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ABSTRACT

Health insurance is increasingly provided through managed competition, in which subsidies for consumers and risk adjustment for insurers are key market design instruments. We illustrate theoretically that, in markets with adverse selection, subsidies provide greater flexibility in tailoring premiums to heterogeneous buyers, and produce equilibria with lower markups and greater enrollment. We assess these effects quantitatively using estimates from the California ACA marketplace.

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1 Introduction

In countries around the world, social insurance – particularly pensions and healthcare – represents a large and growing fraction of public expenditures. Historically, social insurance took the form of direct public provision of insurance. Increasingly, however, social insurance involves public regulation of privately provided products. In the context of health insurance in the United States, examples include the approximately one-half (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 marketplaces created by the 2010 Affordable Care Act (ACA). The trend toward regulated competition in health insurance is not limited to the United States; for example, in the Netherlands, Switzerland, and Chile, significant components of their universal coverage are offered via insurance exchanges similar to those created by the ACA.

In all of these cases, the market sponsor – e.g., 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, two critical market design decisions remain: premium subsidies for consumers and risk adjustment for insurers. Subsidies are usually viewed as the instrument by which premiums are made affordable to consumers; they are, therefore, often linked to the income of potential buyers. By contrast, risk adjustment systems, which compensate participating insurers for enrolling higher-cost buyers, are typically viewed as a way to reduce concerns about adverse selection and insurer risk skimming.

Perhaps as a result, policy discussions and academic analyses predominantly 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 while holding subsidies fixed (e.g., McWilliams, Hsu, and Newhouse, 2012; Brown, Duggan, Kuziemko, and Woolston, 2014; Geruso and Layton, 2020), or on the effect of premium subsidies on enrollment by low-income individuals while holding risk adjustment fixed (e.g., Frean, Gruber, and Sommers, 2017; Finkelstein, Hendren, and Shepard, 2019; Tebaldi, Torgovitsky, and Yang, 2023; Tebaldi, 2025).

In this paper, we observe 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 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 how they substitute or complement each other.

We begin in Section 2 with a standard, stylized model of equilibrium pricing of insurance plans in the presence of adverse selection. In contrast to how 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 spending, 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 risk adjustment flattens the cost curve, it increases equilibrium markups, a point 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, targeted subsidies can reduce inefficiencies arising from adverse selection by targeting different (observable) buyers with different consumer (post-subsidy) premiums, thus incentivizing low-risk types to purchase insurance. We refer to this as the "targeting effect."

The theory provides qualitative results in a simplified setting. To explore the comparison between subsidies and risk adjustment quantitatively, as well as in richer settings, the rest of the paper uses the empirical model of Tebaldi (2025) and his estimates of demand and costs from the first four years (2014-2017) of the ACA health insurance marketplace in California. Insurers in the California marketplace offer four standardized coverage options. They must set a uniform premium for each, which is then automatically adjusted by a regulated age factor. During our study period, the California marketplace enrolled more than a million individuals per year. The vast majority of these enrollees received (age- and income-based) federal subsidies, with approximately 4 billion dollars in annual public expenditures. We consider counterfactual comparisons between risk adjustment and subsidies, while abstracting from many other ACA regulations. Our findings suggest that the qualitative, theoretical observations we point to may be associated with non-trivial quantitative, empirical consequences.

To illustrate the theoretical insights, we first use our estimates to consider hypothetical markets that match our stylized theory by considering symmetric insurers offering a single, uniform contract. Holding market sponsor spending fixed, we compare equilibria under different market design regimes: risk adjustment, uniform subsidies, and targeted (non-uniform) subsidies. The enrollment increase in moving from optimal risk adjustment to optimal uniform subsidies reflects the markup effect, while the enrollment increase in moving from optimal uniform to optimal targeted subsidies reflects the targeting effect. Under perfect competition, the markup effect is null, while the targeting effect increases enrollment. Under a monopolist, both the markup and targeting effect increase enrollment. Relative to uniform subsidies, however, targeted subsidies may create a social trade-off between maximizing enrollment and type-specific surplus, since they may increase subsidies for lower-risk individuals and reduce them for higher-risk individuals. We therefore also consider potential gains from constrained targeted subsidies that respect a "Pareto" restriction: relative to the uniform subsidy, the constrained targeted subsidies must make all consumers pay weakly lower premiums. Depending on the parameters, we are sometimes able to identify constrained targeted subsidies that can increase enrollment relative to uniform subsidies while keeping all consumers at least as well off as under uniform subsidies.

We then consider the more general (and more realistic) case of multi-plan differentiated insurers, where our theoretical findings from a more stylized environment may no longer apply. Empirically, we find that the ability of subsidies to produce higher enrollment than risk adjustment for a given level of market sponsor spending remains in this richer environment, operating both through reducing markups and by encouraging lower-risk consumers to enter the market. Yet, for moderate to high levels of sponsor spending, we are unable to find constrained targeted subsidies that can increase enrollment over uniform subsidies while keeping all consumers at least as well off. Moreover, subsidies may no longer increase consumer surplus relative to risk adjustment: while overall enrollment rises under subsidies, consumers are more likely to select plans with less insurance coverage and thus lower welfare.

Finally, in this richer setting we relax our maintained assumption that risk adjustment and subsidies use the same set of observables and that these observables perfectly capture consumer risk. First, we consider more realistic risk scores, which imperfectly predict cost. With a weaker correction to adverse selection, and therefore lower markups, risk adjustment achieves higher enrollment. In addition, we also consider the common situation in which subsidies vary only with income, and are lower for higher-income individuals.

The power of subsidies to achieve welfare gains in our setting is intricately linked to the restriction that insurers cannot price discriminate besides the mandatory age adjustments (so-called "adjusted community rating"). We view some form of 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 highlights an additional advantage of community rating: it prevents profit-maximizing insurers from undoing the benefits of subsidies via price discrimination. It thus provides the market sponsor with a powerful instrument for increasing insurance enrollment for a given amount of spending.

Importantly, our analysis considers only the pricing distortions created by adverse selection, and not its potential to distort the set of insurance contracts offered. Our analysis is thus in the spirit of Akerlof (1970) and Einav, Finkelstein, and Cullen (2010) which assume that contracts are exogenously fixed, rather than allowing for adverse selection to distort non-price aspects of the contract space as in Rothschild and Stiglitz (1976), Veiga and Weyl (2016), or Azevedo and Gottlieb (2017). In the canonical theory, this non-price contract distortion typically takes the form of a reduction in the amount of insurance coverage, and there is empirical evidence consistent with this type of distortion (e.g., Carey, 2017). In addition, in practice a number of other non-price supply-side distortions may occur, including offering of certain benefits such as gym memberships designed to attract healthier customers

(Cooper and Trivedi, 2012), limiting the providers in a network (e.g., Shepard, 2022; Kreider et al., 2024), or targeted advertising. Our analysis abstracts from these potential non-price distortions and thus from the potential for risk adjustment to mitigate them, as has been emphasized in prior work (e.g., Glazer and McGuire, 2000). In this sense, our conclusion regarding the "superiority" of subsidies thus abstracts from an important potential benefit associated with risk adjustment.

Our paper is closely related to a large number of papers studying health insurance subsidy design (e.g., Chan and Gruber, 2010; Decarolis, 2015; Finkelstein, Hendren, and Shepard, 2019; Jaffe and Shepard, 2020; Decarolis, Polyakova, and Ryan, 2020; Tebaldi, 2025), risk adjustment (e.g., Glazer and McGuire, 2000; Wynand, De Ven, and Ellis, 2000; Ellis, 2008; McWilliams, Hsu, and Newhouse, 2012; Brown, Duggan, Kuziemko, and Woolston, 2014; Layton, McGuire, and Sinaiko, 2016; Einav, Finkelstein, Kluender, and Schrimpf, 2016; Geruso and Layton, 2020; Saltzman, 2021), the ACA marketplaces (e.g., Abraham, Drake, Sacks, and Simon, 2017; Frean, Gruber, and Sommers, 2017; Saltzman, 2019; Panhans, 2019; Tebaldi, Torgovitsky, and Yang, 2023; Dickstein, Ho, and Mark, 2024), and the design of health insurance exchanges more generally (e.g., Handel, Hendel, and Whinston, 2015; Azevedo and Gottlieb, 2017; Curto, Einav, Levin, and Bhattacharya, 2021; Marone and Sabety, 2022; Vatter, forthcoming). As noted earlier, in all of these papers, subsidies and risk adjustments are treated in isolation, and none of these papers engages in the relationship and tradeoffs between subsidies and risk adjustment that is our focus here.

2 A stylized theoretical framework

2.1 Setting and notation

We consider a stylized setting. There is a single, exogenous insurance coverage contract, offered by J competing insurers, each indexed by j; we will relax this assumption in the empirical application. 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 (e.g., due 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). $v_i = (v_{i1}, ..., v_{iJ})$ 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 for now to be the same across insurers; we will relax this assumption in the empirical application. Finally, w_i denotes a vector of observable characteristics, such as age, income, or risk score, which can be used as input to the subsidy or risk adjustment design. We refer to w_i as consumer i's type.

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. Here, however, we restrict our analysis to a generic case of adverse selection. In particular, we denote by $AC_j(p)$ the average cost of individuals covered by contract j, and assume that $\partial AC_j(p)/\partial p_j > 0$ for all j and all premium vectors $p = (p_1, ..., p_J)$. As a result, for every j, marginal buyers are cheaper to cover than inframarginal buyers.

A subsidy design is defined by 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 by 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 $p_j - (c_i - r(w_i))$. Although the ACA implemented zero-sum transfers between insurers, we do not require here that risk adjustments be budget neutral; as a result, in principle, risk adjustment payments can result in greater overall expenditure by the market sponsor, as is the case, for instance, in Medicare Advantage and in Medicare Part D.

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.[1] By "regular" we mean that the risk adjustment reduces adverse selection by compensating insurers more generously for covering more risky buyers, or more precisely that $r(w_i) > r(w_k)$ if and only if $\mathbb{E}[c_i|w_i] > \mathbb{E}[c_k|w_k]$. The restriction to regular risk adjustment implies that homogeneous shifts in prices can be achieved only through uniform subsidies, since regular risk adjustment cannot shift average cost without a simultaneous rotation.

2.2 Perfect competition

We begin by analyzing the case of perfect competition, which arises in our setting when insurers are homogeneous ($v_{i1} = v_{i2} = \ldots = v_{iJ}$, 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.

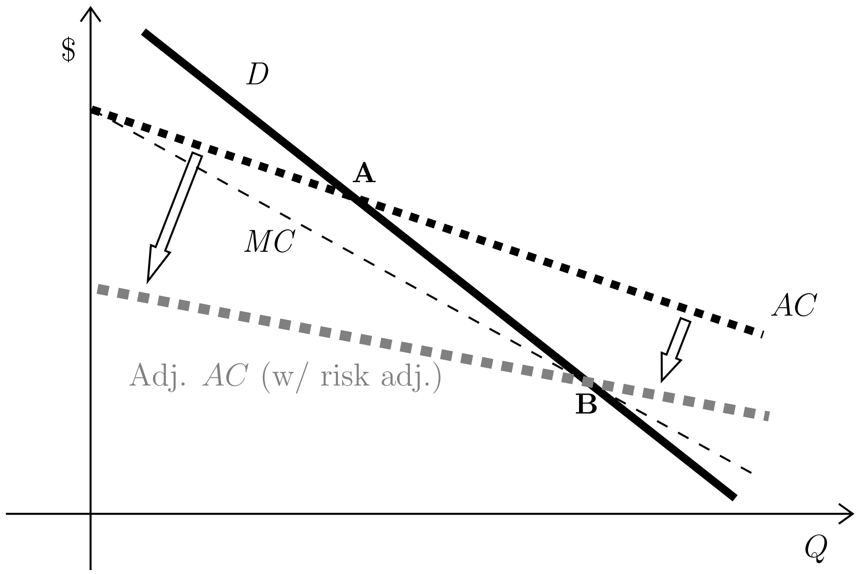
PROPOSITION 1 *Under perfect competition, for any Nash equilibrium that is achievable with risk adjustment, there exists a subsidy design with no risk adjustment that can achieve the same equilibrium, with the same enrollment for all types and the same total spending by the market sponsor.*

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 quantity (or share) of the population who buy insurance at a given price. The marginal cost curve (MC) shows the expected cost for buyers with $v_i = p$, and the average cost curve (AC) shows the expected cost among all consumers who buy insurance at that price. Both curves are downward sloping, indicating the presence of adverse selection: as the price is lowered, the marginal buyer is cheaper to cover than the average existing buyer. Under perfect competition, the equilibrium is given by the intersection of the demand and average cost curve (point A in the top panel of Figure 1).

