Managing Adverse Selection: Underinsurance vs. Underenrollment

Evan Saltzman*

August 3, 2020†

Adverse selection in insurance markets may lead some consumers to underinsure or too few consumers to purchase insurance relative to the socially optimal level. I study whether common government policy interventions can mitigate both underinsurance and underenrollment due to adverse selection. I establish conditions under which there exists a tradeoff in addressing underinsurance and underenrollment. I then estimate a model of the California ACA insurance exchange using consumer-level data to quantify the welfare impact of risk adjustment and the individual mandate. I find (1) risk adjustment reduces underinsurance, but reduces enrollment and (2) the mandate increases enrollment, but increases underinsurance.

Keywords: Adverse selection, individual mandate, risk adjustment, health insurance, ACA.

JEL Codes: I11, I13, L51, L88, H51

*Department of Economics, Emory University, evan.saltzman@emory.edu. I wish to thank my advisors Aviv Nevo, Scott Harrington, Mark Pauly, and Ashley Swanson for advice and helpful feedback. I also thank the editor, 3 anonymous referees, Blake Allison, Shomu Banerjee, Mike Geruso, Claudio Lucarelli, Sara Markowitz, Ian McCarthy, Daniel Polsky, and Robert Town.

†The first version of this article was titled "The Welfare Implications of Risk Adjustment in Imperfectly Competitive Markets."

Governments have increasingly intervened in insurance markets to address inefficiencies resulting from asymmetric information. A common model for government intervention is managed competition, in which insurers compete for consumers in regulated markets called exchanges (Enthoven, 1978). The exchanges established under the Affordable Care Act (ACA) are a prominent example of managed competition.

An important decision in managed competition is how to regulate price discrimination. Rules limiting price discrimination, referred to as "community rating," are pervasive in insurance markets, including Medicare Advantage and the ACA exchanges. Adverse selection may occur if insurers cannot use information on consumer risk such as health status to price discriminate. Prior work finds empirical evidence of adverse selection in both Medicare Advantage (Brown et al., 2014; Newhouse et al., 2015) and the ACA exchanges (Panhans, 2019).

Adverse selection may cause some consumers to buy too little insurance coverage (Rothschild and Stiglitz, 1976) or not insure at all (Akerlof, 1970), relative to the socially optimal level. To illustrate, suppose consumers can either (1) purchase plan L, which has a low premium and limited benefits; (2) purchase plan H, which has a high premium and comprehensive benefits; or (3) forgo insurance. Underinsurance, an intensive margin effect, arises when low-risk consumers are attracted to plan L because of the high relative premium for plan H. Underenrollment, an extensive margin effect, may occur if there is an influx of high-risk consumers into plan L, raising its premium and causing low-risk consumers to forgo insurance.

In this article, I study whether common government policy interventions in insurance markets such as risk adjustment and an individual mandate can simultaneously mitigate underinsurance and underenrollment due to adverse selection. Risk adjustment is an example of a policy that addresses underinsurance. In the ACA exchanges, risk adjustment requires plans with lower-than-average risk consumers make transfer payments to plans with higher-than-average risk consumers. If plan L has lower-than-average risk consumers, risk adjustment imposes additional cost on plan L and provides cost relief to plan H, likely increasing plan L's premium and decreasing plan H's premium. Some enrollees in plan L may switch to plan H, reducing underinsurance, but others may opt to forgo insurance, reducing enrollment. A prominent example of a policy that addresses underenrollment is the individual mandate. The ACA's individual mandate incentivizes enrollment by requiring consumers to purchase insurance or pay a tax penalty. In markets with adverse selection, the mandate motivates low-risk consumers to enroll, improving the risk pool. Low-risk entrants are likely to select plan L, increasing the difference between the plan premiums and potentially leading to a reduction or even unraveling in demand for plan H.

To study the underinsurance-underenrollment tradeoff, I first develop a two-plan model. I show that the tradeoff can occur in markets where both intensive margin (e.g., substitution between plan L and H) adverse selection and extensive margin (e.g., substitution between plan L and no insurance) adverse selection exist. Both margins of adverse selection are likely to occur in practice.

In the second part of the article, I study whether the tradeoff between underinsurance and underenrollment exists in the ACA exchanges. The ACA setting is particularly appealing because (1) there is evidence of both underinsurance and underenrollment and (2) several policies targeting adverse selection are in place, including premium subsidies, risk adjustment, and the mandate. I extend the basic two-plan model to a differentiated products model of the ACA exchanges and estimate it using consumer-level administrative data from the California ACA exchange. My data contain nearly 10 million records between 2014 and 2019 and account for 13% of nationwide enrollment in the ACA exchanges (Kaiser Family Foundation, 2020). Detailed demographic information enables me to calculate consumer-specific plan premiums, subsidies, and penalties for forgoing coverage.

With these data, I develop an empirical approach similar to Starc (2014) that allows me to explicitly account for adverse selection and moral hazard, My model endogenizes consumer demand, plan risk, and average claims. I estimate consumer demand using a nested logit discrete choice model. I address premium endogeneity by exploiting consumer-level variation in premiums created by exogenous ACA regulations. I estimate plan risk and average claims by combining my demand estimates with data from insurer rate filings. I use these estimates to measure how the risk and cost of the marginal consumer varies with premiums and find statistically significant evidence of adverse selection.

I use the estimated model to simulate the impact of risk adjustment in alternative policy environments. This is an important policy counterfactual given recent litigation challenging the ACA risk adjustment program.[1] I find eliminating risk adjustment makes the least comprehensive plans (known as bronze) 13% less expensive and the most comprehensive plans (known as platinum) 60% more expensive. Bronze plan enrollment increases by 19%, whereas platinum plan enrollment declines by 65%. Eliminating risk adjustment increases total exchange enrollment by 1.5% if the mandate is repealed, but has minimal impact on total enrollment if the mandate remains in place. The mandate, therefore, can mitigate the adverse effects of risk adjustment on total enrollment.

I then simulate the impact of the mandate penalty. Repealing the mandate penalty leads to a modest 0.7% increase in average premiums and 2% reduction in total enrollment. Bronze and silver plan enrollment decline by more than 2%, whereas gold and platinum enrollment slightly increase. Because the penalty was set to zero starting in 2019 according to the Tax Cuts and Jobs Act of 2017, I have a unique opportunity to partially validate my simulation results. My finding that mandate repeal would have a modest impact on premiums and enrollment is consistent with observed changes in premiums and enrollment between 2018 and 2019, both in California and nationally.

The primary contribution of this article is to illustrate the underinsurance-underenrollment tradeoff and its existence in the ACA exchanges. This tradeoff is relevant not only for the ACA exchanges, but also other community-rated markets such as Medicare Advantage and Medicare Part D. Most work studying the effects of adverse selection in insurance markets considers either the intensive or extensive margin, but not both simultaneously. Azevedo and Gottlieb (2017) show in a theoretical model of perfect competition how the individual mandate can have the unintended consequence of increasing underinsurance. In concurrent work, Geruso et al. (2019) construct a

[1] In response to the decision in *New Mexico Health Connections v. U.S. Department of Health and Human Services*, the Trump Administration suspended risk adjustment transfers totaling $10.4 billion. The Trump Administration announced on July 24, 2018 that it would restore the risk adjustment program.

novel graphical framework to illustrate the underinsurance-underenrollment tradeoff in the spirit of Einav, Finkelstein, and Cullen (2010). My work complements these studies by showing the tradeoff analytically and finding empirical evidence of its existence in the ACA exchanges.

This article also augments the extensive literature on risk adjustment and the individual mandate. Considerable research examines how well risk adjustment programs equalize firm risk (Brown et al., 2014; Newhouse et al., 2015; Geruso et al., 2016), but less work has studied its impact on coverage and social welfare. Handel, Hendel, and Whinston (2015) and Layton (2017) find that risk adjustment can yield welfare gains by reducing underinsurance, whereas Mahoney and Weyl (2017) show that risk adjustment can reduce total enrollment. Although there is little empirical work on the intensive margin effects of the mandate, previous studies have found the mandate has a beneficial, but small impact on total enrollment and welfare (Hackmann, Kolstad, and Kowalski, 2015; Frean, Gruber, and Sommers, 2017; Sacks, 2017). I build on these studies by considering how risk adjustment and the mandate affect both underinsurance and underenrollment in a single framework. I validate the simulated impact of the mandate against the observed impact in the California exchange after the penalty was set to zero in 2019.

I also contribute to the broader economic literature on health insurance. Recent work has considered the economic tradeoffs between "price-linked" subsidies that adjust to premium changes and "fixed" subsidies or vouchers that are set independently of premiums (Jaffe and Shepard, 2017; Tebaldi, 2017). I extend this literature by studying the interaction of the subsidy design with the individual mandate and risk adjustment. My analysis links to the empirical literature that examines the welfare impact of adverse selection in health insurance markets (Cutler and Reber, 1998; Pauly and Herring, 2000; Cardon and Hendel, 2001; Einav et al., 2013; Handel, 2013; Starc, 2014). This study also adds to the economic literature studying the early experience of the ACA exchanges (Tebaldi, 2017; Abraham et al., 2017; Domurat, 2017; Drake, 2019).

The remainder of this article is organized as follows. Section 1 presents a theoretical model illustrating the underinsurance-underenrollment tradeoff. Section 2 adapts the model to the ACA setting. Section 3 describes the data. Section 4 details how I estimate the model. Section 5 simulates the impact of risk adjustment and the individual mandate. Section 6 concludes.

1 Basic Model

I first develop a tractable model[2] to illustrate the underinsurance-underenrollment tradeoff and understand when it occurs. Consider a competitive market with two firms L and H that each sell one plan with premiums p_L and p_H, respectively. Consumers have a higher willingness to pay for firm H's plan. Consumers can also choose to forgo insurance instead of purchasing a plan. No subsidies are available for purchasing insurance.

Let $q_f \equiv q_f(p_L, p_H)$ be firm f's demand for $f \in \{L, H\}$ with negative own-price partial derivatives $\frac{\partial q_L}{\partial p_L}, \frac{\partial q_H}{\partial p_H} < 0$ and positive cross-price partial derivatives $\frac{\partial q_L}{\partial p_H}, \frac{\partial q_H}{\partial p_L} > 0$. Denote $r_f \equiv r_f(p_L, p_H)$ as the firm's risk score, where $r_L \leq r_H$, and $c_f = \theta(r_f)$ as the firm's average claims, where the mapping $\theta(\cdot)$ is monotonically non-decreasing. For ease of exposition, I assume risk and average claims are perfectly correlated such that $\theta(\cdot)$ is the identity mapping (i.e., $c_f = r_f$). This assumption is relaxed in the next section.[3]

In a market with adverse selection, higher total enrollment $q \equiv q_L + q_H$ reduces market average claims $c \equiv (q_L c_L + q_H c_H)/(q_L + q_H)$. That is, $q(p'_L, p'_H) < q(p''_L, p''_H)$ if and only if $c(p'_L, p'_H) > c(p''_L, p''_H)$ for any premium vectors $p' = (p'_L, p'_H)$ and $p'' = (p''_L, p''_H)$. Firm profit $\pi_f(p_L, p_H) = [p_f - c_f]q_f$. Assume $\left|\frac{\partial c_{f'}}{\partial p_f}\right| < 1$ for $f, f' \in \{L, H\}$ such that average claims does not change by more than the premium change. In equilibrium, firms earn zero profit such that $p_L = c_L$ and $p_H = c_H$. Below I illustrate how risk adjustment and the mandate affect this competitive equilibrium.

[2]To this end, I make several assumptions that I relax in the next section, where I allow for more than two firms selling heterogeneous products, imperfect competition, imperfect risk adjustment, the divergence of average claims and risk, and moral hazard.

[3]I use the terms "risk" and "claims" interchangeably in this section. I distinguish between the two terms in the next section.

Risk Adjustment

Risk adjustment transfers money from the firm with lower-than-average risk (firm L) to the firm with higher-than-average risk (firm H). The risk adjustment transfer equals $RA_f \equiv (rs_f - us_f)P = (rs_f - us_f)C$, where P is total premium revenue, C is total market claims, $rs_f \equiv \frac{c_f q_f}{\sum_{f' \in F} c_{f'} q_{f'}}$ is the plan's risk share of total claims, and $us_f = \frac{h_f q_f}{\sum_{f' \in F} h_{f'} q_{f'}}$ is the utilization share of total claims.[4] The parameter h_f is a utilization factor that accounts for plan generosity and any associated moral hazard. To interpret the risk adjustment transfer, let $h_f = 1$ such that both plans have the same generosity. The transfer equals

$$RA_f = \left[\frac{c_f q_f}{cq} - \frac{q_f}{q}\right] C = (c_f - c)\, q_f$$

The transfer is therefore positive when the firm's average claims exceeds market average claims, negative when the firm's average claims is less then market average claims, and zero when the firm's average claims equals market average claims. Let $\psi \in [0, 1]$ be the level of risk adjustment, where $\psi = 0$ corresponds to no risk adjustment, $\psi = 1$ corresponds to full risk adjustment, and $\psi \in (0, 1)$ corresponds to partial risk adjustment. Firm profit $\pi_f(p_L, p_H) = [p_f - c_f + \psi(c_f - c)]q_f$ and the equilibrium conditions are

$$\begin{aligned} p_L &= c'_L \equiv (1-\psi)c_L + \psi c \\ p_H &= c'_H \equiv (1-\psi)c_H + \psi c \end{aligned} \tag{1}$$

Without risk adjustment, firms set premiums equal to their average claims in equilibrium (i.e., $p_L = c_L$ and $p_H = c_H$). Firms set premiums equal to market average claims in equilibrium with full risk adjustment (i.e., $p_L = p_H = c$).

