Should There be Vertical Choice in Health Insurance Markets?*

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Abstract

The availability of choice over coverage level—"vertical choice"—is widespread in U.S. health insurance markets, but there is limited evidence of its effect on welfare. The socially efficient level of coverage for a given consumer optimally trades off the value of risk protection and the social cost from moral hazard. Providing choice does not necessarily lead consumers to select their efficient coverage level. It may in fact lead to the opposite. We show that in regulated competitive health insurance markets, vertical choice should be offered only if consumers with higher willingness to pay for insurance also have a higher efficient coverage level. We test for this condition empirically using a model of consumer demand for health insurance and healthcare utilization and administrative data from a large employer representing 45,000 households. We estimate substantial heterogeneity in efficient coverage level, but do not find that households with higher efficient coverage level have higher willingness to pay. Optimal regulation is therefore to offer a single coverage level. Relative to a status quo with vertical choice, offering only the optimal single level of coverage increases welfare by $302 per household per year. This policy shift makes the 81 percent of households with the highest willingness to pay better off.

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I Introduction

The availability of choice over financial coverage level—which we term "vertical choice"—is widespread in U.S. health insurance markets.[1] A leading example is the metal tier plans (e.g., Bronze, Silver, Gold) offered on Affordable Care Act exchanges. In contrast, national health insurance schemes typically offer only a single level of coverage. Regulation plays a central role in determining the extent of vertical choice, but the literature in economics provides limited guidance to regulators on this topic. In this paper we develop a theoretical and empirical framework for evaluating the welfare effects of vertical choice.

The argument in favor of vertical choice is the standard argument in favor of product variety: with more choices, consumers can more closely match with their socially efficient product by revealed preference (Dixit and Stiglitz, 1977). However, this argument relies critically on the condition that privately optimal choices align with socially optimal choices. In competitive markets in which costs are independent of private values, this alignment is standard. In markets with selection, this alignment may not be possible. Health insurance markets are classic examples of selection markets. Costs are inextricably related to private values, and asymmetric information prevents prices from reflecting marginal cost (Akerlof, 1970; Rothschild and Stiglitz, 1976). We show that even if such markets are competitive, regulated, and populated by rational consumers, whether more choices can lead to more efficient allocations is theoretically ambiguous.

Our welfare metric derives from the seminal literature on optimal health insurance, which holds that the efficient level of coverage equates the marginal benefit of risk protection and the marginal social cost of spending induced by insurance (Arrow, 1965; Pauly, 1968, 1974; Zeckhauser, 1970). We observe that the efficient level of coverage likely varies across consumers. Optimal regulation aims to design plan menus such that consumers self-select into their efficient level of coverage. The basic fact is that consumers with higher willingness to pay for insurance choose higher levels of coverage. However, a consumer with higher willingness to pay does not necessarily have a higher efficient level of coverage. It is precisely this statement that captures the theoretical ambiguity of whether vertical choice should be offered.

[1] Financial coverage level is determined by plan features such as deductibles and caps on out-of-pocket payments. Though it is currently common, vertical choice is a key point of differentiation among current federal policy proposals. The "Medicare for all" proposal endorsed by Bernie Sanders and Elizabeth Warren would not feature vertical choice, while the plan to introduce a public option to existing exchanges endorsed by Joe Biden and the "American Health Care Act" endorsed by Donald Trump would continue to do so.

We ask whether vertical choice should be offered from the perspective of a market regulator that can offer vertically differentiated plans and can set premiums.[2] The regulator's objective is to set premiums to maximize allocational efficiency of consumers to plans. As is standard in national health insurance schemes and employer-sponsored health insurance, consumer premiums need not equal plan average cost. If the regulator sets premiums such that more than one plan is demanded, we say it has offered vertical choice. Using a graphical framework in the spirit of Einav, Finkelstein and Cullen (2010), we show that the key condition determining whether vertical choice should be offered is whether consumers with higher willingness to pay have a higher efficient coverage level. The principal focus of this paper is to determine whether that is likely to be true.

We begin by presenting a model of consumer demand for health insurance, building closely on the models of Cardon and Hendel (2001) and Einav et al. (2013). The model features two stages. In the first stage, consumers make a discrete choice over plans under uncertainty about their health. In the second stage, upon realizing their health, consumers make a continuous choice of healthcare utilization. We use the model to show that willingness to pay for insurance can be partitioned into two parts: one that is both privately *and* socially relevant (the value of risk protection), and one that is only privately relevant (the value of expected insured spending). Because a portion of private benefit is just a transfer, it is not necessarily the case that higher willingness to pay implies higher social surplus. For example a very sick but risk neutral person obtains a large private benefit from higher coverage, but generates no social benefit. If she consumes more healthcare in response to higher coverage, the regulator would prefer she had lower coverage. The goal of the model is to capture heterogeneity across consumers in the determinants of private and social surplus generated by insurance.

We estimate the model using data from the population of public school employees in Oregon. The data contain the health insurance plan menu, plan choice, and subsequent healthcare utilization of over 100,000 employees and dependents between 2008 and 2013. Crucially for identification, we observe plausibly exogenous variation in the plan premiums and plan options offered to employees. This variation is driven by the fact that plan menus are set independently by each of the 187 school districts in the state, where districts select plans from a common superset determined at the state level. In addition, employees are

[2] By market regulator, we mean the entity that administers and operates a particular health insurance market. In employer-sponsored insurance, this is the employer; in Medicare, this is the Center for Medicare and Medicaid Services; in Norway, this is the Norwegian government. As we will discuss, the regulator can set premiums in a competitive market by strategically taxing and subsidizing plans, or can supply plans itself.

offered several different coverage levels by the same insurer with the same provider network, providing isolated variation along our focal dimension.

Our empirical model incorporates both observed and unobserved heterogeneity in three key dimensions of household type: health status, moral hazard, and risk aversion. We use the model to recover the joint distribution of household types in the population. For each household, we then construct willingness to pay for and the social surplus generated by different levels of coverage. We construct these objects for a set of coverage levels that span the range offered on Affordable Care Act exchanges. Each coverage level, or plan, is characterized by a deductible, a coinsurance rate, and an out-of-pocket maximum. The least generous plan we consider is a "Catastrophic" plan, with a deductible and out-of-pocket maximum of \$10,000. The most generous plan is full insurance.

We do not find that households with higher efficient coverage level have higher willingness to pay. Households with high willingness to pay are primarily so because of high expected insured spending, as opposed to a high value of risk protection. While they do tend to be more risk averse, they are so likely to hit their out-of-pocket maximum that they face little uncertainty over out-of-pocket costs. Households with low willingness to pay tend to be more prone to moral hazard and less risk averse, but also to face more uncertainty over out-of-pocket costs. We find that a single plan is on average the efficient coverage level across the entire distribution of willingness to pay. Optimal regulation is therefore to offer only this plan. Introducing any other plan leads to over- or under-insurance (on average) among households that would select the alternative. The optimal single plan has an actuarial value (AV) of 85 percent. Households' efficient coverage levels range between 70 percent AV and full insurance. There are no households for whom the efficient level of coverage is below 70 percent AV.

The first best allocation of households to plans generates \$1,796 in welfare per household per year relative to allocating all households to the Catastrophic plan. Because households with the same willingness to pay can have different efficient coverage levels, this allocation cannot be achieved unless premiums can vary by households' specific types. Under optimal regulation (the single plan), 31 percent of households are not allocated to their efficient coverage level. Nevertheless, we find that optimal regulation generates 96 percent of the social surplus of the first best allocation. Among plans near the optimal single plan, the welfare stakes of misallocation are small. Allocating all households to a 65 percent AV, 70 percent AV, 85 percent AV, and full insurance plan respectively generates 51, 92, 96, and

91 percent of first best social surplus. The value of risk protection is increasing in coverage level, but does so at a decreasing rate. The social cost of moral hazard is also increasing in coverage level, and does so at an increasing rate. At the optimal allocation, the magnitude of risk protection is roughly six times as large as the social cost of moral hazard. We find that there is therefore a substantially larger welfare loss from providing a very low coverage option than from getting the single optimal level of coverage slightly wrong.

We compare outcomes under various alternative policies, including break-even pricing and full vertical choice over all plans. Under break-even pricing, vertical choice is permitted but prevailing premiums must equal plan average costs. In our population, the market unravels to the lowest level of coverage (the Catastrophic plan) due to adverse selection. Under full vertical choice, subsidies are designed such that all plans are demanded. Using subsidies designed to mimic the enrollment shares observed on Affordable Care Act exchanges, the allocation generates 80 percent of first best surplus. We find that all households prefer vertical choice to the unraveled market, and that 81 percent of households prefer optimal regulation to vertical choice. Social surplus is $302 higher per household per year under optimal regulation than under vertical choice. The 19 percent of households with the lowest willingness to pay are worse off.

Related Literature. Our two-stage model of household demand for health insurance and healthcare utilization is closely related to those of Cardon and Hendel (2001) and Einav et al. (2013). We present a generalized formulation of these models to highlight the fact that the decompositions of willingness to pay and social surplus do not depend on particular functional forms for moral hazard, plan design, or uncertainty over health outcomes. From a methodological perspective, we extend the empirical approach to modeling distributions of household health outcomes. While the healthcare utilization decision occurs at the household level, health status predictors (such as age) are measured at the individual level. We recast household health as the sum of individuals' health and operationalize our approach using an approximation to the sum of lognormal distributions. This method allows us to exploit detailed information on a household's composition of individuals while still limiting the number of parameters to estimate.[3]

Our graphical analysis is based on the widely-used framework developed by Einav, Finkelstein and Cullen (2010). We extend the framework by incorporating a "social surplus curve"

[3] Given the large size of our data (45,000 households choosing among 14 plans over 5 years), limiting the number of parameters to estimate was an important consideration for computational tractability.

that captures the social surplus generated by allocating consumers to a given plan (Figure 1). We also incorporate the framework into our empirical analysis by using our estimates to construct the empirical analogs. Our main findings can be read directly off the figure showing our empirical social surplus curves (Figure 7).

The notion of equilibrium in our model is related to, but departs from standard competitive equilibria studied in health insurance markets in which the premium of each plan must equal the average cost of those who demand it (e.g., Rothschild and Stiglitz (1976), Handel, Hendel and Whinston (2015), Azevedo and Gottlieb (2017)). In our model, a regulator can set premiums arbitrarily. Removing price as an equilibrium object makes a larger set of allocations feasible. We find this desirable both because it reflects realistic regulatory powers and because it focuses attention on the important economic constraint of unobserved types.

Our framework is most closely related to that of Azevedo and Gottlieb (2017). They also use a two-stage model to describe demand for health insurance in a setting with vertically differentiated contracts and multiple dimensions of consumer heterogeneity. While their focus is on competitive equilibria with break-even pricing, their numerical simulations also consider optimal pricing. They document that under certain parameterizations of the distribution of consumer types, offering choice is optimal, while under others it is not.[4] Our paper focuses directly on why this is the case. We are (to our knowledge) the first to characterize the conditions under which it is optimal to offer vertical choice. We also bring to bear a rich empirical approach that permits flexible heterogeneity in the distribution of consumer types.[5]

Finally, our paper also closely relates to the literature on health insurance menu design. Bundorf, Levin and Mahoney (2012) investigate the socially optimal allocation of consumers to insurers in one market and find that optimal allocations cannot be achieved under uniform pricing. Our paper is similar in spirit (and in findings), but analyzes optimal allocations of consumers to coverage levels. Einav, Finkelstein and Levin (2010) discuss, and Geruso (2017) studies empirically, the idea that difficulties in optimal screening can arise when observably different consumers have the same willingness to pay for insurance; this is a central issue in our setting. In concurrent work, Ho and Lee (2019) use a closely related framework to study the choice of optimal coverage level from the perspective of an employer offering a single

[4]Their simulated population of consumers is characterized by a lognormal distribution of types, where moments of the distribution are set to match those estimated empirically in Einav et al. (2013).

[5]We note that Ericson and Sydnor (2017) also consider the question of whether vertical choice is welfare-improving. They focus on consumer confusion as a potential source of inefficiency, while we focus on a setting with rational consumers.

coverage option, with a similar focus on the tradeoff between risk protection and moral hazard. We concentrate on whether or not optimal regulation involves choice.

The paper proceeds as follows. Section 2 presents our theoretical model and derives the objects needed to determine whether vertical choice should be offered. Section 3 describes our data and provides descriptive evidence of the extent of variation it provides. Section 4 presents the empirical implementation of our model. Section 5 presents the model estimates, constructs willingness to pay and social surplus, and evaluates households' efficient level of coverage. Section 6 evaluates welfare under various pricing policies. Section 7 concludes.

II Theoretical Framework

II.A Model

We consider a model of a health insurance market where consumers are heterogeneous along multiple dimensions and the set of traded contracts is endogenous. Contracts differ along a single dimension and we take the set of potential contracts as given. We assume that the regulator cannot (or will not) vary premiums by consumer characteristics and assert that each consumer will select a single contract.[6]

We denote the set of potential contracts by $X = \{x_0, x_1, ..., x_n\}$, where x_0 is a null contract that provides no insurance. Within X, contracts are vertically differentiated only by the level of insurance coverage provided. Consumers are characterized by type $\theta : \{F, \psi, \omega\}$, where F is a distribution of potential health states, $\psi \in \mathbb{R}_{++}$ is a risk aversion parameter, and $\omega \in \mathbb{R}_+$ is the degree to which a consumer changes their behavior in response to insurance (capturing moral hazard). We define a population by a distribution $G(\theta)$.

Consumer Preferences. Consumers are subject to a stochastic health state l, drawn from their distribution F. After their health state is realized, consumers decide the amount $m \in \mathbb{R}_+$ of healthcare utilization ("spending") to consume, where m is measured in dollars. Consumers value healthcare spending and money. We assume that preferences are separable between the two. In deciding how much healthcare to utilize, consumers trade off the associated benefit $b(m, l, \omega)$ and the out-of-pocket (OOP) cost $c(m, x)$, where both

[6] The regulator may not be able to condition premiums on consumer attributes if consumers have private information (see Cardon and Hendel (2001)). It may not want to do so to prevent exposing consumers to costly reclassification risk (see Handel, Hendel and Whinston (2015)).

are both increasing in m. The privately optimal amount of healthcare to consume is $m^*(l,x,\omega) = \text{argmax}_m \left(b(m,l,\omega) - c(m,x)\right)$.[7] Because insurance reduces the cost of healthcare, privately optimal spending is increasing in coverage level.[8] Optimal spending implies optimal benefit $b^*(l,x,\omega)$ and out-of-pocket cost $c^*(l,x,\omega)$.

We take $\omega = 0$ to mean there is no moral hazard, meaning that optimal spending does not vary over contracts: $m^*(l,x,0) = m^*(l,x_0,\omega)\ \forall\ x$. In order to reach an expression for the social cost of moral hazard in terms of fundamentals, we decompose healthcare spending $m^*(l,x,\omega)$ into two parts: (i) "unavoidable spending" $m^*(l,x,0)$ that would occur even absent insurance, and (ii) "moral hazard spending" $m^*(l,x,\omega) - m^*(l,x,0)$ that is induced by insurance.[9] Moral hazard spending is not entirely wasteful. Consumer utility from moral hazard spending (net of associated out-of-pocket cost) is equal to

$$v(l,x,\omega) = \underbrace{b^*(l,x,\omega) - b^*(l,x,0)}_{\substack{\textit{Benefit from moral}\\ \textit{hazard spending}}} - \underbrace{(c^*(l,x,w) - c^*(l,x,0))}_{\substack{\textit{OOP from moral}\\ \textit{hazard spending}}}.$$

Because lower out-of-pocket costs make consumers weakly better off, $v(l,x,\omega)$ is weakly positive. Before the health state is realized, expected utility from contract x at premium p equals

$$U(x,p,\theta) = \mathbb{E}\left[\ u_\psi(\ b^*(l,x,0) - c^*(l,x,0) + v(l,x,\omega) - p)\right|\ l \sim F\right], \tag{1}$$

where u_ψ is strictly increasing with curvature governed by ψ.

Private vs. Social Incentives. Calculations in Appendix A.1 show that if consumer preferences u_ψ feature constant absolute risk aversion, willingness to pay for contract x relative to the null contract x_0 can be expressed as

$$WTP(x,\theta) = \underbrace{\bar{c}(F,x_0,0) - \bar{c}(F,x,0)}_{\substack{\textit{Mean reduced OOP}\\ \textit{from unavoidable spending}}} + \underbrace{\bar{v}(F,x,\omega)}_{\substack{\textit{Mean utility from}\\ \textit{moral hazard spending}}} + \underbrace{\Psi(x,\theta)}_{\substack{\textit{Value of risk}\\ \textit{protection}}}, \tag{2}$$

[7] We assume $m^*(l,x,\omega)$ is unique. We also note that the *socially* optimal amount of healthcare to consume is $m^{eff}(l,\omega) = \text{argmax}_m \left(b(m,l,\omega) - m\right) = m^*(l,x_0,\omega)$. This paper does not tackle allocational efficiency with respect to healthcare utilization. The realized health state l is not contractible.

[8] Following convention, we refer to ω as a moral hazard parameter, but note that in our model it captures only price sensitivity to healthcare spending, and not a hidden action. See Section I.B of Einav et al. (2013) for a fuller discussion of this abuse of terminology.

[9] We assume m^*, b^*, and c^* are weakly increasing in ω. This is a normalization.

where $\bar{c}(F, x, \omega)$ is the expected value of $c^*(l, x, \omega)$ with respect to l, and $\bar{v}(F, x, \omega)$ is similarly defined. Each contract represents a gamble over financial payoffs and utility from healthcare utilization. WTP represents a certainty equivalent, and is therefore equal to an expected value plus a risk premium.[10]

Willingness to pay is composed of three terms: mean reduced out-of-pocket cost from unavoidable spending, mean utility from moral hazard spending, and the value of risk protection.[11] The first term, mean reduced out-of-pocket from unavoidable spending, is a financial expected value that will appear as an equal and opposite cost to the insurer. It is a transfer that is not relevant to social welfare.[12] In contrast, the second and third terms depend on consumer preferences and are relevant to social welfare. Consumers may value the ability to consume more healthcare when they have higher coverage as well as the ability to smooth consumption across health states. Our accounting of social welfare takes this into consideration.

Insurer costs are given by $k(m, x)$, where $m = k(m, x) + c(m, x)$. A reduction in out-of-pocket cost is an increase in insurer cost, so $\bar{c}(F, x_0, 0) - \bar{c}(F, x, 0) = \bar{k}(F, x, 0)$.[13] The social surplus generated by allocating a consumer to contract x (relative to allocating the same consumer to the null contract) is the difference between $WTP(x, \theta)$ and expected insured cost $\bar{k}(F, x, \omega)$:

$$S(x, \theta) = \underbrace{\Psi(x, \theta)}_{\substack{\textit{Value of risk} \\ \textit{protection}}} - \Big(\underbrace{\bar{k}(F, x, \omega) - \bar{k}(F, x, 0) - \bar{v}(F, x, \omega)}_{\substack{\textit{Social cost} \\ \textit{of moral hazard}}}\Big). \tag{3}$$

Because the insurer is risk neutral, it bears no extra cost from uncertain payoffs. If there is moral hazard, the consumer's value of mean insured spending falls below the cost of providing it, generating a welfare loss from insurance.

The socially optimal contract x^{eff} for a particular type of consumer is that which optimally trades off risk protection and the social cost of moral hazard: $x^{eff}(\theta) = \text{argmax}_{x \in X} S(x, \theta)$.

[10]The role of constant absolute risk aversion is to ensure that the risk premium does not depend on the plan premium.

[11]Azevedo and Gottlieb (2017) also discuss how willingness to pay in this setting is composed of these three terms. Our formulation generalizes the decomposition in that it does not depend on particular functional forms for b, c, or F.

[12]The insurer's technology is risk neutrality. It cannot pay doctors a marginal dollar more efficiently than the consumer could do.

[13]To see this, note that $\bar{c}(F, x_0, 0) = \bar{m}(F, x, 0)$. $\bar{k}(F, x, \omega)$ is the expectation of $k^*(l, x, \omega)$ with respect to the distribution of l, where $k^*(l, x, \omega) = k(m^*(l, x, \omega), x)$.

Given premium vector $\boldsymbol{p} = \{p_x\}_{x \in X}$, consumers choose the privately optimal contract x^* that optimally trades off private utility and premium: $x^*(\theta, \boldsymbol{p}) = \text{argmax}_{x \in X}(WTP(x, \theta) - p_x)$.

Supply and Regulation. Contracts are supplied by a regulator, which can observe the distribution of consumer types and can set premiums. The regulator need not break even on any given contract, nor break even in aggregate.[14] It could remove a contract from the set of contracts on offer by setting a premium of infinity. This model of supply is equivalent to a perfectly competitive insurance market with a regulator that has the power to tax and subsidize plans. Precisely such a model is formalized in Section 6 of Azevedo and Gottlieb (2017).

The regulator sets premiums in order to align privately optimal $x^*(\theta, \boldsymbol{p})$ and socially optimal $x^{eff}(\theta)$ allocations as closely as possible. Equilibrium social welfare is given by

$$W(\boldsymbol{p}) = \int S(x^*(\theta, \boldsymbol{p}), \theta)\ dG(\theta).$$

Our question is whether, or when, the regulator's solution will involve vertical choice. That is, will the regulator wish to offer (have enrollment in) more than one contract at the optimal allocation.[15]

II.B Graphical Analysis

We characterize the answer graphically for the case of a market with two potential contracts. This case conveys the basic intuition and can be depicted easily using the graphical framework introduced by Einav, Finkelstein and Cullen (2010).

First, it is useful to recognize that moral hazard and consumer heterogeneity are necessary conditions for the regulator to wish to offer vertical choice. If there were no moral hazard, higher coverage would weakly increase social welfare for every consumer. The optimal contract for all consumers would be the maximum possible coverage level. The regulator would set the premium of that contract to zero and the premiums of all other contracts sufficiently high that they are not chosen. If there were no consumer heterogeneity, all consumers would

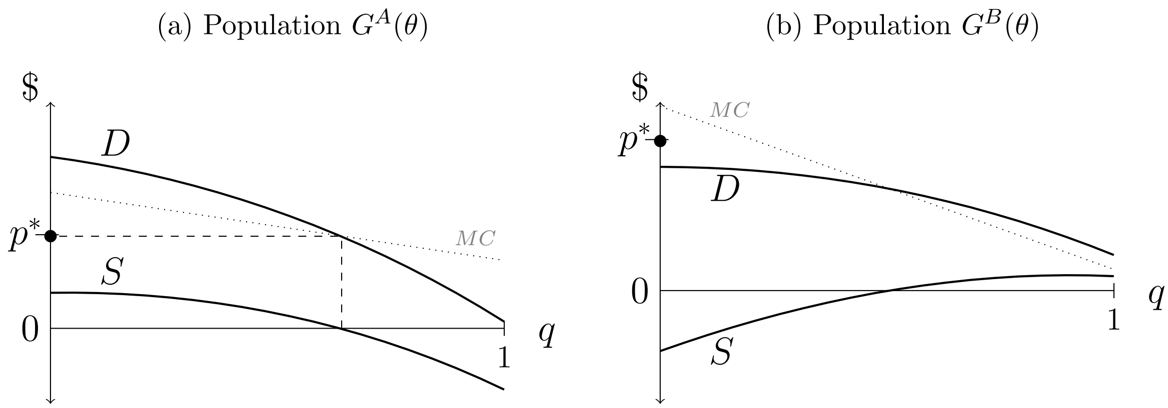
[14] We assume any aggregate deficit can be funded by taxing consumer incomes. Since we assume constant absolute risk aversion, this is not different than increasing premiums on all plans and calling it a tax.

[15] If the regulator sets premiums such that all consumers choose the same plan, then we say that it has not offered vertical choice. This is to avoid discussion of, for example, whether an option of a plan with a premium of infinity is in fact an option at all.

again have the same socially optimal contract, say $\tilde{x}$. The regulator would optimally set the premium of $\tilde{x}$ to be zero and the premiums of all other contracts to be sufficiently high that they are not chosen. In both examples, the optimal allocation does not involve vertical choice. In the following, we explore the more interesting (and more realistic) cases in which consumers do not all have the same optimal contract.[16]

We consider an example with two possible contracts, x_H and x_L, where $x_H > x_L$. Figure 1 depicts two possible markets, corresponding to two populations $G^A(\theta)$ and $G^B(\theta)$. If a consumer does not choose x_H, they receive x_L. Since contracts are vertically differentiated, $WTP(x_H, \theta) \geq WTP(x_L, \theta)$ for all consumers. Each panel shows the demand curve D for contract x_H, representing marginal willingness to pay for x_H relative to x_L. The vertical axis plots the marginal price $p = p_H - p_L$ at which the contracts are offered. The horizontal axis plots the fraction q of consumers that choose x_H.

Figure 1. Markets Where There Should (a) and Should Not (b) be Vertical Choice



Notes: This figure shows two health insurance markets where there are two contracts available: x_H and x_L, where $x_H > x_L$. Each panel shows the demand curve D, the marginal cost curve MC, and the social surplus curve S for contract x_H relative to contract x_L. The left panel depicts an example where the regulator optimally offers vertical choice, and there is enrollment in both contracts. The right panel depicts an example where the regulator optimally does not offer vertical choice, and all consumers choose x_L.

Each panel also shows the marginal cost curve MC and the marginal social surplus curve S. The marginal cost curve measures the expected marginal cost of insuring consumers under x_H relative to x_L. Because consumers with the same willingness to pay can have different costs, MC represents the average marginal cost among all consumers at a particular point on the horizontal axis (a particular willingness to pay). The social social surplus curve S

[16] Requiring that all consumers do not have the same optimal contract is a stronger condition than requiring the presence of both moral hazard and consumer heterogeneity. Heterogeneity in optimal contracts is necessary for the regulator to wish to offer vertical choice. As in the examples above, if consumers are heterogeneous but still have the same optimal contract, the regulator will offer only that one.

plots the vertical difference between D and MC. A particular point on the social surplus curve represents the average marginal social surplus $S(x_H, \theta) - S(x_L, \theta)$ among all consumers at that point on the horizontal axis.

While D and MC must be weakly positive, the presence of moral hazard means that S need not be; it is possible for a consumer to be over-insured. Moreover, our precondition that all consumers do not have the same optimal contract guarantees that in both populations, marginal social surplus will be positive for some consumers and negative for some consumers. Given that S represents the average over consumers at each value of D, this condition does not guarantee that S will itself cross zero. If S does not cross zero, a single plan is on average optimal at every level of willingness to pay, and the regulator will offer only that plan.[17] Since it is necessary for S to cross zero for vertical choice to be optimal, we focus both graphical examples on cases where that occurs.

The key difference between the two populations is whether consumers with high or low willingness to pay have a higher efficient level of coverage. In Figure 1a, marginal social surplus is increasing in marginal willingness to pay. The optimal marginal premium p^* can sort consumers with on-average positive S into x_H, and on-average negative S into x_L. Because private and social incentives are aligned, it is possible to get consumers to self-select efficiently. In Figure 1b, marginal social surplus is decreasing in consumer willingness to pay, and efficient screening is no longer possible.

In population $G^B(\theta)$, any marginal premium between the minimum and the maximum value of D will result in some avoidable amount of "backwards sorting." Consequently, any allocation with enrollment in both plans will be dominated by an allocation with enrollment in only one plan. No sorting dominates backwards sorting because it is always possible to prevent "one side" of the backwards sort by declaring no sorting. To see this, consider the (worst possible) allocation $\tilde{q}$ at the point where S intersects zero; a slightly higher allocation q' strictly dominates, as more consumers with positive marginal social surplus now enroll in contract x_H. The same logic applies to the left of $\tilde{q}$. The only allocations that cannot easily be ruled out as suboptimal are the endpoints, at which all consumers enroll in the same contract. In the example shown, the integral of S is negative, meaning that the population would on average be over-insured in contract x_H. The optimal marginal premium p^* is therefore anything high enough to induce all consumers to choose contract x_L.

[17]For example if S lies everywhere above zero, the regulator will optimally offer only x_H. Note that this result corresponds to what we find empirically (cf. Figure 7).

Considering all cases, if the social surplus curve S crosses zero at most once, vertical choice should be offered if and only if S crosses from above. More generally, the key characteristic of a population that determines whether vertical choice should be offered is whether consumers with higher willingness to pay have a higher efficient coverage level. This condition itself is complex, and both theoretically and by our own metrics of common sense, ambiguous. If healthy consumers change their behavior more in response to insurance, as is suggested by findings in Brot-Goldberg et al. (2017), this would tend to positively align willingness to pay and efficient coverage level. If healthy consumers are more risk averse, as is suggested by findings in Finkelstein and McGarry (2006), this would tend to negatively align willingness to pay and efficient coverage level.

