

# Market Design in Regulated Health Insurance Markets: Risk Adjustment vs. Subsidies\*

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**Abstract:** Health insurance is increasingly provided through regulated competition, in which two key market design instruments are subsidies for consumers and risk adjustment for insurers. Although typically analyzed in isolation, we illustrate through a stylized model that subsidies offer two key advantages over risk adjustment in markets with adverse selection: they provide higher flexibility in tailoring insurance premiums to buyers with different willingness to pay and, under imperfect competition, they produce equilibria with lower markups and greater enrollment. We provide a quantitative assessment of these effects using demand and cost estimates from the 2014 California exchange regulated by the Affordable Care Act. There, we estimate that holding government spending constant, subsidies can increase enrollment by about 6 percentage points (12 percent) over risk adjustment alone, while keeping all consumers weakly better off.

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# 1 Introduction

For modern governments, social insurance – particularly pensions and healthcare – represent a large and growing fraction of expenditures. Historically, these were provided through direct public provision of insurance. Increasingly, however, social insurance involves public regulation of privately-provided products, rather than direct government provision. In the context of health insurance in the United States, examples include the approximately one-third (and growing) share of Medicare provided by private firms through the Medicare Advantage program, the 2006 introduction of Medicare Part D for prescription drug coverage provided by regulated private insurers, and the regulated private health insurance exchanges created by the 2010 Affordable Care Act (ACA). The trend toward regulated competition in health insurance is not limited to the United States; in countries such as the Netherlands, Switzerland, and Chile, large components of their universal coverage are now offered via insurance exchanges that are similar to those created by the ACA.

In all of these cases, the market sponsor (typically a government) sets the rules, and private firms compete within the rules to attract enrollees. Once the sponsor has defined the set of insurance products that can or must be offered, there typically remain two key market design decisions: premium subsidies for consumers and risk adjustment for insurers. Subsidies are typically viewed as the instrument by which premiums are made affordable; they are therefore often linked to the income of potential buyers. Risk adjustment systems, by contrast, are typically viewed as a way to compensate participating insurers for enrolling high-cost buyers in order to reduce concerns about adverse selection and risk skimming.

Perhaps as a result, policy discussions and academic analyses typically study subsidies and risk adjustment in isolation, as two separate and unrelated objects. For example, recent work has focused on the impacts of risk adjustment on cream-skimming in Medicare Advantage (e.g. Newhouse et al. 2012; Brown et al. 2014) and on the impact of premium subsidies on enrollment by low-income individuals in ACA or similar exchanges (e.g. Finkelstein, Hendren, and Shepard forthcoming; Frean, Gruber, and Sommers 2017).

In this paper, we make the simple observation that these two instruments – often set by the same entity – naturally interact through their impact on equilibrium allocation. In

the stylized price theory framework of Einav, Finkelstein, and Cullen (2010), subsidies are instruments that shift out the demand curve, while risk adjustments are instruments that rotate (and potentially shift) the cost curve. Given that equilibrium is determined by the intersection of demand and cost, it seems natural to study these two market design features in tandem and to ask how they may interact and the extent to which they substitute or complement each other.

We begin with a standard, highly stylized setting of an insurance exchange, with horizontally differentiated insurance plans and adverse selection (willingness to pay that is increasing in costs). In contrast to the way subsidies and risk adjustment are typically used in practice, we take a more conceptual approach and allow risk adjustment and subsidies to be functions of the same set of observables. Our main theoretical result is that, for a given level of market sponsor expenditures, subsidies can achieve higher enrollment and higher consumer surplus than risk adjustment; moreover, they can do so while making each type of consumer (weakly) better off.

This superiority of subsidies over risk adjustment stems from two distinct forces. First, because it flattens the cost curve, risk adjustment increases equilibrium markups, a point that has been noted previously in the literature (Starc 2014; Mahoney and Weyl 2017). We show that, as a result, a (uniform) subsidy can achieve higher coverage and higher consumer surplus at a given level of sponsor spending than risk adjustment can. We refer to this as the “markup effect.” Second, non-uniform subsidies can additionally reduce inefficiencies arising from adverse selection by targeting different (observable) types of buyers with different premiums, thus incentivizing low-risk types to purchase insurance. We refer to this as the “premium targeting effect.”

The theory provides qualitative results in a simplified horizontally differentiated setting. To explore the comparison between subsidies and risk adjustment quantitatively, and in a richer setting, we use the estimates of demand and costs in Tebaldi (2018) from the first year (2014) of the ACA health insurance exchange in California. The California exchange is among the three largest ACA marketplaces, with about 1.3 million enrollees in 2014. Over 90% of these enrollees received federal subsidies, with annual public expenditures totaling approximately 3.5 billion dollars. Tebaldi (2018) used the estimates from this setting to ex-

plore optimal subsidy design. We expand the analysis here to consider comparisons between optimal risk adjustment and optimal subsidies.

Holding fixed market sponsor spending, we estimate the enrollment-maximizing equilibrium – and quantitatively compare enrollment, markups, consumer surplus, and producer surplus – under different market regimes: risk adjustment, uniform subsidies, and non-uniform subsidies. The enrollment increase in moving from optimal risk adjustment to optimal uniform subsidies reflects the markup effect; the enrollment increase in moving from uniform to non-uniform subsidies reflects the premium targeting effect. Of course, such premium targeting may make higher-risk types worse off, creating a social trade off between maximizing enrollment and type-specific utility. We therefore also consider potential gains from optimal non-uniform subsidies that respect a Pareto restriction: relative to the optimal uniform subsidy or risk adjustment, the non-uniform subsidies must make all types (weakly) better off.

At roughly current levels of market sponsor expenditures, we estimate that optimal subsidies increase enrollment by about 6 percentage points (12 percent) compared to optimal risk adjustment. In our setting, this is primarily driven by the markup effect, with less than a third of the enrollment gain coming from the premium targeting effect. We also find that in our setting there is little or no penalty on enrollment from imposing the Pareto restriction on the optimal non-uniform subsidy.

Of course, the power of targeted subsidies to achieve welfare gains in our setting is intricately linked to our restriction that the health insurance exchange imposes “community rating,” so that insurers cannot price discriminate among potential buyers. We view community rating as a natural restriction given that it is widely adopted in regulated health insurance markets. Prior work (Handel, Hendel and Whinston 2015) has illustrated both the costs of community rating in terms of inducing adverse selection as well as its benefits from limiting buyer exposure to reclassification risk (i.e. the risk of subsequent premium changes). Our paper thus highlights an additional advantage of community rating: as we discuss below, it prevents profit maximizing insurers from undoing targeted subsidies via price discrimination, and thus provides the market sponsor with a powerful instrument for increasing insurance enrollment for a given amount of spending.

Our paper is related to an increasing number of papers that study subsidy design (Chan and Gruber 2010; Decarolis, Polyakova, and Ryan 2017; Finkelstein, Hendren, and Shepard forthcoming; Jaffe and Shepard 2017; Tebaldi 2018), risk adjustment (Glazer and McGuire 2000; Van de Ven and Ellis 2000; Ellis 2008; Newhouse et al. 2012; Brown et al. 2014; Einav et al. 2016; Layton, McGuire and Sinaiko 2016; Geruso and Layton 2018), the ACA exchanges (Dickstein et al. 2015; Abraham et al. 2017; Frean, Gruber, and Sommers 2017; Tebaldi 2018), and the design of health insurance exchanges more generally (Curto et al. 2014; Handel, Hendel, Whinston 2015; Azevedo and Gottlieb 2017). As noted earlier, in all these papers subsidies and risk adjustments are treated in isolation, and none of these papers engages in the relationship and tradeoffs between them.

Our paper proceeds as follows. In Section 2 we present a stylized theoretical framework and results. Section 3 briefly describes the empirical setting and estimates, which are taken directly from Tebaldi (2018). Section 4 presents our quantitative assessment of alternative market regimes. To do so, we begin by reporting some quantitative comparative statics in a more simplified empirical setting in order to illustrate in a more transparent way some of the underlying economic forces at work. We then report our “bottom line” numbers, that account for many more institutional features of the entire California market than the initial, simplified setting. The last section concludes with a brief discussion of potential reasons why, despite our theoretical and empirical results, risk adjustment remains a popular market design instrument.

## **2 A stylized theoretical framework**

### **2.1 Setting and notation**

We consider a stylized setting. There is a single insurance coverage contract, offered by  $J$  competing insurers, each indexed by  $j$ . As is often the case in regulated insurance markets, insurers are not allowed to charge different prices to different consumers (beyond any price discrimination that is built into the subsidy design), so each insurer  $j$  sets a single price  $p_j$  in a Bertrand-Nash Equilibrium. The insurance contract may be horizontally differentiated

across insurers (due e.g. to different provider networks, or brand preferences).

Potential buyers are heterogeneous, with each consumer  $i$  defined by a triplet  $(v_i, c_i, w_i)$ .  $v_i = (v_{i1}, \dots, v_{iJ})$  is a vector of consumer  $i$ 's willingness to pay for the insurance contracts offered by the different insurers. We denote by  $c_i > 0$  the expected cost to the insurer of covering individual  $i$ , which for simplicity we assume to be the same across insurers. Finally,  $w_i$  denotes a vector of observable characteristics, such as age, income, or health risk score, which in principle can be used as an input to the subsidy or risk adjustment design. We also refer to  $w_i$  as consumer  $i$ 's type, and take the number of types as finite throughout.

In this setting, similarly to the framework in Einav, Finkelstein, and Cullen (2010), the population is represented by the joint distribution of  $v_i$ ,  $c_i$ , and  $w_i$ . This imposes no restrictions on the relationship between preferences, cost, and consumer types, but we note that it is natural to think of adverse selection as a positive correlation between cost  $c_i$  and willingness to pay  $v_{ij}$  (for each  $j$ ). When this is the case, if  $ac_j(p)$  is the average cost of individuals covered by contract  $j$  when premiums are  $p = (p_1, \dots, p_J)$ , adverse selection implies that  $\partial ac_j(p)/\partial p_j > 0$ .

A subsidy design is defined as a function  $s(w_i)$ . If buyer  $i$  buys insurance coverage from insurer  $j$ , she pays  $p_j - s(w_i)$ , the market sponsor pays  $s(w_i)$ , and the insurer's (expected) profits from covering buyer  $i$  are  $p_j - c_i$ .