Appendix A shows that differentiating (1) with respect to the level of risk adjustment ψ yields

[4] Total premium revenue P and total market claims C are equal because the market is competitive and $\sum_f RA_f = 0$.

$$\begin{aligned}
\frac{\partial p_L}{\partial \psi} &= \frac{(c - c_L)\left(1 - \frac{\partial c'_H}{\partial p_H}\right) - (c_H - c)\frac{\partial c'_L}{\partial p_H}}{f(\psi)} \\
\frac{\partial p_H}{\partial \psi} &= \frac{-(c_H - c)\left(1 - \frac{\partial c'_L}{\partial p_L}\right) + (c - c_L)\frac{\partial c'_H}{\partial p_L}}{f(\psi)}
\end{aligned} \tag{2}$$

where $f(\psi) \equiv \left(1 - \frac{\partial c'_L}{\partial p_L}\right)\left(1 - \frac{\partial c'_H}{\partial p_H}\right) - \frac{\partial c'_H}{\partial p_L}\frac{\partial c'_L}{\partial p_H}$. Proposition 1.1 gives sufficient conditions for the underinsurance-underenrollment tradeoff:

Proposition 1.1. *Suppose $f(\psi) > 0$ for $\psi \in [0, 1]$. Risk adjustment decreases total enrollment ($\frac{\partial q}{\partial \psi} < 0$) and decreases underinsurance ($\frac{\partial q_H}{\partial \psi} > 0$) if the following conditions hold:*

1. *No direct substitution occurs between plan H and uninsurance:* $\frac{\partial c}{\partial p_H} = 0$
2. *Extensive margin adverse selection exists:* $\frac{\partial c}{\partial p_L} > 0$
3. *Intensive margin adverse selection exists:* $\frac{\partial c_H}{\partial p_H} > 0$, $\frac{\partial c_L}{\partial p_H} > 0$, $\frac{\partial c_H}{\partial p_L} < 0$
4. *Limited extensive margin adverse selection:* $\frac{\partial c}{\partial p_L} < \frac{q_L}{q}\left(1 - \frac{\partial c_L}{\partial p_L}\right)$
5. *Limited intensive margin adverse selection:* $\frac{\partial c_L}{\partial p_H} < \frac{q_H}{q_L}\left(1 - \frac{\partial c_H}{\partial p_H}\right)$

Proof. See Appendix A. □

Risk adjustment increases firm L's premium ($\frac{\partial p_L}{\partial \psi} > 0$) and decreases firm H's premium ($\frac{\partial p_H}{\partial \psi} < 0$) if the sufficient conditions of Proposition 1.1 are satisfied. These premium changes (1) reduce underinsurance because some of firm L's consumers shift to firm H and (2) reduce enrollment because some of firm L's marginal buyers shift to uninsurance.

Proposition 1.1 shows how consumer substitution patterns determine the existence of the underinsurance-underenrollment tradeoff. Sufficient condition 1 states that consumers do not directly substitute between firm H's plan and the outside option. In other words, an increase in firm H's premium does not affect which consumers select into the insurance market. Sufficient condition 2 states that there is positive correlation between the cost of insured consumers and firm L's premium (i.e., extensive margin adverse selection). Sufficient condition 3 states that the cost of firm H's consumers is positively correlated with its own premium and negatively correlated with its competitor's premium (i.e., intensive margin adverse selection). The cost of firm L's consumers is also positively correlated with firm H's premium. A decrease in firm H's premium incentivizes firm L's riskiest consumers to shift to H, reducing firm L's average claims. Sufficient condition 4 provides an upper bound on how much an increase in firm L's premium can increase the average cost of consumers selecting into the market. In Appendix A, I show that sufficient condition 4 implies that

$$\frac{\partial c'_H}{\partial p_L}\frac{\partial p_L}{\partial \psi} \quad < \quad c_H - c \tag{3}$$

The left-hand side of inequality (3) represents the marginal increase in firm H's average claims that results from risk adjustment increasing firm L's premium and increasing market average claims. This marginal increase cannot exceed the average transfer $(c_H - c)$ received by firm H. Sufficient condition 5 provides an upper bound on how much a decrease in firm H's premium can reduce firm L's cost. In Appendix A, I show that sufficient condition 5 holds implies that

$$-\frac{\partial c'_L}{\partial p_H}\frac{\partial p_H}{\partial \psi} \quad < \quad c - c_L \tag{4}$$

The left-hand side of inequality (4) represents the marginal reduction in firm L's average claims that results from risk adjustment reducing firm H's premium and incentivizing firm L's riskiest consumers to switch to firm H. This marginal reduction cannot exceed the average transfer $(c - c_L)$ paid by firm L.

To summarize, Proposition 1.1 shows that the underinsurance-underenrollment tradeoff occurs if both intensive and extensive margin adverse selection exist and the degree of selection is bounded above. How realistic are the sufficient conditions of Proposition 1.1? The existence of both margins of adverse selection (conditions 2 and 3) and limited substitution between a high-priced, generous plan and uninsurance (condition 1) are likely features of unregulated insurance markets. If price-linked subsidies are available to consumers as in the ACA exchanges, the extent of extensive margin adverse selection may be limited, however. Sufficient conditions 4 and 5 are likely to hold in practice unless average claims and consumer risk aversion are highly correlated and the firms' marginal consumers have very different costs than their average consumers.

In Proposition 1.1, I assume that both plans have the same generosity by setting the utilization factor $h_j = 1$. Allowing for differential plan generosity and any associated moral hazard does not change the qualitative meaning of the sufficient conditions in Proposition 1.1. To see this, suppose plan H becomes more generous. Plan H's risk score increases because it pays a larger share of claims, but so does its utilization factor which accounts for the higher plan generosity and associated moral hazard. Therefore, plan H's risk adjustment transfer does not change. If the increase in plan generosity leads to an increase in selection (Einav et al., 2013), then the transfer would increase.

Individual Mandate

The individual mandate assesses a penalty ρ on consumers who forgo insurance. The equilibrium conditions are

$$\begin{aligned} p_L &= c_L(p_L, p_H, \rho) \\ p_H &= c_H(p_L, p_H, \rho) \end{aligned} \tag{5}$$

Proposition 1.2 gives sufficient conditions for the underinsurance-underenrollment tradeoff:

Proposition 1.2. *The individual mandate increases total enrollment* ($\frac{\partial q}{\partial \psi} > 0$) *and increases underinsurance* ($\frac{\partial q_H}{\partial \psi} < 0$) *if the following conditions hold:*

1. *No direct substitution occurs between plan H and uninsurance:* $\frac{\partial c}{\partial p_H} = \frac{\partial c_H}{\partial \rho} = 0$
2. *Extensive margin adverse selection exists:* $\frac{\partial c}{\partial p_L} > 0$, $\frac{\partial c_L}{\partial \rho} < 0$
3. *Intensive margin adverse selection exists:* $\frac{\partial c_H}{\partial p_H} > 0$, $\frac{\partial c_L}{\partial p_H} > 0$, $\frac{\partial c_H}{\partial p_L} < 0$

Proof. See Appendix A. □

In Appendix A, I show that differentiating (5) with respect to the penalty yields

$$
\begin{aligned}
\frac{\partial p_L}{\partial \rho} &= \frac{\frac{\partial c_L}{\partial \rho}\left(1 - \frac{\partial c_H}{\partial p_H}\right)}{f(0)} \\
\frac{\partial p_H}{\partial \rho} &= \frac{\frac{\partial c_L}{\partial \rho}\frac{\partial c_H}{\partial p_L}}{f(0)}
\end{aligned} \tag{6}
$$

As I establish in Appendix A, the mandate reduces firm L's premium and increases firm H's premium. These premium changes occur because (1) low-risk consumers incentivized to enroll by the mandate choose the cheaper plan L and reduce its risk and (2) marginal buyers of firm H's plan shift to firm L's plan, increasing firm H's risk. Consequently, firm L's enrollment increases and firm H's enrollment decreases.

The sufficient conditions in Proposition 1.2 are similar to those in Proposition 1.1 for risk adjustment. One slight difference is that in conditions 1 and 2, it necessary to account for how the penalty affects risk because the penalty represents the "premium for uninsurance." The limitation on intensive margin adverse selection (sufficient condition 4 in Proposition 1.1) can be omitted.

The basic model shows the underinsurance-underenrollment tradeoff can occur in realistic markets where both margins of selection exist. I now turn to the ACA setting to examine whether the tradeoff occurs in practice.

2 ACA Exchange Model

I extend the basic model to study the tradeoff between underinsurance and underenrollment in the ACA setting. The objective is to develop an estimable model that captures the important market features of the exchanges. Consider a two-stage model where (1) insurers set premiums simultaneously to maximize their expected profit and (2) consumers then select a plan to maximize their expected utility. Below I detail how I model household plan choice and firm premium-setting. I then discuss how the omission of certain market features may bias my empirical results.

Household Plan Choice

Exchange consumers can choose a plan from one of the four actuarial value (AV) or "metal" tiers, including bronze (60% AV), silver (70% AV), gold (80% AV), and platinum (90% AV). Individuals under age 30 can buy a basic catastrophic plan. Silver is the most common choice because eligible consumers must choose silver in order to receive cost sharing reductions (CSRs) that reduce deductibles, copays, etc. CSRs increase the AV of silver plans as discussed in Appendix D. In California, plans within a metal tier are standardized to have the same cost sharing parameters.

In the model, households choose the plan that maximizes their (indirect) utility function

$$U_{ijt} \equiv \beta_i^p p_{ijt}(p) + \beta_i^y y_{ij(t-1)} + x'_{ij}\beta^x + w'_{it}\beta^w + \xi_j + \epsilon_{ijt}^d \tag{7}$$

where $p = \mathbf{p}_t$ is the vector of plan base premiums set by all insurers in each market in year t, $p_{ijt}(p)$ is household i's premium for plan j in year t, $y_{ij(t-1)}$ indicates whether household i chose plan j in the previous year, w_{it} is a vector of demographic characteristics, x_{ij} is a vector of observed product characteristics including the plan AV,[5] ξ_j is a vector of unobserved product characteristics, ϵ_{ijt}^d is an error term, the household i's premium parameter $\beta_i^p = \beta^p + w'_{it}\phi$, and the household's inertia parameter $\beta_i^y = \beta^y + x'_{ij}\kappa + w'_{it}\nu$. CSRs enter equation (7) through the plan AV and premium subsidies reduce the household's premium $p_{ijt}(p)$. The household's premium is calculated as

$$p_{ijt}(p) = \max\left\{ \underbrace{\sigma_{it} p_{jmt}}_{\substack{\text{full}\\ \text{premium}}} - \underbrace{\max\{\sigma_{it} p_{bmt} - \zeta_{it}, 0\}}_{\text{premium subsidy}}, 0 \right\} \tag{8}$$

where σ_{it} is the household's rating factor, p_{jmt} is the base premium of plan j in market m and year t, p_{bmt} is the base premium of the benchmark plan, and ζ_{it} is the household's income contribution cap. The product of the rating factor and the plan's base premium equals the unsubsidized premium. The ACA limits variation in the rating factor to the age, smoking status, and geographic residence of the

[5]The variable x_{ij} has an i subscript because the silver plan AV depends on whether the household receives CSRs.

household's members. Insurers can charge a 64-year-old up to 3 times as much as a 21-year-old. Smokers can be charged 50% more than non-smokers, but some states including California prohibit tobacco rating. Each state also defines geographic rating areas where an insurer's premiums must be the same for consumers of the same age and smoking status. Figure 1 shows the California rating area partition.

The household's premium subsidy equals the difference between what the household would pay for the benchmark plan ($\sigma_{it} p_{bmt}$) and the household's income contribution cap ζ_{it}. The benchmark plan is the second-cheapest silver plan available and varies between consumers because of heterogeneous firm entry. The income contribution cap ranged from 2% of annual income for consumers earning 100% of the federal poverty level (FPL) and 9.5% of annual income for consumers earning 400% of FPL in 2014. Subsidies can be applied to any plan except a catastrophic plan. For some low-income consumers, the premium subsidy may exceed the full premium of certain bronze plans. The subsidy is reduced in these cases to ensure nonnegativity of the premium. Premium subsidies are available to consumers who (1) have income between 100% and 400% of FPL; (2) are citizens or legal residents; (3) are ineligible for public insurance such as Medicare or Medicaid[6]; and (4) lack access to an "affordable plan offer" through employer-sponsored insurance.[7]

The utility of the outside option $U_{i0t} = \beta_i^p \rho_{it} + \epsilon_{i0t}$, where ρ_{it} is the household's penalty for forgoing insurance. The penalty was phased in between 2014 and 2016. The penalty for a single person was the greater of $\$95$ and 1% of income exceeding the filing threshold in 2014 and the greater of $\$695$ and 2.5% of income in 2016. The penalty was set to 0 starting in 2019. Exemptions from the ACA's individual mandate are made for certain groups, including (1) those with income below the tax filing threshold and (2) individuals who lack access to a health insurance plan that is less than 8% of their income in 2014.

[6]In Medicaid expansion states, most households with income below 138% of FPL are eligible for Medicaid. Low-income recent immigrants may be ineligible for Medicaid, but eligible to receive exchange subsidies.

[7]A plan is defined as affordable if the employee's contribution to the employer's single coverage plan is less than 9.5% of the employee's household income in 2014. This percentage increases slightly each year.

