Cost-Sharing Reduction Subsidy: Who Benefits and How It Should be Financed

Evidence from the California Health Exchange

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Abstract

With annual spending of $7 billion, the Affordable Care Act (ACA) Cost-sharing Reduction (CSR) subsidies offer extra benefits such as a lower deductible and a lower out-of-pocket maximum to eligible low-income enrollees who purchase any qualified plan on the exchanges. In October 2017, the government terminated the CSR payments, but still requires insurers to offer such extra benefits. I investigate how CSR defunding impacted insurers, consumers, and public spending. Combining individual-level claims data from a major insurer in California and individual-level enrollment data, I estimate a model of insurance demand and insurers' competition. I find that CSR-eligible households are significantly less price-sensitive and more costly for insurers to cover. Consequently, counterfactuals show that CSR defunding can reduce insurer profits and discourage insurers from participating in the exchanges. The impact on consumer surplus, insurer surplus, and government spending depends on insurers' market participation and how they raise premiums to cover the CSR costs. Removing CSR benefits impairs consumer surplus among the low-income households, and does not reduce government spending.

1 Introduction

The Affordable Care Act (ACA) Cost-sharing Reduction (CSR) subsidy is an important program on the individual health exchange markets (the exchanges) that provides extra coverage to low-income households. The ACA requires CSR provision on a certain types of exchange plans[1], and the costs were paid by the federal government since the enactment of the ACA[2]. In October 2017, however, the Trump administration terminated the CSR payments[3], leaving exchanges at the state level to respond independently. Many insurers experienced an increase in costs and in turn raised premiums. However, due to the price-linked premium subsidy design, one of many unintended effects was greater total public spending of subsidizing the exchanges. Since the 2017 change, no study has unpacked the effects of CSR de-funding, nor is there evidence that quantifies the impact on insurers, consumers, and government spending.

The key to examining CSR de-funding is insurers' response, including premium pricing and market participation. In about 45 states, insurers raised silver premiums to fund the CSRs, a solution known as "silver loading."[4] The rationale behind this is that, because premium subsidies peg to the benchmark silver plan (SLCSP) premiums, increasing silver premiums all together will simultaneously increases the level of premium subsidies. Consumer-paid premiums thus shall be little affected among the subsidized. While several studies report substantial premium increases and enrollment decision changes in 2018 (Anderson et al., 2019; Drake and Anderson, 2020; Rasmussen et al., 2019), those outcomes are not separable from insurers' diminished participation. In California, for example, Anthem left 16 markets in 2018 and narrowed its offering to plans in more restrictive networks in the remaining three markets. However, we know little about how such "silver loading" governs insurers' premium pricing.

[1]Patient Protection and Affordable Care Act, Sec. 1402.

[2]In all ACA exchanges, insurers offer plans that fit in one of four metal tiers based on actuarial value (AV): Bronze (60% AV), Silver (70% AV), Gold (80% AV), and Platinum (90% AV). The CSRs provide additional coverage such as a lower copay, deductible, and out-of-pocket maximum conditioning on a silver plan purchase. The CSR costs are defined as the difference in realized claims costs due to the CSRs. Section 2 provides more institutional details.

[3]CSR payment policy memo: https://www.hhs.gov/sites/default/files/csr-payment-memo.pdf.

[4]The silver loading mechanism is further split into two types. The first type is the standard silver loading, in which the baseline silver premiums are the same regardless of households' eligibility of premium subsidies or CSR subsidies. About 15 states follow this type to silver loading. The other type of silver loading limits the loads only to the subsidized households, thus the unsubsidized households are not directly affected by the loading. This is known as "silver loading switcheroo"; it is reported that 30 states used this approach in 2018. In California, although the state does not allow premiums to differ between the subsidized and unsubsidized population, the state lets the insurers offer unloaded silver plans off the exchange. Thus the unsubsidized households are not affected by the loading if they purchase coverage off-exchange. For more details see Anderson et al. (2019) and a summary spreadsheet here.

Nor do we know how the premium increases and market participation affect consumers. More importantly, the government ended up spending more due to the increased premium subsidy spending outweighing the savings from CSRs (CBO, 2017). Understanding the consequences of CSR defunding and its larger implications on how to finance CSRs in general, are thus public finance questions in the context of the individual health insurance market.

This paper conducts the first analysis of the consequences of CSR de-funding. I focus on Covered California, a state-run individual health exchange market. In addition to federal regulations, California requires standardized benefit designs for all on-exchange plans. The state regulators anticipated the federal CSR payment discontinuation and coordinated insurers to "load" silver premiums in 2018. I test and confirm such pricing strategy, showing that conditioning on the market and insurer, the silver premium increases in California 2018 are driven by the predicted CSRs based on previous premiums, average costs, and the enrollment share of CSR beneficiaries.

I develop a model of the market for California exchange plans that focuses on the joint distribution of household-level health risk and preference for premiums and coverage. Because CSRs increase insurers' silver plan cost-sharing non-linearly with respect to households' income levels, the equilibrium premiums depend on (1) the enrollment mix by CSR-relevant income groups, and (2) the level and slope of average claims of those income groups. With heterogeneous preference of premiums and coverage, tracking individual household's coverage choice and its marginal effect on insurers' costs is the key to examining the CSR financing question.

Previous studies of the California exchange market (Drake, 2018; Saltzman, 2018; Tebaldi, 2019) share a common data limitation on household-level medical costs. I overcome this challenge by obtaining claim-level administrative data from a major insurer who provides coverage to about 20% of California exchange enrollees. This novel dataset allows me to predict household-level medical spending, and use the prediction to estimate demand for coverage and costs to insurers. Specifically, I compute households' and insurers' cost-sharing responsibility of each plan, before and after the CSR de-funding. I then let the predicted household medical spending directly enter the demand model as part of coverage preference. Besides better capturing adverse selection, a major advantage of such modeling is that it allows me to calculate an insurer's marginal costs of covering an additional household. More importantly, it allows me to directly compute the level and slope of each plan's average costs at any given set of premiums.

With predicted medical spending and demand estimates in hand, I first report the own- and cross-tier premium elasticity of coverage by income levels. Because of their link to premium subsidies, silver plans' own-tier premium elasticity increases in income level. In particular, households with an income level below 150% of the federal poverty line (FPL) have inelastic demand for silver plans (elasticity = 0.85). As this income group receives the highest level of CSRs if enrolled in silver plans, their inelastic demand for silver plans suggests potential adverse selection with respect to CSRs.

To illustrate the substitution pattern between coverage levels, I simulate how, under a price-linked premium subsidy, enrollment and average risk of each metal tier change with increased silver premiums. With a 20 percent uniform increase in all silver premiums, total enrollment increases by 2 percentage points. The share of bronze, silver, gold, and platinum enrollment changes by 0 percentage points, -5 percentage points, 2.2 percentage points, and 4.8 percentage points, respectively. Average risk changes as enrollees substitute to a different metal tier. With a 20 percent uniform increase in all silver premiums, the average per-member-per-month (PMPM) medical spending of bronze plans decreases by 6 percent from $540 to $506. The average risk of silver plans also declines, with most significant reduction of 5 percent (from $637 to $607 PMPM) among households with income between 200%-250% the FPL. While the average risk of gold plans remains stable, the average risk of platinum steadily declines by 4 percent.

The simulation exercise suggests that marginal consumers are responsive to changes in relative premiums, and movement by those consumers has equilibrium effects on premiums. Using a demand-based graphic framework (Einav et al., 2010; Geruso et al., 2021), I show that the equilibrium effects matter in welfare calculation. Winners and losers are at both the extensive and intensive margin. The net welfare effect is ambiguous, depending on the joint distribution of risk and price sensitivity. In counterfactual analysis, I simulate the equilibrium conditions of silver loading, together with alternative CSR funding schemes such as global loading, where insurers raise premiums of all metal tiers to cover the CSR costs[5], and a scenario where the CSRs are removed from the exchange. I find that, should insurer participation and plan offering remain the same as in 2017, shifting CSR costs from the government to insurers under silver loading reduces insurer profits by -$362 million. In addition, consumers face a 5 percent average increase in silver premiums and an up to 4 percent premium increase in other metal tier plans. However, because consumers still experience a net increase in out-of-pocket premiums of many silver and platinum plans, consumer surplus only slightly increases by $3

[5]Global loading means insurers increase premiums for all on-exchange plans, including non-silver plans, to fund the CSRs. This approach assumes the CSR-related risks will transfer to other plans as households change coverage level, thus CSR-related risks should not be limited to silver plans. A small number of states (e.g. Indiana, Mississippi) use the global loading approach.

million. Because of the higher per-capita premium subsidy and a larger enrollment, government spending on premium subsidies increases by $344 million, a 14 percent increase from the status quo. The additional spending on premium subsidies offsets about half of the saving from the CSR payment.

Insurers' loss under the 2017 market participation resembles the classic prisoner's dilemma, where the no-exit assumption forces them to bear the net loss. Although I do not dynamically model insurers' exit decisions, I take the 2018 observed market participation as given and repeat the silver loading simulation. With fewer insurers and fewer plan options in the Californian exchange, premiums increase substantially for bronze, silver, and gold plans. In particular, silver premiums increase by an average of 43 percent. While premium subsidies also increase, they do not fully protect consumers from the increased out-of-pocket silver premiums. Yet, with a $106 increase in monthly premium subsidies, consumers pay less for gold and platinum plans. Overall, consumer surplus increases by $37 million, and insurer profits amount to $10 million. On the other hand, government spends $1.5 billion more on premium subsidies, resulting in a net spending increase of $772 million. With the 2018 market participation, $1 of government spending generates $1.94 of consumer and insurer surplus combined. The return per dollar of public spending reduces by 22 percent compared to the status quo.

Under global loading, I find that insurers have less incentive to leave the exchanges. Because global loading allows insurers to spread CSR-related costs to non-silver plans, insurer profits amount to $39 million. Premium increases also show a different pattern under this loading strategy. In particular, bronze plans have the highest average premium increase of 14 percent, followed by gold plans (5 percent) and silver plans (2 percent). More importantly, the per-capita premium subsidy increases by $64/month, near three times of that under the silver loading with the same insurer participation. As a result, consumer surplus increases by $37 million. Government total spending increases by $113 million compared to the status quo, and is solely due to increases in premium subsidy per-capita.

This paper contributes to the broad literature of health insurance and public finance by focusing on the design of the CSR and its role in the exchanges. Regardless of how insurers respond, as long as the ACA requires the CSR provision, and the premium subsidies are linked to the premium of a targeted plan, the federal government will continue to pay for CSR subsidies, only now indirectly via premium subsidies. Moreover, because the premium subsidy targets a much larger consumer body than the CSRs, the federal government is now effectively offering additional subsidies that equal the market-determined value of the average CSRs to those who are not CSR eligible. The efficiency in CSR provision should be discussed in three questions: (1) why the CSRs are needed, (2) how should the value of CSRs be determined, and (3) how CSRs should be distributed.

By examining the first question, this paper adds to the realm of studies on health insurance subsidy design. Besides providing consumers the protection against financial hardship from catastrophic medical spending (Gruber, 2008), coverage expansion such as CSRs also aims to improve the efficiency of coverage provision through a broader pooling, promoting a stable and competitive insurance supply (Culter and Reber, 1998; Einav et al., 2010; Hackmann et al., 2015). In line with Finkelstein et al. (2017), I find that CSRs provide extra incentives that prevent 5 percent low-income and low-risk households from leaving the Californian exchange. Removing CSRs will lead to premium increases ranging from 1 to 10 percent and a consumer surplus reduction of $32 million. Moreover, government spending increases by $54 million in absence of the CSR provision, suggesting an important role of CSRs in lowering the average risk level of the exchanges, and reducing the total costs of the program.

The second question—how should the value of CSRs be determined—relates to the literature on the interplay between subsidy design and premium pricing. Since the de-funding, the value of CSRs is determined by the level of silver premium increases. Yet, premium prices are determined by insurers' incentives and market competition. How to align them with the public interest is a social planner's problem. Previous studies have shown the misalignment between insurers' pricing incentives and subsidy program initiatives. Liu and Jin (2015) find employer contribution in the Federal Employees Health Benefits Program contributes to premium increases. Decarolis (2015) and Decarolis et al. (2020) find that Medicare Part D insurers game for subsidies paid to low-income enrollees; such gaming behavior distorts premiums and raises the program costs. Jaffe and Shepard (2020) find that price-linked subsidies weaken competition and increase the government and consumers' total spending. In the context of CSRs, insurers are discouraged from participating in the exchange due to increased costs. Those decisions in turn affect premium pricing by the remaining insurers. Although this paper does not focus on insurers' pricing incentives, the results suggest that valuing CSRs based on premium prices results in lower return on public spending.

CSR defunding empirically illustrates the effect of the price-linked subsidy design. While it protects consumers from unexpected supply-side shocks, it causes many unintended consequences. Previous studies focus on price-linked subsidy design in a market where plans are horizontally differentiated. This paper adds to the literature by examining this subsidy design in a market with vertically differentiated plans. In such a market, changes in relative premiums lead marginal consumers to substitute across coverage levels. The resulting changes in the average costs have equilibrium effects that may strengthen or attenuate the protection by price-linked subsidy against premium uncertainty. This study shows that equilibrium effects matter and have important welfare implications.

This paper also contributes to the small but emerging literature on demographic externality. Demographic externality means that when risk and price sensitivity are correlated, targeted subsidies under community rating generate inefficiency in subsidy distribution. The notion of demographic externally was first documented by Tebaldi (2019) and generalized by Polyakova and Ryan (2019): because premiums are lower in areas with more price-sensitive consumers, those consumers receive fewer subsidies; they hence pay more for the same plan compared to the otherwise identical individuals who live with less price sensitive neighbors. With the CSRs now effectively valued by silver premiums and paid by premium subsidies, consumers will have to pay more or less for the same level of CSR benefits, depending on the demographics of the market they live in. The resulting inefficiency falls in the broad category of welfare redistribution under community rating (Bundorf et al., 2012; Cutler and Zeckhauser, 2000; Geruso, 2017; Orsini and Tebaldi, 2017).

Lastly, this paper adds to the growing body of work that studies individual health insurance plan choices (Drake, 2018; Ericson and Starc, 2012; Saltzman, 2018). Compared to those studies, I use a richer set of interactions between consumer characteristics and plans' financial features in modeling preferences. I particularly leverage a novel dataset of claim-level medical spending data to predict households' expected medical spending and let the households' expected out-of-pocket spending enter the demand for coverage for each plan alternative. This approach incorporates households' heterogeneous preference at a high granularity level. It allows adverse selection to depend on observable but unpriceable demographics such as gender and income, and private information. The connection between the demand side and the supply side is thus more traceable.

The rest of this paper proceeds as follows. Section 2 summarizes the institutional background and the data environment. Section 3 presents the frameworks and descriptive evidence. Section 4 describes the empirical strategy, including a discrete choice model for the demand estimation, a medical spending model for the cost estimation, and proposals for counterfactual simulations. Section 5 reports the estimation results of the demand and cost model, as well as model validation. Section 6 reports results from the counterfactual analysis. Section 7 concludes.

2 Institution Background and Data

2.1 Covered California

The empirical work in this paper focuses on California's state-based exchange marketplace, Covered California. Like in all ACA exchanges, insurers offer plans that fit in one of four metal tiers based on actuarial value (AV): Bronze (60% AV), Silver (70% AV), Gold (80% AV), and Platinum (90% AV)[6]. Insurers are only allowed to set premiums based on age, geographic rating areas, family compositions, and tobacco use[7]. Compared to other states, California imposes several additional regulations on insurers beyond those required under the ACA. First, insurers participating in a rating area in California must offer at least one plan of each metal tier. Second, plans of the same metal tier are fully standardized. Within a given metal tier, plans have the same financial characteristics, including copay, coinsurance, deductible, and out-of-pocket maximum. Insurers only set premiums and networks to differentiate their products. Lastly, California does not allow premium surcharges for tobacco use.

Covered California consists of 19 rating regions. I define each rating region as a market because it is the geographic unit that insurers set baseline premiums[8]. Table 1 shows each rating region's enrolled population, the number of participating insurers, the average number of accessible plans, market concentration measured by HHI, and the average silver premium for a single 21-year-old enrollee (the base premium) in 2017.

2.2 Subsidies in the Exchanges

The ACA offers two types of subsidies—premium subsidies and cost-sharing reduction (CSR) subsidy—to low-income households to improve coverage and care affordability. Both subsidies play important roles in CSR de-funding. In this section, I first introduce the structure of each type of subsidy. Then I summarize the CSR subsidy de-funding in 2017 and the response by insurers in Covered California.

[6] Plans are allowed to have +/- 2% deviation from the standardized AV.

[7] Premium factors are (1) age, with at most 3:1 ratio of premium for the oldest to the youngest consumers; (2) geographic rating areas; (3) family compositions; and (4) tobacco use, limited to a 1.5:1 ratio. Lastly, policy renewal is guaranteed, and insurers are not allowed to charge a higher premium based on the consumers' medical history.

[8] The baseline premium for a product is the premium for a single 21-year-old adult. Premiums for other ages and household composition is a linear function of household members' age and other dependency status.

Table 1: Market structure in Covered California

Region	N. Enrolled Individuals	Pct Enrolled Individuals	N. Issuers	N. Plans	HHI	Average Baseline Silver Premium ($)
Rural North/Sierra	61,207	3.8	4	27	6282	362.95
Wine Country	59,955	3.72	5	33	4224	372.73
Greater Sacramento Region	91,567	5.69	5	36	4539	390.85
San Francisco	44,670	2.77	6	37	3131	380.10
Contra Costa	48,595	3.02	4	27	5427	374.33
Alameda	74,533	4.63	3	22	5117	347.05
Santa Clara	69,248	4.3	5	35	3246	344.87
San Mateo	28,659	1.78	5	32	4613	403.69
Monterey Bay	32,519	2.02	4	27	3589	381.97
Central Valley North	75,703	4.7	4	27	5172	333.22
Central Valley South	37,236	2.31	4	27	3511	294.52
South Coast	75,210	4.67	3	22	3973	301.13
Southern Desert	13,993	0.87	4	24	5458	318.37
Kern	21,424	1.33	4	27	2766	267.93
Los Angeles East	192,323	11.95	6	40	2274	227.75
Los Angeles West	245,926	15.28	7	45	1797	256.10
Inland Empire	144,301	8.96	5	35	2312	246.75
Orange County	153,589	9.54	6	40	2233	265.13
San Diego	139,177	8.65	6	44	1912	298.87

Premium Subsidies. Premium subsidies are discounts on consumers' monthly premium payments for households with incomes at or below 400% of the Federal Poverty Level (FPL)[9]. The subsidy amount equals the difference between the benchmark plan premium and the consumer's income contribution cap. The benchmark plan is the second-cheapest silver plan (SLCSP) available to the consumer. The consumer's income contribution cap ranged from 2% of annual income for a consumer earning 100% of the FPL and 9.5% of annual income for a consumer earning 400% of the FPL. Consumers can apply the premium subsidy towards the premium of any non-catastrophic metal plan on the exchange. Figure 1a presents a graphic illustration of the premium subsidy rule. Because the subsidy amount is linked with the SLCSP premium, all else equal, any change in the SLCSP premium will directly translate to a same-size change in premium subsidy.

Although the income contribution cap is set by the Internal Revenue Service (IRS), premiums for the SLCSP depend on plan menu, thus vary by rating area, county, and even ZIP code. Not all eligible households receive premium subsidies. It is also possible for households with the same income to receive a different amount of premium subsidies if they live in a different ZIP code and see different SLCSP premiums. The premium subsidies are by law

[9]If any household member is offered employer-based coverage, members in that household are not eligible for premium subsidies.

financed by the federal government.

Cost-Sharing Reduction (CSR) Subsidies. CSRs reduce the out-of-pocket cost-sharing when low-income silver enrollees seek care. In addition to the premium subsidies, households with income below 250% of the FPL receive CSR subsidies if they enroll in a silver plan. Those households face a lower copay, coinsurance, deductible, and out-of-pocket maximum. Reductions in cost-sharing increase a silver plan's actuarial value to above the 70% standard. Specifically, households with income falling in the 100-150%, 151-200%, and 201-250% of the FPL range will receive CSR benefits that boost the actuarial value of a standard silver plan to 94%, 87%, and 73%, respectively (Figure 1b). CSRs automatically reflect on the plan menu when eligible households shop on the exchange. Appendix A shows the difference in plan benefit design between a standard silver plan and a CSR silver plan. Although the source of financing is not specified in the ACA, the realized difference in copay, coinsurance, deductible, etc. between a standard silver plan and a CSR silver plan has initially been paid by the federal government until the third quarter 2017.