A risk adjustment design is defined as a function  $r(w_i)$ . If buyer  $i$  is insured, the market sponsor transfers  $r(w_i)$  on top of the premium the insurer receives; insurer  $j$ 's profits from covering individual  $i$  are therefore  $p_j - (c_i - r(w_i))$ . We note that we do not require risk adjustments to be budget neutral, so in principle risk adjustment payments could result in greater (or lower) overall expenditure by the market sponsor. Importantly, throughout the paper we restrict attention to only “ex ante” and “regular” risk adjustment designs, which are the most common in mature markets. By “ex ante” we mean that the risk adjustment function associated with buyer  $i$  is known at the time of enrollment, and does not depend on buyer  $i$ 's subsequent realized costs or on the realized costs of other buyers in the market.<sup>1</sup> By “regular” we mean that the risk adjustment reduces adverse selection by compensating

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<sup>1</sup>In many new markets, it is not uncommon to see such ex post adjustments that are based on realized costs. As markets mature, however, data availability allows for more accurate risk prediction and a more robust implementation of an ex ante risk adjustment system.

insurers more generously for covering more risky buyers, or more precisely that  $r(w_i) \geq r(w_k)$  if and only if  $E[c_i|w_i] \geq E[c_k|w_k]$ . Under regular risk adjustment, in the presence of adverse selection, the per-enrollee risk adjustment transfer received by  $j$  is increasing in  $p_j$ .

## 2.2 Perfect competition

We begin by analyzing the case of perfect competition, which arises in our setting when insurers are homogeneous ( $v_{i1} = v_{i2} = \dots = v_{iJ}$ , for all  $i$ ). As a result, as in Einav, Finkelstein, and Cullen (2010), the Bertrand-Nash Equilibrium implies that insurers set prices so that price equals average costs, and profits are zero.

In such a case, we obtain the following result.

**Proposition 1** *Under perfect competition, for any Nash equilibrium that is achievable with risk adjustment, there exists a uniform subsidy design with no risk adjustment that can achieve the same equilibrium, with the same enrollment for all types and the same total spending by the market sponsor.*

The proof is in the appendix. The intuition is simple and is illustrated in Figure 1. It plots demand and average cost curves as in Einav, Finkelstein, and Cullen (2010). The demand curve shows the share of the population who buy insurance at a given price. The average cost curve shows the average expected claims among all consumers who buy insurance at that price; it is downward sloping, indicating the presence of adverse selection: as the price is lowered, the marginal buyer is lower expected cost than the average existing buyers. Under perfect competition, the equilibrium is given by the intersection of the demand and average cost curve.

The left panel illustrates the impact of risk adjustment. Risk adjustment flattens – and potentially shifts – the average cost curve, leading to a new market equilibrium with greater insurance coverage and lower insurer prices. Proposition 1 implies that this market equilibrium can alternatively be achieved by reverting back to the original cost curve, and using a uniform subsidy to achieve an appropriate parallel shift of the demand curve; this is illustrated in the right panel of Figure 1. Since the same equilibrium is achieved with zero profits, market sponsor spending must also be the same.

Proposition 1 implies that, under perfect competition, any equilibrium that can be implemented via risk adjustment could also be implemented by setting the appropriate level of a uniform subsidy. Importantly, however, the converse is not true. That is, it is not the case that any equilibrium under a subsidy design can be implemented using appropriate risk adjustment. To see this, note that under risk adjustment, because insurers must set a single price, all buyers pay the same price, so equilibrium allocations must be monotone in willingness to pay. That is, if  $v_i > v_k$  and individual  $k$  buys insurance in equilibrium then individual  $i$  also does. In contrast, non-uniform subsidies could be such that different consumer types face different prices, and if  $s(w_k)$  is sufficiently greater than  $s(w_i)$  the above monotonicity property could be violated, and the equilibrium may give rise to non-monotone insurance allocations. Non-uniform subsidies, in other words, provide an additional instrument and therefore may be able to achieve a greater set of equilibrium allocations than with uniform subsidies.

### 2.3 Imperfect competition

We now consider a situation in which different buyers may have different valuations for different insurers. In such a situation, insurers have some amount of market power, and in a Bertrand-Nash Equilibrium markups are positive. Here we obtain the following result, where for simplicity we focus on the case of symmetric insurers, as in Mahoney and Weyl (2017).

**Proposition 2** *Under imperfect competition and adverse selection, for any symmetric Nash equilibrium that is achievable with regular risk adjustment and no subsidies, in which markups are strictly positive, there is a (uniform) subsidy with no risk adjustment that leads to an equilibrium with the same enrollment for all types, and lower total spending for the market sponsor.*

The formal proof is in the appendix, but the intuition is the same as in Starc (2014) and Mahoney and Weyl (2017), and can be illustrated by examining the following insurer's first order condition:

$$p = ac(p) - \frac{q(p)}{q'(p)} (1 - ac'(p)), \quad (1)$$

where  $q(\cdot)$  and  $ac(\cdot)$  are the residual demand and residual average cost curves faced by the insurer. The key object in the first order condition is  $ac'(\cdot)$ , the derivative of the  $ac(\cdot)$  curve with respect to the insurer's own price. With adverse selection ( $ac'(\cdot) > 0$ ), the marginal buyer is cheaper than the average buyer and is therefore relatively attractive to cover, exerting downward pressure on prices and markups. Regular risk adjustments reduce that the difference in costs between the marginal buyer and the average buyer (because the insurers are compensated more generously for covering high risk individuals), so  $ac'(\cdot)$  is lower, thus reducing the pressure on prices and leading to greater markups. In other words, while in the perfect competition case the cost reductions implied by risk adjustment are fully passed through to consumers, when insurers have market power this pass through is incomplete, and subsidies are therefore a cheaper tool to lower consumer prices (and increase enrollment).

Proposition 2 implies that we can switch from any risk adjustment design to an environment with a uniform subsidy, leading to lower markups, greater coverage, and lower spending by the market sponsor. This has only considered uniform subsidies. In addition, the earlier observation about non-uniform subsidies described in the context of perfect competition remains: Risk adjustments (and/or uniform subsidies) imply monotone (in willingness to pay) insurance allocations. Any non-uniform subsidy could relax this, and thus offers the market sponsor a greater set of equilibrium allocations that could be implemented.

## 2.4 Summary

Taken together, these results imply that, for any given level of spending by the market sponsor, subsidies can produce higher coverage (and consumer surplus) than risk adjustment. We call the enrollment difference between risk adjustment and uniform subsidies a “market power effect,” by which subsidies lower insurers’ markups for any coverage level that can be achieved. We call the additional enrollment gain from moving from uniform to non-uniform subsidies – and thus allowing the sponsor to provide different subsidies to different types of consumers – a “targeting effect,” by which subsidies can be targeted to provide more incentives for the low-risk types to enter the insurance pool.

The rest of the paper provides a quantitative assessment of these qualitative effects, using

data and estimates from ACA Health Insurance Exchange in California. The quantitative analysis relaxes several of the simplifying assumptions of our stylized theory. In particular, we allow for insurers to offer more than one plan, with vertically (as well as horizontally) differentiated products, and we allow for asymmetric costs across insurers. While the above theoretical results do not necessarily hold in such a richer setting, in practice the qualitative theoretical results always hold in all the (reported and unreported) quantitative exercises we have performed.

## 3 Empirical setting

### 3.1 Setting and data

**The health insurance exchange in California** We use data from the first year (2014) of the California Health Insurance Exchange (“Covered California”), which was initiated by the Affordable Care Act (ACA). The California exchange is among the largest of the ACA exchanges, with about 1.3 million individuals obtaining health insurance coverage via this exchange during the first year. Given that over 90% of the buyers are subsidized and that the California exchange substantially restricts the scope of insurers’ coverage design, it makes for a useful context in which we can quantitatively assess the interaction between risk adjustment and subsidies.

Covered California adopted all the regulations that are mandated by the national ACA reform, and also imposed several additional restrictions. We summarize the key features; more detailed description is available in Tebaldi (2018). Covered California partitions the state into 19 geographic regions, each constituting a separate market. Insurers decide to participate in the market on a region-by-region basis. There are 3 to 6 insurers participating in each region. The two largest insurers, Anthem Blue Cross and Blue Shield of California, enroll 66% of individuals in Covered California, and market share grows to almost 90% when also considering HealthNet and Kaiser Permanente.

Within each region, participating insurers have to offer a set of four standardized coverage options. The standardized options are labeled by metals – bronze, silver, gold, and platinum –

with each metal indicating a different level of coverage generosity, with approximate actuarial values that range from 60% (bronze) to 90% (platinum).<sup>2</sup> The details of each contract are also standardized, as shown in Appendix Table A1. Note that for silver plans (and only for silver plans), subsidized buyers receive cost-sharing subsidies in addition to premium subsidies. As shown in Appendix Table A1, for low income individuals these cost-sharing subsidies make silver coverage dominate the gold and sometimes even the platinum plan, as the silver coverage becomes more generous than these other metals but still has lower premiums.

Despite these standardizations, insurers still differ along two important dimensions. They set different premiums as explained below, and they offer a different network of medical providers. The latter is an important source of unobserved heterogeneity across plans that our econometric model will account for. Fortunately, the provider network does not change with the level (metal) of the financial coverage (within insurers).

Premium setting is subject to regulation, essentially constraining each plan-metal combination  $j$  in a given market (region) to set a single (base) price  $b_j$ . (In what follows, we will refer to plan-metal combinations by the shorthand "plan"). This base price is then mapped to the premium  $p_{ij}$  the individual has to pay and the subsidized portion of it  $s_{ij}$  that is paid by the government. These mappings are based on known, pre-specified (by the market sponsor) formulas, which depend on the individual's age and income. Specifically, premiums are the product of the base price and an age factor  $p_{ij} = f(\text{age}_i)b_j$ , where  $f(\text{age})$  is a concave monotone function that is increasing from 1 (for 21 years old individuals) to 3 (for 64 years old individuals). The subsidy amount is then given by  $s_{ij} = \max\{0, p_{ij} - \bar{p}_i\}$ , where  $\bar{p}_i = g(\text{age}_i, \text{income}_i)$  is set in a way that is benchmarked against the price the individual would have to pay for the second cheapest silver plan in the region.<sup>3</sup> Individual  $i$  thus pays  $p_{ij} - s_{ij}$  out of pocket when selecting plan  $j$ . An important feature of this regulation

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<sup>2</sup>There is a fifth coverage level, "catastrophic coverage," which offers lower coverage than bronze. It is a high deductible plan that is only available to individuals who are younger than 35 and who do not benefit of premium subsidies. These plans are not relevant for our analysis, so we abstract from them throughout the paper.