There is a question of what characteristics drive variation in willingness to pay, and in turn how those characteristics are correlated with the efficient level of coverage. The net result depends on the joint distribution of expected health spending, uncertainty in health spending, risk aversion and moral hazard in the population. Moreover, it depends on how these primitives map into marginal willingness to pay and marginal insurer cost across nonlinear insurance contracts, as are common in U.S. health insurance markets and present in the empirical setting we study. Ultimately, whether high willingness to pay consumers should have higher coverage than low willingness to pay consumers is an open empirical question.

III Empirical Setting

In this section, we describe our empirical setting. Section III.A describes the data. Section III.B presents descriptive evidence of the variation in our data, discusses our primary identifying assumption, and provides reduced form evidence of moral hazard.

III.A Data

Our data are derived from the employer-sponsored health insurance market for public school employees in Oregon between 2008 and 2013. The market is operated by the Oregon Educators Benefit Board (OEBB), which manages benefits for the employees of Oregon's 187 school districts. Each year, OEBB negotiates with insurers and creates a state-level "master list" of plans that school districts can offer to their employees. Each plan has an associated full premium. During our time period, OEBB contracted with three insurers, each of which offered a selection of plans. School districts then independently select a subset of plans from the state-level menu and set their "employer contribution" to plan premiums, creating variation across school districts in the subsidized premiums and set of plans available to employees. Between 2008 and 2010, school districts could offer at most four plans; after 2010, there was no restriction on the number of plans a district could offer, but many still offered only a subset.

The data contain the menu of plan options available to each employee, realized plan choices, plan characteristics, and medical and pharmaceutical claims data for all insured individuals. We observe detailed demographic information about employees and their families, including age, gender, zip code, health risk score, family type, and employee's occupation type.[18,19] An employee's plan menu consists of the plan choice set and plan prices. Prices consist of the subsidized premium, potential contributions to a Health Savings Account (HSA) or a Health Reimbursement Arrangement (HRA), and potential contributions towards a vision or dental insurance plan.[20]

The decentralized determination of plan menus provides a plausibly exogenous source of variation in both prices and choice sets. While all the plan menus we observe are quite generous in that the plans are highly subsidized, there is substantial variation across districts in the range of coverage levels offered and in the exact nature of the subsidies.[21] Moreover, school districts can vary plan menus at the family type and employee type level, resulting

[18] Individual risk scores are calculated based on prior-year medical diagnoses and demographics using Johns Hopkins ACG Case-Mix software. This software uses the diagnostic information contained in past claims data as well as demographic information to predict future healthcare spending. See, for example, Brot-Goldberg et al. (2017), Carlin and Town (2008), or Handel and Kolstad (2015) for a more in-depth explanation of the software and examples of its use in economic research.

[19] Possible employee occupation types are licensed administrator, non-licensed administrator, classified, community college non-instructional, community college faculty, confidential, licensed, substitute, or superintendent. Within each category, an employee can be either full-time or part-time. Possible family types are employee only; employee and spouse; employee and child(ren); and employee, spouse, and child(ren).

[20] Decisions about HSA/HRA and vision/dental contributions are also made independently by school districts. An HRA is a notional account that employers can use to reimburse employees' uninsured medical expenses on a pre-tax basis; balances typically expire at the end of the year or when the employee leaves the employer. An HSA is a financial account maintained by an external broker to which employers or employees can make pre-tax contributions. The data on employer premium contributions and savings account contributions were hand-collected via surveys of each school district. Additional details about the data collection process can be found in Abaluck and Gruber (2016).

[21] The majority of school districts used either a fixed dollar contribution or a percentage contribution, but the levels of the contribution varied widely. Other districts used a fixed employee contribution. In addition, the districts' policies for how "excess" contributions were treated varied; in some cases, contribution amounts in excess of the full plan premium could be "banked" by the employee in a HSA or HRA, or else contributed towards the purchase of a vision or dental insurance plan, either in full, in part, or not at all.

in variation both within and across school districts. These benefits decisions are made by school district employee and administrator committees, and subsidy designs are influenced by bargaining agreements with the local teachers union. Between 2008 and 2013, we observe 13,661 unique combinations of year, school district, family type, and employee type, resulting in 7,835 unique plan menus.

Household Characteristics. We restrict our sample to households where the oldest member is not older than 65, the employee is not retired, and for whom all members are enrolled in the same plan for the entire year. Further, because we require one prior year of claims data in order to estimate an individual's prospective risk score, we begin our sample in 2009, and require households to have one year of data prior to inclusion. Our sample consists of 44,562 unique households, representing 117,949 unique individuals between 2009 and 2013.[22]

Table 1 provides annual summary statistics on our panel of households. Across all years, the age of the average employee is 47.4, while the age of the average enrollee (employees and their families) is 39.8. Enrollees are 54 percent female, and 72 percent of households are "families" (purchased health insurance to cover more than the employee alone). Households have on average 2.54 enrollees.

Employees received large subsidies towards the purchase of health insurance. The average household paid only $880 per year for their plan; the median household paid nothing. Meanwhile, the average full premium paid to insurers was $11,500, meaning the average household received an employer contribution of $10,620. Households had average out-of-pocket spending of $1,694, and households plus insurers had average total spending of $10,754.

Households were highly likely to remain in the same plan and with the same insurer that they chose last year, when possible. OEBB can adjust the master list of plans available, and school districts can adjust choice sets over time. Such adjustments forced 19.6 percent of household-years to switch plans and 1.4 percent to switch insurers. Among household-years where the incumbent plan/insurer *was* available, 17.2 percent voluntarily switched plans, and 3.4 percent voluntarily switched insurers. This variation is particularly important in our empirical model in identifying "inertia" associated with switching plans or insurers.

We divide the state into a small number of regions because in our empirical model we allow preferences for each insurer to vary by region. We use three regions based on groups of adjacent Hospital Referral Regions (HRRs): the Portland and Salem HRRs in northwest

[22] Table A.1 provides additional details on the construction of this sample.

Table 1. Household Summary Statistics

Sample demographics	2009	2010	2011	2012	2013
Number of households	31,074	29,538	29,279	27,897	24,283
Number of enrollees	78,932	75,129	75,601	72,311	63,264
Enrollee age, mean (med.)	39.7	39.8	39.8	40.1	40.0
	(38.0)	(38.0)	(37.7)	(38.0)	(37.8)
Enrollee percent female	0.54	0.54	0.54	0.54	0.54
Premiums					
Employee premium ($), mean (med.)	885	1,023	523	1,079	905
	(0)	(0)	(0)	(0)	(0)
Full premium ($), mean (med.)	11,170	11,785	10,433	12,253	12,000
	(11,665)	(11,801)	(11,021)	(12,278)	(12,362)
Household health spending					
Total spending ($), mean (med.)	10,563	10,405	10,911	10,984	10,967
	(4,753)	(4,589)	(4,595)	(4,569)	(4,559)
OOP spending ($), mean (med.)	1,152	1,634	1,884	1,897	1,998
	(743)	(1,089)	(1,306)	(1,292)	(1,234)
Plan switches (percent)					
Forced to switch plan	0.06	0.34	0.12	0.05	0.46
insurer	0.01	0.02	0.02	0.02	0.00
Unforced, switched plan	0.13	0.23	0.22	0.22	0.04
insurer	0.06	0.05	0.03	0.01	0.02
Household structure (percent)					
Individual	0.27	0.28	0.28	0.28	0.28
Family	0.73	0.72	0.72	0.72	0.72

Notes: Enrollees are employees plus their family members. Statistics about premiums are for households' chosen plans, as opposed to for all possible plans. Sample medians are shown in parentheses.

Oregon (containing 64 percent of households), the Eugene and Medford HRRs in southwest Oregon (containing 26 percent of households), and the Bend, Spokane, and Boise HRRs in eastern Oregon (containing 10 percent of households).[23]

Plan Characteristics. During our sample period, OEBB contracted with three insurers: Kaiser, Providence, and Moda. Kaiser offers HMO plans that require enrollees to use only Kaiser healthcare providers and obtain referrals for specialist care. Moda and Providence offer PPO plans with broad provider networks. Kaiser and Providence each offered between two and three plans per year at high coverage levels. Moda offered between seven and nine plans per year, with wide variation in coverage level across plans. Within each insurer, plans were differentiated only by coverage level.

[23] As HRRs do not respect state boundaries, some HRRs in our regions have names of cities outside Oregon, but nonetheless contain parts of Oregon. For more information as well as HRR maps, see http://www.dartmouthatlas.org/data/region.

Table 2 summarizes the master list of plans made available by OEBB in 2009. The insurer premium reflects the per-employee premium negotiated between OEBB and the insurer. This full premium varies formulaically by family type; the premium shown is for an employee plus spouse. Plan cost sharing features vary by whether the household is an individual (the employee alone) or a family (anything else). The deductible and out-of-pocket maximum (OOP Max.) shown are for in-network services for a family household.

Table 2. Plan Characteristics, 2009

Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.97	11,869	0	1,200	0.07
Kaiser - 2	0.96	11,342	0	2,000	0.11
Kaiser - 3	0.95	10,995	0	3,000	0.00
Moda - 1	0.92	13,340	300	500	0.27
Moda - 2	0.89	12,808	300	1,000	0.05
Moda - 3	0.88	12,088	600	1,000	0.11
Moda - 4	0.86	11,578	900	1,500	0.10
Moda - 5	0.82	10,723	1,500	2,000	0.13
Moda - 6	0.78	9,691	3,000	3,000	0.04
Moda - 7	0.68	7,401	3,000	10,000	0.01
Providence - 1	0.96	14,359	900	1,200	0.07
Providence - 2	0.95	14,009	900	2,000	0.02
Providence - 3	0.94	13,779	900	3,000	0.01

Notes: Actuarial value (AV) is calculated as the ratio of average insured spending to average total spending among all households, using counterfactual calculations of insured spending for households that did not choose a certain plan. Insurer premium reflects the premium negotiated between OEBB and the insurer. The deductible and out-of-pocket maximum shown are for in-network services for a family household.

One way to summarize and compare plan coverage levels is using actuarial value (AV), which reflects the share of total population spending that would be insured under a given plan. Less generous plans correspond to those with a lower actuarial value. To calculate actuarial value, we simulate the out-of-pocket spending that *all* households would have had in every potential plan, and then compute average insured spending divided by average total spending across all households for each plan.[24] In this way, the measure is not affected by selection or moral hazard effects.

The plan offerings in later years look qualitatively similar to those in 2009.[25] The notable

[24] We calculate counterfactual out-of-pocket spending using the "claims calculator" developed for this setting by Abaluck and Gruber (2016).

[25] Corresponding tables for the plans offered between 2010 and 2013 are available in Table A.2.

exception is that Providence was no longer available in 2012 and 2013. Moda maintained a roughly 75 percent market share throughout 2009 to 2013; Kaiser and Providence initially split the remaining share, but Kaiser steadily gained share thereafter. For the purposes of our empirical model, we estimate cost-sharing features that best fit the relationship between out-of-pocket spending and total spending observed in the claims data; this procedure is described in Appendix A.2.

III.B Descriptive Evidence

This section describes the variation in our data and estimates moral hazard in our setting. These estimates provide a moral hazard elasticity that is directly comparable to others in the literature. They also provide suggestive evidence of heterogeneity in treatment intensity, which is an important aspect of our structural model. While this section is essential for evaluating our identifying assumptions, we note that it is not necessary for understanding our structural model or subsequent analysis, which proceed in Section IV.

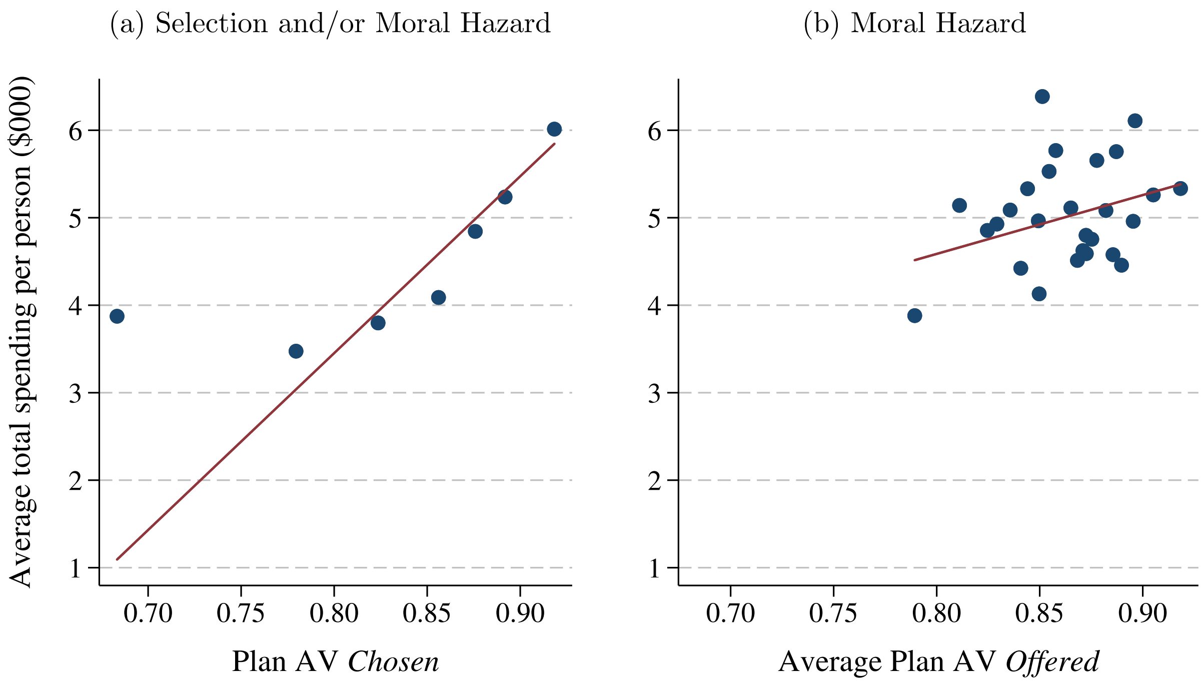
While our primary sample consists of data from 2009–2013, we conduct our descriptive analysis using only data from 2008.[26] The OEBB marketplace began operating in 2008, so in that year, all employees were choosing from among this set of plans for the first time. This "active choice" year permits us to look cleanly at how plan choices and realized healthcare spending depended on plan menus without also having to account for how prior year plan menus affected current year plan choices. While our structural model will capture these dynamics, we feel they are better avoided at this stage.

Variation in Coverage Level and Spending. We first graphically examine the extent of selection and/or moral hazard in the data. Figure 2 shows the relationship between healthcare spending and plan actuarial value among the set of households that chose Moda in 2008. We limit our focus to Moda here because we would like to hold the insurer fixed, and there is little variation in coverage level among the plans offered by Kaiser and Providence. The left panel of Figure 2 groups households by their *chosen* plan and plots average spending among households in each plan. There is one observation for each of the seven Moda plans. Households enrolled in more generous plans spend more on average than households enrolled in less generous plans. The lines of best fit in each panel are weighted by the number of

[26] Cost-sharing features of 2008 plans are presented in Table A.2; they are very similar to the plans offered in 2009. We apply all the same sample construction criteria to our 2008 sample except that the households be present for one prior year. Summary statistics on the 2008 sample can be found in Table A.4.

households represented.

Figure 2. Average Spending by Coverage Level *Chosen* and *Offered*



Notes: This figure shows the relationship between average total spending per person and plan actuarial value among households that selected Moda in 2008. In the left panel, each dot represents a plan. In the right panel, each dot represents a plan menu. Lines of best fit are weighted by the number of households represented.

The right panel groups households by the average actuarial value that the household was *offered* and plots average spending for households in plan menu. There is one observation for each unique plan menu. Households that were offered higher coverage had higher spending on average, suggesting that coverage level may have causally affected spending. While suggestive, this graphical analysis raises some important concerns. First and foremost, we must establish that plan menu generosity is not correlated with other factors that determine healthcare spending. In addition, the 'average plan AV offered' may not be a good measure of the coverage level likely to be chosen from a given plan menu. The plans are not all offered on an even footing (prices vary as well) and households also consider plans offered by Kaiser and Providence. We first address the exogeneity of plan menu generosity and then address these operational issues using an instrumental variables analysis.

Identifying Assumption. Our aim is to recover the causal effect of a household's chosen insurance plan on its total healthcare spending. As in much of this literature, our primary challenge is to disentangle the effects of moral hazard and adverse selection.[27] We address this challenge using choice set variation. We estimate how plan menus—choice sets and prices—affect plan choices, and in turn how plan choices affect total healthcare spending, as described by equations (4) and (5):

$$plan_k = f(\mathbf{menu}_d, \mathbf{X}_k, \xi_k), \tag{4}$$

$$y_k = g(plan_k, \mathbf{X}_k, \xi_k). \tag{5}$$

Here, $plan_k$ represents the plan chosen by household k, $\mathbf{menu}_d$ represents the plan menu available to the school district-family type-employee type combination d (to which household k belongs), $\mathbf{X}_k$ are observable household characteristics, ξ_k are unobservable household characteristics, and y_k is total healthcare spending. Because household characteristics appear in both equations, the challenge in estimating the effect of $plan_k$ on y_k is that a household's chosen plan is correlated with its unobservable characteristics ξ_k.

Our identifying assumption is that plan menus are independent of household unobservables ξ_k conditional on household observables $\mathbf{X}_k$. The most important threat to identification in this paper is that school districts chose plan menu generosity in response to unobservable information about employees that would also drive healthcare spending. Plan choice sets and employer contributions are determined at the school district level by a benefits committee consisting of district administrators and union representatives. Our understanding is that there is little "public input" from employees, who are generally satisfied with their (on average highly generous) offerings. While we cannot observe it, we understand that some variation in benefit generosity is offset by compensating variation in wages. Given the detailed health information provided by claims data, nothing about our understanding of this process leads us to believe that plan menus are endogenous to unobservable employee health.

That said, we investigate by attempting to explain plan menu generosity with observable household characteristics. We argue that if plan menus were not responding to *observable* information about household health, it is unlikely that they were responding to *unobservable* information. We find this argument all the more compelling because we almost certainty have better observable information on household health than did school districts at the time they made plan menu decisions. We find that conditional on family type, there is

[27]See Einav and Finkelstein (2018) for a recent review of the empirical literature on moral hazard.

no correlation between plan menu generosity and household risk score (see Table A.6).[28] Appendix A.3 replicates this analysis for 2009–2013, to the same effect. It also presents additional regressions testing for what *does* explain variation in plan menus. We find that, among other things, plan menu generosity is higher for certain union affiliations, lower for substitute teachers and part-time employees, decreasing in district average house price index, and decreasing in the percent of Republicans in a school district.

Estimates of Moral Hazard. We parameterize $plan_k$ to be an indicator variable for the identity of the insurer and a continuous variable for the actuarial value. We then parameterize equation (5) according to

$$\log(y_k) = \delta_f \mathbf{1}_{f(k)=f} + \gamma \log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda} + \beta \mathbf{X}_k + \xi_k, \tag{6}$$

where $\mathbf{1}_{f(k)=f}$ is an indicator for the insurer chosen by household k and $AV_{j(k)}$ is the actuarial value of the plan chosen by household k. The parameter δ_f represents insurer-specific treatment effects on total spending.[29] Our parameter of interest is γ, which represents the responsiveness of total spending to plan generosity, holding the insurer fixed (at Moda). We follow the literature in formulating the model such that γ represents the elasticity of total spending with respect to the average out-of-pocket price per dollar of total spending.[30]

Our aim is to estimate equation (6) using two-stage least squares, instrumenting for the chosen insurer ($\mathbf{1}_{f(k)=f}$) and actuarial value ($AV_{j(k)}$) using $\mathbf{menu}_{d(k)}$. But $\mathbf{menu}_{d(k)}$ is complex. Plan menus contain multiple plans, and plans vary by their coverage level, the identity of their insurer, their employee premium, and their potential HSA/HRA and vision/dental contribution. We transform these multidimensional options into instruments (predicted values of $\mathbf{1}_{f(k)=f}$ and $AV_{j(k)}$) using a conditional logit model. The logit specification allows us to predict the probability that a given household would choose a given plan when presented with plan menu $\mathbf{menu}_d$ *as if* the household had been acting like the average household in the data. Variation in the resulting predicted choice probabilities is driven only by variation in plan menus, and not by household characteristics.

[28] We calculate household risk score as the average risk score among individuals in that household. As we do not have data before 2008, the 2008 regression uses risk scores calculated using 2008 claims data.

[29] These may arise due to "supply side" effects arising from differences in provider prices, provider networks, care management practices, or due to "demand side" effects from differences in average plan generosity.

[30] To accommodate the fact that two percent of households have zero spending, we add one to total spending.

We estimate the following model:

$$plan_k = \underset{j \in \mathcal{J}_d}{\text{argmax}}(\alpha p_{jd} + \alpha^{VD} p_{jd}^{VD} + \alpha^{HA} p_{jd}^{HA} + \nu_j + \epsilon_{jk}), \tag{7}$$

where $\mathcal{J}_d$ is the set of plans available in plan menu d. Plan prices are given by the employee premium p_{jd}, the vision/dental subsidy p_{jd}^{VD}, and the HSA/HRA contribution p_{jd}^{HA}. Plan characteristics are captured nonparametrically by plan fixed effects ν_j. All household-specific determinants of plan choice are contained in the error term ϵ_{jk}, which is assumed to have a Type-1 extreme value distribution. The estimated parameters of equation (7) are presented in the first column of Table A.5. As expected, households dislike premiums, like HSA/HRA and vision/dental subsidies, and prefer higher coverage plans to lower coverage plans.

We use the choice probabilities predicted by the logit model to construct our instruments, denoting the predicted probability that a household presented with plan menu $\mathbf{menu}_d$ would choose plan j as ρ_{jd}.[31] Our instruments are the probability a household would choose a given insurer and the expected actuarial value of a household's plan choice conditional on insurer, respectively given by:

$$\begin{aligned} \rho_{fd} &= \sum_{j \in \mathcal{J}_d^f} \rho_{jd}, \\ \widehat{AV}_{fd} &= \sum_{j \in \mathcal{J}_d^f} \left(\frac{\rho_{jd}}{\rho_{fd}}\right) AV_j, \end{aligned} \tag{8}$$

where $\mathcal{J}_d^f$ is the set of plans in $\mathbf{menu}_d$ offered by insurer f.

Table 3 reports the two-stage least squares estimates of equation (6). We instrument for $\mathbf{1}_{f(k)=f}$ using using ρ_{fd} and for $\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda}$ using $\log(1 - \widehat{AV}_{d,Moda})\rho_{d,Moda}$. We report only the coefficient of interest (γ), but all specifications also contain insurer fixed effects, as well as controls for household risk score and family structure. The first column presents the model estimated without instruments, and the second column presents the model estimated using instrumental variables. Comparing the coefficients in columns 1 and 2, moral hazard explains 46 percent of the observed relationship between plan generosity and total spending. Our overall estimate of the elasticity of demand for healthcare spending in the population is -0.27, which is broadly similar to the benchmark of -0.2 estimated by the RAND experiment (Manning et al., 1987; Newhouse, 1993).

[31] Formally: $\rho_{jd} = \frac{\exp(U_{jd})}{\sum_{g \in \mathcal{J}_d} \exp(U_{gd})}$, where $U_{jd} = \alpha p_{jd} + \alpha^{VD} p_{jd}^{VD} + \alpha^{HA} p_{jd}^{HA} + \nu^j$.

Table 3. Estimates of Moral Hazard

	OLS *All*	IV *All*	IV *Individuals*	IV *Families*
	(1)	(2)	(3)	(4)
$\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda}$	-0.580	-0.269		
	(0.053)***	(0.084)***		
$\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda} \times Q_1$			-0.220	-0.415
			(0.290)	(0.131)***
$\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda} \times Q_2$			-0.410	-0.235
			(0.189)**	(0.088)***
$\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda} \times Q_3$			-0.253	-0.218
			(0.136)*	(0.090)**
$\log(1 - AV_{j(k)})\mathbf{1}_{f(k)=Moda} \times Q_4$			-0.017	0.074
			(0.346)	(0.145)
R^2	0.19	0.19	0.44	0.37
Observations	35,146	35,146	8,962	26,184

Notes: This table shows the OLS and IV estimates of equation (6), describing the relationship between household total spending and plan generosity. The unit of observation is a household, and the dependent variable is log of 1 + total spending. In columns 3 and 4, coefficients can vary by household risk quartile Q_n. Columns 1 and 2 are estimated on all households, while columns 3 and 4 are estimated only on individual or family households, respectively. All specifications also include insurer fixed effects and controls for household risk score and family structure. Standard errors (in parentheses) are clustered by household plan menu, of which there are 533 among individual households and 1,750 among family households. * p<0.10, ** p<0.05, *** p<.01.

Columns 3 and 4 introduce heterogeneity in γ by household health. For each household type (individual or family), we classify households into quartiles based on household risk score, where Q_n denotes the quartile of risk (Q_4 is highest risk). We construct separate instruments for each of the eight household types by estimating the logit model only among that subsample of households.[32] We find noisy but large differences in γ across household risk quartiles and between individual and family households.[33]

Variation in γ could reflect either heterogeneity in the intensity of treatment across groups (extent of exposure to varying marginal prices of healthcare across plans), or heterogeneity in treatment effect across groups (different responsiveness to varying marginal prices of healthcare across plans), or both. While this analysis cannot distinguish between these two effects,

[32] The estimates of equation (7) for each subsample are presented in Table A.8.

[33] We can reject the hypothesis that the four coefficients are equal at the 10 percent level for families, but not for individuals.

we find suggestive evidence that this heterogeneity in some part reflects differential treatment intensity. Appendix A.3 presents an analysis comparing realized spending outcomes of households in different risk quartiles with the variation in plan cost-sharing features that gives rise to different (end of year) marginal out-of-pocket prices. We find that the household types for which we estimate higher γ are also more likely to be exposed to varying marginal out-of-pocket costs. Separating variation in treatment intensity from variation in treatment effect is an important advantage of our structural model.

IV Empirical Model

IV.A Parameterization

We parameterize household utility and the distribution of health states, allowing us to represent our theoretical model fully in terms of data and parameters to be estimated. We extend the theoretical model to account for the fact that in our empirical setting, there are multiple insurers, consumers are households made up of individuals, consumers may value a dollar of premiums and a dollar of out-of-pocket spending differently, and consumers make repeated plan choices over time.

Household Utility. Following Cardon and Hendel (2001) and Einav et al. (2013), we parameterize utility from healthcare spending to be quadratic in its distance above the health state. Household k's valuation of spending level m given health state realization l is given by

$$b(m, l, \omega_k) = (m - l) - \frac{1}{2\omega_k}(m - l)^2, \tag{9}$$

where ω_k governs the curvature of the benefit of additional spending and ultimately the degree to which optimal utilization will vary across coverage levels. Given an (increasing and concave) out-of-pocket cost function $c_{jt}(m)$ for plan j in year t, optimal total healthcare spending is given by $m^*_{jt}(l, \omega_k) = \text{argmax}_m\,(b(m, l, \omega_k) - c_{jt}(m))$.[34] Solving yields $m^*_{jt}(l, \omega_k) = \omega_k(1 - c'_{jt}(m^*_{jt})) + l$.

This parameterization of household utilization choice is attractive because it produces reasonable predicted behavior under nonlinear insurance contracts and it is tractable enough

[34] The out-of-pocket cost function $c_{jt}(m)$ is indexed by t because cost-sharing parameters vary within a plan across years. Note that $c_{jt}(m)$ in fact also varies by household type (individual versus family), but we omit an additional index to save on notation.

to be used inside an optimization routine.[35] Additionally, ω_k can be usefully interpreted as the incremental spending induced when moving a household from no insurance (when marginal out-of-pocket cost is one and $m^* = l$) to full insurance (when marginal out-of-pocket cost is zero and $m^* = \omega + l$). Substituting for m^*, we denote the benefit of optimal utilization as $b^*_{jt}(l, \omega_k)$ and the associated out-of-pocket cost as $c^*_{jt}(l, \omega_k)$. Households face uncertainty about payoffs through uncertainty in $b^*_{jt}(l, \omega_k) - c^*_{jt}(l, \omega_k)$.[36]

We further assume that households have constant absolute risk aversion (CARA) preferences. Facing uncertainty about their healthcare needs, household k in year t derives the following expected utility from plan choice j:

$$U_{kjt} = \int_0^{\infty} -\exp\left(-\psi_k x_{kjt}(l)\right) dF_{kft}(l), \tag{10}$$

where ψ_k is the coefficient of absolute risk aversion, x_{kjt} is the payoff associated with realization of health state l, and F_{kft} is the distribution of health states. Health state distributions can vary by insurer $f(j)$ in order to capture differences in provider prices across insurers (discussed further below).