2.3 Termination of the Federal Payment for CSR Subsidies

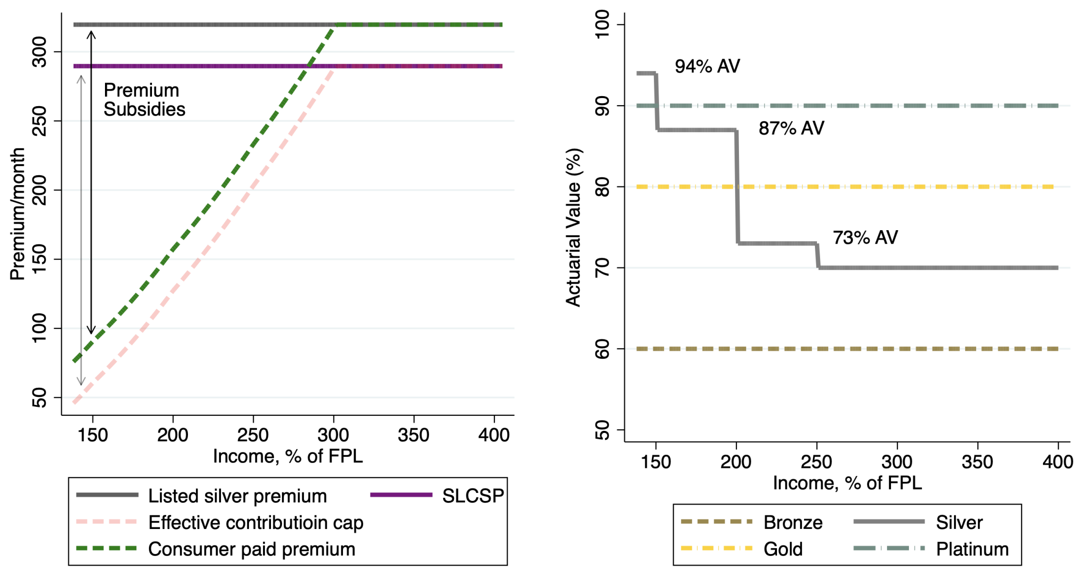
A lawsuit initiated by the U.S. House of Representative Republican members in November 2014 sought to terminate direct federal CSR funding. The suit claimed that Congress had not appropriated the money to fund the CSR payments. In October 2017, the federal government terminated CSR subsidy payment, although the ACA still requires insurers to provide CSR benefits to eligible consumers. This policy change forced the insurers to internalize the non-reimbursable CSR subsidy as costs.

In anticipation of the CSR de-funding, Covered California commissioned a study evaluating the potential consequences on enrollment if the CSR costs were funded by raising all silver premiums (Yin and Domurat, 2017). This coping strategy is later known as the "silver loading." The rationale behind this is that, because the premium subsidy has a dollar-to-dollar tied to the SLCSP, increases in silver premiums will result in similar increases in premium subsidies for eligible enrollees. The net silver premium paid by those enrollees, who account for about 90% of Covered California enrollees[10], will be mostly unaffected. Immediately following the announcement of CSR de-funding, Covered California directed insurers to increase the on-exchange silver plan premiums to cover the expected CSR costs. The Californian exchange also directed its issuers to offer non-mirrored off-exchange silver plans whose premiums

[10] Author's calculation based on Covered California enrollment data 2014-2018.

Figure 1: Premium subsidies and Cost-Sharing Reduction subsidies

(a) Premium subsidies **(b)** CSR subsidies summarized by actuarial values



Notes: Panel (a) shows how premium subsidies are calculated and applied at purchase of coverage. The purple line indicates the premium of the benchmark silver plan (SLCSP). In 2017, the average SLCSP is $284/month. The premium subsidy is calculated as the distance between the SLCSP and households' monthly contribution cap; the latter increases in households' income. For a household with income of 150% FPL, their monthly contribution cap is $61 month. This household receives $223/month premium subsidies (gray vertical line), and can use them to purchase any on-exchange non-catastrophic plan (black vertical line). A household with income of 300% FPL has monthly contribution cap of $288/month. Even though they are eligible for premium subsidies, they will not receive premium subsidies because their contribution cap exceeds the SLCSP. Panel (b) summarizes CSR subsidies by metal tiers' actuarial values with respect to enrollee income. CSR subsidies only applies to households with income below 250% FPL and only if they enroll in a silver plan.

are unaffected by the CSR cost loading to provide affordable plan options to unsubsidized households.

2.4 Testing the Silver Loading Rule

Define Load. Silver premiums increased significantly more between 2017 and 2018 than earlier plan years due to the silver loading. The average base rate (for a 21-year-old single adult) silver premiums in Covered California increase by 19 percent; the base rate premiums of the SLCSP increase by about 22 percent. Although insurers set premiums by rating area, the degree of loading appears to be independent from the CSR eligibility prevalence (see Appendix C for details). Interviews with actuaries suggest that the degree of loading is a function of the share of CSR beneficiaries out of all silver enrollees weighted by their CSR benefits. Formally, let p^s and $\widetilde{p^s}$ denote the pre- and post-loading silver premium, respectively.

$$\widetilde{p^s} = p^s + \underbrace{\mathbb{1}_{\text{load}} \frac{\sum_{i \in d^s} c_i^{\text{csr}}(y_i)}{\sum_{i \in d^s}}}_{\text{Load}}, \tag{1}$$

where d^s is the collection of individuals who choose the silver plan, and c_i^{csr} denotes the payment for the CSR benefits if a CSR eligible individual i chooses the silver plan. The fraction on the right-hand side is the load per silver enrollees, which equals the total CSR costs divided by the total number of silver enrollees. The post-loading silver premium equals pre-loading premium plus the load.

Inside the fraction, the individual-level CSR costs are expressed as

$$c_i^{\text{csr}}(y_i) = w(y_i)\bar{c^s}, \tag{2}$$

$$w(y_i) = \begin{cases} \frac{94-70}{70} & \text{if } y_i \in [138\%\text{FPL}, 150\%\text{FPL}] \\ \frac{87-70}{70} & \text{if } y_i \in (150\%\text{FPL}, 200\%\text{FPL}] \\ \frac{73-70}{70} & \text{if } y_i \in (200\%\text{FPL}, 250\%\text{FPL}] \\ 0 & \text{otherwise} \end{cases} . \tag{3}$$

The step-wise weighting function $w(\cdot)$ of income y represents the degree of CSR benefit relative to a standard silver plan. $\bar{c^s}$ denotes the average silver plan costs to the insurer. Let $q(y)$ denote the distribution of demand with respect to enrollee income y. Equation (1) can be wrote as

$$\widetilde{p^s} = p^s + \mathbb{1}_{\text{load}} \frac{\int_{d^s} w(y)q(y)dy}{Q_{d^s}} \bar{c^s} = p^s + \mathbb{1}_{\text{load}} \delta(\mathbf{p}_c)\bar{c^s}. \tag{4}$$

δ is a unit-free CSR AV cost factor that quantifies the level of silver loading, and it is a function of plan premiums. The higher value of δ, the more CSR-related costs need to be loaded to silver premiums. In particular, $\delta = 0$ if there are no CSR eligible households in the market, or no CSR eligible household purchases a silver plan. Although theoretically possible, the former case is not the interest of the discussion– there will be no need for this study if so. The latter case occurs when the net silver premium is high enough that CSR eligible households are unwilling to pay the additional premium for improved coverage, even though their CSR eligibility entitles coverage superior to a gold or a platinum plan. Table 2 summarizes the distribution of plan-level CSR beneficiary share of silver enrollment and δ in Covered California between 2016 and 2019.

Table 2: Distribution of CSR beneficiary of silver enrollees and δ

t	2016	2017	2018	2019
Δp_t (%)				
Mean	1.1	10.5	21	3.9
SD	5.4	7.4	10.4	4.7
Min	-11.2	-3.6	-14.6	-8.3
Max	12.2	22.5	58.9	16.3
CSR beneficiary share (%)				
Mean	74	71	75	76
SD	10.6	11.2	8.7	7.9
Min	44	32	47	50
Max	100	100	93	93
δ				
Mean	0.17	0.16	0.17	0.17
SD	0.03	0.03	0.03	0.02
Min	0.10	0.06	0.11	0.11
Max	0.26	0.29	0.25	0.25
N. plan-region	101	115	95	95

Test Loading in California. Rearrange Equation (4), $\frac{\widetilde{p}-p}{p} = \underset{\text{load}}{\mathbb{1}} \delta \frac{\bar{c}}{p}$. Ideally, I shall test this relationship only using the 2017-2018 data if I can observe the pre-loading premium. However, because premiums increase about 10% every year even in absence of loading, I cannot use p_{2017} to approximate for the pre-loading premium p. In other words, let $\Delta p_t = \frac{p_t - p_{t-1}}{p_{t-1}}$, then

$$\Delta p = \begin{cases} \text{premium increase} + \underset{\text{load}}{\mathbb{1}} \delta \frac{\bar{c}}{p}, & t = 2018 \text{ \& silver plans} \\ \text{premium increase}, & \text{otherwise} \end{cases} . \tag{5}$$

I test the relationship between loading and silver premium increases using Covered California enrollment data, with detailed data description presented in Section 2.5. I start by isolating the 63 unique silver plans (j)[11] that were offered in California between 2015 and 2019, and apply a difference-in-difference framework as shown in Equation (6) to study the event of silver loading. The first difference is the variation in $\delta\frac{\bar{c}}{p}$, and the second difference is the CSR policy shock in 2018.

$$\Delta p_{jrt} = \Big[\sum_t \mathbb{1}_t \times \beta_t \times (\delta\frac{\bar{c}}{p})_{jr,t-1}\Big] + (\delta\frac{\bar{c}}{p})_{jr,t-1} + \alpha_r + \alpha_{b(j)} + \alpha_t + \epsilon_{jrt}. \tag{6}$$

The dependent variable is the silver premium increase in percentage, Δp, at the plan-region-year level. The summation inside the bracket is a difference-in-difference style specification that allows the effect of load on silver premium increases $(\delta\frac{\bar{c}}{p})_{jr,t-1}$ to flexibly vary by year. α_r is the region fixed effect that controls for market-level characteristics that affect premium increases. $\alpha_{b(j)}$ is the insurer fixed effect that captures firm-wide pricing policy. α_t is the year fixed effect, and ϵ_{jrt} is the error term. The main effect of $(\delta\frac{\bar{c}}{p})_{jr,t-1}$ and other fixed effects together capture premium increases unrelated to silver loading.

Due to data limitation on region-level plan costs, I do not observe $\bar{c}$ for each plan-region-year[12]. Using aggregated $\bar{c}$ with plan-region level p^s will generate incorrect statistical inference. On the other hand, using aggregate-level p^s and Δp will attenuate variations driven by δ and reduce the statistical power. I assume silver plans at the regional level are fair-priced, hence $\frac{\bar{c}}{p^s} = 1$. I return to examine the correlation between δ and $\delta\frac{\bar{c}}{p^s}$ using estimates from the structural demand model. The correlation of 0.93 suggests the assumption $\frac{\bar{c}}{p^s} = 1$ does not invalidate the diff-in-diff estimates.

The coefficients of interest are β_ts, which are hypothesized to be 1 for β_{2018}, and 0s for other years. Table 3 column (1)-(2) report the coefficients β_t. In both specification, β_{2018} are statistically significant positive and not statistically different from 1 (F-value reported in the bottom row). Neither β_{2017} nor β_{2019} are statistically different from 0. The main effect of δ is negative but not precisely estimated.

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[11]Because of the short list of continuous plans that are offered throughout the studied period, I include any silver plan in region r in year t whose issuers operated in the rating area r in year $t-1$.

[12]The CCIIO cost data aggregate cost at plan-year level.

Table 3: Effect of CSR costs δ on percentage increase in base silver premiums

	Silver Only		All Plans	
	(1)	(2)	(3)	(4)
2016 as reference				
$\delta \times$ 2017 Silver	−0.637	−0.540	−0.021	−0.108
	(0.339)	(0.327)	(0.396)	(0.394)
$\delta \times$ 2018 Silver	1.131***	1.171***	1.247***	1.250***
	(0.296)	(0.284)	(0.370)	(0.368)
$\delta \times$ 2019 Silver	−0.391	−0.364	0.244	0.225
	(0.364)	(0.348)	(0.410)	(0.408)
δ	−0.077	−0.174	−0.385	
	(0.166)	(0.160)	(0.221)	
δ^*				−0.028
				(0.046)
Year FE	X	X	X	X
Rating area FE	X	X	X	X
Insurer FE	X	X	X	X
Network FE		X	X	X
Metal main & interaction			X	X
Observations	340	340	1769	1769
R-squared	0.786	0.806	0.756	0.758
F ($\beta_{\delta\times 2018\,\text{silver}} = 1$)	0.197	0.360	0.446	0.461

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In an alternative specification, I include plans of all metal tiers and test a triple-difference specification analogous to Equation (6). Specifically, the coefficients of interests are βs of the interactions between year dummy, metal tier dummy, and $\delta\frac{\bar{c}}{p}$ (again, assume $\frac{\bar{c}}{p} = 1$). δ is calculated as $\frac{\int_{d^m} w(y)q(y)dy}{Q_{d^m}}$ for respective metal tier m, where the weight $w(\cdot)$ is defined in Equation (3). The hypothesis under this specification is $\beta_{\text{silver},2018} = 1$ and 0 for the other year-metal combination. The estimates are reported in Table 3, column (3). The main results are very similar to the silver-only specification. Moreover, coefficients to the interaction between δ and non-2018 silver plans, $\beta_{s,t\neq 2018}$, and coefficients to interaction between δ and non-silver metal tiers in all years, $\beta_{m\neq s,t}$, are all insignificant.

The triple-difference applies the same CSR cost weights to all CSR-eligible enrollees, regardless of their actual metal tier choices. Such weights, however, are arbitrary with respect to non-silver plan premium pricing. The insignificant estimates of $\beta_{m\neq s,t}$ are as expected, but the main effects and the interactions with δ are not the best controls for non-silver plans. In column (4), I repeat the triple-difference regression but replace δ by the plain CSR-eligible enrollee share, $\delta^* = \frac{\int_{d^m} q(y)dy}{Q_{d^m}}$, for non-silver plans. The coefficients of interest are robust and the relationship between the CSR AV cost factor δ and silver premium increases is unchanged.

2.5 Data Enviornment

The empirical work in this paper draw from several data sources.

Enrollment and Outside Options. I obtain individual-level enrollment data through a public records act request under the California Public Records Act. The enrollment data includes information on individual and household identifiers, plan selection, rating area, age, income as a percentage of the FPL, gross premium, and post-subsidy premium. I use the CMS public user files[13] and the HIX Compare Data[14] to recover the plan options at 3-digit ZIP code level[15]. I use the 2017-2018 American Community Survey (ACS) (Ruggles et al., 1995) to supplement data for households who choose not to enroll through Covered California (hereafter, the outside option). I exclude any households enrolled in or eligible for another source of coverage, such as Medicaid and employer-sponsored insurance from the ACS sample, and combine with Covered California enrollment data to form the universe of all households who shop for individual health insurance on Covered California. I collapse enrollment data at the household level. The analysis data consist of about 2 million households enrolled in Covered California, and 1.4 million eligible households simulated from the ACS data who chose not to enroll on the exchange.

Table 12 reports the summary statistics of potential buyers in Covered California. Enrolled households differ from households who chose the outside option in income and household size. The enrolled households appear to have a lower income, entailing a greater share eligible for

[13]CMS marketplace products available at: https://www.cms.gov/CCIIO/Resources/Data-Resources/sbm-puf. Last access on October 31, 2021.

[14]Available at: https://hixcompare.org/. Last access on October 31, 2021.

[15] (n.d.) partial rating area and partial-county plan offering common in the all exchange marketplaces. In California, 114 out of 204 plans offered in plan year 2017 are partially offered in some counties. The precision of plan options at the 3-digit ZIP code level is important for validating the SLCSP plan and inferring the amount of premium subsidy for enrolled households.

the premium subsidy and the CSR subsidy. The share of outside option is noticeably higher among young adults and families.

Variation in plan choice sets is considerable. In California, the number of available plans ranges from 4 to 36. Premiums also vary substantially, even within a metal tier. The pre-subsidy silver premium for a 21-year-old single adult ranges from $104/month to $268/month.

Medical Spending. I obtain proprietary claim-level administrative data from a national insurer who participated in the ACA exchange marketplace in 14 states. From 2014 to 2017, the insurer operated in all 19 rating areas in California, and stably accounted for more than 20 percent of the Covered California enrollment. The cost data include individual and household identifiers; demographics information: 5-digit ZIP code, age, gender; and claims: diagnosis code, CPT code, allowed claim amount, HCI service type, CMS specialty code, and place code. I also observe information on enrolled metal tier, CSR variation, enrollment duration, and premium subsidy amount.

Privacy regulation prohibits any possible crosswalk between the enrollment data and the claims data. In fact, the claims data do not reveal the Health Insurance Oversight System (HIOS) identifier of the enrolled plan. More importantly, I do not observe the rating areas that enrollees live in. I recover each enrollee's rating areas using their 5-digit ZIP code, enrolled plan network, and pre-subsidy premium. The recovered enrollment by rating area matches the enrollment data very well (Appendix D).

I use the claims data to estimate claim costs to the insurer as well as the CSR subsidy costs that were shifted from the government. Also, I follow the HHS-HCC risk adjustment model in Pope et al. (2014) and compute each enrollee's risk score (Appendix E). Lastly, I augment the costs data using the CMS annual rate review data[16], which contains plan-level average costs for all plans sold on Covered California. Table 4 summarizes the medical consumption and the risk scores of the Covered California enrollees that I observed in the proprietary claims data.

[16] Available at: https://www.cms.gov/CCIIO/Resources/Data-Resources/ratereview.

Table 4: Summary statistics of claims data

	PMPM Allowed Amount						Adjusted HHS-HCC Risk Score					
Metal tier	Mean	SD	25pt	50pt	75pt	99pt	Mean	SD	25pt	50pt	75pt	99pt
Bronze	201	2503	0	0	45	3269	0.44	1.14	0.17	0.34	0.43	3.59
Silver	421	2920	0	40	165	7482	0.67	1.89	0.17	0.37	0.53	8.05
73% Silver	467	2964	0	37	170	8092	0.75	1.92	0.31	0.37	0.58	8.32
87% Silver	488	3390	0	43	196	7830	0.74	1.96	0.26	0.37	0.56	8.23
94% Silver	565	4690	0	47	224	8844	0.75	2.08	0.26	0.37	0.56	8.34
Gold	844	3869	1	67	302	17392	0.87	2.34	0.17	0.37	0.59	10.81
Platinum	1955	6709	18	165	824	26950	1.72	4.25	0.25	0.43	1.18	24.00

Notes: This table summarizes the risk profile of enrollees from the proprietary claims data. The risks are summarized by metal tier average and measured by (1) per-member-per-month (PMPM) allowed amount and (2) the Adjusted HHS-HCC risk score. Construction of the HHS-HCC risk score is documented in Appendix E.

3 Framework

Silver loading increased the premium subsidy by 18 percent per Californianenrollee in 2018. Greater premium subsidies increase willingness-to-pay (WTP) and hence the demand for coverage. Frean et al. (2017) use data from ACS, and Sacks (2018) uses data from the Current Population Survey (CPS) to find that premium subsidies significantly reduce the uninsurance rate. With silver loading, Drake and Anderson (2020) find that the extreme cases of $0 premium plans are associated with a 14 percent increase in enrollment among low-income households. It is also reported that exchange enrollees became more likely to change plans, especially across metal tiers in 2018 compared to earlier years (Rasmussen et al., 2019). I apply the framework in Geruso et al. (2021), more fundamentally as in Einav et al. (2010), to show the extensive and intensive enrollment changes. The framework illustrates the impact of CSR de-funding similarly to that in Kolstad and Kowalski (2012), Kowalski (2014), and Panhans (2019). I will show graphically how those changes lead to risk re-sorting in the presence of adverse selection, and how they eventually cause social welfare gains and losses that are theoretically ambiguous.

3.1 Premium Subsidies, Enrollment, and Risk Sorting

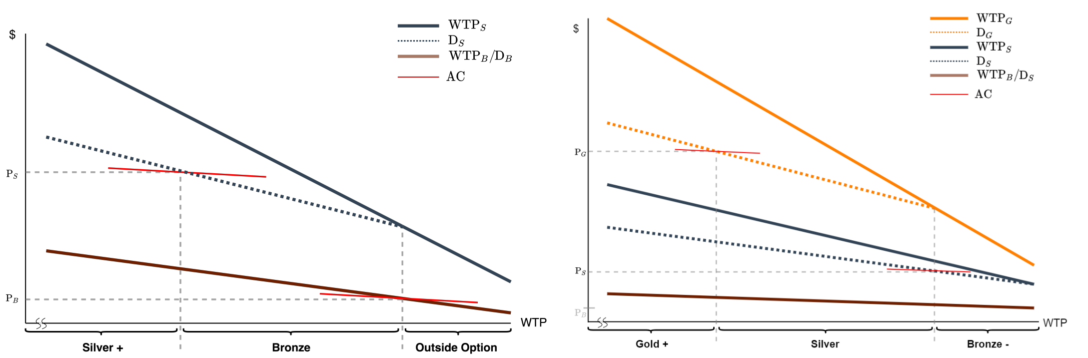
I focus on the subsidized exchange enrollees because they consist about 90 percent of the Covered California population (see Appendix F for analysis of the unsubsidized population).

Figure 2b sets up the framework graphically. The horizontal axis indexes consumers' WTP for insurance coverage, declining from left to right. The entire horizontal space represents the entire population who are eligible to purchase insurance on the exchange. The solid brown line (WTP_B) is the WTP for bronze coverage net the mandate penalty. The WTP for uninsurance is normalized to \$0 so that WTP_B is also the demand curve for bronze (D_B).