<sup>3</sup>This description applies for a single individual. Because income is typically measured at the household level, in practice the income and the subsidy formula are averaged over all covered individual within a household. The empirical exercise accounts for this additional complication, but we abstract from it in the text in order to ease notation and exposition.

is that buyers face identical choice sets but different prices, and because each plan sets a single base price the price variation across individuals is fully induced by the properties of the pre-specified formulas. This will prove useful for identification.

**Data** We use the same data as in Tebaldi (2018). We have the complete enrollment file of the California exchange for the 2014 coverage period; for each household enrolled in the exchange we observe the age and gender of its members, income, geographic location, premium paid, and plan selection. We combine these data with information on premiums, financial characteristics, and geographic availability for all the plans offered in the exchange. In addition, at the plan level (but not at the individual level) we observe the average (ex-post) realized amount of medical claims. Finally, in addition to these data on actual buyers, we use the American Community Survey (ACS) to construct a measure of potential buyers across different demographics in each region. We define a household as a potential buyer if it is either uninsured in 2013 or purchases insurance in the individual (non-group) market in 2013.

Table 1 summarizes the characteristics of actual and potential buyers. Actual buyers tend to be relatively older and poorer. Several aspects shown in Table 1 are critical for our subsequent analysis. First, the majority of individuals (64%) select silver plans, presumably because – as mentioned earlier – cost-sharing subsidies make Silver plans substantially more attractive for subsidized households. Second, almost all actual buyers (94% of the households) are subsidized. Among subsidized buyers, 89% buy silver or bronze, which is why in our quantitative analysis below we consider only silver and bronze plan enrollment.

Table 2 shows plan-level summary statistics. Two observations are important to highlight. First, with the exception of platinum plans, plan revenues are (on average) substantially above their incurred claims, but only due to the large amount of subsidies as enrollees' payments are substantially below plans' cost. Second, the data are consistent with the existence of asymmetric information, where higher coverage plans are associated with greater costs (Chiappori and Salanie 2000).<sup>4</sup> This could reflect either adverse selection or moral

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<sup>4</sup>This is true even after adjusting for the mechanical fact that for a given level of health care use, plans with greater coverage will report higher claims; since we know the difference in advertised actuarial value (see Appendix Table A1) this is a simple mechanical adjustment to make.

hazard. A key focus of this paper will be the analysis of subsidies and risk adjustment in the presence of adverse selection; the empirical model we describe in the next section allows for such adverse selection, and the estimates provide direct evidence of adverse selection.

### 3.2 Empirical model

The baseline demand and cost estimates are the same as in Tebaldi (2018). For completeness we provide here a brief summary. A household  $i$  is associated with a vector of observable characteristics (age, income, region, and household size), denoted by  $z_i$ . A plan  $j$  is associated with its base price  $b_j$ , and a vector of observable characteristics (actuarial value, five insurer dummy variables, and region), denoted by  $x_j$ . For each household-plan combination we can then construct the implied premium  $p_{ij}$  and subsidy  $s_{ij}$ .

**Demand** We specify a mixed logit demand model, where the random utility coefficients are drawn from a finite support as in Berry, Carnall, and Spiller (2006) or Train (2008). Formally, the utility that household  $i$  derives from purchasing plan  $j$  is given by

$$u_{ij} = x_j' \beta_i - p_{ij} + \sigma_i \varepsilon_{ij}, \quad (2)$$

where  $(\beta_i, \sigma_i) \sim_{iid} F(\beta, \sigma | z_i)$  and  $\varepsilon_{ij}$  is drawn, iid, from a type 1 extreme value distribution. The outside option is denoted by  $j = 0$  and we adopt the standard normalization by which  $x_0 = 0$  and  $p_{i0} = 0$  for all  $i$ .

As mentioned, we assume that  $F(\beta, \sigma | z_i)$  has a finite support that include four possible values  $\{(\beta^k, \sigma^k)\}_{k=1}^4$ , where  $F(\cdot)$  follows a logistic distribution over this support:

$$F(\beta^k, \sigma^k | z_i) = \frac{\exp(\delta^k z_i)}{\sum_{l=1}^4 \exp(\delta^l z_i)}, \quad \text{for } k = 1, 2, 3, 4. \quad (3)$$

That is, the support of the random coefficient does not depend on the household characteristics, but the probability over this support does.

We allow demand to vary flexibly across markets (regions) by estimating it separately region by region. Overall, in each region there are 39 demand parameters: 28 parameters

that define the support of  $(\beta^k, \sigma^k)_{k=1}^4$ , and 11  $\delta$ 's (three  $\delta$ 's for each  $k = 1, 2, 3, 4$ , with one of these normalized to zero) that affect the distribution over this support as a function of household demographics.

Identification is discussed extensively in Tebaldi (2018). Loosely, the intuition for identification is that we only exploit the regulation-induced variation in prices of the same products within a region across buyers with different characteristics. We combine this with the functional form restrictions specified in (3), imposing constraints on how preferences can vary with age, income, and household size. In addition, identification of the value households place on the generosity of insurance (actuarial value) also relies on the discontinuity of cost-sharing subsidies at certain income thresholds (see Appendix Table A1, Panel B).

**Cost** We assume that the (expected) cost to the insurer of plan  $j$  from covering household  $i$  is given by

$$c_{ij} = \phi x_j + \gamma z_i + \omega_{ij}. \quad (4)$$

In this specification,  $\phi$  captures cost differences across plans that are driven by differences in the geographic market, insurer, or generosity of insurance, holding the set of enrollees fixed. The parameter vector  $\gamma$  captures the extent to which insurers face different expected costs when enrolling households with different observable characteristics.

Finally, we assume that  $\omega_{ij} = \lambda \nu_i + \eta_{ij}$ , where  $\eta_{ij}$  is an iid error term while  $\nu_i$  allows us to incorporate potential adverse selection by capturing the relationship between willingness to pay for higher coverage and plan cost. Specifically, we assume that  $\nu_i$  is the household-specific coefficient on insurance generosity, which is a summary measure of the household's willingness to pay for greater coverage regardless of insurer choice. Adverse selection would be captured by  $\lambda > 0$ , which would imply that households with greater willingness to pay for coverage are associated with greater expected cost from coverage.

Because we observe choices at the household level but costs only at the plan level, in order to estimate equation (4) we aggregate it across all enrollees of a given plan. That is, for each  $j$  we define  $\bar{z}_j$  and  $\bar{\nu}_j$  as the average  $z_i$  and  $\nu_i$ , respectively, across households enrolled in  $j$ .  $z_i$  is observed so aggregation is straightforward. In contrast,  $\nu_i$  is unobserved,

so we replace it with the posterior  $E(v_i|i \text{ chose } j)$ .<sup>5</sup> We then estimate

$$c_j = \phi x_j + \gamma \bar{z}_j + \lambda \bar{\nu}_j + \bar{\eta}_j \quad (5)$$

via OLS.

### 3.3 Baseline estimates

Appendix Tables A2 and A3 provide details of the estimated demand and costs, respectively. These are discussed in detail in Tebaldi (2018). In Figure 2 we try to summarize the estimates by focusing on the key primitives that will enter our simulations of equilibrium under alternative designs of subsidies and risk adjustment schemes.

To construct the figure, we take every individual in the data and compute for her two summary measures of willingness to pay and expected cost. For willingness to pay, we compute the posterior estimate (conditional on actual choice) of the individual’s parameter on actuarial value, and map it to the individual’s willingness to pay for a 20 percentage point increase in the actuarial value of coverage (which is approximately moving individual from bronze to silver coverage for the average individual in the sample). For expected cost, we use equation (4) and assume that the individual is covered by Anthem’s silver plan, which is the largest plan in the sample. The figure then reports the average and distribution of expected cost as a function of the individual’s willingness to pay.

Figure 2 illustrates the extent of adverse selection: individuals with greater willingness to pay have higher expected costs. For example, individuals who are willing to pay approximately 500 dollars per-year to increase their coverage by 20 percentage points of actuarial value are (on average) expected to cost the insurer about 2,000 dollars for the Anthem silver plan. By contrast, individuals who are willing to pay as much as 2,000 dollars for the same increase in coverage have more than twice as high costs for the Anthem silver plan, approximately 4,600 dollars. The figure also illustrates the heterogeneity across individuals: as shown by the vertical range of the dashed lines in Figure 2, there is a fair amount of heterogeneity in the expected cost of individuals even conditional on their willingness to

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<sup>5</sup>That is, for each household we compute  $E(v_i|i \text{ chose } j) = \sum_{k=1}^k \nu_i \frac{F(\beta^k, \sigma^k | z_i) \Pr[i \text{ chose } j | v_i]}{\Pr[i \text{ chose } j]}$ .

pay, which implies that selecting on demographics or other individual characteristics could have important implications for the nature and extent of adverse selection.

## 4 Risk adjustment vs. subsidies in the California market

### 4.1 Setup

We use the estimates of demand and cost in the California health insurance exchange to solve for market equilibria under alternative, counterfactual risk adjustment or subsidy schemes. For each buyer  $i$ , we begin by generating an observable discrete variable  $w_i$  that indicates a type, which is assumed to be observable by the market sponsor.

To facilitate meaningful comparisons, in all equilibrium simulations we hold fixed across alternative market design regimes the total amount of spending by the market sponsor, which we denote by  $K$ . In what follows, we show results for a range of values for  $K$ . For each value of  $K$  we assume that the market sponsor's objective is to maximize overall enrollment<sup>6</sup> subject to the budget constraint and one of the four specific restrictions on the market design regimes we consider.

We consider the following four market design regimes: (i) a risk adjustment regime, in which the market sponsor chooses the risk adjustment function  $r(w_i)$ , which reflects the additional (positive or negative) transfer an insurer obtains for covering a buyer of type  $w_i$ ; (ii) a uniform subsidy regime, in which the market sponsor chooses a single number  $s$ , which is the uniform subsidy that potential buyers can use toward premium payments; (iii) a targeted subsidy regime, in which the market sponsor chooses a function  $s(w_i)$ , which represents the subsidy amount that a potential buyers can use toward premium payment; and (iv) a Pareto-constrained targeted subsidy regime, which is similar to case (iii) above, but constraints the subsidies so that the equilibrium outcome (weakly) Pareto dominates the

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<sup>6</sup>The results are almost identical when the sponsor's objective is to maximize consumer welfare. This is because in most exercises allocations are driven by a uniform out of pocket premium, which sorts consumers to insurance allocations based on their willingness to pay, which corresponds to their welfare from having insurance. The only exercise where this is not the case is when we allow targeted subsidies, but even then the results remain qualitatively very similar.

one that is obtained under uniform subsidy, so that targeting cannot harm any consumer.