Let the household demand function $q_{ijt}(\mathbf{p})$ be the probability household i chooses plan j in year t. The effect of a premium change on a subsidized consumer's demand is given by

$$\frac{\partial q_{ikt}(p)}{\partial p_{jmt}} = \sum_{l \in J_{mt}} \frac{\partial q_{ikt}(p)}{\partial p_{ilt}(p)} \frac{\partial p_{ilt}(p)}{\partial p_{jmt}}$$

for all plans j, k in the set of available plans J_{mt}. Assuming a strictly positive subsidy that does not exceed the full, unsubsidized premium, it follows from equation (8) that

$$\frac{\partial p_{ilt}(p)}{\partial p_{jmt}} = \begin{cases} 0 & l = j, j = b \\ \sigma_{it} & l = j, j \neq b \\ -\sigma_{it} & l \neq j, j = b \\ 0 & l \neq j, j \neq b \end{cases} \tag{9}$$

For a non-benchmark plan, an infinitesimal premium increase results in consumers paying more for that plan only. An infinitesimal increase in the benchmark premium does not affect what subsidized consumers pay for the benchmark plan, but reduces what consumers pay for all other plans because of the larger subsidy. The complex relationship between insurer and consumer premiums, endogenous determination of the benchmark premium, and variation in the benchmark plan across consumers due to heterogeneous entry create significant computational challenges. I carefully model the endogenous subsidy design despite the high computational cost because of the critical role premium subsidies play in addressing adverse selection.

Firm Premium-Setting

A risk-neutral profit-maximizing firm sets the base premium p_{jmt} for each plan j that it sells in each market m and period t to maximize

$$\pi_{ft}(p) \quad = \quad R_{ft}(p) - C_{ft}(p) + RA_{ft}(p) + RI_{ft}(p) - V_{ft}(p) - FC_{ft} \tag{10}$$

where $R_{ft}(p)$ is total premium revenue, $C_{ft}(p)$ is total claims, $RA_{ft}(p)$ is risk adjustment received, $RI_{ft}(p)$ is reinsurance received, $V_{ft}(p)$ is variable administrative cost (e.g., commissions or fees), and FC_{ft} is fixed cost.

Pope et al. (2014) derive the ACA risk adjustment transfer formula. Plans with lower-than-average risk make payments to plans with higher-than-average risk such that $\sum_f RA_{ft}(p) = 0$. The ACA design contrasts with the one used in Medicare Advantage, where risk adjustment payments are benchmarked to the risk of those choosing the outside option (i.e., traditional Medicare) and do not necessarily sum to zero. Under the ACA's single risk pool provisions, risk adjustment occurs at the state level for all firms participating in the individual market, including firms offering plans off the exchanges. Risk adjustment reduces firm incentives to market in favorable geographic regions of the state or off the exchanges. Risk adjustment also discourages strategic variation in premiums by plan generosity, but does not explicitly restrict such variation. The risk adjustment pool consists of all metal plans. Catastrophic plans have a separate risk adjustment pool.

Appendix C shows how the risk adjustment transfer formula in Pope et al. (2014) can be aggregated to the firm's risk adjustment transfer

$$RA_{ft}(p) = R_t(p) \sum_{m \in M, j \in J_{fmt}} [rs_{jmt}(p) - us_{jmt}(p)] \tag{11}$$

where J_{fmt} is the set of plans offered by firm f in market m and year t and total premium revenue $R_t(p) = \sum_f R_{ft}(p)$.[8] The plan's *risk share* of total claims $rs_{jmt}(p)$ equals

$$rs_{jmt}(p) = \frac{r_{jmt}(p) q_{jmt}(p)}{\sum_{m \in M, l \in J_{mt}} r_{lmt}(p) q_{lmt}(p)}$$

where J_{mt} is the set of all plans offered in market m and year t. The risk score $r_{jmt}(p) = r_{jmt}(\mathbf{s}_{jmt}(p), AV)$ measures the plan's relative claims risk as a function of the plan's enrollee characteristics (as represented by the vector of demographic shares $\mathbf{s}_{jmt}(p)$) and the plan AV. For example, if $r_{jmt}(p) = 1$ and $r_{kmt}(p) = 2$, then plan k would be expected to have twice the average claims of plan j. The

[8] ACA risk adjustment formula (11) assumes firms price at average claims, which could introduce error if there are administrative costs or markups. In the perfectly competitive setting of the basic model, total premium revenue and total claims are equal.

risk share includes the effects of adverse selection, moral hazard, and the plan design. The plan's *utilization share* of total claims $us_{jmt}(p)$ equals .

$$us_{jmt}(p) = \frac{h_j q_{jmt}(p)}{\sum_{m \in M, l \in J_{mt}} h_l q_{lmt}(p)}$$

where $h_j \equiv h_j(AV)$ is an exogenous expected utilization factor that varies only by plan AV and accounts for moral hazard. The utilization share includes the effect of moral hazard and the plan design, but not adverse selection. The difference between the risk share and utilization share is the plan's *relative* risk due to selection. A positive difference indicates a plan has high risk relative to its expected utilization and receives a risk adjustment transfer; a negative difference indicates a plan has low risk relative to its expected utilization and pays a risk adjustment transfer.

Reinsurance was a temporary program in effect through 2016 that helped to offset the realized claims of high-utilization consumers. Let ι_{ft} be the AV of the reinsurance contract (i.e., the expected percentage of claims paid by the reinsurer). Reinsurance received $RI_{ft}(p) = \iota_{ft} C_{ft}(p)$. Substituting the reinsurance formula into equation (10) yields

$$\pi_{ft}(p) \quad = \quad R_{ft}(p) - (1 - \iota_{ft}) C_{ft}(p) + RA_{ft}(p) - V_{ft}(p) - FC_{ft} \tag{12}$$

The corresponding first-order conditions are

$$MR_{jmt}(p) \quad = \quad (1 - \iota_{ft}) MC_{jmt}(p) - MRA_{jmt}(p) + v_{ft} \frac{\partial q_{ft}(p) / \partial p_{jmt}}{\partial q_{jmt}(p) / \partial p_{jmt}} \tag{13}$$

for all markets m where plan j is offered by the firm in year t, where $q_{ft}(p)$ is total firm demand, v_{ft} is per-consumer variable administrative cost, and formulas for marginal revenue $MR_{jmt}(p) \equiv \frac{\partial R_{ft}(p)}{\partial q_{jmt}(p)}$, marginal claims $MC_{jmt}(p) \equiv \frac{\partial C_{ft}(p)}{\partial q_{jmt}(p)}$, and marginal transfer $MRA_{jmt}(p) = \frac{\partial RA_{ft}(p)}{\partial q_{jmt}(p)}$ are given in Appendix B. The right-hand side of (13) is marginal cost. Reinsurance unambiguously reduces marginal cost, whereas the effect of risk adjustment depends on how the marginal consumer affects the firm's risk due to selection. The marginal transfer is positive for plans with relatively high-risk enrollees and negative for plans with relatively low-risk enrollees.

Appendix B shows how every variable in equation (13) can be written in terms of three variables (and their Jacobians), including: (1) the household choice probabilities $q_{ijt}(p)$; (2) the risk scores $r_{jmt}(p)$; and (3) the plan average claims function $c_{jmt}(p)$.

Model Limitations

Although I model many of the key features of the ACA exchanges, I am unable to model some policy details. I lack demand data on individual plans sold outside the ACA exchanges. Only unsubsidized consumers are likely to consider off-exchange plans, which are ineligible for subsidies. Off-exchange plans have to comply with ACA regulations and are rated together with exchange plans as part of a single risk pool. On average, California exchange plans paid a per-consumer risk adjustment transfer to off-exchange plans of only \$0.80 in 2014 (compared to average claims of \$314) and \$1.10 in 2015 (compared to average claims of \$338) (Department of Managed Health Care, 2016). Hence, selection between exchange and off-exchange plans is small.

Because modeling the ACA's endogenous subsidy imposes significant computational challenges, I make compromises elsewhere. I do not permit insurer entry and exit in the model. Although elimination of policies targeting adverse selection could prompt some insurers to exit, no California insurers exited any rating areas in 2019 when the mandate penalty was set to zero. Ignoring insurer entry and exit does not preclude the possibility that specific plans offered by an insurer could unravel. I also assume that products sets and characteristics are exogenous. This assumption is not particularly onerous because of the ACA's metal tier structure and strict regulations on minimum essential benefits. California has standardized cost sharing parameters and requires insurers to offer a plan in each metal tier. Firms could use narrow provider networks and restrictive formularies to attract low-risk consumers in the absence of risk adjustment. Ignoring provider networks and formularies could bias the magnitude of my estimates, but is unlikely to have a bearing on my central research question of whether there is tradeoff between underinsurance and underenrollment.

3 Data

To estimate the model, I use detailed consumer-level enrollment data from the California ACA exchange from 2014 through 2019. There are approximately 10 million records during this time period. Figure 2 indicates that the California exchange has robust firm participation. There are 4 dominant firms – Anthem, Blue Shield, Centene, and Kaiser – and 9 regional firms.[9] Anthem's decline in market share is the result of its exit from all but 3 of the 19 rating areas in 2018. The administrative data indicate every enrollee's selected plan and demographic information such as age, county of residence, income, and subsidy eligibility. These demographic characteristics and rating factors from insurer rate filings enable me to (1) define the household's complete menu of plan choices and (2) calculate the household-specific premium from the base premium. In Appendix E, I describe how I construct the uninsured population.

Table I presents summary statistics on exchange enrollees. Silver is the most commonly selected option because consumers must choose a silver plan to receive CSRs. Enrollment in silver plans notably drops in 2018 because of California's adoption of "silver loading" in response to the Trump Administration's cancellation of CSR payments to insurers.[10] The modest enrollment in gold and platinum plans suggests there is underinsurance, whereas the large share who are uninsured (roughly one-third of the total population) indicates there is also underenrollment. Very few consumers choose catastrophic plans. Because of this low enrollment and the separate catastrophic risk adjustment pool, I eliminate catastrophic plans from my empirical analysis.

Cost data come from insurer rate filings (Department of Managed Health Care, 2016) and the

[9]These firms include Chinese Community Health Plan, Contra Costa, L.A. Care Health Plan, Molina Healthcare, Oscar, Sharp Health Plan, United Healthcare, Valley Health Plan, and Western Health Advantage.

[10]When CSR payments to insurers were halted, insurers were still required to fund CSRs. Some states including California worked with insurers to load the additional cost of providing CSRs on to silver plan premiums only. Many unsubsidized consumers shifted from silver plans to gold and bronze plans as a consequence.

medical loss ratio (MLR) reports (Centers for Medicare and Medicaid Services, 2017). The insurer rate filings provide key market-level information, including risk adjustment, reinsurance, and firm claims. Figure 3 summarizes risk adjustment transfers. Blue Shield attracts the riskiest consumers, whereas regional insurers attract the least risky consumers. Selection across the metal tiers is even more stark; platinum plans *receive* substantial risk adjustment transfers, whereas bronze plans *pay* large risk adjustment transfers. I obtain state-level data on variable administrative costs and fixed costs from the MLR reports. The utilization factors come directly from the formula used by CMS (Pope et al., 2014). Although I do not directly observe plan risk scores, I solve for them using formula (11) and data on risk adjustment transfers, premium revenue, and utilization shares.

4 Estimation

In this section, I explain how I use the generalized method of moments (GMM) to estimate the household choice probabilities, risk scores, and average claims. I construct four sets of moment conditions: (1) demand moments; (2) risk score moments; (3) average claims moments; and (4) the first-order conditions for profit maximization. Below I explain how I form each set of moments.

Demand Moments

To estimate demand, I model equation (7) as a nested logit at the consumer level, where the vector of error terms ϵ_i has the generalized extreme value distribution. I create a nest containing all exchange plans and a nest containing only the outside option. This two-nest structure captures the key observed substitution pattern between the silver tier and the outside option resulting from the ACA's linkage of CSRs to the purchase of silver plans. The household choice probabilities are

$$q_{ijt}(p;\boldsymbol{\beta}) \quad = \quad \frac{e^{V_{ijt}(p)/\lambda}\left(\sum_j e^{V_{ijt}(p)/\lambda}\right)^{\lambda-1}}{1+\left(\sum_j e^{V_{ijt}(p)/\lambda}\right)^{\lambda}} \tag{14}$$

where $V_{ijt}(p) \equiv \beta_i^p p_{ijt}(p) + \beta_i^y y_{ij(t-1)} + x_{ij}'\beta^x + w_{it}'\beta^w + \xi_j$, the parameter vector $\boldsymbol{\beta} = (\beta_i^p, \beta_i^y, \beta^x, \beta^w)$, and λ is the nesting parameter. The (k, j) element of the Jacobian of equation (14) is

$$\frac{\partial q_{ikt}(p)}{\partial p_{ijt}} = \begin{cases} \beta_i^p q_{ijt}(p) \left[\frac{1}{\lambda} + \frac{\lambda-1}{\lambda} q_{ijt}'(p) - q_{ijt}(p)\right] & k = j \\ \beta_i^p q_{ijt}(p) \left[\frac{\lambda-1}{\lambda} q_{ijt}'(p) - q_{ijt}(p)\right] & k \neq j \end{cases} \tag{15}$$

where $q_{ijt}'(p)$ is the probability of choosing j, conditional on choosing a plan.

Exogenous sources of variation in absolute premiums (i.e., relative to the outside option) are required to identify the effect of premiums on households' extensive margin decision to purchase an exchange plan. I use exogenous variation in absolute premiums in my data that results from the phasing-in of the mandate penalty between 2014 and 2016 and zeroing out of the penalty in 2019. Because I have panel data, I can observe the same household making enrollment decisions facing different absolute premiums. Kinks in the penalty formula also vary across time. The penalty therefore creates substantial temporal and cross-sectional variation in absolute premiums. Other local sources of exogenous variation in absolute premiums that I could use include (1) the 57% increase in the government's age rating curve between ages 20 and 21; (2) the subsidy eligibility threshold at 400% of FPL; and (3) exemptions from the mandate. I used a regression discontinuity design for each of these thresholds to investigate whether exchange enrollment decisions were responsive at these thresholds, but did not find evidence of a statistically significant response.