The payoff of health state realization l when enrolled in plan j is given by

$$x_{kjt}(l) = -p_{kjt} + \alpha^{OOP}\left(b^*_{jt}(l, \omega_k) - c^*_{jt}(l, \omega_k)\right) + \delta^{f(j)}_{kj} + \gamma^{inertia}_{kjt} + \beta \mathbf{X}_{kjt} + \sigma_\epsilon \epsilon_{kjt}, \tag{11}$$

where p_{kjt} is the household's plan premium (net of the employer contribution), $b^*_{jt}(l, \omega_k) - c^*_{jt}(l, \omega_k)$ is the net benefit of the optimal utilization choice measured in units of out-of-pocket dollars, $\delta^{f(j)}_{kj}$ are insurer fixed effects that control for brand and other insurer characteristics, $\gamma^{inertia}_{kjt}$ are a set of fixed effects for both the plan and the insurer a household was enrolled in the previous year, and $\mathbf{X}_{kjt}$ is a set of additional covariates that can affect household utility.[37] The payoff x_{kjt} is measured in units of premium dollars. Out-of-pocket costs can be valued

[35] The model predicts that if a consumer realizes a health state just under the plan deductible, she will take advantage of the proximity to cheaper healthcare and consume a bit more (putting her into the coinsurance region). Likewise if she realizes a health state just under the out-of-pocket maximum. Figure A.2 provides a depiction of optimal spending behavior predicted by this model.

[36] Under our parameterization, $b^*_{jt}(l, \omega_k) = \frac{\omega_k}{2}(1 - c'_{jt}(m^*_{jt})^2)$. Because both b^*_{jt} and c^*_{jt} are increasing in ω, a larger ω will contribute to a less risky distribution of payoffs. All else equal, this would work to align willingness to pay and efficient coverage level. An important motivation for the inclusion of unobservable heterogeneity in risk aversion is to allow it to vary flexibly with respect to the amount of moral hazard.

[37] These are: HRA or HSA contributions HA_{kjt}, vision and dental plan contributions VD_{kjt}, and a fixed effect $\nu^{NarrowNet}_{jt}$ for the plan Moda gave a limited provider network in 2011 and 2012. The associated parameters for health account and vision/dental contributions are α^{HA} and α^{VD}, respectively.

differently than premiums through parameter α^{OOP}.[38] Finally, ϵ_{kjt} represents a household-plan-year specific idiosyncratic preference shock, with magnitude σ_ϵ to be estimated. We assume that the shocks are independently and identically distributed Type 1 Extreme Value. In each year, households choose the plan j^*_{kt} that maximizes expected utility from among the set of plans $\mathcal{J}_{kt}$ available to them:

$$j^*_{kt} = \underset{j \in \mathcal{J}_{kt}}{\text{argmax}}\ U_{kjt}.$$

Distribution of Health States. We parameterize the distribution F_{kft} under the assumption that individuals face lognormal distributions of health states, and households face the sum of draws from individuals' distributions. We estimate the parameters of individuals' health state distributions, allowing parameters to vary with individual characteristics. We represent a household's distribution using a lognormal that approximates the sum of draws from independent lognormals.[39] This novel method of modeling the distribution of health states allows us to capture and exploit the large amount of heterogeneity in household composition that exists in our data. Importantly, it also allows us to closely fit observed spending distributions using a smaller number of parameters than would be required if covariates were measured at the household level.

An individual i faces uncertain health state $\tilde{l}_{it}$ that has a shifted lognormal distribution with parameters μ_{it} and σ_{it} and support $(-\kappa_{it}, \infty)$:

$$\log(\tilde{l}_{it} + \kappa_{it}) \sim N(\mu_{it}, \sigma^2_{it}).$$

The parameter κ_{it} is included to capture the mass of individuals with zero spending that are observed in the data. If κ_{it} is positive, then negative health states are permitted, which may imply zero spending.[40] Parameters μ_{it}, σ_{it}, and κ_{it} are parameterized to vary with individual demographics, including risk score, which can vary over time.

A household k faces an uncertain health state $\tilde{l}_{kt}$ that has a shifted lognormal distribution

[38] Our model cannot distinguish between potential reasons why premiums may be valued differently from out-of-pocket costs. For example, we expect the tax deductibility of premiums would push α^{OOP} up, while systematic underestimation of out-of-pocket spending would push α^{OOP} down.

[39] We calculate the parameters of the approximating distribution using the Fenton-Wilkinson method; additional details can be found in Appendix B.1

[40] If a household realizes a negative health state, this implies zero spending as long as ω_k is not too large that optimal spending becomes positive. Operationally, this entails amending the optimal spending policy to be: $m^*_{jt}(l, \omega_k) = \max(0, \omega_k(1 - c'_{jt}(m^*_{jt})) + l)$.

with parameters μ_{kt} and σ_{kt} and support $(-\kappa_{kt}, \infty)$. Under the approximation, household parameters μ_{kt}, σ_{kt}, and κ_{kt} can be calculated as functions of the individual parameters μ_{it}, σ_{it}, and κ_{it} of the individuals in the household. Variation in μ_{kt}, σ_{kt}, and κ_{kt} across households and within households over time arises from variation in household composition: the number of individuals and each individual's demographics. In addition to this observable heterogeneity, we also incorporate unobserved heterogeneity in household health though parameter μ_{kt}. In this way, adverse selection (on unobservables) is permitted because households can hold private information about their health that can drive both plan choice decisions and spending outcomes.

Finally, to account for the fact that there are multiple insurers in our empirical setting, we introduce an additional set of parameters ϕ_f to serve as exchange rates for monetary health states across insurers. These parameters are intended to capture differences in total healthcare spending that are driven by differences in provider prices across insurers. For example, an identical doctor's visit might lead to different amounts of total spending across insurers simply because each insurer paid the doctor a different price. We do not want such variation to be attributed to differences in underlying health or healthcare utilization. We therefore capture it in a structured way by estimating insurer-level parameters that multiply realized health states, transforming them from underlying "quantities" into the monetary spending amounts that we observe in the claims data.[41] A household's money-metric health state l is then the product of an insurer-level multiplier ϕ_f and the underlying "quantity" health state $\tilde{l}$, where $\tilde{l}$ is lognormally distributed depending only on household characteristics. Taken together, the distribution F_{kft} is defined by

$$l = \phi_f \tilde{l},$$
$$\log(\tilde{l} + \kappa_{kt}) \sim N(\mu_{kt}, \sigma_{kt}^2).$$

IV.B Identification

We aim to recover the joint distribution across households of willingness to pay, risk protection, and the social cost of moral hazard associated with different levels of insurance. Variation in these objects arises from variation in either household preferences (risk aversion and

[41] In reality, ϕ_f will also capture other multiplicative differences across insurers such as care management protocols or provider practice patterns, but we find it likely that most of the variation in ϕ_f comes from differences in average provider prices across insurers. Our estimates of ϕ_f conform to our priors on provider price variation across insurers, most notably that Kaiser pays lower prices.

moral hazard parameters) or in the ex ante distribution of health states. Our primary identification concerns are (i) distinguishing preferences from private information about health, (ii) distinguishing taste for mean out-of-pocket spending (α^{OOP}) from risk aversion, and (iii) identifying heterogeneity in the risk aversion and moral hazard parameters.

We first explain how ω, capturing moral hazard, is distinguished from unobserved variation in μ_{kt}, capturing adverse selection. In the data, there is a strong correlation between chosen plan generosity and total healthcare spending (see Figure 2a). A large part of this relationship can be explained by observable household characteristics. However, absent the inclusion of ω or unobserved heterogeneity in μ_{kt}, there is residual unexplained positive correlation between chosen coverage level and spending. This residual correlation could be attributable to either the effect of lower out-of-pocket prices driving utilization (moral hazard) or private information about health affecting both utilization and coverage choice (adverse selection). Just as in the instrumental variables analysis in Section III.B, the key to distinguishing between these two explanations is the variation in plan menus.

We observe similar households facing different menus of plans.[42] As a result, some households are more likely to choose higher coverage only because of the plan menu they face. The extent to which households facing more generous plan menus are also observed to have higher healthcare spending identifies the level of moral hazard ω. On the other hand, we also observe cases where similar households face similar menus of plans, but make different plan choices. This variation identifies the degree of private information about health, as well as the magnitude of the idiosyncratic preference shock ϵ. Conditional on observables, if households that choose more generous coverage also realize higher healthcare spending, then this variation will be attributed to private information about health. Otherwise, any residual unexplained variation in plan choice will be attributed to the idiosyncratic preference shock.

Both risk aversion and the relative valuation of premiums and out-of-pocket spending (α^{OOP}) affect households' preference for more or less generous insurance but do not affect their healthcare spending. To distinguish between these parameters, we use cases where observably different households face similar menus of plans. Risk aversion is identified by the degree to which households' taste for higher coverage is positively related to uncertainty in out-of-pocket spending, holding expected out-of-pocket spending fixed. α^{OOP} is identified by the rate at which households trade off premiums with expected out-of-pocket spending, holding uncertainty in out-of-pocket spending fixed.

[42]Our identification argument for moral hazard is similar to that made in Cardon and Hendel (2001).

Unlike the preceding arguments, identification of unobserved heterogeneity in risk aversion ψ and the moral hazard parameter ω relies on the panel nature of our data. Plan menus, household characteristics, and plan characteristics change over time. We therefore observe the same households making choices under different circumstances. If we had a large number of observations for each household and sufficient variation in circumstances, the preceding arguments could be applied household by household to identify a household-specific value of ψ and ω. In this case, heterogeneity in these parameters across households would be nonparametrically identified. In reality, we have at most five observations of each household. We ask less of this data by placing a parametric form on the distribution of types and estimating only the variance and covariance of types across households. As an example, if some households consistently make choices consistent with high risk aversion and others consistently make choices consistent with low risk aversion, this will show up as a high variance in the unobserved component of the risk aversion parameter.

IV.C Estimation

We allow the parameters of the individual health state distributions μ_{it}, σ_{it}, and κ_{it} to vary by time-varying individual demographics:

$$\begin{aligned}\mu_{it} &= \boldsymbol{\beta}^{\mu}\mathbf{X}^{\mu}_{it},\\ \sigma_{it} &= \boldsymbol{\beta}^{\sigma}\mathbf{X}^{\sigma}_{it},\\ \kappa_{it} &= \boldsymbol{\beta}^{\kappa}\mathbf{X}^{\kappa}_{it}.\end{aligned} \tag{12}$$

$\mathbf{X}^{\mu}_{it}$, $\mathbf{X}^{\sigma}_{it}$, and $\mathbf{X}^{\kappa}_{it}$ contain indicators for the 0–30th, 30–60th, 60–90th, and 90–100th percentiles of individual risk scores.[43] $\mathbf{X}^{\mu}_{it}$ and $\mathbf{X}^{\kappa}_{it}$ also contain a linear term in risk score, which is estimated separately for the 0–90th risk score percentile group and the 90–100th percentile group. $\mathbf{X}^{\mu}_{it}$ also contains an indicator for whether the individual is under 18 years old and for whether the individual is a female between the ages of 18 and 30.

Using the derivations shown in Appendix B.1, household health state distribution param-

[43]As the distribution of risk score is highly right skewed, these groupings allow us to fit the data better than if we use true quartiles.

eters are calculated as a function of individual parameters:

$$
\begin{aligned}
\sigma^2_{kt} &= \log[1 + \left[\sum_{i\in\mathcal{I}_k} \exp(\mu_{it} + \frac{\sigma^2_{it}}{2})\right]^{-2} \sum_{i\in\mathcal{I}_k} (\exp(\sigma^2_{it}) - 1)\exp(2\mu_{it} + \sigma^2_{it})], \\
\bar{\mu}_{kt} &= -\frac{\sigma^2_{kt}}{2} + \log[\sum_{i\in\mathcal{I}_k} \exp(\mu_{it} + \frac{\sigma^2_{it}}{2})], \\
\kappa_{kt} &= \sum_{i\in\mathcal{I}_k} \kappa_{it},
\end{aligned}
\tag{13}
$$

where $\mathcal{I}_k$ represents the set of individuals in household k. We incorporate private information about health at the household level by adding normally distributed unobservable heterogeneity in μ_{kt}. The household-specific mean of μ_{kt} is given by $\bar{\mu}_{kt}$, and the variance is given by σ^2_μ. A large σ^2_μ means that households have substantial private information about their health that cannot be explained by observables.

We similarly model the risk aversion (ψ_k) and moral hazard (ω_k) parameters with both observable and unobservable heterogeneity. Across parameters, we assume that μ_{kt}, ψ_k, and ω_k are jointly normally distributed, according to

$$
\begin{bmatrix} \mu_{kt} \\ \omega_k \\ \log(\psi_k) \end{bmatrix} \sim N\left(\begin{bmatrix} \bar{\mu}_{kt} \\ \boldsymbol{\beta}^\omega \mathbf{X}^\omega_k \\ \boldsymbol{\beta}^\psi \mathbf{X}^\psi_k \end{bmatrix}, \begin{bmatrix} \sigma^2_\mu & & \\ \sigma^2_{\omega,\mu} & \sigma^2_\omega & \\ \sigma^2_{\psi,\mu} & \sigma^2_{\omega,\psi} & \sigma^2_\psi \end{bmatrix} \right). \tag{14}
$$

Covariates $\mathbf{X}^\omega_k$ and $\mathbf{X}^\psi_k$ include an indicator for whether the household has children and a constant.[44]

We model inertia at both the plan and the insurer level: $\gamma^{inertia}_{kjt} = \gamma^{plan}_k \mathbf{1}_{k,j=j(t-1)} + \gamma^{ins}_k \mathbf{1}_{k,f=f(t-1)}$. We allow γ^{plan}_k to vary linearly with household age and allow the intercept to vary by whether the household has children.[45] We allow γ^{ins}_k to vary linearly with household risk score. We include household risk score here to capture whether sicker households face higher barriers to switching insurers (and therefore provider networks). Additionally, in 2013, Moda rebranded and changed the names of all of its plans, and added a plan, in a way that did not result in a direct mapping between all 2012 and 2013 plans. To capture this flexibly, we estimate a separate insurer-level inertia parameter for Moda plans in 2013. We allow insurer fixed effects ($\delta^{f(j)}_k$) to vary by household age and whether a household has children,

[44] If a household changes whether they have children during the sample, we assign it to its modal status.

[45] Household age is calculated as the mean age of all adults in a household across all years.

and allow the intercepts to vary by geographic region to capture the relative attractiveness of insurer provider networks across different parts of the state (as well as other sources of geographical heterogeneity in insurer preferences). We normalize the insurer fixed effect for Moda to be zero. As the parameters of the individual health state distributions are allowed to vary freely, the "provider price" parameters require normalization: ϕ_{Moda} is normalized to one.

We estimate the model via simulated maximum likelihood. Our estimation approach follows Revelt and Train (1998) and Train (2009), with the important distinction that we model a discrete/continuous choice. Our construction of the discrete/continuous likelihood follows Dubin and McFadden (1984). The likelihood function for a given household is the conditional density of its observed sequence of total healthcare spending amounts, given its observed sequence of plan choices. We use Gaussian quadrature to integrate numerically over the distribution of unobserved heterogeneity as well as the distributions of household health states. Additional details on the estimation procedure are provided in Appendix B.2.

V Results

V.A Model estimates

Table 4 presents the estimated parameters of our empirical model. Column 3 presents our primary specification as described in Section IV. Columns 1 and 2 present simpler specifications that are useful in understanding and validating the model. The table excludes insurer fixed effects and health state distribution parameters; these can be found in Table A.10.

Column 1 presents a version of the model where there is no moral hazard and there is no heterogeneity in health across individuals. That is, we do not allow μ_{it}, σ_{it}, or κ_{it} to vary by observable individual characteristics. However, unobservable heterogeneity in household health (through σ_{μ}) is still permitted. In column 2, we introduce the full extent of observable individual heterogeneity in health. A key difference across columns 1 and 2 is in the magnitude of the adverse selection parameter σ_{μ}, which falls by more than half. When rich observable heterogeneity in health is introduced to the model, the estimated amount of unobservable heterogeneity in health falls substantially. Moral hazard is introduced in column 3. Here, an important difference is the increase in the estimated amount of risk aversion. When moral hazard is introduced, the model can explain a larger part of the

Table 4. Parameter Estimates

Variable	(1) Parameter	(1) Std. Err.	(2) Parameter	(2) Std. Err.	(3) Parameter	(3) Std. Err.
Employee Premium ($000s)	$-1.000^{\dagger}$		$-1.000^{\dagger}$		$-1.000^{\dagger}$	
OOP spending, $-\alpha^{OOP}$	−1.504	0.024	−1.519	0.024	−1.348	0.028
HRA/HSA contrib., α^{HA}	0.292	0.023	0.293	0.023	0.250	0.023
Vision/dental contrib., α^{VD}	1.346	0.025	1.340	0.025	1.143	0.037
Plan inertia, γ^{plan}	4.272	0.095	5.009	0.059	4.265	0.098
Plan inertia * (Age−40), γ^{plan}	0.019	0.002	0.073	0.006	0.018	0.002
Plan inertia * $\mathbf{1}$[Children], γ^{plan}	0.189	0.040	1.208	0.119	0.188	0.041
Insurer inertia,γ^{ins}	6.097	0.116	4.605	0.231	6.030	0.120
Insurer inertia * Risk score, γ^{ins}	0.182	0.026	0.501	0.074	0.117	0.026
Moda-specific inertia, 2013	1.824	0.196	1.924	0.199	1.555	0.198
Moda narrow net. plan	−2.662	0.165	−2.665	0.165	−2.459	0.169
Kaiser prov. price, ϕ_K	0.669	0.007	0.831	0.006	0.766	0.000
Providence prov. price, ϕ_P	1.038	0.017	1.096	0.017	1.061	0.006
Risk aversion ψ	−0.495	0.059	−0.597	0.065	0.313	0.049
Risk aversion * $\mathbf{1}$[Children], ψ	−0.344	0.070	−0.221	0.062	−1.103	0.096
SD of risk aversion, σ_ψ	0.921	0.037	0.997	0.102	0.603	0.131
SD of mu, σ_μ	0.853	0.003	0.314	0.049	0.271	0.005
Moral hazard, ω					1.133	0.000
Moral hazard * $\mathbf{1}$[Children], ω					0.615	0.000
SD of moral hazard, σ_ω					0.145	0.073
Corr(μ, ψ), $\rho_{\mu,\psi}$	0.354	0.000	0.168	0.088	0.710	0.102
Corr(ψ, ω), $\rho_{\psi,\omega}$					−0.168	0.045
Corr(μ, ω), $\rho_{\mu,\omega}$					0.027	0.013
Scale of logit error, σ_ϵ	2.516	0.027	2.519	0.027	2.406	0.028
Insurer * {Region, Age, $\mathbf{1}$[Child.]}	Yes		Yes		Yes	
Heterogeneity in spending dists.			Yes		Yes	
Number of observations	679,773		679,773		679,773	

Notes: This table presents parameter estimates from our empirical model. Column 3 presents our primary estimates, while columns 1 and 2 present alternative specifications. All models are estimated on an unbalanced panel of 44,562 households over five years. Coefficients of absolute risk aversion are relative to thousands of dollars. Estimates from column 3 are the inputs into the calculation in Section V.B. To make non-interacted coefficients more readily interpretable, we use (Age−40). †By normalization.

dispersion in spending for observably similar households. This implies that households are facing less risk, and that more risk aversion is necessary to explain the same plan choices. Because estimated risk aversion increases, the relative valuation of premiums and out-of-pocket costs (α^{OOP}), which had been compensating for low risk aversion, falls.

In column 3, we estimate an average moral hazard parameter (ω) of $1,115 among individuals and $1,542 among families.[46] Recall that ω represents the additional total spending that would be induced when moving a household from no insurance to full insurance. For scale, we estimate an average household health state of $4,702 for individual households

[46]For comparison, the average ω estimated by Einav et al. (2013) is $1,330.

and \$11,044 for families. These estimates imply that moving from a plan with a 50 percent coinsurance rate to full insurance would result in an increase in total healthcare spending equal to 11 percent of mean unavoidable spending for individuals, and 7 percent for families.

We estimate a large degree of risk aversion. Our estimates imply a mean (median) coefficient of absolute risk aversion of 1.12 (0.84) across households.[47] Put differently, to make households indifferent between (i) a payoff of zero, and (ii) an equal odds gamble between gaining \$100 and losing \$X, the mean (median) value of \$X in our population is \$90.17 (\$92.94).[48] Our estimates of risk aversion are with respect to financial risk as well as health risk (through b^*_{jt}), and so are not directly comparable to estimates that consider only financial risk. The standard deviation of the uncertain portion of payoffs ($b^*_{jt} - c^*_{jt}$) with respect to the distribution of health states is \$853 on average across households-plans-years. This corresponds to an average standard deviation of out-of-pocket costs of \$1,358. To avoid a normally distributed lottery (in units of $b^*_{jt} - c^*_{jt}$) with mean zero and standard deviation \$853, the median household would be willing to pay \$305.

The importance of unobserved heterogeneity varies for health, risk aversion, and moral hazard.[49] The estimated amount of private information about health is fairly small once we account for the full set of household observables as well as moral hazard: unobserved heterogeneity in μ_{kt} accounts for 8 percent of the total variation in μ_{kt} across household-years.[50] Unobserved heterogeneity in the moral hazard parameter accounts for 9 percent of its total variation across households. On the other hand, unobserved heterogeneity in risk aversion accounts for 54 percent of its total variation.

Conditional on observables, we find that households that are idiosyncratically risk averse also have private information that they are unhealthy ($\rho_{\mu,\psi} > 0$) and are less prone to moral hazard than expected ($\rho_{\psi,\omega} < 0$). We find that households with private information that they are unhealthy are also more prone to moral hazard than expected ($\rho_{\mu,\omega} > 0$). Accounting for

[47] We measure monetary variables in thousands of dollars; dividing our estimated coefficients of absolute risk aversion by 1,000 makes them comparable to estimates that use risk is measured in dollars.

[48] In this example, a risk neutral household would have a value of \$X equal to \$100 and an infinitely risk averse household would have a value of \$X equal to \$0. Using the same example, Handel (2013) reports a mean \$X of \$91.0, Einav et al. (2013) report a mean \$X of \$84.0, and Cohen and Einav (2007) report a mean \$X of \$76.5.

[49] Following Revelt and Train (2001), we derive each household's posterior type distribution using Bayes' rule, conditioning on their observed choices and the population distribution. For the purposes of examining total variation in types across households (accounting for both observed and unobserved heterogeneity), we assign each household the expectation of their type with respect to their posterior distribution. This procedure is described in detail in Appendix B.3.

[50] This finding is consistent with the minimal selection on unobservables found by Cardon and Hendel (2001).

both unobservable *and* observable variation, we find that risk aversion and moral hazard have a strong negative correlation of -0.90. Among households with (without) children, expected health state $\mathbb{E}[\tilde{l}]$ has a correlation of 0.15 (0.13) with risk aversion, and a correlation of 0.05 (0.08) with the moral hazard parameter. Figure A.3 plots the unconditional joint distribution of these three key dimensions of household type.

Our estimates imply substantial disutility from switching insurers and plans. Average disutility across households from switching insurers is \$6,372, with a standard deviation of \$91. Average disutility from switching plans (but not insurers) is \$4,466, with a standard deviation of \$1,739. We estimate that insurer inertia is increasing in household risk score, and that plan inertia is increasing in household age and is on average \$188 higher for households with children.[51] The exceptionally large magnitudes of our inertia coefficients reflect in large part the infrequency with which households switch plans and insurers, as described in Table 1. Only 3.3 percent of household-years ever voluntarily switch insurers and 13.6 percent of household-years ever voluntarily switch plans.

Finally, the estimates in column 3 indicate that households weight out-of-pocket expenditures 34.8 percent more than plan premiums. We believe this could be driven by a variety of factors, including (i) household premiums are tax deductible, while out-of-pocket expenditures are not; and (ii) employee premiums are very low (at the median, zero), perhaps making potential out-of-pocket costs in the thousands of dollars seem relatively more salient. A single household in Oregon with income of \$80,000 paid an effective state plus federal income tax rate of 28.9 percent in 2013. Using this tax rate, a dollar of out-of-pocket spending (after-tax) would be equivalent to 1.41 dollars of premiums (pre-tax). We also find that households value a dollar in HSA/HRA contributions on average 75 percent less than a dollar of premiums. This is consistent with substantial hassle costs associated with these types of accounts, as documented by Reed et al. (2009) and McManus et al. (2006).

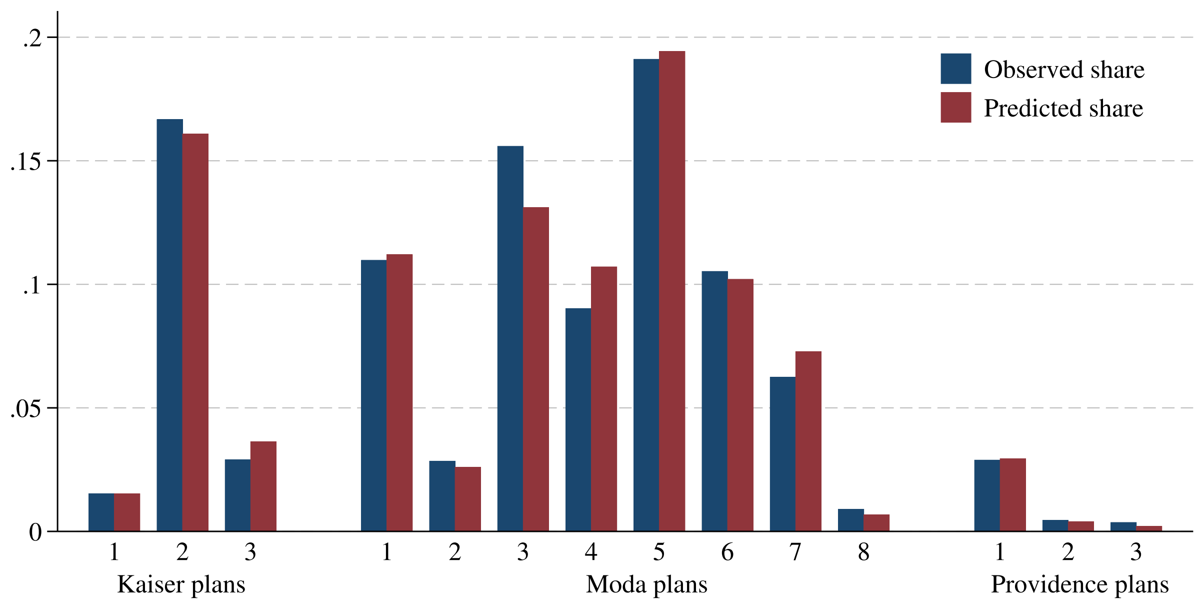
Model Fit. We conduct two procedures to evaluate model fit, corresponding to the two stages of the model. First, we compare households' predicted plan choices to those observed in the data. Figure 3 displays the predicted and observed market shares for each plan, pooled across all years in our sample.[52] Shares are matched exactly at the insurer level

[51]We do not investigate the micro-foundations of our estimates of household disutility from switching; see Handel (2013) for a full treatment of inertia in health insurance.

[52]Figure A.4 provides the corresponding comparisons separately for each year. As another metric, the model predicts 72 percent of household plan choices correctly (assigns the highest predicted probability to the correct plan). If households were modeled as choosing randomly from their plan choice set, 23 percent of

due to the presence of insurer fixed effects, but are not matched exactly plan by plan. Predicted choice probabilities over plans within an insurer are driven by plan prices, inertia, and households' valuation of different levels of coverage through their expectation of out-of-pocket spending, their value of risk protection, and their expectation of utility from the consumption of healthcare services. Given the relative inflexibility of the model with respect to household choice of coverage level within an insurer, the fit is quite good.

Figure 3. Model fit: Plan choices



Notes: The figure shows predicted and observed market shares at the plan level. All years are pool together, so the observation is the household-year. Predicted shares are calculated using the estimates in column 3 of Table 4 and Table A.10.