The simulation works as follows. For each market design regime and a value of the sponsor’s budget  $K$ , we compute a Bertrand-Nash equilibrium in premiums under each value of the market design parameter/s, and then search for the market design parameter/s that would maximize the sponsor’s objective function (which is total enrollment in the baseline case). Thus, for each value of  $K$  we then obtain four different optimal solutions – one for each market design regime – which we then describe and analyze.

We use the results to obtain quantitative estimates for the theoretical predictions derived in Section 2. We go about this exercise in two steps. In the first step, we use the empirical estimates from the California market, but simplify the setting enough to make the empirical context very close to the stylized theoretical setting we analyzed in Section 2. Specifically, we only consider a single coverage plan, two symmetric insurers, and a single market (region). This (overly) simplified setting guarantees that our theoretical predictions hold, and also allows us to provide cleaner intuition for the key forces that are at play. Naturally, such simplification makes the quantitative estimates in this section less empirically relevant.

Then, in the second step, we undo many of the simplifications and approximate more closely the actual setting of the California market. Specifically, we allow multiple coverages, expand the analysis to all regions, and incorporate the actual set of (asymmetric) insurers that operate in each region. This setting allows us to obtain quantitative estimates that are more meaningful, but with arguably less clear intuition than the simplified setting.

## 4.2 A simplified setting

We begin by generating results in a simplified setting of the California market, which is well approximated by the stylized theoretical setting Section 2. To do this, we focus on a single market, Los Angeles county, which is the largest region in Covered California. We then assume that buyer type is binary by computing the distribution of  $c_i$  and assuming that whether the individual’s cost is above or below the median is observable:  $w_i = L$  if  $c_i$  is below the median, and  $w_i = H$  otherwise.

Furthermore, we adapt our estimates to fit the case of a symmetric single-product duopoly. Each of the two insurers  $j = A, B$  offers only a single silver plan to single buyers

with income between 100-300% of the Federal Poverty Level, and we assume that the two plans are symmetric, and only differ horizontally, with certain buyers preferring the network of physicians covered by A and others preferring the network of B. Formally, each potential buyer is associated with a two-dimensional vector of willingness to pay  $v_i = (v_{iA}, v_{iB})$  and an identical (to both insurers) expected cost  $c_i$ , and the joint distribution of  $v_{iA}$  and  $v_{iB}$  and  $c_i$  is obtained from our baseline estimates that are described in Section 3, where  $(v_{iA}, c_i)$  and  $(v_{iB}, c_i)$  are drawn from our estimates for Anthem’s silver plan, which is offered in every rating region in California. This translates to the aggregate and residual demand in the (simplified) market. This setting reflects a symmetric duopoly where firms have market power due to horizontal tastes but they do not systematically differ in terms of cost or attractiveness of their products.

Figure 3(a) presents the main results, by showing overall enrollment for different levels of government spending ( $K$ ) under the four different market design regimes. The vertical distance between the different lines can be used as a metric to assess the different effects, as it represents the number of new enrollees we obtain “for free” (keeping the budget the same) as we move from a risk adjustment regime to a flat subsidy regime, and then to a targeted subsidy regime. The first difference corresponds to the market power effect, and the second to the targeting effect. As discussed in the Introduction, the power of the targeting effect is intricately linked to the restriction – in our model and in most regulated health insurance markets – that insurers cannot freely price discriminate against observably different consumers. If they could, we find (in unreported analyses) that non-uniform subsidies are often unable to increase enrollment over optimal risk adjustment; this is because in the absence of risk adjustment, profit maximizing insurers have incentives to set prices higher on the observably high risk, driving them out of the market.

Figure 3(a) also shows that while the ranking across the regimes is, not surprisingly, consistent with the theory, the quantitative importance of each effect varies considerably with the overall enrollment share, which is closely related to the identity of the marginal enrollee. For example, at low levels of government spending the market power effect is negligible, and the targeting effect is very large; enrollment can be almost doubled through optimal targeting. However, at higher budgets and higher enrollment levels, the market power

effect becomes more dominant and the targeting effect shrinks. The intuition can be seen in Figure 3(b), which presents the optimal levels of subsidies (uniform and targeted) at the different budget levels. At lower budget levels (and low levels of subsidies), enrollment is primarily driven by high risk enrollees, making it much more valuable to attract marginal low risk potential buyer, who “bring” to the market high consumer surplus that can be partially passed on to inframarginal enrollees.

Figure 4(a) illustrates the underlying “mechanics” for these overall effect. Each point in the graph represents a pair of overall coverage for each type. The dashed, iso-WTP line represents the locus of coverage pairs that correspond to identical willingness to pay of the marginal buyer across both types. A risk adjustment or a flat subsidy regime forces equilibrium allocation to lie on this line, while a targeted subsidy regime frees up the market sponsor to find equilibrium allocation that are not on this line. The large black dots in Figure 4(a) represent the optimal allocation under the four different regimes for a budget of  $K = \$150$  per potential buyer (which is the level of sponsor’s spending in the Los Angeles county region). Going from left to right, one can see that the market power effect allows more individuals of either type to get coverage because premiums (and markups) are lower under a flat subsidy relative to a risk adjustment regime. Yet, in both cases the allocation is forced to lie on the iso-WTP line. A targeted subsidy allows the market sponsor to offer a greater subsidy amount to low risk types, which in turn brings more of them to the market, reduces overall premiums, and can therefore can maintain similar equilibrium prices for high risk types (this specific channel is the focus of Tebaldi, 2018). Finally, this effect can be even larger in terms of overall enrollment if the market sponsor can “afford” some coverage reduction of high risk types, as shown in the right-most dot in Figure 4(a).

Figure 4(b) presents the corresponding demand and cost curves to each case, which are the empirical analog of the theoretical figure (Figure 1). Black lines represent demand curves and gray lines represent cost curves. The risk adjustment regime is shown by the dotted lines, with the square showing the equilibrium allocation (and the vertical distance to the dotted gray line showing the equilibrium markups). The solid lines and triangle equilibrium allocation represent the uniform subsidy regime; although hard to visually see it, the cost curve (absent risk adjustments) is steeper, leading to lower markups and higher enrollment

due the market power effect. Finally, the dashed lines and the circle allocation represent the targeted subsidy case, which leads to even higher levels of enrollment.

### 4.3 Main results

We now move from the above, overly simplified setting to a setting that is much closer to the empirical setting of Covered California. The downside of this more complex setting is that heterogeneity across markets and plans makes intuition sometimes more tricky. The upside is that the quantitative results may be viewed as more empirically relevant.

Specifically, relative to the simplified setting described above, we now consider the full set of 19 regions covered by the California market, and consider the full set of (heterogenous) insurers that operate in each market. We also allow insurers to offer two products, silver and bronze, rather than silver alone (recall silver and bronze are effectively the only two contracts purchased by subsidized enrollees, which is our focus). We also enrich the consumer type space from two types to six: for each buyer  $i$ , we generate an observable variable  $w_i$  that interacts three risk types – low, medium, and high expected risk, defined based on the within-region terciles of the distribution of  $c_i$  – and two income types – low and high, which are defined as above or below 200% of the Federal Poverty Line. Finally, in addition to the four market design regimes we considered in the context of the simplified setting, we also consider a fifth, “hybrid” regime in which subsidies may only vary by income, while risk adjustment may only vary by risk, which attempts to approximate the nature of the current policy environment.

The results are summarized in Table 3 and Figure 5, which are focused on  $K = \$300$  per potential enrollee year, which is roughly similar to the amount spent in Covered California for the population we consider here.<sup>7</sup> The first column of Table 3 shows results for the optimal risk adjustment policy. This policy pays insurers \$1,200 per enrollee-year for medium and high risk enrollees with low income, \$960 per enrollee-year for medium risk enrollees with high income, and \$1,440 per enrollee-year for high risk enrollees with high income. It results

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<sup>7</sup>In Covered California, this amount is approximately \$500 for the entire population and approximately \$300 for the population of subsidized single adults, which we focus on for our quantitative exercise. These figures are computed as the ratio between the total amount of subsidy outlays and the number of potential buyers as measured in the ACS.

in enrollment of almost 50% of potential buyers. As showed in Figure 5, about 41% of these enrollees are high risk types, 32% are medium risk types, and the remaining 27% are low risk. Risk adjustment lowers average cost for insurers by 43%, from \$2,107 to \$1,232 per enrollee-year.

The second column of Table 3 shows the outcomes of the market moving from risk adjustment to a uniform subsidy. The optimal value of this subsidy is \$720 per enrollee-year. Under this regime, enrollment increases to 53.5%. As highlighted by our theoretical results in the simple setting, this higher enrollment follows from the fact that insurers charge lower markups, which on average decrease from \$682 to \$447 per enrollee-year. Importantly, enrollees also purchase more generous coverage, with the share of Silver plans among buyers growing from 61% to 66%.<sup>8</sup> Figure 5 illustrates that the risk composition of enrollment is quite similar to the one achieved under optimal risk adjustment.

In the third column of Table 3, we report the outcomes of the third regime we consider: optimal targeted subsidies in which the Pareto-constraint is imposed, so that no type is facing higher premiums than under uniform subsidies. In terms of policy, the only difference is that low risk, low income types receive a subsidy of \$1,200 per enrollee-year, while the other types still receive \$720. This implies that low risk, low income types face lower premiums, enter the market, lower average cost, and thus generate downward pressure on equilibrium premiums. Enrollment under this regime is 55.5%, or almost 6 percentage points (12 percent) higher than under optimal risk adjustment. Targeted subsidies naturally change the composition of enrollment: it decreases the share of high risk enrollees to 39% and increases the share of low risk types to 30%, as it is designed to do.

The case in which subsidies are set to maximize overall enrollment without requiring that no type is worse off than under uniform subsidies is reported in the fourth column of Table 3. In this case high risk types would receive a subsidy of \$480, medium risk types would receive a subsidy of \$720, and high risk types would receive \$1,200. While this policy would achieve slightly higher overall enrollment (56.0%), the high risk types would be worse off,

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<sup>8</sup>This change in coverage generosity is the reason why average cost and average premium paid are not strictly lower than under optimal risk adjustment in the first column of Table 3. The average level of risk among enrollees is lower, but they tend to purchase more generous coverage which implies a higher cost for the insurers. These changes in coverage levels were not present in the stylized setting that we considered earlier in the paper.

with their enrollment dropping by 4.4% compared to uniform subsidies (Figure 5).