Identification of the intensive margin decision between alternative exchange plans requires exogenous variation in choice sets and relative premiums (i.e., between plans). Because of the kinks in premium formula (8), some bronze plans may be free to low-income consumers. In particular, some consumers may receive a smaller subsidy for certain bronze plans if the subsidy exceeds the full premium. For these bronze plans, the consumer premium $p_{ij} = 0$. In my data, over one-third of consumers had access to at least one free bronze plan. The set of "free" plans varies considerably by (1) households characteristics such as age, household size, and income; (2) market-specific premium differentials between bronze plans and the benchmark silver plan; (3) time, particularly after the adoption of silver loading in 2018. The variation in “free” plans that results from the ACA’s subsidy formula creates exogenous variation in relative premiums.

Because risk adjustment directly affects firm pricing decisions, it is essential that premium differences across insurers and markets are identified. Unobservables at the insurer’s discretion such as provider networks and formularies may be correlated with premiums. I address this concern by estimating equation (7) with insurer-market fixed effects. Ho and Pakes (2014) and Tebaldi (2017) follow a similar approach. My estimates are similar when including insurer-market fixed effects.

Risk Score Moments

The second set of moments match the model’s predicted plan risk scores with the observed plan risk scores (calculated from the rate filing data as described above). I predict risk scores as a function of observable enrollee characteristics and the plan AV using the estimating equation

$$\ln r_{jmt}(p;\boldsymbol{\beta},\boldsymbol{\gamma}) \;=\; \sum_{d\in D}\gamma^d s_{djmt}(p;\boldsymbol{\beta}) + \gamma^{av}AV_j + \epsilon^r_{jmt} \tag{16}$$

where the predicted demographic share $s_{djmt}(\cdot)$ is the share of plan j’s enrollment in market m and year t with demographic characteristic d, AV_j is the plan AV, ϵ^r_{jmt} is an error term, and the parameter vector $\boldsymbol{\gamma}=(\gamma^d,\gamma^{av},\gamma^n)$. The (k,j)-element of the Jacobian matrix equals

$$\frac{\partial r_{kmt}(p)}{\partial p_{jmt}} \;=\; \frac{r_{kmt}(p)}{q_{kmt}(p)}\sum_{d\in D}\gamma^d\left[\frac{\partial q_{dkmt}(p)}{\partial p_{jmt}} - s_{dkmt}(p)\frac{\partial q_{kmt}(p)}{\partial p_{jmt}}\right] \tag{17}$$

where $\frac{\partial q_{kmt}(p)}{\partial p_{jmt}}$ is calculated using equation (15). Equation (17) measures the sensitivity of plan risk to premiums and is an input for computing marginal claims $MC_{jmt}(p)$ in equation (28) and marginal transfer $MRA_{jmt}(p)$ in equation (29).

Computing risk scores using equation (16) is similar to the regression approach used to compute ACA risk scores (Kautter et al., 2014). ACA risk scores use patient-level data on age, gender, and diagnosed medical conditions. A separate regression model is estimated for each age group (adult, child, and infant) and each metal tier. Because I have plan-level risk score data, I cannot exactly replicate the ACA risk score methodology. I instead pool across the metal tiers and include the plan AV as a regressor. I also lack data on patient medical conditions. Omitting medical conditions may bias estimates of the parameter vector γ^d. To address this potential source of bias, I compute predicted demographic shares using the estimated consumer-level choice probabilities from equation (14) instead of the observed demographic shares, which are likely to be endogenous. I compute the demographic share $s_{djmt}(p;\boldsymbol{\beta}) = \frac{\sum_{i\in I}(\mathbb{I}_{i,m,d})q_{ijt}(p;\boldsymbol{\beta})}{\sum_{i\in I}(\mathbb{I}_{i,m})q_{ijt}(p;\boldsymbol{\beta})}$ using the predicted choice probabilities from equation (14), where the indicator $\mathbb{I}_{i,m,d}$ equals 1 if household i lives in market m and has demographic characteristic d and equals 0 otherwise. Choice model (14) can be interpreted as the first-stage of an IV regression for computing unbiased estimates of plan risk scores. A similar empirical strategy is widely used in the hospital choice literature to compute measures of hospital market concentration (e.g., Kessler and McClellan (2000)). The identifying assumption is that the predicted demographic shares are based on exogenous determinants of consumer plan demand.

Average Claims Moments

The third set of moments match predicted plan average claims with observed plan average claims. I predict average claims as a function of the plan risk score using the estimating equation

$$\ln c_{jmt}(p;\boldsymbol{\beta},\boldsymbol{\gamma},\boldsymbol{\theta}) \quad = \quad \theta^r \ln r_{jmt}(p;\boldsymbol{\beta},\boldsymbol{\gamma}) + x_j'\theta^x + \theta^u u_t + n_m'\theta^n + \epsilon^c_{jmt} \tag{18}$$

where $r_{jmt}(\cdot)$ is the predicted risk score computed using equation (16), x_j are product characteristics (not including plan AV), u_t is a linear trend, n_m' are market fixed effects, ϵ^c_{jmt} is an error term, and $\boldsymbol{\theta} = (\theta^r, \theta^x, \theta^u, \theta^n)$ are parameters. The (k, j)-element of the Jacobian matrix equals

$$\frac{\partial c_{kmt}(p)}{\partial p_{jmt}} \quad = \quad \theta^r \frac{c_{kmt}(p)}{r_{kmt}(p)} \frac{\partial r_{kmt}(p)}{\partial p_{jmt}} \tag{19}$$

The key identification challenge is to obtain an unbiased estimate of the risk score parameter θ^r.

I compute predicted plan risk scores using equation (16) instead of the observed plan risk scores, which are likely to be endogenous. If the ACA risk score perfectly captures plan claims risk, then enrollee characteristics should only affect plan average claims through the plan risk score and not directly affect average claims. Imperfections in the ACA risk score are reflected in the estimated risk score parameter. This implies that the policy counterfactuals in this article should be interpreted as assessing the impact of ACA risk adjustment, not "perfect risk adjustment."

Summary

The four sets of moment conditions that I use to estimate $\boldsymbol{\beta}, \boldsymbol{\gamma}$, and $\boldsymbol{\theta}$ are summarized below:

$$
\begin{aligned}
\frac{1}{N^{IJT}} \sum_{i \in I, j \in J, t \in T} \frac{\chi_{ijt} \partial \ln q_{ijt}(p; \boldsymbol{\beta})}{\partial \boldsymbol{\beta}} &= \mathbf{0} \\
\frac{1}{N^{JMT}} \sum_{j \in J, m \in M, t \in T} \mathbf{z}^r_{jmt} \left(\ln r_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}) - \boldsymbol{\gamma}' \mathbf{z}^r_{jmt} \right) &= \mathbf{0} \\
\frac{1}{N^{JMT}} \sum_{j \in J, m \in M, t \in T} \mathbf{z}^c_{jmt} \left(\ln c_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta}) - \boldsymbol{\theta}' \mathbf{z}^c_{jmt} \right) &= \mathbf{0} \\
\frac{1}{N^M_{jt}} \sum_{m \in M} g_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta}) &= 0, \qquad \forall j \in J_t, t \in T \qquad (20)
\end{aligned}
$$

where N^{IJT} is the total number of plan choices available to all households in all years, N^{JMT} is the total number of plans available in all markets and years, N^M_{jt} is the number of markets where plan j is offered in year t, χ_{ijt} indicates whether household i chose plan j at time t, the risk score variables $\mathbf{z}^r_{jmt} \equiv (s_{djmt}(p, \boldsymbol{\beta}), AV_j)$, the average claims variables $\mathbf{z}^c_{jmt} \equiv (\ln r_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}), x_j, u_t, n_m)$, and the first-order condition values

$$
g_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta}) \equiv MR_{jmt}(p; \boldsymbol{\beta}) - (1 - \iota_{ft}) MC_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta}) + MRA_{jmt}(p; \boldsymbol{\beta}, \boldsymbol{\gamma}) - v_{ft} \frac{\frac{\partial q_{ft}(p; \boldsymbol{\beta})}{\partial p_{jmt}}}{\frac{\partial q_{jmt}(p; \boldsymbol{\beta})}{\partial p_{jmt}}}
$$

Because model (20) over-identifies the model parameters, I use two-step feasible GMM to find the values of $\boldsymbol{\beta}, \boldsymbol{\gamma}$, and $\boldsymbol{\theta}$ that minimize the GMM objective $[\mathbf{m}(\boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta})]' \mathbf{W}^{-1} [\mathbf{m}(\boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta})]$, where

$\mathbf{m}(\boldsymbol{\beta}, \gamma, \boldsymbol{\theta})$ is the vector of moment values in model (20) and the optimal weight matrix $\mathbf{W}$ is a consistent estimate of the variance-covariance matrix of the moment values.

My estimation approach is tailored to the available consumer-level data on plan choices and plan-level data on costs. With consumer-level data on costs, I could instead specify a consumer utility function that captures preferences for both plans and utilization and calculate plan-level claims by aggregating consumer-level utilization. As a second-best alternative, I follow the approach of Starc (2014) and jointly estimate consumer-level demand, plan-level risk, and plan-level claims using GMM. Although these parameters are consistent with each other, they may not reflect consumer-level variation in moral hazard or selection on moral hazard (Einav et al., 2013).

Table III summarizes the estimates of $\boldsymbol{\beta}, \gamma$, and $\boldsymbol{\theta}$ for three specifications. The results are qualitatively similar across specifications, although the magnitude of the parameters is generally larger in the third specification where I add insurer-market fixed effects and demographic intercepts (i.e., dummy variables that equal 1 if a household purchases an exchange plan and has a given demographic characteristic such as income above 400% of FPL). The estimated parameters have the expected sign. Consumers prefer plans with a higher actuarial value and fewer network restrictions. Strong evidence of inertia exists as the previous choice parameter is large and positive. Table II shows the implied (unsubsidized) premium elasticities and semi-elasticities of demand for the second specification. My estimates are consistent with other estimates of premium sensitivity in the California exchange (Tebaldi, 2017; Domurat, 2017; Saltzman, 2019; Drake, 2019).[11] The second panel of Table III indicates that plans with larger shares of males or enrollees between the ages of 18 and 34 have lower risk scores. I also find that a one percent increase in the predicted risk score yields about a one percent increase in average claims. The linear trend parameter indicates that average claims grow by about 5% each year.

[11] See Saltzman (2019) for a full comparison of these estimates. My estimates are somewhat smaller than Domurat (2017) and Saltzman (2019), but slightly larger than Tebaldi (2017) and Drake (2019).

5 Simulations

Simulation Design

I use the estimated model to simulate the impact of risk adjustment and the individual mandate in the ACA exchanges. To estimate the model, I assume that the observed ACA premiums define a Nash equilibrium that satisfies the firms' first-order conditions defined in (13). This Nash equilibrium occurs in the ACA policy environment where risk adjustment, the individual mandate, and ACA price-linked subsidies are in place. I simulate 6 counterfactuals that involve combinations of 3 policy changes: (1) repealing risk adjustment; (2) repealing the individual mandate; and (3) replacing the ACA's endogenous subsidy with a voucher. I simulate the elimination of risk adjustment by solving for the vector of premiums that satisfy the first-order conditions

$$MR_{jmt}(p) \quad = \quad (1-\iota_{ft})MC_{jmt}(p) + \upsilon_{ft}\frac{\partial q_{ft}(p)/\partial p_{jmt}}{\partial q_{jmt}(p)/\partial p_{jmt}} \tag{21}$$

for all plans j. I simulate mandate repeal by setting the penalty to zero in the outside option utility and then resolving the first-order conditions (either (13) or (21) depending on whether risk adjustment is in place). I replace ACA subsidies with vouchers by making the benchmark premium in formula (8) a constant equal to the observed benchmark premium and then resolving the first-order conditions. Fixing the benchmark premium replaces formula (9) with

$$\frac{\partial p_{ilt}(p)}{\partial p_{jmt}} = \begin{cases} \sigma_{it} & l = j \\ 0 & l \neq j \end{cases} \tag{22}$$

Resolving first-order conditions (13) and (21) is very computationally burdensome. To ease the computation, I run every policy counterfactual once for each year in my data with a sample of $ns = 500$ households. The simulation results that I present are a simple average across years. I keep the number of variables manageable by assuming the geographic rating factors (i.e., ratio of premium in a rating area to the plan base premium) are exogenous. This assumption could downward bias my estimates of risk adjustment's impact if insurers risk select across rating areas. In practice, geographic rating factors are closely reviewed by California regulators and must be supported with cost data.

For each simulation, I compute several measures. Coverage is calculated using equation (14) and firm profit using equation (10). I also compute consumer surplus $CS_i = (\lambda/\alpha_i)\ln\left(\sum_{j\in J}\exp\left(U_{ij}/\lambda\right)\right)$. Government spending on premium subsidies equals the sum of subsidies received by each consumer in formula (8). Spending on CSRs is computed using formula (30) in Appendix D. I calculate government spending on uncompensated care by multiplying the number of uninsured that I estimate in each scenario by \$2,025, the estimated annual uncompensated care cost per uninsured[12], and a factor accounting for the change in the uninsured population's risk score. Total social welfare $SW \equiv CS + \pi - GS$ equals the sum of total consumer surplus CS, total firm profit π, and total government spending GS.

Risk Adjustment Results

Table IV shows the impact of risk adjustment in alternative policy environments. Repealing risk adjustment reduces bronze and silver premiums by 13% and 2%, respectively, and increases gold and platinum premiums by 17% and 60%, respectively. These premium changes result in enrollment increases of 19% and 3% in bronze and silver plans, respectively, and enrollment declines of 36% and 65% in gold and platinum plans, respectively. Although the intensive margin effects are robust in alternative policy environments, there is some difference in the extensive margin effects. Eliminating risk adjustment has a positive, but very small positive impact on exchange enrollment with the mandate and an endogenous subsidy in place (i.e., comparing the base scenario with scenario 1 in Table IV). Without a mandate, repealing risk adjustment increases exchange enrollment

[12] I multiply the per-capita amount of medical costs that are paid on behalf of the nonelderly uninsured as estimated by Coughlin et al. (2014) by an inflation factor using data from the National Health Expenditure Accounts to adjust the estimates to the timeframe of this study (Centers for Medicare and Medicaid Services, 2018).

by nearly 23,000 or about 1.5% (i.e., comparing scenarios 2 and 3 in Table IV). These results suggest that risk adjustment addresses underinsurance, but exacerbates underenrollment. The mandate, however, can mitigate the negative effects of risk adjustment on the extensive margin. Even with a mandate, the impact of risk adjustment on total enrollment is relatively small and pales in comparison to the impact on consumer sorting across plans. The reason for this result is that the estimated intensive margin elasticities are significantly larger than the estimated extensive margin elasticities (Table II). In markets with larger extensive margin elasticities and less competition than California, the effect of risk adjustment on total enrollment could be larger.

