with health insurance. The wage-age slope for the uninsured, however, is rather flat. Furthermore, wage differences between the insured and uninsured are much larger for college graduates than for non-college graduates. In general, the average wage of the insured with IHI is somewhere between the wage of those with ESHI and the uninsured. The model is able to generate a positive association between age, wage, and ESHI because workers move up to high-productivity firms, through on-the-job search over the life cycle, and those firms tend to offer ESHI and can also post higher skill prices to attract workers. The model can generate an average wage for workers with IHI higher than the wage for the uninsured because those low-income uninsured workers are provided implicit public insurance through the consumption floor. Quantitatively, the model somewhat underpredicts the average wage for older workers with IHI, partly because of the relatively small sample size for IHI holders. Overall, the model can account for wage and health insurance status over the life cycle across education groups.

	College graduate				Non-College graduate			
	Data		Model		Data		Model	
Age	ESHI	IHI	ESHI	IHI	ESHI	IHI	ESHI	IHI
25-31	0.87	0.03	0.77	0.01	0.61	0.02	0.74	0.01
32-38	0.91	0.02	0.84	0.01	0.73	0.01	0.79	0.01
39-45	0.91	0.02	0.87	0.01	0.77	0.02	0.81	0.01
46-52	0.91	0.02	0.90	0.02	0.81	0.02	0.83	0.02
53-59	0.88	0.04	0.88	0.03	0.81	0.03	0.79	0.04

Table 6: Health insurance coverage rate among all workers: model vs. data

Table 8 reports the model fit for the pattern of health status conditional on insurance and employment status. Employed workers with ESHI are the healthiest; the employed who do not have ESHI are less healthy, and the non-employed are the least healthy. The model can generate this pattern because health insurance leads to more health care utilization, improving future health. The model can also account for the small fraction of healthy workers among the non-employed because unhealthy workers have a higher disutility of work. Table 9 shows the model fit for the health transition rate. The data demonstrate a stark difference in health transitions between college graduates and non-college

	College graduate						Non-College graduate					
	Data			Model			Data			Model		
Age	ESHI	IHI	uninsured	ESHI	IHI	uninsured	ESHI	IHI	uninsured	ESHI	IHI	uninsured
25-31	1.87	1.25	0.97	1.89	1.55	1.08	1.28	1.07	0.78	1.15	1.17	0.82
32-38	2.28	2.06	1.08	2.18	1.84	1.14	1.44	1.21	0.92	1.30	1.36	0.92
39-45	2.43	1.99	1.08	2.37	1.58	1.19	1.60	1.38	0.92	1.43	1.11	0.96
46-52	2.34	2.05	1.03	2.45	1.55	1.18	1.59	1.46	0.87	1.52	1.20	0.98
53-59	2.39	2.56	1.04	2.44	1.41	1.14	1.52	1.73	0.73	1.56	1.16	0.87

Table 7: Wage distribution: model vs. data (the unit is $10,000 in four-months)

	College graduate		Non-College graduate	
Employment Status	Data	Model	Data	Model
Emp. with ESHI	0.94	0.95	0.90	0.89
Emp. w/o ESHI	0.88	0.90	0.84	0.87
Nonemployed	0.71	0.77	0.64	0.63

Table 8: Health status: model vs. data

graduates. The model explains this pattern as being due to the introduction of an unobserved type, which is correlated with education status.[51] Table 10 shows how well the model fits medical expenditure patterns conditional on health status and health insurance status. Regardless of health status, the insured spend more than the uninsured. Although the model underpredicts the level of medical expenditure among the uninsured-unhealthy mainly because of the small sample size problem, it captures the overall pattern of the data reasonably well. Finally, Table 11 shows that the model fits well for firm-side moments, such as the coverage rate and firm size distributions, because of the mechanisms discussed in Section 2.3.1.[52]

5.3 The Model Validation: Comparison with the Early Impact of the ACA

I perform an out-of-sample validation exercise exploiting the actual ACA impact. Table 12 shows the comparison between the predicted impact of the ACA from the model and the actual impact of the ACA in 2015 from the data. I postpone explaining the underlying mechanisms of these outcomes to Section 6.2. The ACA in 2015 includes the provisions of subsidies in HIX. However, the key differences between the ACA 2015 and the full ACA studied in Section 6.2 are as follows: (a) lower tax penalties on the uninsured and on large firms in 2015; and (b) because only 60% of the states follow the ACA's Medicaid provision, it is assumed that Medicaid is offered with a probability of 60% for the eligible population. I use the American Community Survey for the uninsured and employment

[51]The transition rate from unhealthy to unhealthy in the data is not smooth over ages because of the small sample size.
[52]The fit for the remaining targeted moments is available on request.

	College graduate				Non-College graduate			
	Data		Model		Data		Model	
Age	$H \to H$	$U \to U$	$H \to H$	$U \to U$	$H \to H$	$U \to U$	$H \to H$	$U \to U$
25-31	0.98	0.20	0.96	0.27	0.97	0.17	0.92	0.28
32-38	0.99	0.18	0.96	0.29	0.96	0.40	0.91	0.35
39-45	0.97	0.50	0.96	0.30	0.95	0.37	0.91	0.37
46-52	0.97	0.11	0.96	0.27	0.93	0.44	0.93	0.41
53-59	0.94	0.38	0.95	0.35	0.87	0.49	0.90	0.49

Table 9: Health transition: model vs. data

	Insured				Uninsured			
	Data		Model		Data		Model	
Age	healthy	unhealthy	healthy	unhealthy	healthy	unhealthy	healthy	unhealthy
25-39	0.13	0.52	0.05	0.43	0.04	0.22	0.01	0.06
40-49	0.22	0.54	0.21	0.75	0.07	0.30	0.11	0.36
50-59	0.42	0.90	0.36	0.86	0.18	0.35	0.18	0.27

Table 10: Medical expenditure: model vs. data (the unit is $10,000 in annual terms)

rates and the report from the Department of Health and Human Services status for HIX enrollment (Department of Health and Human Services (2015)). The firm-side-data are from Kaiser. I compare the differences between 2012 and 2015. A caveat for this comparison is that the model only considers the steady state and ignores the business cycle effects or transitory effects of the ACA, which may show up in the data.

The first and second columns in Table 12 show the overall changes in the data. The uninsured rate decreased from 25% in 2012 to 18% in 2015. Interestingly, the number of male enrollments in HIX among individuals aged 55-64 is 0.94 million, which is 35% more than the number of male enrollees aged 26-34 (0.69 million) (Department of Health and Human Services (2015)). The non-employment rate has few changes, which are also documented in the literature (see references in Section 2.5). Regarding firm-side statistics, the ESHI offer rate decreases from 56% to 51%, which is mainly concentrated among small firms.[53] The third and fourth columns in Table 12 show the corresponding changes of outcomes in the model between the pre-ACA and the 2015 ACA. Because the pre-ACA model targets the 2007 economy, the model in general underpredicts the level of the uninsured rate and non-employment rate. However, the magnitude of changes predicted from the model is largely consistent with the data. Moreover, it can account well for the magnitude of the age difference of participants in HIX, which is a focus of this paper. Thus, the above evidence supports the model's ability to evaluate alternative health insurance systems.