The last column of Table 3 considers the situation in which subsidies are set as a function of income, while risk adjustment is set as a function of expected cost. This constrained policy represents only a small improvement compared to uniform subsidies (now low income enrollees are provided a more generous subsidy), while performing worse than any policy with targeted subsidies. Risk adjustment is barely adopted, with a small transfer of \$240 per enrollee-year to insurers for each high risk type purchasing coverage. This is consistent with our main takeaway: if subsidies can be set flexibly across types then risk adjustment is suboptimal, but it can be useful when (political) constraints limit heterogeneity in subsidies.

## 5 Conclusions

Our objective in the paper was to highlight that it makes sense to think jointly about subsidies and risk adjustment – two common market design instruments often employed by the same market sponsor – rather than to analyze each in isolation, as is typically done in both academic and health policy circles. Once we recognize that by shifting market demand and rotating market costs, respectively, subsidies and risk adjustment jointly interact to determine market equilibrium, the standard practice of thinking about subsidies as a way to achieve “affordability” and risk adjustment as a way to ameliorate adverse selection seems unsatisfactory.

We show theoretically that, at least under very stylized assumptions, subsidies can achieve greater enrollment for a given level of market sponsor spending. Using data and existing estimates from California’s ACA health insurance exchange in 2014, we estimate that, holding sponsor spending fixed at roughly the level of current federal subsidy expenditures in this market, subsidies can increase enrollment by about 6 percentage points (12 percent) compared to optimal risk adjustment. Further, this increase in enrollment is achieved while holding all types (weakly) better off compared to the risk adjustment equilibrium.

A natural question is why, despite these theoretical and empirical results, risk adjustment remains an increasingly popular market design instrument. One possible economic explanation is that risk adjustment serves other functions beyond its role in pricing that we

considered here. In particular, by decreasing the relative profitability to insurers of healthier compared to less healthy enrollees, risk adjustment may be important for reducing insurer cream-skimming efforts using non-price instruments, such as benefit design or marketing.<sup>9</sup> There are also potential political economy explanations. For example, while our theoretical and empirical analysis allows risk adjustment and subsidies to condition on the same type space, in practice offering greater subsidies to healthy consumers – as optimal subsidies often require – may conflict with naive intuition and may be politically difficult. Likewise, insurer profits may be higher under risk adjustment, creating a potential political force in favor of them. In this sense, our results can be thought of as providing a quantitative assessment of the costs of such potential constraints, in the context of California’s ACA health insurance exchange.

More broadly, our intent here is not to prescribe specific market design strategies for health insurance exchanges, but rather to highlight the important sense in which two market design tools are highly related, and to provide some quantitative assessment of the trade-off associated with greater reliance on risk adjustment relative to a richer and more flexible subsidy design.

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<sup>9</sup>Another potential economic rationale for risk adjustment is that it allows conditioning payments on ex post realized costs, whereas subsidies must be based on ex ante measures. However, ex-post risk adjustment seems suboptimal, as it increases gaming opportunities, and this may be why we rarely see it in mature markets.

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## Appendix A: Proofs

In what follows,  $q_j(p)$  denotes enrollment in insurer  $j$ 's plan when prices are  $p$ , and  $ac_j(p)$  the average cost of  $j$  when consumers face prices  $p$ . Additionally, we use  $R_j(p)$  to indicate the per-enrollee risk adjustment transfer to insurer  $j$  when consumers face prices  $p$ . Adverse selection is defined as  $\partial ac_j(p)/\partial p_j > 0$  for all  $j$ , so in the presence of adverse selection a regular risk adjustment implies  $\partial R_j(p)/\partial p_j > 0$ .

### A.1 Proof of Proposition 1

Let  $p^*$  be an equilibrium prices when the risk adjustment  $r(w)$  is adopted and  $s(w) = 0$  for all  $w$ . Because  $v_{i1} = v_{i2} = \dots = v_{iJ}$  for all  $i$ , equilibrium is symmetric and insurers set the same price  $p_1^* = p_2^* = \dots = p_J^* = \bar{p}$  and obtain the same risk risk adjustment transfer  $R_j(p^*) = \bar{R}$ . Moreover, because insurers are identical, Bertrand-Nash equilibrium prices are set such that all insurers break even (as in Einav, Finkelstein, and Cullen, 2010):

$$\bar{p} = ac_j(p^*) - \bar{R}. \quad (6)$$

Consider now the alternative policy in which there is no risk adjustment, while subsidies are

$$s(w) = \bar{s} = \bar{R}, \text{ for all } w. \quad (7)$$

The price  $\hat{p} = ac_j(p^*)$  is then the new equilibrium, since  $\hat{p} = \bar{p} + \bar{s}$ , and thus

$$\hat{p} = \bar{p} + \bar{s} = ac_j(p^*) - \bar{R} + \bar{s} = ac_j(\hat{p} - \bar{s}), \quad (8)$$

so insurers break even. At this equilibrium, enrollment is the same for all types since net-of-subsidy prices are the same as in the original equilibrium, and the sponsor spending is the same since the per-enrollee payment in equation (7) is defined as the average risk adjustment payment under the original policy.  $\square$

## A.2 Proof of Proposition 2

Consider first the Bertrand-Nash equilibrium with risk adjustment. Given the symmetric case we consider in the proposition, we focus on a symmetric equilibrium, such that  $p_j^* = p^*$  and  $R_j(p^*) = R^*$ . In such an equilibrium, the following first order condition is satisfied:

$$p_j^* = ac_j(p^*) - R_j(p^*) - \frac{q_j(p^*)}{\partial q_j(p^*)/\partial p_j} \left( 1 - \frac{\partial ac_j(p^*)}{\partial p_j} + \frac{\partial R_j(p^*)}{\partial p_j} \right). \quad (9)$$

Consider now a case with no risk adjustment and a uniform subsidy that is given by

$$s^* \equiv R_j(p^*) + \frac{q_j(p^*)}{\partial q_j(p^*)/\partial p_j} \frac{\partial R_j(p^*)}{\partial p_j}. \quad (10)$$

This level of subsidy is constructed so that it satisfies two key properties. First, it gives rise to a (symmetric) equilibrium in which each insurer  $j$  sets premium  $\hat{p}_j = p_j^* + s^*$ . To see this, note that with subsidy  $s^*$  and no risk adjustment, equilibrium must satisfy the following first order condition

$$\hat{p}_j = ac_j(\hat{p} - s^*) - \frac{q_j(\hat{p} - s^*)}{\partial q_j(\hat{p} - s)/\partial p_j} \left( 1 - \frac{\partial ac_j(\hat{p} - s^*)}{\partial p_j} \right). \quad (11)$$

Replacing  $p_j^* = \hat{p}_j - s^*$  implies

$$p_j^* + s^* = ac_j(p^*) - \frac{q_j(p^*)}{\partial q_j(p^*)/\partial p_j} \left( 1 - \frac{\partial ac_j(p^*)}{\partial p_j} \right), \quad (12)$$

and substituting for  $s^*$  its construction from equation (10) yields the original first order condition from equation (9).

The second property of this particular construction of  $s^*$  is that

$$s^* \equiv R_j(p^*) + \frac{q_j(p^*)}{\partial q_j(p^*)/\partial p_j} \frac{\partial R_j(p^*)}{\partial p_j} < R_j(p^*), \quad (13)$$

where the inequality follows from the fact that demand slopes down  $-\frac{q_j(p^*)}{\partial q_j(p^*)/\partial p_j} < 0$  – and regular risk adjustments under adverse selection imply that  $\frac{\partial R_j'(p^*)}{\partial p_j} > 0$ . This concludes the proof because it shows a subsidy design in which demand and insurance allocation remain

the same as under risk adjustments, but sponsor expenditure is lower.□

Figure 1: Intuition for Proposition 1

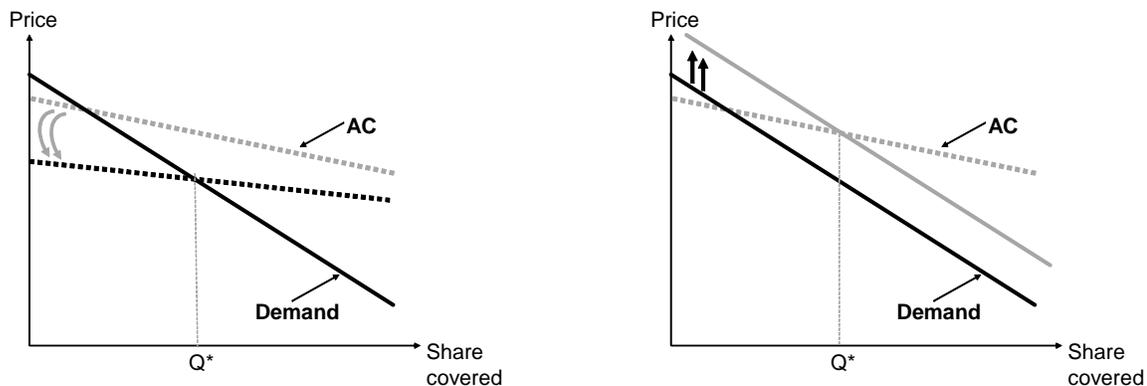


Figure provides intuition for the proof of Proposition 1. Figure plots demand and average cost curves, with competitive equilibrium given by the intersection of the two. In the left panel we illustrate the case of risk adjustment, which shifts and rotate the average cost curve. The right panel shows how a parallel shift in the demand curve, the result of a uniform subsidy, could achieve the same equilibrium allocation.