Table IV reports the changes in per-capita social welfare (absolute welfare levels are not identified). I compute per-capita amounts by dividing all total dollar amounts by the number of consumers in the market, including those choosing the outside option. Overall, the welfare impact of repealing risk adjustment is small. Welfare losses of $35/year in consumer surplus and $60/year in profit are largely offset by $113/year in reduced government premium subsidy spending. Premium subsidy spending declines without risk adjustment because of reductions in the benchmark silver premium. Reductions in consumer surplus and firm profit could be mitigated if subsidies were maintained at their level in the base scenario, but higher subsidy spending would offset these gains (i.e., comparing scenarios 5 and 6).

Individual Mandate Results

Table IV also shows the impact of the mandate in alternative policy environments. In contrast to risk adjustment, repealing the mandate results in very modest premium increases of less than 1% across the metal tiers. This result is robust in alternative policy environments. Bronze and silver plan enrollment decline by 1.5% and 2.5%, respectively, gold plan enrollment increases by 1%, and platinum plan enrollment is largely unchanged. Total exchange enrollment falls by 2%. The mandate therefore mitigates underenrollment, but exacerbates underinsurance. The only significant welfare change is the loss of mandate penalty revenue, which falls by \$220 per year and consumer.

The relatively modest impact of the mandate may seem surprising given its prominence in public policy discussion and legal action. One possible explanation is that the penalty amount is small relative to the cost of coverage, even when the penalty was fully phased in. Robust competition between firms also limits firms' market power to raise premiums if the mandate were repealed.

Model Validation

Because the mandate penalty was set to 0 in 2019, I can partially validate my predictions of the mandate's impact. Although elimination of the mandate penalty was the most significant and publicized policy change in 2019, other notable changes included (1) the Trump Administration's easing of restrictions on short-term health plans, which likely increased premiums and (2) the suspension of the Health Insurance Providers Fee under Section 9010 of the ACA, which likely reduced premiums. Another concern is that 2019 rate increases could reflect corrections for mispricings of past policy changes, such as the elimination of CSR payments to insurers in 2018.

With these caveats in mind, I compare observed enrollment changes in the California exchange between 2018 and 2019 and predicted enrollment changes between the base scenario and scenario (2) in Table V. The larger distortion in bronze and silver enrollment compared to gold and platinum enrollment mirrors my predictions. Both observed and predicted declines in total enrollment are nearly identical at 2%. Nationwide, exchange enrollment dropped by 2.6% from 11,750,175 in 2018 to 11,444,141 in 2019 (Kaiser Family Foundation, 2020).

Premium changes are more difficult to compare. My model predicts that eliminating the mandate increased premiums by 0.7% (i.e., comparing the base scenario to scenario 2). The California exchange reports that the 2019 rate increase was 0.3 percentage points above the 5-year average premium increase of 8.4%, very close to my estimate. Exchange officials, however, attribute 3.5 percentage points of the 2019 premium increase to the elimination of the mandate penalty (California Health Benefit Exchange, 2018). Nationally, the average benchmark premium dropped 0.5% on average in 2019 despite elimination of the penalty (Kaiser Family Foundation, 2020).

6 Conclusion

In this article, I study whether common government policy interventions can address both underinsurance and underenrollment simultaneously. I show there is a tradeoff in addressing the intensive and extensive margin effects of adverse selection which could have important implications for social welfare. I illustrate the tradeoff by studying the impact of risk adjustment and the individual mandate both theoretically and empirically in the ACA exchanges. I find that risk adjustment addresses underinsurance, but reduces enrollment. The effects on enrollment are small, however, particularly when the mandate is in effect. Conversely, the mandate increases enrollment, but also increases underinsurance. I find the impact of the mandate is relatively modest, consistent with the observed impact of the mandate when the penalty was set to zero in 2019.

There are several opportunities to extend the analysis in this article. It would be valuable to study how market structure affects underinsurance-underenrollment tradeoff. Adding a network formation stage to the model where providers and insurers bargain over inclusion in the network would partially address the assumption that product characteristics are exogenous. A framework that models how insurers learn over time could improve the accuracy of the welfare estimates.

The challenge in mitigating both underinsurance and underenrollment due to adverse selection has important implications for the design of efficient insurance markets. Policies targeting either underinsurance or underenrollment (but not both) can have unintended consequences. The risk adjustment design used in Medicare Advantage, where risk adjustment payments from the government to participating plans are benchmarked to the risk of those choosing the outside option, may address both underinsurance and underenrollment. Financing such a risk adjustment program could be costly and involve significant opportunity costs. Relaxing community rating regulations would target the chief cause of adverse selection in insurance markets, but expose consumers in poor health to high premiums (Handel et al., 2015). High-risk pools or guaranteed renewable insurance with longer time horizons (Pauly et al., 1995; Herring and Pauly, 2006) are alternatives to community rating that may avoid the underinsurance-underenrollment tradeoff examined in this article.

References

Akerlof, G.. "The Market for Lemons: Quality Uncertainty and the Market Mechanism." *Quarterly Journal of Economics* Vol. 84 (1970), pp. 488-500.

Azevedo, E. and Gottlieb, D. "Perfect Competition in Markets with Adverse Selection." *Econometrica*, Vol. 85 (2017), pp. 67–105.

Brown, J., Duggan M., Kuziemko, I., and Woolston, W. "How Does Risk Selection Respond to Risk Adjustment? New Evidence from the Medicare Advantage Program." *The American Economic Review*, Vol. 104 (1994), pp. 3335-3364.

California Health Benefit Exchange. "Covered California Releases 2019 Individual Market Rates: Average Rate Change Will Be 8.7 Percent, With Federal Policies Raising Costs." last modified 2018, https://www.coveredca.com/newsroom/news-releases/.

Cardon, J. and Hendel, I. "Asymmetric Information in Health Insurance: Evidence from the National Medical Expenditure Survey." *RAND Journal of Economics*, Vol. 32 (2001), pp. 408–427.

Centers for Medicare and Medicaid Services. "Market Rating Reforms." last modified 2013, http://www.cms.gov/CCIIO/Programs-and-Initiatives/Health-Insurance-Market-Reforms/state-rating.html.

Centers for Medicare and Medicaid Services. "Medical Loss Ratio Data and System Resources." last modified 2017, https://www.cms.gov/CCIIO/Programs-and-Initiatives/ Premium-Stabilization-Programs/Downloads/RI-RA-Report-Draft-6-30-15.pdf.

Centers for Medicare and Medicaid Services. "National Health Expenditure Data." last modified 2018, https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html.

Coughlin, T., Holahan, J., Caswell, K., and McGrath, M. "Uncompensated Care for Uninsured in 2013: A Detailed Examination." last modified 2014, https://kaiserfamilyfoundation.files.wordpress.com/2014/0 uncompensated-care-for-the-uninsured-in-2013.pdf.

Cutler, D. and Reber, S. "Paying for Health Insurance: the Trade-off Between Competition and Adverse Selection." *Quarterly Journal of Economics*, Vol. 113 (1998), pp. 433–466.

Department of Managed Health Care. "Premium Rate Review Filings." last modified 2016, http://wpso.dmhc.ca.gov/ratereview/.

Domurat, R. "How Do Supply-Side Regulations in the ACA Impact Market Outcomes? Evidence from California." Department of Economics, University of California, Los Angeles, Los Angeles, 2017.

Drake, C. "What Are Consumers Willing to Pay for a Broad Network Health Plan?: Evidence from Covered California." *Journal of Health Economics*, Vol. 65 (2019), pp. 63–77.

Einav, L., Finkelstein, A., and Cullen, M. "Estimating Welfare in Insurance Markets Using Variation in Prices." *Quarterly Journal of Economics*, Vol. 125 (2010), pp. 877–921.

Einav, L., Finkelstein, A., Ryan, S., Schrimpf, P., and Cullen, M. "Selection on Moral Hazard in Health Insurance." *The American Economic Review*, Vol. 103 (2013), pp. 178–219.

Enthoven, A. "Consumer Choice Health Plan." *New England Journal of Medicine*, Vol. 298 (1978), pp. 650–658.

Frean, M., Gruber, J., and Sommers, B. "Premium Subsidies, the Mandate, and Medicaid Expansion: Coverage Effects of the Affordable Care Act." *Journal of Health Economics*, Vol. 53 (2017), pp. 72–86.

Geruso, M., Layton, T., McCormack, G., and Shepard, M.. "The Two Margin Problem in Insurance Markets." NBER Working Paper no. 26288, Harvard Kennedy School, Harvard University, 2019.

Geruso, M., Layton, T., and Prinz, D. "Screening in Contract Design: Evidence from the ACA Health Insurance Exchanges." *American Economic Journal: Economic Policy*, Vol. 11 (2019), pp. 64–107.

Hackmann, M., Kolstad, J., and Kowalski, A. "Adverse Selection and an Individual Mandate: When Theory Meets Practice." *The American Economic Review*, Vol. 105 (2015), pp. 1030–1066.

Handel, B. "Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts." *The American Economic Review*, Vol. 103 (2013), pp. 2643–2682.

Handel, B., Hendel, I., and Whinston, M. "Equilibria in Health Exchanges: Adverse Selection Versus Reclassification Risk." *Econometrica*, Vol. 83 (2015), pp. 1261–1313.

Herring, B. and Pauly, M. "Guaranteed Renewability in Insurance." *Journal of Health Economics*, Vol. 25 (2006), pp. 395–417.

Ho, K. and Pakes, A. (2014). "Hospital Choices, Hospital Prices, and Financial Incentives to Physicians." *The American Economic Review*, Vol. 104 (2014), pp. 3841–3884.

Jaffe, S. and Shepard, M. "Price-linked Subsidies and Health Insurance Markups." Harvard Kennedy School, Harvard University, Cambridge, 2017.

Kaiser Family Foundation. "State Health Facts: Health Reform." last modified 2020, https://www.kff.org/state-category/health-reform/health-insurance-marketplaces/.

Kautter, J., Pope, G., Ingber, M., Freeman, S., Patterson, L., Cohen, M., and Keenan, P. "The HHS-HHC Risk Adjustment Model for Individual and Small Group Markets Under the Affordable Care Act." *Medicare and Medicaid Research Review*, Vol. 4 (2014), pp. 1–46.

Kessler, D. and McClellan, M. "Is Hospital Competition Socially Wasteful?" *Quarterly Journal of Economics*, Vol. 115 (2000), pp. 577–615.

Layton, T. (2017). "Imperfect risk adjustment, risk preferences, and sorting in competitive health insurance markets." *Journal of Health Economics*, Vol. 56 (2017), pp. 259-280.

Mahoney, N. and Weyl, E. "Imperfect Competition in Selection Markets." *The Review of Economics and Statistics*, Vol. 99 (2017), pp. 637–651.

Newhouse, J., Price, M., McWilliams, J., Hsu, J., and McGuire, T. "How Much Favorable Selection Is Left in Medicare Advantage?" *American Journal of Health Economics*, Vol. 1 (2015), pp. 1–26.

Panhans, M. "Adverse Selection in ACA Exchange Markets: Evidence from Colorado." *American Economic Journal: Applied Economics*, Vol. 11 (2019), pp. 1–36.

Pauly, M. and Herring, B. "An Efficient Employer Strategy for Dealing with Adverse Selection in Multiple-Plan Offerings: An MSA example." *Journal of Health Economics*, Vol. 19 (2000), pp. 513– 528.

Pauly, M., Kunreuther, H., and Hirth, R. "Incentive-Compatible Guaranteed Renewable Health Insurance Premiums." *Journal of Risk and Uncertainty*, Vol. 10 (1995), pp. 143–156.

Pope, G., Bachofer, H., Pearlman, A., Kautter, J., Hunter, E., Miller, D., and Keenan, P. "Risk Transfer Formula for Individual and Small Group Markets Under the Affordable Care Act." *Medicare and Medicaid Research Review,* Vol. 4 (2014), pp. 1-46.

Rothschild, M. and Stiglitz J. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." *Quarterly Journal of Economics*, Vol. 90 (1976), pp. 629–649.

Sacks, D. "How Do the Mandate and the Premium Tax Credit Affect the Individual Insurance Market?" Kelley School of Business, Indiana University, Bloomington, 2017.

Saltzman, E. "Demand for Health Insurance: Evidence from the California and Washington ACA Exchanges." *Journal of Health Economics*, Vol. 63 (2019), pp. 197–222.

Starc, A. "Insurer Pricing and Consumer Welfare: Evidence from Medigap." *RAND Journal of Economics*, Vol. 45 (2014), pp. 198–220.

Tebaldi, P. "Estimating Equilibrium in Health Insurance Exchanges: Price Competition and Subsidy Design Under the ACA." Department of Economics, University of Chicago, Chicago, 2017.