[53] The MEPS insurance component also reports the ESHI offer rate, and its publicly available aggregate statistics show the same trend pattern in the ESHI offer rate as the one in Kaiser.

	Data	Model
Average establishment Size	20.82	20.71
... for those that offer health insurance	29.64	30.20
... for those that do not offer health insurance	7.89	8.61
The frac. of firms having less than 50 workers	0.93	0.88
Health insurance Coverage Rate	0.59	0.56
... for those having less than 50 workers	0.56	0.51
... for those having more than 50 workers	0.93	0.91

Table 11: Model fit for firm-side moment

	Data: pre-ACA (2012)	Data: post-ACA (2015)	Model: pre-ACA	Model: 2015 ACA
Uninsured rate	0.25	0.18	0.21	0.12
$\frac{\text{age 55-64 male HIX enrollment}}{\text{age 26-34 male HIX enrollment}}$	-	$1.35\left(=\frac{0.94\text{million}}{0.69\text{million}}\right)$	-	1.25
Non-employment rate	0.11	0.10	0.07	0.07
ESHI offer rate	0.56	0.51	0.56	0.55

Table 12: The early impact of the ACA: the comparison between 2015 data and counterfactual experiment from the model based on 2015 policy scale of the ACA ("ACA 2015" or "partial ACA")
Note: Because the age of the terminal period is 61 in the model (Section 4.2), I adjust the number of HIX enrollments at age 62-64 to be the same as age 59-61 for this calculation.

6 Designing the Health Insurance System

This section studies the optimal design of the health insurance system. First, I define the government problem. Next, I conduct comparative statics of ACA policies to display various mechanisms. Then, I describe results from the optimal joint design of individual insurance regulations and the optimal joint design of individual insurance and ESHI policies. Although the model can be used to evaluate a more global optimal design of the health insurance system, I focus on the most relevant policy instruments.

6.1 The Government Problem

The government chooses a combination of health insurance policies, $\mathbf{T_{HI}}$, to maximize social welfare $SW(\mathbf{T_{HI}})$ subject to government revenue under the full ACA, EXP^{ACA}:[54],[55]

$$\max_{\mathbf{T_{HI}}} SW(\mathbf{T_{HI}}) \text{ subject to } EXP(\mathbf{T_{HI}}) \geq EXP^{ACA}. \tag{24}$$

[54]It is important to note that both the social welfare function and budget constraints are smooth functions with respect to the policy parameters because of the preference shock to purchase IHI. Thus, one can numerically solve this problem using a derivative-based nonlinear optimization (with nonlinear inequality constraints) solver.

[55]Note that one can also choose a different objective function, such as to minimize the number of uninsured individuals subject to the government budget balance. Given the policy instrument considered in this paper, it leads the government to impose an extremely high tax penalty on the uninsured, which effectively achieves universal coverage. Thus, it is more appropriate to jointly consider social welfare as a criterion in this exercise.

Specifying the social welfare function can be done in several ways. By following the standard approach used in the social insurance and optimal taxation literature, I assume that the government is utilitarian and the social welfare function is the ex-ante lifetime utility of newborn individuals:[56]

$$SW(\mathbf{T_{HI}}) = \sum_{\mathbf{x_0}} V(\mathbf{x_0})u\left(\mathbf{x_0}\right).$$

The government expenditure $EXP(\mathbf{T_{HI}})$ is given by

$$EXP(\mathbf{T_{HI}}) = RV_{tax}(\mathbf{T_{HI}}) + RV_p(\mathbf{T_{HI}}) - EXP_{sub}(\mathbf{T_{HI}}),$$

where $RV_{tax}(\mathbf{T_{HI}})$ is the revenue from the income and payroll tax, $RV_p(\mathbf{T_{HI}})$ is the revenue from tax penalties (mandate) imposed on individuals and firms, and $EXP_{sub}(\mathbf{T_{HIX}})$ is subsidies for health insurance, which consist of the expenditure on the premium subsidies to HIX and Medicaid.[57] In Appendix H, I show how each of these terms is derived. Note that this formulation does not consider implicit public insurance for the uninsured through the consumption floor as government expenditure. If the provisions of charity care were considered as a government expenditure, uncompensated care could generate negative externalities to the insured, a point explored in several recent studies (e.g., Finkelstein et al. (2019)). In Appendix H, I also investigate the optimal policy design assuming that uncompensated care is a government expenditure and find that the main result in this section remains qualitatively the same. [58]

6.2 ACA Policies: Aggregate and Heterogeneous Impacts

To proceed with the analysis of optimal designs, it is useful to conduct comparative statics to understand the mechanisms behind how each policy affects outcomes and their interplays, at both the aggregate and individual levels.[59] Table 13 shows the outcomes of several aggregate variables from simulating the full ACA and a variety of its combinations. The impact of the full ACA is reported in Column (2). The uninsured rate decreases from 21% to 5%; 10% of individuals have health insurance from HIX. The Medicaid provision also substantially reduces the uninsured rate by covering 7% of non-employed workers. Compared with the ACA 2015 presented in Table 12, the decline in the uninsured rate is much more significant because the full ACA has larger tax penalties and expands Medicaid nationally (see Section 5.3and Appendix G for details). Almost no unhealthy individuals

[56]See Conesa et al. (2009) and Einav et al. (2010), for a similar choice of welfare function. Of course, one can experiment with different social welfare weights or use a more sophisticated approach proposed by O'dea (2018).

[57]Medicaid provides full insurance, and therefore $S^M\left(\mathbf{x_t}\right)$ is equal to the expected medical expenditure.

[58]Note that this paper does not ask what are the government preferences (or the social weight) that rationalize the choice of health care policies in the last decade. Studying the political economy behind the implementation of health care reforms is an interesting area of research.

[59]Note that there are two distinct features of evaluating the ACA relative to the previous works (e.g., Aizawa and Fang (2013, 2018)). First, the model produces rich heterogeneous impacts of the ACA, as well as their general equilibrium interactions. Second, the analysis also incorporates an additional major ACA policy instrument such as age-based pricing regulation.

are among the uninsured after the ACA because those unhealthy individuals can obtain health insurance either from HIX or from Medicaid. Because more individuals are insured, the average medical expenditure per capita also increases by 12%. The government's total revenue per capita declines by 5% because of subsidies to HIX and the Medicaid provision.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	pre-ACA	ACA	ACA w/o IM	ACA w/o Subs	ACA w/o EM	ACA w/ MPR = 1	ACA w/ MPR=5	ACA w/o Medicaid
Panel A: Effects on the Firm Side								
ESHI offer rate: firm size$\geq$50	0.91	0.97	0.93	0.99	0.96	0.93	0.97	0.94
ESHI offer rate: firm size$<$50	0.51	0.50	0.50	0.53	0.50	0.50	0.50	0.50
ESHI offer rate (average)	0.56	0.55	0.55	0.59	0.55	0.55	0.55	0.55
Labor productivity	2.48	2.48	2.48	2.49	2.48	2.48	2.48	2.48
Output per capita	1.95	1.95	1.95	1.95	1.94	1.94	1.95	1.95
Panel B: Effects on Worker's Health Insurance and Labor Market Status								
Uninsured rate	0.21	0.05	0.14	0.11	0.06	0.07	0.045	0.12
Frac. ind. with ESHI	0.77	0.78	0.77	0.82	0.78	0.77	0.78	0.78
Frac. ind. with IHI	0.01	0.10	0.02	0.00	0.09	0.10	0.10	0.10
Non-employment rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Average wage	1.63	1.62	1.62	1.63	1.62	1.62	1.62	1.62
Panel C: Effects on Worker's Other Outcomes								
medical expenditure per capita	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
HIX premium for the youngest	-	0.04	0.08	0.32	0.04	0.11	0.028	0.04
Frac. unhealthy workers	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Frac. unhealthy uninsured	0.17	0.00	0.02	0.09	0.00	0.00	0.00	0.19
Panel C: Effects on Government Revenue (Per Capita, all in $10,000):								
Revenue from income tax	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Subsides to HIX & Medicaid	-	0.03	0.03	0.02	0.03	0.03	0.03	0.004
Revenue from penalties	-	0.002	0.001	0.003	0.002	0.002	0.001	0.01
Total revenue	0.66	0.63	0.63	0.64	0.63	0.63	0.63	0.65