Figure 2: Summary of baseline estimates

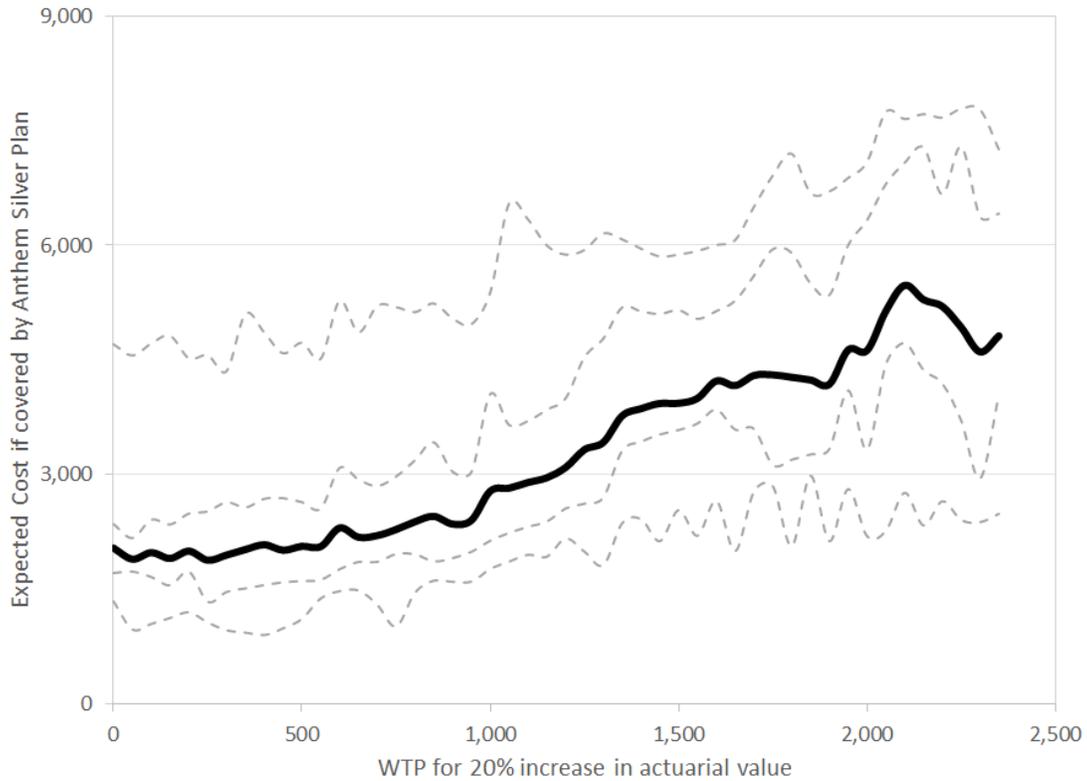


Figure uses the baseline estimates to plot the expected cost under Anthem silver plan (the largest plan) against the willingness to pay for a 20 percentage points increase in the actuarial value of the coverage. The solid black line present the average expected cost across all individual with a given willingness to pay, and the dashed gray lines present the 1st, 10th, 90th, and 99th percentiles in the distribution of individuals with a given willingness to pay. The upward sloping nature of the graph indicates the extent of adverse selection.

Figure 3(a): Total enrollment in the simplified setting

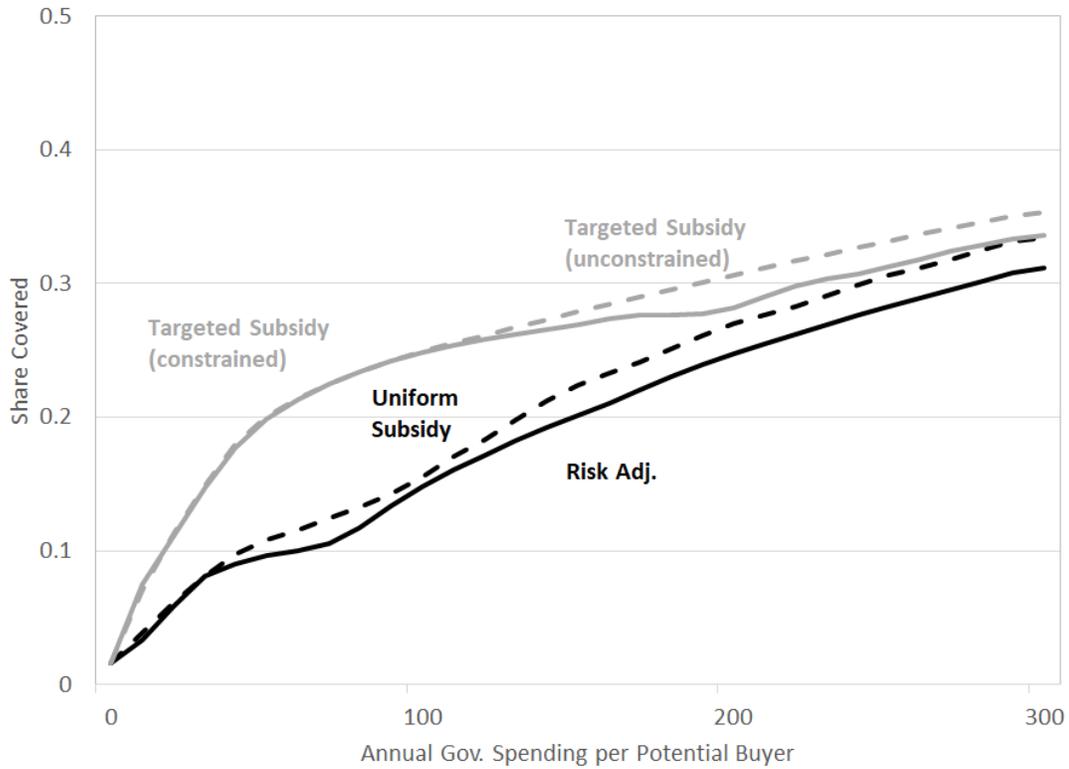


Figure shows the maximum enrollment (y-axis) achieved under different regimes for varying values of public spending (x-axis) in the simplified setting (see Section 4.2). Each line corresponds to a different policy regime: risk adjustment, flat subsidies, targeted subsidies in which we impose that no buyer faces a higher premium than under optimal flat subsidies, and targeted subsidies without this constraint. For each regime and each level of budget, we simulate premiums in Los Angeles for the case in which two identical firms offer one Silver plan and compete by setting premiums.

Figure 3(b): Subsidy levels in the simplified setting

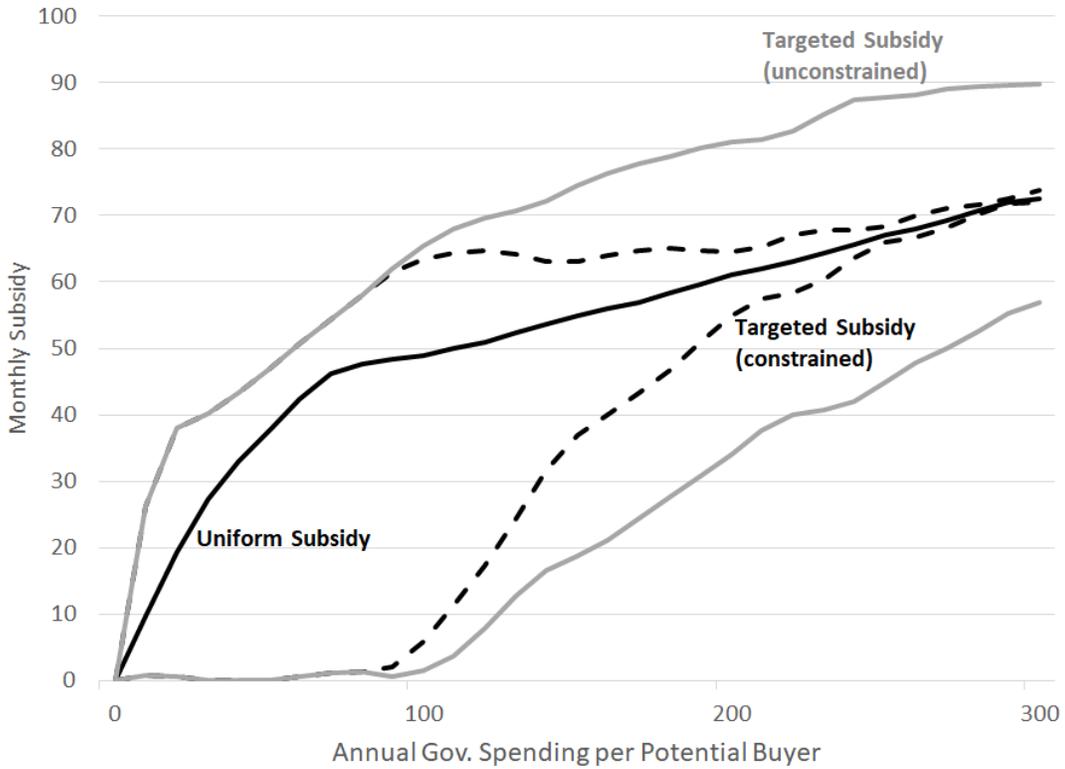


Figure corresponds to Figure 3(a), and shows the policy parameters for the subsidy regimes. The solid black line shows how the optimal flat subsidy varies across different levels of budget. The dashed black lines show the targeted subsidies when we impose the constraint that no type is worse off than under optimal flat subsidies. The top line is the subsidy to the low-risk types, the bottom line is the subsidy to the high-risk types. The solid gray lines show the targeted subsidies when we do not impose any constraint. The top line is the subsidy to the low-risk types, the bottom line is the subsidy to the high-risk type.

Figure 4(a): Equilibrium enrollment of high and low cost types in the simplified setting