[Appendices for Online Publication Only]

Appendix A: Proofs for the Basic Model

Proof of Proposition 1.1

Differentiating equilibrium conditions (1) with respect to ψ yields

$$\begin{aligned}\frac{\partial p_L}{\partial \psi} &= \frac{\partial c_L'}{\partial \psi} = (c - c_L) + (1-\psi)\frac{\partial c_L}{\partial \psi} + \psi \frac{\partial c}{\partial \psi} \\ &= (c - c_L) + (1-\psi)\left(\frac{\partial c_L}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial c_L}{\partial p_H}\frac{\partial p_H}{\partial \psi}\right) + \psi\left(\frac{\partial c}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial c}{\partial p_H}\frac{\partial p_H}{\partial \psi}\right) \qquad (23)\end{aligned}$$

$$\begin{aligned}\frac{\partial p_H}{\partial \psi} &= \frac{\partial c'_H}{\partial \psi} = -(c_H - c) + (1-\psi)\frac{\partial c_H}{\partial \psi} + \psi \frac{\partial c}{\partial \psi} \\ &= -(c_H - c) + (1-\psi)\left(\frac{\partial c_H}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial c_H}{\partial p_H}\frac{\partial p_H}{\partial \psi}\right) + \psi\left(\frac{\partial c}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial c}{\partial p_H}\frac{\partial p_H}{\partial \psi}\right) \end{aligned} \tag{24}$$

Solving equation (24) for $\frac{\partial p_H}{\partial \psi}$ yields

$$\frac{\partial p_H}{\partial \psi} = \frac{-(c_H - c) + (1-\psi)\frac{\partial c_H}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \psi \frac{\partial c}{\partial p_L}\frac{\partial p_L}{\partial \psi}}{1 - (1-\psi)\frac{\partial c_H}{\partial p_H} - \psi \frac{\partial c}{\partial p_H}} \tag{25}$$

Substituting the right-hand side of equation (25) into equation (23) and solving for $\frac{\partial p_L}{\partial \psi}$ yields

$$\frac{\partial p_L}{\partial \psi} = \frac{(c - c_L)\left(1 - \frac{\partial c'_H}{\partial p_H}\right) - (c_H - c)\frac{\partial c'_L}{\partial p_H}}{f(\psi)}$$

Substituting for $\frac{\partial p_L}{\partial \psi}$ in equation (24) and solving for $\frac{\partial p_H}{\partial \psi}$ yields

$$\frac{\partial p_H}{\partial \psi} = \frac{-(c_H - c)\left(1 - \frac{\partial c'_L}{\partial p_L}\right) + (c - c_L)\frac{\partial c'_H}{\partial p_L}}{f(\psi)}$$

I now establish that the partial derivative $\frac{\partial p_L}{\partial \psi}$ is positive and the partial derivative $\frac{\partial p_H}{\partial \psi}$ is negative. The common denominator $f(\psi) > 0$ by assumption. The numerator of the partial derivative $\frac{\partial p_H}{\partial \psi}$ is negative because condition 4 in Proposition 1.1 can be written as

$$\begin{aligned} \frac{\partial c}{\partial p_L} < \frac{q_L}{q}\left(1 - \frac{\partial c_L}{\partial p_L}\right) &\Rightarrow \psi \frac{\partial c}{\partial p_L} + (1-\psi)\frac{q_H}{q}\frac{\partial c_H}{\partial p_L} < \frac{q_L}{q}\left(1 - (1-\psi)\frac{\partial c_L}{\partial p_L}\right) \\ &\Leftrightarrow \psi\left(1 + \frac{q_L}{q_H}\right)\frac{\partial c}{\partial p_L} + (1-\psi)\frac{\partial c_H}{\partial p_L} < \frac{q_L}{q_H}\left(1 - (1-\psi)\frac{\partial c_L}{\partial p_L}\right) \\ &\Leftrightarrow \frac{\partial c'_H}{\partial p_L} < \frac{q_L}{q_H}\left(1 - \frac{\partial c'_L}{\partial p_L}\right) \\ &\Leftrightarrow (c - c_L)\frac{\partial c'_H}{\partial p_L} < \frac{c - c_L}{c_H - c}\frac{q_L}{q_H}(c_H - c)\left(1 - \frac{\partial c'_L}{\partial p_L}\right) \\ &\Leftrightarrow -(c_H - c)\left(1 - \frac{\partial c'_L}{\partial p_L}\right) + (c - c_L)\frac{\partial c'_H}{\partial p_L} < 0 \end{aligned}$$

where the first line follows because $\psi \in [0, 1]$, $\frac{\partial c_L}{\partial p_L} > 0$, and $\frac{\partial c_H}{\partial p_L} < 0$, and the fifth line follows because the total transfer paid by firm L equals the total transfer received by firm H. The numerator of the partial derivative $\frac{\partial p_L}{\partial \psi}$ is positive because condition 5 in Proposition 1.1 can be written as

$$\begin{aligned}
\frac{\partial c_L}{\partial p_H} < \frac{q_H}{q_L}\left(1 - \frac{\partial c_H}{\partial p_H}\right) \quad &\Rightarrow \quad (1-\psi)\frac{\partial c_L}{\partial p_H} < \frac{q_H}{q_L}\left(1 - (1-\psi)\frac{\partial c_H}{\partial p_H}\right) \\
&\Leftrightarrow \quad (c_H - c)(1-\psi)\frac{\partial c_L}{\partial p_H} < \frac{c_H - c}{c - c_L}\frac{q_H}{q_L}\left(1 - (1-\psi)\frac{\partial c_H}{\partial p_H}\right)(c - c_L) \\
&\Leftrightarrow \quad (c_H - c)(1-\psi)\frac{\partial c_L}{\partial p_H} < \left(1 - (1-\psi)\frac{\partial c_H}{\partial p_H}\right)(c - c_L) \\
&\Leftrightarrow \quad (c_H - c)\frac{\partial c'_L}{\partial p_H} < \left(1 - \frac{\partial c'_H}{\partial p_H}\right)(c - c_L) \\
&\Leftrightarrow \quad (c - c_L)\left(1 - \frac{\partial c'_H}{\partial p_H}\right) - (c_H - c)\frac{\partial c'_L}{\partial p_H} > 0
\end{aligned}$$

where the first line follows because $\psi \in [0,1]$, the third line follows because the total transfer paid by firm L equals the total transfer received by firm H, and the fourth line follows because $\frac{\partial c}{\partial p_H} = 0$. It follows that $\frac{\partial p_L}{\partial \psi} > 0$ and $\frac{\partial p_H}{\partial \psi} < 0$. Now consider the effect of risk adjustment on enrollment in firm H's plan. Observe that

$$\frac{\partial q_H}{\partial \psi} = \frac{\partial q_H}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial q_H}{\partial p_H}\frac{\partial p_H}{\partial \psi} > 0$$

because $\frac{\partial q_H}{\partial p_L} > 0$, $\frac{\partial p_L}{\partial \psi} > 0$, $\frac{\partial q_H}{\partial p_H} < 0$, and $\frac{\partial p_H}{\partial \psi} < 0$. Hence, risk adjustment reduces underinsurance. Now consider the effect of risk adjustment on total enrollment. The effect of risk adjustment on market average risk is given by

$$\frac{\partial c}{\partial \psi} = \frac{\partial c}{\partial p_L}\frac{\partial p_L}{\partial \psi} + \frac{\partial c}{\partial p_H}\frac{\partial p_H}{\partial \psi} > 0$$

because $\frac{\partial p_L}{\partial \psi} < 0$ and by assumption, $\frac{\partial c}{\partial p_L} > 0$ and $\frac{\partial c}{\partial p_H} = 0$. Because $q(p'_L, p'_H) < q(p''_L, p''_H)$ if and only if $c(p'_L, p'_H) > c(p''_L, p''_H)$ for any premium vectors $p' = (p'_L, p'_H)$ and $p'' = (p''_L, p''_H)$, it follows that risk adjustment must decrease total enrollment (i.e., $\partial q / \partial \psi < 0$).

In Section 1.1, I claim that sufficient condition 4 in Proposition 1.1 implies inequality (3). To see this, observe that

$$\begin{aligned}
\frac{\partial c}{\partial p_L} < \frac{q_L}{q}\left(1-\frac{\partial c_L}{\partial p_L}\right) &\Rightarrow -(c_H-c)\left(1-\frac{\partial c_L'}{\partial p_L}\right)+(c-c_L)\frac{\partial c_H'}{\partial p_L}<0 \\
&\Leftrightarrow \frac{(c_H-c)\left(1-\frac{\partial c_L'}{\partial p_L}\right)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-(c-c_L)\frac{\partial c_H'}{\partial p_L}\left(1-\frac{\partial c_H'}{\partial p_H}\right)}{\left(1-\frac{\partial c_L'}{\partial p_L}\right)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-\frac{\partial c_H'}{\partial p_L}\frac{\partial c_L'}{\partial p_H}}>0 \\
&\Leftrightarrow (c_H-c)-\frac{\partial c_H'}{\partial p_L}\left(\frac{(c-c_L)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-(c_H-c)\frac{\partial c_L'}{\partial p_H}}{\left(1-\frac{\partial c_L'}{\partial p_L}\right)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-\frac{\partial c_H'}{\partial p_L}\frac{\partial c_L'}{\partial p_H}}\right)>0 \\
&\Leftrightarrow \frac{\partial c_H'}{\partial p_L}\frac{\partial p_L}{\partial \psi}<c_H-c
\end{aligned}$$

In Section 1.1, I also claim that sufficient condition 5 in Proposition 1.1 implies inequality (4) holds. To see this, observe that

$$\begin{aligned}
\frac{\partial c_L}{\partial p_H} < \frac{q_H}{q_L}\left(1-\frac{\partial c_H}{\partial p_H}\right) &\Rightarrow (c-c_L)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-(c_H-c)\frac{\partial c_L'}{\partial p_H}>0 \\
&\Leftrightarrow \frac{(c-c_L)\left(1-\frac{\partial c_H'}{\partial p_H}\right)\left(1-\frac{\partial c_L'}{\partial p_L}\right)-(c_H-c)\frac{\partial c_L'}{\partial p_H}\left(1-\frac{\partial c_L'}{\partial p_L}\right)}{\left(1-\frac{\partial c_L'}{\partial p_L}\right)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-\frac{\partial c_H'}{\partial p_L}\frac{\partial c_L'}{\partial p_H}}>0 \\
&\Leftrightarrow (c-c_L)+\frac{\partial c_L'}{\partial p_H}\left(\frac{-(c_H-c)\left(1-\frac{\partial c_L'}{\partial p_L}\right)+(c-c_L)\frac{\partial c_H'}{\partial p_L}}{\left(1-\frac{\partial c_L'}{\partial p_L}\right)\left(1-\frac{\partial c_H'}{\partial p_H}\right)-\frac{\partial c_H'}{\partial p_L}\frac{\partial c_L'}{\partial p_H}}\right)>0 \\
&\Leftrightarrow -\frac{\partial c_L'}{\partial p_H}\frac{\partial p_H}{\partial \psi}<c-c_L
\end{aligned}$$

Proof of Proposition 1.2

Differentiating equilibrium equations (5) with respect to ρ yields

$$\frac{\partial p_L}{\partial \rho} = \frac{\partial c_L}{\partial p_L}\frac{\partial p_L}{\partial \rho}+\frac{\partial c_L}{\partial p_H}\frac{\partial p_H}{\partial \rho}+\frac{\partial c_L}{\partial \rho} \tag{26}$$

$$\frac{\partial p_H}{\partial \rho} = \frac{\partial c_H}{\partial p_L}\frac{\partial p_L}{\partial \rho}+\frac{\partial c_H}{\partial p_H}\frac{\partial p_H}{\partial \rho}+\frac{\partial c_H}{\partial \rho}=\frac{\partial c_H}{\partial p_L}\frac{\partial p_L}{\partial \rho}+\frac{\partial c_H}{\partial p_H}\frac{\partial p_H}{\partial \rho} \tag{27}$$

where $\frac{\partial c_H}{\partial \rho} = 0$ by assumption. Solving for $\frac{\partial p_H}{\partial \rho}$ in equation (27) yields

$$\frac{\partial p_H}{\partial \rho} = \frac{\frac{\partial c_H}{\partial p_L}\frac{\partial p_L}{\partial \rho}}{1 - \frac{\partial c_H}{\partial p_H}}$$

Substituting into equation (26) and solving for $\frac{\partial p_L}{\partial \rho}$ yields

$$\frac{\partial p_L}{\partial \rho} = \frac{\frac{\partial c_L}{\partial \rho}\left(1 - \frac{\partial c_H}{\partial p_H}\right)}{f(0)}$$

Finally,

$$\frac{\partial p_H}{\partial \rho} = \frac{\frac{\partial c_L}{\partial \rho}\frac{\partial c_H}{\partial p_L}}{f(0)}$$

Now I establish $\frac{\partial p_L}{\partial \rho} < 0$ and $\frac{\partial p_H}{\partial \rho} > 0$. The numerator of the partial derivative $\frac{\partial p_L}{\partial \rho}$ is negative because $\frac{\partial c_L}{\partial \rho} < 0$ and $\frac{\partial c_H}{\partial p_H} < 1$. The numerator of the partial derivative $\frac{\partial p_H}{\partial \rho}$ is positive because $\frac{\partial c_L}{\partial \rho}$ and $\frac{\partial c_H}{\partial p_L}$ are negative. The common denominator $f(0) = \left(1 - \frac{\partial c'_L}{\partial p_L}\right)\left(1 - \frac{\partial c'_H}{\partial p_H}\right) - \frac{\partial c'_H}{\partial p_L}\frac{\partial c'_L}{\partial p_H}$ is strictly positive because $\frac{\partial c'_L}{\partial p_L}, \frac{\partial c'_H}{\partial p_H} < 1$, $\frac{\partial c'_H}{\partial p_L} < 0$, and $\frac{\partial c'_L}{\partial p_H} > 0$. Hence, the mandate penalty decreases firm L's premium ($\frac{\partial p_L}{\partial \rho} < 0$) and increases firm H's premium ($\frac{\partial p_H}{\partial \rho} > 0$).