At equilibrium, bronze premium (P_B) intersects bronze's average costs and demand. Consumers to the right of the intersection remain uninsured, and those to the left of the intersection purchase insurance on the exchange. The downward sloping AC curve reflects adverse selection (Einav et al., 2010). The solid teal line (WTP_S) is WTP for silver coverage net mandate penalty. Demand for the silver is the population with $\text{WTP}_S - \text{WTP}_B \geq P_S - P_B$ (Keeler et al., 1998), represented by the dash teal line (D_S). At equilibrium, the silver premium (P_S) and the marginal bronze buyer are determined by the intersection of silver average cost and silver demand. Panel (b) "zoom-out" Panel (a) to include the more generous gold plan in the same framework.

Figure 2: Silver Loading Impact on Demand and Subsidized Enrollee Sorting: the Setting

(a) Silver vs. Bronze vs. Uninsurance **(b)** Gold vs. Silver vs. Bronze

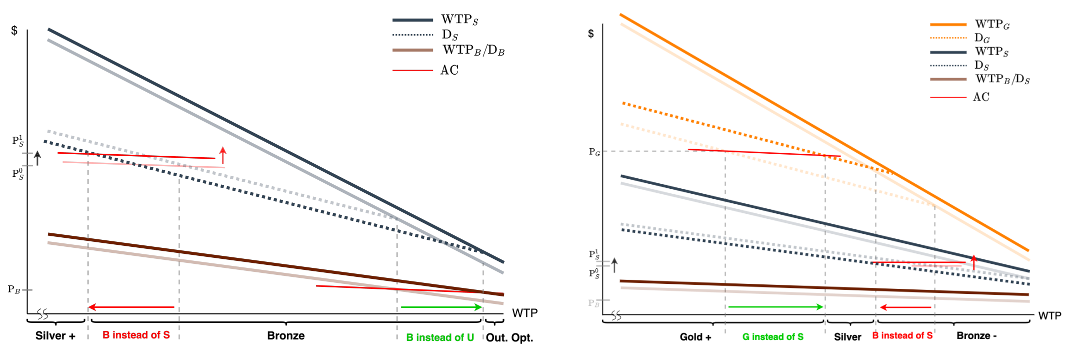


Notes: The graphs show the initial equilibrium of uninsurance, bronze plan enrollment, silver plan enrollment, and gold plan enrollment. Panel (a) shows the equilibrium of uninsurance, bronze and silver. As the lowest coverage level, WIP for bronze is the same as the demand curve for bronze. The intersection of bronze AC and bronze demand determines bronze premium P_B and the extensive margin type, who is indifferent between a bronze plan and uninsurance. The silver demand curve D_S starts at the extensive margin, and extends leftwards. Its intersection with silver AC determines the silver premium P_S and the bronze enrollee who is indifferent between a bronze and a silver plan. This marginal person determines the start of the gold demand in Panel (b).

Silver loading forces CSR subsidy costs on the insurers, the average cost for silver hence shifts upward. In the meantime, silver loading boosts up the per-capita premium subsidies, shifting WTP curves up for all plans. In the formal two-margin framework, the new market equilibriums are determined by the dynamics between demand, marginal cost, and average cost[17]. For the demonstration simplicity, I abstract away from describing the equilibrium generating process. Given adverse selection, I use the marginal consumers' movement between any pair of high- and low-coverage after the silver loading to predict the direction of AC curve shifting, and present the final position of the AC curves in the new equilibriums.

Figure 3: Silver Loading Impact on Demand and Subsidized Enrollee Sorting

(a) Silver vs. Bronze vs. Uninsurance **(b)** Gold vs. Silver vs. Bronze



Notes: The graphs show the equilibrium changes due to silver loading. The key exogenous changes are (1) the upward shift of silver AC due to the silver loading, and (2) the upward shift of all WTP curves due to increased premium subsidies. Movements of all the other curves are due to equilibrium effects. Panel (a) shows the equilibrium effect of a lower extensive margin leads a downward shift of silver demand curve, thus more individuals switch from silver to bronze. Panel (b) shows the equilibrium effect passes on to gold, where the gold demand shift upwards, and individuals on the left margin of silver shift to gold. See text body for details.

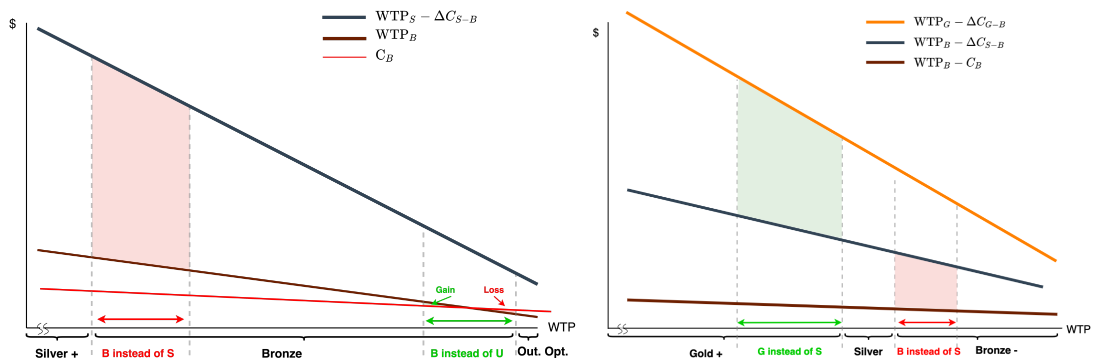
Figure 3a shows the new equilibrium between bronze and uninsurance, where the new (darker) WTP_B intersects with the bronze's new AC curve. Formally, the new AC curve is determined by the marginal risk of the newly insured and those who switch from silver to bronze. By the primary effect of the healthier newly insured, the bronze's new equilibrium moves downward along its AC curve. The new equilibrium has a lower P_B, which shifts *down* the silver demand curve. Silver enrollees with lower WTP switch on the intensive margin to lower coverage. "Zooming-out" to Figure 3b, a higher P_S leads the marginal silver enrollees to switch to gold. Because those switchers are healthier than the existing gold enrollees, the gold plan's average cost is lower in the new equilibrium. For the silver plan, because the average health risk is positively affected by the silver-to-gold switchers, but negatively affected by the silver-to-bronze switchers, the net effect is ambiguous.

Figure 4 visualizes the welfare impact. The solid lines now represent WTPs *net* the cost difference between the respective metal tier and the bronze plan. They also subtract the increased WTP by higher premium subsidies, since they are transfers from the government to consumers. As a result, the solid lines in Figure 4 are interpreted as the societal WTP for

[17] For details see Geruso et al. (2021).

Figure 4: Welfare Impact on Subsidized Enrollees by Silver Loading

(a) Silver vs. Bronze vs. Uninsurance **(b)** Gold vs. Silver vs. Bronze



Notes: The graphs show social welfare impact of silver loading on the subsidized households. Panel (a) shows the case that consumers switch on the extensive margin between uninsurance and bonze, and the intensive margin between bronze and silver. The solid lines are WTP net the difference in plan costs, and net increased premium subsidy. The welfare gain in consumer surplus is shaded in green. The welfare loss by silver consumers who switches to bronze is shaded in red. Additional loss due to allocation inefficiency is also shown in red. Panel (b) shows welfare impact on consumers who switches from silver to gold. See text body for details.

different coverage levels. The color blocks depict welfare gains (in green) and losses (in red) due to silver loading. Figure 4a focus on the welfare impact on silver and bronze enrollees. While some newly insured experience a welfare gain at the extensive margin, the others cause an efficiency loss because their willingness-to-pay for coverage is lower than the social costs to provide it. At the intensive margin, silver-to-bronze switchers experience a welfare loss. Figure 4b includes another intensive margin welfare change—the gains by silver enrollees who switch to the gold plan. Overall, this suggests that the net welfare effects of silver loading are theoretically ambiguous.

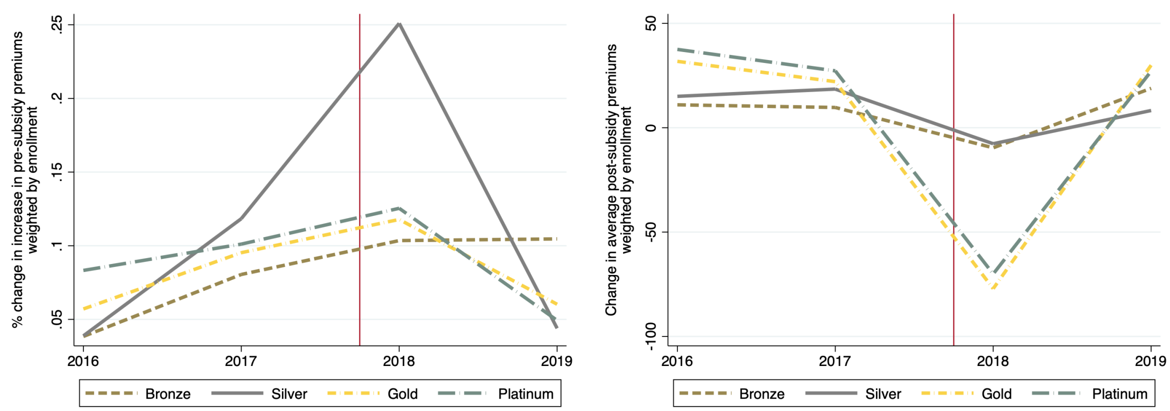
I repeat the same welfare analysis among the unsubsidized enrollees in Appendix F. Although the unsubsidized population experiences the same change in relative premiums between any given pair of high- and low-coverage plans as the subsidized one, their WTP is unaffected by the loading. Comparing Figure 4 (subsidized) and Figure 12 (unsubsidized), the subsidized population appears to have more silver enrollees switchers.

3.2 Descriptive Evidence

Figure 5a plots the trend of percentage change in average enrollment weighted premium prices of each metal tiers. While the trends are almost parallel for bronze, gold, and platinum plans between 2017 and 2018, silver premium increases peaked in 2018 at 25 percentage points. Because of their links to premium subsidies, post-subsidy premiums drop. Since only the out-of-pocket premium differences influence metal tier choices, Figure 5b shows the trend of the *level* change in post-subsidy premiums of each metal tier. All metal tiers show a dip below 0 in 2018, suggesting the average premium paid by enrollees *decreased* due to the greater premium subsidies. The observation that the level change in net silver premiums is slightly negative in 2018 indicates a reduction in unsubsidized silver enrollment, combined with a downward shift in the income level of subsidized silver enrollment. Most noticeably, thanks to the increased premium subsidy, the net premiums for gold and platinum plans significantly dropped by about $70 (about 20 percentage point drop) in 2018. The fact that the dips for gold and platinum are deeper than that for bronze suggests more premium subsidy beneficiaries switching to those generous plans. I describe the switching pattern in Table 5.

Figure 5: Change in gross and net premium prices

(a) Percentage change in pre-subsidy premiums **(b)** Level change in post-subsidy premiums



Notes: Panel (a) shows the trend of percentage change in pre-subsidy premiums of the four main metal tiers in Covered California. For each enrollee, the premiums are normalized to the baseline premium (for 21-year-old adult) such that the change is not affected by the age factors. The increase is weighted by enrollment. Panel (b) shows the trend of changes in the post-subsidy premiums levels. Similarly, the premiums are also normalized to the baseline and weighted by enrollment.

Metal switching from (to) silver substantially increased (decreased) between 2017 and 2018. Individuals receiving premium subsidies (white rows) show increased shares that stay with, or move from silver to more generous plans such as gold and platinum. In particular, about 4 percentage points more subsidized silver enrollees switch to gold plans. Retention for gold and platinum plans increased by 10 percentage points and 7 percentage points, respectively. Subsidized bronze enrollees also increased the share that switch to Gold. In contrary, unsubsidized enrollees show a weaker trend in staying or moving to generous metal tiers. Instead of re-shopping for coverage, many left the exchange (column “outside option”). Because the enrollment data do not trace enrollees’ insurance status and insurance type before they came to the exchange, I cannot report the difference in extensive margin change—whether there are more uninsured individuals in 2018 than in 2017. In the last two rows ("outside option"), I report changes in metal tier choices by new exchange enrollees. In 2018, bronze and gold plan became more attractive to the new enrollees, with subsidized consumer favors gold plans while unsubsidized enrollees favor bronze plans.

Table 5: Transition between metal tiers significantly change in 2018

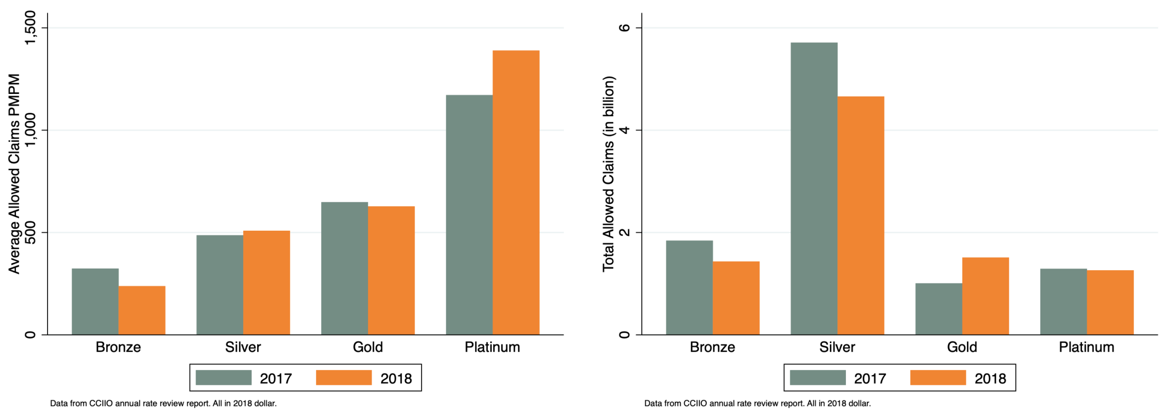
t \ $t+1$	Premium Subsidy	**Bronze**	**Silver**	**Gold**	**Platinum**	**Catas.**	**Outside Option**
Bronze	Y	-1.8%	-1.3%	2.8%	0.3%	0.0%	0.0%
	N	-0.3%	-0.7%	0.2%	0.0%	0.0%	0.7%
Silver	Y	1.1%	**-5.8%**	**4.1%**	0.6%	0.0%	0.0%
	N	1.0%	**-5.6%**	**0.8%**	0.0%	0.0%	3.8%
Gold	Y	0.9%	**-12.8%**	**10.1%**	1.8%	0.0%	0.0%
	N	1.2%	**-4.2%**	**0.5%**	0.1%	0.1%	2.3%
Platinum	Y	0.2%	**-8.7%**	1.1%	**7.3%**	0.0%	0.0%
	N	0.5%	**-1.8%**	1.7%	-1.8%	0.1%	1.4%
Catastrophic	Y	8.5%	-18.7%	9.2%	1.2%	-0.1%	0.0%
	N	-0.9%	-0.8%	0.2%	-0.1%	-0.5%	2.0%
Outside Option	Y	2.6%	-15.5%	11.0%	1.8%	0.0%	
	N	10.1%	-19.6%	7.8%	0.5%	1.2%	

Notes: Denote metal tier switching by the share of individuals who enrolled in metal m in time $t+1$ conditioning on his/her metal choice in time t: $(m_{t+1}|m_t)$. Consumers makes enrollment decisions from five coverage levels: b(ronze), s(silver), g(old), p(latinum), c(atastrophic), or n(not enroll). For a given m_t^*, the switching pattern is described by a transition vector $\langle b_{t+1}, s_{t+1}, g_{t+1}, p_{t+1}, c_{t+1}, n_{t+1}|m_t^*\rangle$; the vector sums up to 100%. Stacking the transition vectors of all m_t^* alternatives generates the transition matrix of metal choices, with the rows indexing the metal choice in plan year t, and the columns indexing the metal choice in plan year $t+1$. Cell $(b,s)_t$, for example, indicates the share of year t bronze enrollees who enroll in silver in year $t+1$. I take the difference between the transition matrix for the 2017-2018 switching and that for 2016-2017 switching such that the new cell $(b,s)_\Delta$ denotes the change in metal switching: $(b,s)_\Delta = (b,s)_{t=2017} - (b,s)_{t=2016}$. The differenced transition matrix is presented in Table 5, with each cell further grouped by enrollees' premium subsidy status in year $t+1$. All differences are significant have t-statistics significant at 1% level.

With the consumer changing coverage levels, the framework predicts a lower average risk of bronze and gold plans after the silver loading. Figure 6 reports the average and total allowed claims risk using the annual rate review data from the CCIIO. The empirical observations are consistent with the theoretical predictions. Overall, the average risk across all metal tiers is slightly lower in 2018 ($65 lower per-member-per-month). For the total enrollment, although there is no significant increase in the number of enrollees, the average weeks that a household stays enrolled in the exchange increase from 38.6 weeks to 41.8 weeks.

Figure 6: Change in the average and total risks in 2018

(a) Change in PMPM allowed claims **(b)** Change in total allowed claims



Notes: Both figures are calculated using the CCIIO annual rate review data. All numbers are in 2018 dollar.

4 Structural Model and Estimation

To quantify the welfare changes to consumers and insurers, I model consumers' plan choices using a discrete choice model. In this section, I first describe the demand model (Section 4.1). A key choice determinant is households' projected medical spending. The construction of this variable is documented in Section 4.2. I then model the insurers' costs (Section 4.3) and the equilibrium conditions for counterfactual simulation (Section 4.4). The welfare matrix is described in Section 4.5.

4.1 Demand

I estimate a nested logit choice model for insurance demand. Insurance decisions are made at the household level, particularly because both premium subsidy and CSR subsidy schedule are based on household income and household composition[18]. Households choose between

[18]Previous work on ACA plan choices such as Saltzman (2019), Drake (2019), Tebaldi (2019) all treat household as the unit for insurance decision making. Empirically, more than 98% of households observed on the Covered California purchased enrolled in the same plan at a single purchase.

Covered California plans and an outside option of uninsurance based on relative price and coverage of each option. Each household h is characterized by observable demographics $\mathbf{Z}_{ht} = \{z_{ht}, d_{ht}, a_{ht}, y_{ht}\}$: z is the rating region the household resides in; d is the household's gender composition and number of dependents; a is the household total age factor[19]; and y is the household income as a percentage of the FPL.

Household h has an indirect utility function such that plan j in year t generates mean utility

$$u_{hjt} = -\alpha_h^p \widetilde{p_{hjt}^c} - \alpha_h^{\text{AV}}(C_{ht})\text{AV}_{hj} + \boldsymbol{\nu}_j + \psi_{hjt} + \xi_{jt}. \quad (7)$$

Household utility depends on average monthly premium per household member $\widetilde{p_{hjt}^c}$, preference of coverage, approximated by a plan's actuarial value (AV_{hj}), the mean utility of plan's non-financial features $\boldsymbol{\nu}_j$, choice friction ψ_{hjt}, and plan's unobserved characteristics ξ_{jt}.

Premium. Premiums for the households depend on household composition, household income, and household residence.

$$\widetilde{p_{hjt}^c} = \max\left\{r_{ht}\widetilde{p_{jt}} - \underbrace{\max\{r_{ht}\widetilde{\underline{p}_{ht}^s} - \text{cap}_{ht}, 0\}}_{\text{Premium Subsidy}}, 1\right\}, \quad j \neq 0 \quad (8)$$

By the ACA premium subsidy schedule, the total premium a household pays for plan j is the baseline premium $\widetilde{p_{jt}}$ (after CSR loading) adjusted by the sum of household members' age multiplier $r_t(a_{ht})$ net the household subsidy. The subsidy amount is the gap between age multiplier adjusted second-lowest-cost-silver-plan (SLCSP) $r_{ht}\widetilde{\underline{p}_{ht}^s}$ and the household's maximum contribution $\text{cap}(y_{ht})$. Because many plans are offered to partial county, even within a rating area, the SLCSP premium $\widetilde{\underline{p}_{ht}^s}$ varies by county and by ZIP code. The contribution cap as a proportion of household income increases linearly in income level for households that earn between 100% and 400% FPL. To address preference heterogeneity common in the health insurance market (Geruso, 2017) and to closely track substitution patterns for the three CSR eligible income groups, I allow the marginal utility of premium $-\alpha_h^p$ to vary by household income and households' average age bracket in order to track how the plan-level loading needs respond to silver premium pricing, that is $\frac{\partial \delta}{\partial p^s}$. In practice, I let α_h^p to be additive of income, age,

[19] Covered California adopted the federal age curve for aged-based premium adjustment. Following the age curve change in 2018, the age factors for enrollees younger than 21 year old increased exogenously, affecting about 10% of enrolled households and potential buyers. See Footnote 26 for more details.

and household composition specific premium preference: $\alpha_h^p = \alpha_{y_h}^p + \alpha_{a_h}^p + \alpha_{d_h}^p$. Specifically, $\alpha_{y_h}^p$ varies across five income groups: income under 150% FPL, income between 150% and 200% FPL, income between 200% and 250% FPL, income between 250%, and 400% FPL and income above 400% FPL. The first three income groups correspond to households that are eligible for the three levels of CSR subsidies, and are also eligible for premium subsidies. The fourth income group (250% and 400% FPL) corresponds to households only eligible for premium subsidies. The last income group is households eligible for neither subsidies. The age-specific premium preference $\alpha_{a_h}^p$ varies by five age groups[20]. The household composition component $\alpha_{d_h}^p$ allows single-member households to have a different premium preference from families.