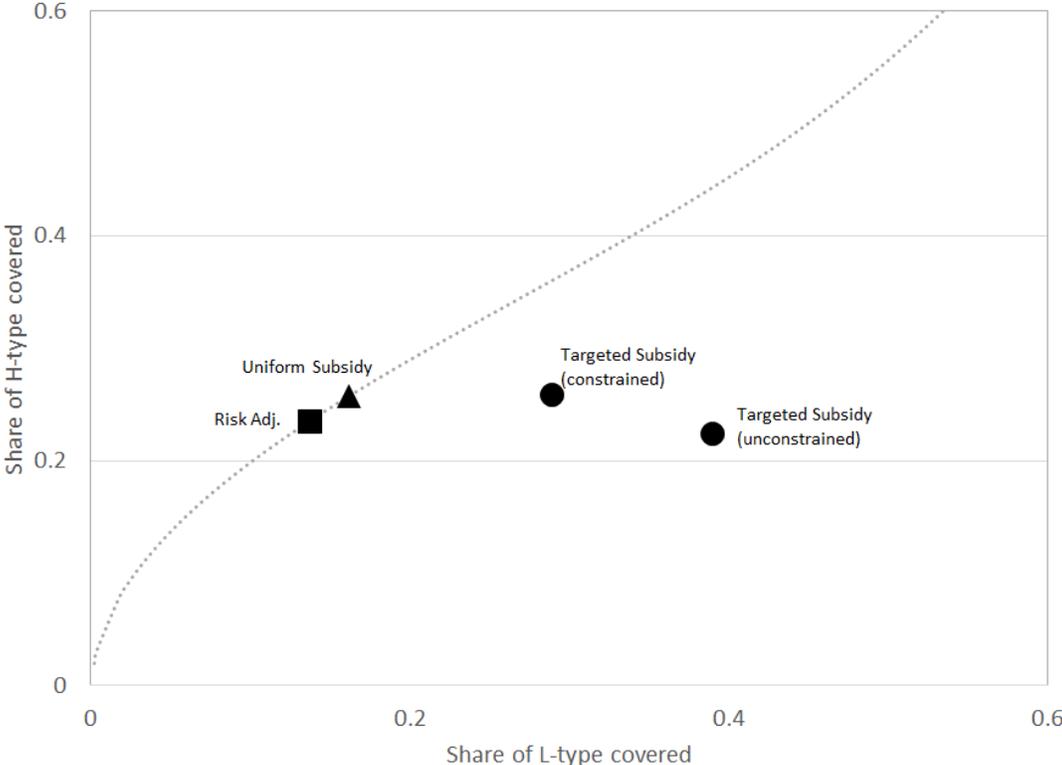


Figure shows equilibrium enrollment of low-risk types (x-axis) and high-risk types (y-axis) for the optimal policy regimes at a budget of \$150 per potential buyer (per year) for the simplified setting of a symmetric duopoly in the Los Angeles market. Each dot corresponds to the enrollment share of each type when insurers set premiums in equilibrium under optimal risk adjustment, uniform subsidies, non-uniform subsidies constrained to keep all types weakly better off, and unconstrained non-uniform subsidies.

Figure 4(b): Demand and cost curves in the simplified setting

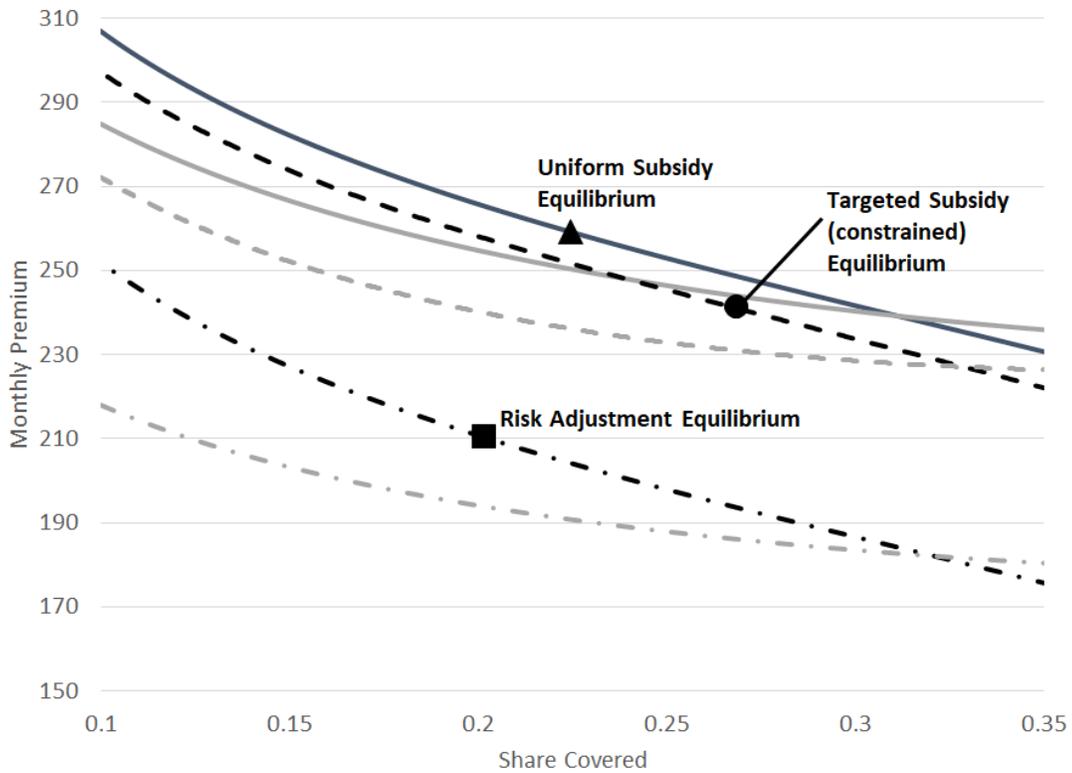
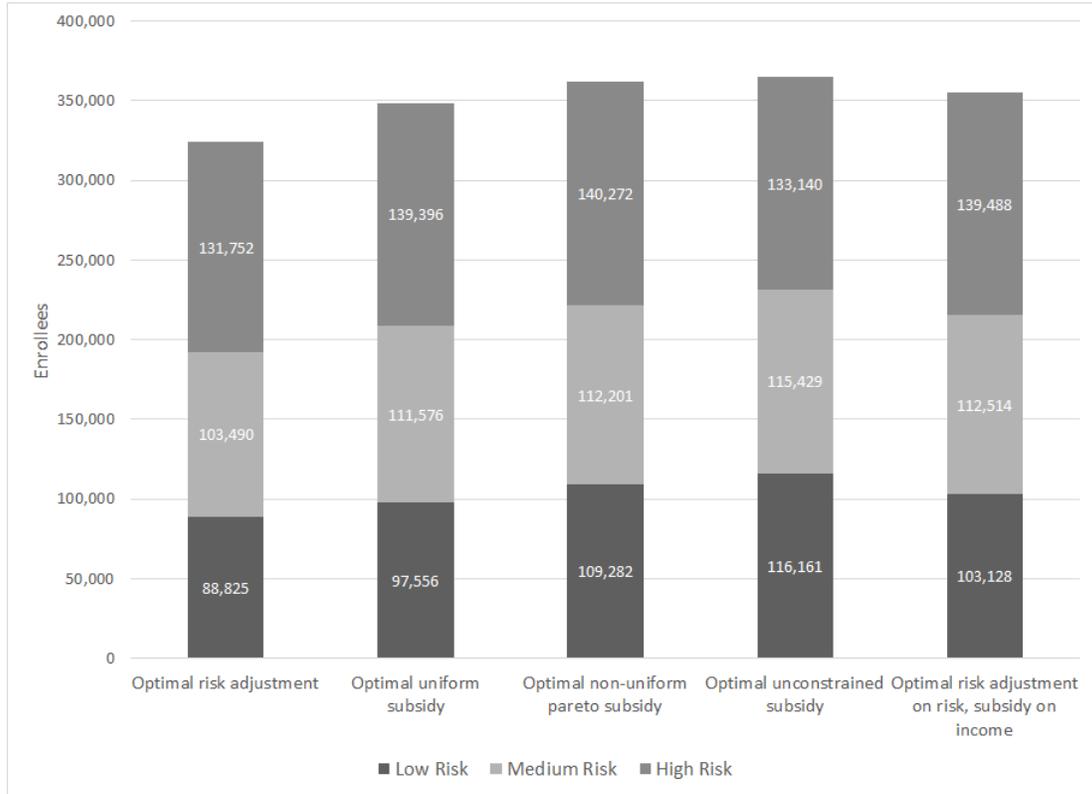


Figure shows demand and cost curves, and corresponding equilibrium outcomes, under different policy regimes for a budget of \$150 per potential buyer (per year). The dash-dotted black line is the demand curve when no subsidies are offered, while the dash-dotted gray line is the average cost curve under optimal risk adjustment. The black square is the equilibrium point resulting under optimal risk adjustment. The solid black line is the demand curve under optimal flat subsidies, while the solid gray line is the average cost curve when under optimal flat subsidies; this is equal to the primitive average cost. The black triangle is the equilibrium point resulting under optimal flat subsidies. The dashed black line is the demand curve under optimal targeted subsidies imposing that no types are worse off than under optimal flat subsidies. The dashed gray line is the corresponding average cost curve; this differs from the primitive average cost since targeted subsidies change the selection of types, increasing the participation of low-risk, low-cost types. The black circle is the resulting equilibrium point under optimal targeted subsidies.

Figure 5: Willingness-to-pay and cost across the six risk-income types



The figure shows the composition of enrollment across low, medium, and high-risk types for the five policy regimes we consider in the general case. We simulate equilibrium for each regime, in each rating region, for a budget of \$300 per potential buyer (per year). We consider all insurers offering coverage in Covered California, each offering a Bronze and a Silver plan. For each bar, the bottom (dark gray) section corresponds to the number of low-risk types purchasing coverage, the light gray section in the middle corresponds to the number of medium-risk types purchasing coverage, and the top shaded section corresponds to the number of high-risk types purchasing coverage.

Table 1: Summary statistics

	Observation	Mean
<b>A. Potential buyers</b>		
Age	3,392,942	41.34 (13.02)
Share subsidized (% FPL < 400)	3,392,942	0.66
Income as % of FPL (if subsidized)	2,231,013	231.65 (80.8)
Purchase coverage (households)	3,392,942	0.26
Purchase coverage (individuals)	6,122,167	0.21
<b>B. Actual buyers</b>		
Age	877,365	43.19 (12.98)
Share subsidized (% FPL < 400)	877,365	0.94
Income as % of FPL (if subsidized)	826,484	215.2 (63.2)
Bronze coverage	1,288,099	0.24
Silver coverage	1,288,099	0.64
Gold coverage	1,288,099	0.06
Platinum coverage	1,288,099	0.05

Table reports summary statistics for potential buyers and actual buyers in our data set; for continuous outcomes, standard deviations are reported in (parentheses). Panel A reports summary statistics for potential buyers using data from the 2013 ACS to describe the set of potential buyers in 2013. All estimates are reported at the household level except for when we report the share of individuals who purchase coverage. Panel B uses administrative data on enrollees in the California exchange in 2014. Demographics are reported at the household level (age is the average age of the household enrollees), while coverage is reported at the individual level (but shares are essentially identical at the household level).