Table 13: Counterfactual policy experiments: the "full" ACA and its alternatives

Notes: Column (1) reports the statistics generated under the pre-ACA economy; Column (2) is about the (full) ACA; Column (3) is about the ACA without the individual mandate; Column (4) is about the ACA without premium subsidies in HIX; Column (5) is about the ACA without the employer mandate; Column (6) is about the ACA with the maximum premium ratio (MPR) in HIX being set to be 1; Column (7) is about the ACA with MPR=5; Column (8) is about the ACA without Medicaid expansion; all variables represented by monetary amounts are four-month-level amounts ($10,000).

Quantitatively, the main change in the labor market is asymmetric responses of ESHI offer rates by firm size. The ESHI offer rate among large firms increases from 91% to 97%, while the ESHI offer rate with fewer than 50 workers decreases from 51% to 50%. Large firms increase the ESHI offer rate because of the employer mandate, which applies only to firms with more than 50 workers. On the other hand, small firms lower the ESHI offer rate because of the income-based premium subsidies of HIX, as those firms tend to be low-productivity firms and post lower skill prices. Interestingly, aggregate labor productivity (the ratio of output over the employed), output, and employment show little change as a consequence of a variety of forces. First, employment and labor productivity may increase if an increase in health insurance coverage raises the number of healthy individuals: it lowers the disutility of work and the productivity loss from bad health.[60] Moreover, HIX allows individuals to choose jobs without considering whether they offer ESHI (i.e., there is a reduction in job lock and job push). However, because individuals can gain Medicaid without working, employment might be reduced. Moreover, because the ACA design of premium subsidies and pricing regulation lowers the effective price for low-income and older individuals, those populations may now prefer jobs that do not offer ESHI. Thus, they may not take a job offering ESHI even if they are more productive, which may lower labor productivity. These forces counteract each other, leading to a very modest impact on employment and labor productivity.

Figures 1 and 2 display outcomes at the individual level. Figure 1 shows the uninsured rate among the employed over the life cycle by education status. First, for both education groups, we observe the decline in the uninsured rate at all ages. Interestingly, the fraction of the uninsured among individuals older than 55 is close to zero, and there is a huge drop in the number of uninsured people in low-education groups. Figure 2 shows the take-up rate of HIX and the fraction of ESHI coverage over the life cycle. The take-up rate is defined as the ratio of the number of individuals purchasing HIX over the number of individuals who have neither ESHI nor Medicaid coverage. The take-up rate has an interesting U-shape: it is high for young individuals, then decreases with age, and then increases again starting at age 40.[61] In general, young individuals have less incentive to purchase health insurance from HIX because they tend to face an actuarially unfair premium: they tend to be healthy, and they are partially pooled with old individuals because of the MPR. However, the youngest individuals have an incentive to take up HIX because of the age-independent tax penalties. The take-up rate initially decreases with age because of the premium increase. But it increases again because the fraction of unhealthy individuals, who demand health insurance the most, increases with age. Moreover, although the fraction of ESHI coverage under the ACA is larger than the one under the pre-ACA for most age groups, this difference disappears as age increases. Indeed, it is slightly lower for the oldest individuals. Because the ACA's HIX design is attractive to the old and low-income populations, they tend to sort into jobs without ESHI.

In order to understand the role of each policy instrument and their interactions, I report the aggregate impacts under various different combinations of the ACA in Columns (3)-(8) of Table 13. The ACA without the individual mandate increases the uninsured rate from 5% in the ACA to 14% because the number of individuals in both ESHI and HIX decreases. Moreover, the ESHI offer rate among large firms also decreases. The ACA without premium subsidies also increases the uninsured rate to 11%. The coverage through HIX is close to zero, indicating that adverse selection eliminates HIX without subsidies. Contrary to the case of the ACA without the individual mandate, the fraction of individuals with ESHI, as well as firms' ESHI offer rate, are higher than the ones under the ACA.

[60] See Finkelstein et al. (2012) for evidence from randomized experiments in Oregon that people who are newly insured through Medicaid improve their self-reported health status.

[61] Note that under the ACA 2015, the model generates a take-up rate that increases with age because tax penalties are small, which can be inferred from Figure 3.