Coverage. Preference for plan coverage depends on households' demographics in two aspects. First, the actuarial values of silver plans boost up to 73%, 87%, or 94% for CSR eligible households, depending on the households' income as a percentage of the FPL. Thus, I use the CSR eligibility adjusted actuarial value, AV_{hj}, in calculating the indirect utility. Second, households of higher health risk, C_{ht}, may place a greater value on plan coverage (adverse selection). Moreover, conditioning on health risk, household income levels may govern coverage preference. To capture both adverse selection and preference heterogeneity, I let $\alpha_h^{\text{AV}} = \alpha^{\text{AV}} + \alpha_{yh}^{\text{AV}} \times (C_{ht}^{\text{pctl}} - 1)$, where α_{yh}^{AV} varies by the same five income groups as defined in premium preference. The interaction with per-person health risk percentile C_{ht}^{pctl} (measured within a region) captures adverse selection: conditioning on income group, high-risk households gain higher utility from generous coverage. I will dedicate Section 4.2 for the modeling household's expected medical spending C_{ht}. In short, the projected medical spending depends on observable household characteristics. Because I extrapolate medical spending parameters from a single insurer's claims data, I let the medical spending enter the utility function via its first moment instead of its distribution. By this, I trace risk selection yet abstract away from the assumption that households are fully informed about the current distribution of their medical consumption.

Non-financial Characteristics. Within a metal tier, plans differ in other dimensions such as brand and network. Preference of those non-financial features is captured by $\boldsymbol{\nu}_j$. The last observed component is monetized choice friction ψ_{hjt}. I allow choice friction at the insurer (f) and plan level (j): $\psi_{hjt} = \psi_{hjt}^{f^t = f^{t-1}} + \psi_{hjt}^{d^{t-1}=j}$.

[20] I let the age-specific premium preference to differ for households with average age younger than 21 year old, between 21 and 30 year old, between 31 and 40 year old, between 41 and 50 year old, and older than 51.

Outside Option. The utility u_{h0t} of the outside option of uninsurance equals

$$u_{h0t} = -\alpha_h^p \rho_h + \nu_0(\mathbf{Z}_{ht}), \tag{9}$$

where ρ is the mandate penalty, and ν_0 is the utility of uninsurance. Similar specification is also used in Jaffe and Shepard (2020) and Polyakova and Ryan (2019) to captures the difference in the average level of utility that consumers get from (not) purchasing any insurance plan. Because the income-specific marginal utility is the key to capture the substitution patterns for the CSR eligible households, I allow ν_0 to vary by the same five income groups as previously defined. In addition, I let single-member households have a different mean utility of the outside option to capture their potential lower disutility of uninsurance. Overall, letting ν_0 to vary by household demographics allows me to better match with the observed substitution pattern, especially the elasticity of insurance demand with respect to post-subsidy plan premiums.

I cluster choice alternatives by two nests k: (1) a nest containing only the outside option, and (2) a nest containing all exchange plans. This two-nest structure addresses the potential concern that a logit model might overestimate substitution to the outside option because of its proportional substitution assumption.

I assume random utility with additive and separable choice noise. Specially, I assume that the utility $v_{hjt} = u_{hjt} + \varepsilon_{hjt}$, where ε_{hjt} follows a Type-I extreme distribution with variance σ_r that varies by rating region. Households make choices d_{ht} from choice set $\mathcal{J}_{ht}$ such that $d_{ht} = \arg\max_{j \in \mathcal{J}_{ht}} \{v_{hjt}\}$.

4.2 Expected Total Medical Spending

I assume medical incidences arrive in a Poisson process with rate $\lambda_{it(r)}$ for member i in household h that lives in region r. In practice, I model and estimate cost parameters region by region, thus for simplicity I suppress r in the subscription. Suppose the l^{th} incidence incurs costs L^l, and $\{L_{it}^l\}$ constitutes an i.i.d. sequence of random variable generated from a exponential distribution with parameter θ_{it}[21]. The total medical expenditure equals

$$\tilde{c}_{it} = \sum_{l=1}^{N_{it}} L_{it}^l, \tag{10}$$

[21]Both the exponential and Weibull distribution generates a better fit than log-normal distribution in model fitting. In choice-model validation within the insurer that provided the proprietary claims data, the exponential and Weilbull model produces similar choice predictions. Yet, the exponential distribution requires one fewer parameter in modeling. I thus use exponential distribution as the preferred model.

where

$$N_{it} \sim \text{Poisson}\,(\lambda_{it})\,, \quad \lambda_{it} = \exp(\mathbf{Z}_{it}\gamma^n),$$

$$L_{it} \sim \text{Exp}(\theta_{it}), \qquad \theta_{it} = \exp(\mathbf{Z}_{it}\gamma^l),$$

Both frequency and severity are functions of individual characteristics $\mathbf{Z}_{it}$. The total medical expenditure $\tilde{c}_{it}$ is the convolution between the incidence frequency and severity. By assumption that $\{L_i^l\}$ is i.i.d.,

$$C_{it} = \mathbb{E}(\tilde{c}_{it}) = \mathbb{E}(N_{it})\mathbb{E}(L_{it}) = \lambda_{it}/\theta_{it}. \tag{11}$$

The projected medical spending C_{ht} for household h is $\sum_{i\in h} C_{it}$. The per-person risk percentile C_{ht}^{pctl} in the demand model is calculated as the within region percentile of $\{\frac{1}{n_h}C_{ht}\}$.

Essentially, I model the medical spending as a compound Poisson process. This decision is for the following reasons. First and foremost, it aligns with the actuarial pricing model (Cerchiara and Magatti, 2014; Klugman et al., 2008). The Poisson distribution of frequency N_{it} ensures probability mass for \$0 spending. Compared with other truncated models, the compound Poisson requires less parametrization and is less computationally intense. Second, the compound Poisson has the desired additive property that entails a simple closed-form first moment $\mathbb{E}(\tilde{c}_{it})$, as well as the aggregation of the expectation of medical spending within a household. The closed-form first moment significantly reduces the computation burden in the choice model estimation. Moreover, it provides a simple yet actuarially consistent way to compute equilibrium premium prices.

4.3 Expected Costs to Insurer

Insurers' costs to cover household h under plan j consists of two parts: claims costs based on standardized coverage by metal tier, and CSR benefit costs C_h^{csr} if those costs are borne by the insurers:

$$C_{hjt} = \begin{cases} C_{ht} - \text{OOP}_{hjt} & h \text{ is not CSR eligible} \\ C_{ht} - \text{OOP}_{hjt} & h \text{ is CSR eligible } \& \; j \neq \text{silver} \\ C_{ht} - \text{OOP}_{ht,70\%\text{ Silver}} + \mathbb{1}_{\text{load}} C_{ht}^{\text{csr}} & h \text{ is CSR eligible } \& \; j = \text{silver} \end{cases}.$$

The OOP$(\cdot)$ denotes households' projected out-of-pocket (OOP) medical spending. It is a function of households' total medical expenditure projection C_{ht}, the plan's coverage matrix

$\mathbf{X}_j$, and household demographics $\mathbf{Z}_{ht}$ such as the number of dependents[22]. Here I focus on three key benefit attributes: deductibles, coinsurance, and maximum OOP limit. As a stylistic demonstration, OOP_{hjt} is a step-wise function of the household-level aggregate expected total medical expenditures C_{ht}:

$$\text{OOP}_{hjt} = \begin{cases} C_{ht} & C_{ht} < \text{Deductible}_{hj} \\ \text{Deductible}_{hj} + \text{Coin.}_{hj} \times (C_{ht} - \text{Deductible}_{hj}) & C_{ht} \in [\text{Deductible}_{hj}, \text{OOP max}_{hj}] \\ \text{OOP max}_{hj} & C_{ht} > \text{OOP max}_{hj} \end{cases}.$$

Because the plans on Covered California are standardized, a plan's metal tier $m(j)$ fully captures the above three attributes of each plan. However, because the coverage for a silver plan varies depending on a household's CSR eligibility, the benefit attributes are household-specific. In practice, triggers of family deductible and family out-of-pocket maximum require conditions on both individual members' spending as well as the household's total spending. I follow the exact individual and family deductible rules in calculating households' expected OOPs.

The CSR benefit costs C^{csr}_{ht} only incurred after 2018 when the insurers started to bear CSR costs. They are the differences between the accumulative amount a CSR household would have paid in a standard silver plan, and what the household actually pays with CSRs. Define

$$C^{\text{csr}}_{ht} = \text{OOP}_{ht,\text{70\% Silver}} - \text{OOP}_{ht,\text{CSR Silver}}. \tag{12}$$

where $\text{OOP}_{ht,\text{CSR Silver}}$ denotes a household's expected out-of-pocket medical spending under the CSR corresponding actuarial values, and $\text{OOP}_{ht,\text{70\% Silver}}$ denotes its out-of-pocket medical spending under a standard silver plan (70% AV)[23].

[22]Conditioning on the same medical expenditure per household member, larger families will have lower OOPs per member under the same coverage

[23]The realized CSR costs to the insurers requires modeling of utilization frequency by service type, e.g. primary care physician visit, specialist visit, test, imaging, etc. For low utilization services such as advanced imaging, the claims data are short in power to model them on the full set of individual characteristics. Conversations with actuaries confirms that the current model that treats CSR costs as a proportion of the average silver plan costs is generally consistent with actuarial pricing, especially how the actuaries adjusted the 2018 silver premiums prices for loading. In Section 2.4, where I similarly model the CSR costs, the predicted silver premium increases are consistent with the 2018 premium data. The current model thus should suffice to capture the CSR costs shifted to the insurers.

4.4 Equilibrium Premium Pricing

Revenue Source. In an environment without risk-adjustment, the net revenue from an household h under plan j is $\widetilde{p_{hjt}} - C_{hjt}$. With risk-adjustment, the literature assumes that the risk adjustment will (almost) fully capture risk selection of each plan, thus risk selection (beyond what's accounted by age and geographic risk factors) based on hidden sickness is irrelevant (Handel et al., 2019; Jaffe and Shepard, 2020; Polyakova and Ryan, 2019; Tebaldi, 2019). Another common approach is to estimate an adjustment factor for the premiums p_{jt}, or an adjustment factor for the costs C_{hjt}, such that after adjustment, the premium minus cost reflects the post risk adjustment profit from selling plan j to household h. Because I predict claims costs for individual household, I directly compute risk-adjustment transfer τ received for covering household h as the difference between the insurer's predicted average claims and $\bar{C_f}$, and the predicted average claims weighted across all firms $\bar{C}$:

$$\tau_{ht} = n_{ht} \times (\bar{C_f}(\mathbf{p}_t) - \bar{C}(\mathbf{p}_t)). \tag{13}$$

Equation 13 is derived based on the risk-adjustment payment calculation from Pope et al. (2014) and Kautter et al. (2014), and is extensively discussed in Saltzman (2020). The net profit from for household under plan j is:

$$\widetilde{p}_{hjt} - C_{hjt} + \tau_h(\mathbf{p}_t). \tag{14}$$

Risk corridors expired in 2016, a year before the studied period. Thus it does not enter the profit function.

Premium Pricing. Formally, in a given region r, the insurer offers one product in each metal tier. The insurer sets a post-loading price vector $\widetilde{\mathbf{p}} = \langle p^b, \widetilde{p^s}, p^g, p^p \rangle$ to maximize total profits across all products.

$$\begin{aligned} \Pi(\mathbf{p}_t) &= \sum_{j \in \mathcal{M}} Q_{jt}(\widetilde{\mathbf{p}}_t)(\widetilde{p}_{jt} r_{jt} - \mathbb{E}(C_{hjt}) + \tau_t) \\ &= \sum_{j \in \mathcal{M}} \sum_{h} \Pr_{hjt}(\widetilde{p}_{hjt} - C_{hjt} + \tau_{ht}(\widetilde{\mathbf{p}}_t)). \end{aligned} \tag{15}$$

where $\sim$ on price vector denotes the post-loading premiums as defined in Equation (4), and superscript c denotes post premium subsidy. The Nash-in-price equilibrium is defined by the first-order condition $d\Pi/d\widetilde{\mathbf{p}} = 0$, given all prices set by other insurers. I numerically solve the optimal $\widetilde{\mathbf{p}}^*$ in equilibrium under the ACA medical loss ratio (MLR) constraint[24].

4.5 Welfare Calculation

I use the estimated model to compute social welfare before and after the silver loading is token in place. The social welfare has three components: consumer surplus (CS), insurer profits (Π), and government subsidy spending (GS),

$$W = CS + \Pi - GS. \tag{16}$$

Producer surplus Π is calculated following Equation (15), where risk adjustment is already included as a part of revenue. Following in Small and Rosen (1981), the consumer surplus for household h given their cost and demand parameters Θ_h takes the form of log-sum:

$$CS_{ht} = \frac{1}{\alpha_h} \ln \Big(\sum_{j \in \mathcal{J}_h} \exp(u_{hjt}(\Theta_h)) \Big), \tag{17}$$

Summing up all households in the sample yields the total consumer surplus.

Government subsidy spending consists of two parts: premium subsidy payment and CSR benefit payment. For household h, the government pays premium subsidies equal $\max\{m_h \widetilde{\underline{p}^s_h} - \text{cap}_h, 0\}$, where $\widetilde{\underline{p}^s_h}$ is the post-loading, if applied, second-lowest-cost-silver-premium (Equation (8)). For enrolled household h, the government pays CSR benefit c^{csr}_{ht} in 2017, which is defined as in Equation (12). In total, government spending on subsidies equals

$$GS = \underbrace{\sum_h \sum_{j \in \mathcal{J}_h, j \neq 0} \Pr_{hjt} \max\{m_h \widetilde{\underline{p}^s_{ht}} - \text{cap}_h, 0\}}_{\text{premium subsidy}} + \underbrace{(1 - \underset{\text{load}}{\mathbb{1}}) \sum_h \sum_{j \in \mathcal{J}_h, j \in \text{silver}} \Pr_{hjt} c^{\text{csr}}_{ht}}_{\text{CSR subsidy}}. \tag{18}$$

Silver loading ($\underset{\text{load}}{\mathbb{1}} = 1$) saves government spending on CSRs. However, a higher $\widetilde{\underline{p}^s_{ht}}$ increases premium subsidy per individual enrollee as well as the total enrollment. The net change in government spending is ambiguous.

The last piece of the welfare matrix is potential savings in public spending by insuring

[24]The MLR regulation stipulates that insurers in the ACA market spend at least 80 percent of their revenue on healthcare claims and quality improvement, constraining the markups to be at most 25 percent, and requiring insurers to rebate extra revenue consumers. Although I cannot observe insurer's spending on quality improvement, which needs to be added to the claim spending, Cicala et al. (2019) suggests that this type of spending is very small. I implicitly impose the 80% MLR constraint on first order condition.

households on the exchanges. I account for the fact that when a consumer enrolls in an exchange plan, the government is likely to save on uncompensated care payments. Following the Kaiser Family Foundation and Urban Institute 2013 report on public spending on uncompensated care for the uninsured (Coughlin et al., 2014), I assume that the uninsured only pay 35 percent of their expected medical spending, leaving the rest to government uncompensated care payments. Because the cost model predicts the *ex-post* expected medical spending after households take-up insurance, I account for cost increases due to insurance coverage (i.e., moral hazard) by dividing a cost factor $\phi = 0.25$ based on the results from the Oregon Heath Insurance Experiment (Finkelstein et al., 2017, 2019, 2012). Formally uncompensated care payments for a household C^U_{ht} is

$$C^U_{ht} = \frac{0.65C_{ht}}{1+\phi}\mathrm{Pr}_{h0t} \tag{19}$$

The government outlay equals the spending on premium and CSR subsidies minus saving on uncompensated care payments.

5 Model Estimates and Results

Cost Model. Table 16 presents estimations of the frequency parameters γ^n and severity parameters γ^l. I use the number of claims filed per month to predict care utilization frequency, and use the panel of allowed amount of all claims to estimate the claim severity. Both sets of parameters are estimated using GLM. The cost models aim to best fit the observed care utilization pattern in the claims data based on a rich set of individual demographic characteristics while preserving estimation power. The reported parameters are thus for a model fitting purpose rather than recovering a causal relationship. Since the model contains interactions of demographic characteristics, including a high degree polynomial of age, the variation in the estimated parameters by demographic groups is not alone very informative. Figure 15 plots predictions of logged individual-level PMPM expected medical spending (frequency×severity) by income group. The distribution of predicted medical spending is similar across the three CSR relevant income groups, and noticeably lower for income group eligible for premium subsidy but ineligible for CSR benefits. The unsubsidized households have the lowest average risk.

Demand Model. The probability for household h to choose plan j is

$$\Pr(d_{hjt}) = \frac{e^{u_{hjt}/\sigma\lambda_k} \sum_{j\in k}(e^{u_{hjt}/\sigma\lambda_k})^{\lambda_k-1}}{\sum_{k=1}^{2}\sum_{j\in k}(e^{u_{hjt}/\sigma\lambda_k})^{\lambda_k}}. \tag{20}$$

I estimate the demand model in two steps. First, I use the proprietary data to estimate the medical incidence rate and severity parameters $\Theta^S : \{\gamma^n, \gamma^l\}$ for each rating area. Then I feed those estimates as truth to plan choice estimation. The claims data contain a rich set of enrollee's demographics. Most importantly, I observe the pre- and post-subsidy premium of each household. Although I do not observe households' exact income, the amount of premium subsidy together with 5-digit ZIP level SLCSP premium allows me to recover their income level as percentages of FPL. This enables me to estimate cost parameters using the same set of demographic characteristics $\mathbf{Z}_{ht}$ used in the demand estimation. With cost parameters, I estimate the demand model using maximum likelihood.

Identification of premium sensitivity raises from the following sources: (1) the upper-income limit for subsidy eligibility that creates a discontinuity in household premiums at 400% of FPL; (2) the 57% increase in the age rating curve that creates a discontinuity in premiums between ages 20 and 21 in 2017[25]; (3) the 2018 policy decision to increase in premium age-factor curve for individuals under the age of 21 creates exogenous premium variation between 2017 and 2018[26] (Table 15). I combine 2017-2018 enrollment data in the demand estimation to fully leverage the above sources of premium variations. The premium increase due to silver loading also contributes to exogenous premium shock across plan years. However, the degree of silver loading is endogenous to local demand, as it depends on the demand of the silver coverage of each issuer and network, as well as the share of the silver demand by CSR eligible households. To address this endogenous problem, I include insurer-year fixed effect in the utility function. Although the canonical approach that estimates plan-level mean utility (Berry et al., 1995) is more commonly used, the plan-level dummies would absorb household-level premium variations that are key to the identification. Thus, I apply the control function approach as in Petrin and Train (2010) and Saltzman (2018) to address the additional endogeneity issue.

Table 6 reports a summary of the demand estimates from the nested-logit specification.

[25] Also see Saltzman (2018) for identification strategies for ACA enrollment decisions in earlier years.

[26] CMS announcement and guideline are accessible at https://www.cms.gov/CCIIO/Resources/Regulations-and-Guidance/Downloads/Final-Guidance-Regarding-Age-Curves-and-State-Reporting-12-16-16.pdf.

Table 6: Average Estimate of Demand Model

	Household-weighted mean coefficient	Mean coefficient S.E.	Min of 19 regions	Max of 19 regions	S.D. of 19 regions
Net Premium ($100 monthly per person)					
Premium, 138%-150% FPL	-1.135^{***}	0.081	−3.968	−0.115	0.124
Premium, 150%-200% FPL	-1.340^{***}	0.185	−4.190	−0.349	0.029
Premium, 200%-250% FPL	-1.110^{***}	0.223	−3.971	−0.183	0.017
Premium, 250%-400% FPL	-1.127^{***}	0.199	−3.968	−0.121	0.028
Premium, > 400 FPL	-1.204^{***}	0.187	−4.002	−0.115	0.035
Premium, family	−0.012	0.130	−0.137	0.124	0.052
Premium, <21 year old	1.301^{***}	0.285	−1.050	2.664	0.018
Premium, 21-30 year old	0.348^{**}	0.164	−0.761	3.296	0.028
Premium, 31-40 year old	0.305^{*}	0.157	−0.367	2.851	0.022
Premium, 41-50 year old	0.512^{***}	0.185	−0.550	3.124	0.020
Premium, >51 year old	0.339^{*}	0.193	−0.247	3.397	0.009
Expected consumer OOP ($100 monthly per person)					
OOP, 138%-150% FPL	< 0.001	0.080	< 0.001	< 0.001	< 0.001
OOP, 150%-200% FPL	< 0.001	0.184	< 0.001	< 0.001	< 0.001
OOP, 200%-250% FPL	< 0.001	0.226	−0.013	< 0.001	< 0.001
OOP, 250%-400% FPL	< 0.001	0.183	−0.003	< 0.001	< 0.001
OOP, > 400 FPL	< 0.001	0.077	< 0.001	< 0.001	< 0.001
Actuarial Value					
AV	2.313^{***}	0.481	0.196	7.984	1.454
AV×(risk percentile − 1), 138%-150% FPL	0.034	0.071	< 0.001	0.050	0.002
AV×(risk percentile − 1), 150%-200% FPL	0.026	0.037	0.009	0.058	0.001
AV×(risk percentile − 1), 200%-250% FPL	0.007	0.079	< 0.001	0.039	< 0.001
AV×(risk percentile − 1), 250%-400% FPL	0.008	0.072	< 0.001	0.026	< 0.001
AV×(risk percentile − 1), > 400 FPL	< 0.001	0.080	< 0.001	< 0.001	< 0.001
Network					
HMO/HSP	Reference				
PPO	0.572^{***}	0.102	−0.872	7.337	0.067
EPO	0.827^{***}	0.085	−0.718	1.746	0.067
Insurer					
Anthem	Reference				
Blue Shield	0.353^{***}	0.101	−1.147	2.048	0.068
Kaiser	0.924^{***}	0.101	−11.482	2.123	0.070
Oscar	-1.212^{***}	0.182	−1.361	−0.643	0.105
Molina	1.521^{***}	0.125	0.739	7.281	0.077
CCHP	−0.670	0.483	−0.672	−0.669	0.004
Health Net	0.914^{***}	0.122	−0.517	2.583	0.102
Health Net Life	-0.615^{***}	0.211	−0.890	−0.045	0.012
Valley Health	0.868	0.546	0.868	0.868	< 0.001
Sharp Health	1.408^{***}	0.338	1.408	1.408	< 0.001
LA Care	0.332^{*}	0.183	−0.105	0.824	0.097
Western	−0.181	0.234	−0.250	−0.075	0.007
Friction					
Insurer friction	1.822	0.080	0.370	2.390	0.526
Plan friction	2.564	0.080	0.594	3.705	0.854
Nest parameter	0.752^{***}	0.044	0.184	1	0.241

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Since I estimate the demand model region-by-region, I report the average coefficients weighted by each rating areas' total number of potential buyers. The significance level is calculated using the mean coefficients and the combined asymptotic distributions of all regions. Premiums sensitivity do not monotonically decrease in income. In fact, households in the lowest income group (138%-150% FPL) are the least responsive to premiums, whereas households with income of 150%-200% FPL are the most premium sensitive. Since I also allow the marginal utility of premium to vary by the average household age, the distribution of age group within income group is also relevant in predicting households' response to premium changes.