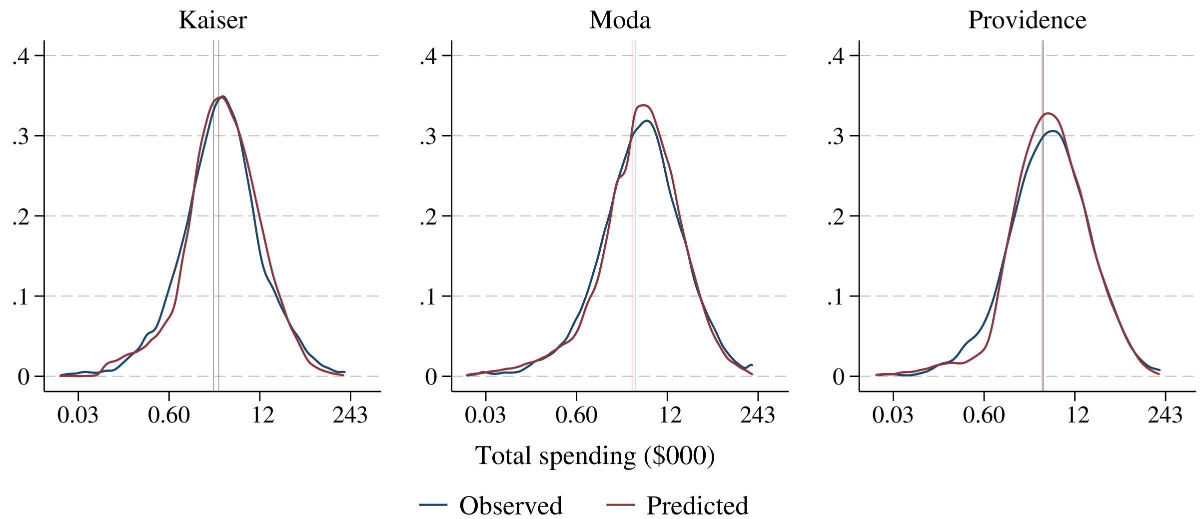
In our second exercise, we compare the predicted distributions of households' total healthcare spending to the distributions of total healthcare spending we observe in the data. In a given year, each household faces a predicted distribution of health states and a corresponding plan-specific distribution of total healthcare spending, as defined by our model and estimated parameters. To construct the predicted distribution of total spending in a population of households, we take a random draw from the predicted distribution of each household corresponding to the household's chosen plan. Figure 4 presents kernel density plots of the predicted and observed distribution of household total spending among household-years enrolled by each insurer.[53] The vertical lines in each plot represent the mean of the respective distribution. Overall across all household-year observations, average total healthcare

plan choices would be predicted correctly (i.e., the average choice set size is approximately 4 plans).

[53]Figures A.5 and A.6 present similar comparisons by family size and quartile of household risk score.

spending is observed to be \$10,754 and is predicted to be \$10,738.

Figure 4. Model Fit: Healthcare Spending



Notes: The figure shows kernel density plots of the predicted and observed distribution of total healthcare spending on a log scale among households enrolled with each of the three insurers. All years are pooled together, so the observation is the household-year. The vertical lines represent the mean of the respective distribution. Predicted distributions are estimated using parameter estimates from column 3 in Table 4 and Table A.10.

V.B Willingness to Pay and Social Surplus

Using our estimates, we next construct each household's willingness to pay for insurance, as well as the social surplus generated by its allocation to different levels of insurance. We conduct our remaining analyses on a set of vertically differentiated plans that roughly correspond to the types of coverage offered on Affordable Care Act (ACA) exchanges.[54] Our candidate plans are 'Full insurance', 'Gold', 'Silver', 'Bronze', and 'Catastrophic', corresponding to an actuarial value of 1.00, 0.85, 0.70, 0.60, and 0.50.[55] The out-of-pocket cost functions of these plans are depicted in Figure A.7.

Willingness to Pay. For the purposes of our remaining analyses, we put aside intertemporal

[54] We use these "artificial" plans instead of the set of Moda plans in our data because the Moda plans are densely packed in coverage space and are also not perfectly vertically differentiated. The plans we do consider span the full range of Moda plans offered, but are evenly distributed in coverage space and are truly vertically differentiated.

[55] These actuarial values are calculated with respect to the population in our data. The exact deductible, coinsurance rate, and out-of-pocket maximum of the plans are \$1,000, 15%, \$2,000 for Gold; \$3,500, 20%, \$4,500 for Silver; \$7,000, 30%, \$7,500 for Bronze; and \$10,000, 30%, \$10,000 for Catastrophic.

variation in households' estimated distribution of health states and focus on the first year that each household appears in the data. We also use the provider price parameter $\phi = 1$, corresponding to that used for Moda. This leaves us with one type for each household: $\{F_k, \psi_k, \omega_k\}$, just as in our theoretical model.[56] We first express utility in certainty equivalent units:

$$\begin{aligned} CE_{kj} &= -\psi_k^{-1} \log(-U_{kj}) \\ &= \bar{x}_{kj} - \psi_k^{-1} \log\left(\int_0^\infty \exp\left(-\psi_k(x_{kj}(l) - \bar{x}_{kj}\right) dF_k(l)\right), \end{aligned}$$

where $x_{kj}(l)$ is the payoff associated with health state l in plan j (equation (11)), and $\bar{x}_{kj}$ is the expectation of $x_{kj}(l)$ with respect to the distribution of l. Willingness to pay for marginally more generous insurance is equal to the difference in certainty equivalent between a (higher coverage) focal plan and the (lowest coverage) reference plan (j_0), when both plans have zero premium. We make comparisons over plans holding all non-financial features fixed, so inertia terms and insurer fixed effects cancel. We set α^{OOP} to one so that premiums and out-of-pocket costs are valued one-for-one.[57] With attention restricted to the dimension of coverage level, willingness to pay depends only on the benefit of healthcare spending, out-of-pocket costs, and riskiness in both:

$$\begin{aligned} WTP_{kj} &= CE_{kj} - CE_{k,j_0} \\ &= \bar{c}_{k,j_0} - \bar{c}_{kj} + \bar{b}_{kj} - \bar{b}_{k,j_0} + \Psi_{kj}, \end{aligned}$$

where $\bar{c}_{kj}$ is the expectation of out-of-pocket costs $c_j(m_j^*(l, \omega_k))$ with respect to the distribution of l, and $\bar{b}_{kj}$ is defined similarly. As in our theoretical expression for WTP, we pull out the mean and leave deviations from the mean lumped into Ψ_{kj}, which measures the value of risk protection. If consumers are risk averse and plan j provides a less risky distribution of out-of-pocket spending than does plan j_0, Ψ_{kj} will be positive. Whereas our theoretical reference plan was the null contract x_0, our empirical reference plan j_0 is the Catastrophic plan. We hereinafter refer to "willingness to pay" for a given plan, but bear in mind that

[56] To account for unobservable heterogeneity, we assign household types by integrating over each household's posterior distribution of types. This caveat likewise applies to the calculations of certainty equivalent and social surplus that follow. We omit these steps in this section because the notation is cumbersome, but it is provided in Appendix B.3.

[57] We do this because otherwise welfare could be created simply by moving a dollar of spending between premiums and out-of-pocket, which we find undesirable. If we leave α^{OOP} as estimated, optimal levels of insurance increase as out-of-pocket costs are so disliked.

this is *marginal* willingness to pay with respect to this particular reference point.

Figure 5 presents the distribution of willingness to pay among family households.[58] Households are ordered on the horizontal axis according to their willingness to pay. The highest willingness to pay households are on the left, as in a demand curve. Figure 5, as well as the figures that follow, is composed of connected binscatter plots. For each percentile of willingness to pay, households in that percentile are grouped together and the average value of the vertical axis variable (in this case, willingness to pay itself) is plotted for each plan. These 100 points for each plan are then connected with a line.[59] As the plans are vertically differentiated, all households are willing to pay more for higher coverage. The highest willingness to pay households are willing to pay $10,000 more for the full insurance plan rather than the Catastrophic plan.

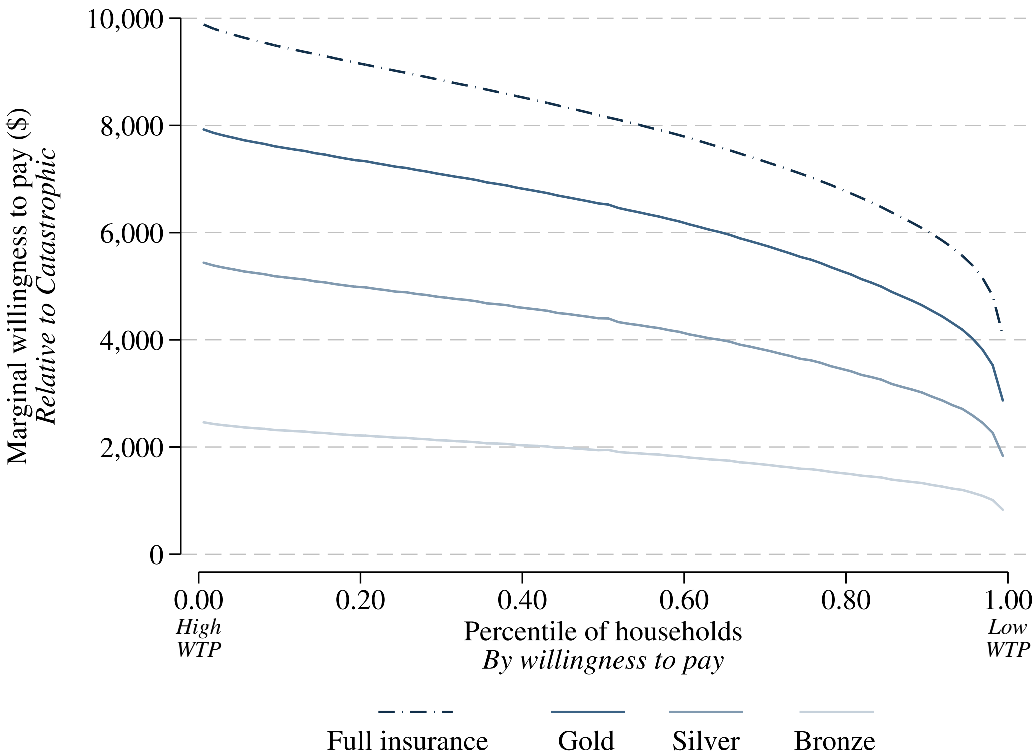
As in equation (2), we can decompose willingness to pay for each plan into its three component parts: mean reduced out-of-pocket costs from unavoidable medical spending, mean benefit from moral hazard spending, and the value of risk protection. Recall that only the latter two components are relevant to social welfare. Figure A.8 presents this decomposition of willingness to pay for the Gold plan (the shape of the breakdown is similar for all plans). We find that mean reduced out-of-pocket costs for unavoidable medical spending represents the majority of willingness to pay for most households, but there is substantial variation across the distributions of willingness to pay. The highest willingness to pay households have nearly 100 percent of their willingness to pay driven by mean reduced out-of-pocket costs, while for the lowest willingness to pay households it is only about 25 percent. Importantly, this means that the highest willingness to pay households are not generating *any* social surplus from having more comprehensive insurance.

Social Surplus. Using willingness to pay, we can determine households' *privately* optimal plan choices given any premiums. We next specify *socially* optimal plan choices. As in Section II, we calculate the social surplus generated by allocating a household to a given

[58] We focus our analysis of results on the set of family households because families make up 75 percent of our sample and our set of candidate plans is chosen to mimic the coverage levels offered to families.

[59] The households are in fact ordered by their willingness to pay for the Silver plan, but because the ordering is nearly identical across plans, the lines in this plot are monotonically decreasing and appear smooth (if it were not the case, the connected binscatter plot would have a "jagged" look). The fact that the ordering of households is the same across plans is important because it permits a graphical analysis on multiple plans analogous to that used in the two plan example in Figure 1.

Figure 5. Willingness to Pay



Notes: The figure shows the distribution of willingness to pay. Households are arranged on the horizontal axis according to their marginal willingness to pay relative to the Catastrophic plan. The plot consists of four connected binscatter plots with respect to 100 bins of households ordered by willingness to pay.

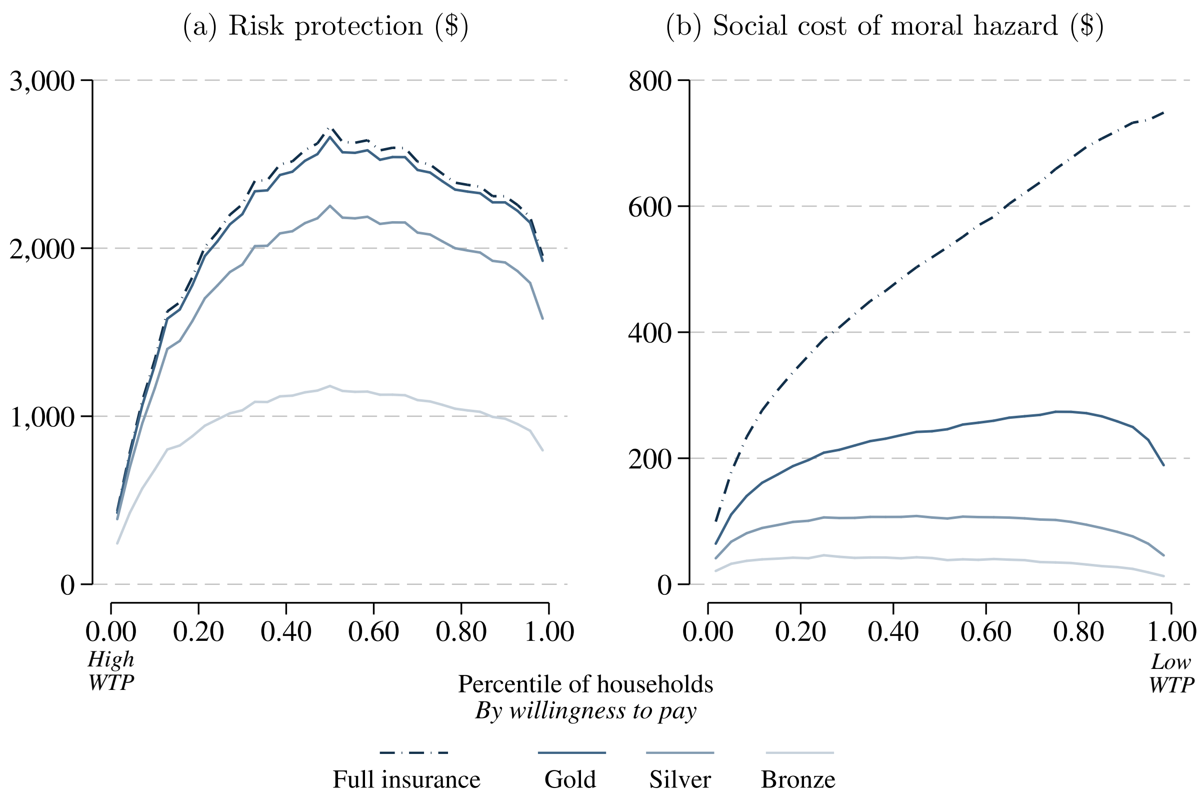
plan as the difference between willingness to pay and expected insurer cost:

$$SS_{kj} = \underbrace{\Psi_{kj}}_{\substack{Value\ of\ risk\\ protection}} - \underbrace{\left((\bar{k}_{kj} - \bar{k}_{k,j_0}) - (\bar{c}_{k,j_0} - \bar{c}_{kj} + \bar{b}_{kj} - \bar{b}_{k,j_0})\right)}_{\substack{Social\ cost\\ of\ moral\ hazard}},$$

where $\bar{k}_{kj}$ is the expectation of insured spending $k_j(m_j^*(l, \omega_k))$ with respect to the distribution of l. The value of risk protection will vary in the population to the extent that there is variation in risk aversion and in the probability that households realize health states that would result in different levels of out-of-pocket cost across plans. The social cost of moral hazard will vary in the population to the extent that there is variation in the moral hazard parameter and in the probability that households realize health states that would result in different marginal out-of-pocket cost across plans.

To understand the contribution of each of these components to the overall relationship between willingness to pay and social surplus, we first plot them separately. Figure 6a presents households' value of risk protection for each plan across the distribution of willingness to pay. We find that the majority of the social welfare gains from more generous insurance are driven by households with intermediate levels of willingness to pay. This "shape" of risk protection could be driven either by the distribution of risk aversion or the distribution of risk in the population. We investigate by examining the joint distribution of risk aversion and willingness to pay (see Figure A.9a). While there is substantial variation in the risk aversion parameter, average risk aversion is monotonically increasing in willingness to pay. The inverted U-shape in Figure 6a must therefore be driven by the shape of household *risk*.

Figure 6. Value of Risk Protection and Social Cost of Moral Hazard



Notes: The figure shows the marginal value of risk protection and the marginal social cost of moral hazard. Households are arranged on the horizontal axis according to their marginal willingness to pay. The left panel shows the marginal value of risk protection in the given plan relative to the Catastrophic plan. The right panel shows the marginal social cost of moral hazard in the given plan relative to the Catastrophic plan. Both panels are composed of connected binscatter plots with respect to 50 bins of households ordered by willingness to pay.

The inverted U-shape of risk makes sense given the nonlinear nature of the plans we consider. Very sick households are overwhelmingly likely to realize health states above the out-of-pocket maximum of every plan, leaving essentially no uncertainty in out-of-pocket spending. On the other hand, very healthy households are overwhelmingly likely to realize health states below the deductible of all plans, rendering the plans roughly identical for them. The households that do face substantial uncertainty in their out-of-pocket spending across plans are those for which much of the density of their health state distribution lies in the range of total spending where out-of-pocket costs vary both across plans and across health states.[60]

Figure 6b shows the distribution of the social cost of moral hazard. The figure provides two important insights. First, high willingness to pay households on average do not change their behavior across the range of plans we consider. While they may have *already* been consuming more healthcare in the Catastrophic plan than they would have done absent any insurance at all, the difference between the full insurance plan and the Catastrophic plan is minimal. On the other hand, households with low willingness to pay on average do change their behavior substantially over this range of coverage levels. This pattern is driven by the interaction of health state distributions and the nonlinear contracts (treatment intensity), as well as by the fact that the household moral hazard parameter is decreasing in willingness to pay (treatment effect).[61] The second insight is that the Gold plan can recover more than half of the social cost of moral hazard induced by the full insurance plan. The $1,000 deductible is enough to undo the majority of the social cost of moral hazard under full insurance, while, as seen in Figure 6a, giving up only a small amount of risk protection.

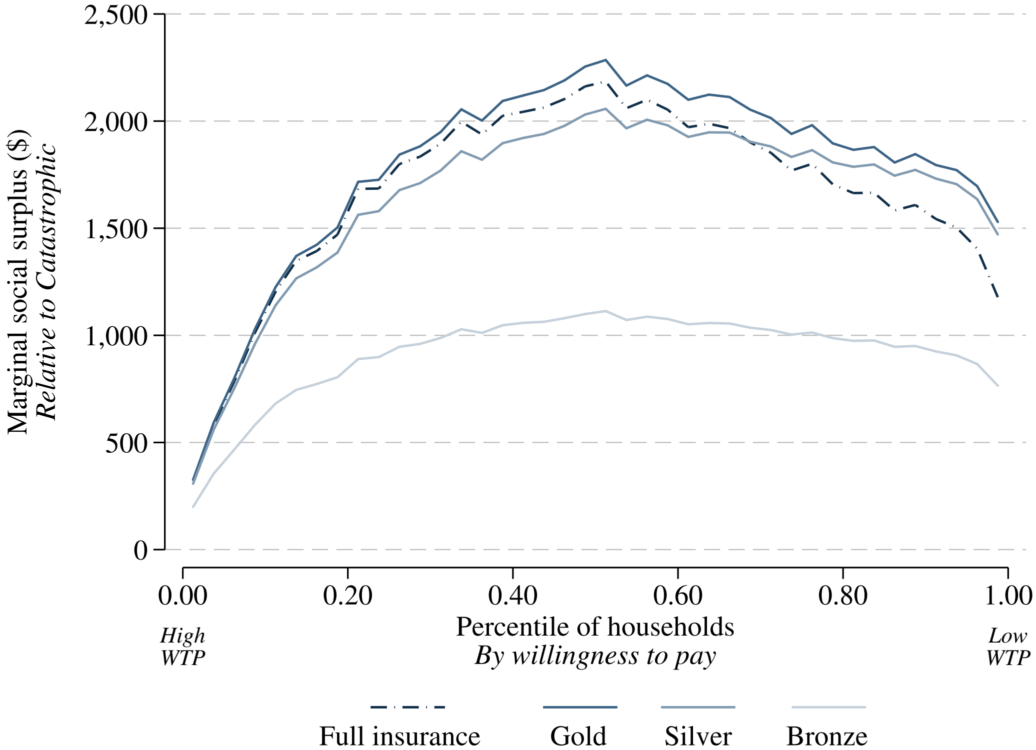
Finally, we construct the social surplus curve for each plan by vertically summing Figure 6a and (the negative of) Figure 6b. Figure 7 presents the social surplus generated by allocating households to a given plan relative to the Catastrophic plan. The plot consists of a connected binscatter for each plan, with respect to 50 (to reduce noise) quantiles of willingness to pay. At a given quantile of willingness to pay, the social surplus curves measure the average social surplus generated if all households at that quantile were allocated to a given plan.

The social surplus curves for all plans are above zero, meaning that the Catastrophic plan is the worst plan, from a social welfare perspective, at any level of willingness to pay. The Bronze plan is strictly second worst. Among the other plans, we find that the Gold plan generates weakly greater average surplus than any other plan at every level of willingness to pay. This figure is the empirical analog of the theoretical examples in the two-contract

[60]Figure A.10 shows the distributions of health states faced by households, by willingness to pay.

[61]Variation in treatment intensity can be inferred from the health state distributions at different levels of willingness to pay, shown in Figure A.10. Variation in treatment effect can be seen in the distribution of moral hazard parameter by willingness to pay, shown in Figure A.9b.

Figure 7. Social Surplus



Notes: The figure shows the marginal value of social surplus among family households. Households are arranged on the horizontal axis according to their marginal willingness to pay. The figure is composed of connected binscatter plots with respect to 50 bins of households ordered by willingness to pay.

setting in Section II.B. The Catastrophic plan is the "low" contract and the four others are potential "high" contracts. Vertical choice should only be offered if the high-willingness to pay consumers should have more insurance than the low-willingness to pay consumers. As in the theoretical example, this statement corresponds to a "crossing" of upper-envelope social surplus curves, with the higher coverage plan to the left. Here, the upper envelope of social surplus curves is composed of a single plan. A regulator facing this population of consumers would find it optimal to forgo vertical choice and offer only the Gold plan.

While the Gold plan is the efficient plan *on average* at every level of willingness to pay, it is not the efficient plan for every household. Figure A.11 displays the heterogeneity in households' efficient plans. It shows that the Silver plan is the efficient level of coverage for 30 percent of households, full insurance is efficient for 1 percent of households, and the Gold plan is efficient for 69 percent of households. While the efficient coverage level does vary, it is not correlated with willingness to pay. The optimal feasible allocation under community rated prices would achieve social surplus equal to the integral of the Gold plan's social surplus curve in Figure 7. In the next section, we quantify welfare and compare outcomes under alternative pricing policies.

VI Counterfactual Pricing Policies

We compare outcomes under five pricing policies: (i) our baseline of regulated competition with community rating, (ii) regulated competition with type-specific pricing (iii) break-even pricing with community rating, (iv) break-even pricing with type-specific pricing, and (v) subsidies to support full vertical choice. Regulated competition is the baseline policy in this paper, where the regulator can observe the distribution of consumer types and can tax or subsidize plan premiums (equivalent to a centralized market designer). Break-even pricing is the case in which premiums must equal average costs on a plan by plan basis, rendering the market susceptible to unraveling due to adverse selection.[62] Subsidies to support full vertical choice is a policy of subsidies set with the intention of supporting the availability of (enrollment in) every plan.

We consider two scenarios in which prices can vary by consumer attributes: (ii) and (iv). If observable dimensions of consumer type are predictive of their efficient coverage level, allowing plan menus to be tailored to specific types may improve allocations. We divide consumers into four groups: childless households under age 55, childless households over age 55, households under age 40 with children, and households over age 40 with children. The age cutoffs are chosen to divide households in half within each group (childless or not). We choose age and whether the household has children because these are used in ACA exchanges and are also the important observables on which parameters of our model may vary.

We benchmark outcomes against the first best allocation of households to plans (as depicted in Figure A.11). This allocation results in one percent of households in the full insurance plan, 69 percent of households in the Gold plan, and 30 percent of households in the Silver plan. The first best allocation generates \$1,796 in social surplus per household relative to the counterfactual of allocating all households to the Catastrophic plan. Expected total spending per household under this allocation is \$12,140, and expected insurer cost per household is \$10,067. This allocation cannot be supported by prices unless prices can vary by specific consumer types such as risk aversion and the moral hazard parameter.

[62] This case can be thought of as "unregulated competition" up to the regulation that only our pre-specified set of plans can be offered.

Table 5 summarizes these results, as well as the results for our five pricing policies. For each policy, we show the percent of households Q enrolled in each plan at the optimal feasible allocation, the percent of first best social surplus that is achieved, and the average expected insurer cost AC among households in each plan. Costs are measured in thousands of dollars. Social surplus is still normalized to zero for the Catastrophic plan. The welfare gains from more generous insurance are concave in coverage level. If the regulator were to offer only a single plan, the percent of first best surplus generated by allocating all households to the Bronze plan is 51 percent, to the Silver plan is 92 percent, to the Gold plan is 96 percent, and to full insurance is 91 percent.

Table 5. Outcomes of Alternative Pricing Policies

	Policy	% of First Best Surplus		Potential Plans				
				Full	Gold	Silver	Bronze	Ctstr.
*	First best	1.000	*Q:*	0.01	0.69	0.30	0.00	0.00
			AC:	5.55	9.37	11.67	–	–
(i)	Regulated competition with community rating	0.965	*Q:*	0.00	1.00	0.00	0.00	0.00
			AC:	–	10.71	–	–	–
(ii)	Regulated competition with type pricing	0.965	*Q:*	0.00	1.00	0.00	0.00	0.00
			AC:	–	10.71	–	–	–
(iii)	Break-even pricing with community rating	0.000	*Q:*	0.00	0.00	0.00	0.00	1.00
			AC:	–	–	–	–	6.21
(iv)	Break-even pricing with type pricing	0.230	*Q:*	0.00	0.00	0.00	0.33	0.67
			AC:	–	–	–	7.58	5.99
(v)	Subsidies to support vertical choice	0.797	*Q:*	0.01	0.07	0.63	0.28	0.01
			AC:	59.53	32.41	8.39	1.89	0.28

Notes: This table summarizes the outcomes of the five pricing policies we consider as well as the first best outcome, among the 32,377 family households. At the first best allocation, per-household social surplus is \$1,796 and average expected insurer cost is \$10,067. Q represents the percent of households enrolled in each plan, and AC represents the average expected insurer cost (in thousands of dollars) among households enrolled in a given plan.

Alternative (i) is our baseline pricing policy where the regulator can design the market but is restricted to community rated pricing. As indicated by Figure 7, under this scenario it is welfare maximizing to offer only Gold. The average insurer cost of all households in the Gold plan is \$10,706. In order to break even, the regulator sets a premium equal to \$10,706 per household.[63] Interestingly, though 31 percent of households are misallocated under this

[63] Given there is only one possible option, households must pay the premium. A premium that everyone must pay could just as well be thought of as a tax.

policy, it generates 96.5 percent of the welfare generated under the first best allocation. Among the households for whom the Gold plan was not optimal, there is little variation in efficiency across the top plans.

Because pricing policy (i) is almost as efficient as the first best outcome, there is little scope for improvement by varying prices by consumer types in alternative (ii). Even so, we find that allowing the regulator to price discriminate does not improve allocational efficiency at all. Age and whether or not a household has children does not predict households' efficient level of insurance. Within each of the four household subgroups, the Gold plan is on average the most efficient across the distribution of willingness to pay, so the regulator finds it optimal to only offer the Gold plan within each subgroup.