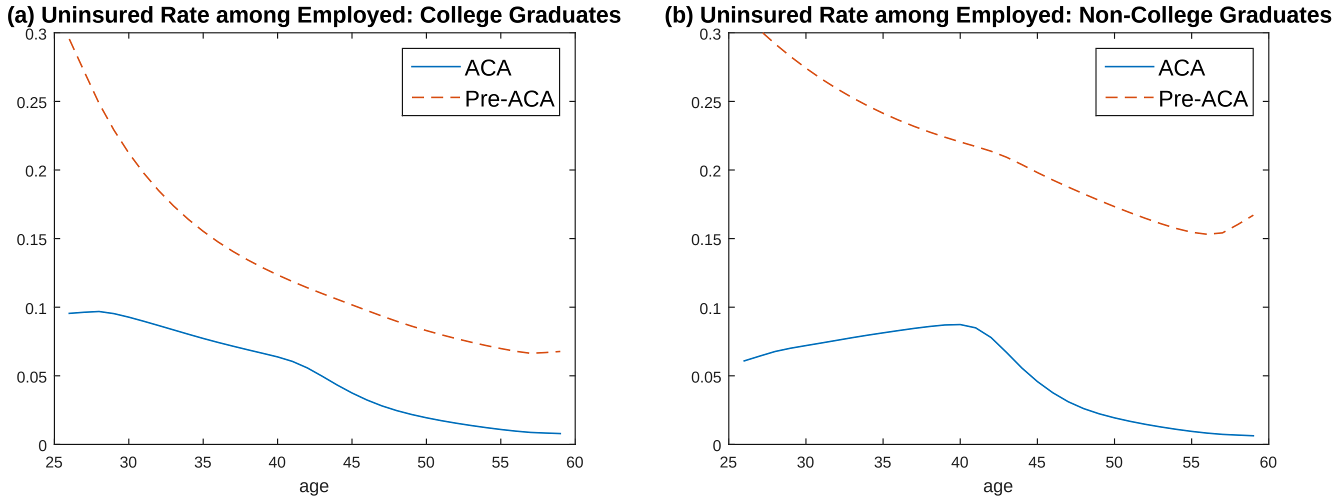

Figure 1: Uninsured rate among employed over the life cycle by education

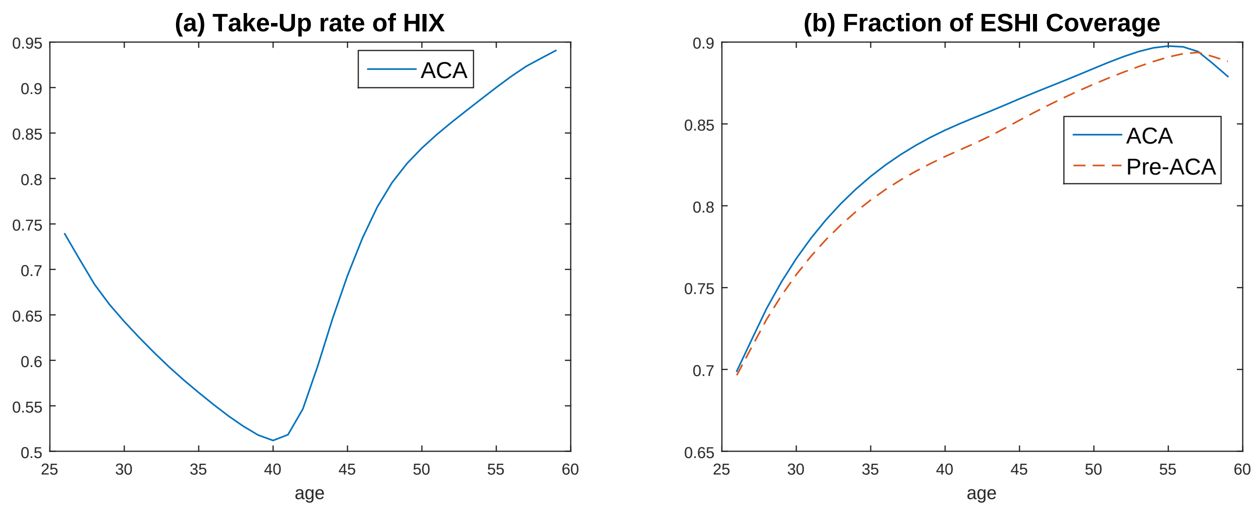

Figure 2: Take-up rate for HIX and the fraction of ESHI coverage
Note: The take-up rate for HIX is defined as the fraction of individuals purchasing health insurance from HIX among those who have neither ESHI nor Medicaid.

The ACA without the employer mandate has an uninsured rate similar to the ACA. It decreases the ESHI offer rate among large firms from the ACA, although the ESHI offer rate is still higher than the one under the pre-ACA because the individual mandate increases the ESHI offer rate. The maximum premium ratio (MPR) also has an significant impact on the uninsured rate. The ACA with MPR set to 1 substantially increases the uninsured rate, from 5% in the ACA to 7%. Interestingly, the ACA with MPR set to 5 has a lower uninsured rate compared with the ACA.

Figure 3 shows heterogeneous impacts under different policy combinations. First, the ACA without the individual mandate leads to a higher uninsured rate than the ACA for all age groups, as well as a lower take-up rate in HIX and lower ESHI coverage. Because the individual mandate lowers the value of being uninsured, individuals have more incentive to have health insurance regardless of the source of coverage. This also gives firms an incentive to offer ESHI. As a result, the individual man-

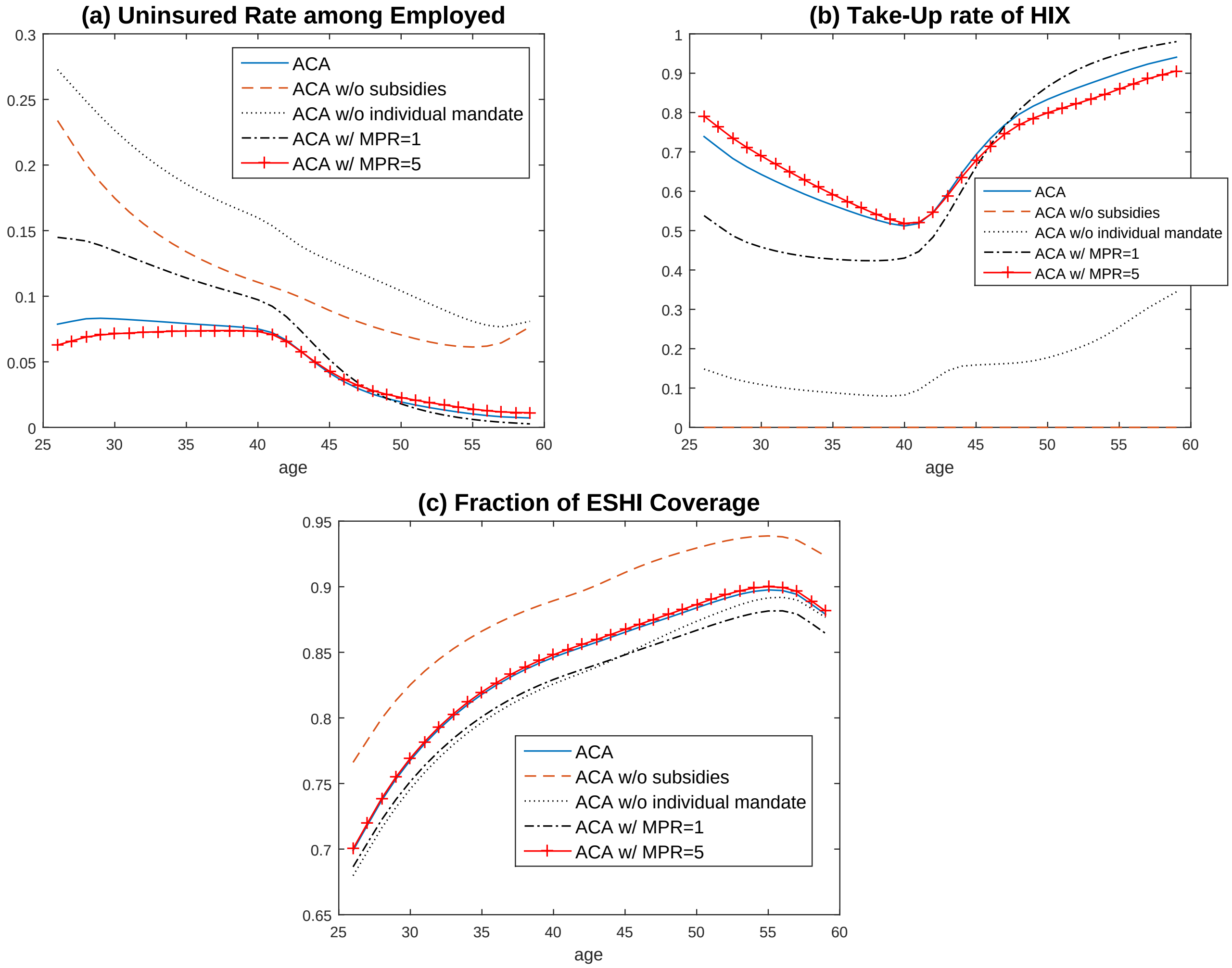

Figure 3: Evaluating ACA policy instruments on uninsured, HIX take-up, and ESHI coverage rates