A key interest of the demand model is how households' metal tier choice response to premiums. In Table 7, I report the average own- and cross-tier premium elasticities of coverage. For a one percent increase in the silver base premium (for a 21-year-old adult), enrollment of the 94% CSR silver, 87% CSR silver, and 73% CSR silver decreases by 0.8, 2.4, and 3.3 percent, respectively. On the other hand, the enrollment of standard silver plan decreases by 7.2 percent. Silver premium increases lead to a higher share of CSR silver enrollment. At plan level, $\frac{d\text{CSR share}}{dp^s}$ ranges from -0.3 to 0.3, with a enrollment weighted mean of 0.05.

5.1 Model Fit and Validation

In Table 8 column (1)-(2), I show that the demand model is flexible to produce an accurate prediction of coverage choices. Column (3)-(5) compare the distribution of the predicted total risk measured by the PMPM allowed amount with that reported in the CCIIO data. In particular, I compare the reported risks (column 3) with the prediction based on the observed coverage choices (column 4), and the prediction based on the predicted coverage choices (column 5). Column 4 shows that the cost model predicts risks vary close to the CCIIO data. In Figure 16, I show that the model also performs well at predicting plan-level risks. Column 5 suggests that when combining choice and cost prediction, the model tends to under predict the risks for gold and platinum plans, and over predict the risks for the 87% and 94% CSR silver plans. In the rest of this session, I will discuss the possible sources of the prediction errors and how I check the robustness.

Robustness Check. Because the 87% and 94% CSR silver variations are cheaper and more generous than the gold and platinum plans, eligible households with high expected medical spending are better-off by enrolling in the CSR silver variations instead of gold or platinum plans. Our demand estimation suggests that about a third of low-income gold and platinum enrollees would choose a CSR silver variation given the predicted premium and coverage

Table 7: Cross-tier Elasticities

Panel (a): 138%-150% FPL, eligible for CSR 94% silver + premium subsidy

1% increase in	% change in probability of choosing				
base premium of	Outside	Bronze	Silver	Gold	Platinum
Mandate penalty	−0.3779	0.0353	0.0353	0.0352	0.0351
Bronze	0.2364	−3.0111	0.3268	0.3258	0.3253
Silver	2.3496	3.4797	−0.8628	3.4788	3.3891
Gold	0.0909	0.1536	0.1536	−5.0432	0.1462
Platinum	0.0893	0.1296	0.1296	0.1296	−5.8136

Panel (b): 150%-200% FPL, eligible for CSR 87% silver + premium subsidy

1% increase in	% change in probability of choosing				
base premium of	Outside	Bronze	Silver	Gold	Platinum
Mandate penalty	−0.4348	0.1086	0.1086	0.1086	0.1076
Bronze	0.6046	−4.1119	1.0054	1.0056	0.9921
Silver	2.4517	4.2168	−2.4495	4.2176	4.2126
Gold	0.2254	0.3557	0.3560	−7.3099	0.3691
Platinum	0.1170	0.1832	0.1834	0.1835	−8.8179

Panel (c): 200%-250% FPL, eligible for CSR 73% silver + premium subsidy

1% increase in	% change in probability of choosing				
base premium of	Outside	Bronze	Silver	Gold	Platinum
Mandate penalty	−0.2706	0.1470	0.1470	0.1470	0.1470
Bronze	0.6710	−2.6465	1.2738	1.2738	1.2738
Silver	0.9622	1.7128	−3.3456	1.7128	1.7128
Gold	0.3146	0.5776	0.5776	−5.3122	0.5776
Platinum	0.1888	0.3418	0.3418	0.3418	−6.8260

Panel (d): 250%-400% FPL, eligible for premium subsidy

1% increase in	% change in probability of choosing				
base premium of	Outside	Bronze	Silver	Gold	Platinum
Mandate penalty	−0.1904	0.2224	0.2224	0.2220	0.2218
Bronze	0.5095	−2.4045	1.0915	1.0923	1.0923
Silver	0.5577	1.0130	−3.4845	1.0141	1.0154
Gold	0.2539	0.5215	0.5215	−4.8203	0.5222
Platinum	0.1497	0.3086	0.3086	0.3086	−6.0680

Panel (f): >400% FPL

1% increase in	% change in probability of choosing				
base premium of	Outside	Bronze	Silver	Gold	Platinum
Mandate penalty	−0.1322	0.3186	0.3186	0.3186	0.3186
Bronze	0.3050	−2.4650	0.8489	0.8489	0.8489
Silver	0.2552	0.5310	−3.7153	0.5310	0.5310
Gold	0.1656	0.3804	0.3804	−4.6800	0.3804
Platinum	0.1068	0.2205	0.2205	0.2205	−6.0087

Table 8: Enrollment and Cost Prediction Validation

	Enrollment Share		PMPM Allowed Amount ($)		
	(1)	(2)	(3)	(4)	(5)
	Enrollment Data	Prediction	CCIIO Report	Prediction using Observed Choice	Prediction using Predicted Choice
Potential Buyers	45.6%	44.9%	-	250	204
Bronze	14.9%	16.2%	342	361	445
Silver	35.2%	31.1%	476	553	623
Standard Silver	8.9%	6.8%	-	304	333
73% Silver	5.2%	4.4%	-	570	638
87% Silver	13.7%	12.7%	-	631	707
94% Silver	7.4%	7.2%	-	698	754
Gold	2.6%	6.0%	634	616	496
Platinum	1.6%	1.9%	1146	1313	650

preference. The predicted PMPM allowed amount is thus higher with predicted choice probability (column 5) than that with observed plan choice (column 4) for CSR silver plans, and lower for gold and platinum plans. In robustness check, I first let the perceived OOP directly enter the utility, and allow the CSR eligible households to approximate their expected OOP to be a weighted average between their OOP under a standard silver and that under their eligible CSR silver plan variation: $\text{OOP}_{ht} = \kappa \text{OOP}_{ht}^{70} + (1-\kappa)\text{OOP}_{ht}^{\text{csr}}$. The estimations and resulting risk predictions are unchanged.

In the second specification, I allow the households to have private information on their care utilization frequency and severity. That is,

$$N_{it} \sim \text{Poisson}\left(\lambda_{it}\right), \quad \lambda_{it} = \exp(\mathbf{Z}_{it}\gamma^{n} + e_{n,it}),$$

$$L_{it} \sim \text{Exp}(\theta_{it}), \qquad \theta_{it} = \exp(\mathbf{Z}_{it}\gamma^{l} + e_{l,it}),$$

$$\begin{pmatrix} e_{n,it} \\ e_{l,it} \end{pmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_n & \sigma_{nl} \\ \sigma_{nl} & \sigma_l \end{bmatrix} \right).$$

In addition to the deterministic part $\mathbf{Z}_{it}\gamma$, both frequency and severity now have an unobservable component $e_{\cdot,i}$, which I interpret as the private risks unobservable to the insurer, or misperception of medical spending. I estimate this model using simulated maximum likelihood (Train, 2009). The enrollment and risk prediction are very similar to the main specification. Moreover, without coverage preference generalized by AV, households' cost-sharing OOP alone, with or without the unobserved risks, does not predict the demand well. The improvement of model fit by adding OOP to the indirect utility is marginal.

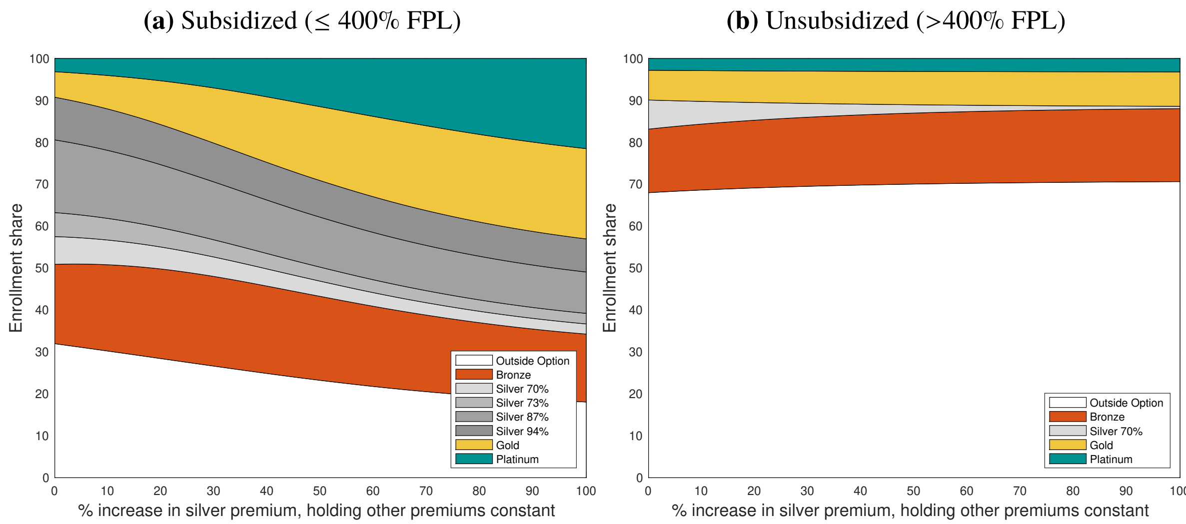
The difference between the observed and predicted metal tier choices and average risk is likely due to unobserved heterogeneity in preferences. Although the current demand model imposes no restriction on how preferences vary across rating area, within a rating area and demographic group (income-age-household-composition), households are restricted to have the same marginal utility, thus their substitution patterns are subject to the IIA assumption. To further relax preference restrictions, I add a random coefficient part to premium coefficients such that $\alpha_h^p = \alpha_{y_h}^p + \alpha_{a_h}^p + \alpha_{d_h}^p + \sigma_{y_h} v_h$, where $v_h \sim N(0,1)$ and variance σ_{y_h} varies by income group. I estimate the random coefficient mixed logit model using simulated maximum likelihood (Train, 2009). The mean premium coefficients of each income group are almost the same as the main specification, and the distribution of the random coefficients is very tight around the income group mean (results not reported here). Thus, I will use the results of the main nest-logit specification in the simulation exercises.

5.2 Naive Silver Loading Simulation

This session reports an exercise that simulates the enrollment and average risk resulting from an X% increase in all silver premiums. The core argument of silver loading is that the premium subsidies are linked to the SLCSP premium such that a more generous premium subsidy can offset the silver premium increase. Thus, the silver plans remain affordable to consumers who receive premium subsidies (90% of enrollment in California) even with the loaded CSR costs. However, the increased subsidies cannot offset the change in relative premiums between silver plans and other metal tiers. Hence, an increase in silver premiums leads to coverage change in intensive marge (metal tier switching), regardless of the existence and the design of premium subsidies. On the extensive margin, while the increased premium discourages unsubsidized households, the increased subsidies bring more subsidized potential buyers to the risk pool. This exercise ignores the equilibrium effects and separately simulates the demand response and average risk changes following a silver premium increase.

Figure 7a reports the simulated enrollment share as all silver premium increases by 1 to 100 percent among households eligible for premium subsidies. The simulation applies demand estimates to the 2017 data, and assumes all silver plans simultaneously increase premiums by the same percentage. In this setting, the rank for silver premiums as well as the insurer of the SLCSP remains unchanged. The dollar amount of the SLCSP premiums increase translates to the post-subsidy premium reduction a dollar to a dollar. However, because I simulate premium increases by percentage, an 1 percent SLCSP premium increase does not fully offset premium increases of more expensive plans. Figure 7a assembles the demand curves of metal tier among the subsidized population analogous to the framework in Section 3, as the simulation of silver premium increase exogenously shifts the relative premium with respect to silver plans, $p_{m \neq s} - p_s$, for the enrolled, and the relative price of coverage for the unenrolled.

Figure 7: Simulation of enrollment with X% increase in silver premiums



Notes: Simulated enrollment share when raising all silver premium by X% and holding other premiums constant. Panel (a) reports how enrollment share of each metal tier changes, including CSR silver variations, as silver premiums increase. Because the increase in silver premiums translates to increase in premium subsidies a dollar to a dollar, a 1% increase in silver premium (the unit of the horizontal axis) is approximately a $3 increase in monthly premium subsidy for a 21-year-old single member household. Equivalently, it is a $3 *decrease* of the premiums relative to silver for the enrolled, and a $3 *decrease* in the price of coverage for the potential buys. Panel (b) report the change in enrollment share of the unsubsidized population. In contrary to the subsidized population, a 1% increase in silver premiums translate to a $3 *increase* in the premiums relative to silver for the enrolled, but no change to the price of coverage for the potential buyers.

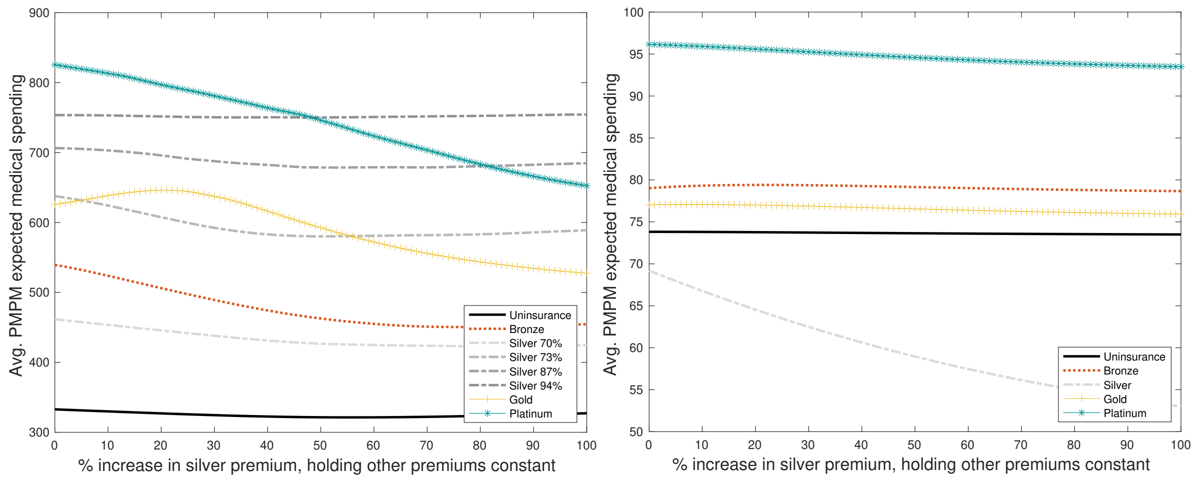
The simulated change in enrollment is consistent with the two-margin framework predictions (Section 3). At the extensive margin, insurance take-up increases substantially as silver premiums, and premium subsidies, increase. For a 20 percent increase in silver premium, which in the 2017 setting is equivalent to an average of $51 monthly increase in premium subsidy for a 21-year-old single-member household, insurance take-up among the subsidized population increase by 3 percentage points. The enrollment share of bronze plans is stable along the horizontal axis. This is because the flow into bronze plans (from potential buyers) is roughly the same as the flow from bronze plans (to silver and gold plans). Consistent with the framework prediction, silver enrollment share decreases as silver premium increases. Unsurprisingly, the share of CSR plan enrollment of all silver enrollment *increases* in silver premiums, since subsidized but ineligible for CSR benefits households are more sensitive to silver premium increases than CSR eligible households. In California, 75 percent of silver enrollees are CSR beneficiaries in 2017; this number increased to 77 percent in 2018. With a 20 percent market-wise increase of silver premiums, the share of CSR enrollment increase by 1 percentage point. The higher CSR share of silver enrollment implies a lower effective elasticity for the non-SLCSP silver plan (See discission in Appendix G). Enrollment in gold and platinum plans increases as they become relatively cheaper compared to silver plans. With a 20 percent silver premium increase, the share of gold enrollment increases from 6 percent to 10 percent. The gold enrollment almost doubles despite the fact that more than half of the subsidized population is eligible for the dominating 87% or 94% CSR silver plans.

In comparison, Figure 7b plots the simulated enrollment share among the unsubsidized households. With a 20 percent silver premium increase, silver enrollment is almost halved, while other metal tiers' enrollment only increases slightly. The probability of opting out of the exchange also increases. The prediction is consistent with the stylized framework in Appendix F, and similar to the actual Covered California enrollment change between 2017 and 2018.

In the presence of adverse selection, coverage changes at both extensive and intensive suggest risk resorting. Figure 8 plots the predicted average risks (approximated by PMPM allowed amount) for each metal tier following an X% silver premium increase. The left panel focuses on the subsidized households. With a 20 percent simulated silver premium increase, the average risk of bronze plans decreases by 6 percent from \$540 to \$506. While the average risk of standard silver plans (70% AV) declines across the entire horizontal axis, the decline of risk of the 73% and the 87% CSR silver fades out when silver premium increase exceeds 40%; the slope is less negative for the 87% CSR silver. Because the 94% CSR silver plans are most heavily subsidized and offer the most generous coverage, they have *inelastic* demand and the average risk curve is observably flat. The average risk of gold plans plateaus and then decreases as silver premium increase exceeds 20 percent. Platinum plans show a steady and steep decreasing trend as silver premium increases.

Figure 8: Simulation of risk resorting with X% increase in silver premiums

(a) Subsidized (≤ 400% FPL) **(b)** Unsubsidized (>400% FPL)



Notes: Simulated average per-member-per-month (PMPM) when raising all silver premium by X% and holding other premiums constant. Panel (a) reports how the average risk of each metal tier changes, including CSR silver variations, as silver premiums increase. Because the increase in silver premiums translates to increase in premium subsidies a dollar to a dollar, a 1% increase in silver premium (the unit of the horizontal axis) is approximately a \$3 increase in monthly premium subsidy for a 21-year-old single member household. Equivalently, it is a \$3 *decrease* of the premiums relative to silver for the enrolled, and a \$3 *decrease* in the price of coverage for the potential buys. Panel (b) report the change in average risk of the unsubsidized population. In contrary to the subsidized population, a 1% increase in silver premiums translate to a \$3 *increase* in the premiums relative to silver for the enrolled, but no change to the price of coverage for the potential buyers.

The right panel shows the risk resorting among the unsubsidized households. The vertical axis scale suggests that the unsubsidized population on average has lower risks than the subsidized population. Even for platinum plans, the expected medical spending is about \$100 PMPM. The prediction may underestimate the average risk as the unsubsidized population only consists of less than10% total population in Covered California. Neither the enrollment nor the claims data contains larger sample for estimation of this group. That said, each metal tier's average risk is relatively stable, except for silver plans where the average risk steadily drops as enrollees substitute to other metal tiers.

6 Counterfactual

I used the demand and cost model to simulate pricing equilibriums under alternative CSR financing strategies. The goal is to compare the impact of equilibrium premium pricing, consumer surplus, and government spending. I do not use the observed premium prices or assume Covered California is in equilibrium in 2017, as those premium prices do not emerge from the same demand-supply model as what I will use in the counterfactual scenarios. As in the standard practice, I start with simulating the status quo, a Nash equilibrium of Covered California in 2017, and compare simulated CSR financing strategies to the status quo.

Both insurers' participation decisions and the premium age curve changed in California in 2018. To isolate the effect of CSR funding policy, I simulate counterfactuals assuming that insurers' participation and premium age curve as the same as in 2017. I focus on three CSR funding strategies:

Silver loading, where insurers cover the CSR costs by only increasing the silver premiums. Although Covered California also directed insurers to offer non-mirroring plans off the exchange such that unsubsidized households can purchase plans with unloaded premiums, it is beyond this paper's scope and data availability to model the off-exchange market. I focus on the on-exchange market and assume the unsubsidized households do not have the off-exchange options[27].