Alternative (iii) analyzes the case where equilibrium premiums must be set such that all plans break even. We calculate the competitive equilibrium using the algorithm proposed in Azevedo and Gottlieb (2017).[64] We find that in this population, the market fully unravels to the Catastrophic plan. The premium and expected insurer cost per household at the Catastrophic plan is $6,210. While choice is permitted under this policy, an unregulated market cannot deliver it. Alternative (iv) considers which allocations could be supported under break-even pricing if prices could vary by consumer subgroup. We find that both populations of households without children (both above and below age 55) can support a pooling equilibrium at the Bronze plan. A higher coverage level can be supported within these subpopulations because there is less variation in willingness to pay. On the other hand both markets for households with children still unravel to the Catastrophic plan. This allocation recovers 23 percent of first best social surplus.

The first four policies are natural benchmarks, but none turn out to feature vertical choice. The regulator bans vertical choice under regulated competition, and adverse selection prevents the availability of choice under break-even pricing. In reality, vertical choice does exist. It is sustained in U.S. health insurance markets in part (if not all) by a variety of subsidies, transfers, and tax policies. To mimic this outcome, alternative (v) considers premiums that support enrollment shares matching the true metal-tier shares observed on ACA exchanges in 2018.[65] The targeted shares are those shown in Table 5. The premiums that can support these shares and break even in aggregate are $13,492 for full insurance, $11,536 for Gold,

[64] Like the authors, we use a mass of behavioral consumers equal to 1 percent of the population of households. See Azevedo and Gottlieb (2017) for additional details.

[65] Shares are pulled from Kaiser Family Foundation "Marketplace Plan Selections by Metal Level," available at https://www.kff.org/health-reform/state-indicator/marketplace-plan-selections-by-metal-level.

$9,102 for Silver, $6,992 for Bronze, and $6,085 for Catastrophic. Because households with mid-range willingness to pay (for whom welfare increases steeply at low coverage levels, see Figure 7) now choose the Silver plan, this allocation recovers 80 percent of first best social surplus.

Distributional Outcomes. The population faces an unavoidable healthcare spending bill of $11,455 per household. It is unavoidable because it arises even if all households have the least generous insurance (Catastrophic). While full insurance offers the benefit of risk protection, it also raises the spending bill to $12,497 per household due to moral hazard. The spending bill is funded by a combination of out-of-pocket costs and insurer costs. Insurer costs are in turn funded by premiums or by taxes. We do not distinguish between the two: an increase in premiums on all plans by $5 is equivalent to a tax of $5. If all households had Catastrophic coverage, in expectation 49 percent of spending would be paid out-of-pocket and 51 percent of spending would be insured. If all households had full insurance, 100 percent of spending would be insured. There are large differences among the policies in the source of funding for the population healthcare spending bill, and in turn, how evenly the spending bill is shared across households. If all households had full insurance, the spending bill would be split perfectly evenly in the population.[66] If all households had no insurance, each household would pay their own expected cost.[67]

Our welfare measure considers only efficiency. A natural question is how equitably surplus is distributed in the population. We explore the distribution of surplus under three of our candidate policies: (i) optimal regulation ("All Gold"), (iii) break-even pricing ("All Catastrophic"), and (v) subsidies to support vertical choice ("Vertical Choice"). Because we estimate willingness to pay relative to the Catastrophic plan, we likewise measure surplus relative to the Catastrophic plan. For a given focal policy, we calculate marginal consumer surplus for each household as their marginal willingness to pay less the marginal premium for their chosen plan. Marginal premium is equal to the difference between the premium of the household's chosen plan under the focal policy and the break-even premium of the Catastrophic plan when all households are allocated to it ($6,210). The sum of consumer

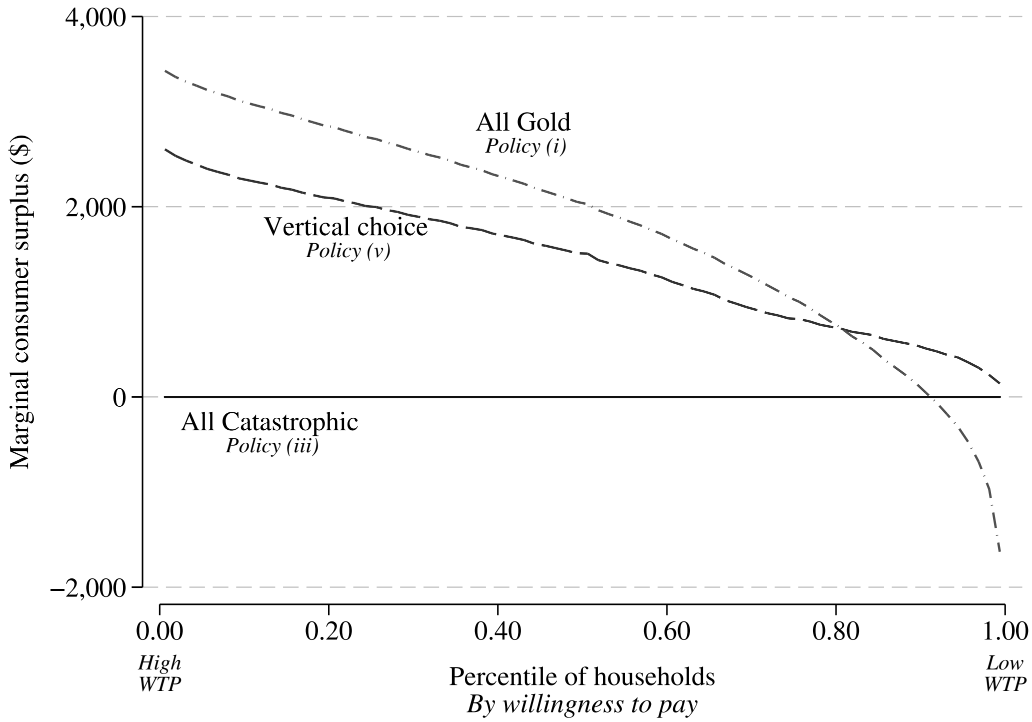
[66] In reality, if there were a single required premium, this would be assessed as a tax (as in countries that run a national health insurance scheme). In that case, premiums would not be split evenly, but according to the prevailing income tax system.

[67] In this case, the top 10 percentile WTP households would pay 30 percent of the population spending bill, while the bottom 10 percentile WTP households would pay 3 percent. Many households could not afford to pay their expected cost, which is one reason why we do not consider a no insurance contract. Figure A.12 provides a depiction of the breakdown of out-of-pocket versus insured spending across the population under each policy.

surplus across all households under a given policy equals the total social surplus generated by that policy.

Figure 8 shows the distribution of consumer surplus under the three policies across the distribution of willingness to pay.[68] We find that 91 percent of households prefer optimal regulation under policy (i) to the alternative of an unregulated (and unraveled) market. We find that *all* households prefer vertical choice under policy (v) to the alternative of an unraveled market. Strikingly, we also find that 81 percent of households prefer optimal regulation to vertical choice. While a shift to optimal regulation from vertical choice would make 19 percent of households worse off, only 9 percent of households would be at least $500 worse off. The shift would raise welfare by $302 per household per year.

Figure 8. Distribution of Consumer Surplus



Notes: The figure shows the distribution of consumer surplus in the population under three alternative policies, corresponding to the policies presented in Table 5. Households are arranged on the horizontal axis according to their willingness to pay.

[68] The difference between the "All Gold" consumer surplus curve in Figure 8 and the Gold plan social surplus curve in Figure 7 is that the former shows who receives the surplus while the latter shows who generates the surplus. The integrals of the two curves are the same.

VII Conclusion

This paper presents a framework for examining how policymakers should evaluate whether or not to offer a choice over coverage levels in health insurance markets. Our framework incorporates consumer heterogeneity along numerous dimensions, endogenous healthcare utilization through moral hazard, and permits menus of multiple nonlinear insurance contracts among which traded contracts are endogenous. Our analysis emphasizes the importance of distinguishing between the components of willingness to pay for insurance that are transfers and the components that are relevant to social welfare. Transfers play a large role in health insurance markets. Health status is persistent and contracts (at least in the U.S.) often span only a short, one-year time horizon.[69] The implication is that a large part of healthcare spending can be foreseen, so it may not be possible to align private incentives to maximize personal transfer and social incentives to mitigate financial uncertainty. The presence of moral hazard means the problem is more complex than simply mandating full insurance for everyone.

We show that the key condition for vertical choice to be desirable is whether high willingness to pay consumers have higher efficient levels of coverage. In reverse, this implies that a lowest-coverage plan should only be offered if the lowest willingness to pay consumers should have it. In our empirical setting, the lowest coverage plan we consider is a high deductible health plan. We find that low willingness to pay consumers are sufficiently risk averse to warrant higher coverage, and thus that a high deductible health plan should not be offered in the market. On the other hand, a highest-coverage plan should only be offered if the highest willingness to pay consumers should have it. The highest coverage plan we consider is full insurance, and we find that it would more efficient for the high willingness to pay consumers to have less coverage. Between these extremes, we find that private values for coverage level are not positively correlated with social values, and thus that choice over coverage level should not be offered. We find that the best single plan to offer (among those we consider) has an actuarial value of 85 percent, but also that the social welfare stakes with respect to the exact plan design are low in the range of 80 percent to 90 percent actuarial value.

We limit our attention to a range of coverage levels over which uncertainty about healthcare utilization represents a purely financial gamble. Important considerations that our model

[69] Handel, Hendel and Whinston (2017) consider long-term contracts in health insurance markets. It would be interested to consider the welfare effects of vertical choice in that setting.

does not address arise when consumers face liquidity constraints (Ericson and Sydnor, 2018) and when consumers can be protected from large losses by limited liability in addition to by insurance (Gross and Notowidigdo, 2011). These distortions would become more pronounced outside the range of coverage levels we consider, and it would be interesting to explore their effects on our conclusions. In addition, the socially optimal level of healthcare utilization in our model is that which would occur in the least generous insurance contract. If healthcare providers charge supracompetitive prices or if there are externalities with respect to the consumption of healthcare services, it may be the case that inducing additional health spending with insurance is desirable. Such distortions would likely push up efficient coverage levels. Finally, an important simplification of our model is that healthcare is a homogenous good over which consumers must only choose the quantity to consume. In reality, healthcare is multidimensional and the time and space over which utilization decisions are made is complex. We see the extension of our model to capture other dimensions of healthcare utilization to be an important direction for future research.

References

Abaluck, Jason, and Jonathan Gruber. 2016. "Evolving Choice Inconsistencies in Choice of Prescription Drug Insurance." *American Economic Review*, 106(8): 2145–84.

Akerlof, George A. 1970. "The Market for "Lemons": Quality Uncertainty and the Market Mechanism." *Quarterly Journal of Economics*, 84(3): 488–500.

Arrow, Kenneth J. 1965. "Uncertainty and the Welfare Economics of Medical Care: Reply (The Implications of Transaction Costs and Adjustment Lags)." *The American Economic Review*, 55(1/2): 154–158.

Azevedo, Eduardo M., and Daniel Gottlieb. 2017. "Perfect Competition in Markets With Adverse Selection." *Econometrica*, 85(1): 67–105.

Bogin, Alexander, William Doerner, and William Larson. 2019. "Local House Price Dynamics: New Indices and Stylized Facts." *Real Estate Economics*, 47(2): 365–398.

Brot-Goldberg, Zarek C., Amitabh Chandra, Benjamin R. Handel, and Jonathan T. Kolstad. 2017. "What does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics*." *The Quarterly Journal of Economics*, 132(3): 1261–1318.

Bundorf, M. Kate, Jonathan Levin, and Neale Mahoney. 2012. "Pricing and welfare in health plan choice." *American Economic Review*, 102(7): 3214–3248.

Cardon, James H., and Igal Hendel. 2001. “Asymmetric Information in Health Insurance: Evidence from the National Medical Expenditure Survey.” *The RAND Journal of Economics*, 32(3): 408–427.

Carlin, Caroline, and Robert Town. 2008. “Sponsored Health Plans.” *ReVision*, 0–67.

Cobb, Barry, Rafael Rumí, and Antonio Salmerón. 2012. “Approximating the Distribution of a Sum of Log-normal Random Variables.” *Proceedings of the 6th European Workshop on Probabilistic Graphical Models, PGM 2012*.

Cohen, Alma, and Liran Einav. 2007. “Estimating Risk Preferences from Deductible Choice.” *American Economic Review*, 97(3): 745–788.

Dixit, Avinash K., and Joseph E. Stiglitz. 1977. “Monopolistic Competition and Optimum Product Diversity.” *The American Economic Review*, 67(3): 297–308.

Dubin, Jeffrey A., and Daniel L. McFadden. 1984. “An Econometric Analysis of Residential Electric Appliance Holdings and Consumption.” *Econometrica*, 52(2): 345–362.

Einav, Liran, Amy Finkelstein, and Jonathan Levin. 2010. “Beyond Testing: Empirical Models of Insurance Markets.” *Annual Review of Economics*, 2(1): 311–336.

Einav, Liran, Amy Finkelstein, Stephen P. Ryan, Paul Schrimpf, and Mark R. Cullen. 2013. “Selection on moral hazard in health insurance.” *American Economic Review*, 103(1): 178–219.

Einav, Liran, Amy N. Finkelstein, and Mark Cullen. 2010. “Estimating Welfare in Insurance Markets Using Variation in Prices.” *The Quarterly Journal of Economics*, CXV(3).

Einav, Liran, and Amy Finkelstein. 2018. “Moral Hazard in Health Insurance: What We Know and How We Know It.” *Journal of the European Economic Association*, 16(4): 957–982.

Ericson, Keith Marzilli, and Justin R Sydnor. 2018. “Liquidity Constraints and the Value of Insurance.” National Bureau of Economic Research Working Paper 24993.

Ericson, Keith Marzilli, and Justin Sydnor. 2017. “The Questionable Value of Having a Choice of Levels of Health Insurance Coverage.” *Journal of Economic Perspectives*, 31(4): 51–72.

Fenton, L. F. 1960. “The sum of log-normal probability distributions in scatter transmission systems.” *IRE Transactions on Communication Systems*, 8: 57–67.

Finkelstein, Amy, and Kathleen McGarry. 2006. “Multiple Dimensions of Private Information: Evidence from the Long-Term Care Insurance Market.” *American Economic Review*, 96(4): 938–958.

Geruso, Michael. 2017. “Demand heterogeneity in insurance markets: Implications for equity and efficiency.” *Quantitative Economics*, 8(3): 929–975.

Gross, Tal, and Matthew J. Notowidigdo. 2011. "Health insurance and the consumer bankruptcy decision: Evidence from expansions of Medicaid." *Journal of Public Economics*, 95(7): 767 – 778.

Handel, Benjamin, Igal Hendel, and Michael Whinston. 2015. "Equilibria in Health Exchanges : Adverse Selection vs . Reclassification Risk." *Econometrica*, 83(4): 1261–1313.

Handel, Benjamin R. 2013. "Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts." *American Economic Review*, 103(7): 2643–2682.

Handel, Benjamin R., and Jonathan T. Kolstad. 2015. "Health Insurance for "Humans": Information Frictions, Plan Choice, and Consumer Welfare." *American Economic Review*, 105(8): 2449–2500.

Handel, Benjamin R, Igal Hendel, and Michael D Whinston. 2017. "The Welfare Effects of Long-Term Health Insurance Contracts." National Bureau of Economic Research Working Paper 23624.

Ho, Kate, and Robin Lee. 2019. "Health Insurance Menu Design: Managing the Spending Coverage Tradeoff." *Presentation. Conference Celebrating the Scholarly Career of Mark Satterthwaite*, Kellogg School of Management.

Manning, Willard G., Joseph P. Newhouse, Naihua Duan, Emmett B. Keeler, and Arleen Leibowitz. 1987. "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment." *The American Economic Review*, 77(3): 251–277.

McManus, Margaret A., Stephen Berman, Thomas McInerny, and Suk-fong Tang. 2006. "Weighing the Risks of Consumer-Driven Health Plans for Families." *Pediatrics*, 117(4): 1420–1424.

Miranda, Mario J., and Paul L. Fackler. 2002. *Applied Computational Economics and Finance.* MIT Press.

Newhouse, Joseph. 1993. "Free for All? Lessons from the RAND Health Insurance Experiment." *Cambridge, MA. Harvard University Press.*

Pauly, Mark V. 1968. "The Economics of Moral Hazard: Comment." *American Economic Review*, 58(3): 531–537.

Pauly, Mark V. 1974. "Overinsurance and Public Provision of Insurance : The Roles of Moral Hazard and Adverse Selection." *The Quaterly Journal of Economics*, 88(1): 44–62.

Reed, Mary, Vicki Fung, Mary Price, Richard Brand, Nancy Benedetti, Stephen F. Derose, Joseph P. Newhouse, and John Hsu. 2009. "High-Deductible Health Insurance Plans: Efforts To Sharpen A Blunt Instrument." *Health Affairs*, 28(4): 1145–1154. PMID: 19597214.

Revelt, David, and Kenneth Train. 1998. "Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level." *The Review of Economics and Statistics*, 80(4): 647–657.

Revelt, David, and Kenneth Train. 2001. "Customer-Specific Taste Parameters and Mixed Logit: Households' Choice of Electricity Supplier." , (0012001).

Rothschild, Michael, and Joseph Stiglitz. 1976. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." *The Quarterly Journal of Economics*, 90(4): 629–649.

Train, Kenneth. 2009. *Discrete Choice Methods with Simulation: Second Edition.* Cambridge University Press.

Zeckhauser, Richard. 1970. "Medical Insurance: A Case Study of the Tradeoff Between Risk Spreading and Appropriate Incentives." *Journal of Economic Theory*, 2(1): 10–26.

Appendix A

A.1 Calculation of willingness to pay for insurance

The expected utility of a consumer of type θ for contract x at premium p is given by $U(x, p, \theta)$, as defined in equation (1) and repeated here:

$$U(x,p,\theta) = \mathbb{E}\left[\, u_\psi(\; b^*(l,x,0) - c^*(l,x,0) + v(l,x,\omega) - p) \middle|\; l \sim F\right].$$

We can express the corresponding certainty equivalent $CE(x, p, \theta)$ as that which solves $u(CE(x, p, \theta)) = U(x, p, \theta)$. We can further write:

$$\begin{aligned} CE(x,p,\theta) &= u_\psi^{-1}(U(x,p,\theta)) \\ &= EV(x,\theta) - p + u_\psi^{-1}(U(x,p,\theta)) - EV(x,\theta) + p \\ &= EV(x,\theta) - p - RP(x,p,\theta), \end{aligned}$$

where $EV(x, \theta) - p$ is the expected payoff and $RP(x, p, \theta)$ is the risk premium associated with the lottery. In particular,

$$\begin{aligned} EV(x,\theta) &= \bar{b}(F,x,0) - \bar{c}(F,x,0) + \bar{v}(F,x,\omega) \\ RP(x,p,\theta) &= EV(x,\theta) - p - u_\psi^{-1}(U(x,p,\theta)), \end{aligned} \tag{15}$$

where $\bar{b}(F, x, \omega)$ is the expected value of $b^*(l, x, \omega)$ with respect to l, and $\bar{c}(F, x, \omega)$ and $\bar{v}(F, x, \omega)$ are similarly defined. A consumer's willingness to pay for contract x relative to the null contract x_0 is equal to $\tilde{p}$ that solves:

$$\begin{aligned} CE(x, \tilde{p}, \theta) &= CE(x_o, p_o, \theta) \\ EV(x, \theta) - \tilde{p} - RP(x, \tilde{p}, \theta) &= EV(x_0, \theta) - p_0 - RP(x_0, p_0, \theta) \\ \tilde{p} - p_0 &= EV(x, \theta) - EV(x_0, \theta) + RP(x_0, p_0, \theta) - RP(x, \tilde{p}, \theta), \end{aligned}$$

To obtain a closed form expression for willingness to pay, we assume constant absolute risk aversion, and thus that the risk premium RP does not depend on the premium.[70] In this case, marginal willingness to pay for contract x relative to the null contract is given by:

$$\begin{aligned} WTP(x, \theta) &= EV(x, \theta) - EV(x_0, \theta) + RP(x_0, \theta) - RP(x, \theta) \\ &= \bar{c}(F, x_0, \omega) - \bar{c}(F, x, 0) + \bar{v}(F, x, \omega) + \Psi(x, \theta), \end{aligned}$$

where $\Psi(x, \theta) = RP(x_0, \theta) - RP(x, \theta)$. The last step uses the facts that (i) $\bar{b}(F, x, 0) = \bar{b}(F, x_0, 0)$ because the choice of optimal healthcare utilization is the same across contracts if there is not moral hazard, and (ii) $\bar{v}(F, x_0, \omega) = 0$ because there is not spending due to moral hazard in the null contract.

A.2 Estimation of plan cost sharing features

A key input to our empirical model is the cost sharing function of each plan that maps healthcare utilization into out-of-pocket costs. While Table 2 describes plans using the deductible and in-network out-of-pocket maximum, they are in reality characterized by a much more complex set of payment rules, including co-payments, specialist visit coinsurance, out-of-network fees, and fixed charges for emergency room visits. To structurally model moral hazard, we make the important simplification that healthcare is a homogenous good over which the consumer must choose only the quantity to consume. As described in Section II, consumers decide how much healthcare to consume based in part on out-of-pocket cost. To that end, our empirical model requires as an input a univariate function that maps total healthcare spending into out-of-pocket spending.

A natural choice for such a function might be to use the deductible, non-specialist coinsurance rate, and in-network out-of-pocket maximum. However, in our setting, the out-of-pocket

[70] In equation (15), p cancels out completely. This assumption is often reasonable given that marginal premiums between relevant plans are small relative to consumer wealth.

cost function described by these features does not correspond well to the shape of the relationship between out-of-pocket spending and total spending that we observe in the claims data. In particular, we often observe out-of-pocket spending amounts that exceed plans' in-network out-of-pocket maximum. Because of this, we take a different approach.

We define plan cost sharing functions by three parameters: a deductible, a coinsurance rate, and an out-of-pocket maximum. Taking the true deductibles as given (since these correspond well to the data), we estimate a coinsurance rate and an out-of-pocket maximum that minimizes the sum of squared residuals between predicted and observed out-of-pocket spending. We observe realized total healthcare spending for each household in the claims data. Predicted out-of-pocket spending is calculated by applying the deductible and supposed coinsurance rate and out-of-pocket maximum. Observed out-of-pocket spending is either observed directly in the claims data (if a household chose that plan) or else calculated counterfactually. We calculate counterfactual out-of-pocket spending using the "claims calculator" developed for this setting by Abaluck and Gruber (2016). We carry out this procedure separately for each plan, year, and family status (individual and family).[71]

Figure A.1 shows the data used to estimate the cost sharing features of a particular plan (Moda Plan 3 for individual households in 2012). Each open circle indicates a household; total healthcare spending is on the horizontal axis and out-of-pocket spending is on the vertical axis.[72] The dark dots are a binscatter plot of the gray open circles data, using 100 data points. The observed, basic cost sharing features of the plan are a deductible of \$300, non-specialist coinsurance rate of 20 percent, and in-network out-of-pocket maximum of \$2,000. It is clear that the data do not correspond well to a \$2,000 out-of-pocket maximum. The red line shows the "estimated" cost sharing function of the plan: the estimated coinsurance rate is 20.5 percent and the estimated out-of-pocket maximum is \$3,218. Table A.3 presents the estimated cost sharing features for all plans in all years.

A.3 Descriptive Evidence: Additional Details

Explaining Variation in Plan Menu Generosity. We replicate the analysis comparing plan menu generosity to observed household health risk in 2009–2013; these estimates are

[71] So that the cost-sharing estimates are not affected by large outliers, we drop observations where out-of-pocket spending was above \$20,000 or total healthcare spending was above \$100,000.

[72] Because there are thousands of individual households in 2012, the plot only shows the dots for a 20 percent random sample.

presented in Table A.6. The logit model (equation (7)) that produces predicted actuarial value is estimated separately for each year; these estimates are presented in Table A.5. We can consistently reject the hypothesis that household risk scores are correlated with plan menu generosity, conditional on family structure. We also consistently find that plan menus are most generous for single employee coverage and least generous for employee plus family coverage. This is consistent with our understanding of OEBB's benefit structure and is common in employer-sponsored health insurance.

We further explore what covariates, in addition to family structure, *do* seem to explain variation in plan menu generosity. Table A.7 presents three additional regressions using the 2008 sample of predicted actuarial value on employee-level covariates (part-time versus full-time status, occupation type, and union affiliation) as well as school district-level covariates (home price index and percent of Republicans). Employees are either part-time or full-time. There are eight mutually exclusive employee occupation types; the regressions omit the type "Licensed Administrator."[73] There are five mutually exclusive union affiliations and employees may also not be affiliated with a union; the regressions omit the non-union category. We calculate the average home price index (HPI) in a school district by taking the average zip-code level home price index across employees' zip-code of residence.[74] *Pct. Republican* measures the percent of households in a school district that are registered as Republicans as of 2016.[75]

We find that plan menus are less generous on average for part-time employees, are substantially less generous for substitute teachers, and are more generous for employees at community colleges. Certain union affiliations are also predictive of more or less generous plan menus. Across school districts, predicted actuarial value is decreasing in both the logged home price index as well as the percent of registered Republicans.

Heterogeneity in Moral Hazard. In section III.B, we present evidence of heterogeneity in moral hazard across quartiles of household risk score. Here, we explore the extent to which this heterogeneity can be explained by variation in the intensity of treatment. Assignment into a lower or higher coverage plan could affect total spending by exposing consumers to

[73] "Licensed" refers to the possession of a teaching license.

[74] We use 5-Digit zip-code level home price indices from Bogin, Doerner and Larson (2019). The data and paper are accessible at http://www.fhfa.gov/papers/wp1601.aspx.

[75] Data on percent of registered voters by party is available at the county level; we construct school district measured by taking the average over employees' county of residence. Voter registration data in Oregon can be downloaded at https://data.oregon.gov/api/views/6a4f-ecbi.

lower or higher out-of-pocket costs. However, if a consumer is so healthy that they would almost always be consuming healthcare at levels below the deductible of both plans, then there is in fact no variation in coverage level for that consumer. The same could be true of very sick households that, knowing they will always spend the out-of-pocket maximum, will consume healthcare in the same way in both plans.

Table A.9 compares the realized spending outcomes of households in different risk quartiles with the variation in plan cost-sharing features that gives rise to different marginal out-of-pocket prices. The top panel of Table A.9 shows the observed distributions of total spending among the four quartiles of risk for individual and family households. The bottom panel shows the (in-network) deductible and out-of-pocket maximum (OOP Max.) for each of the Moda plans in 2008. We find that the heterogeneity in our moral hazard estimates in Table 3 lines up well with households' potential exposure to varying marginal out-of-pocket costs. For example, individual households in the first quartile have the majority of the density of their spending distribution around or below the plan deductibles. Individual households in the third and fourth quartiles of individual households have the majority of their spending near or above the plan out-of-pocket maximums.

The patterns of heterogeneity in our estimates of moral hazard in Table 3 correspond well to the likely variation in marginal out-of-pocket prices facing each type of household. For example, we estimate the largest amount of moral hazard for the second quartile of individual households, whose spending distribution more closely spans the range over which there would in fact be marginal out-of-pocket price variation across plans. Likewise for family households, those in the fourth quartile nearly all have spending above the highest out-of-pocket maximum, and we do not estimate any moral hazard within this group. While this exercise is merely suggestive, it points to the fact that a key dimension of heterogeneity is the extent to which households are exposed to differential out-of-pocket spending across nonlinear insurance contracts. Our theoretical and empirical models are well-equipped to capture this issue.

Appendix B Estimation Details

B.1 Fenton-Wilkinson Approximation

As there is no known closed form solution for the distribution of the sum of lognormal random variables, the Fenton-Wilkinson approximation is widely used in practice.[76] Under the Fenton-Wilkinson approximation, the distribution of the sum of draws from independent lognormal distributions can be represented by a lognormal distribution. The parameters of the approximating lognormal distribution are chosen such that its first and second moments match the moments of the true distribution of the sum of lognormals, which it is simple to calculate. In our application, the sum of lognormals is the household's health state distribution and the independent lognormals being summed are the household's individuals' health state distributions. Individuals are assumed to face lognormal distributions of health states according to:

$$\log(\tilde{l}_i + \kappa_i) \sim N(\mu_i, \sigma_i^2).$$

All parameters may vary over time (since individual demographics vary over time), but t subscripts are omitted here for simplicity. The moment matching conditions for the distribution of a household level health state are:

$$E(\tilde{l}_k + \kappa_k) = \sum_{i \in \mathcal{I}_k} E(\tilde{l}_i + \kappa_i), \tag{16}$$

$$Var(\tilde{l}_k + \kappa_k) = \sum_{i \in \mathcal{I}_k} Var(\tilde{l}_i + \kappa_i), \tag{17}$$

$$E(\tilde{l}_k) = \sum_{i \in \mathcal{I}_k} E(\tilde{l}_i). \tag{18}$$

where $\mathcal{I}_k$ is the set of individuals in household k. Equation (16) sets the mean of the household's health state distribution equal to the sum of the means of each individual's health state distributions. Equation (17) matches the variance. Because we have a third parameter to estimate (the shift, κ_k), we use a third moment matching condition to match the first moment of the unshifted distribution, shown in equation (18).