date increases both the HIX take-up rate and ESHI coverage. The removal of tax penalties essentially eliminates the U-shape pattern of the take-up rate because the tax penalty is the channel for allowing the youngest individuals to participate in HIX. Second, the ACA without premium subsidies has a higher uninsured rate than the ACA and an almost zero take-up rate. Contrary to the case of the ACA without the individual mandate, there is a substantial increase in ESHI coverage: because HIX is less attractive due to adverse selection but individuals want to avoid paying penalties, individuals prefer a job with ESHI, indicating that premium subsidies have a substitution effect regarding the choice of ESHI and HIX. Subsidies make individuals leave the ESHI pool because they are available only through HIX. Such a substitution effect does not arise from the individual mandate. Interestingly, age-rating regulation has an important allocation role. The "ACA with MPR=5" has a lower uninsured rate for almost all the groups including older individuals, as well as a higher take-up rate and a lower ESHI coverage rate than the ACA. The take-up rate has a U-shape, as evident in the ACA. This pattern is substantially different from the "ACA with MPR=1," where all the patterns are opposite. To understand the mechanisms, it is useful to look at the changes in premiums. The "ACA with MPR=5" has a lower premium than the "ACA with MPR=1" for most age groups. The key mechanism is that if the MPR is set high, it makes HIX attractive to younger individuals, increasing their participation. Because younger individuals are healthier, it improves the risk pool, which can even lower the insurance premium that older individuals face. Finally, like ACA, these policies have little impact on labor productivity and employment, but they have an important impact on ESHI coverage, which has implications for coverage rates and government expenditure.

These findings indicate the importance of accounting for labor market sorting to evaluate the designs of the health insurance system. It is important to note that, given the small impact on labor productivity, one can see that these policies have modest effects on job-to-job transition rates or the labor market sorting per se.[62] However, as shown above, the presence of the labor market sorting, which affects the composition of workers across firms, determines how health insurance policies affect ESHI provisions, the sorting patterns in health insurance markets, and government expenditure.

6.3 The Optimal Joint Design of Individual Insurance Regulations

As the first main analysis, I consider the optimal joint design of three individual insurance regulations, $\mathbf{T_{HI}} = \{\omega_{AGE}, S^{HIX}, IM^{II}\}$: (1) age-based pricing regulation ω_{AGE}, (2) premium subsidies S^{HIX}, and (3) a tax penalty on the uninsured IM^{II}.[63] Specifically, ω_{AGE} determines the MPR between the youngest and the oldest in HIX, which was 3 under the ACA. The premium subsidies and tax penalty are specified as a flexible, polynomial function of age t and income y: $S^{HIX}\left(y, t, R^{HIX}(t)\right) = s^{HIX}(y,t)R^{HIX}(t)$ and $IM^{II} = IM^{II}(y,t)$.[64] I consider that the government can condition premium subsidies and tax penalties on individual age for the following reasons. First, insurance premiums in HIX are, to some extent, pooled across individuals with different ages because of the age-based pricing regulation. Second, I find in Section 6 that there is a sharp difference in the impact of the ACA across different age groups. In optimizing these parameters, I hold fixed other policy instruments introduced by the ACA.

The optimal policy parameters are reported in Table 14. The main features of the optimal policy relative to the ACA scheme are: (a) it allows a larger MPR between the youngest and the oldest, $\omega_{AGE} = 4.94$, than the one under the ACA, $\omega_{AGE} = 3$; (b) conditional on the premium, premium subsidies decrease in age, whereas they are constant under the ACA; (c) on the other hand, the tax penalty to the uninsured (individual mandates) is flat over ages, and the magnitude is close to the minimum penalty imposed under the ACA. Essentially, the optimal policy makes it less beneficial for older individuals to purchase health insurance from HIX relative to younger individuals, compared

[62]The comparative statics results on the job-to-job transition rate are available on request. Note that the findings that health insurance policies themselves may have a small impact on job mobility are consistent with Dey and Flinn (2005).

[63]I do not consider the possibility that the government simultaneously adjusts the income tax rate. Doing so would complicate the interpretation of the results because it may be affected by the optimality of the current income tax system.

[64]Note that I specify that the ACA policy parameters take particular values under this functional form, as explained in Appendix G.

with the policies under the ACA.

	(1)	(2)	(3)	(4)
	ACA	Optimal	Optimal: subsidies & MPR only	Optimal: subsidies only
Policy Parameters for Premium Rating Regulation				
MPR: ω_{AGE}	3.00	4.94	4.70	3.00
Policy Parameters for Premium Subsidies				
const. term of subsidy: ω_a^s	4.08	3.48	3.86	4.06
income coeff. of subsidy: ω_b^s	-3.88	-1.75	-2.05	-2.10
income squared coeff. of subsidy: ω_c^s	-1.15	-0.001	-0.001	-0.001
age coeff. of subsidy: ω_d^s	0.0	-0.0215	-0.024	-0.026
age squared coeff. of subsidy: ω_e^s	0.0	-0.000	-0.000	-0.000
Policy Parameters for Tax Penalties on the Uninsured				
const. term of penalty: ω_a^I	0.03	0.031	0.03	0.03
income coeff. of penalty: ω_b^I	-0.002	0.00	-0.002	-0.002
income squared coeff. of penalty: ω_c^I	0.003	0.00	0.003	0.003
age coeff. of penalty: ω_d^I	0.0	0.00	0.0	0.0
age squared coeff. of penalty: ω_e^I	0.0	0.00	0.0	0.0
Welfare gain (%)	-	5%	5%	5%

Table 14: Optimal joint design of individual insurance regulations

Note: (a) ω_{AGE} determines the MPR. (b) Subsidies are parameterized as $S^{HIX}\left(y,t,R^{HIX}(t)\right) = \frac{\exp(\omega_a^s+\omega_b^s y_t+\omega_c^s y_t^2+\omega_d^s t+\omega_e^s t^2)}{1+\exp(\omega_a^s+\omega_b^s y_t+\omega_c^s y_t^2+\omega_d^s t+\omega_e^s t^2)} R^{HIX}(t)$. (c) Tax penalties are parameterized as $IM^{II}(y,t) = \omega_a^I + \omega_b^I y_t + \omega_c^I y_t^2 + \omega_d^I t + \omega_e^I t^2$.(d) The amount of welfare gain is measured by the dollar amount of per capita lump-sum transfers given to all individuals in the pre-ACA economy to achieve the same level of utility under economy with the optimally chosen policies, and it is reported as the percentage of medical expenditure under the ACA ($\approx \$2,700$). (e) In implementation, the youngest age in the model takes $t = 1$ and the unit of t is four months, ranging in $t \in [1, \ldots 132]$. (f) Column (1) reports the policy parameters under the full ACA. (g) Column (2) reports the policy parameters under the optimal joint design of individual insurance regulations. (h) Column (3) reports the main policy parameters under the optimal joint design of individual insurance regulations with the restriction that the tax penalty imposed on the uninsured is the same as in the full ACA. (i) Column (4) reports the main policy parameters under the optimal joint design of individual insurance regulations with the restriction that both the tax penalty imposed on the uninsured and the MPR are the same as in the full ACA.