Global loading, where insurers cover the CSR costs by assuming those costs are shared equally among enrollees of all metal tier products. The rationale behind this is that because households will respond to premium changes by changing coverage levels, CSR-associated risks should be assumed upon all plans. The costs should be spread evenly by all enrollees.

No CSR subsidies, where the government terminates the CSR subsidy provision, and insurers set premium prices accordingly. This scenario aims to examine how the CSR provision impacts the market stability of the exchanges.

In the static model, I do not allow insurers to exit the market in spite of potential negative profits. This setting means to show how CSR costs are transferred to insurers and discourage their incentive to participate in the California exchange market. Instead of modeling insurers' exit decisions as dynamic equilibrium outcomes, I take those decisions from 2018 data as given and simulate the equilibrium premiums under the 2018 market participation. Due to the price-linked premium subsidy design, the equilibriums are not unique and depend on the issuer of the SLCSP in each market. Thus, I report the simulation results that render insurers the least loss or least positive profits.

[27]Although I do not model the off-exchange market, I am currently working on an extension case where each silver plan has separate baseline premiums for the CSR eligible and ineligible households. This scenario is known to policymakers as the "Silver Loading Switcheroo," and is used by 30 state-run exchanges in 2018 (Anderson et al., 2019).

6.1 Equilibrium Premiums and Coverage Choices

Silver Loading. Table 9 reports the equilibrium baseline listed premiums (for a 21-year-old single adult household) and consumer-paid premiums under the three counterfactual scenarios. The listed premium prices are averaged by metal tier and weighted by the market size of rating regions. Under the silver loading (2017 market participation), silver premiums on average increase by 5 percent, while premiums for bronze, gold, and platinum plans change by 2 percent, -3 percent, and 4 percent, respectively. Importantly, although premiums of the benchmark silvers (SLCSP) also increase by 5 percent, due to considerable variation across markets, increased premium subsidies do not result in a non-positive change in the consumer-paid silver premiums. On the other hand, the increased premium subsidies attenuate the increases in consumer-paid premiums for other metal tiers (column 6). At this equilibrium, insurers incur a net loss of $333 million[28].

The negative profit suggests insurers' incentive to leave the exchanges. Although the current model takes insurers' participation as given and does not allow the equilibrium premiums to depend on participation decisions, I examine the exit incentives by comparing the silver loading counterfactual under the 2017 market participation (column 3-6) with a silver loading counterfactual under the 2018 market participation (column 7-10). With fewer insurers in many rating rations, the 2018 silver loading counterfactual shows a more significant increase in premiums, especially the silver plans. In particular, the baseline silver premiums increase by 43 percent compared to the status quo, and the baseline premiums for bronze, gold, and platinum change by 9 percent, 11 percent, and -2 percent, respectively. The SLCSP premiums in the 2018 silver loading scenario only increase by an average of 36 percent. As a result, silver plans become less affordable. On the other hand, a large increase in premium subsidies resulting in lower consumer-paid premiums for gold and platinum plans. More importantly, insurers earn positive profits (10 million), although only a third of the status quo level. Comparison of the silver loading counterfactual with the 2017 and 2018 market participation suggests their profit-maximizing incentive can rationalize insurers' withdrawal.

In Figure 9a, I report the distribution of change in probability of choosing each metal tier. The distribution of changes in coverage choice probability is wide and heterogeneous across income levels (Table 10) due to different preferences of premiums and coverage. Under silver loading with 2017 market participation, the probability of choosing the outside option increases by 0.2 percentage point. The probability mass above zero is mainly by unsubsidized

[28]The negative profit is robust to simulations with various starting points, where I choose the starting points by multiplying the premiums in status quo by [1.05, 1.1, . . . , 1.3].

households. The probability of choosing a bronze plan increases by 0.3 percentage points. Unsurprisingly, the probability of choosing a silver plan decreases by 2 percentage points, and the reduction is more significant among the lower-income groups. The probability of choosing a gold plan and a platinum plan increases by 0.6 percentage points and 1 percentage point, respectively.

Table 9: Average premium changes in alternative CSR financing scenarios

Panel A: Silver Loading										
	Status Quo		Silver Loading, 2017				Silver Loading, 2018			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
($/mo)	Listed Price	Consumer Paid	Listed Price	Δ (%)	Consumer Paid	Δ (%)	Listed Price	Δ (%)	Consumer Paid	Δ (%)
Bronze	268.4	218.5	276.5	3%	219.9	1%	292.1	9%	219.4	0%
Silver	311.2	228.7	326.5	5%	237.1	4%	446.1	43%	307.8	35%
Gold	492.4	420.4	478.5	-3%	400.4	-5%	544.2	11%	416.4	-1%
Platinum	591.1	526.8	613.9	4%	543.8	3%	578.0	-2%	455.7	-13%
SLCSP	211.4		222.8	5%			287.8	36%		

Panel B: Other CSR financing scenarios										
	Status Quo		Global Loading				No CSR			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
($/mo)	Listed Price	Consumer Paid	Listed Price	Δ (%)	Consumer Paid	Δ (%)	Listed Price	Δ (%)	Consumer Paid	Δ (%)
Bronze	268.4	218.5	304.7	14%	201.1	-8%	295.2	10%	233.1	7%
Silver	311.2	228.7	318.0	2%	206.2	-10%	308.7	-1%	216.0	-6%
Gold	492.4	420.4	518.5	5%	422.7	1%	515.6	5%	437.9	4%
Platinum	591.1	526.8	588.4	0%	500.6	-5%	596.0	1%	522.8	-1%
SLCSP	211.4		258.6	22%			230.8	9%		

Notes: The table reports the change in average listed and consumer-paid premium by metal tier. The listed price reports the average baseline premium for a 21-year-old adult weighted by rating region market size. The consumer-paid premium reports the average post-subsidy premium weighted by predicted enrollment probability. The row of SLCSP report the average benchmark silver premium of each rating region weighted by market size.

Global Loading. Instead of only raising silver premiums to cover the CSR costs, global loading allows insurers to increase premiums of all metal tiers to address the CSR costs. While premiums of non-silver plans also change under silver loading, the key difference is that: under silver loading, the premium changes of other metal tiers are due to the equilibrium effect by silver enrollees who change coverage level; under global loading, premiums of those metal tiers change because the insurers assume the CSR-associated risks are equally shared and added to all enrollees.

Panel B of Table 9 reports the average equilibrium under global loading. To isolate the effect due to CSR financing strategy, I simulate the global loading counterfactual using

Table 10: Changes in metal tier choice probability under alternative CSR financing scenarios

	Not enroll		Bronze		Silver		Gold		Platinum	
Panel A: Silver Loading, 2017										
138%-150% FPL	-0.1	[3.7]	0.4	[4.7]	-0.9	[12.3]	-0.7	[6.4]	1.2	[6.9]
150%-200% FPL	-0.2	[5.5]	0.8	[6.7]	-3.2	[14.0]	1.1	[7.1]	1.5	[6.4]
200%-250% FPL	-0.7	[4.7]	-0.1	[8.1]	-1.9	[9.0]	1.3	[6.9]	1.4	[9.8]
250%-400% FPL	-0.6	[5.6]	0.4	[6.2]	-1.4	[7.1]	1.0	[5.1]	0.6	[3.4]
>400% FPL	2.0	[8.4]	-0.2	[7.4]	-1.9	[4.9]	-0.2	[4.1]	0.3	[3.1]
Panel B: Global Loading										
138%-150% FPL	-0.3	[2.5]	1.6	[6.6]	-3.3	[8.6]	-0.2	[5.8]	2.3	[7.1]
150%-200% FPL	-0.5	[4.9]	1.9	[8.0]	-2.4	[10.6]	-0.7	[7.6]	1.8	[7.9]
200%-250% FPL	0.2	[4.7]	1.4	[9.7]	-1.3	[7.9]	-0.2	[7.6]	-0.2	[9.4]
250%-400% FPL	1.6	[7.7]	0.6	[9.5]	-1.9	[7.2]	-0.3	[7.8]	0.1	[5.4]
>400% FPL	6.6	[9.9]	0.1	[8.9]	-3.3	[5.3]	-2.3	[5.2]	-1.0	[3.5]
Panel C: No CSR										
138%-150% FPL	4.4	[6.4]	7.9	[9.6]	-23.0	[17.7]	3.7	[9.5]	7.1	[12.3]
150%-200% FPL	3.5	[6.9]	5.4	[9.8]	-16.0	[15.3]	2.3	[11.3]	4.9	[10.7]
200%-250% FPL	1.0	[5.3]	0.2	[10.1]	-1.9	[8.6]	0.5	[9.5]	0.2	[8.4]
250%-400% FPL	1.4	[7.0]	-1.5	[9.0]	-0.9	[8.2]	0.7	[8.9]	0.3	[4.7]
>400% FPL	3.9	[7.2]	1.1	[7.9]	-1.5	[6.5]	-0.5	[4.7]	-0.8	[2.5]

Notes: The table reports the mean and standard deviation of changes in metal tier choice probability. For each household, I calculate the probability of choosing each metal tier at status quo and that the under the three counterfactual scenarios. The numbers without bracket present the mean change in probability of choosing the metal tier indicated by the column. The numbers inside bracket present the standard deviation of the changes in probability.

the 2017 market participation. Silver premiums increase by only 2 percent. Moreover, the SLCSP premiums increase by 22 percent, resulting in a 10 percent reduction in the average consumer-paid silver premiums. While the listed bronze premiums increase by 14 percent, the consumer paid bronze premiums decrease by 8 percent thanks to the increased premium subsidies.

Figure 9b shows the distribution of changes in metal tier choice probability under global loading. The probability of choosing the outside option on average increases by 2 percentage points. The probability of choosing a bronze plan or a silver plan decreases by a similar magnitude as under silver loading (1 percentage point and -2.4 percentage points, respectively). The probability of choosing a gold and platinum plan decreases by 1 percentage point and increases by 0.4 percentage point, respectively.

No CSRs. Lastly, in the scenario where the CSR subsidies are completely removed, the average premium increases show a different pattern. Bronze premiums have the largest average increase (10 percent), followed by gold premiums (5 percent) and platinum premiums (1 percent). On average, silver premiums decrease by 1 percent, mainly due to a reduced average risk as high-risk former CSR-eligible households switch to gold and platinum plans.

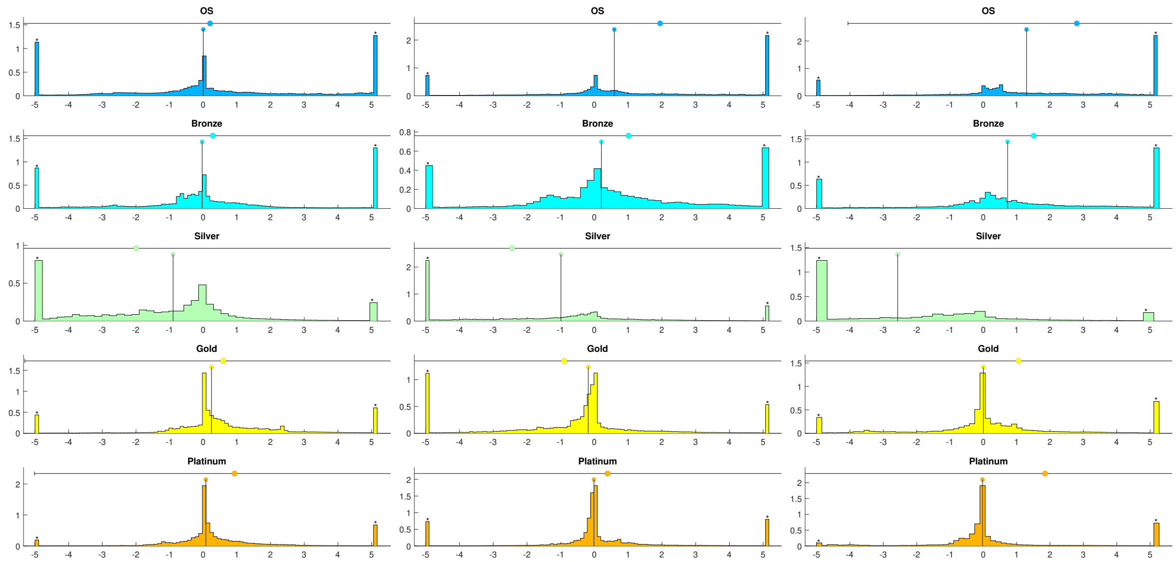
Low-income households are most affected by the potential CSR removal. As silver plans become less attractive to eligible households, about 5 percent of the low-risk former CSR-eligible households will leave the exchange. On the other hand, due to the reduction of consumer-paid silver premiums, the overall choice probability of choosing the outside option increases by 3 percentage points. Risks of the staying CSR-eligible households will still be borne by insurers, as they will switch to other metal tiers based on preferences of premiums and coverage. In particular, the probability of choosing silver plans decreases by 7 percentage points, and the probability of choosing non-silver plans increases by 1 to 2 percentage points. This substitution pattern contributes to premiums increases of non-silver plans.

6.2 Welfare Comparison

Table 11 summarizes the equilibrium conditions of all counterfactual scenarios. Panel A reports welfare impact on consumer, insurer, and government spending. At status quo (column 1), the government spends a total of $3.1 billion on subsidies, including $2.4 billion on premium subsidies and $0.7 billion on CSR benefits. Savings on the uncompensated care amount to $2.7 billion, resulting in a net government outlay of $423 million. Insurer profits amount to $29 million, much lower than the government's CSR payment. Should the CSR

Figure 9: Distribution of change in probability choosing metal tiers

(a) Silver Loading **(b)** Global Loading **(c)** No CSR



costs be transferred from the government to the insurers, insurers will either suffer a net loss or increase premiums substantially to keep break-even. At status quo, the return on public fund is \$2.5 per dollar.

Silver Loading. De-funding of CSRs shifts the cost burden to insurers and consumers. Column 2 reports a net insurers' loss under silver loading with 2017 market participation. While insurers bear the majority of CSR costs, the government spends \$344 million more on premium subsidies, indirectly financing part of the CSR costs. As a result, the government only saves about 50% of its previously paid CSR costs. Because consumers experience a net increase in out-of-pocket premiums, consumer surplus declines by \$3 million. With insurers' net loss, the total social surplus decrease by \$18 million. In this scenario, \$1 saving in government spending is at the cost of a \$1.05 reduction in consumer and insurer surplus.

The silver loading with 2017 market participation does not speak fully for the CSR de-funding consequences. As previously discussed, insurers will not operate at a negative profit. The net government saving shown in column (2) only suggests how restricting market exit would limit insurers' ability to survive when facing a large cost shock—the CSR costs in the status quo are 23 times the size of insurers' profit. Column (3) reports the simulated welfare impact when sliver loading is taken place after insurers adjusted market participation in 2018. With fewer insurers and fewer plans in Covered California, consumers experience a greater increase in listed premium prices, including the SLCSP premiums. This results in a

$106 per month increase in per-capita premium subsidy. On the one hand, consumer surplus increases by 37 million. On the other hand, the additional spending on premium subsidy ($1,454 million) more than doubles the savings on CSRs. Insurer profits, although positive, reduce by two-thirds. The social surplus reduces to $2 billion, with a $1 return on a dollar of public spending.

Global Loading. Alternatively, global loading is less costly to public spending and less discouraging to insurers. Column (4) reports the global loading welfare results where the market participation is kept the same as in 2017. Because spreading the CSR costs to all enrollees allows insurers to cover part of CSR cost from non-silver enrollees who do not generate CSR costs, insurers are able to make a positive profit ($39 million) and remain in the market. As shown in Panel C, the average total risk by coverage is similar between column (2) and column (4), so is insurers' cost-sharing. The higher premiums of bronze and gold contribute to insurers' profit. Compared to the 2018 silver loading condition, the global loading allows the government to spend $659 million less on premium subsidies. In this scenario, $1 of government outlay generates $1,94 of consumer and insurer surplus, nearly doubling the return on public spending under 2018 silver loading.

No CSRs. When CSRs are removed, the enrollment rate decreases from 60 percent to 57 percent (Panel B, column 5). Especially, 5% of CSR-eligible households will leave the exchange market. For the staying low-income households, their expected monthly medical spending increase from $164 to $363, more than doubling in the absence of CSR subsidies. Removing CSR provision changes the risk profile of all metal tiers. As shown in Panel C column (5), the average risk of households eligible for the 87% CSR silver plans decreases by 3 percent. Meanwhile, the average risk of bronze plans increases by 13 percent from $371 to $420 per month. The average risk of gold plans increases by 2 percent from $484 to $496 per month, and the average risk of platinum plans decreases by 3 percent from $648 to $628 per month.

Due to both reduced coverage and changes in net premiums, consumer surplus decreases by 32 million. Compared to the status quo, the government spends $54 million more in total subsidy payments and $78 million more in uncompensated care payments. The social surplus reduces by $121 million, resulting in a return of $1.92 on a dollar of public spending.

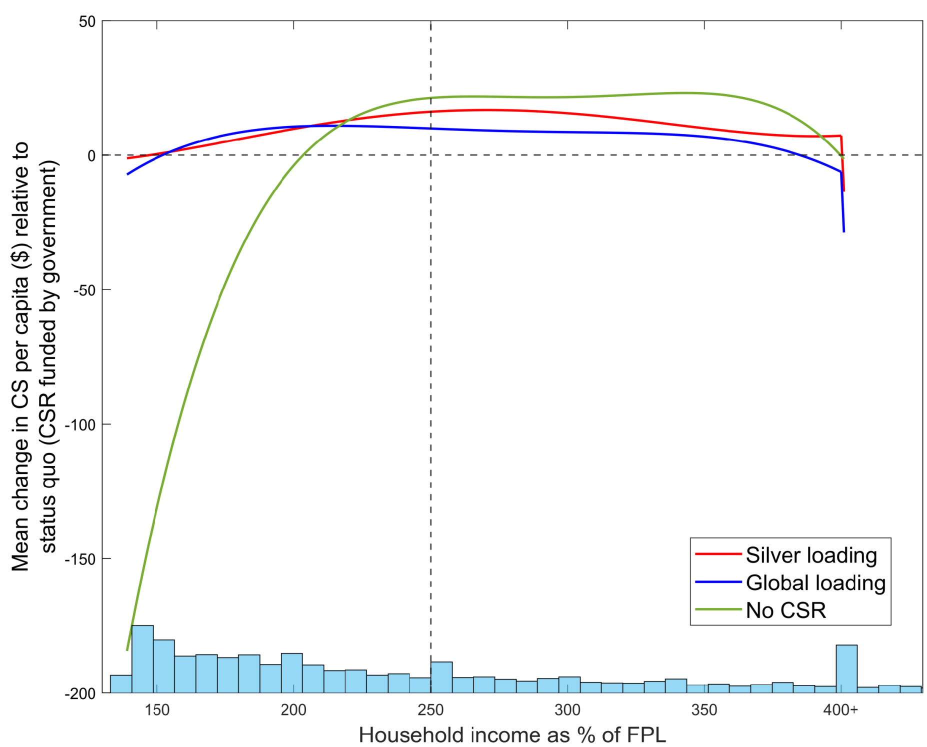
Who Benefits. Change in consumer surplus varies by CSR funding scenarios. It is important to emphasize that improvement or impairment of consumer surplus is not uniform across

Table 11: Counterfactual analysis on welfare

	(1) Status Quo	(2) Silver Loading 2017	(3) Silver Loading 2018	(4) Global Loading	(5) No CSR
Panel A: Welfare ($ million)					
CS	1,025	1,028	1,062	1,021	993
Π	29	-333	10	39	73
CS+Π	1,054	695	1,072	1,060	1,066
Govt. Outlay	423	81	1,071	548	556
Prem. Subsidies (+)	2,394	2,738	3,848	3,189	3,130
CSR benefits (+)	682	0	0	0	0
Avoided C^U (–)	2,653	2,657	2,777	2,641	2,575
CS+Π-G	631	613	2	512	510
Return on Public Fund	2.49	8.53	1.00	1.94	1.92
Panel B: Enrollment (%)					
Not enroll	40%	41%	39%	42%	43%
Bronze	16%	17%	14%	17%	18%
Silver	31%	29%	26%	29%	24%
Silver 70%	8%	8%	6%	7%	8%
Silver 73%	4%	4%	3%	4%	4%*
Silver 87%	12%	11%	10%	11%	8%*
Silver 94%	7%	7%	6%	6%	5%*
Gold	8%	8%	8%	7%	9%
Platinum	5%	5%	13%	5%	6%
Panel C: Average Risk ($ PMPM)					
Not enroll	216	213	196	210	221
Bronze	371	382	395	395	420
Silver					
Silver 70%	316	316	349	328	312
Silver 73%	598	588	650	592	599*
Silver 87%	706	695	722	699	688*
Silver 94%	765	762	818	766	764*
Gold	484	497	523	508	496
Platinum	648	652	637	670	628
Market avg.	514	518	562	530	524
Insurers' share	322	380	436	387	336
Consumers' share	137	137	126	143	148

income levels. As discussed in Section 3, consumers gain or lose depending on their out-of-pocket premiums and the coverage level they change to. Because both factors vary by income, I calculate the per-capita consumer surplus of each income level as a percentage of FPL. Figure 10 plots the difference between the per-capita consumer surplus of each CSR financing strategy and the status quo. Each colored curve is a fitted 5$^{\text{th}}$ degree polynomial with respect to household income (as a percentage of FPL). The per-capita consumer surplus change is similar under silver loading and global loading. Individual consumers have welfare gains ranging from \$0 to \$20 under silver loading. The improvement is slightly smaller under global loading. In either scenario, there is no significant difference in mean per-capita welfare change across income levels, except the unsubsidized households who pay the full costs of premium increases.