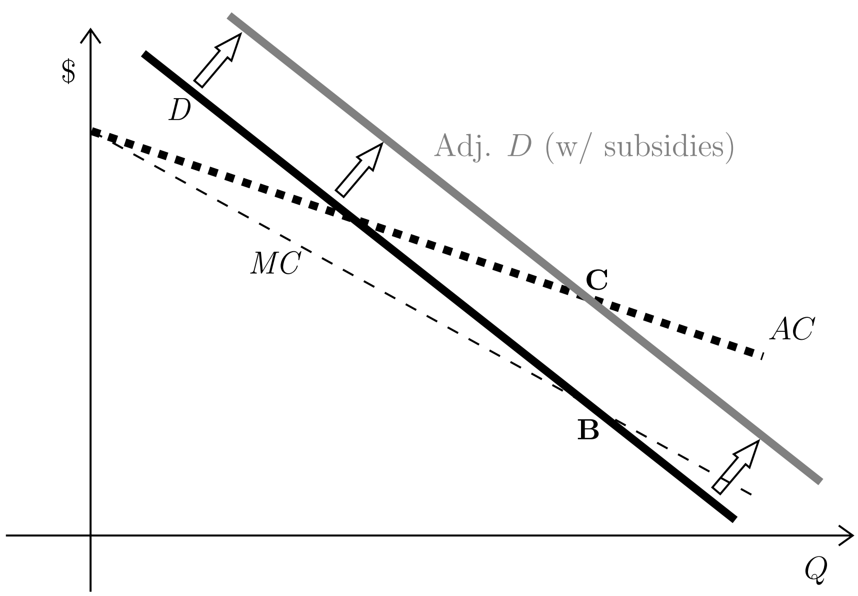
[1] In many new markets, it is not uncommon to see such ex-post adjustments that are based on realized costs. As markets mature, however, data availability allows for more accurate risk prediction and a more robust implementation of an ex-ante risk adjustment system.

Figure 1: Illustration of Proposition 1

(a) Risk adjustment



(b) Subsidies



Notes: *Graphical illustration of Proposition 1. The top panel shows how risk adjustment can move equilibrium from A to the efficient outcome B. The bottom panel shows how subsidies can achieve equilibrium C, where enrollment is identical to B.*

The top panel of Figure 1 illustrates the impact of risk adjustment. Risk adjustment rotates (flattens) and shifts the average cost curve, leading to a new market equilibrium (point B) with greater insurance coverage and lower insurer prices. In the figure, risk adjustment achieves the efficient outcome, that is the point (point B) at which demand intersects the marginal cost curve.

Proposition 1 implies that this market equilibrium can alternatively be achieved with the same level of market sponsor spending by reverting back to the original average cost curve, and instead using a (uniform) subsidy to accomplish an appropriate parallel shift of the demand curve; this is illustrated in the bottom panel of Figure 1. In the new equilibrium (point C), enrollment is identical to the efficient outcome at point B that was achieved under risk adjustment (top panel), while profits are zero, so market sponsor spending must also be the same.

While the proposition states 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, 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 potential customers face the same consumer 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, targeted (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 could involve some insured individuals having lower willingness to pay than some individuals without insurance. Therefore, targeted subsidies provide additional flexibility to the market sponsor and are able to achieve a greater set of equilibrium allocations than risk adjustment or uniform subsidies. This additional flexibility can be leveraged to improve outcomes in the spirit of Bundorf, Levin, and Mahoney (2012).

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:

PROPOSITION **2** *Under imperfect competition and adverse selection, for any symmetric Nash equilibrium that is achievable with regular risk adjustment and no subsidies, and 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 and it is constructive, showing how to calculate the subsidy that leads to a "better" equilibrium for the market sponsor, relative to any risk adjustment. The intuition is similar to the one in Starc (2014) and Mahoney and Weyl (2017), and can be illustrated by examining the following insurer's first-order condition that must hold in equilibrium:

$$p_j = AC_j(p_j, p_{-j}) - \frac{q_j(p_j, p_{-j})}{\partial q_j(p_j, p_{-j})/\partial p_j} \left(1 - \partial AC_j(p_j, p_{-j})/\partial p_j\right), \tag{1}$$

where $q_j(\cdot)$ and $AC_j(\cdot)$ are the residual demand and residual average cost curves faced by the insurer offering plan j. The key object in the first-order condition is $\partial AC_j(\cdot)/\partial p_j$, the derivative of the $AC_j(\cdot)$ curve with respect to the insurer's own price. With adverse selection ($\partial AC_j(\cdot)/\partial p_j > 0$), the marginal buyer is cheaper than the average buyer and is therefore relatively attractive to cover, exerting downward pressure on prices and markups. In other words, insurers are more resistant to increasing premiums because the marginal buyers they would lose as a result are relatively cheaper and therefore more attractive to retain.

Regular risk adjustments reduce the difference in costs between the marginal buyer and the average buyer (because the insurers are compensated more generously for covering higher-risk individuals), so $\partial AC_j(\cdot)/\partial p_j$ is lower, thus reducing the pressure on prices and leading to greater markups. Uniform subsidies avoid this by not altering the slope of the residual average cost curves. In the perfect competition case the cost reductions implied by risk adjustment are fully passed through to consumers. But 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 (strictly) lower markups and lower spending by the market sponsor. A simple corollary is that some of this lower spending could be used to increase the subsidy and thereby lead to higher overall enrollment. In addition, the earlier observation about targeted subsidies described in the context of perfect competition remains: risk adjustments (and/or uniform subsidies) imply monotone (in willingness to pay) insurance allocations. Targeted subsidies can relax this, and provide a market-design instrument that could differentially attract the participation of low-cost and/or high-elasticity individuals. Under imperfect competition and adverse selection, both forces put additional downward pressure on prices, and targeted subsidies can lead to equilibria with lower public spending and lower prices for all buyers.[2]

2.4 Summary

Taken together, these results imply that, for any given level of spending by the market sponsor, subsidies can produce higher coverage than risk adjustment. We call the enrollment difference between risk adjustment and uniform subsidies a "markup 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 targeted 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 lower-risk types to enter the insurance pool.

The rest of the paper provides a quantitative assessment of these qualitative results, using data and estimates from the ACA's health insurance marketplace in California. We first consider an empirical environment in which all the assumptions of our theoretical discussion hold; this allows us to quantify the results of Propositions 1 and 2. We then explore quan-

[2]See Veiga (2023) and Tebaldi (2025) for a theoretical and empirical application to targeting subsidies on age. We will provide additional applications in our empirical work below.

titative analyses that relax several of the simplifying assumptions of our stylized theoretical setting, including allowing for insurers to offer more than one plan, with vertically (as well as horizontally) differentiated products.

3 Empirical setting

The setting, data, empirical specification, and resulting estimates are all taken directly from Tebaldi (2025). We summarize the key features here.

3.1 Setting and data

Setting. Our setting is the first four years (2014-2017) of the California health insurance marketplace ("Covered California"), which was initiated by the Affordable Care Act (ACA). The California marketplace was one of the largest among the fifty states, with more than one million enrolled individuals per year during our sample period.

Covered California partitioned the state into 19 geographic rating regions, each constituting a separate market. Every year, insurers decided whether to participate in the market on a region-by-region basis. We therefore define a market by a region-year combination, and our data covers 76 markets (19 regions over 4 years). There were 3 to 7 insurers participating in each market in our data.

California regulators substantially restricted the scope of insurers' coverage design. This makes Covered California a useful context in which we can assess the interaction between risk adjustment and subsidies without having to consider other market design elements such as plan features. The regulators required that, within each market, participating insurers offer all four standardized coverage options. These 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).[3] For silver plans (and only for silver plans), subsidized buyers also received cost-sharing reductions

[3]There was a fifth coverage level, "catastrophic coverage," which offers lower coverage than bronze. It was a high-deductible plan that was only available to individuals who are younger than 35 and who were not eligible for premium subsidies. Since we will limit our empirical analysis to subsidy-eligible individuals, these plans are not relevant for our analysis, and we abstract from them throughout.

(funded by the government) in addition to premium subsidies. For low-income individuals, these additional subsidies often made silver coverage dominate the corresponding gold coverage, and sometimes even the corresponding platinum coverage.

Despite the standardization of cost-sharing within metal tiers, insurers still differed along two important dimensions. They set different premiums as explained in more detail below, and they offered different networks of medical providers, along with different restrictions on going out of network. These network differences are an important source of heterogeneity across plans that our empirical model will account for.

Premiums were set at the plan level.[4] Premium setting was subject to regulation, constraining each plan j in a given market to set a single (base) price b_j. This base price was then mapped to the consumer premium p_{ij}, of which $s_{ij} = \min\{s_i, p_{ij}\}$ was paid by the government and $p_{ij} - s_{ij}$ was paid by the individual. These mappings were based on known, pre-specified (by the ACA) formulas, which depended on the individual's age and household income. Specifically, premiums were the product of the base price and an age factor $p_{ij} = f(age_i)b_j$,[5] and s_i was given by $s_i = \max\{0, p_i^* - \overline{p}_i\}$, where p_i^* was equal to the price (p_{ij}) of the second-cheapest silver plan in the market, and $\overline{p}_i = g(income_i)$ was an increasing function of the individual's household income.

Data. The data include individual-level enrollment data obtained directly from Covered California and plan-level data on claims from the Center for Medicare and Medicaid Services (CMS). The analysis is limited to adults aged 26-64 who are eligible for premium subsidies. This group accounted for 78% of all enrollment in Covered California during our 2014-2017 sample period, for a total of 3.4 million person-years.

For each enrollee the data contain age, household income (measured as a percentage of the Federal Poverty Level), geographic location, the amount paid by the consumer ($p_{ij} - s_{ij}$), and the plan that was selected. These data are combined with information on premiums

[4] There were some cases in which a single insurer offered both HMO and PPO plans in a given metal tier, for a given region and enrollment year. In such cases the insurer would be associated with more than four plans in the (region-year) market.

[5] $f(age)$ is a monotone function that is increasing from 1 (for 21 years old individuals) to 3 (for 64 years old individuals).

(p_{ij}), financial characteristics, and geographic availability for all the plans offered in each market. For most plans, CMS provides the average (ex-post) realized amount of medical claims. Finally, the American Community Survey (ACS) is used to construct a measure of potential buyers across different demographics in each market and the Medical Expenditure Panel Survey (MEPS) is used to calibrate the level of expected medical costs and how they vary by age among insured individuals. Following industry practices, an individual is defined as a potential buyer in a given year (in a given region) if they are either uninsured or purchased insurance in the exchanges or in the individual (non-group) market in the prior year.

Among the more than 12 million potential buyers identified in the ACS, about one third select a plan in Covered California during our study period. On average, these buyers pay almost $1,500 per year in post-subsidy premiums and receive an average premium subsidy of about $3,900. After accounting for cost-sharing reductions, the selected plans cover 78% of annual medical spending on average. Most enrollees select either a bronze (24%) or silver (68%) plan. Half of the enrollees select an HMO plan. Except for platinum plans, plan revenues are (on average) substantially above average claims. This is driven by the subsidies; enrollees' payments are (on average) substantially below cost. Consistent with adverse selection, higher-coverage plans are associated with greater total (covered and uncovered) costs.

The average plan in the data enrolls 2,300 individuals. The four largest insurers – Anthem, Blue Shield, HealthNet, and Kaiser – offer the vast majority of the plans observed in the data (889 out of 1,104) and cover 89% of enrollees. This relative dominance mostly reflects regional entry decisions; when present in a market, smaller insurers play an important role, and have an average enrollment of 1,360 individuals in each plan they offer.