Column (2) in Table 15 reports the outcome under the optimal joint design of individual insurance regulations. First, it shows that the uninsured rate is now 2.7%, which is substantially lower than the one achieved under the full ACA (5%). Enrollment in HIX increases dramatically, from 10% to 16%, while ESHI coverage decreases by 3 percentage points. Thus, the increase in HIX participants is partially due to the inflow from the ESHI pool. Given the MPR, it can be seen that the health insurance premium in HIX is lower for almost all age groups than it is under the ACA. Second, the ESHI offer rate also decreases, particularly among relatively less productivity firms, while the magnitude does not change among firms with very high productivity and very large firms. Third, there is little impact on other labor market outcomes. Fourth, the risk pool in HIX improves significantly, consisting of much healthier individuals. In order to measure the welfare gain relative to the ACA, I assume that the government provides a lump-sum transfer to all individuals in the ACA economy. I find that the ACA will achieve the same level of utility as the optimal if the government provides the transfer, which is \$135 annually per capita. The transfer corresponds to 5% of the medical expenditure. This additional government expenditure eventually contributes to an increase in the overall government expenditure

	(1)	(2)	(3)	(4)
	ACA	Optimal	Optimal: subsidies & MPR only	Optimal: subsidies only
Panel A: Effects on the Firm Side				
ESHI offer rate: firm size≥50	0.97	0.92	0.92	0.92
ESHI offer rate: firm size<50	0.50	0.49	0.49	0.49
ESHI offer rate (average)	0.55	0.54	0.54	0.54
Labor productivity (in $10,000)	2.48	2.48	2.48	2.48
Panel B: Effects on the Worker Side				
Uninsured rate	0.05	0.027	0.03	0.03
Frac. ind. with ESHI	0.78	0.75	0.75	0.75
Frac. ind. with HIX	0.10	0.16	0.15	0.15
Non-employment rate	0.07	0.07	0.07	0.07
HIX premium for the youngest (in $10,000)	0.04	0.026	0.028	0.04
Frac. unhealthy among ind. with HIX	0.086	0.067	0.069	0.069

Table 15: The Aggregate outcomes under the optimal joint design of individual insurance regulations
Notes: (a) Column (1) reports the main aggregate outcomes under the full ACA. (b) Column (2) is under the optimal joint design of individual insurance regulations. (c) Column (3) is under the optimal joint design of individual insurance regulations with the restriction that the tax penalty imposed on the uninsured is the same as in the full ACA. (d) Column (4) is under the optimal joint design of individual insurance regulations with the restriction that both the tax penalty imposed on the uninsured and MPR are the same as in the full ACA.

of 1%, which is substantial.

Columns (3) and (4) report the optimal structure if we restrict the policy spaces. Column (3) reports the optimal design result where individual mandates are the same as in the ACA. Column (4) reports the optimal premium subsidies assuming that both the individual mandates and the maximum premium ratio are set the same as in the ACA. The qualitative feature of the optimal subsidies schemes will be similar to the one under Column (2). Overall, these results confirm that the major source of the welfare gain relative to the ACA is from the more flexible subsidies designs.

Figure 4 shows the life-cycle patterns of the uninsured rate, the take-up rate of HIX, and ESHI coverage. First, the uninsured rate is lower than the ACA in almost all age groups. Similarly, the take-up rate increases substantially for almost all age groups. The substantial increase in the take-up rate among young individuals contributes to improving the risk pool in HIX. Note that the uninsured rate has a hump-shaped pattern, so that it is low for young individuals, then slightly increases with age, and then decreases again.[65] However, given the very small variation in the increase of the uninsured rate among the youngest groups (less than 2 percentage points), the general feature of the outcome is a significant reduction in the uninsured rate among the young population from the ACA. Second, although the fraction of ESHI coverage decreases in all age groups, the decline is much more modest for older individuals, indicating that they still maintain coverage through ESHI. Instead, younger individuals are more likely to switch to HIX to gain coverage.

An important feature of the optimal structure is that while premium subsidies are substantially

[65]This pattern is driven by the fact that premium subsidies are largest for the young and are decreasing in age, while the fraction of unhealthy individuals, who demand health insurance the most, increases with age. These opposing forces lead to the hump-shaped pattern in the figure.

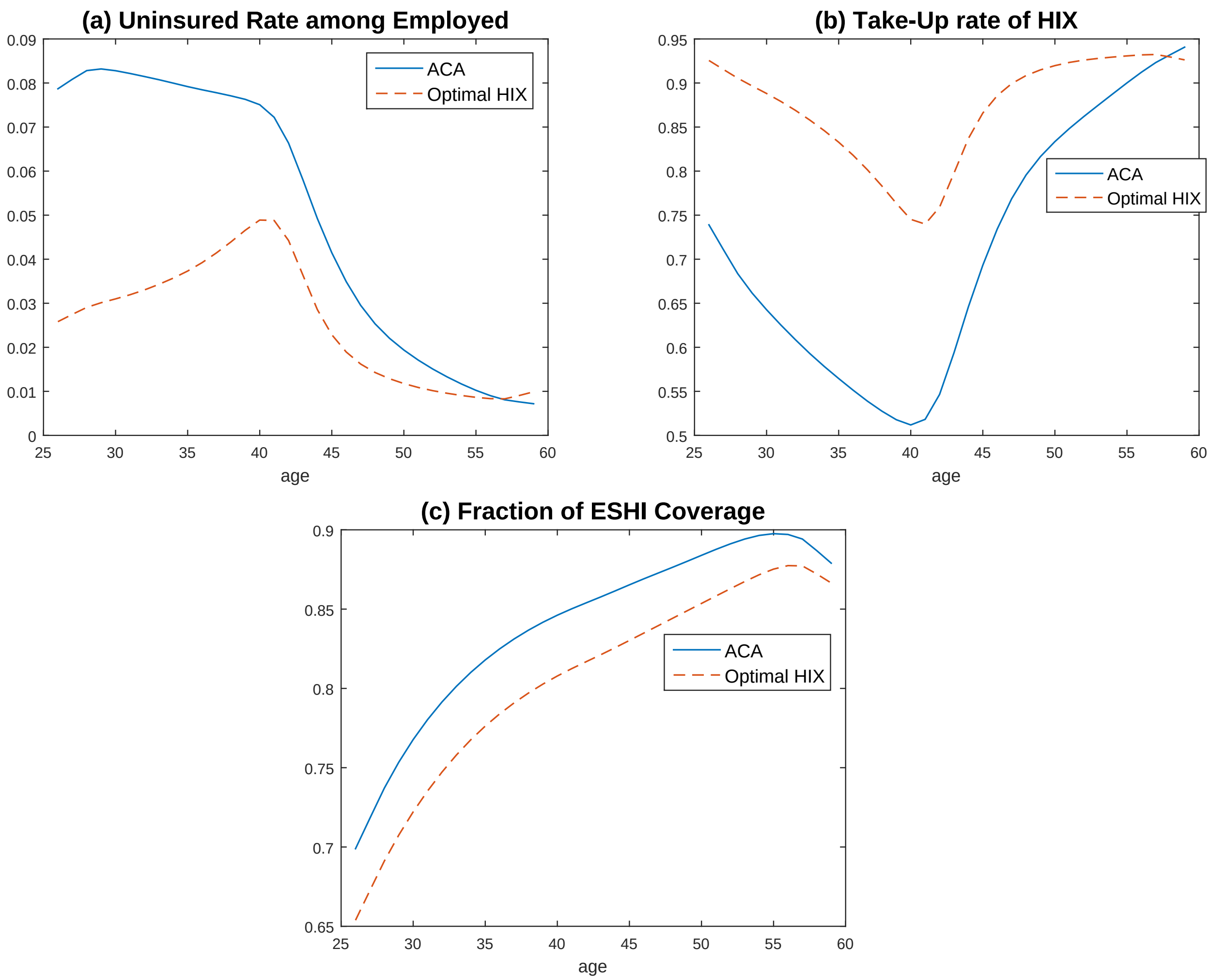

Figure 4: Implication of optimal joint design of individual insurance regulations (optimal HIX) on the uninsured, HIX take-up, and ESHI coverage rates