Under the approximating assumption that $l_k + \kappa_k$ is distributed lognormally, and substituting the analytical expressions for the mean and variable of a lognormal distribution, these

[76]See Fenton (1960), and for a summary, Cobb, Rumí and Salmerón (2012).

equations become:

$$\exp(\mu_k + \frac{\sigma_k^2}{2}) = \sum_{i \in \mathcal{I}_k} \exp(\mu_i + \frac{\sigma_i^2}{2})$$
$$(\exp(\sigma_k^2) - 1)\exp(2\mu_k + \sigma_k^2) = \sum_{i \in \mathcal{I}_k} (\exp(\sigma_i^2) - 1)\exp(2\mu_i + \sigma^2)$$
$$\exp(\mu_k + \frac{\sigma_k^2}{2}) - \kappa_k = \sum_{i \in \mathcal{I}_k} \exp(\mu_i + \frac{\sigma_i^2}{2}) - \kappa_i$$

This leaves three equations in three unknowns for the parameters of a household's distribution. The solutions for μ_k, σ_k^2, and κ_k are as follows:

$$\sigma_k^2 = log[1 + \left[\sum_{i \in \mathcal{I}_k} \exp(\mu_i + \frac{\sigma_i^2}{2})\right]^{-2} \sum_{i \in \mathcal{I}_k} (\exp(\sigma_i^2) - 1)\exp(2\mu_i + \sigma_i^2)]$$
$$\mu_k = -\frac{\sigma_k^2}{2} + log[\sum_{i \in \mathcal{I}_k} \exp(\mu_i + \frac{\sigma_i^2}{2})]$$
$$\kappa_k = \sum_{i \in \mathcal{I}_k} \kappa_i$$

Given these algebraic solutions for the parameters of a household's distribution, we need only to estimate the individual-level parameters.

B.2 Estimation Algorithm

In this appendix we describe the details of the algorithm used to estimate our model of health insurance and healthcare demand. We estimate the model using a simulated maximum likelihood approach similar to that described in Revelt and Train (1998) and Train (2009), with the appropriate extension to a discrete/continuous choice model in the style of Dubin and McFadden (1984). The maximum likelihood estimator selects the parameter values that maximize the conditional probability density of households' observed total healthcare spending, given their plan choices.

The model contains three dimensions of unobservable heterogeneity: risk aversion, household health, and the moral hazard parameter. Random variables $\beta_{kt} = \{\psi_k, \mu_{kt}, \omega_k\}$ are distributed as described by equation (14). We denote the full set of model parameters to estimate as θ, which among other things contains the parameters of the distribution of the random variables. Given a guess of θ, we simulate the distribution of β_{kt} using Gaussian quadrature with 27 support points, yielding simulated points $\beta_{kts}(\theta) = \{\psi_{ks}, \mu_{kts}, \omega_{ks}\}$, as well as weights W_s.[77,78] For each simulation draw s, we then calculate the conditional density at households' observed total healthcare spending and the probability of households' observed plan choices.

We first construct individual-level health state distribution parameters μ_{it}, σ_{it}, and κ_{it} from θ and individual demographics, as described in equations 12. We then construct household-level health state distribution parameters μ_{kts}, σ_{kt}, and κ_{kt} using the formulas given in equations 13 and the draws of $\beta_{kts}(\theta)$. The model predicts that upon realizing their health state l, households choose total healthcare spending m by trading off the benefit of healthcare utilization with its out-of-pocket cost. Specifically, accounting for the fact that zero spending arises from negative health states, the model predicts optimal healthcare spending $m^*_{jt}(l, \omega_{ks}) = \max(0\ ,\ \omega_{ks}(1 - c'_{jt}(m^*)) + l)$ if household k were enrolled in plan j in year t. Inverting the expression, the implied health state l_{kjts} that would have given rise to observed spending m_{kt} under moral hazard parameter ω_{ks} is given by

$$l_{kjts} : \begin{cases} l_{kjts} < 0 & m_{kt} = 0 \\ l_{kjts} = m_{kt} - \omega_{ks}(1 - c'_{jt}(m_{kt})) & m_{kt} > 0. \end{cases}$$

Note that $c'_{jt}(m^*) = 1$ when $m_{kt} = 0$.

Household monetary health states are distributed lognormally according to:

$$l = \phi_f \tilde{l}$$
$$\log(\tilde{l} + \kappa_{kt}) \sim N(\mu_{kts}, \sigma^2_{kt})$$

There are two possibilities to consider. If m_{kt} is equal to zero, the implied health state l_{kjts} is negative. Given the monetary health state l_{kjts}, the implied "quantity" health state is equal to $\tilde{l}_{kjts} = \phi_f^{-1} l_{kjts}$, where f is the insurer offering plan j. Since $\phi_f > 0$, the probability of observing negative l_{kjts} is the probability of observing $\tilde{l}_{kjts} \leq \kappa_{kt}$ if $\tilde{l}_{kjts}$ is lognormally distributed with mean and variance parameters μ_{kts} and σ^2_{kt}. If m_{kt} is greater than zero, it is useful to define $\lambda_{kjts} = \phi_f^{-1} l_{kjts} + \kappa_{kt}$. The density of m_{kt} in this case is given by

[77] Note that some components of ψ_{ks}, μ_{kts}, and ω_{ks} do not depend on unobservables, and are fixed functions of θ and household demographics.

[78] We use the Matlab program *qnwnorm* to implement this method, with three points in each dimension of unobserved heterogeneity. The program can be obtained as part of Mario Miranda and Paul Fackler's CompEcon Toolbox; for more information see Miranda and Fackler (2002).

the density of λ_{kjts} conditional on $m_{kt} > 0$. Taken together, the probability density of total spending m conditional on plan, parameters, and household observables $\mathbf{X}_k$ is given by $f_m(m_{kt}|c_{jt}, \beta_{kts}, \theta, \mathbf{X}_{kt}) = P(m = m_{kt}|c_{jt}, \beta_{kts}, \theta, \mathbf{X}_{kt})$, where

$$f_m(m_{kt}|c_{jt}, \beta_{ks}, \theta, \mathbf{X}_{kt}) = \begin{cases} \Phi\left(\frac{\log(\kappa_{kt})-\mu_{kt}}{\sigma_{kt}}\right) & m_{kt} = 0, \\ \phi_f^{-1}\Phi'\left(\frac{\log(\lambda_{kjts})-\mu_{kt}}{\sigma_{kt}}\right) & m_{kt} > 0, \end{cases}$$

and $\Phi(\cdot)$ is the standard normal cumulative distribution function. For a given guess of parameters, there are certain values of m_{kt} for which the probability density is zero. In order to rationalize the data at all possible parameter guesses, we use a convolution of $f_m(m_{kt}|c_{jt}, \beta_{ks}, \theta, \mathbf{X}_{kt})$ and a uniform distribution over the range [-1e-75, 1e75].[79]

Next, we calculate the probability of a household's observed plan choice. Given θ and β_{kts}, we simulate the distribution of monetary health states l_{kjtsd} using $D = 30$ support points:

$$l_{kjtsd} = \phi_f\left(e^{\mu_{kts}+\sigma_{kt}Z_d} - \kappa_{kt}\right),$$

where Z_d is a vector of points that approximates a standard normal distribution using Gaussian quadrature, with associated weights W_d. We then calculate the optimal healthcare spending choice m_{kjtsd} associated with each potential health state, according to $m^*_{kjtsd} = \max(0\ ,\ \omega_{ks}(1 - c'_{jt}(m^*_{kjtsd})) + l_{kjtsd})$. Because marginal out-of-pocket costs depend on where the out-of-pocket cost function is evaluated, there is not a closed-form solution for m^*_{kjtsd}. Instead, we derive cutoff values on the health state that determine which out-of-pocket cost "region" a household will find optimal.

Plans in our empirical setting are characterized by a deductible, a coinsurance rate, and an out-of-pocket maximum. Because the plans are piece-wise linear (in three pieces), one must only try out three candidate values of $c'(m)$, and then compare optimized utility in each case in order to find the global optimal spending choice. Specifically, $c'(m) = 1$ if spending m is in the deductible region, $c'(m) = c$ in the coinsurance region, and $c'(m) = 0$ in the out-of-pocket maximum region. By performing a generic version of this calculation, we can construct the relevant cutoff values for the health state. Define a plan to consist of a deductible D, a coinsurance rate C, and an out-of-pocket maximum O. Define $A = C^{-1}(O - D(1 - C))$ to be the level of total spending above which the consumer would reach their out-of-pocket

[79]We have experimented with varying these bounds and found that it does not affect parameter estimates as long as the uniform density is sufficiently small.

maximum. Under moral hazard parameter ω, the relevant cutoff values are

$$
\begin{aligned}
Z_1 &= D - \omega(1-C)/2 \\
Z_2 &= O - \omega/2 \\
Z_3 &= A - \omega(1-C/2),
\end{aligned}
$$

where $Z_1 \leq Z_2 \leq Z_3$ so long as $O \geq D$ and $C \in [0,1]$. There are two types of plans to consider. If D and A are sufficiently far apart (there is a sufficiently large coinsurance region), then only the cutoffs Z_1 and Z_3 matter, and it may be optimal to be in any of the three regions, depending on where the health state is relative to those two cutoff values. If D and A are close together, it will never be optimal to be in the coinsurance region (better to burn right though it and into the free healthcare of the out-of-pocket maximum region), and the cutoff Z_2 will determine whether the deductible or out-of-pocket maximum region is optimal. If the realized health state is negative, optimal spending will equal zero. In sum, optimal spending m^* conditional on health state realization l, moral hazard parameter ω and plan characteristics $\{D, C, O\}$ is given by

$$
\text{If} \quad A - D > \omega/2: \qquad m^* = \begin{cases} \max(0,l) & l \leq Z_1, \\ l + \omega(1-C) & Z_1 < l \leq Z_3, \\ l + \omega & Z_3 < l; \end{cases}
$$

$$
\text{If} \quad A - D \leq \omega/2: \qquad m^* = \begin{cases} \max(0,l) & l \leq Z_2, \\ l + \omega & Z_2 < l. \end{cases}
$$

Derivations are available upon request. A graphical example (of the case in which the coinsurance region is sufficiently large) is shown in Figure A.2b. All plans in our empirical setting have $A - D > \omega/2$ at reasonable values of ω.

With distributions of m^*_{kjtsd} in hand for each household, plan, year, and draw of β_{ks}, we can calculate households' expected utility from enrolling in each potential plan in their choice set. We construct the numerical approximation to equation (10) using the quadrature weights W_d:

$$
U_{kjts} = -\sum_{d=1}^{D} \left[W_d \; \exp\left(-\psi_k x_{kjts}(l_{kjtsd})\right) \right],
$$

where the monetary payoff x is calculated as in equation (11). To avoid numerical issues arising from double-exponentiation, we estimate the model in terms of certainty equivalent units of U_{kjts}:

$$U^{CE}_{kjts} = \bar{x}_{kjts} - \frac{1}{\psi_k} \log\left(\sum_{d=1}^{D} \left[W_d \ \exp\left(-\psi_k(x_{kjts}(l_{kjtsd}) - \bar{x}_{kjts})\right)\right]\right),$$

where $\bar{x}_{kjts} = \mathbb{E}_d[x_{kjts}(l_{kjtsd})]$.

Choice probabilities, conditional on β_{kts}, are given by the standard logit formula:

$$L_{kjts} = \frac{\exp(U^{CE}_{kjts}/\sigma_\epsilon)}{\sum_{i\in\mathcal{J}_{kt}} \exp(U^{CE}_{kits}/\sigma_\epsilon)}.$$

The numerical approximation to the likelihood of the sequence of choices and healthcare spending amounts for a given household is given by

$$LL_k = \sum_{j=1}^{J} d_{kjt} \sum_{s=1}^{S} W_s \prod_{t=1}^{T} f_m(m_{kt}|\theta, \beta_{kts}, c_{jt}, \mathbf{X}_{kt}) L_{kjts},$$

where $d_{kjt} = 1$ if household k chose plan j in year t and zero otherwise. The simulated log-likelihood function for parameters θ is

$$SLL(\theta) = \sum_{k=1}^{K} \log\left(LL_k\right).$$

B.3 Recovering household-specific types

We assume that household types $\beta_{kt}(\theta) = \{\psi_k, \mu_{kt}, \omega_k\}$ are distributed according to equation (14). After estimating the model and obtaining $\hat{\theta}$, we want to use each household's observed choices to back out which type they themselves are likely to be. Let $g(\beta|\hat{\theta})$ denote the population distribution of types. Let $h(\beta|\hat{\theta}, y)$ denote the density of β conditional on parameters $\hat{\theta}$ and a sequence of observed healthcare spending amounts and plan chocies y. Using what Revelt and Train (2001) term the "conditioning of individual tastes" method, we recover households' posterior distribution of β using Bayes' rule:

$$h(\beta|\hat{\theta}, y) = \frac{p(y|\beta)g(\beta|\hat{\theta})}{p(y|\hat{\theta})}.$$

Taking the numerical approximations, $p(y|\hat{\theta})$ is simply the household-specific likelihood function LL_k for an observed sequence of spending amounts and choices, $g(\beta|\hat{\theta})$ is the quadrature weights W_s on each simulated point, and $p(y|\beta)$ is the *conditional* household likelihood:

$$LL_{ks} = \sum_{j=1}^{J} d_{kjt} \prod_{t=1}^{T} f_m(m_{kt}|\theta, \beta_{ks}, c_{jt}, \mathbf{X}_{kt}) L_{kjts}.$$

Taken together, the numerical approximation to each household's posterior distribution of unobserved heterogeneity is given by

$$h_{ks}(\beta|\hat{\theta}, y_k) = \frac{LL_{ks}\, W_s}{LL_k},$$

where $\sum_s h_{ks}(\beta|\hat{\theta}, y_k) = 1$.

We use these household specific distributions over types to calculated expected quantities of interest for each household. In particular, we calculate WTP_{kjt} and SS_{kjt} as

$$WTP_{kjt} = \sum_{s} h_{ks}(\beta|\hat{\theta}, y_k) WTP_{kjts},$$
$$SS_{kjt} = \sum_{s} h_{ks}(\beta|\hat{\theta}, y_k) SS_{kjts}.$$

B.4 Joint distribution of household types

The joint distribution of household types is of central importance to this paper. Here, we investigate the distribution implied by our primary estimates in column 3 of Table 4. For each household, we first calculate the expectation of their type with respect to their posterior distribution of unobservable heterogeneity:

$$\psi_k = \sum_{s} h_{ks}(\beta|\hat{\theta}, y_k) \psi_{ks},$$
$$\omega_k = \sum_{s} h_{ks}(\beta|\hat{\theta}, y_k) \omega_{ks}.$$

In place of μ_{kt}, a more relevant measure of household health is the expected health state, or in other words, expected total unavoidable spending. Using the expectation of a shifted lognormal variable and price parameter $\phi = 1$, the expected health state $\bar{l}_{kt}$ is given by

$$\bar{l}_{kt} = \sum_{s} h_{ks}(\beta|\hat{\theta}, y_k)(\exp(\mu_{kts} + \frac{\sigma^2_{kt}}{2}) - \kappa_{kt}).$$

To limit our focus to one type for each household, we look at $\bar{l}_{kt}$ for the first year each household appears in the data. Figure A.3 presents the joint distribution of household types along the dimensions of risk aversion (ψ), moral hazard (ω), and expected health state ($\log(\mathbb{E}[\text{Health state}])$). We measure the health state on a log scale for readability.

Table A.1. Sample Construction

Criteria	2009	2010	2011	2012	2013
Individuals in membership file	161,502	162,363	156,113	156,042	157,799
Not eligible for coverage	7,370	8,265	8,422	8,719	8,388
Retiree, COBRA, or oldest member over 65	13,180	12,567	12,057	11,603	11,840
Partial year coverage	17,115	18,649	19,283	21,281	23,074
Covered by multiple plans	1,447	1,947	2,038	2,239	2,336
Opted out	3,241	4,205	4,321	4,576	4,529
Not in intact family	8,389	9,188	9,181	8,925	10,265
No prior year of data	6,175	3,947	2,455	3,104	3,702
Missing premium or contribution data	25,653	28,466	22,755	23,284	30,401
Final total	78,932	75,129	75,601	72,311	63,264

Notes: This table shows counts of individuals dropped due to each sample selection criterion. Drops are made in the order in which criteria appear.

Table A.2. Plan Characteristics

2008					
Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.97	10,567	0	1,200	0.07
Kaiser - 2	0.96	10,098	0	2,000	0.10
Moda - 1	0.92	11,955	300	500	0.28
Moda - 2	0.89	11,481	300	1,000	0.06
Moda - 3	0.88	10,841	600	1,000	0.11
Moda - 4	0.86	10,382	900	1,500	0.07
Moda - 5	0.82	9,615	1,500	2,000	0.12
Moda - 6	0.78	8,689	3,000	3,000	0.03
Moda - 7	0.68	6,643	3,000	10,000	0.00
Providence - 1	0.96	11,564	900	1,200	0.14
Providence - 2	0.95	11,475	900	2,000	0.02

2010					
Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.96	12,537	0	2,400	0.17
Kaiser - 2	0.95	12,150	0	3,000	0.03
Moda - 1	0.89	17,042	600	1,200	0.10
Moda - 2	0.86	15,817	600	1,500	0.01
Moda - 3	0.85	14,344	600	1,800	0.17
Moda - 4	0.84	12,877	900	2,000	0.12
Moda - 5	0.82	11,781	1,500	2,000	0.21
Moda - 6	0.78	10,596	3,000	3,000	0.09
Moda - 7	0.75	8,083	3,000	10,000	0.02
Providence - 1	0.91	18,121	1,200	1,200	0.04
Providence - 2	0.89	17,647	1,800	1,800	0.01

Notes: Actuarial value (AV) is calculated as the ratio of average insured spending to average total spending among all households, using counterfactual calculations of insured spending for households that did not choose a certain plan. Insurer premium reflects the premium negotiated between OEBB and the insurer. The deductible and out-of-pocket maximum shown are for in-network services for a family household.

Table A.2. Plan Characteristics, cont.

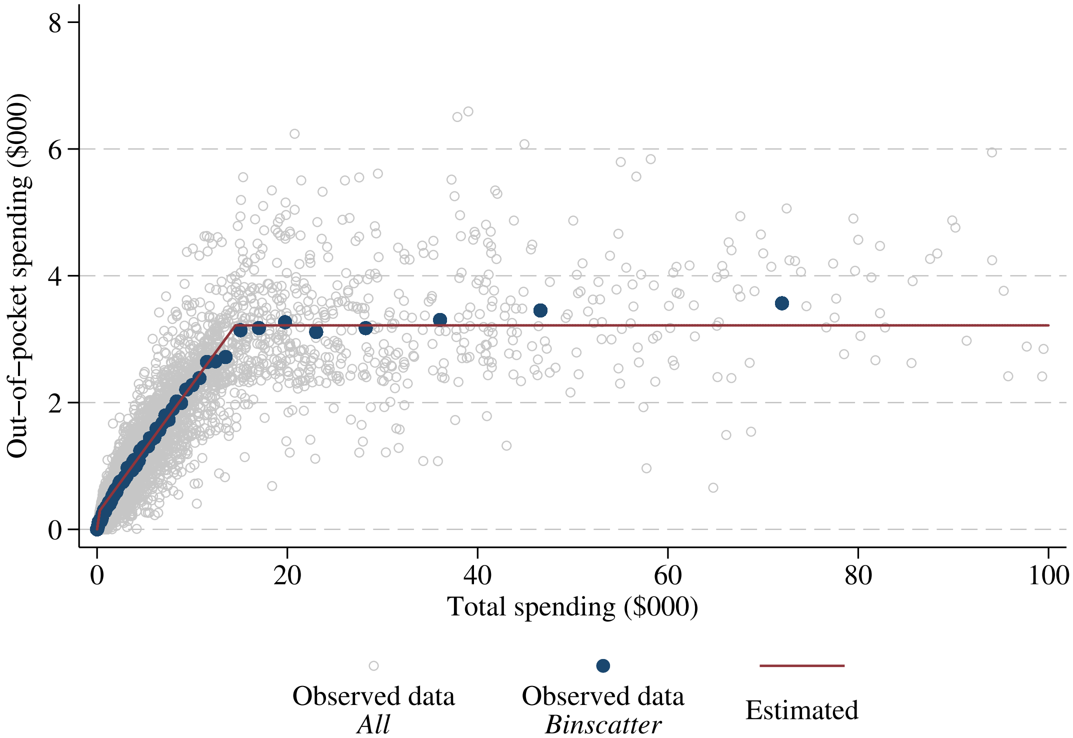
2011 Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.95	11,958	0	2,400	0.16
Kaiser - 2	0.92	10,954	300	4,000	0.04
Moda - 1	0.86	16,900	600	4,500	0.06
Moda - 2	0.84	13,405	900	6,000	0.00
Moda - 3	0.84	13,726	900	6,000	0.15
Moda - 4	0.83	12,261	1,200	6,300	0.09
Moda - 5	0.82	11,021	1,500	6,600	0.24
Moda - 6	0.78	9,481	3,000	6,600	0.15
Moda - 7	0.75	8,445	3,000	10,000	0.05
Providence - 1	0.87	16,168	300	3,600	0.02
Providence - 2	0.84	15,090	900	6,000	0.00

2012 Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.95	14,508	0	2,400	0.18
Kaiser - 2	0.93	13,283	450	4,000	0.04
Moda - 1	0.87	20,029	600	4,500	0.06
Moda - 2	0.85	15,469	900	6,000	0.01
Moda - 3	0.85	16,616	900	6,000	0.12
Moda - 4	0.84	15,039	1,200	6,300	0.06
Moda - 5	0.83	13,707	1,500	6,600	0.22
Moda - 6	0.79	12,051	3,000	6,600	0.17
Moda - 7	0.76	9,082	3,000	10,000	0.11

2013 Plan	AV	Insurer Premium ($)	Deductible ($)	OOP Max. ($)	Market Share
Kaiser - 1	0.95	15,369	0	3,000	0.20
Kaiser - 2	0.94	13,950	600	4,400	0.03
Moda - 1	0.87	21,285	600	6,000	0.03
Moda - 2	0.85	17,055	1,050	7,200	0.08
Moda - 3	0.84	14,234	1,500	7,800	0.22
Moda - 4	0.82	13,211	2,250	8,400	0.06
Moda - 5	0.80	12,362	3,000	9,000	0.11
Moda - 6	0.78	11,337	3,750	12,000	0.05
Moda - 7	0.77	9,276	3,000	10,000	0.13
Moda - 8	0.76	10,250	4,500	15,000	0.05

Notes: Actuarial value (AV) is calculated as the ratio of average insured spending to average total spending among all households, using counterfactual calculations of insured spending for households that did not choose a certain plan. Insurer premium reflects the premium negotiated between OEBB and the insurer. The deductible and out-of-pocket maximum shown are for in-network services for a family household.

Figure A.1. Example of Plan Cost Sharing Features Estimation



Notes: The figure shows the data used to estimate the cost sharing features of Moda Plan 3 for individual households in 2012. Each gray dot represents a household. The blue dots are a binscatter plot of the gray data, using 100 data points. The basic cost sharing features of the plan are a deductible of $300, non-specialist coinsurance rate of 20 percent, and in-network out-of-pocket maximum of $2,000. The red line shows the "estimated" cost sharing schedule of the plan that minimizes the sum of squared errors between predicted and observed out-of-pocket spending. The estimated coinsurance rate is 20.5 percent and the estimated out-of-pocket maximum is $3,218.

Table A.3. Estimated Plan Characteristics

2009	Individuals			Families		
Plan	Ded.	Coins.	OOP Max.	Ded.	Coins.	OOP Max.
Kaiser - 1	0	0.03	564	0	0.03	645
Kaiser - 2	0	0.03	684	0	0.04	760
Kaiser - 3	0	0.03	734	0	0.04	791
Moda - 1	100	0.10	1,613	300	0.10	2,009
Moda - 2	100	0.18	1,922	300	0.15	2,662
Moda - 3	200	0.20	2,081	600	0.15	3,062
Moda - 4	300	0.19	2,796	900	0.15	3,835
Moda - 5	500	0.22	3,164	1,500	0.16	4,296
Moda - 6	1,000	0.22	3,713	3,000	0.12	5,422
Moda - 7	1,500	0.42	4,693	3,000	0.30	8,086
Providence - 1	300	0.02	790	900	0.00	900
Providence - 2	300	0.03	867	900	0.00	986
Providence - 3	300	0.04	1,116	900	0.01	1,296

2010	Individuals			Families		
Plan	Ded.	Coins.	OOP Max.	Ded.	Coins.	OOP Max.
Kaiser - 1	0	0.03	697	0	0.04	805
Kaiser - 2	0	0.04	820	0	0.05	885
Moda - 1	200	0.14	2,526	600	0.12	3,430
Moda - 2	200	0.21	2,846	600	0.18	3,967
Moda - 3	200	0.21	3,189	600	0.18	4,299
Moda - 4	300	0.22	3,109	900	0.18	4,079
Moda - 5	500	0.22	3,321	1,500	0.16	4,572
Moda - 6	1,000	0.22	3,844	3,000	0.12	5,684
Moda - 7	1,500	0.19	4,913	3,000	0.15	7,579
Providence - 1	400	0.05	1,523	1,200	0.02	1,851
Providence - 2	600	0.06	1,998	1,800	0.02	2,473

2011	Individuals			Families		
Plan	Ded.	Coins.	OOP Max.	Ded.	Coins.	OOP Max.
Kaiser - 1	0	0.04	883	0	0.06	974
Kaiser - 2	100	0.06	1,340	300	0.06	1,831
Moda - 1	200	0.22	2,608	600	0.18	4,316
Moda - 2	300	0.22	3,201	900	0.17	5,094
Moda - 3	300	0.22	3,246	900	0.17	5,202
Moda - 4	400	0.22	3,324	1,200	0.17	5,367
Moda - 5	500	0.22	3,529	1,500	0.16	5,727
Moda - 6	1,000	0.22	4,061	3,000	0.13	6,728
Moda - 7	1,500	0.21	4,914	3,000	0.15	7,663
Providence - 1	100	0.18	2,164	300	0.16	3,496
Providence - 2	300	0.15	2,911	900	0.13	4,378

Notes: Table shows plan deductibles (Ded.), estimated coinsurance rates (Coins.), and estimated out-of-pocket maximums (OOP Max.).

Table A.3. Estimated Plan Characteristics, cont.

2012	Individuals			Families		
Plan	Ded.	Coins.	OOP Max.	Ded.	Coins.	OOP Max.
Kaiser - 1	0	0.04	911	0	0.06	995
Kaiser - 2	150	0.07	1,709	450	0.05	2,160
Moda - 1	200	0.21	2,571	600	0.17	4,154
Moda - 2	300	0.21	3,187	900	0.17	4,981
Moda - 3	300	0.20	3,218	900	0.17	5,025
Moda - 4	400	0.21	3,291	1,200	0.16	5,104
Moda - 5	500	0.21	3,493	1,500	0.16	5,498
Moda - 6	1,000	0.21	4,000	3,000	0.12	6,608
Moda - 7	1,500	0.21	4,927	3,000	0.15	7,662

2013	Individuals			Families		
Plan	Ded.	Coins.	OOP Max.	Ded.	Coins.	OOP Max.
Kaiser - 1	0	0.04	911	0	0.06	1,040
Kaiser - 2	200	0.03	867	600	0.01	951
Moda - 1	200	0.20	3,237	600	0.17	4,893
Moda - 2	350	0.20	3,842	1,050	0.16	5,647
Moda - 3	500	0.20	4,175	1,500	0.15	6,160
Moda - 4	750	0.20	4,704	2,250	0.14	6,989
Moda - 5	1,000	0.19	5,186	3,000	0.12	7,714
Moda - 6	1,250	0.19	6,414	3,750	0.12	9,187
Moda - 7	1,500	0.21	4,865	3,000	0.15	7,650
Moda - 8	1,500	0.19	7,620	4,500	0.11	10,614

Notes: The table shows plan deductibles (Ded.), estimated coinsurance rates (Coins.), and estimated out-of-pocket maximums (OOP Max.).