3.2 Econometric specification

For each individual i in a given market (rating region and year), we collect their age, household income, and year in the vector $z_i = (age_i, income_i, year_i)$. For each plan j offered in a given market, we observe its base price b_j, its actuarial value AV_j, and a vector of observable characteristics x_j, which consists of insurer indicators (that capture brand reputation and provider network) and an HMO indicator variable (that captures the restriction on using out-of-network providers and, as mentioned earlier, can vary within an insurer-metal tier). For each individual-plan combination, the above observables are then mapped into the implied consumer premium p_{ij}, implied subsidy s_{ij}, and implied actuarial value AV_{ij}.[6]

Following the theoretical framework, the key primitives that govern demand and cost are each individual's willingness to pay for each plan offered in their market, v_{ij}, and the expected cost to the insurer associated with covering each potential buyer, c_{ij}. We specify each in turn.

Willingness to pay is given by:

$$v_{ij} = \alpha_{z_i}^{-1} \left(\mu_{z_i} + \beta_i AV_{ij} + \gamma_{z_i} x_j + \xi_{z_i j} + \epsilon_{ij} \right), \tag{2}$$

where the term $\xi_{z_i j}$ is an individual-plan characteristic that is known to the insurer, affects individual choice, but is not observed in our data, μ_{z_i} is a constant term varying with age, income, and year, and ϵ_{ij} is a (standard) iid Type 1 Extreme Value idiosyncratic error term which generates a mixed logit demand specification. In this specification, unobserved heterogeneity across individuals is captured by β_i, the coefficient on the actuarial value of the plan, which is assumed to be lognormally distributed. All other demand parameters vary only with observables.[7] In practice, the distribution of the ratio β_i/α_{z_i} will capture much of the heterogeneity across individuals in willingness to pay for insurance.

Insurer j's expected cost of covering individual i is given by:

$$c_{ij} = AV_j \exp\left(\rho_i + \phi x_j\right). \tag{3}$$

Expected cost is thus the expected *total* cost of the individual $\exp(\rho_i + \phi x_j)$, multiplied by

[6] More specifically, as described in Section 3.1, the base price is mapped into the premium based on the individual's age, the subsidy is derived as a function of the individual's income and the second-cheapest silver plan premium in their market, and the actuarial value varies with individual's income for silver plans (only for silver plans) due to cost-sharing reductions.

[7] Appendix A of Tebaldi (2025) provides the specific functional forms by which the observables are mapped into each of the other demand parameters.

the portion of it, AV_j, that is covered by the plan.[8] Expected total cost in turn is specified as the product of an individual component, $\exp(\rho_i)$, and a plan component that does not vary across individuals. Because $\exp(\rho_i)$ is the only component in c_{ij} that varies across individuals, it will be the key object for risk adjustment in what follows. We construct what we will refer to as a "perfect" risk score by normalizing $\exp(\rho_i)$:

$$w_i = \frac{\exp(\rho_i)}{\mathbb{E}\exp(\rho_i)}, \tag{4}$$

where the expectation is taken over the entire population of potential buyers in the market.

Finally, we specify:

$$\rho_i = \eta^o age_i + \eta^u(\beta_i/\alpha_{z_i}). \tag{5}$$

As mentioned, the ratio β_i/α_{z_i} will capture much of the heterogeneity across individuals in willingness to pay for insurance, so the parameter η^u governs the extent of adverse selection. A positive η^u implies that individuals who tend to have higher willingness to pay for insurance are also those who are more costly to insure.

Estimation and Identification. Demand parameters are estimated using simulated maximum likelihood (where simulations are needed to integrate over the unobserved heterogeneity in β_i), adopting a control function approach to address endogeneity due to correlation between premiums, p_{ij}, and unobserved plan characteristics, $\xi_{z_i,j}$. The parameter η^o, which governs the level of total expected medical cost and how it varies by age among insured individuals, is calibrated directly from data from the MEPS. The remaining cost parameters (η^u and ϕ) are obtained via simulated method of moments, minimizing the sum of squared differences between observed and model-predicted average claims.

Identification of the demand parameters in equation (2) relies on two sources of variation. First, cost-sharing reductions for enrollees in the silver plans generate sharp discontinuities

[8] Note that this is AV_j rather than AV_{ij} because the cost-sharing subsidies, which are the source of variation in actuarial value across individuals within a plan, are paid by the government and not by the insurer.

in AV_{ij} at three income cutoffs (150%, 200%, and 250% of the Federal Poverty Level). Since other characteristics are smooth and continuous in income, differences in choice shares around the cutoffs inform our estimates of willingness to pay for insurance generosity.[9] Second, because a single pricing decision deterministically affects the premiums paid by individuals of different ages, insurers are more likely to set a higher base price, b_j, in markets with a relatively older population. Since we control for age directly when estimating demand through the μ_{z_i} term, this regulation generates a useful "Waldfogel-style" instrumental variable (Waldfogel, 2003): conditional on her age, individual i is more likely to face higher premiums in markets with a higher share of older potential buyers, thus generating identifying variation in prices, which is (arguably) orthogonal to the unobserved individual-plan characteristics in the demand equation, $\xi_{z_i,j}$.

Turning to the cost parameters in equations (3) and (5), plan effects (ϕ) are identified by the correlation between average claims and plan characteristics. The parameter η^u which, as discussed, governs adverse selection is identified by the correlation between residual variation in average claims and the composition of enrollment in terms of β_i/α_{z_i}, identified along with demand.

3.3 Estimates of model primitives

The model and its estimates deliver the primitives highlighted in the theoretical framework, namely for each potential buyer, the joint distribution of (v_i, c_i, w_i) defined in Section 2: individual i's willingness to pay for each plan j offered in the market, $v_i = (v_{i1}, ..., v_{iJ})$, the cost to the insurer from covering individual i by each plan j, $c_i = (c_{i1}, ..., c_{iJ})$, and individual i's risk score, w_i.[10] These are the primitives that we will use in the next sections to generate the counterfactual exercises motivated by the theory laid out in Section 2. Here we provide a short summary that highlights some of the key moments of their joint distribution.

Table 1 summarizes the marginal distributions of v_i, c_i, and w_i. The first row considers

[9] This research design is similar in spirit to Lavetti, DeLeire, and Ziebarth (2023) who use the income-based discontinuities in cost sharing reductions in silver plans to study the impact of cost-sharing on total medical spending.

[10] For now, we consider the "perfect" risk score defined in equation (4). Later in the paper, we will consider alternative, imperfect risk scores.

Table 1: Summary of Model Estimates

	Mean	Std. Dev.	p10	Median	p90
WTP for 10 pp increase in AV (β/α) ($US)	427	376	108	320	867
Prob. of enrollment if all $p = \$1,000$	0.470	0.349	0.055	0.392	0.989
Drop in enrollment if $p = \$1,000 \rightarrow \$1,120$	0.084	0.058	0.002	0.089	0.160
Expected cost for insurer c_{ij} ($US)	2,882	3,180	908	2,013	5,591
Risk score w_i	1.00	0.99	0.37	0.73	1.83

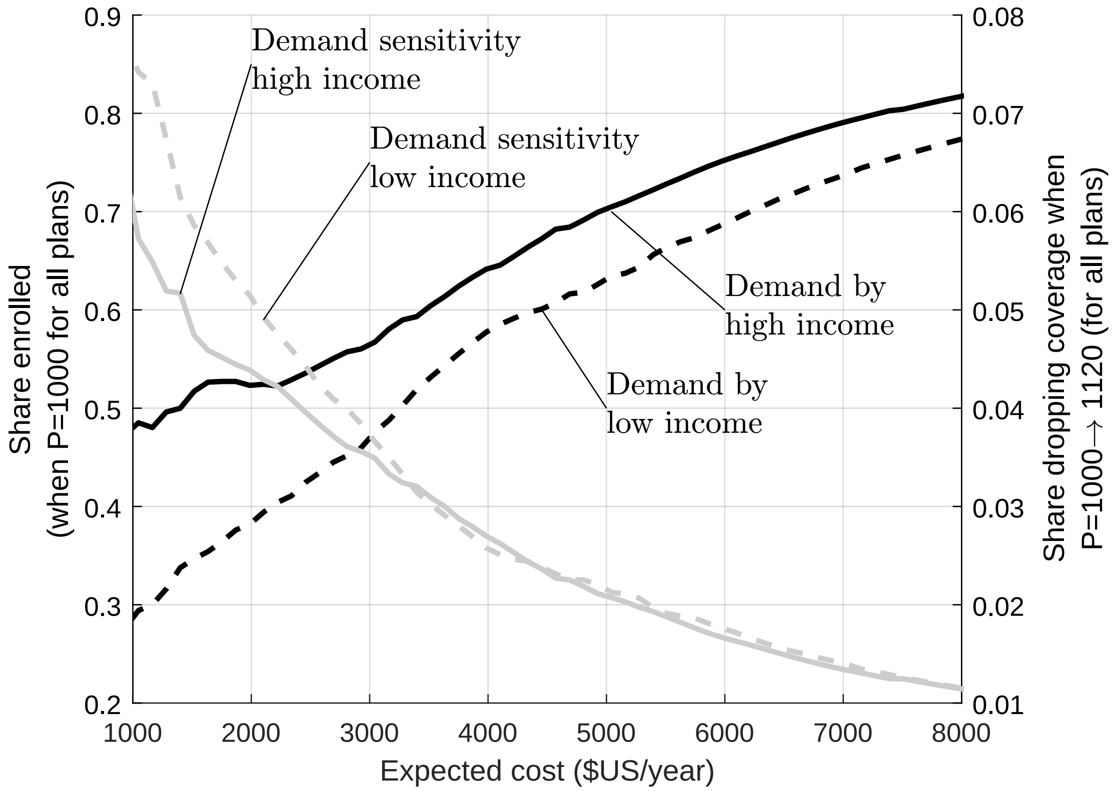
Notes: *The table presents summary statistics of key model estimates across the individuals in our sample. The first three rows show the distribution of key demand estimates; specifically, they show willingness to pay for a 10 percentage points increase in the actuarial value of the coverage, AV (this is driven by the estimate of the ratio β_i/α_{z_i}), the probability of enrolling if all plans' annual consumer premiums were $1,000, and the percentage drop in this probability if annual consumer premiums increased from $1,000 to $1,120. The fourth row summarizes expected cost for the insurer across individuals given their chosen plans (c_{ij}), and the last row shows the risk score (w_i) as defined in equation (4).*

the willingness to pay for actuarial value (AV), as measured by the ratio β_i/α_{z_i}. The average actuarial value in our sample is about 80%. We find that individuals are, on average, willing to pay an additional $427 per year to increase actuarial value by 10 percentage points. This willingness to pay is highly heterogeneous; it is less than $108 for 10% of the population, but higher than $867 for another 10%. The next two rows show that this heterogeneity in willingness to pay for coverage translates into substantial heterogeneity in the probability of enrolling in the marketplace. It shows that if all plans' (annual) consumer premiums were set to $1,000 (about two-thirds of the average consumer premium in our sample), enrollment probabilities across individuals would vary a lot (with a median of 0.39), and that if consumer premiums were to increase by $120 per year (from this $1,000 baseline), 8.4% of individuals would drop out of the marketplace.

The penultimate row shows that expected annual costs to the insurer (c_{ij}) are estimated to be $2,882 for the average individual in our sample, with a large standard deviation of $3,180.[11] These costs are the product of the individual's expected annual medical spending and their chosen plan. Based on data from the MEPS, Tebaldi (2025) estimated average projected annual medical spending for the demographic group we study to be just over

[11]We top code simulated health expenditure so that the riskiest individuals have expected cost at most 20 times as large as the average. While affecting less than 0.04% of the simulated population, this improves the numerical performance of our equilibrium simulations by preventing extreme (and unrealistic) values of subsidies or risk adjustment transfers.