decreasing in age, tax penalties are not. This difference shows that premium subsidies and individual mandates are not perfect substitute policies. Both larger subsidies and higher tax penalties give individuals more incentives to obtain health insurance. However, while larger subsidies give individuals an incentive to purchase health insurance from HIX rather than obtain health insurance from employers, higher penalties do not directly give such an incentive to individuals. Therefore, in order to give an incentive to old individuals to obtain health insurance from employers, premium subsidies are set to decrease in age. This differential impact of the premium subsidies and tax penalties has not been pointed out in existing works that study HIX designs because they do not consider ESHI. This indicates the importance of accounting for ESHI provisions, even for understanding how to jointly determine individual market regulations.[66]

[66]It is important to note that the model is able to jointly determine the optimal age-based rating regulation and the optimal age-dependent subsidies and penalties. The actual pricing variation of premiums due to the age-based rating regulation is subject to the break-even condition of HIX, which determines the average premium. On the other hand, subsidies or individual mandates are not directly subject to the break-even condition. Thus, they are not identical.

The optimal structure lowers the risk of being uninsured in almost all age groups and changes the sorting of workers between HIX and ESHI. Intuitively, the government wants to smooth access to and the premium for health insurance over individual life cycles. To achieve this goal, three features of the model lead to age-dependent policies in the optimal design. The first channel is the heterogeneity of the availability of ESHI, which is determined in the labor market. Because older individuals stay in the labor market longer than the young, they are more likely to experience receiving a job offer with ESHI at some point during their life cycle. This pattern is seen as the positive correlation between ESHI coverage and age in the model. Thus, even if old individuals face a higher cost of obtaining health insurance from HIX, they can still gain coverage from ESHI. On the other hand, the insurance status of the young is affected more by the cost that they face with HIX because they are less likely to have ESHI. Hence, providing more subsidies to the young greatly lowers the risk of being uninsured over the life cycle.

Second, the additional participation of young individuals affects the health insurance premium in HIX for older individuals through their partial pooling in HIX. Because young individuals are likely to be healthy, their participation can also slightly lower the health insurance price that older individuals face. Thus, the chance that older individuals will obtain health insurance is not significantly reduced.

Third, through the endogenous responses of the ESHI provisions, the sorting of workers between HIX and ESHI changes. Low-productivity firms, which tend to have a greater number of younger workers because of labor market sorting, decrease the ESHI offer rate and allow their workers to take advantage of obtaining health insurance from HIX at a lower cost. That is, the presence of labor market sorting influences the policy responses of ESHI provision, which affects the sorting pattern in health insurance markets. This adjustment itself does not have much of an effect on the uninsured rate, but it does change the composition of risk pools across insurance markets: the risk pool of HIX consists of a greater number of younger workers, whereas the risk pool of ESHI consists of a greater number of older workers. This contributes to improving the risk pool in HIX. Because older individuals are likely to work at high-productivity and very large firms that still offer ESHI, they still maintain coverage through ESHI.

To understand the quantitative significance of each mechanism, I recompute the optimal joint design of individual insurance regulations under the following constraints: (a) fix the offer distribution of the compensation package at the ACA values; (b) fix the HIX premium (and MPR) at the ACA values; (c) fix both the offer distribution of the compensation package and the HIX premiums at the ACA values. In this exercise, I fix the individual mandate policy parameters at the ACA value. If I determine the individual mandate in case (c), zero penalties will be optimal because there is no impact on equilibrium prices. This generates a mechanical welfare gain, which is undesirable for a meaningful comparison. Here, I only report the implications for major outcome variables and welfare in Table 16; the optimal policy parameters are reported in Table A5 in Appendix H.2. As shown in Column (3) of Table 16, I first find that the welfare gain is much more modest if the ESHI offer rate is not adjusted. This is interesting given that the uninsured rate is similar to the full optimal

	ACA	Optimal	Fixed offer dist.	Fixed premium	Fixed offer dist. and premium
			Panel A: Effects on the Firm Side		
ESHI offer rate: firm size≥50	0.97	0.92	0.97	0.92	0.97
ESHI offer rate: firm size<50	0.50	0.49	0.50	0.49	0.50
ESHI offer rate (average)	0.55	0.54	0.55	0.55	0.55
Labor productivity (in $10,000)	2.48	2.48	2.48	2.48	2.48
			Panel B: Effects on the Worker Side		
Uninsured rate	0.05	0.027	0.03	0.04	0.03
The frac. ind. with ESHI	0.78	0.75	0.78	0.76	0.78
The frac. ind. with HIX	0.10	0.16	0.12	0.14	0.12
Non-employment rate	0.07	0.07	0.07	0.07	0.07
HIX premium for the youngest (in $10,000)	0.04	0.026	0.03	0.04	0.04
Frac. unhealthy among ind. with HIX	0.086	0.067	0.072	0.072	0.073
Welfare gain relative to the ACA (%)	-	5%	2%	3.5%	1.5%

Table 16: Disentangling mechanisms for the optimal joint design of individual insurance regulations

Notes: Each column reports the main aggregate and welfare outcomes with different policy parameters: (a) Column (1) is the full ACA. (b) Column (2) is the optimal joint design of individual insurance regulations. (c) Column (3) is the optimal joint design of individual insurance regulations with the restriction that the offer distribution of the compensation package is the same as in the full ACA. (d) Column (4) is the optimal joint design of individual insurance regulations with the restriction that the HIX premium is the same as in the full ACA. (e) Column (5) is the optimal joint design of individual insurance regulations with the restriction that the offer distribution of the compensation package and the HIX premium are the same as in the full ACA. (f) The amount of welfare gain is measured by the dollar amount of per capita lump-sum transfers given to all individuals in the pre-ACA economy to achieve the same level of utility under the economy with the optimally chosen policies and it is reported as the percentage of medical expenditure under the ACA ($\approx \$2,700$).

result (Column (2)). Thus, a large part of the welfare gain comes from changes in the worker sorting between HIX and ESHI. Column (4) reports the main result if the HIX premium is fixed as in the ACA. In this case, the uninsured rate is higher, indicating that the equilibrium premium response is important to determine the uninsured rate. Column (5) reports the case that both the ESHI offer rate and the HIX premium are fixed as the ACA values. It shows that the uninsured rate is still lower than the ACA, because younger individuals obtain premium subsidies, and they are more price sensitive. Overall, change in the sorting patterns between HIX and ESHI is the most significant.