Table A.4. Household Summary Statistics (2008)

Sample demographics	2008
Number of households	45,012
Number of enrollees	116,267
Employee age, mean (med.)	45.5
	(47.0)
Enrollee age, mean (med.)	38.2
	(35.8)
Enrollee percent female	0.53
Premiums	
Employee premium ($), mean (med.)	596
	(0)
Full premium ($), mean (med.)	10,107
	(10,605)
Household health spending	
Total spending ($), mean (med.)	9,956
	(4,485)
OOP spending ($), mean (med.)	957
	(620)
Household structure (percent)	
Individual	0.25
Family	0.75
Region (percent)	
Portland-Salem	0.64
Eugene-Medford	0.26
Bend-Spokane-Boise	0.10

Notes: Summary statistics are shown for households in the 2008 analysis sample used in our descriptive analyses. Enrollees are employees plus their family members. Statistics about premiums are for households' chosen plans, as opposed to for all possible plans. Sample medians are shown in parentheses.

Table A.5. Plan Choice Logit Model (equation (7))

	2008	2009	2010	2011	2012	2013
Employee premium ($000)	-0.789	-0.674	-0.505	-0.372	-0.515	-0.490
	(0.017)	(0.014)	(0.008)	(0.010)	(0.008)	(0.008)
HRA/HSA contrib. ($000)	0.112		0.358	0.134	0.269	0.534
	(0.759)		(0.044)	(0.024)	(0.019)	(0.015)
Vision/dental contrib. ($000)	0.654	0.408	0.480	0.794	0.553	0.710
	(0.021)	(0.022)	(0.019)	(0.017)	(0.017)	(0.017)
Kaiser - 1	-0.771	-0.728				
	(0.026)	(0.030)				
Kaiser - 2	-1.287	-1.112	-0.846	-0.469	-0.375	-0.074
	(0.031)	(0.032)	(0.034)	(0.035)	(0.034)	(0.044)
Kaiser - 3		-1.563	-1.042	-0.985	-1.629	-1.820
		(0.384)	(0.056)	(0.051)	(0.048)	(0.058)
Moda - 1	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†
Moda - 2	-1.113	-1.184	-0.911	-2.088	-2.578	-0.593
	(0.026)	(0.032)	(0.058)	(0.163)	(0.072)	(0.045)
Moda - 3	-1.226	-1.110	-0.518	-0.373	-0.389	-0.957
	(0.022)	(0.025)	(0.029)	(0.034)	(0.033)	(0.046)
Moda - 4	-1.751	-1.540	-1.356	-1.192	-1.554	-2.261
	(0.028)	(0.030)	(0.034)	(0.037)	(0.039)	(0.055)
Moda - 5	-1.951	-1.881	-1.341	-0.878	-0.999	-2.391
	(0.034)	(0.037)	(0.040)	(0.039)	(0.037)	(0.055)
Moda - 6	-2.785	-2.871	-2.205	-1.406	-1.917	-3.182
	(0.048)	(0.051)	(0.050)	(0.043)	(0.046)	(0.065)
Moda - 7	-4.391	-4.260	-3.388	-1.959	-3.007	-3.492
	(0.098)	(0.098)	(0.074)	(0.050)	(0.060)	(0.073)
Moda - 8						-3.679
						(0.068)
Providence - 1	0.001	0.048	0.135	-0.778		
	(0.019)	(0.028)	(0.038)	(0.053)		
Providence - 2	-0.600	-0.314				
	(0.043)	(0.049)				
Providence - 3		-0.048	-0.159	-0.939		
		(0.078)	(0.083)	(0.436)		
Number of observations	163,431	121,744	116,541	114,527	163,278	163,683

Notes: This table presents the parameter estimates from the conditional logit model described by equation (7), presented separately for each year. The unit of observation is the household-plan. Moda plan 1 (the highest coverage Moda plan) is the omitted plan.
†By normalization.

Table A.6. Plan Menu Generosity and Household Health

	2008	2009	2010	2011	2012	2013
Household Risk Score	-0.006	0.017	0.020	0.002	0.006	0.000
	(0.039)	(0.016)	(0.011)*	(0.009)	(0.010)	(0.012)
Family Type						
Employee Alone	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†
Employee + Spouse	-1.389	-1.369	-1.498	-1.040	-1.626	-1.612
	(0.077)***	(0.040)***	(0.029)***	(0.025)***	(0.026)***	(0.031)***
Employee + Child	-0.542	-0.634	-0.907	-0.616	-1.092	-0.937
	(0.084)***	(0.053)***	(0.039)***	(0.031)***	(0.031)***	(0.037)***
Employee + Family	-1.792	-1.882	-1.804	-1.306	-2.147	-2.102
	(0.064)***	(0.037)***	(0.028)***	(0.023)***	(0.025)***	(0.029)***
Dependent variable mean	88.7	88.5	84.6	82.7	83.3	82.6
R^2	0.020	0.084	0.154	0.115	0.242	0.220
Number of observations	37,666	31,074	29,538	29,279	27,897	24,283

Notes: The dependent variable is plan menu generosity as measured by predicted actuarial value conditional on choosing Moda, $\widehat{AV}_{d,Moda}$, as estimated by the logit model in equation (7) and calculated according to equation (8). $\widehat{AV}_{d,Moda}$ is multiplied by 100 to increase parameter magnitudes. The level of observation is the household. Household risk score is the mean risk score among all individuals in a household, and has been z-scored such that the variable has a mean of zero and a standard deviation of one within each year. * p<0.10, ** p<0.05, *** p<.01.

†By normalization

Table A.7. Explaining Plan Menu Generosity: 2008

	(1)	(2)	(3)	(4)
Household Risk Score	-0.006	0.016	0.011	0.025
	(0.039)	(0.039)	(0.038)	(0.040)
Family Type				
Employee Alone	0.000†	0.000†	0.000†	0.000†
Employee + Spouse	-1.389	-1.374	-1.251	-1.085
	(0.077)***	(0.083)***	(0.083)***	(0.085)***
Employee + Child	-0.542	-0.535	-0.478	-0.462
	(0.084)***	(0.085)***	(0.084)***	(0.082)***
Employee + Family	-1.792	-1.819	-1.688	-1.437
	(0.064)***	(0.071)***	(0.071)***	(0.074)***
Part-time		-0.428	-0.448	-0.867
		(0.133)***	(0.133)***	(0.139)***
Occupation Type				
Admin.		-1.745	-1.883	-2.685
		(0.455)***	(0.459)***	(0.501)***
Classified		-0.598	-0.469	-0.155
		(0.283)**	(0.414)	(0.457)
Comm. Coll. Fac.		0.553	1.138	1.044
		(0.287)*	(0.430)***	(0.470)**
Comm. Coll. Non-Fac.		0.671	0.457	0.077
		(0.288)**	(0.288)	(0.302)
Confidential		-2.759	-2.883	-3.133
		(0.855)***	(0.856)***	(0.915)***
Licensed		0.001	1.645	1.628
		(0.278)	(0.459)***	(0.505)***
Substitute		-11.051	-9.312	-9.354
		(0.283)***	(0.457)***	(0.496)***
Union Affiliation				
AFT			0.251	-0.398
			(0.374)	(0.432)
IAFE			0.758	1.222
			(0.404)*	(0.458)***
OACE			2.671	1.617
			(0.389)***	(0.449)***
OEA			-1.799	-1.765
			(0.434)***	(0.491)***
OSEA			-0.086	-0.426
			(0.395)	(0.449)
District characteristics				
ln(HPI)				-0.876
				(0.085)***
Pct. Republican				-14.077
				(0.467)***
Dependent variable mean	88.7	89.0	89.1	98.3
R^2	0.020	0.031	0.046	0.073
Number of observations	37,666	37,666	37,666	35,698

Notes: The dependent variable is plan menu generosity as measured by predicted actuarial value conditional on choosing Moda, $\widehat{AV}_{d,Moda}$, as estimated by the logit model in equation (7) and calculated according to equation (8). $\widehat{AV}_{d,Moda}$ is multiplied by 100 to increase parameter magnitudes. The level of observation is the household. Household risk score is the mean risk score among all individuals in a household, and has been z-scored such that the variable has a mean of zero and a standard deviation of one within each year. * p<0.10, ** p<0.05, *** p<.01. †By normalization

Table A.8. Conditional Logit Model of Household Plan Choice in 2008

	Ind. Q_1	Fam. Q_1	Ind. Q_2	Fam. Q_2	Ind. Q_3	Fam. Q_3	Ind. Q_4	Fam. Q_4
Employee premium ($000)	-1.602***	-1.014***	-1.345***	-1.019***	-1.401***	-0.949***	-1.302***	-0.870***
	(0.128)	(0.047)	(0.114)	(0.049)	(0.113)	(0.053)	(0.108)	(0.056)
Vision/dental contrib. ($000)	1.301***	0.943***	1.254***	0.884***	1.089***	0.621***	1.042***	0.495***
	(0.092)	(0.061)	(0.094)	(0.065)	(0.094)	(0.071)	(0.099)	(0.076)
HSA/HRA contrib. ($000)				-6.871		2.774***		-6.703
				(318.561)		(1.068)		(526.706)
Kaiser - 1	-0.074	1.351**	-1.452**	-0.856	1.069	0.863	2.149***	0.525
	(0.420)	(0.531)	(0.671)	(0.747)	(0.799)	(0.918)	(0.782)	(0.801)
Kaiser - 2	0.575	1.765***	-0.960	-0.278	1.483*	1.376	2.468***	1.135
	(0.410)	(0.517)	(0.657)	(0.731)	(0.791)	(0.899)	(0.774)	(0.789)
Moda - 1	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†	0.000†
Moda - 2	-1.175***	-0.425***	-1.077***	-1.011***	-0.498*	-0.571**	-0.644**	-0.930***
	(0.185)	(0.161)	(0.242)	(0.215)	(0.260)	(0.254)	(0.270)	(0.214)
Moda - 3	-0.865***	-0.298	-0.880***	-1.162***	-0.290	-0.395	-0.108	-0.810**
	(0.202)	(0.240)	(0.332)	(0.334)	(0.372)	(0.399)	(0.383)	(0.333)
Moda - 4	-1.265***	-0.331	-1.535***	-1.719***	-0.370	-0.535	-0.100	-1.194**
	(0.280)	(0.349)	(0.477)	(0.488)	(0.534)	(0.584)	(0.553)	(0.486)
Moda - 5	-1.083***	-0.065	-1.419**	-1.896**	0.386	-0.119	0.623	-1.029
	(0.407)	(0.527)	(0.713)	(0.740)	(0.805)	(0.885)	(0.832)	(0.737)
Moda - 6	-1.053*	-0.086	-1.903*	-2.678**	0.515	-0.517	1.390	-1.634
	(0.592)	(0.770)	(1.048)	(1.084)	(1.171)	(1.295)	(1.210)	(1.082)
Moda - 7	-2.060**	0.093	-3.330*	-5.027***	0.880	-0.940	1.879	-1.986
	(0.997)	(1.304)	(1.757)	(1.854)	(1.968)	(2.225)	(2.058)	(1.842)
Providence - 1	-0.251	1.141*	-1.448*	-0.696	0.474	2.210**	0.840	-0.613
	(0.566)	(0.659)	(0.863)	(0.850)	(0.920)	(0.938)	(0.922)	(0.747)
Providence - 2	0.300	1.533**	-1.022	-0.194	1.017	2.809***	1.215	-0.121
	(0.536)	(0.639)	(0.836)	(0.830)	(0.894)	(0.915)	(0.915)	(0.728)
Number of osbervations	8,487	25,054	8,367	25,416	8,285	25,393	8,077	25,326

Notes: The table presents the results of estimating equation (7) separately by quartile of household risk score within individual and family households in 2008. The columns indicate which sample is being used: Individuals (Ind.) versus families (Fam.) and the household risk quartile Q_n, where Q_4 is the sickest households. The omitted plan fixed effect is for Moda plan 1 (the most generous Moda plan). The coefficient on employee premium (measured in thousands of dollars) is normalized to -1.

†By normalization.

Table A.9. Spending Distributions and Moda Plan Characteristics, 2008

Panel A: Total Spending Distributions by Risk Quartile

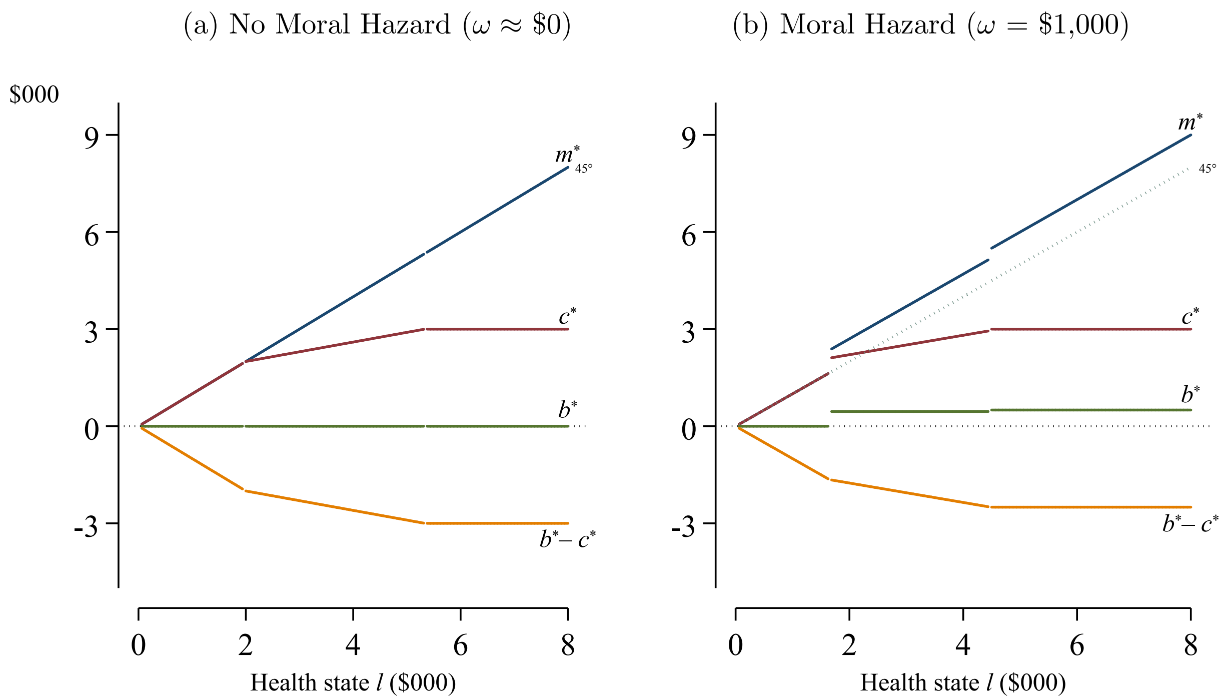
	Percentile of total spending				
Risk quartile	10th	25th	50th	75th	90th
Individuals					
$Q1$	0	30	381	851	1,454
$Q2$	293	721	1,286	1,984	3,025
$Q3$	782	1,688	2,861	4,266	5,987
$Q4$	1,869	4,134	7,155	12,765	21,240
Families					
$Q1$	418	985	1,959	3,508	6,718
$Q2$	1,489	2,567	4,212	6,584	10,984
$Q3$	3,373	5,261	7,811	11,745	17,301
$Q4$	5,096	9,820	15,401	22,637	29,615

Panel B: Plan Characteristics

	Moda plan						
	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7
Individuals							
Deductible	100	100	200	300	500	1,000	1,500
OOP Max.	500	1,000	1,000	1,500	2,000	2,000	5,000
Families							
Deductible	300	300	600	900	1,500	3,000	3,000
OOP Max.	500	1,000	1,000	1,500	2,000	3,000	10,000

Notes: This table shows the distributions of household realized total healthcare spending and the plan characteristics of Moda plans in 2008. Panel A shows the spending distributions, by quartile of household risk score within Individual and Family households. Panel B shows the in-network deductible and out-of-pocket maximum (OOP Max.) for each of the Moda plans.

Figure A.2. Healthcare Spending Choice Example



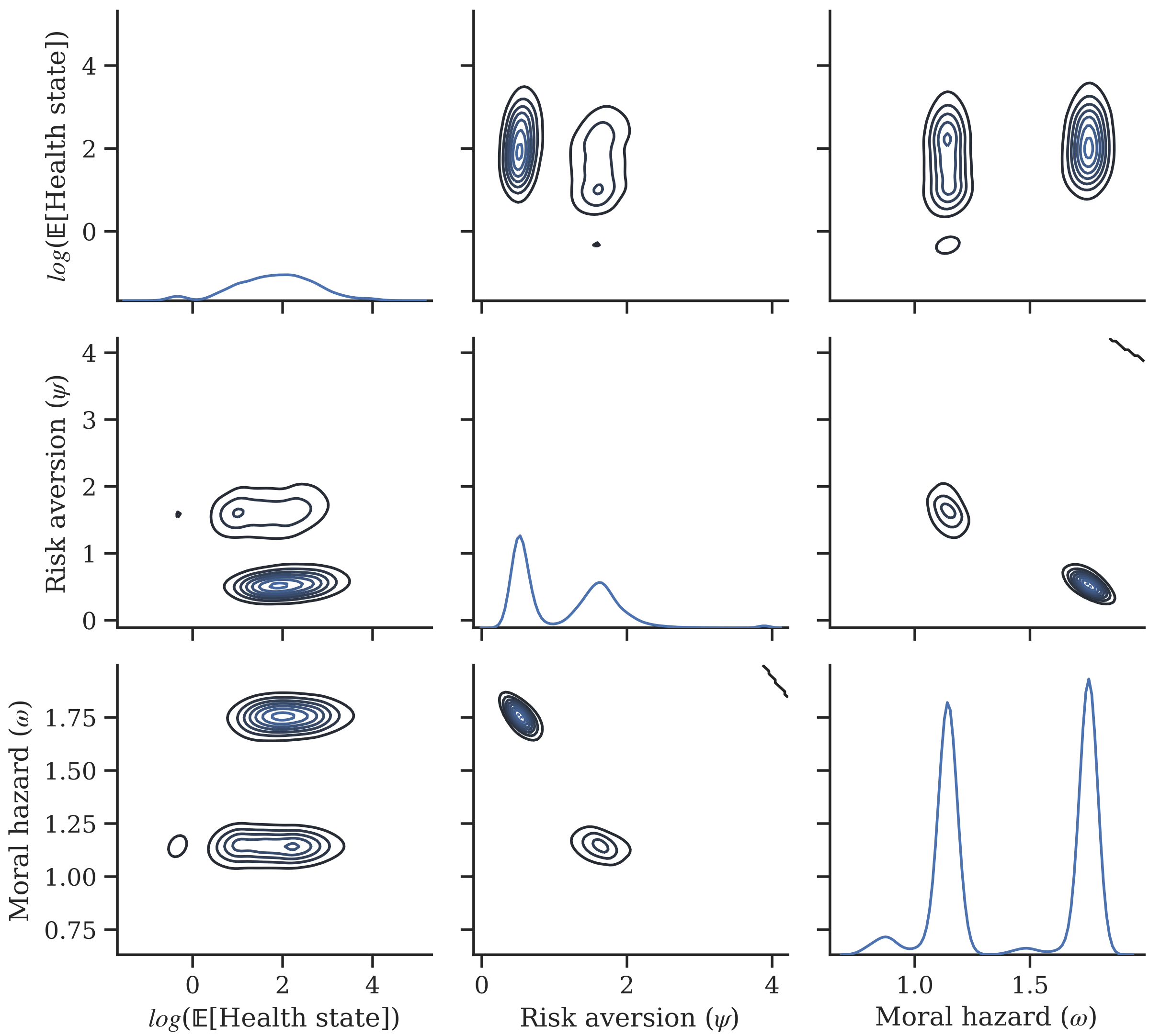
Notes: The figure shows optimal healthcare spending behavior predicted by our specification of household preferences over healthcare utilization (given in equation (9)). Optimal behavior is calculated assuming enrollment in an insurance contract with a deductible of $2,000, a coinsurance rate of 30%, and an out-of-pocket maximum of $3,000. Predicted behavior is shown under no moral hazard in panel (a) and under some moral hazard ($\omega = \$1{,}000$) in panel (b). Possible health state realizations are plotted on the horizontal axis. Optimal total healthcare spending m^* is shown for each health state; when there is no moral hazard, it is optimal to set total spending equal to the health state. Optimal healthcare spending m^* implies some correspondingly optimal out-of-pocket costs c^*, utility from healthcare utilization b^*, and *net* utility from healthcare utilization $b^* - c^*$. Conditional on plan choice, households face a lottery over net utility $b^* - c^*$, where the uncertainty is with respect to their distribution of health states.

Table A.10. Additional Demand Model Parameter Estimates

Variable	(1) Parameter	(1) Std. Err.	(2) Parameter	(2) Std. Err.	(3) Parameter	(3) Std. Err.
Insurer fixed effects						
Kaiser * (Age−40) ($000s)	−0.073	0.005	−0.078	0.005	−0.071	0.005
Providence * (Age−40) ($000s)	−0.073	0.008	−0.122	0.009	−0.074	0.008
Kaiser * **1**[Children] ($000s)	−1.608	0.119	−1.509	0.120	−0.546	0.124
Providence * **1**[Children] ($000s)	−1.373	0.174	−2.116	0.199	−0.480	0.177
Kaiser * Region 1 ($000s)	−1.692	0.093	−1.477	0.091	−1.976	0.095
Kaiser * Region 2 ($000s)	−5.112	0.254	−4.949	0.254	−5.343	0.252
Providence * Region 1 ($000s)	−4.420	0.156	−3.899	0.158	−4.530	0.159
Providence * Region 2 ($000s)	−5.727	0.211	−5.301	0.213	−5.701	0.213
Providence * Region 3 ($000s)	−5.153	0.233	−4.716	0.235	−5.633	0.234
Health state distributions						
κ	0.167	0.002				
κ * Risk QT 1			0.123	0.004	0.184	0.000
κ * Risk QT 2			0.174	0.004	0.201	0.000
κ * Risk QT 3			0.162	0.004	0.302	0.000
κ * Risk QT 4			0.095	0.037	0.182	0.022
κ * Risk QT <4 * Risk score			0.156	0.023	0.270	0.017
μ	0.618	0.006				
μ * Female 18–30			0.142	0.014	0.059	0.016
μ * Age < 18			0.020	0.014	−0.015	0.016
μ * Risk QT 1			−0.267	0.025	−0.421	0.021
μ * Risk QT 2			0.555	0.012	0.212	0.010
μ * Risk QT 3			0.709	0.008	0.420	0.007
μ * Risk QT 4			1.355	0.015	1.279	0.013
μ * Risk QT <4 * Risk score			1.025	0.016	1.184	0.018
μ * Risk QT 4 * Risk score			0.311	0.005	0.326	0.004
σ	1.117	0.002				
σ * Risk QT 1			1.408	0.010	1.450	0.008
σ * Risk QT 2			1.129	0.005	1.392	0.004
σ * Risk QT 3			1.067	0.003	1.244	0.003
σ * Risk QT 4			0.992	0.005	1.047	0.005

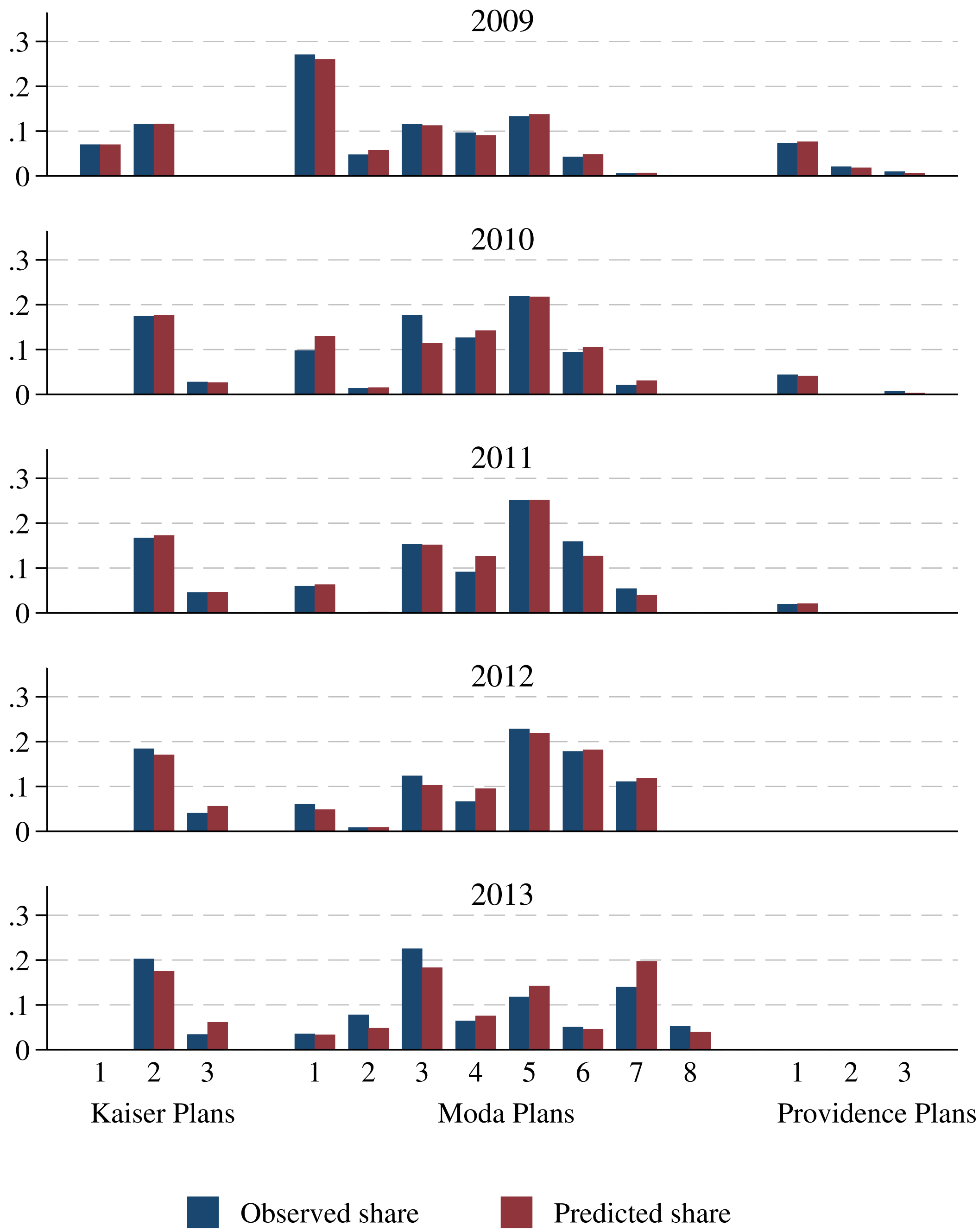
Notes: This table presents the parameter estimates that were not presented in the main table (Table 4), including insurer fixed effects and the health state distribution parameters. Column 1 estimates a model without individual observable heterogeneity. "Risk QT" refers to an indicator for an individual's risk quartile, where "Risk QT 4" is the sickest individuals. To make non-interacted coefficients more readily interpretable, Age is adjusted to be (Age−40). Higher risk scores correspond to worse predicted health.