Table 2: Plan pricing and enrollment

Tier	Observation	Mean	Std. Dev.	10th Pct	50th Pct	90th Pct
<b>Panel A. Bronze</b>						
Enrollees	82	3,764	3,575	434	2,692	8,726
Pre-subsidy premium	82	3,906	567	3,208	3,859	4,574
Post-subsidy premium	82	1,260	447	708	1,265	1,855
Average incurred claims	80	2,637	1,737	1,686	1,708	6,432
<b>Panel B. Silver</b>						
Enrollees	82	10,033	11,852	387	6,571	28,661
Pre-subsidy premium	82	5,303	860	4,181	5,307	6,500
Post-subsidy premium	82	1,522	585	873	1,421	2,325
Average incurred claims	80	3,497	1,284	2,562	2,948	6,432
<b>Panel C. Gold</b>						
Enrollees	82	940	1,148	61	618	2,503
Pre-subsidy premium	82	5,961	1,043	4,480	6,025	7,288
Post-subsidy premium	82	3,504	765	2,410	3,495	4,691
Average incurred claims	80	4,526	1,809	2,825	4,373	6,432
<b>Panel D. Platinum</b>						
Enrollees	82	822	916	33	573	1,829
Pre-subsidy premium	82	6,680	1,300	4,805	6,719	7,981
Post-subsidy premium	82	4,474	1,075	3,329	4,339	5,757
Average incurred claims	80	7,903	5,159	2,825	6,961	16,279

Table summarizes, for each coverage level, the number of enrollees, the per-person pre-subsidy premium received by the insurer, the per-person post-subsidy premium paid by buyers, and the per-person realized average cost. Each observation is an insurer-region pair, for a total of 82 plans. Two insurer-region observation are missing from the claims data: two small local insurers, Contra Costa and Valley, did not report claims for the 2014 coverage period.

Table 3: Equilibrium outcomes under alternative market regimes

	Risk adjustment	Uniform subsidy	Constrained targeted subsidy	Unconstrained targeted subsidy	Risk adj. on risk, subsidy on income
Total Enrollment	324,067	348,529	361,755	364,730	355,130
Shared Enrolled	0.497	0.535	0.555	0.560	0.545
Share purchasing low-deductible	0.612	0.657	0.632	0.648	0.634
Average pre-subsidy premium	1,914	2,649	2,648	2,607	2,515
Average pre-risk adjustment cost	2,107	2,202	2,180	2,158	2,114
Average risk-adjusted cost	1,232	2,202	2,180	2,158	2,020
Average annual markup	682	447	469	449	495
Total profits (million)	221	156	170	164	176
Consumer surplus (million)	448	487	528	532	530
Risk adjustment transfers (per month):					
Low Income, Low Cost	0	0	0	0	0
Low Income, Medium Cost	1,200	0	0	0	0
Low Income, High Cost	1,200	0	0	0	240
High Income, Low Cost	0	0	0	0	0
High Income, Medium Cost	960	0	0	0	0
High Income, High Cost	1,440	0	0	0	240
Subsidy amount (per month):					
Low Income, Low Cost	0	720	1,200	1,200	960
Low Income, Medium Cost	0	720	720	720	960
Low Income, High Cost	0	720	720	480	960
High Income, Low Cost	0	720	720	1,200	480
High Income, Medium Cost	0	720	720	720	480
High Income, High Cost	0	720	720	480	480

The table shows equilibrium outcomes and policy parameters under different market design regimes. The budget is equal to \$300 per potential enrollee-year (according to our estimates, this is approximately the average in Covered California). Each column correspond to a different regime. In the top panel, top rows correspond to total enrollment, percentage of potential enrollees purchasing coverage, and percentage change in total enrollment relative to optimal risk adjustment (first column). Other rows in the top panel show the percentage of enrollees purchasing a low-deductible (Silver) plan, annual pre-subsidy premium, annual average cost before risk adjustment, annual average cost after risk adjustment, average markup per-buyer per-year, total profits (\$million per-year), and total consumer surplus (\$million per-year). The bottom panel shows the annual risk adjustment and subsidies for each policy regime.

## Appendix Table A1: Coverage details

	Annual deductible	Annual max out-of-pocket	Primary visit	ER visit co-pay	Specialist visit co-pay	Preferred drugs co-pay	Advertised actuarial value <sup>a</sup>
<b>Panel A. Insurance coverage before cost-sharing reductions</b>							
Bronze	\$5,000	\$6,250	\$60	\$300	\$70	\$50	60%
Silver	\$2,250	\$6,250	\$45	\$250	\$65	\$50	70%
Gold	\$0	\$6,250	\$30	\$250	\$50	\$50	79%
Platinum	\$0	\$4,000	\$20	\$150	\$40	\$15	90%
<b>Panel B. Silver coverage after cost-sharing reductions</b>							
Silver, >250% FPL	\$2,250	\$6,250	\$45	\$250	\$65	\$50	70%
Silver, 200-250% FPL	\$1,850	\$5,200	\$40	\$250	\$50	\$35	74%
Silver, 150-200% FPL	\$550	\$2,250	\$15	\$75	\$20	\$15	88%
Silver, 100-150% FPL	\$0	\$2,250	\$3	\$25	\$5	\$5	95%

Table describes the features associated with the different levels of coverage in the Covered California marketplace.

<sup>a</sup> Advertised actuarial values are computed by each insurer using a representative sample of claims provided by Covered California.

## Appendix Table A2: Demand estimates

		Mean	10th Pct	25th Pct	Median	75th Pct	90th Pct
<b>Panel A. Annual premium (\$1,000s)</b>							
Subsidized	no children, under-50	-1.580	-2.871	-2.314	-1.510	-0.849	-0.289
	no children, over-50	-1.482	-2.370	-1.802	-1.399	-1.062	-0.760
	with children	-0.442	-1.064	-0.751	-0.341	-0.046	0.077
Unsubsidized		-1.553	-2.827	-2.218	-1.529	-0.797	-0.232
<b>Panel B. Actuarial value (%)</b>							
Subsidized	no children, under-50	0.078	0.011	0.036	0.082	0.118	0.141
	no children, over-50	0.113	0.051	0.073	0.115	0.147	0.169
	with children	0.046	0.005	0.014	0.036	0.071	0.103
Unsubsidized		0.079	0.021	0.044	0.084	0.115	0.130
<b>Panel C. Difference between Blue Cross Blue Shield and Anthem</b>							
Subsidized	no children, under-50	0.242	-1.127	-0.374	0.452	1.140	1.720
	no children, over-50	0.240	-1.375	-0.449	0.607	1.278	1.732
	with children	0.541	-0.765	-0.276	0.953	1.601	1.877
Unsubsidized		0.202	-0.680	-0.330	0.386	1.067	1.611
<b>Panel D. Difference between HealthNet and Anthem</b>							
Subsidized	no children, under-50	-0.349	-2.324	-1.250	0.049	0.416	0.665
	no children, over-50	-0.453	-1.680	-1.143	-0.157	0.133	0.291
	with children	0.106	-1.541	-0.233	0.373	0.735	1.083
Unsubsidized		-0.446	-2.096	-1.183	-0.156	0.223	0.731
<b>Panel E. Difference between Kaiser and Anthem</b>							
Subsidized	no children, under-50	-0.108	-1.727	-0.363	0.346	0.717	1.154
	no children, over-50	0.042	-1.854	0.058	0.544	0.987	1.370
	with children	-0.161	-1.847	-0.574	0.323	0.750	1.015
Unsubsidized		-0.023	-1.736	-0.140	0.340	0.744	1.103
<b>Panel F. Difference between other minor insurers and Anthem</b>							
Subsidized	no children, under-50	-1.370	-2.141	-1.973	-1.721	-1.096	-0.060
	no children, over-50	-1.708	-2.387	-2.294	-2.102	-1.185	-0.455
	with children	-1.365	-2.335	-2.026	-1.656	-1.219	0.691
Unsubsidized		-1.386	-2.217	-1.994	-1.742	-0.668	-0.051

Table shows summary statistics of random coefficients based on mixed logit estimates. For each parameter and demographic group, the table shows the average of the corresponding coefficient, as well as 10th, 25th, 50th, 75th, and 90th percentiles. Within each group, the parameters vary across regions, and across different combinations of age, income, and household size.

Appendix Table A3: Cost estimates

	Log-annual claims						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<b>Panel A. Product characteristics</b>							
Bronze	(Omitted)						
Silver	0.478*** (0.132)	0.399*** (0.144)	0.344** (0.140)	0.432** (0.170)	0.370*** (0.141)	0.306** (0.140)	0.411** (0.170)
Gold	0.648*** (0.078)	0.619*** (0.079)	0.597*** (0.077)	0.608*** (0.085)	0.604*** (0.080)	0.582*** (0.075)	0.598*** (0.083)
Platinum	1.219*** (0.098)	1.171*** (0.100)	1.158*** (0.097)	1.189*** (0.107)	1.130*** (0.104)	1.113*** (0.097)	1.153*** (0.106)
<b>Panel B. Buyer characteristics</b>							
Age	0.0188** (0.00846)	0.0187** (0.00838)	0.0206** (0.00830)	0.0221** (0.00911)	0.0187** (0.00803)	0.0198** (0.00817)	0.0217** (0.00889)
FPL	0.00277 (0.00251)	0.00243 (0.00253)	0.00207 (0.00236)	0.00321 (0.00297)	0.00275 (0.00245)	0.00227 (0.00234)	0.00351 (0.00298)
Household	0.087 (0.112)	0.057 (0.111)	0.144 (0.131)	0.199 (0.153)	0.057 (0.115)	0.138 (0.135)	0.185 (0.157)
Low WTP (<1700)		(Omitted)	(Omitted)	(Omitted)			
High WTP (>1700)		0.113 (0.078)	0.172** (0.077)	0.123 (0.089)			
WTP in [0,1100]					(Omitted)	(Omitted)	(Omitted)
WTP in (1100,1400]					0.078 (0.105)	0.096 (0.096)	0.094 (0.116)
WTP in (1400,1700]					0.133 (0.109)	0.124 (0.100)	0.099 (0.118)
WTP in (1700,2000]					0.260** (0.115)	0.291*** (0.109)	0.243* (0.132)
WTP > 2000					0.147 (0.126)	0.263** (0.121)	0.173 (0.137)
Region FE	Y	Y	Y	Y	Y		
Insurer FE	N	N	Y	N	Y		
Insurer-Region	N	N	N	Y	N	N	Y
Observations	338	338	338	338	338	338	338
R-squared	0.463	0.467	0.572	0.597	0.472	0.575	0.600

Table shows parameters of the cost model estimated from equation (4). Each observation is an insurer-region-tier triplet, where I exclude Catastrophic coverage since it is not available for subsidized enrollees. After this exclusion, claims data used for estimation cover over 90% of enrollment, with two missing carriers (Contra Costa and Valley). Buyer characteristics are computed as average across enrollees of the plan, where WTP is the posterior of the ratio  $\beta/\alpha$ , conditional on observed choice, based on mixed logit estimates. Robust standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1