One may wonder whether the welfare gain through age-dependent policies partially reflects the lack of borrowing and saving. If individuals are committed to staying with HIX over the life cycle, providing more subsidies to the young may generate a consumption-smoothing benefit over the life cycle, given the upward-sloping wage process through human capital accumulation. However, the above decomposition analysis suggests that such an effect is likely to be very limited. If it exists, it should be mainly captured by the case in Column (5), where there are no equilibrium effects. However, given the result in Column (5), such an effect can account for less than a third of the full welfare gain. The main reason is that individuals are not committed to staying with HIX while subsidies are only available at HIX. The young and old individuals who enroll with HIX are likely to be of different types. Thus, subsidies will not provide consumption smoothing for the same individuals.

6.4 The Optimal Joint Design of ESHI and Individual Insurance Policies

Given the above findings, the question is whether the government can further improve the existing system if it can simultaneously adjust its spending on ESHI, which currently takes a form of implicit subsidies through the tax exemption of ESHI. To investigate this possibility, I analyze the government problem that optimally chooses both premium subsidies in HIX and a tax credit for ESHI, $\mathbf{T_{HI}} = \{S^{HIX}, S^{ESHI}\}$. Specifically, I assume that the ESHI premium (per worker in each firm) is treated as taxable income and that the employed with ESHI receive a tax credit from the government, which is again a nonlinear function of age and income.[67] This changes the individual budget constraint to

$$\begin{aligned} C_t &= \tau_w(w_t + R^{ESHI}(p)\mathbf{1}(HI=1))P_t + (1-P_t)b - OOP^{HI}(z_t m_t, y_t) - \mathbf{1}(HI=0)IM(y) \\ &\quad -\mathbf{1}(HI=2)\left(R^{HIX}(t) - S^{HIX}\left(y, R^{HIX}(t), t\right)\right) + \mathbf{1}(HI=1)S^{ESHI}\left(y, R^{ESHI}(p), t\right), \end{aligned}$$

where $R^{ESHI}(p)$ is the expected medical expenditure of the average worker at firms with productivity p and $S^{ESHI}$is the tax credit to ESHI, which is specified as a polynomial function of the worker's age and income: $S^{ESHI}\left(y, R^{ESHI}(p), t\right) = s^{ESHI}(y,t)R^{ESHI}(p)$. I then solve the optimal design problem in (24) by simultaneously choosing S^{HIX} and S^{ESHI}. For simplicity, I fix the MPR and individual mandates as the value obtained as the optimal policy parameters in Section 6.3.

I report the aggregate outcomes and welfare impacts in Table 17 and the optimal structure in Table A6 in Appendix H.2. Qualitatively, the HIX policy components remain the same even if the government can determine tax credits to ESHI. The optimal structure of tax credits for ESHI decreases with income and increases with age. This system achieves a much larger welfare gain, around 11% of the medical expenditure. Interestingly, the optimal structure expands coverage through HIX but contracts ESHI coverage by substantially increasing subsidies in HIX. To understand this result, it is useful to recognize two important differences between HIX and ESHI: first, access to and the premium for health insurance from HIX are independent of labor market dynamics, whereas those for ESHI may change if individuals switch to another job or lose their current job. Thus, one benefit of expanding HIX is to offer protection against reclassification risks generated by labor market dynamics. On the other hand, HIX may be subject to adverse selection to a more significant extent than ESHI. Although changing insurance choices is relatively easy for individuals in the individual market, it is difficult for individuals with ESHI, especially in the frictional labor market, because they need to change jobs. This makes individuals commit to staying at jobs with ESHI, regardless of their health status, solving the adverse selection problem. Quantitatively, the optimal policy expands HIX because age-dependent subsidies in HIX already ameliorate adverse selection (Section 6.3).[68]

[67]Thus, subsidies enter directly into the budget constraint instead of implicit subsidies through the tax deductibility of ESHI in the pre-ACA.

[68]Note that a part of the welfare gain should reflect the progressive nature of the ESHI tax credit, which is now decreasing in income. This differs from the tax treatment of ESHI under the pre-ACA, which is regressive because higher-income individuals are more likely to obtain ESHI. However, given the relatively small magnitude of the ESHI tax credit, this redistribution channel itself is likely to be limited. Finally, the positive dependence of ESHI subsidies on age still gives

	(1)	(2)	(3)
	ACA	Optimal individual insurance regulation	Optimal: ESHI and individual insurance policies
		Panel A: Effects on the Firm Side	
ESHI offer rate: firm size≥50	0.97	0.92	0.85
ESHI offer rate: firm size<50	0.50	0.49	0.45
ESHI offer rate (average)	0.55	0.54	0.50
Labor productivity (in $10,000)	2.48	2.48	2.48
		Panel B: Effects on Worker's Health Insurance and Labor Market Status	
Uninsured rate	0.05	0.027	0.022
Frac. ind. with ESHI	0.78	0.75	0.61
Frac. ind. with HIX	0.10	0.16	0.29
Non-employment rate	0.07	0.07	0.07
Welfare gain (%)	-	5%	11%
		Panel C: Effects on the Government Revenue (per-capita, in $10,000)	
Revenue from income tax	0.66	0.66	0.68
Subsides to HIX & Medicaid	0.03	0.03	0.05
Revenue from Penalties	0.002	0.001	0.008
ESHI tax credit	-	-	0.008

Table 17: Aggregate outcomes under the optimal joint design of ESHI and individual insurance policies
Notes: (a) Column (1) reports the main aggregate outcomes under the full ACA. (b) Column (2) is under the optimal joint design of individual insurance regulations. (c) Column (3) is under the optimal joint design of individual insurance and ESHI.

Lowering ESHI subsidies is similar to introducing a Cadillac tax to ESHI plans, which will impose a tax on generous ESHI plans and will be implemented starting in 2022. The main lesson from this exercise is that these additional revenues can be used to finance subsidies in HIX, which expands individual markets and makes access to health insurance more stable over the life cycle.

7 Conclusion

In this paper, I study the optimal policy design in the context of the U.S. health insurance system where both employers and individual markets may offer insurance. I develop and estimate a life-cycle equilibrium labor market search model in which firms choose the ESHI provision and workers sort themselves into jobs with different compensation packages over the life cycle. I study the optimal joint design of major policies in the ACA and explore implications of tagging these policies according to individual characteristics. I find that the optimal structure lowers the tax benefit of ESHI and makes individual insurance more attractive to younger workers. Through changes in ESHI provisions, more young workers sort into individual markets, improving their risk pools and lowering the uninsured risk. Thus, an important lesson is that it is fruitful to look at the interaction between ESHI and individual insurance to assess health insurance system designs.

Obviously, this is a first step toward better understanding how to design the health insurance

incentives for older individuals to obtain health insurance through ESHI.

system. There are a number of promising avenues for future research. First, although the current analysis focuses on the joint designs of ESHI and individual insurance policies, it is also important to study how Medicaid should be designed. Aizawa and Fu (2019) explore the design issues of Medicaid by modeling geographical heterogeneity. Moreover, it is also important to investigate the welfare impact of health insurance programs by incorporating various additional channels (e.g., saving and borrowing) that are left out under the current framework.

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