Figure 2: Expected cost, willingness-to-pay, and demand sensitivity



Notes: *The figure summarizes aspects of the joint distribution of demand and cost in our sample. It plots annual expected healthcare spending on the horizontal axis for an individual enrolled in the modal silver plan. The left vertical axis plots the share enrolled in the market when the annual consumer premium is $1,000 for all plans. The right vertical axis plots the percent decline in the overall probability of enrollment in response to a $120 per year increase in the consumer premium. We distinguish between individuals with income above and below 250% of the Federal Poverty Line.*

$4,100, and the average cost for the insurer in Table 1 reflects that, on average, insurers cover 70% of expenditure. This is consistent with the modal enrollee selecting a silver plan. The last row of the table summarizes the individual's risk score w_i, defined in equation (4), which is invariant across plans. Individuals at the 90th percentile of the risk distribution have expected medical expenditures that are almost five times as large as those at the 10th percentile.

The quantitative results of our counterfactual exercises will depend not only on the marginal distributions of the triplet (v_i, c_i, w_i) – which are summarized in Table 1 – but also on their joint distribution. Figure 2 therefore illustrates how demand and demand sensitivity vary with expected cost. We plot expected annual cost for the insurer when the individual is enrolled in the modal silver plan on the horizontal axis. On the left vertical axis we show the average probability of enrolling in the market if all consumer premiums for all plans are $1,000; we show this separately for individuals with income above or below 250% of the Federal Poverty Level. On the right vertical axis we show the decline in the probability of enrollment when premiums go up, separately for the same income groups.

Figure 2 shows the presence of adverse selection in our empirical context: within a given income group, higher-cost individuals are, on average, significantly more willing to pay for insurance. It also shows that at a given cost, higher income individuals are more likely to purchase coverage and are less sensitive to premiums increases, as are higher cost individuals. For example, we estimate that, at consumer premiums of $1,000, about 50% of the high income group with an expected cost of $2,000 would purchase coverage. This share is about 10 percentage points lower among those with income lower than 250% of the Federal Poverty Level. Moreover, if premiums were to increase by $120 per year, there would be a decline of about 5% in the enrollment probability of low-income individuals with an expected cost of $2,000, and a smaller decline (of about 4.2%) in the enrollment probability of high-income individuals. In comparison, at the same level of premiums, about 80% of those with an expected cost of $7,000 would purchase coverage, and income differences in price sensitivity are smaller. For this group, a $120 premium increase would push less than 2% of enrollees out of the marketplace.

From Figure 2 we can also see that it is possible to "rank" individuals in such a way that those with lower expected cost are less likely to be enrolled and more sensitive to premium changes, and vice versa. As shown in Section 2, this adverse selection is sufficient for subsidies to perform better than risk adjustment. We now turn to a quantitative evaluation of alternative market designs in this setting.

In the remainder of the paper, we will use the California marketplace and these estimates of demand and cost in order to solve for market equilibria under alternative, counterfactual risk adjustment or subsidy schemes. Naturally, we have many degrees of freedom in the way we perform these exercises, so we do not view these exercises as providing a precise policy prescription. Rather, they are illustrative of the range of plausible magnitudes associated with the theoretical mechanisms highlighted in Section 2.

4 Alternative market designs with a single plan

In this section, we consider a setting in which there is only one single coverage option, a silver plan, in each market. This allows us to illustrate – and quantify – the theoretical results from Section 2. In the subsequent section we will explore robustness to relaxing some of the key, simplifying assumptions of the theory.

4.1 Setup

We consider the market sponsor's objective to be maximizing overall enrollment subject to a budget constraint. The market sponsor can pick from a class of alternative market design regimes we consider. Motivated by the theoretical results in Section 2, we consider several market design regimes.

We consider a *risk adjustment* regime, in which the market sponsor chooses the risk adjustment payment function $r(w_i) = \mu \cdot w_i$ with $\mu > 0$. That is, insurers are paid an amount for each enrollee that is proportional to the enrollee's risk score. Higher values of μ imply more aggressive risk adjustment and a flatter average cost curve.

We contrast the effects of risk adjustment with that of 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.

We also consider a *targeted subsidy* regime, in which the market sponsor chooses a function $s(w_i)$, which represents the subsidy amount that a potential buyer of type w_i can use toward premium payment. In particular, we consider functions of the form $s(w_i) = \lambda_0 (1 - \lambda_1(1 - 1/w_i'))$, where w_i' is the risk score, w_i, but winsorized at its 10th and 90th percentiles.[12] Here, λ_0 controls the "level" of subsidies, while λ_1 controls its "targeting." Setting $\lambda_1 = 0$ corresponds to the case of uniform subsidies, while values of $\lambda_1 > 0$ provide higher subsidies to lower-cost individuals and lower subsidies for higher-cost individuals. The larger the value of λ_1, the stronger the targeting of subsidies toward lower-cost potential buyers.

[12]That is, w_i' is equal to the 10th percentile of the w_i distribution for all values of w_i that are below it, and w_i' is equal to the 90th percentile of the w_i distribution for all values of w_i that are above it. Absent this adjustment, very low (high) values of w_i would lead to subsidies that are exponentially large (small).

Relative to uniform subsidies, such premium targeting thus creates a social trade-off between maximizing enrollment and type-specific surplus. We therefore also consider potential gains from constrained targeted subsidies that respect a "Pareto" restriction: relative to the uniform subsidy, the constrained targeted subsidies must make all consumers pay weakly lower premiums. A *constrained targeted subsidy* regime is thus one that is the same as the targeted subsidy regime except that the values of λ_0 and λ_1 are chosen subject to the additional constraint that at the equilibrium outcome no consumer pays a higher premium than under the optimal uniform subsidy (for the same budget).

For each of these four market design regimes, we compute equilibrium under a wide range of values of the market design parameters, and then search for the ones that maximize the objective subject to the sponsor's budget constraint. Thus, for each value of the budget, we obtain four different solutions, one for each market design regime, that are optimal over the range of designs we consider; Appendix B describes the computation in more detail. To facilitate meaningful comparisons across alternatives, we will often compare outcomes across market design regimes holding fixed the total amount of spending by the market sponsor, expressed in dollars per year per potential buyer.

4.2 One market

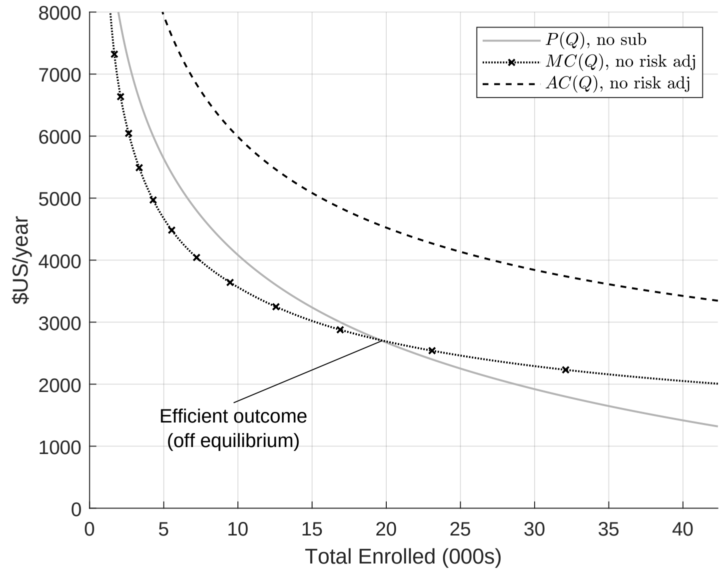
We first focus on one specific market, the 2014 West Los Angeles rating region, to provide empirical illustrations of the theoretical results from Section 2.

Figure 3 illustrates the market primitives and Proposition 1 by generating the empirical analog to Figure 1. In the top panel, the gray solid line shows demand, while the black dashed line and the dotted line with markers illustrate, respectively, average and marginal cost. Demand and marginal cost intersect at the efficient allocation, at which about 20,000 enrollees purchase coverage. However, demand is always below average cost and at the competitive equilibrium without any intervention by the market sponsor this market completely unravels.

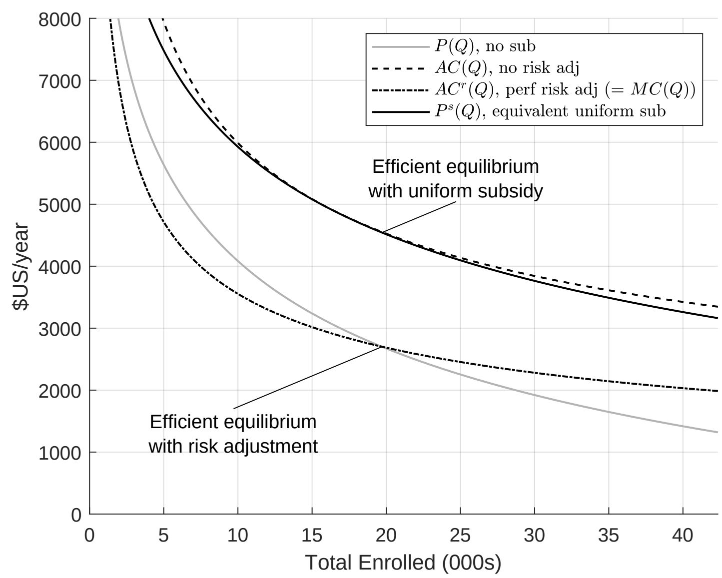
The bottom panel illustrates two alternative market designs, each achieving the efficient outcome with a total spending by the market sponsor (G) of \$70 per potential buyer. At this level of spending, risk adjustment – which shifts and flattens the average cost curve –

Figure 3: Empirical Example of Proposition 1: 2014 West Los Angeles Region

(a) Market Primitives



(b) Perfect Competition: Risk Adjustment vs. Uniform Subsidy



Notes: *The figure considers a homogeneous silver plan offered by multiple insurers in a perfectly competitive market, using estimates from the West Los Angeles rating region in 2014 and assumed total spending by the market sponsor of \$70 per potential buyer. The top panel shows the primitives (demand, marginal cost, and average cost without any intervention of the market sponsor) and highlights the efficient allocation. The bottom panel shows the optimal risk adjustment achieving the efficient outcome (which corresponds to* $\mu = \$1100$*), and an optimal uniform subsidy at the same level of market sponsor spending (which corresponds to a subsidy* s *of \$1,843).*

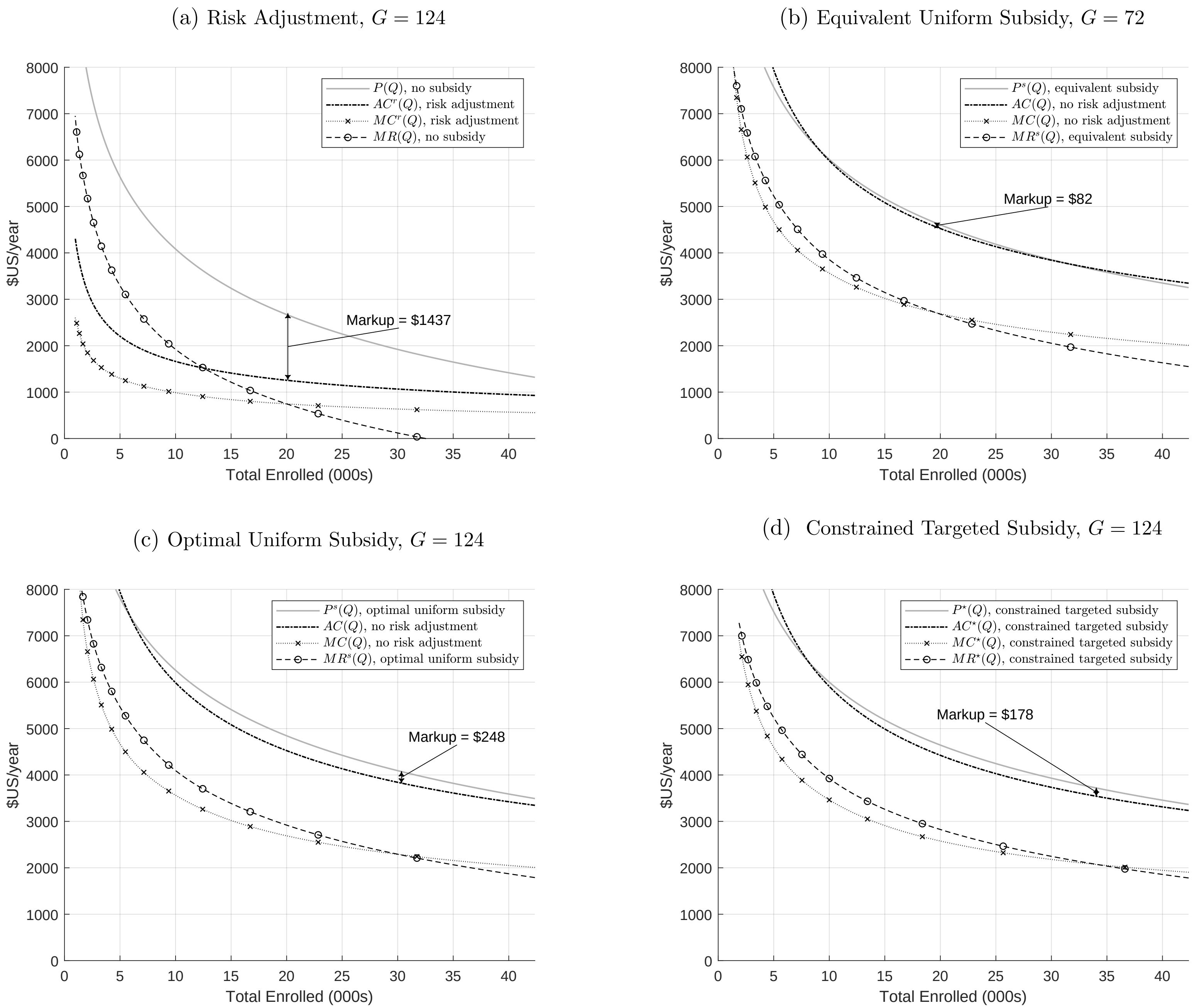
leads to one market equilibrium, while uniform subsidies – which shift the demand curve – leads to another equilibrium. Both designs achieve the same, efficient enrollment, with the same market sponsor spending, illustrating Proposition 1. Note that the vertical distance between the two equilibrium outcomes represents the size of the subsidy ($1,843); consumer premiums are the same under both regimes.

Figure 4 considers instead the case when insurance is offered by a monopolist in the same market. Following Proposition 2, we proceed in steps, as illustrated across the different panels. The top left panel shows the risk adjustment that achieves the efficient level of enrollment (20,000 as shown in Figure 3). This policy sets $\mu = \$1,955$, which is 80% larger than the value set in the perfectly competitive case since the pass-through of sponsor's payments to consumers is imperfect due to market power. At the equilibrium with this risk adjustment, the average markup is $1,437, and the total spending by the market sponsor (G) to achieve the efficient outcome increases to $124 per potential buyer, almost twice as large as under perfect competition.

In the top right panel of Figure 4 we follow the construction in Proposition 2 (see equation (A.2) in Appendix A for details) and use instead an "equivalent" uniform subsidy ($s = \$1,933$) to achieve the same enrollment. Under this regime, the markup is now substantially lower ($82 compared to $1,437 under risk adjustment). The uniform subsidy is thus able to achieve the same enrollment as risk adjustment but at substantially lower spending by the market sponsor: total spending by the market sponsor drops by 40%, to $72 per potential buyer, almost as low as in the perfectly competitive case.

The resulting savings can be used to further increase enrollment without exceeding the budget (which we hold fixed to $124 as determined by the risk adjustment policy in the top left panel). In the bottom left panel of Figure 4 we show the uniform subsidy that maximizes enrollment under this budget. This optimal (uniform subsidy) policy sets $s = \$2,173$ and increases enrollment by 50% for a total of about 30,000 enrollees. This difference in enrollment holding total spending at $124 is the markup effect. Compared to the risk adjustment under the same budget, the markup charged by the monopolist is 87% lower ($177 as opposed to $1,437).

Figure 4: Empirical Example of Proposition 2: Monopolist in 2014 West Los Angeles Region

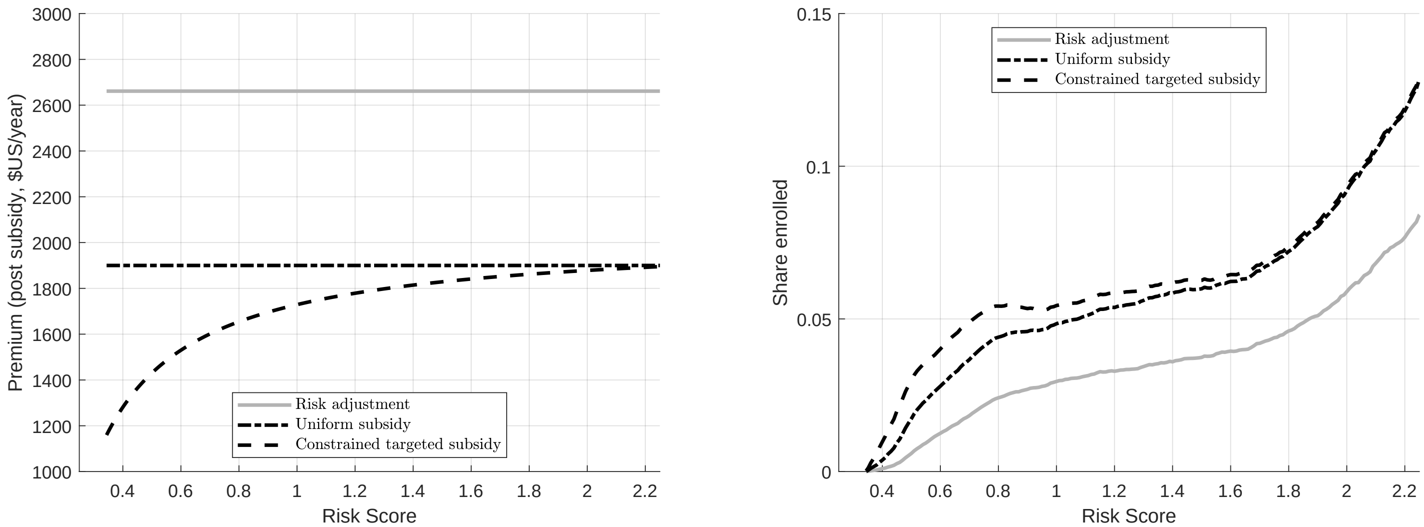


Notes: *Across different panels, we illustrate the mechanisms described in Proposition 2. The risk adjustment achieving the efficient enrollment level in panel (a) can be replaced by either a uniform subsidy achieving the same enrollment at lower markups and sponsor spending (G) in panel (b), or by an optimal uniform subsidy achieving higher enrollment at equal spending by the market sponsor in panel (c). Lastly, in panel (d), optimal targeted subsidies that are constrained to keep all types at least as well off as under uniform subsidies can increase enrollment further under the same budget. We refer the reader to the main text for more details.*

Figure 5: Allocations Under Alternative Policies in the Empirical Example

(a) Post-Subsidy Premium by Risk Score

(b) Share Enrolled by Risk Score



Notes: *The figure illustrates the equilibrium allocations of Figure 4 across different policies and different risk types. The left panel shows the premium after subsidies that individuals pay when purchasing insurance under risk adjustment (top left panel of Figure 4), optimal uniform subsidy (bottom left panel), and optimal constrained targeted subsidy (bottom right panel). The right panel shows the share of individuals purchasing insurance under the same policies as a function of their risk score* w_i.

Lastly, a targeted subsidy can further improve outcomes while ensuring that all consumers are better off. This is illustrated in the bottom right panel of Figure 4, where we consider the optimal constrained targeted subsidy; we set $\lambda_1 = 0.15$ and increase λ_0 as long as the sponsor's spending in equilibrium does not rise above $124. This results in $\lambda_0 = 1,980$. Relative to the optimal uniform subsidy, the optimal targeted subsidy changes the sorting of consumer premiums across different risk types, favoring those with lower risk. As a result, marginal revenue and marginal cost cross at an even higher (approximately 34,000) level of enrollment, corresponding to a 20% targeting effect relative to risk adjustment. Naturally, if we removed the constraint that no consumer pays higher premiums than under the optimal uniform subsidy, we could increase enrollment even further (for the same budget).

These alternative policies lead to different equilibria by altering the post-subsidy consumer premiums and the resulting probability of enrollment across different risk types. Different compositions of average and marginal buyers in turn alter the pricing incentives by the monopolist. Figure 5 shows these effects in the above example. In the left panel, we show how post-subsidy premiums vary across individuals with different risk scores for the three policies considered in Figure 4, holding market sponsor spending fixed at $124. The solid gray line shows the equilibrium price obtained under risk adjustment. This price is equal for all individuals, as it is the case for the uniform subsidy. However, because of the markup effect, it is 30% lower ($1,900 as opposed to $2,650) under the optimal uniform subsidy compared to risk adjustment. By contrast, under the optimal constrained targeted subsidy, the post-subsidy premium is increasing in risk score. Individuals with a risk score of 0.6 pay $1,350 per year, those with an average risk score of 1 pay $1,700, while those with risk scores larger than 1.6 pay almost as much as and eventually the same as under the uniform subsidy ($1,900). This targeting implies that, while the propensity to enroll increases for all individuals under uniform or constrained targeted subsidies compared to risk adjustment, under constrained targeted subsidies the enrollment propensity increases disproportionally among those with lower risk, as shown in the right panel of Figure 5.

4.3 All markets

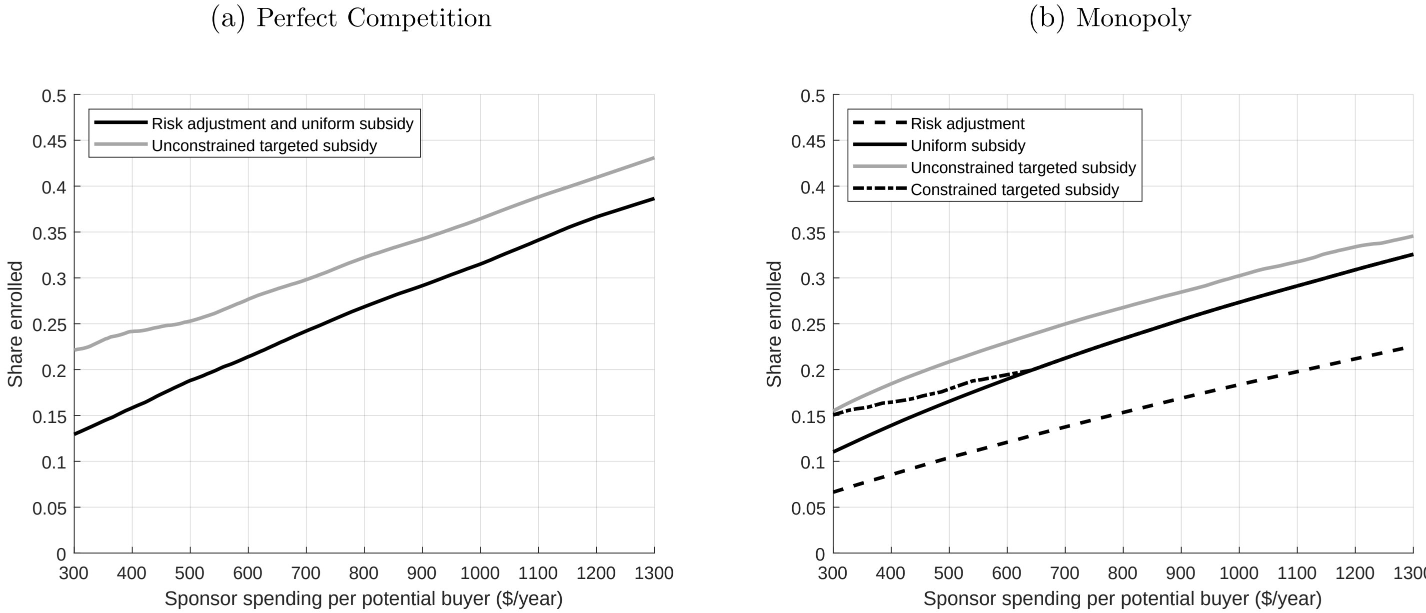
We now consider all markets in our data (rather than just one), and a greater range of market designs. We continue to examine two extreme market structures: a monopolistic market and a perfectly competitive market in which multiple insurers offer the same plan, so equilibrium profits are zero. Figure 6 shows average enrollment rates (across all markets) as a function of sponsor spending (expressed in dollars per potential buyer).