It follows that the full derivative $\frac{dc_H}{d\rho} > 0$ because the right-hand side of equation (27) equals $\frac{dc_H}{d\rho}$. Because $\frac{dc_H}{dq_H} < 0$,

$$\frac{dq_H}{d\rho} = \frac{\frac{dc_H}{d\rho}}{\frac{dc_H}{dq_H}} < 0$$

which implies the mandate penalty increases underinsurance. Also observe that

$$\frac{\partial c}{\partial \rho} = \frac{\partial c}{\partial p_L}\frac{\partial p_L}{\partial \rho} + \frac{\partial c}{\partial p_H}\frac{\partial p_H}{\partial \rho} < 0$$

because $\frac{\partial p_L}{\partial \rho} < 0$ and by assumption $\frac{\partial c}{\partial p_L} > 0$ and $\frac{\partial c}{\partial p_H} = 0$. Because $q(p'_L, p'_H) < q(p''_L, p''_H)$ if and only if $c(p'_L, p'_H) > c(p''_L, p''_H)$ for any premium vectors $p' = (p'_L, p'_H)$ and $p'' = (p''_L, p''_H)$, the mandate must increase total enrollment (i.e., $\frac{dq}{d\rho}$ is positive).

Appendix B: Mathematical Formulas in ACA Exchange Model

In this appendix, I write the variables in equation (13) in terms of three variables: (1) the household choice probabilities $q_{ijt}(p)$; (2) the risk scores $r_{jmt}(p)$; and (3) plan average claims $c_{jmt}(p)$. Marginal revenue $MR_{jmt}(p)$, marginal claims $MC_{jmt}(p)$, and the marginal transfer $MRA_{jmt}(p)$ can be expressed as

$$MR_{jmt}(p) = \left(\frac{\partial q_{jmt}(p)}{\partial p_{jmt}}\right)^{-1} \sum_{i\in I, k\in J_{fmt}} \sigma_{it} \left(q_{ijt}(p) + p_{kmt}\frac{\partial q_{ikt}(p)}{\partial p_{jmt}}\right)$$

$$MC_{jmt}(p) = \left(\frac{\partial q_{jmt}(p)}{\partial p_{jmt}}\right)^{-1} \sum_{k\in J_{fmt}} \left[c_{kmt}(p)\frac{\partial q_{kmt}(p)}{\partial p_{jmt}} + q_{kmt}(p)\frac{\partial c_{kmt}(p)}{\partial p_{jmt}}\right] \tag{28}$$

$$\begin{aligned} MRA_{jmt}(p) &= \left(\frac{\partial q_{jmt}(p)}{\partial p_{jmt}}\right)^{-1} \sum_{k\in J_{fmt}} \left[\frac{\partial R_t(p)}{\partial p_{jmt}} \left(rs_{kmt}(p) - us_{kmt}(p)\right) \right. \\ &\quad \left. + \; R_t(p)\left(\frac{\partial rs_{kmt}(p)}{\partial p_{jmt}} - \frac{\partial us_{kmt}(p)}{\partial p_{jmt}}\right)\right] \end{aligned} \tag{29}$$

where

$$\frac{\partial R_t(p)}{\partial p_{jmt}} = \sum_{l\in J_{mt}} MR_{lmt}(p)\frac{\partial q_{lmt}(p)}{\partial p_{jmt}}$$

$$\frac{\partial us_{kmt}(p)}{\partial p_{jmt}} = \left(\sum_{m\in M, l\in J_{mt}} h_l q_{lmt}(p)\right)^{-1} \left[h_k \frac{\partial q_{kmt}(p)}{\partial p_{jmt}} - \frac{h_k q_{kmt}(p)}{\sum_{m\in M, l\in J_{mt}} h_l q_{lmt}(p)} \sum_{l\in J_{mt}} h_l \frac{\partial q_{lmt}(p)}{\partial p_{jmt}}\right]$$

$$\begin{aligned} \frac{\partial rs_{kmt}(p)}{\partial p_{jmt}} &= \left(\sum_{m\in M, l\in J_{mt}} r_{lmt}(p) q_{lmt}(p)\right)^{-1} \left[\left(r_{kmt}(p)\frac{\partial q_{kmt}(p)}{\partial p_{jmt}} + q_{kmt}(p)\frac{\partial r_{kmt}(p)}{\partial p_{jmt}}\right)\right. \\ &\quad \left. - \; \frac{r_{jmt}(p) q_{jmt}(p)}{\sum_{m\in M, l\in J_{mt}} r_{lmt}(p) q_{lmt}(p)} \sum_{l\in J_{mt}} \left[r_{lmt}(p)\frac{\partial q_{lmt}(p)}{\partial p_{jmt}} + q_{lmt}(p)\frac{\partial r_{lmt}(p)}{\partial p_{jmt}}\right]\right] \end{aligned}$$

Appendix C: Risk Adjustment Under the ACA

In this appendix, I derive the ACA risk adjustment formula. I start with Pope et al. (2014)'s transfer formula as derived in their first appendix, which allows plans to vary only by their actuarial values (and not by differences in firm efficiency, geographic costs, allowable rating factors, or moral hazard).[13] Pope et al. (2014) show that the per-member per-month risk adjustment transfer can be calculated according to formula $(A14)$:

$$T_j = \left(PLRS_j - \frac{AV_j}{\sum_l AV_l s_l} \right) \overline{p}$$

where $PLRS_j$ is plan j's plan liability risk score, $\overline{p}$ is the share-weighted average statewide premium, AV_l is the actuarial value of plan l, and s_l is plan l's market share. The per-member per-month plan transfer $ra_{jmt}(p)$ in my notation, is

$$ra_{jmt}(p) = \left(\frac{r_{jmt}(p) \sum_{m \in M, l \in J_{mt}} q_{lmt}(p)}{\sum_{m \in M, l \in J_{mt}} r_{jmt}(p) q_{lmt}(p)} - \frac{h_j \sum_{m \in M, l \in J_{mt}} q_{lmt}(p)}{\sum_{m \in M, l \in J_{mt}} h_l q_{lmt}(p)} \right) \overline{p}$$

The total risk adjustment transfer $RA_{jmt}(p)$ equals

$$RA_{jmt}(p) = ra_{jmt}(p) q_{jmt}(p) = (rs_{jmt}(p) - us_{jmt}(p)) \left(\overline{p} \sum_{m \in M, l \in J_{mt}} q_{lmt}(p) \right)$$

Summing across all markets where firm f sells plans yields formula (11):

$$RA_{ft}(p) = R_t(p) \sum_{m \in M, j \in J_{fmt}} [rs_{jmt}(p) - us_{jmt}(p)]$$

Appendix D: Cost Sharing Reductions

In this appendix, I discuss how the ACA provides CSRs to consumers and construct a formula for computing government spending on CSRs. To receive CSRs, eligible consumers with income below 250% of FPL must purchase a silver plan. CSRs increase the actuarial value of the silver plan from

[13] I start with this formula because I want to capture all differences in expected risk, except for cost sharing and any associated moral hazard, in the plan's risk score (i.e., cost sharing and moral hazard are addressed through the utilization share). In contrast, the plan liability risk score $PLRS_j$ as defined in Pope et al. (2014)'s second appendix does not account for certain differences such as variation in geographic cost. Instead, Pope et al. (2014) account for these differences by applying factors in the transfer formula.

70% to 94% for consumers with income below 150% of FPL (group 1), to 87% for consumers with income between 150% and 200% of poverty (group 2), and to 73% of poverty for consumers with income between 200% and 250% of poverty (group 3). Ignoring moral hazard, the government's expected outlay is 24% of claims for group 1, 17% for group 2, and 3% for group 3. To account for moral hazard, I follow Pope et al. (2014) and assume there is no moral hazard for consumers in the 73% plan, whereas consumers in the 87% and 94% plans increase consumption by 12%. Including moral hazard, the government's expected outlay is 26.88% of claims for group 1, 19.04% for group 2, and 3% for group 3. Government spending on cost sharing reductions equals

$$CSR = \sum_{i \in I, j \in J} s_i^g q_{ij}(p)(\sigma_{ij}^c c_j'(p)) \tag{30}$$

where s_i^g is the government's expected share for consumer i as defined above, $q_{ij}(p)$ is the household choice probability, σ_{ij}^c is a cost factor accounting for the plan and the household members' ages and geographic residence, and $c_j'(p)$ is plan base claims. The cost factors come from insurer rate filings (Department of Managed Health Care, 2016). Plan base claims are computed from the estimated household choice probabilities and data on firm average claims and cost factors.

Appendix E: Construction of the Uninsured Population

I model dynamic switching both between plans and into and out of the exchange market using six years of longitudinal data on exchange customers. Previous studies of the exchanges have treated demand as static, merging administrative data on exchange enrollees with survey data such as the American Community Survey (ACS) on the uninsured to form the universe of potential exchange consumers (Tebaldi, 2017; Domurat, 2017; Saltzman, 2019). The sample of uninsured in the ACS is limited and ACS geographic identifiers are difficult to match with those in my administrative data. In contrast, I form the uninsured population using data on consumers in the Covered California data for years in which they did not have exchange coverage. For example, consumers with exchange coverage in 2015 and 2016 are considered uninsured in 2014, 2017, and 2018 if they remained eligible for the exchange market. Consumers might lose exchange market eligibility if they gain access to employer-sponsored insurance or public insurance (e.g., Medicaid or Medicare).

Because my data do not indicate when enrollees lose exchange market eligibility, I use data from the Survey of Income and Program Participation (SIPP) to impute consumer eligibility. The SIPP is well-suited for the imputation because (1) it asks the insurance status of respondents for every month over a three-year period (2013-2015) and (2) it includes detailed information on the chief reasons for consumers' coverage status, such as whether the respondent obtained or lost an offer of employer-sponsored insurance, moved in or out of California, or became eligible or ineligible for Medicare or Medicaid. For SIPP respondents who newly obtained or gave up individual market coverage, I construct a *transitioned* variable that indicates whether the respondent gained or lost eligibility for the individual market. The *transitioned* variable takes value 1 if the respondent (1) belongs to a household that obtained or lost an offer of employer-sponsored insurance; (2) moved out of or into California; (3) the respondent turned 65 and qualified for Medicare; and (4) the respondent became eligible for Medicaid following a drop in income. I estimate a logit model regression of the *transitioned* variable on the demographic variables available in both the SIPP and the Covered California data, including age, income, gender, race, and household size. I use the estimated logit to predict whether Covered California consumers observed for only some years of the study timeframe transitioned into or out of the exchange market. Consumers transitioning into or out of the exchange market are removed from the study population during years when they are not enrolled in an exchange plan.

Figure 1: Premium Rating Regions in California

Notes: Figure shows the premium rating regions in the California exchange (Department of Managed Health Care, 2016). California's 58 counties are divided into 19 rating areas.

Figure 2: Insurer Market Share By Year in the California Exchange

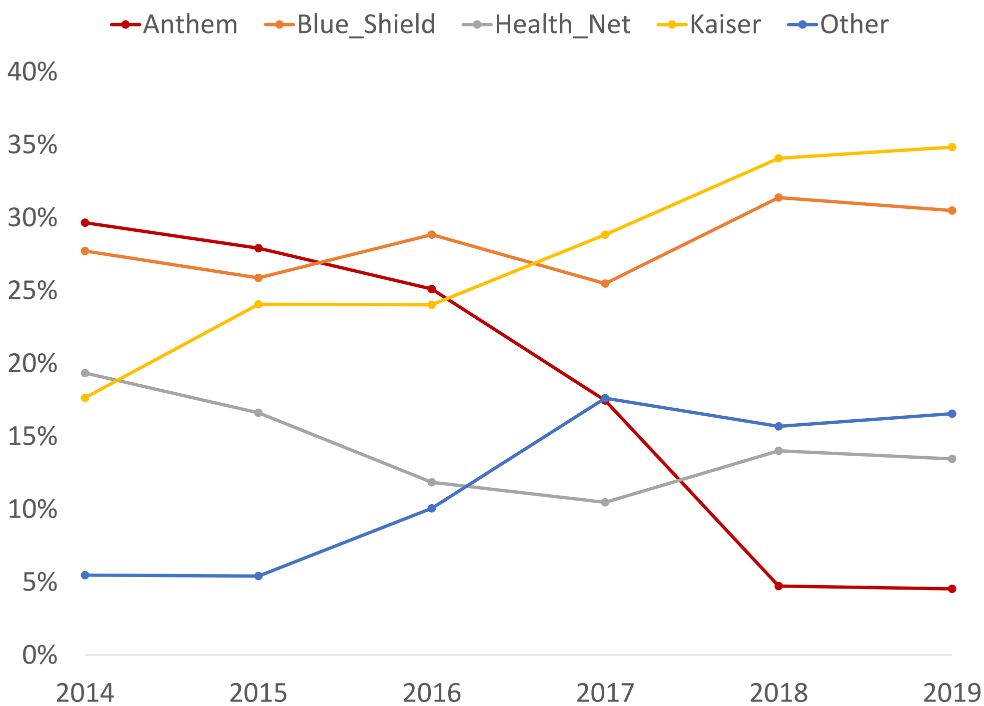
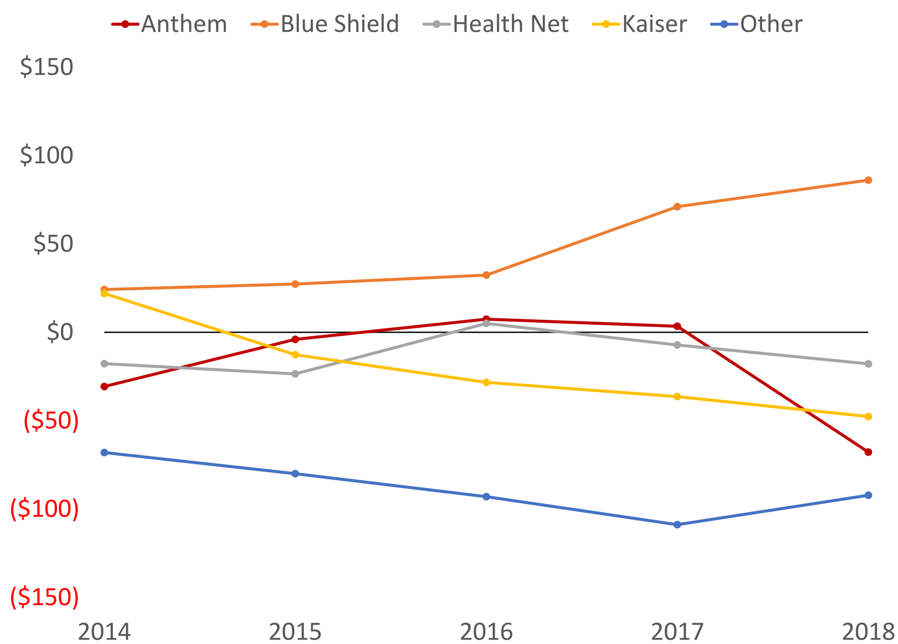