Figure 10: Impact on consumer surplus by income level



Among all counterfactual scenarios, removing CSR surplus has the most significant impact on consumer surplus. With reduced benefit, one may expect that all CSR-eligible households are worse off. However, facing lower out-of-pocket silver premiums, households eligible for the low-level CSRs may not be hurt if their marginal disutility of premium is greater than the marginal utility of coverage. The green line in Figure 10 shows that only households with income below the 200% FPL are worse-off when CSRs are removed. For those who have higher income, the benefits of lower net premiums outweigh the reduced coverage.

How CSRs should be financed. From a policymaker's perspective, CSR provision lowers the average risk on the exchanges, hence reducing the premium subsidy payments via the price-linked subsidy and reducing the potential spending on uncompensated care. Keeping the CSR provision aligns with the public interest. It generates a $133 million net saving and a higher return of consumer and insurer surplus on public spending. Counterfactuals also suggest that financing CSRs under the status quo achieves the highest social welfare. The de-funding does not result in a net government saving on total payment subsidizing the exchanges, and it impairs consumer and insurer surplus. Should the de-funding continues, the global loading generates a better outcome, as it keeps insurers' incentives to participate in the exchange without a substantial increase in public spending.

7 Conclusion

This paper examines the effects of CSR de-funding on the exchange market and provides empirical evidence on how alternative CSR financing strategies affect consumers, insurers, and government spending. I estimate a model of plans on the Californian exchange and simulate the market under alternative CSR financing strategies. Insurers account for risk selection of households into different coverage levels and the equilibrium effects by marginal households' response to premium changes.

Simulation exercises suggest that CSR de-funding discourages insurers from participating in the exchange. With fewer insurers and plan options, silver premiums increase by 43% if insurers are only allowed to raise silver premiums to cover CSR costs. This results in a substantial increase in public spending. With the per-capita premium subsidies increased by $82 per month, and enrollment increased by $34 thousand, the government spends $1.5 billion more in subsidizing the California exchange. Alternatively, allowing insurers to raise premiums of all plans to cover CSR costs is less disturbing to the market: insurers are able to maintain current market participation, premiums increase by a lesser extent, and social surplus declines by a smaller amount.

Should the CSRs be funded by premium loading, the total consumer surplus is only marginally affected. However, the unsubsidized exchange enrollees are undoubtedly worse-off across all loading strategies because of their full exposure to premium increases. In California, although the unsubsidized had access to more affordable options off the exchange, this population still accounted for more than 10 percent of the exchange enrollment after the silver loading in 2018. It is beyond the scope of this paper to investigate how the unsubsidized households shop across markets (i.e., on-exchange vs. off-exchange), but the welfare loss by this group should they obtain coverage from the exchange must be taken into consideration when determining how to finance the CSRs.

CSR provision is important to consumer surplus and public budget. Removing CSRs results in a $32 million reduction in consumer surplus, primarily among households with income below 200% FPL. It also increases public spending by $133 million, including $54 million more on subsidizing the California exchange, and $79 million more on potential uncompensated care payments. Overall, providing CSRs under the federal budget achieves the highest social surplus and return to public spending.

As pointed out earlier, the current analyses have several limitations. First, due to data limitations, I model the costs using claims data from a single insurer. The model does not capture the cost differences across insurers due to contracting with providers. In fact, the predicted product-level average costs are about 3% higher than the insurer reported cost. The overprediction in costs can bias the equilibrium predictions. Second, when calculating equilibrium premiums, I assume market participation is static, and insurers' existing decisions do not depend on the expected profit level. Thus it does not fully explain the dynamic of insurers' participation incentives in an imperfectly competitive market like the exchanges. Extending the analyses in this paper to account for market dynamics are left as directions for future research.

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Appendices

A Comparison of standard silver and CSR silver variation

Panel A:	Standard 70% Silver			
Coverage Category	Bronze	Silver	Gold	Platinum
	60% AV	70% AV	80% AV	90% AV
Preventive Care Copay	0	$0	$0	$0
Primary Care Visit Copay	$60 for 3 visits	$45	$30	$20
Specialty Care Visit Copay	$70	$65	$50	$40
Urgent Care Visit Copay	$120	$90	$60	$40
Emergency Room Copay	$300	$250	$250	$150
Lab Testing Copay	30%	$45	$30	$20
X-Ray Copay	30%	$65	$50	$40
Generic Medicine Copay	$20	$20	$20	$5
Annual OOP (Individual)	$6,350	$6,350	$6,350	$4,000

Panel B:	87% CSR Silver Variation			
Coverage Category	Bronze	Silver 87	Gold	Platinum
	60% AV	87% AV	80% AV	90% AV
Preventive Care Copay	0	$0	$0	$0
Primary Care Visit Copay	$60 for 3 visits	$15	$30	$20
Specialty Care Visit Copay	$70	$20	$50	$40
Urgent Care Visit Copay	$120	$90	$60	$40
Emergency Room Copay	$300	$250	$250	$150
Lab Testing Copay	30%	$15	$30	$20
X-Ray Copay	30%	$20	$50	$40
Generic Medicine Copay	$20	$20	$20	$5
Annual OOP (Individual)	$6,350	$2,250	$6,350	$4,000

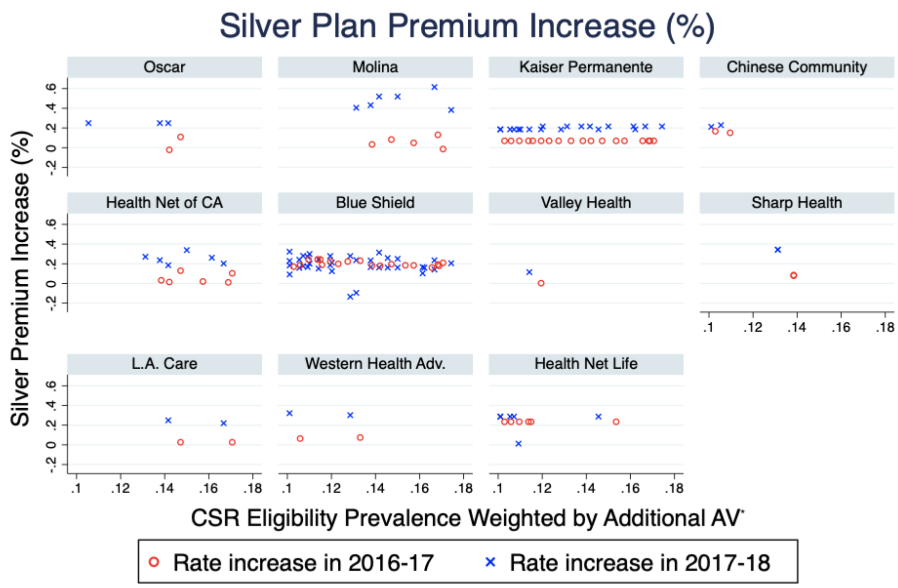
B Summary statistics of Covered California

Table 12: Summary statistics of Covered California households

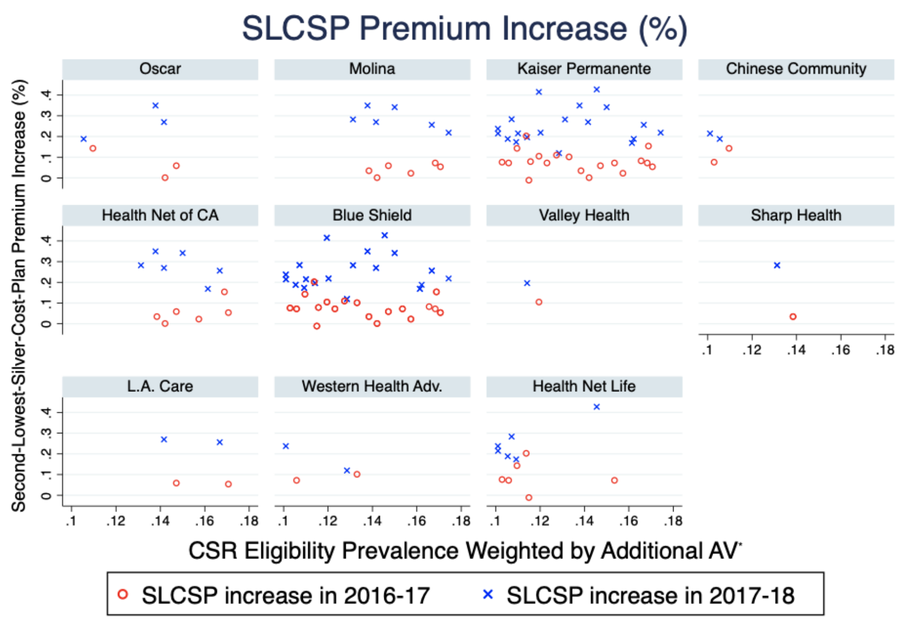
	2017		2018	
	Exchange Enrollees	Outside Option	Exchange Enrollees	Outside Option
Household				
Household size				
1	69.25%	52.77%	70.24%	53.42%
2	22.39%	29.27%	21.67%	28.52%
3	5.14%	9.23%	4.93%	9.16%
4	2.61%	5.26%	2.54%	5.48%
>4	0.62%	3.47%	0.63%	3.43%
Income				
138% to 150% FPL	15.65%	2.05%	16.33%	1.59%
150% to 200% FPL	33.83%	10.86%	32.79%	10.24%
200% to 250% FPL	17.75%	11.81%	18.25%	11.42%
250% to 400% FPL	21.31%	28.44%	22.17%	28.25%
>400% FPL	11.46%	46.84%	10.47%	48.49%
Subsidy eligibility				
Premium subsidy	88.54%	53.16%	89.53%	51.51%
(Received)	83.15%	-	85.86%	
CSR subsidy	67.24%	24.72%	67.36%	23.26%
(Received)	49.24%	-	45.31%	
Average age				
<20	1.58%	1.69%	1.53%	1.82%
21-30	21.40%	24.27%	21.38%	23.79%
31-40	22.28%	33.48%	22.50%	34.57%
41-50	18.08%	23.05%	17.80%	21.78%
51-60	24.79%	13.42%	24.60%	14.12%
61-64	11.87%	4.08%	12.20%	3.92%
N. household	1,050,243	703,869	994,709	646,678

Plan choice				
Metal tier				
Bronze	28.08%		29.68%	
Silver	63.38%		55.61%	
Gold	4.69%		10.29%	
Platinum	3.14%		3.67%	
Catastrophic	0.71%		0.76%	
Metal tier among CSR eligible households				
Bronze	22.26%		22.65%	
Silver	73.23%		67.26%	
Gold	2.46%		7.21%	
Platinum	1.76%		2.60%	
Catastrophic	0.29%		0.29%	
N. choices				
Minimum	12		9	
Mean	32		32	
Median	33		33	
Maximum	43		42	
Share of $0 plans				
$0 Bronze	45.79%	5.39%	61.38%	19.74%
$0 Silver	4.63%	0.50%	8.89%	1.32%
Subsidy amount ($) /person				
Mean	285		369	
P25	136		188	
P50	228		296	
P75	388		504	

C Silver premium increased by 20% in 2018



The sample include 121 silver plans that are offered both in plan year 2016 and plan year 2017 in the same rating area.
The x-axis is the CSR eligibility weighted by the actuarial value of the corresponding three CSR silver plan variations.
Premium increase is calculated using the 21-year-old single adult rate.



The x-axis is the CSR eligibility weighted by the average additional AV value resulting from the corresponding eligible subpopulation.

D Demographics Recovered in Claims Data

Table 13: Recovered enrollment share by rating regions within the proprietary insurer

Region	Enrollment	
	Enrollment Share observed in Covered California Data(%)	Enrollment Share Recovered from Claims Data(%)
1	16.52	17.43
2	1.51	1.68
3	5.13	5.54
4	1.00	1.07
5	0.40	0.51
6	1.18	1.32
7	7.83	8.54
8	1.02	1.11
9	4.10	4.29
10	17.79	19.82
11	3.46	3.44
12	9.34	9.99
13	1.02	1.08
14	1.99	2.15
15	4.33	3.53
16	11.32	6.71
17	2.45	2.04
18	7.90	7.88
19	1.70	1.86
Total N. of Individual	280,773	275,287

Notes: This table compares enrollment share by rating regions within the proprietary insurer that provides the claims data. The proprietary data do not have information on rating area, or the plan identifier that can crosswalk with the Covered California enrollment data. I recover the rating area as follows. First, I use the 5-digit ZIP codes to approximate for the rating region. The crosswalk between the 3-digit ZIP codes and rating area can be fund on the CMS website. I then use the unique combination of plans' metal tier, network, and HSHP/HSA option to match with the insurer's plan offered in Covered California to obtain the precise rating region for enrollees whose ZIP code belongs to multiple rating areas. The plan offering data is obtained from the HIX Comparison.

Table 14: Distribution of recovered income group in claims data

	Income Bracket	
	Income Distribution observed in Covered California (%)	Income Group Recovered from Claims Data (%)
138%-150% FPL	14.13	13.14
150%-200% FPL	29.15	27.83
200%-250% FPL	17.47	15.32
250%-300% FPL	14.5	16.68
300%-350% FPL	8.48	4.52
350%-400% FPL	5.2	4.50
>400% FPL	11.07	18.01
Total N. of Individual	280,773	275,287

Notes: This table compares the income groups recovered for the enrollees of the proprietary insurer using claims data information. The claims data do not contain information on income. I recover this information as the follows. First, I use the enrollees' pre- and post-subsidy premiums to calculate households' total premium subsidies. Then I link each household with their ZIP code specific SLCSP premiums, which are computed using the CMS public user file. Then I recover the households' contribution caps, which is the difference between the SLCSP premium and premium subsidy. Finally, because the contribution caps is linearly in income, I recover the income following the IRS instruction on Form 1095-A.

E Risk score construction

In this exercise, I apply HHS-HCC risk adjustment to claims of on-exchange members and small group members in California.For each member-enrollment, we compute two risk scores based on the HHS-HCC risk adjustment methodology. We compare the two HHS-HCC based risk scores, summarize them by enrollment segment and metal tier, and add each of them to the current difference-in-difference regression as a control variable and compare the results.

E.1 HHS-HCC Risk Adjustment and Risk Score

The Affordable Care Act authorizes the Department of Health and Human Services (HHS) to utilize criteria and methods similar to those utilized under Medicare Parts C or D to implement risk adjustment. The purpose of risk adjustment is to lessen or eliminate the influence of risk selection on the premiums that plans charge. The HHS risk adjustment methodology is based on the premise that premiums should reflect the differences in plan benefits, quality, and efficiency, and not the health status of the enrolled population. The HHS risk adjustment methodology includes the risk adjustment model and the payment transfer formula.

The HHS risk adjustment model uses an individual's demographic data and diagnoses to determine a risk score, which is a relative measure of how costly that individual is anticipated to be to the plan (i.e. a relative measure of the individual's actuarial risk to the plan). Risk adjustment modeling determines the base actuarial risk based on predicted costs for a plan's enrollees.

Calculation of the HHS-HCC risk adjustment proceeds in the following steps:

(i) Generate bins for age-gender.

(ii) Filter diagnosis based on a CPT/HCPCS code.

(iii) Crosswalk ICD-10 CM diagnosis codes to generate CCs.

(iv) Apply hierarchy to generate HCCs.

(v) Generate groups, severity measurement and interaction indicators for adult, child, and infant populations. Each population has its own set of risk variables and corresponding risk multipliers.

(vi) For an enrollee in a given metal level plan, the total predicted plan liability is the sum of the incremental predicted plan liability (multipliers) from the relevant metal level model. For adults and children, this is the sum of the age-gender, HCC, and disease interaction multipliers. For infants, this is the sum of the maturity/disease-severity category and additive sex multipliers, if male. Separating models by metal tiers is intended to capture the insurer's cost-sharing that vary by metal tiers.

The methodology and a DIY instruction on risk score calculation are available on the CMS website[29]. This exercise translates the DIY program to Stata.

E.2 Application of the HHS-HCC to CA claims Data

I apply the HHS-HCC risk adjustment model to the proprietary claims data, which contains 22% California on-exchange enrollees that who enrolled via a major insurer in 2017.

The 2017 HHS-HCC risk adjustment includes in the adult model a baseline factor of enrollment duration. The enrollment duration factor is additive to the HCC and demographic factors. In recognition that members enrolling for a shorter period of time tend to incur higher medical consumption (adverse selection in enrollment duration), shorter enrollment duration corresponds to a greater multiplier. The enrollment duration component is in the same spirit as we use annualized medical consumption as the outcome variable. We thus leave the enrollment duration component in the risk adjustment as it is.

The 2017 HHS-HCC risk adjustment also adjusts for induced demand due to cost-sharing reduction (CSR). Because CSR plans have higher actuarial value, members of CSR plans presumably utilize more care due to their lower cost-sharing. Because the adjustment for CSR is based on moral hazard, not the explicit or hidden health risk, I exclude the CSR adjustment part in the risk score calculation.

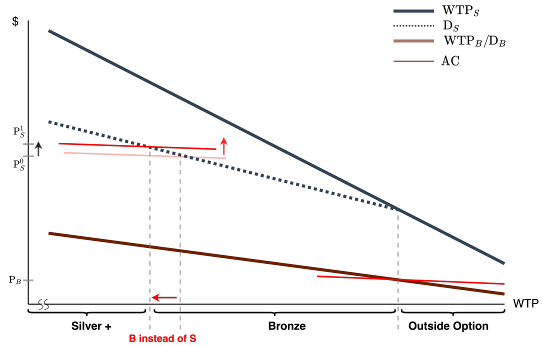
Recall that the HHS-HCC score accounts for the insurer's cost-sharing that differ by metal tiers. That is, for any given HCC or demographic factor, the corresponding risk multiplier is higher for a member enrolled in a Platinum plan than that for a member enrolled in a Silver plan. This, however, defeats the purpose of calculating the risk score. Our goal of adding a risk score as a control variable is to absorb the effects of health status on medical consumption, assuming those effects do not vary plan choice. In other words, the ideal risk score should ignore the plan's liability. As a result, I calculate a second risk score, a "baseline" risk score such that, regardless of a member's actual metal tier, I apply a Bronze plan's HCC and demographic multipliers to that members' diagnosis. By forcing every HCC and demographic factor to have the same risk multiplier across all metal tiers, the "baseline" risk score ignores plan's liability and only captures members' health risk. The "baseline" risk score is highly correlated with the HHS-HCC risk score (correlation = 0.99).

[29]The risk score algorithm accessible at https://www.cms.gov/CCIIO/Resources/Regulations-and-Guidance/Downloads/Updated-CY2018-DIY-instructions.pdf

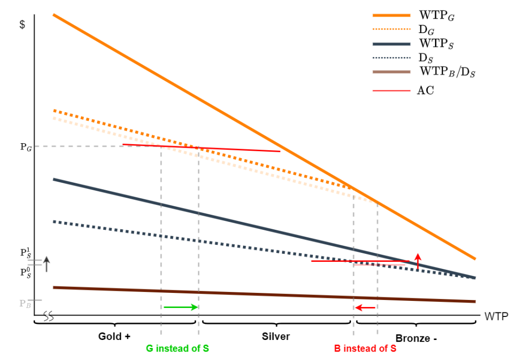
F Impact of Silver Loading among Unsubsidized Enrollees

Figure 11: Silver Loading Impact on Demand and unsubsidized Enrollee Sorting

(a) Silver vs. Bronze vs. Uninsurance



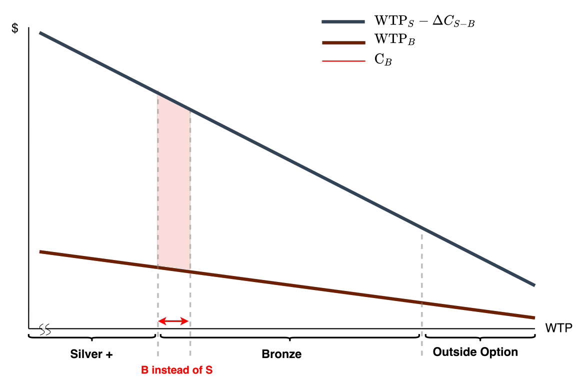
(b) Gold vs. Silver vs. Bronze



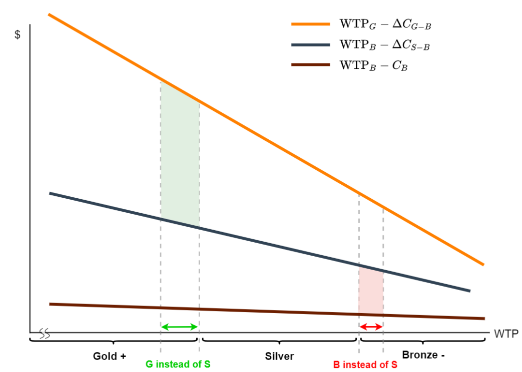
Notes: The graphs show the equilibrium changes due to silver loading among the unsubsidized households. The key exogenous changes is the upward shift of silver AC due to the silver loading. Because households do not receive premium subsidies, there is no change in WTP curves. Panel (a) shows that higher silver AC curve results in individuals switching from silver to bronze. Panel (b) shows the equilibrium effect passes on to gold, where the gold demand shift upwards, and individuals on the left margin of silver switch to gold.

Figure 12: Welfare Impact on unsubsidized Enrollees by Silver Loading

(a) Silver vs. Bronze vs. Uninsurance



(b) Gold vs. Silver vs. Bronze



Notes: The graphs show social welfare impact of silver loading on unsubsidized households. Panel (a) shows the case that consumers switch on the intensive margin between bronze and silver. The solid lines are WTP net the difference in plan costs, and net increased premium subsidy. The welfare loss by silver consumers who switches to bronze is shaded in red. Panel (b) shows welfare impact on consumers who switch from silver to gold.

G Impact on Silver Premium Pricing: Adverse/Advantageous Selection of CSR Costs

This section models the interaction between price-linked premium subsidy and cost shocks such as the CSR silver loading. Suppose the insurer provides one plan for each metal tier m, $m \in \mathcal{M} = \{b, s, g, p\}$. Insurer choose price $\mathbf{p} = \langle p^b, p^s, p^g, p^p \rangle$ to maximize total profit. For the silver plan, the insurer chooses the *unloaded* p^s, then load the CSR costs. Profit maximization and the first-order condition for tier m:

$$\Pi(\mathbf{p}) = \sum_{k \in \mathcal{M}} Q^k(\widetilde{\mathbf{p}_c})(\widetilde{p^k} - c^k),$$
$$\frac{\partial \Pi}{\partial p^m} = \sum_{k \in \mathcal{M}} \frac{dQ^k(\widetilde{\mathbf{p}_c})}{dp^m}(\widetilde{p^k} - c^k) + Q^m(\widetilde{\mathbf{p}_c}) = 0.$$

Letting $\sim$ denote the premium after loading, $\widetilde{\mathbf{p}_c}$ denotes the post-loading post-subsidy premiums a household pays. In a policy environment with no loading, $\widetilde{\mathbf{p}_c} = \mathbf{p}_c$, where $\mathbf{p}_c = \mathbf{p} - S(p^s)$, with $S(\cdot)$ being the subsidy schedule as a function of the benchmark silver premium.

Facing this price vector, each consumer i chooses a metal tier m. The total derivative of quantity with respect to pre-loading premium equals

$$\frac{dQ^k(\widetilde{\mathbf{p}_c})}{dp^m} = \frac{\partial Q^k}{\partial \widetilde{p_c^m}} - \Big(\sum_{n \in \mathcal{M}} \frac{\partial Q^k}{\partial \widetilde{p_c^n}}\Big)\frac{\partial S}{\partial p^m} + \mathbb{1}_{\text{load}}\,\mathbb{1}_{\text{m=s}}\,\bar{c^s}\Big(\sum_{n \in \mathcal{M}} \frac{\partial Q^k}{\partial \widetilde{p_c^n}}\Big)\frac{\partial \delta}{\partial p^m} \tag{21}$$

$$= \begin{cases} \dfrac{\partial Q^k}{\partial \widetilde{p_c^m}} & m \neq s \\ \\ \dfrac{\partial Q^k}{\partial \widetilde{p_c^m}} - \displaystyle\sum_{n \in \mathcal{M}} \frac{\partial Q^k}{\partial \widetilde{p_c^n}}\frac{\partial S}{\partial p^s} + \mathbb{1}_{\text{load}}\,\bar{c^s}\sum_{n \in \mathcal{M}} \frac{\partial Q^k}{\partial \widetilde{p_c^n}}\frac{\partial \delta}{\partial p^m} & m = s \end{cases}. \tag{22}$$

That is, the slope of demand has three terms: the standard demand slope, the effect due to premium subsidy, and the effect due to loading is effective and applys to silver plans. The $\frac{\partial S}{\partial p^s} = \frac{dS}{d\widetilde{p^s}}\frac{d\widetilde{p^s}}{dp^s}$ in the second term describes the subsidy distortion. Under the ACA price-linked subsidy schedule, the post-loading second-lowest-cost-silver-plan (SLCSP) premium $\underline{\widetilde{p^s}}$ net the subsidy equals to a household's maximum contribution.

$$S(p^s) = \underline{\widetilde{p^s}} - \text{cap}.$$

Thus $\frac{dS}{dp^s} = 1$ for the SLCSP, and 0 otherwise. Putting together, if the insurer offers the SLCSP, the total derivative of quantity with respect to premium for metal m is

$$\frac{dQ^k(\widetilde{\mathbf{p}}_c)}{dp^m} = \begin{cases} \dfrac{\partial Q^k}{\partial \widetilde{p_c^m}} & m \neq s \\ \\ \dfrac{\partial Q^k}{\partial \widetilde{p_c^s}} - \underbrace{\dfrac{\partial \widetilde{p^s}}{\partial p^s} \sum_{n \in \mathcal{M}} \dfrac{\partial Q^k}{\partial \widetilde{p_c^n}}}_{\text{subsidy link}} + \underbrace{\mathbb{1}_{\text{load}} \bar{c}^s \dfrac{\partial \delta}{\partial p^s} \sum_{n \in \mathcal{M}} \dfrac{\partial Q^k}{\partial \widetilde{p_c^n}}}_{\text{loading link}} & m = s \end{cases}. \tag{23}$$

By the definition of δ in Equation (4):

$$\frac{\partial \widetilde{p^s}}{\partial p^s} = 1 + \mathbb{1}_{\text{load}} \bar{c}^s \frac{\partial \delta}{\partial p^s}. \tag{24}$$

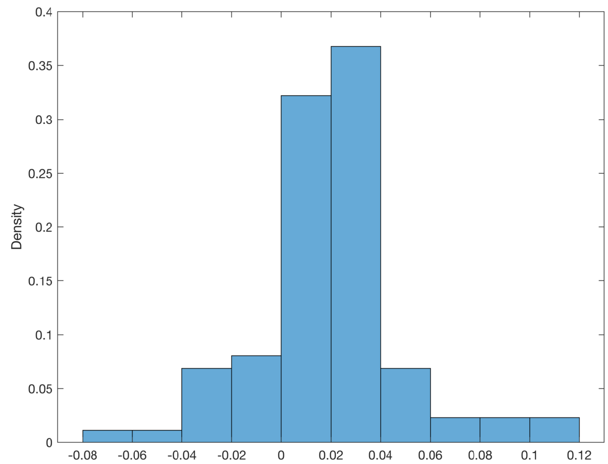
Although loading add additional distortion to the demand slope, the effect is offset by a weaker (or stronger) subsidy link due to the loading definition. Thus the loading keeps the subsidy link unchanged the SLCSP. In fact, it can be further reduced such that $\frac{dQ^k}{dP^s} = -\sum_{n \neq s} \frac{\partial Q^k}{\partial \widetilde{p_c^s}}$.

For a non-SLCSP offering issuer, the total derivative equals

$$\frac{dQ^k(\widetilde{\mathbf{p}}_c)}{dp^m} = \begin{cases} \dfrac{\partial Q^k}{\partial \widetilde{p_c^m}} & m \neq s \\ \\ \dfrac{\partial Q^k}{\partial \widetilde{p_c^s}} + \underbrace{\mathbb{1}_{\text{load}} \bar{c}^s \dfrac{\partial \delta}{\partial p^s} \sum_{n \in \mathcal{M}} \dfrac{\partial Q^k}{\partial \widetilde{p_c^n}}}_{\text{loading link}} & m = s \end{cases}. \tag{25}$$

The loading adds distortion to the non-SLCSP silver plans. The direction depends on the sign of $\frac{\partial \delta}{\partial p^s}$. Assuming that only price differences, not levels, matter for demand, a same amount of price increase price for all metal tiers within the insurer do not change the share of silver demand. However, it increases the relative price against plans of other insurers, as well as the outside option (uninsurance). Hence the total demand by this insurer declines, thus $\sum_{n \in \mathcal{M}} \frac{\partial Q^k}{\partial \widetilde{p_c^n}} < 0$. A negative $\frac{\partial \delta}{\partial p^s}$ will weaken the price sensitivity of non-SLCSP silver plans; a positive $\frac{\partial \delta}{\partial p^s}$ will strengthen it. Thus, a key empirical interest is to estimate $\frac{\partial \delta}{\partial p^s}$.

Figure 13: Distribution of $\frac{d\delta}{dp^s}$

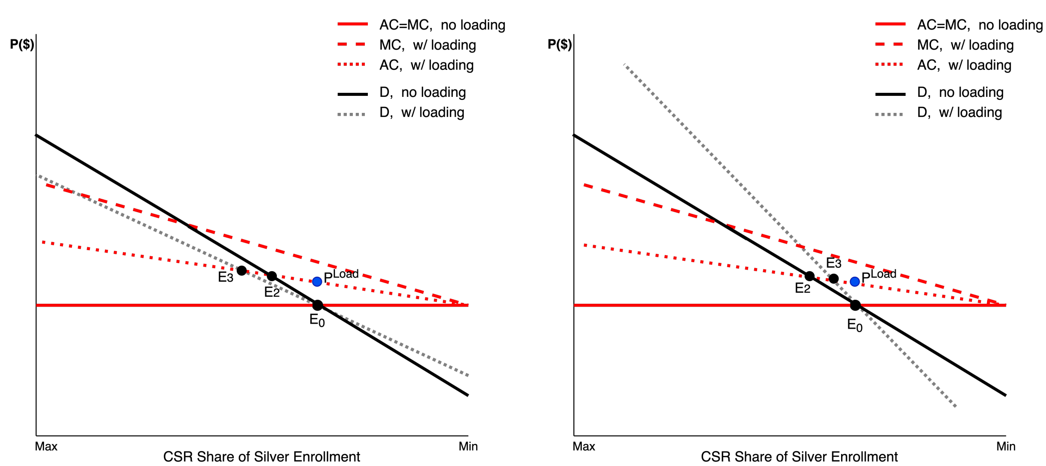


Notes: This figure report the distribution of the marginal effect of baseline (21-year-old single adult) silver premium on δ, the CSR benefit costs being shared equality among all silver enrollees of each silver plan offered in 2017.

On the supply side, if CSR eligible enrollees are more price sensitive than others ($\frac{\partial \delta}{\partial p^s}$<0), loading CSR costs to silver premium will by itself reduce the share of CSR eligible households among all silver enrollments. To see this graphically, in Figure 14a, E_0 is the initial equilibrium. A negative $\frac{\partial \delta}{\partial p^s}$ implies a shallower demand curve with loading (the dashed line). Assuming the CSR enrollees are equally healthy as others, the post-loading equilibrium is E_3, whose coordinate has a *higher* premium and a higher share of CSR enrollees than the projected equilibrium E_2.

Figure 14: Over- and under-prediction of CSR silver premium loading

(a) CSR advantageous selection **(b)** CSR adverse selection



In contrast, if the non-CSR eligible enrollees are more price sensitive, that is, $\frac{\partial \delta}{\partial p^s}$ is positive, the effective demand with loading is steeper. In Figure 14b, the new equilibrium E_3 has a lower share of CSR silver enrollment than the projected E_2, as well as a lower premium.

H Age curve change in 2018

Table 15: Change in age factors in 2018

Age Band	2017 Age Factor	2018 Age Factor
0-14	0.635	0.765
15	0.635	0.833
16	0.635	0.859
17	0.635	0.885
18	0.635	0.913
19	0.635	0.941
20	0.635	0.970
21-64	Unchanged	

I Estimates of cost parameters

Table 16: Cost parameters from claims data

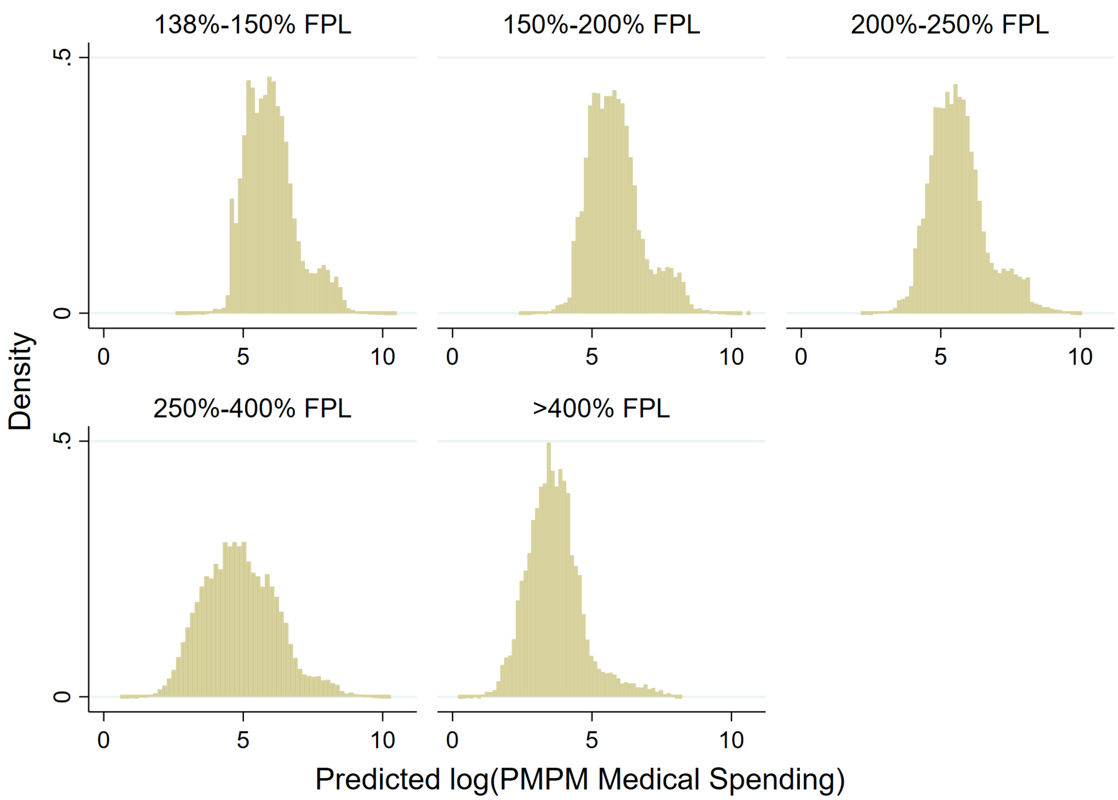
	(1) Frequency (λ)	(2) Severity (θ)
Age	−0.0874***	−0.0537***
Age^2	0.00228***	0.00141***
Age^3	−0.0000140***	−0.0000152***
Female	−0.552***	0.260***
Individual (single-member household)	0.128	0.0591
Female × age	0.0920***	0.00345
Female × individual	0.384*	−0.917***
Individual × age	0.0466***	−0.011**
Female × Individual × age	−0.0533***	0.109***
Individual × age^2	−0.00199***	−0.000558***
Individual × age^2	−0.00103***	0.0000411
Female × individual × age^2	0.00117**	−0.00323***
Female × age^3	0.0000114***	0.00000999***
Individual × age^3	0.00000480	0.00000229
Female × individual × age^3	−0.00000687	0.0000271***
138%-150% FPL	Reference	Reference
150%-200% FPL	−0.268***	−0.0756***
200%-250% FPL	−0.493***	−0.0592***
250%-300% FPL	−0.292***	−0.0858***
300%-350% FPL	−1.521***	0.169***
350%-400% FPL	−2.087***	−0.105***
>400% FPL	−2.322***	−0.146***
150%-200% FPL × age	0.00205**	0.00436***
200%-250% FPL × age	0.00268**	0.00253***
250%-300% FPL × age	−0.0017*	0.00406***
300%-350% FPL × age	0.0165***	−0.00118
350%-400% FPL × age	0.0255***	−0.000389
>400% FPL × age	0.0253***	0.00381***
Premium Subsidy	0.394***	−0.245***
Premium Subsidy × age	0.00701**	0.00602***

Rating Area 1	Reference	Reference
Rating Area 2	−0.0532	0.0120
Rating Area 3	−0.0413*	−0.0270***
Rating Area 4	−0.0673	−0.0260*
Rating Area 5	−0.170***	−0.582***
Rating Area 6	−0.156***	−0.349***
Rating Area 7	−0.443***	0.214***
Rating Area 8	−0.249***	0.258***
Rating Area 9	−0.110***	−0.276***
Rating Area 10	0.0930***	0.318***
Rating Area 11	0.0825***	0.371***
Rating Area 12	0.360***	0.328***
Rating Area 13	0.0402	−0.131***
Rating Area 14	0.118***	0.442***
Rating Area 15	−0.198***	0.423***
Rating Area 16	0.265***	0.402***
Rating Area 17	0.0748**	0.357***
Rating Area 18	−0.274***	0.217***
Rating Area 19	0.103***	0.0670***
Constant	−0.782***	−5.597***
Observation	N. Claims/enroll.	Allowed/claim
N. observation	221,228	1,786,939

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

J Distribution of Predicted PMPM Medical Spending

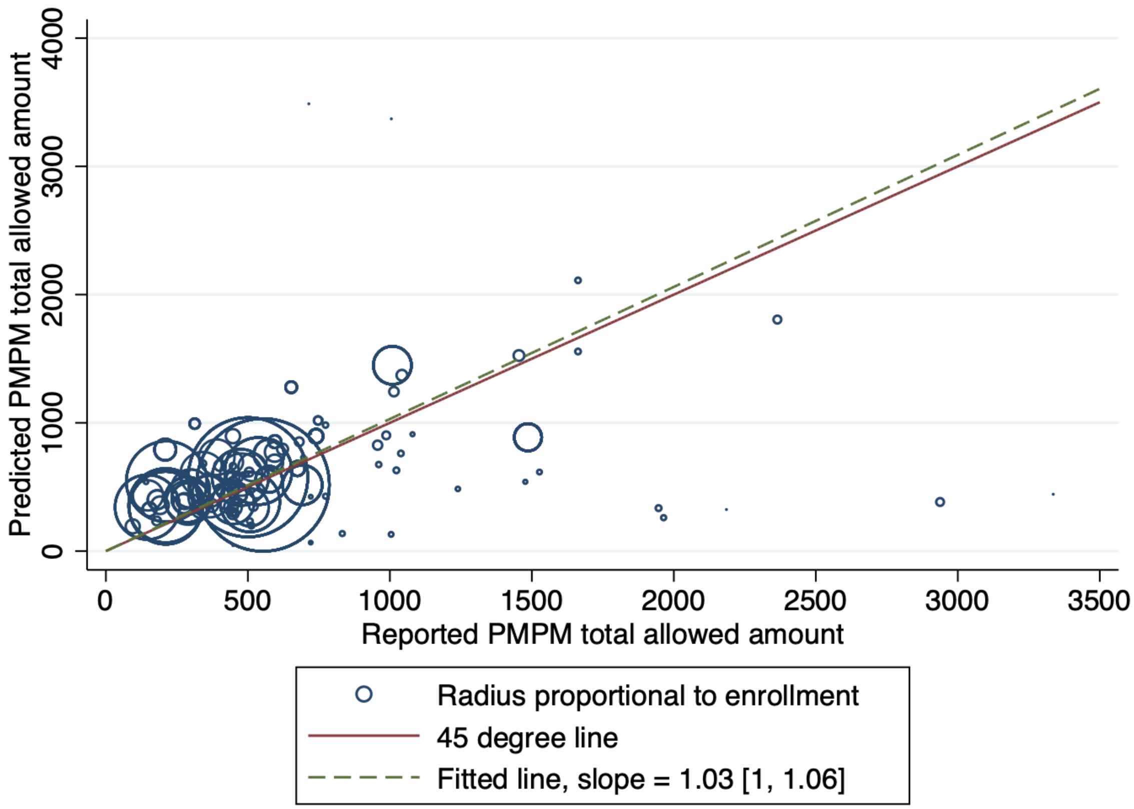
Figure 15: Distribution of predicted PMPM medical spending, by income group



Notes: Distribution of predicted $\log C_i = \log(\mathbb{E}(\tilde{c}_i) = \lambda_i/\theta_i$ by income group for 2017 plan year. λ_i and θ_i are predicted using GLM estimates γ^n and γ^l.

K Validation of Plan-Level Risk Prediction

Figure 16: Comparison of predicted and reported plan-level total risk



Notes: This figure compares the predicted average risk and the CCIIO reported average risk at product level. Product is defined as a superset of plans offered in multiple rating areas that share the same financial and non-financial features. In the Health Insurance Oversight System (HIOS), product is defined by unique plan identifiers. The cost model predicts average risk at plan level, or product-region level. To compare prediction with reported average risk, I aggregate total predicted plan-level risk at product level and divided by product-level enrollment. The horizontal axis is the product-level average risk measured by PMPM allowed amount. The vertical axis is the product-level predicted average risk. Each circle corresponds to a product, with the radius proportional to the product's total enrollment. The circles align along the 45 degree line. Regression of the predicted average risk on the reported risk suggests a correlation of 1.03, CI = [1, 1.06]. The regression result reject correlation of 1 just at 5% level (F-value = 0.46).