The left panel of Figure 6 considers the case of perfect competition. Here, there is no markup effect so risk adjustment and uniform subsidies are equivalent (solid black line). In contrast, optimal unconstrained targeted subsidies generate higher enrollment for any level of spending. At the average level of sponsor spending under the ACA in our data, which is approximately $1,000 per potential buyer,[13] the targeting effect leads to enrollment that is 10 percentage points (31%) higher under targeted subsidies relative to risk adjustment and uniform subsidies. In the perfect competitive case, however, higher-risk buyers pay more under targeted subsidies, since in the absence of markups it is not possible to increase enrollment while simultaneously ensuring lower spending and lower premiums for all consumers, and therefore constrained targeted subsidies can do no better than the optimal uniform subsidy.

The right panel examines alternative designs under monopoly. Naturally, vis-à-vis perfect competition, enrollment at any level of sponsor spending is lower due to market power, which leads to higher equilibrium prices with the insurer capturing some share of the surplus. For example, at any level of sponsor spending, risk adjustment under monopoly produces enrollment that is just over 80% of what enrollment would be under perfect competition.

[13] The average enrollment share is 0.27 and the average subsidy is $3,928; c.f. Table 2 in Tebaldi (2025).

Figure 6: Risk Adjustment vs. Subsidies: A Homogeneous Plan



Notes: *The figure considers the simple case of a homogeneous silver plan in every market, and plots the share enrolled as a function of market sponsor spending (per potential buyer) across the 76 region-year markets in our data. For "constrained targeted subsidies" we consider the highest level of enrollment achieved by any rotation (λ_1), imposing that all individuals pay weakly lower premiums compared to the case of risk adjustment. For unconstrained targeted subsidies we consider the highest level of enrollment achieved by any rotation (λ_1), but now without the additional constraint that all individuals pay premiums weakly lower than the risk adjustment case. The figure is constructed by simulating equilibrium for every design and every market separately over a grid of values for μ, λ_0, and λ_1. We then interpolate average enrollment and total spending across markets using moving average filters. Appendix B provides more details.*

More importantly, in the context of monopoly – unlike that of perfect competition – the equilibrium enrollment under risk adjustment (dashed black line) and under uniform subsidies (solid black line) now differ substantially (at the same level of sponsor spending) due to the markup effect. For example, at the average level of sponsor spending under the ACA ($1,000 per potential buyer), the share of individuals purchasing coverage under risk adjustment is about 0.18, but it increases by 50%, to 0.27, under uniform subsidies. Unconstrained targeted subsidies achieve even higher enrollment (solid gray line), bringing the share enrolled up to 0.30, or about an 67% increase relative to risk adjustment. The additional 3 percentage point enrollment gain under monopoly from unconstrained targeted subsidies over uniform subsidies is smaller than the 8 percentage point enrollment gain generated by these unconstrained targeting subsidies under perfect competition (left panel). Targeting subsidies to lower-risk individuals attracts a larger share of them to the market, which reduces average costs; however, this cost reduction is partly captured by the monopolist in the form of higher profits, rather than perfectly passed through to lower premiums (which is the case with perfect competition), which is why the targeting effect is smaller under monopoly.

Finally, under monopoly, there is also scope for improving over a uniform subsidy through constrained targeted subsidies in which every consumer faces a (weakly) lower post-subsidy price relative to uniform subsidies and hence is (weakly) better off. Such Pareto improvements are not, however, always feasible. The figure shows that for low enough levels of market spending (and hence enrollment), when adverse selection is more severe, we can find targeted subsidies that make all buyers better off relative to a uniform subsidy, increase enrollment, and do not increase additional spending by the sponsor. This corresponds to the dash-dot line in the right panel of Figure 6. At spending equal to \$500 per potential buyer, these constrained targeted subsidies achieve one-third of the gains of targeted subsidies relative to uniform subsidies. At higher levels of spending we are unable to find such Pareto-better policy in our simulations.

5 Market designs with richer market structures

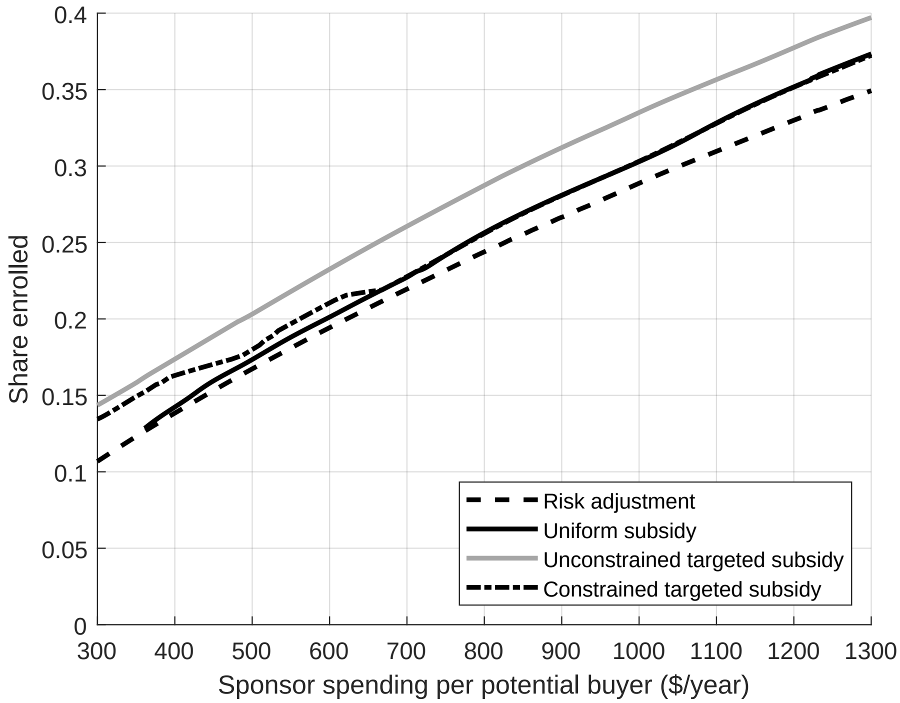
We now probe robustness to relaxing some of the key assumptions in the theoretical propositions. Specifically, instead of imposing that insurers offer a homogeneous (silver) plan within each market, we now allow these plans to be horizontally differentiated across insurers (e.g., based on provider network and/or insurer brand preferences), and for insurers to have asymmetric costs. We also now allow each insurer to offer multiple (two, silver and bronze) insurance coverage options, so that there is a vertical differentiation between the plans offered by each insurer.

5.1 Alternative market designs

Figure 7 illustrates our results graphically, comparing enrollment across risk adjustment and optimal subsidies (both uniform and targeted) with varying levels of spending by the market sponsor. Given the existence of two plans (silver and bronze) with differing actuarial values (AV), risk adjustment now takes the form $r(w_i) = AV \cdot \mu \cdot w_i$ such that $\mu > 0$ and $AV = 0.6$ for bronze plans and $AV = 0.7$ for silver plans. That is, risk adjustment is now proportional to risk score and plan generosity, following the common practice in risk adjustment models, including the one adopted under the ACA (Pope et al., 2014).

In terms of total enrollment, the ordering between risk adjustment and subsidies highlighted in Section 2 appears to be robust to relaxing the assumptions of symmetric insurers offering only one plan and allowing for horizontal and vertical differences across plans. For

Figure 7: Risk Adjustment vs. Subsidies: Heterogeneous Multiproduct Oligopoly



Notes: *The figure considers differentiated multi-plan insurers, each offering bronze and silver plans, and plots the share enrolled as a function of market sponsor spending (per potential buyer) across the 76 region-year markets in our data. For "constrained targeted subsidies" we consider the highest level of enrollment achieved by any rotation of the subsidy schedule (λ_1), imposing that all individuals pay weakly lower premiums compared to the case of risk adjustment. For unconstrained targeted subsidies we consider the highest level of enrollment achieved by any rotation (λ_1), but now without the additional constraint that all individuals pay premiums weakly lower than under uniform subsidies. The figure is constructed by simulating equilibrium for every design and every market separately over a grid of values for μ, λ_0, and λ_1. We then interpolate average enrollment and total spending across markets using moving average filters. Appendix B provides more details.*

example, for a level of spending similar to the one observed under the ACA – approximately $1,000 (see footnote 13) – unconstrained targeted subsidies can achieve a 17% increase in enrollment relative to risk adjustment (from 0.29 to 0.34). As with the single-product monopolist case analyzed in Figure 6, at lower levels of sponsor spending we find that constrained targeted subsidies under which all buyers pay lower premiums are able to improve upon uniform subsidies.

Table 2 summarizes these and other outcomes across risk adjustment and subsidy designs, holding spending fixed at $1,000 per potential buyer. It shows enrollment rates overall and the share of enrollees with below-median risk score. It also shows the highest consumer premium that anyone pays (across all types, in our analysis this is the premium paid by those with the highest risk score), the market sponsor spending per enrollee, consumer surplus, enrollment-weighted average actuarial value, and average markups.

The first three columns summarize the results for risk adjustment, uniform subsidies, and

Table 2: Comparing Designs at Sponsor Spending of $1000 per Potential Buyer

	Risk Adjustment	Non-Tiered Subsidies Uniform	Non-Tiered Subsidies Targeted	Tiered Subsidies Uniform	Tiered Subsidies Targeted
Share enrolled	0.289	0.303	0.335	0.311	0.394
Share of enrollees with risk score < median	0.382	0.426	0.616	0.418	0.592
Premium paid, highest risk score ($US)	997	301	1414	366	1713
Sponsors's spending per enrollee ($US)	3574	3408	3043	3355	2869
Consumer Surplus per potential enrollee ($US)	300	284	275	309	313
Average actuarial value of chosen plan (%)	66.98	61.09	60.83	63.56	64.19
Average per-enrollee markup ($US)	876	568	580	330	578

Note: *The table summarizes equilibrium outcomes for the case of heterogeneous insurers offering bronze and silver plans across different risk adjustment and subsidy designs. Spending by the market sponsor is held fixed at $1,000 per potential buyer, the average ACA level (c.f. footnote 13).*

(unconstrained) targeted subsidies.[14] As seen in Figure 7, total enrollment is higher under optimal uniform subsidies than under risk adjustment (30% vs 29%), and higher still under targeted subsidies (34%). In both cases, relative to risk adjustment, subsidies reduce adverse selection in enrollment, as measured by the share of enrollees that are low risk, and generate lower markups; targeted subsidies in particular bring in a much larger share of lower risk enrollees through offering them lower subsidies.

However, Table 2 also reveals that the average actuarial value of the chosen plan is lower under uniform subsidies (61.1%) and targeted subsidies (60.8%) than under risk adjustment (67%). This reflects the fact that, under subsidies, more buyers select the bronze (vs. silver) plan than they do under risk adjustment. As a result, despite the fact that total enrollment is higher and markups are lower under subsidies than under risk adjustment, consumer surplus is actually *highest* under risk adjustment. The key economic force now at work is that, with vertically differentiated plans, adverse selection now operates on two margins (as studied in Geruso, Layton, McCormack, and Shepard, 2023): the extensive margin of whether the individual is covered (as we have considered thus far) and the intensive margin of the amount of coverage (since riskier individuals are also more willing to pay for generous coverage). While targeted subsidies are better than risk adjustment in reducing selection on the extensive margin, when plans are vertically differentiated risk adjustment now has an advantage over subsidies in limiting the intensive-margin risk of the unraveling of the market for the more comprehensive coverage.

[14] As seen in Figure 7, at this level of spending, we are unable to find a constrained targeted subsidy design that can increase enrollment over uniform subsidies.

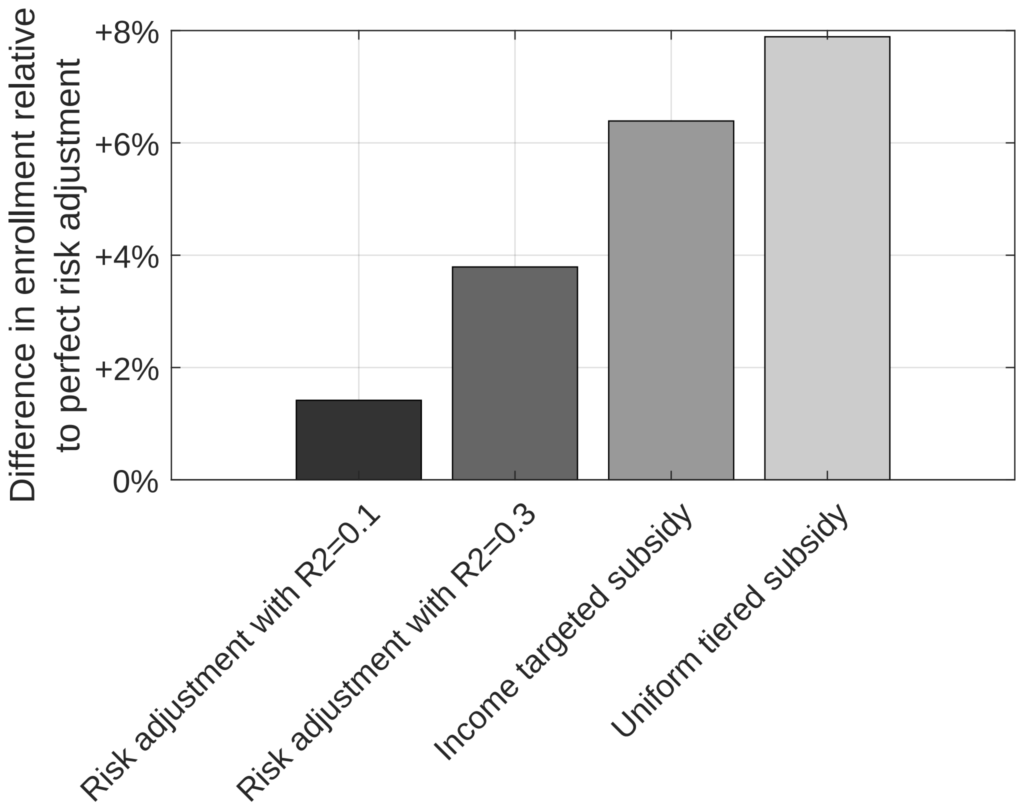
To see this more clearly, the last two columns of Table 2 introduce a new market design instrument: tiered (uniform or targeted) subsidies that can vary across metal tiers, mimicking the way risk adjustment transfers vary with plan generosity. Specifically, rather than $s(w_i)$, the subsidy is equal to $AV \cdot s(w_i)$ (as for risk adjustment, $AV = 0.6$ for bronze plans and $AV = 0.7$ for silver plans). Tiered subsidies provide stronger incentives to purchase more generous plans, and in doing so can limit the unraveling of high-generosity coverage in much the same way that risk adjustment does. Tiered subsidies perform better than their non-tiered counterparts in terms of higher total enrollment, higher average actuarial values, lower markups, and higher consumer surplus. Indeed, with tiering allowed, subsidies now outperform risk adjustment in terms of consumer surplus. Tiered subsidies are preferable to risk adjustment for the same reasons highlighted in Section 2: they increase the pass-through of sponsor spending to consumers and allow for additional enrollment incentives for low-risk types.

These results illustrate how, once we allow for vertical plan differentiation, a focus only on total enrollment and sponsor spending can mask an important potential advantage for risk adjustment over subsidies that are constant across plan tiers. As we demonstrate, however, a more flexible subsidy design – that allows the subsidy amount to vary with plan generosity in a manner not unlike the ACA's additional subsidy to the silver plan that comes via lowering out-of-pocket spending (Lavetti et al., 2023) – can restore the advantage of subsidies over risk adjustment, at least in our empirical example. However, this particular example raises a broader point that our theoretical analysis – and most of our empirical analyses – abstracted from: the non-price contract distortions that adverse selection can create, and the potential for risk adjustment to mitigate these distortions (Glazer and McGuire, 2000). By decreasing the relative profitability to insurers of healthier compared to less healthy enrollees, risk adjustment may, for example, reduce insurer incentives to cream-skimming using non-price instruments, such as benefit design or marketing (see Appendix C).

5.2 More realistic targeting

In all the analyses thus far, we have considered "perfect" observability of types, so that w_i tracks "perfectly" individual expected cost (see equation (4)). We now explore two more realistic situations in which the observables used in risk adjustment and in subsidies are neither perfect nor identical. For targeted subsidies, we now allow payments to vary only with income, and consider the common case in which higher-income individuals receive lower subsidies. For risk adjustment, we consider risk scores that approximate the current state-

Figure 8: Difference in Enrollment Relative to Risk Adjustment with $R^2 = 1$



Note: *The figure summarizes the comparison of enrollment achieved by different designs, holding market sponsor spending fixed at \$1,000 per potential buyer. Enrollment under "perfect" risk adjustment with $R^2 = 1$ is normalized to zero. We then consider noisy risk adjustment with $R^2 = 0.1$ and $R^2 = 0.3$. This is constructed by setting $w_i = e^{\rho_i}/\mathbb{E}[e^{\rho}] + \omega_i$, where ω_i is drawn iid randomly across individuals to target the R-square of a linear regression of cost on w_i. The third bar corresponds to subsidies targeted only on income, as common in many markets. The last bar correspond to tiered uniform subsidies, already analyzed in Section 4.*

of-the-art risk scoring models, which have an R^2 from a regression of medical spending on risk scores that is far from the ideal case of $R^2 = 1$ that we have considered so far (McGuire, Zink, and Rose, 2021). Specifically, we replace the perfect risk score from above with a noisy one, which we design to be such that the R^2 of our risk adjustment model is either 0.1 or 0.3. Appendix B provides more details.

Figure 8 summarizes the enrollment achieved under these various designs, holding market sponsor spending per potential buyer fixed at \$1,000 as in Table 2. We report the percentage difference in enrollment relative to the perfect risk adjustment with $R^2 = 1$ (see Table 2). Adding noise to the risk adjustment restores adverse selection and lowers markups, increasing enrollment by 1.7% when $R^2 = 0.1$ and by almost 4% when $R^2 = 0.3$.

As expected, targeting subsidies on income performs worse than subsidies on risk. Quantitatively, providing higher subsidies to low-income consumers leads to total enrollment that is 6% higher than (perfect) risk adjustment, three fourth of the gains obtained under tiered uniform subsidies. A comparison between noisy risk adjustment and income-targeted subsidies – the two policies that one may expect to see more often in marketplaces – shows that enrollment under the latter design would be smaller. If there were institutional limits to the use of risk-targeted subsidies this result could be a justification for the widespread use of (noisy) risk adjustment in combination with income-targeted subsidies.

6 Conclusions

Our paper has emphasized the importance of jointly considering 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 altering market demand and 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 marketplace during 2014-2017, we illustrated the theoretical results quantitatively and explored robustness to relaxing many of the stylized assumptions of the theory.

A natural question raised by our theoretical and empirical results is why risk adjustment remains a popular market design instrument. One natural 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 of insurers of healthier compared to less health enrollees, risk adjustment may be important for reducing insurer incentives to cream-skim using non-price instruments, such as benefit design or marketing.[15] Indeed, when we relaxed some of the assumptions of the theory to allow for insurers to offer multiple, vertically differentiated plans, we saw in our empirical results a potential advantage for risk adjustment in reducing selection on the intensive margin of plan generosity, even though subsidies still did better on the extensive margin of enrollment, an example of the two-margin selection

[15]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 (see, e.g., Geruso and Layton, 2020), and this may be why we rarely see it in mature markets.

problem highlighted by Geruso, Layton, McCormack, and Shepard (2023).

There are also potential political economy explanations for the continued use of risk adjustment. For example, while our theoretical and empirical analyses allow risk adjustment and subsidies to condition on the same type space, in practice offering greater subsidies to healthy consumers – as optimal subsidies would often require – may conflict with naive intuition and may be politically difficult. Likewise, insurer profits may also be higher under risk adjustment, creating a potential political force in favor of them. Lastly, regulators may find it easier to calculate risk adjustment transfers since these may require only claims data, while subsidy design combines cost curves with demand estimates across types. Selecting and designing the optimal policies in a specific setting must then accommodate not only political and institutional constraints but also face possible challenges due to data requirements.

From this perspective, our results can be thought of as providing a quantitative assessment of the costs of such potential constraints or how large the unmodeled benefits of risk adjustment would need to be, 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, in a stylized environment, of the trade-off associated with greater reliance on risk adjustment relative to a richer and more flexible subsidy design.

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APPENDIX

A Theoretical Appendix

Definitions. Given the primitives introduced in Section 2, the average cost function for contract j is

$$AC_j(p) = \frac{C_j(p)}{q_j(p)} = \frac{\displaystyle\int \mathbf{1}\left\{v_{ij} - p_j \geq v_{ik} - p_k \text{ for all } k, \text{ and } v_{ij} - p_j \geq 0\right\} \, c_i dF(i)}{\displaystyle\int \mathbf{1}\left\{v_{ij} - p_j \geq v_{ik} - p_k \text{ for all } k, \text{ and } v_{ij} - p_j \geq 0\right\} \, dF(i)},$$

where $C_j(\cdot)$ and $q_j(\cdot)$ are, respectively, the total cost and total enrollment functions.

Under a risk adjustment $r(\cdot)$ average cost becomes

$$AC_j^r(p) = \frac{C_j(p)}{q_j(p)} = \frac{\displaystyle\int \mathbf{1}\left\{v_{ij} - p_j \geq v_{ik} - p_k \text{ for all } k, \text{ and } v_{ij} - p_j \geq 0\right\} \left(c_i - r(w_i)\right) \, dF(i)}{\displaystyle\int \mathbf{1}\left\{v_{ij} - p_j \geq v_{ik} - p_k \text{ for all } k, \text{ and } v_{ij} - p_j \geq 0\right\} \, dF(i)},$$

and the total and average spending by the market sponsor are, respectively

$$G^r(p) = \int \mathbf{1}\left\{\max_j \left\{v_{ij} - p_j\right\} \geq 0\right\} \, r(w_i) \, dF(i), \quad g^r(p) = \frac{G^r(p)}{\sum_j q_j(p)}.$$

Under a subsidy design $s(\cdot)$ the enrollment function for plan j is

$$q_j^s(p) = \int \mathbf{1}\left\{v_{ij} - p_j \geq v_{ik} - p_k \text{ for all } k, \text{ and } v_{ij} - p_j \geq -s(w_i)\right\} \, dF(i),$$

which simplifies to $q_j^s(p) = q_j(p - s)$ if $s(\cdot)$ is a (constant) uniform subsidies. Total and average market sponsor spending are $G^s(p) = \int \mathbf{1}\left\{\max_j \left\{v_{ij} - p_j\right\} \geq -s(w_i)\right\} \, s(w_i) \, dF(i)$, and $g^s(p) = G^s(p) / \left(\sum_j q_j^s(p)\right)$. Under uniform subsidies $s(w_i) = s$ (for all w_i) these are simply $G^s(p) = s \sum_j q_j(p - s)$, and $g^s(p) = s$.

Proof of Proposition 1. Let $p^\star$ be the vector of equilibrium prices when the risk adjustment $r(w_i)$ is adopted and there are no subsidies. Since contracts are homogeneous, $p_1^\star = p_2^\star = \ldots = p_J^\star = \overline{p}$, and all insurers have the same average costs and obtain the same per-enrollee risk adjustment transfer equal to $g^r(p^\star)$. In equilibrium $\overline{p} = AC_j^r(p^\star) = AC_j(p^\star) - g^r(p^\star)$.

Consider now the alternative policy in which there is no risk adjustment, while subsidies are $s(w_i) = \overline{s} = g^r(p^\star)$, for all w_i. The price vector $\widehat{p} = (\widehat{p}_1, \widehat{p}_2, \ldots, \widehat{p}_J)$ with $\widehat{p}_j = \widehat{p} = AC_j(p^\star)$ for all j is then the new equilibrium, since $\widehat{p} = \overline{p} + \overline{s}$, and thus $\widehat{p} = AC_j(p^\star) - g^r(p^\star) + \overline{s} = AC_j(\widehat{p} - \overline{s})$, 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 $g^s(\widehat{p}) = \overline{s} = g^r(p^\star)$. ■

Proof of Proposition 2. Begin with the equilibrium $p^\star$ under the risk adjustment $r(w_i)$. The first order condition in equation (1) must hold, where we replace $AC(\cdot)$ with $AC^r(\cdot)$. Since we assume symmetry of contracts, they all receive the same average risk adjustment transfer equal to $g^r(p^\star)$. The first order condition can then be rewritten as

$$p_j^\star = \underbrace{AC_j(p^\star) - g^r(p^\star)}_{AC_j^r(p^\star)} - \frac{q_j(p^\star)}{\partial q_j(p^\star)/\partial p_j}\left(1 - \partial AC_j^r(p^\star)/\partial p_j\right). \tag{A.1}$$

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

$$s(w_i) = s^\star = g^r(p^\star) + \frac{q_j(p^\star)}{\partial q_j(p^\star)/\partial p_j}\frac{\partial g^r(p^\star)}{\partial p_j} \quad \text{for all } w_i. \tag{A.2}$$

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 $\widehat{p}_j = p_j^\star + s^\star$. To see this, note that with subsidy $s^\star$ and no risk adjustment, equilibrium must satisfy the following first-order condition

$$\widehat{p}_j = AC_j(\widehat{p} - s^\star) - \frac{q_j(\widehat{p} - s^\star)}{\partial q_j(\widehat{p} - s^\star)/\partial p_j}\left(1 - \partial AC_j(\widehat{p} - s^\star)/\partial p_j\right). \tag{A.3}$$

Replacing $p_j^\star = \widehat{p}_j - s^\star$ implies $p_j^\star + s^\star = AC_j(p^\star) - \frac{q_j(p^\star)}{\partial q_j(p^\star)/\partial p_j}\left(1 - \frac{\partial AC_j(p^\star)}{\partial p_j}\right)$, and substituting for $s^\star$ its construction from equation (A.2) yields the original first-order condition from equation (A.1) so that the first order condition in equation (A.3) must hold.

The second property of this particular construction of $s^\star$ is that $s^\star = g^s(\widehat{p}) = g^r(p^\star) + \frac{q_j(p^\star)}{\partial q_j(p^\star)/\partial p_j}\frac{\partial g^r(p^\star)}{\partial p_j} < g^r(P^\star)$, where the inequality follows from the fact that demand slopes downward — $\frac{q_j(p^\star)}{\partial q_j(p^\star)/\partial p_j} < 0$ — and regular risk adjustments under adverse selection imply that $\frac{\partial g^r(p^\star)}{\partial p_j} > 0$. ■

B Details of counterfactual simulations

Counterfactual policies varying budget. Here we describe in more details how we obtain the results in Sections 4 and 5, where we solve for equilibria over a large grid of policy parameters and then find the policies that maximize enrollment subject to sponsor budget.

For risk adjustment, we set up a grid of values of $\boldsymbol{\mu} = \left\{\mu^1, \mu^2, \ldots, \mu^N\right\}$ and for every region-year market we solve for the equilibrium $p^{sol,n}$ under risk adjustment $r(w_i) = \mu^n w_i$, where $sol = pc, ipc$ distinguishes between perfect and imperfect competition.[16] We use

[16]Under perfect competition (left panel of Figure 6), $p^{pc,n}$ solves $p^{pc,n} = AC^r(p^{pc,n})$. Under imperfect competition we consider two cases. For monopoly (right panel of Figure 6) we find the profit-maximizing

the resulting combinations of $\{\mu^n, p^{sol,n}\}$ to compute total enrollment $Q^{sol,n} = \sum_j q_j(p^{sol,n})$ and sponsor total ($G^{sol,n}$) and per-buyer ($g^{sol,n}$) spending. We then expand our grid by interpolating values using granular moving averages, and find the value $n^\star$ that solves

$$\max_n Q^{sol,n} \ s.t. \ G^{sol,n} \leq B,$$

where B is the total budget.

The procedure for subsidies is analogous. For uniform subsidies we set up a grid of values $\mathbf{S} = \{s^1, s^2, \ldots, s^N\}$, while for targeted subsidies we consider the two-dimensional grid of values $\lambda^k = (\lambda_0^n, \lambda_1^m)$ where $\lambda_0^n = s^1, s^2, ..., s^N$ while $\lambda_1^m = \{0.06, 0.11, 0.17, \ldots, 0.39, 0.44, 0.5\}$.

Noisy risk adjustment and income-targeted subsidies. At the end of Section 5.2 we modify our analysis to include "imperfect" risk adjustment and income-based subsidies.

For the former, we construct a noisy signal of risk for every individual in our data. That is, we set $w_i = \exp(\rho_i)/\mathbb{E}\exp(\rho_i) + \omega_i$, where ω_i is drawn independently from a normal distribution with standard deviation that is set to ensure that the R^2 of a linear regression of $\exp(\rho_i)$ on w_i is equal to 0.1 or 0.3, values that we consider following the literature on risk adjustment.

For the case of income-based subsidies we simply set $w_i = \text{Income}_i/\mathbb{E}(\text{Income}_i)$. We then follow the steps we followed for targeted subsidies, and consider $s(w_i) = \lambda_0 (1 - \lambda_1(1 - 1/w_i))$, varying λ_0 and λ_1 over a grid.

C The Role of Cream-Skimming

Our analysis focuses on insurers setting premiums keeping contract characteristics fixed. One natural question is whether insurers can engage in other activites (e.g. benefit design or marketing) to cream-skim only healthy types and discourage enrollment of individuals with higher expected cost. If this was the case, it is possible that risk adjustment would mitigate this phenomenon while subsidies would not.

To explore this possibility in our stylized empirical context we set up a simple simulation exercise in which we replicate the analysis of the monopolist insurer offering a silver plan, but we let the monopolist have an additional action through which they can reduce the

premium $p^{ipc,n}$, for multiproduct oligopoly (Figures 7-8 and Table 2) we use a nonlinear optimizer to find the vector $p^{ipc,n}$ that minimizes the total square deviations from the Bertrand-Nash first order conditions, and then check that there are no profitable global deviations.

probability of enrollment across different risk types. More precisely, we allow the monopolist to maximize profits not only with respect to premium but also with respect to a cream-skimming (or advertising) parameter a such that demand by individuals of type w_i is

$$q(p, a; w_i) = q(p; w_i) \times \left(\frac{2e^{-aw_i}}{1 + e^{-aw_i}} \right). \tag{A.4}$$

Setting $a = 0$ brings us back to our baseline model, while higher values of a imply that the monopolist tries to avoid risky types through supply strategies other than higher prices. Given risk adjustment $r(w_i)$ and/or subsidies $s(w_i)$ the monopolist solves

$$\max_{a,p} \int q(p - s(w_i), a; w_i)\,(p - c_i + r(w_i))\, dF(i). \tag{A.5}$$

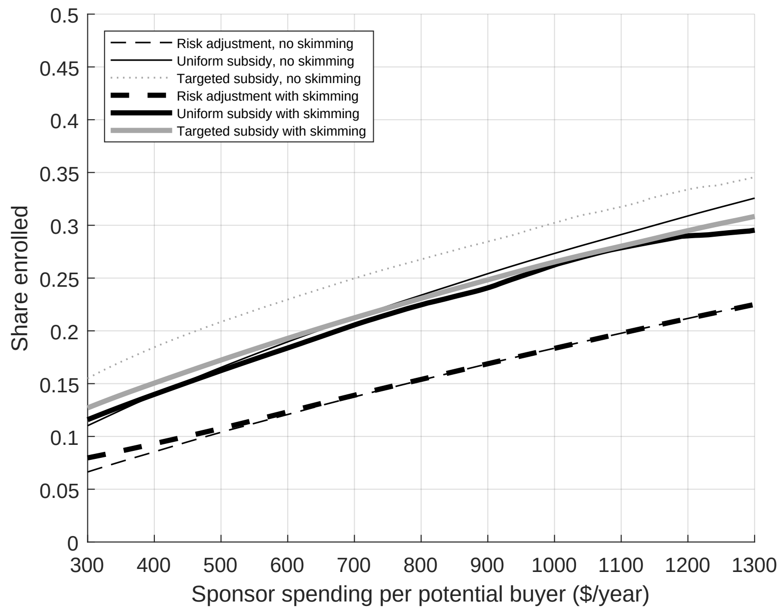
When selecting the optimal a the monopolist trades off enrollment (and revenue) against the probability of enrolling types for which expected profits are negative. While here we selected a specific functional form, primarily dictated by computational convenience, this captures the key forces that interact with risk adjustment and subsidies when insurers can strategically reduce enrollment among specific groups.

Figure A.1 shows how the results in Section 4.2 change when we allow the monpolist to cream-skim using the technology specified in equation (A.4). In the top panel we overlay the relationship between sponsor spending and enrollment obtained for the monopolist forced to set $a = 0$ to the same relationship when the monopolist can freely pick a. Consistently with the idea by which risk adjustment is essential to remove cream-skimming incentives, the figure shows that for any spending level greater than \$600 the monopolist sets $a = 0$ under (perfect) risk adjustment. Instead, under both uniform and targeted subsidies, at the spending level of \$1,000 which we used as reference throughout, enrollment is 2-5 percentage points lower due to cream-skimming. When the sponsor spending is lower, and adverse selection more severe, cream-skimming leads to higher enrollment under risk adjustment and uniform subsidies relative to the case in which $a = 0$. Intuitively, by limiting the enrollment among risky types, average cost is lower and the monopolist sets lower premiums, which in turns increase enrollment among other, lower risk individuals.

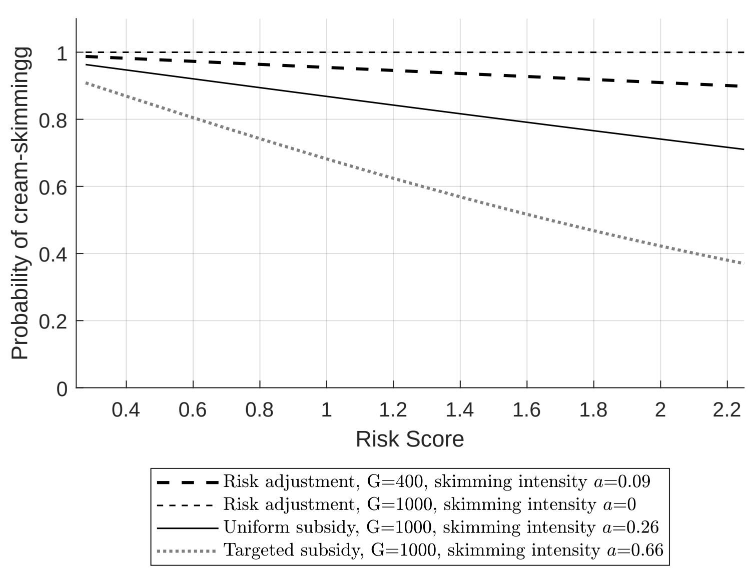
The bottom panel of Figure A.1 illustrates the optimal level of cream-skimming chosen by the monopolist under different policies and levels of sponsor spending. Consistently with intuition and with our discussion above, under risk adjustment cream-skimming is always lower than under subsidies, and absent for sufficiently high levels of spending. Under

Figure A.1: Risk Adjustment vs. Subsidies: A Cream-Skimming Monopolist

(a) Enrollment varying sponsor spending



(b) Optimal skimming by a monopolist, alternative market designs



Notes: *The figure considers the role of cream-skimming by a monopolist offering a silver plan. The top panel compares equilibrium enrollment under alternative policies compared to the baseline case illustrated in the right panel of Figure 6. The bottom panel shows the extent of cream-skimming for different levels of sponsor spending and different policies.*

subsidies, even for high levels of spending by the sponsor the monopolist avoids between 20 and 40% of types with risk score greater than 1.

From this simple exercise we can conclude that, as expected, the extent to which cream-skimming through non-pricing strategies is a concern, risk adjustment becomes more desirable and the gains of subsidies are reduced. In our simulations the markup effect continues to dominate, but this is likely to be context specific and depending on the technological and legal constraints limiting skimming by insurers.