Figure 3: Per-Member Per-Month Risk Adjustment Received (Paid) By Year



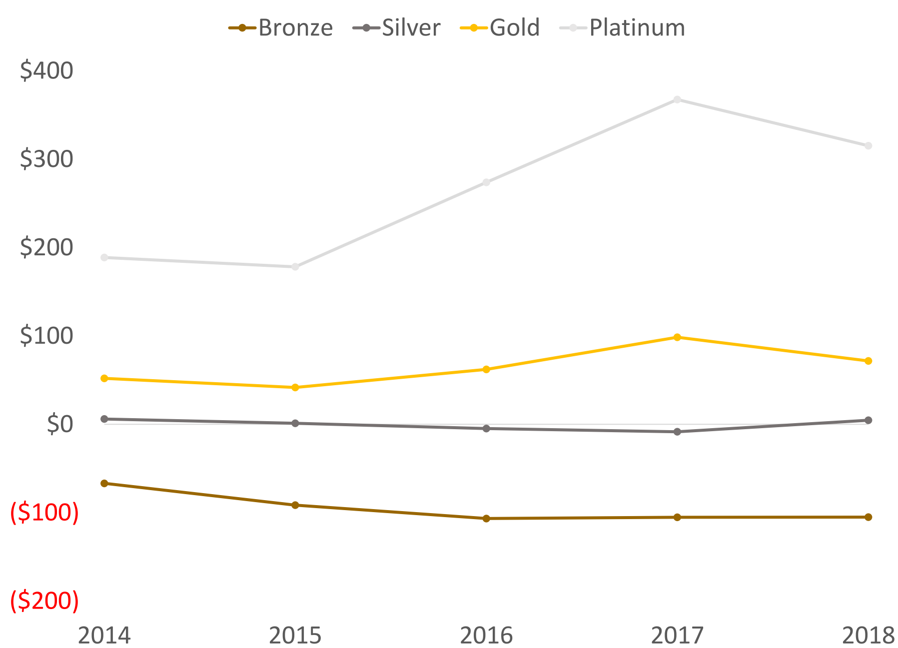


Table I: Choice and Demographic Distribution By Year

	2014	2015	2016	2017	2018	2019	Overall
Market Size	2,197,669	2,420,764	2,461,389	2,444,685	2,429,209	2,272,457	14,226,173
Total Enrollment	1,362,316	1,639,923	1,702,160	1,697,074	1,710,469	1,553,374	9,665,316
Metals							
Catastrophic	1.0%	0.8%	1.0%	1.1%	1.2%	1.3%	1.1%
Bronze	23.7%	25.2%	26.3%	26.7%	28.9%	28.8%	26.7%
Silver	63.9%	63.8%	63.7%	63.8%	54.7%	55.3%	60.8%
Gold	6.0%	5.5%	5.1%	5.2%	11.2%	10.9%	7.3%
Platinum	5.4%	4.7%	3.9%	3.2%	3.9%	3.7%	4.1%
Network Type							
HMO	43.1%	48.3%	46.5%	58.4%	64.3%	65.4%	54.6%
PPO	56.9%	51.7%	53.5%	41.6%	35.7%	34.6%	45.4%
Income							
138% FPL or less	4.7%	3.5%	3.3%	4.0%	4.0%	3.5%	3.8%
138% FPL to 150% FPL	14.1%	14.3%	14.6%	14.7%	14.4%	14.0%	14.4%
150% FPL to 200% FPL	32.8%	32.8%	31.9%	30.3%	28.8%	28.4%	30.8%
200% FPL to 250% FPL	16.8%	16.7%	16.3%	16.3%	16.7%	16.7%	16.6%
250% FPL to 400% FPL	22.4%	23.4%	23.6%	23.6%	25.8%	27.4%	24.4%
400% FPL or greater	9.3%	9.3%	10.3%	11.0%	10.3%	9.9%	10.0%
Subsidy Status							
Subsidized	89.6%	88.8%	87.5%	86.5%	87.3%	87.7%	87.8%
Unsubsidized	10.4%	11.2%	12.5%	13.5%	12.7%	12.3%	12.2%
Age							
0-17	5.7%	6.0%	6.2%	6.7%	7.3%	7.3%	6.5%
18-25	11.1%	11.3%	11.1%	10.7%	10.5%	10.0%	10.8%
26-34	16.3%	16.9%	17.4%	17.6%	17.7%	17.3%	17.2%
35-44	16.6%	15.9%	15.3%	15.1%	15.2%	15.1%	15.5%
45-54	24.4%	23.5%	22.8%	22.2%	21.4%	21.0%	22.5%
55+	25.8%	26.3%	27.2%	27.8%	27.9%	29.3%	27.4%
Gender							
Female	52.6%	52.2%	51.9%	52.2%	52.5%	52.5%	52.3%
Male	47.4%	47.8%	48.1%	47.8%	47.5%	47.5%	47.7%
Race							
Asian	22.8%	21.8%	22.0%	22.6%	23.0%	23.4%	22.6%
Black/African American	2.7%	2.5%	2.4%	2.4%	2.4%	2.4%	2.5%
Hispanic	27.5%	28.2%	28.0%	28.3%	28.4%	27.8%	28.0%
Non-Hispanic White	39.4%	39.5%	39.6%	38.5%	37.1%	36.8%	38.5%
Other Race	7.7%%	7.9%	7.9%	8.2%	9.1%	9.6%	8.4%

Table II: Estimated Mean Elasticities and Semi-Elasticities

	Own-Premium		Exchange Coverage	
	Elasticity	Semi-Elasticity	Elasticity	Semi-Elasticity
Overall	-5.3	-10.7	-0.6	-1.2
Income (% of FPL)				
0-250	-5.5	-11.2	-0.6	-1.3
250-400	-5.0	-10.3	-0.5	-1.1
400+	-4.0	-8.3	-0.4	-0.9
Gender				
Female	-5.1	-10.4	-0.6	-1.2
Male	-5.5	-11.1	-0.6	-1.3
Age				
0-17	-6.9	-12.8	-0.8	-1.5
18-34	-8.0	-14.9	-0.9	-1.7
35-54	-5.4	-10.0	-0.6	-1.2
55+	-3.9	-7.2	-0.4	-0.8
Race/Ethnicity				
Asian	-6.1	-12.2	-0.7	-1.4
Black	-4.9	-9.8	-0.5	-1.1
Hispanic	-6.1	-12.2	-0.7	-1.4
Other	-5.1	-10.4	-0.6	-1.2
Non-Hispanic White	-4.7	-9.6	-0.5	-1.1

Notes: Table shows mean (unsubsidized) premium elasticities and semi-elasticities of demand by demographic group for the base case estimates. The first column reports the mean own-premium elasticity of demand. The second column reports the mean own-premium semi-elasticity of demand, which is the the percentage change in a plan's enrollment associated with a \$100 increase in its annual premium. The third column reports the mean own-premium elasticity for exchange coverage (i.e., the percentage change in exchange enrollment associated with a one percent increase in the base premium of all exchange plans). The fourth column reports the mean own-premium semi-elasticity for exchange coverage, which is the percentage change in exchange enrollment associated with a \$100 annual increase in all exchange premiums. I use the plan market shares as weights to compute the mean elasticities and semi-elasticities.

Table III: Main Parameter Estimates

	(1)	(2)	(3)
Insurer-Market Fixed Effects		✓	✓
Demographic Intercepts			✓
Demand Parameters ($\boldsymbol{\beta}$)			
Monthly Premium (\$100)	-0.205^{***}	-0.230^{***}	-0.309^{***}
	(0.010)	(0.011)	(0.011)
AV	1.316^{***}	1.379^{***}	2.107^{***}
	(0.043)	(0.042)	(0.055)
Silver	0.307^{***}	0.394^{***}	0.524^{***}
	(0.015)	(0.020)	(0.017)
HMO	-0.039^{***}	-0.112^{***}	-0.162^{***}
	(0.008)	(0.011)	(0.014)
Previous Choice	0.866^{***}	1.116^{***}	1.701^{***}
	(0.066)	(0.085)	(0.104)
Risk Score Parameters (γ)			
AV	2.980^{***}	2.992^{***}	2.827^{***}
	(0.141)	(0.140)	(0.152)
Share Ages 18 to 25	-0.803	-0.910	-0.913^{*}
	(0.598)	(0.600)	(0.551)
Share Ages 26 to 34	-0.776^{**}	-0.732^{**}	-0.886^{***}
	(0.368)	(0.371)	(0.335)
Share Ages 35 to 54	-0.140	-0.296	0.565
	(0.376)	(0.372)	(0.383)
Share Male	-1.056^{***}	-1.085^{***}	-0.988^{***}
	(0.319)	(0.319)	(0.309)
Average Claims Parameters ($\boldsymbol{\theta}$)			
Log Risk Score	1.089^{***}	1.090^{***}	1.098^{***}
	(0.027)	(0.027)	(0.030)
HMO	-0.025	-0.024	-0.042
	(0.038)	(0.038)	(0.039)
Trend	0.043^{***}	0.041^{***}	0.051^{***}
	(0.009)	(0.009)	(0.009)
Anthem	0.143	0.150	0.113
	(0.106)	(0.106)	(0.114)
Blue Shield	0.196^{**}	0.203^{**}	0.149
	(0.091)	(0.091)	(0.102)
Kaiser	0.158^{*}	0.159^{*}	0.139
	(0.087)	(0.087)	(0.101)
Health Net	0.123^{*}	0.125^{*}	0.089
	(0.073)	(0.072)	(0.080)

Notes: Robust standard errors are in parentheses (*** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level).

Table IV: Policy Simulation Results

	Base	(1)	(2)	(3)	(4)	(5)	(6)
Scenario Definitions							
Risk adjustment	✓		✓			✓	
Individual mandate	✓	✓			✓		
Endogenous subsidy	✓	✓	✓	✓			
Monthly Premiums							
Bronze	$228	$197	$228	$198	$198	$226	$198
Silver	$289	$285	$292	$285	$281	$286	$282
Gold	$334	$391	$333	$391	$390	$332	$390
Platinum	$381	$609	$384	$609	$608	$390	$609
Anthem	$323	$320	$323	$322	$315	$311	$317
Blue Shield	$283	$290	$285	$290	$288	$282	$288
Health Net	$262	$266	$268	$267	$263	$263	$264
Kaiser	$299	$313	$302	$314	$311	$299	$311
Other Insurer	$261	$263	$261	$263	$262	$261	$262
Coverage							
Bronze	341,495	406,209	336,499	403,543	388,927	330,515	386,259
Silver	1,221,553	1,256,129	1,192,172	1,248,017	1,279,979	1,208,139	1,269,802
Gold	109,960	70,124	110,911	68,472	70,355	109,009	68,480
Platinum	87,274	30,400	87,267	29,613	30,402	84,413	29,583
Anthem	338,997	341,202	340,682	337,500	345,390	354,159	341,127
Blue Shield	479,728	481,217	471,572	478,784	484,219	468,686	481,000
Health Net	287,250	289,939	276,791	286,929	290,643	279,322	287,727
Kaiser	447,041	437,094	431,607	434,211	438,739	429,476	435,441
Other Insurer	207,267	213,411	206,196	212,222	210,671	200,433	208,828
Total Coverage	1,760,283	1,762,863	1,726,849	1,749,646	1,769,663	1,732,076	1,754,124
Welfare Changes							
Consumer Surplus		($35)	$35	($5)	$51	$67	$72
Profit		($60)	$21	($52)	($95)	($51)	($92)
Government Spending							
Prem. Subsidies		($113)	($8)	($123)	$1	($7)	($24)
CSRs		$7	($6)	$5	$12	($3)	$10
Penalties		($1)	($220)	($220)	($4)	($220)	($220)
Uncomp. Care		($2)	$27	$9	($8)	$23	$5
Social Welfare		$13	($177)	($168)	($53)	($217)	($230)

Notes: Table shows the results of 6 counterfactual scenarios that involve combinations of 3 policy changes: (1) repealing risk adjustment; (2) repealing the individual mandate; and (3) fixing the subsidy at its level in the base scenario so that the subsidy does not adjust to premiums. The first panel defines each of the scenarios; the base scenario corresponds to the ACA. The second panel shows the effect on weighted-average premiums by metal tier and by insurer for a 40-year-old. Average premiums for any other age are proportional to the reported premiums according to the ACA's age rating curve (Centers for Medicare and Medicaid Services, 2013). Plan premiums are weighted by the realized ACA plan market shares for all scenarios. The third panel reports the impact on insurance coverage. The fourth panel shows the change in annual per-capita social welfare relative to the base scenario.

Table V: Effect of Repealing Individual Mandate on Enrollment

	Observed: 2018 vs. 2019 in Table I	**Predicted**: Base vs. (2) in Table IV
Bronze	-3.5%	-1.5%
Silver	-1.7%	-2.4%
Gold	-0.8%	0.9%
Platinum	-1.5%	-0.0%
Total	-2.0%	-1.9%