Figure A.3. Joint Distribution of Household Types



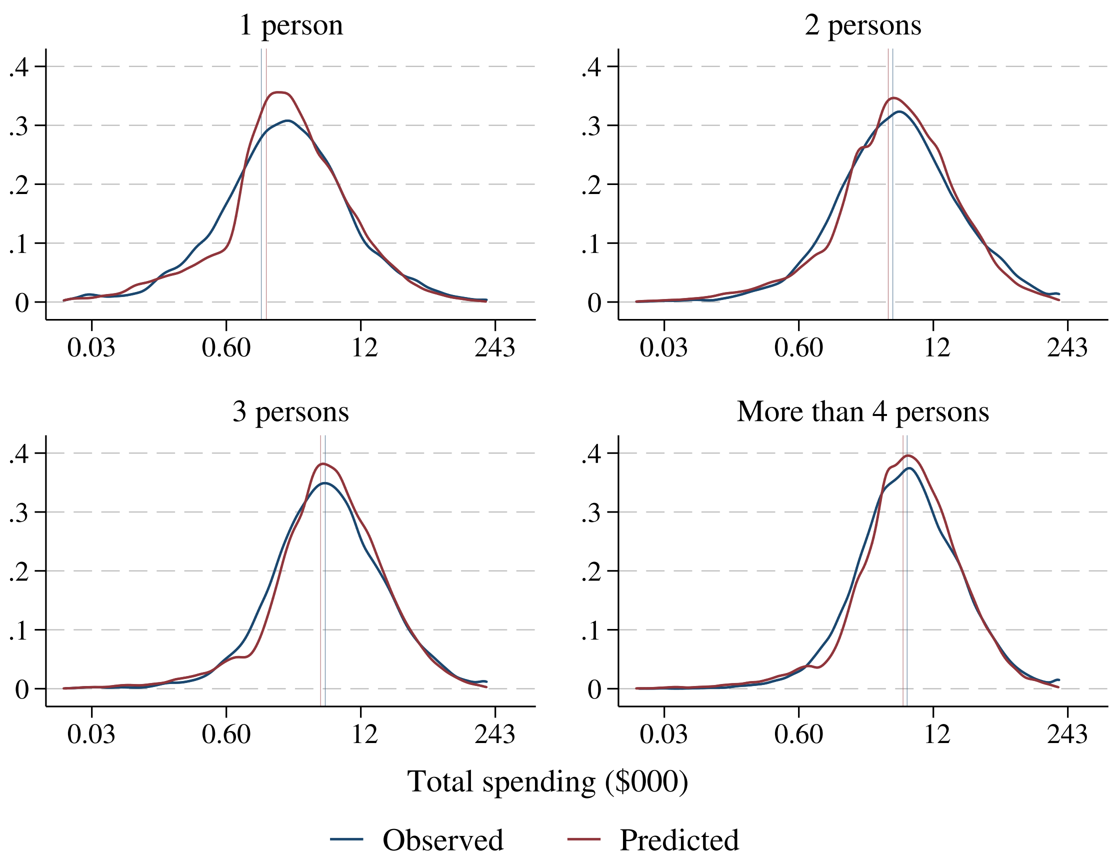
Notes: The figure shows the joint distribution of household types implied by the estimates in column 3 of Table 4. Households are assigned to a particular type according to the procedure described in Section B.4. Because expected health shock can vary over years within a household, for the purposes of this figure we use the first year a household appears in the data. Expected health state ($\mathbb{E}$[Health state]) is equal to a household's expected total unavoidable healthcare spending.

Figure A.4. Model Fit: Plan Choices Year by Year



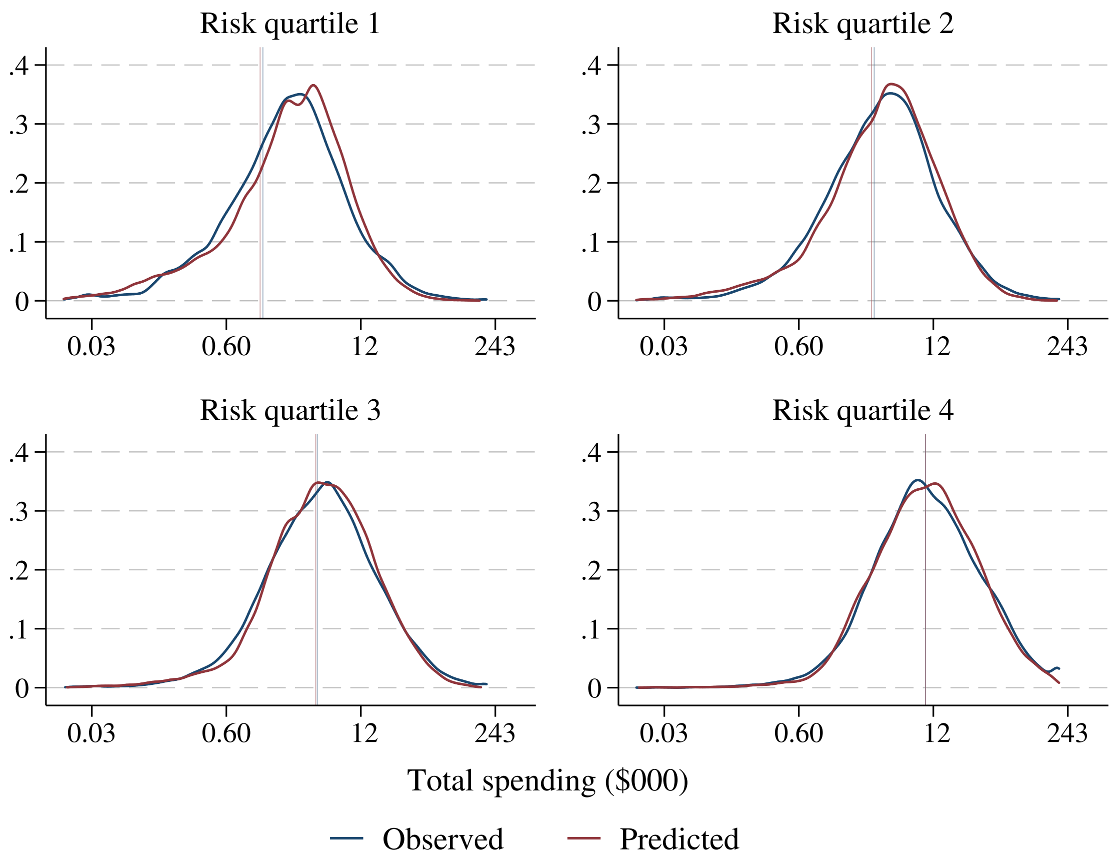
Notes: The figures shows predicted and observed market shares at the plan level. In each year, the level of observation is the household. Predicted shares are estimated using the parameters in column 3 of Table 4.

Figure A.5. Model Fit: Healthcare Spending by Number of Family Members



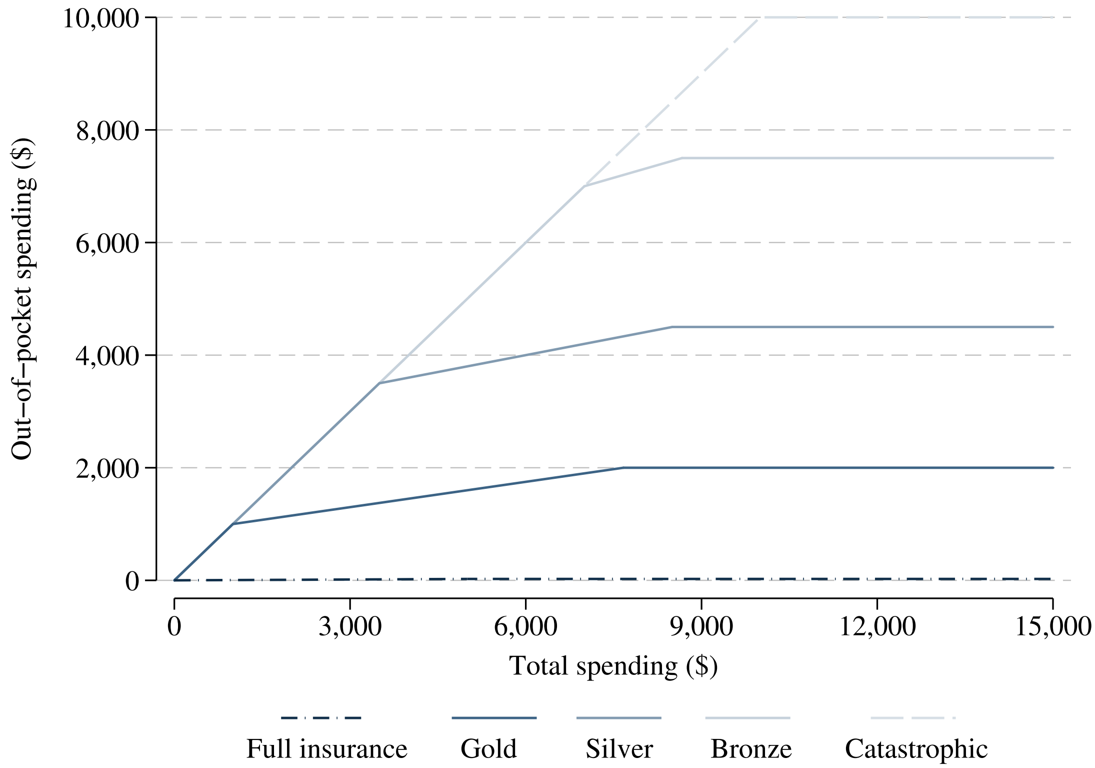
Notes: The figure shows kernel density plots of the predicted and observed distribution of total healthcare spending on a log scale, separately among households with different numbers of family members. All years are pooled together, so the observation is the household-year. The vertical lines represent the mean of the respective distribution. Predicted distributions are estimated using the parameters in column 3 of Table 4.

Figure A.6. Model Fit: Healthcare Spending by Household Health Risk



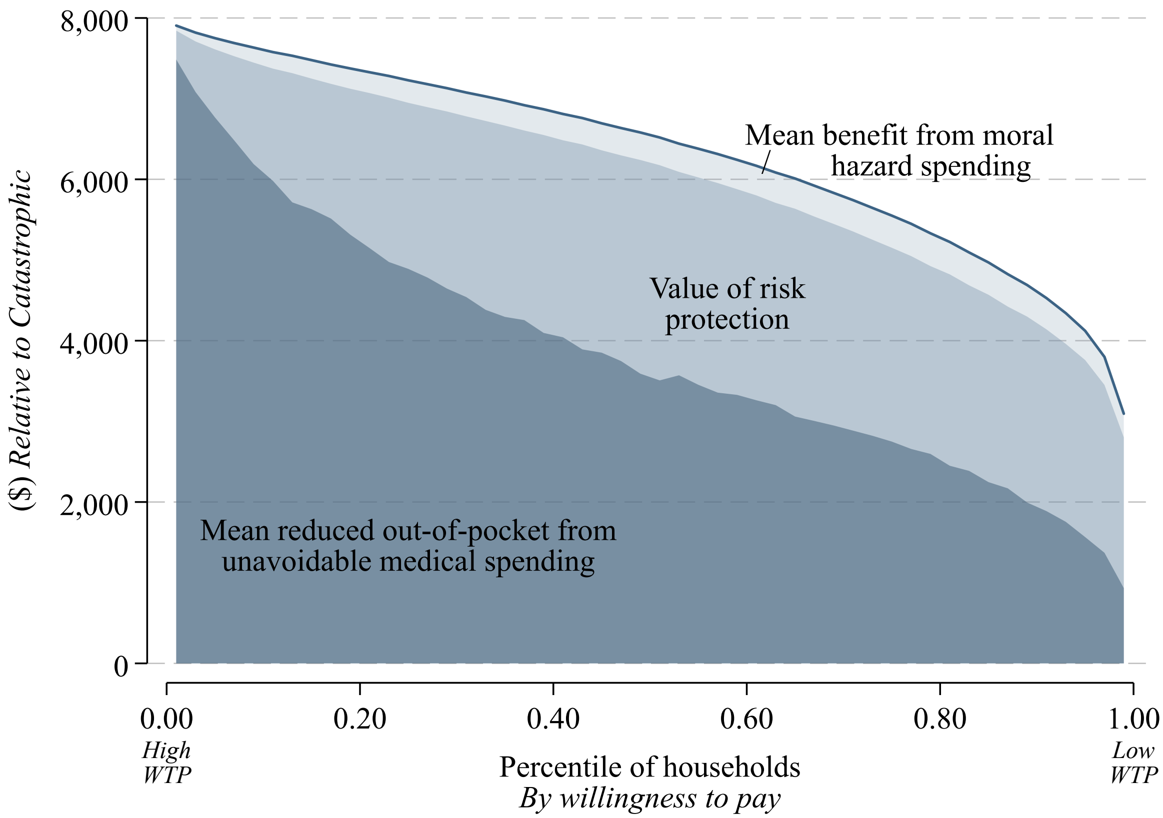
Notes: The figure shows kernel density plots of the predicted and observed distribution of total healthcare spending on a log scale, separately among households in each quartile of household health risk. Household health risk is measured as the mean risk score across individuals in the household. Quartile 4 is the sickest households. All years are pooled together, so the observation is the household-year. The vertical lines represent the mean of the respective distribution. Predicted distributions are estimated using the parameters in column 3 of Table 4.

Figure A.7. Counterfactual Potential Plans: Out-of-pocket Cost Functions



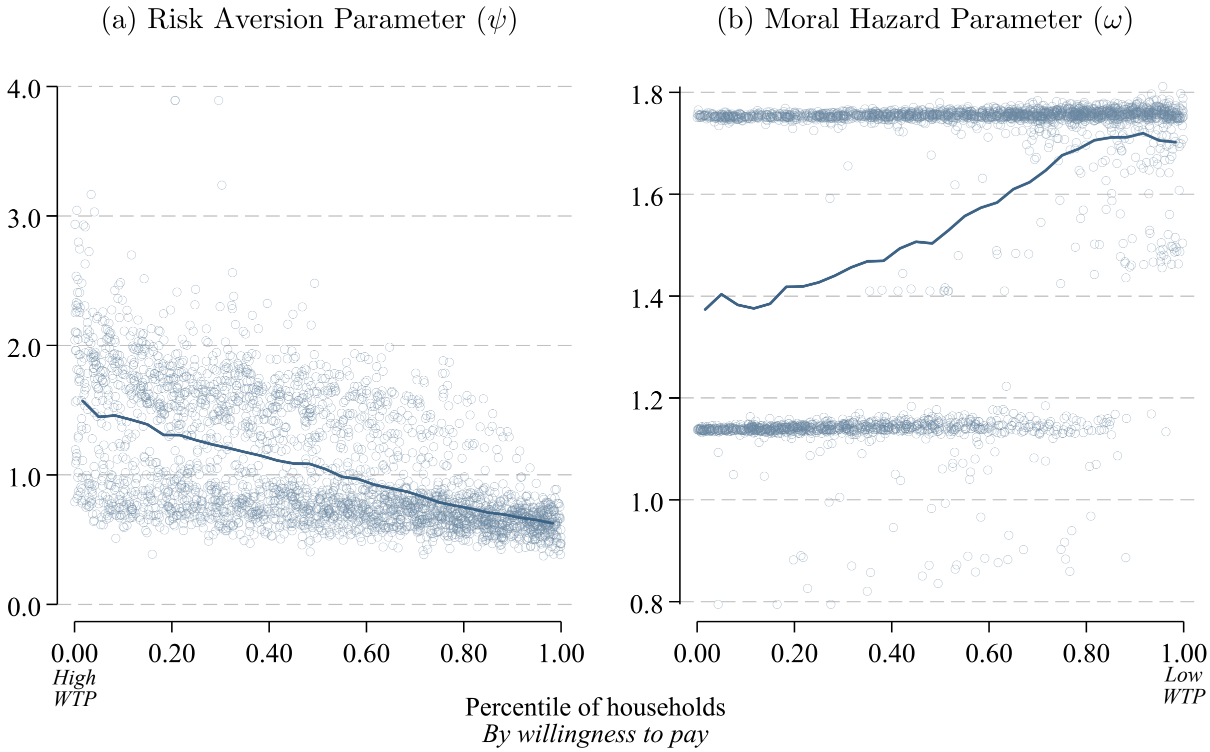
Notes: The figure shows the cost sharing schedules for the five potential plans we consider in our counterfactuals. These plans are chosen to align with the plan designs and coverage levels of typical plans on the Affordable Care Act exchanges. The exact deductible, coinsurance rate, and out-of-pocket maximum of the plans are $1,000, 15%, $2,000 for Gold; $3,500, 20%, $4,500 for Silver; $7,000, 30%, $7,500 for Bronze; and $10,000, 30%, $10,000 for Catastrophic.

Figure A.8. Breakdown of Willingness to Pay for Gold Plan



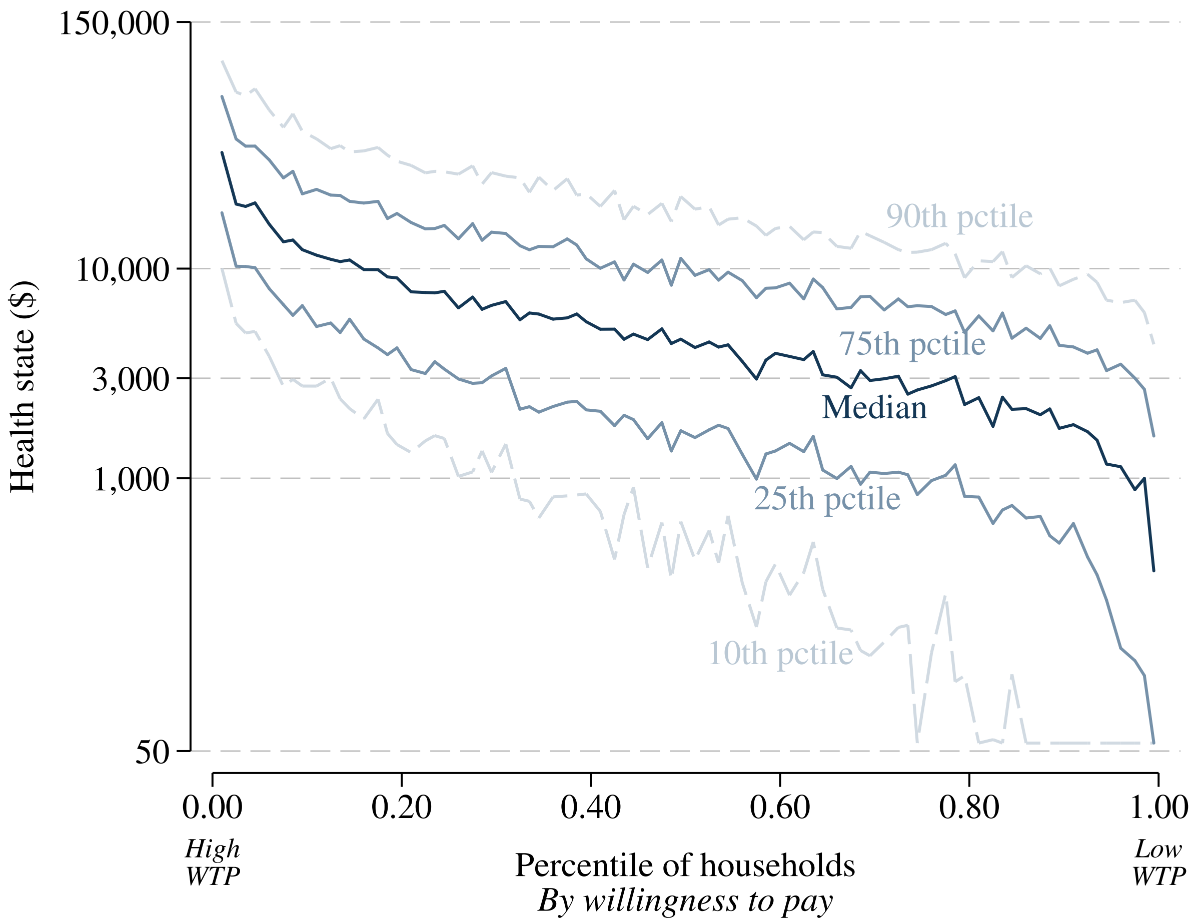
Notes: The figure shows the breakdown of willingness to pay for the Gold plan relative to the Catastrophic plan into its three component parts: mean reduced out-of-pocket costs from unavoidable medical spending, the value of risk protection, and mean benefit from moral hazard spending. Households are arranged on the horizontal axis according to their willingness to pay. The height of the shaded areas represent the average of each component of willingness to pay for households at that percentile of willingness to pay.

Figure A.9. Risk Aversion and Moral Hazard Parameters by Willingness to Pay



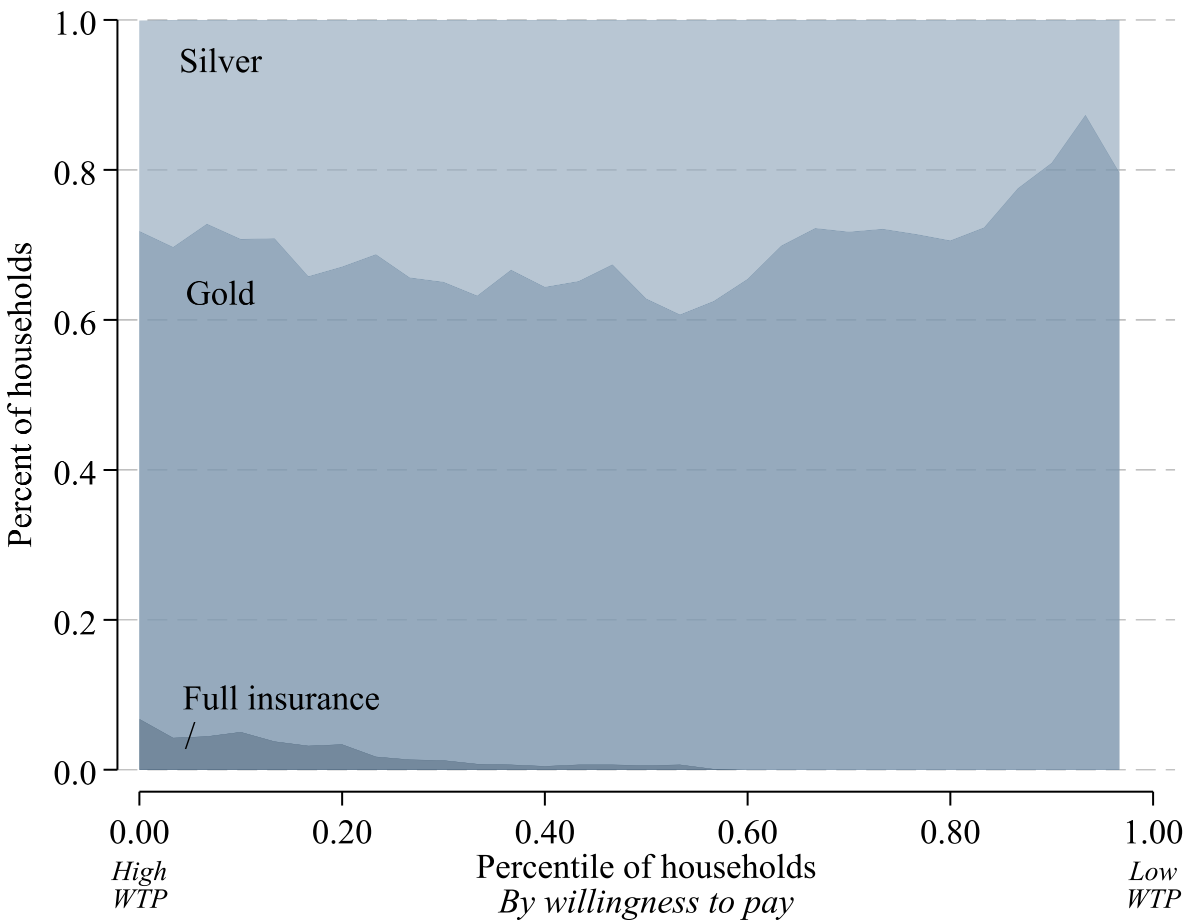
Notes: The figure shows the distribution of households' risk aversion parameter and moral hazard parameter across the distribution of willingness to pay. Each dot represents a household, for a 10 percent random sample of households. The dark line is a binscatter plot over all households, representing the mean value of the vertical axis variable at each percentile of willingness to pay. The clumping at certain parameter values is driven by the intercepts (children versus no children) coupled with the normality assumption on unobserved heterogeneity.

Figure A.10. Household Health State Distributions by Willingness to Pay



Notes: The figure shows the distribution of health states faced by the set of households at each percentile of willingness to pay. Health state distributions are represented by their 10th, 25th, 50th, 75th, and 90th percentiles. A health state realization is equal to unavoidable total healthcare spending. The vertical axis is on a log scale in order to show the clearly the relationship between health state distributions and relevant values on the out-of-pocket cost schedule of the plans we consider in Section V.B.

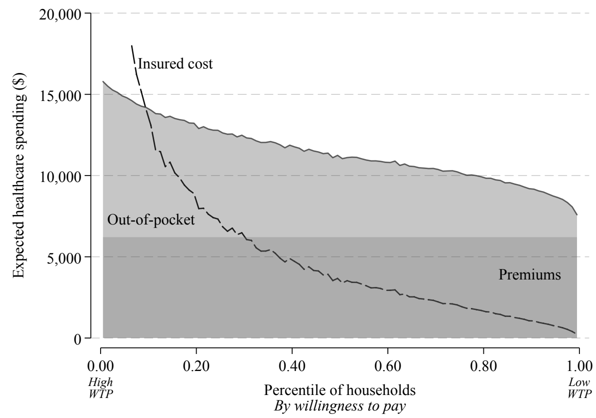
Figure A.11. Efficient Coverage Level by Willingness to Pay



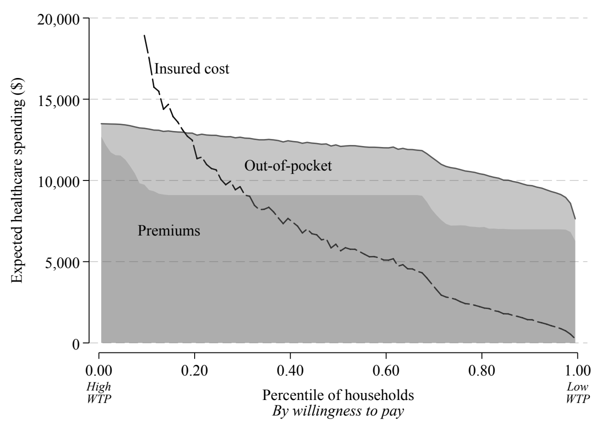
Notes: The figure shows the optimal level insurance for each household in the population. Households are ordered on the horizontal axis according to their willingness to pay. The vertical axis shows the fraction of households at each percentile of willingness to pay for which each level of coverage is optimal.

Figure A.12. Distributions of Spending and Premiums by Willingness to Pay

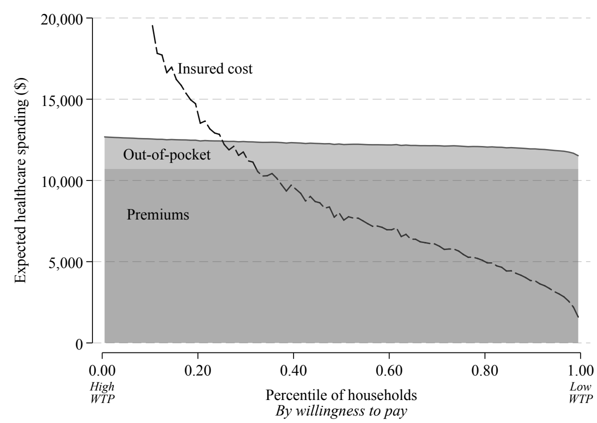
(a) Spending under All Catastrophic



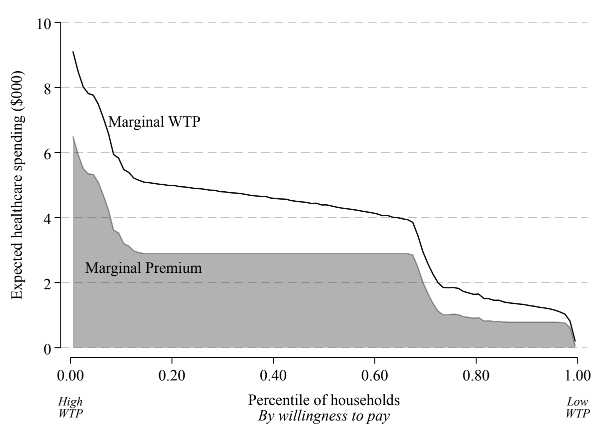
(b) Spending under Vertical Choice



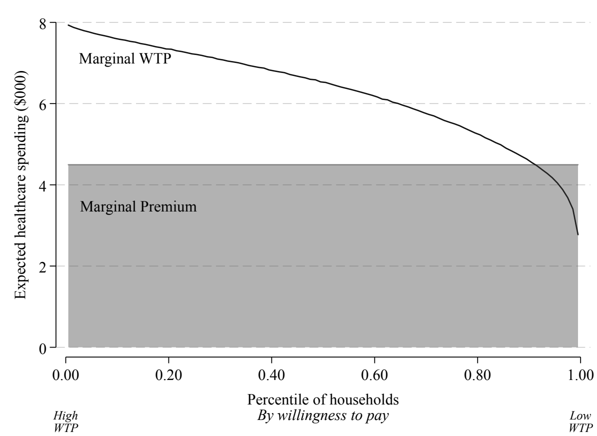
(c) Spending under All Gold



(d) Marginal P, WTP under Vertical Choice



(e) Marginal P, WTP under All Gold



Notes: