The Effect of Medical Loss Ratio Regulation on Insurer Pricing

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Abstract

The Affordable Care Act Medical Loss Ratio (MLR) regulation limits each insurers' profit by setting a minimum requirement on the ratio of medical spending to premium revenue. However, this regulation may undermine the incentives for insurers to bargain for lower prices when negotiating prices with health care providers. I build a bargaining model of how MLR constraint affects price negotiation between insurers and providers. This model illustrates the insurer trade-off between lower premiums and higher service prices and reveals how bargaining for lower prices is reduced. Predictions from the model are tested in a structural model of MLR regulation on negotiated prices and insurers' costs using data from the individual Health Insurance Exchange Marketplace. Welfare calculations using estimated demand, cost, and bargaining parameters suggest that the MLR regulation led to higher health service prices and higher out-of-pocket payments.

Keywords Medical loss ratio, price negotiation, insurers, providers

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1 Introduction

Regulating a firm's profitability is a common way for governments to try to obtain efficient outcomes in critical markets. It is particularly important for the health care market where private firms exploit their pricing leverage when complementing public provisions (Einav, Finkelstein and Polyakova, 2018; Curto et al., 2019; Duggan, Starc and Vabson, 2016). Unlike traditional rate-of-return regulation, which regulates the ratio of profit to capital costs, the Affordable Care Act (ACA) limited the ratio of a variable cost measurement (approximately) to revenue, which the ACA terms the Medical Loss Ratio (MLR). The ACA MLR regulation requires insurance firms in the private insurance market to spend at least 80% to 85% of their premium revenue on medical care and improving the quality of care. The regulator's goal is presumably to limit insurer markups, hoping that this will improve the quality of insurance plans while keeping plan premiums low. Between 2014 to 2018, 16 million individuals purchased insurance plans in the individual private insurance market each year, accounting for $74 billion of premium payment and $65 billion of medical claims spending (Cox, Fehr and Levitt, 2019; Fehr, Cox and Levitt, 2019). Understanding the mechanism of how regulation affects pricing and medical spending is critical for evaluating this regulation and for designing future policies.

Although the average MLR in the individual market jumped from 84.1% in 2011 to 92.9% in 2016 (CCIIO, 2017), it is far from obvious that higher MLR translated into lower absolute markups of insurance firms, better insurance plans, or more affordable health care services. Along with the increase in MLRs, existing studies find that the MLR regulation is also associated with improvements of financial performance of insurers (McCue, Hall and Liu, 2013; Cox, Fehr and Levitt, 2019; Fehr, McDermott and Cox, 2020) and increases in medical costs (McCue and Hall, 2015; Cicala, Lieber and Marone, 2019; Callaghan, Plummer and Wempe, 2020). These papers link the regulation to insurers' financial measures but fail to identify viable mechanisms for these effects.

One possible unintended effect of MLR regulation is that it disincentivizes insurance firms from containing costs when negotiating health service prices. Recent papers model insurers as bargaining with health care providers on health service prices to reduce the medical bills they pay to providers (Gowrisankaran, Nevo and Town, 2015; Craig, Ericson and Starc, 2018; Gaynor, Ho and Town, 2015; Barrette, Gowrisankaran and Town, 2020). This bargaining process opens a channel for insurers to change their cost containment behavior due to MLR regulation. When insurers have relatively large bargaining power, they may realize that pursuing optimal solutions with low service prices will make them non-compliant with the regulation. Consequently, insurers may concede part of their bargaining power and profit, and allow higher health service prices.

Although higher medical spending might be good for patients if it translated into better health outcomes, an increase in health service prices is unambiguously not. Due to the non-zero consumer cost-sharing systems, many patients will pay more for medical bills as prices increase. Therefore, when insurance companies give up on bargaining for low prices, patients pay more out of pocket for health care services.

In this paper, I develop a model of how insurers negotiate health service prices and determine premiums under MLR regulation. My model reveals the mechanism by which this regulation affects the price bargaining equilibrium and insurers' premium choices. By combining this model with demand estimation, I empirically show how the ACA MLR regulation affects negotiated prices, insurers' cost, and consumer welfare in the individual Health Insurance Exchange Marketplace.

I start by modeling the demand for insurance plans. I adopt a discrete choice model with random coefficients from previous studies (Berry, Levinsohn and Pakes, 1995; Nevo, 2001) to describe how consumers choose insurance plans based on premiums and other plan features. Knowing the demand for insurance plans, I build a two-stage model with constraint of insurers' pricing under MLR regulation. At the first stage—the price negotiation stage, insurers and providers bargain on the health service prices, both aware of MLR regulation and consumer demand. The bargaining equilibrium depends on the MLR regulation, the relative bargaining power of the two sides, and consumer demand. At the second stage—where insurers maximize their profits by choosing premiums, I introduce MLR regulation as a constraint imposed on insurers' MLRs. This constraint will be binding if insurers' firm-level MLRs are below the threshold required by the regulation.

Following that, I show graphically how binding MLR regulation rules out bargaining equilibria with low negotiated service prices. By imposing MLR regulation onto the optimal prices and premium choices, I show how that premium-price combinations with low negotiated price are no longer optimal because of the regulation.

This two-stage model provides a straightforward empirical approach for estimating the effect of MLR regulation. I estimate this model using data from the individual Health Insurance Exchange Marketplace, which has covered 10 million people every year since it launched in 2014. After estimating the demand for health insurance plans, I structurally estimate the effect of the ACA MLR regulation, insurers' bargaining power, and fixed cost. Consistent with my theoretical model, my estimates suggest that the MLR regulation leads to higher negotiated prices and higher costs to insurers.

The estimates lend themselves to welfare analysis of counterfactual market settings that change insurers' pricing and the market outcomes. Based on those structural estimates, I introduce the ACA MLR regulation and the price negotiation one by one to decompose their effects on the negotiated prices, premiums, and welfare. Results from the counterfactual analysis imply that if the service prices are fixed at the pre-regulation negotiated level, insurance plans would be more affordable and cover more people. However, when service prices are negotiated by insurers and health care providers, the MLR regulation results in higher service prices and higher premiums. Therefore, consumers will need to pay more out of pocket for both health care services and insurance plans.

One of this paper's primary contributions is using a structural model to reveal the mechanism by which MLR regulation can affect potentially insurers' costs and pricing. Building on the reduced-form evidence from previous studies (Cicala, Lieber and Marone, 2019; Callaghan, Plummer and Wempe, 2020), this paper explicitly shows how insurers respond to the ACA MLR regulation via price negotiation and structurally estimates the effect of MLR regulation. This model has three attractive features. First, by structurally estimating this model, I am able to draw conclusions about the regulation's effects on welfare. Second, this model does not require data on negotiated prices, which are rarely available in the private insurance market. Third, this structural estimation is more attractive when pre-regulation data is not available—when the market started after the regulation was implemented.

Following this, the second contribution is disentangling the effect of MLR regulation and that of price negotiation. I use estimates obtained from the structural model and construct two counterfactual scenarios where either the profit regulation or the price negotiation are in play, but not both. By comparing these two scenarios with the real ACA exchange marketplace, I find that it is the combination of the regulation and negotiation that leads to higher service prices, higher premiums, and consequently similar proft level but higher OOP payment for consumers.

This paper also contributes to the empirical studies of the ACA Exchange Marketplace. The demand estimation in this paper provides baseline estimates of demand in all the Federally-Facilitated Marketplaces, which complement previous studies that focus on the Massachusetts pre-ACA marketplace (Ericson and Starc, 2015; Jaffe and Shepard, 2017) and that focuses on one or two state-based ACA exchange marketplaces (Abraham et al., 2017; Tebaldi, 2017; Saltzman, 2019; Drake, 2019).

The paper proceeds as follows. Section 2 overviews the existing related literature. Section 3 introduces the ACA MLR regulation and the Health Insurance Exchange Marketplace. Section 4 presents the theoretical framework along with a graphical illustration that unfolds the effect of MLR regulation on insurers' pricing. Section 5 describes how the sample is constructed and provides descriptive statistics of the final sample. In Section 6, I describe my empirical strategy and identification assumptions. Section 7 presents the main results. Section 8 discusses possible alternatives and simulates the markets in alternative settings. Section 9 concludes.

2 Related Literature

This paper mainly relates to three strands of literature: rate-of-return regulation, insurer-provider negotiation, and the Marketplace.

My work relates to a broad literature on rate-of-return regulation. Averch and Johnson (1962) explain how rate-of-return regulation leads to the distortion of resource allocation. In the health care market, Acemoglu and Finkelstein (2008) shows the effect of the Medicare payment reform on the capital-labor ratios. Unlike those policies that focus on the capital ratio, MLR regulation imposes a requirement on the ratio of variable cost to revenue, approximately. Cicala, Lieber and Marone (2019) discuss the similarity of the MLR regulation and the rate-of-return regulation with single input.

With regard to MLR regulation, the literature is relatively small. Karaca-Mandic, Abraham and Simon (2015) use pre-ACA data to show that the medical loss ratio is a good measure of insurers' price-cost margins. They also find that MLRs are significantly lower in monopoly markets than in markets with two or more insurers. Abraham, Karaca-Mandic and Simon (2014) find that MLRs increased in the individual market in the first year after the ACA MLR regulation. McCue, Hall and Liu (2013) assess the changes between 2010 and 2011 in insurers' financial performance and find that in 2011, the administrative cost ratios and the operating margins both decreased, especially for individual health insurers. Later, McCue and Hall (2015) study the data from the second year and find a continuous increase in MLRs and a continuous decrease in the administrative cost ratios. Recently, Cicala, Lieber and Marone (2019) use the difference-in-differences method to study the effect of the ACA MLR regulation on medical cost and premiums. They find that the regulation is associated with higher claims cost but has statistically no effect on the premiums. Callaghan, Plummer and Wempe (2020) find similar consequences following the implementation of the ACA MLR regulation. They show that the MLRs increased remarkably since 2011, and that increase in MLRs comes primarily from the increase in claim cost, not the reduction in premium. Building on these reduced-form results, I introduce the price negotiation between insurers and health care providers to the model. Price negotiation is an essential channel for insurers to contain medical costs and strategically maintain their compliance status under MLR regulation. Another difference between my paper and existing studies is that those studies exploit the pre-post variation, which does not exist for the Marketplace. To fill this vacuum, I employ a structural model and use the cross-sectional variation to estimate the effect of MLR regulation in the relatively new market.

My work also relates to papers that study the insurer-provider negotiation in different institutional contexts. Reduced-form evidence shows that an increase in bargaining power (due to mergers or measured by market HHI) relates to a reduction in physician earnings and an increase in the substitution of nurses for physicians (Dafny, Duggan and Ramanarayanan, 2012). Roberts, Chernew and McWilliams (2017) show that low service prices are associated with large market shares. Cooper et al. (2019) find that hospital prices are lower in higher concentrated insurer markets and lower concentrated hospital markets. Trish and Herring (2015) find that high concentration of provider markets is associated with the higher premiums after control the concentration of insurance market. Using the bilateral Nash bargaining model developed by Horn and Wolinsky (1988), researchers structurally examine the role of price negotiation in the health care market. Grennan (2013, 2014) studies the bargaining between hospitals and medical devices suppliers. Gowrisankaran, Nevo and Town (2015) examine the bargaining between hospitals and insurers in Virginia. Ho (2009), Ho and Lee (2017) and Ho and Lee (2019) examine the bargaining between hospitals and insurers in California, primarily focusing on the network formation. Those papers highlight the importance of the insurer-provider negotiation. Because of the time period studies, MLR regulation was absent in those papers. I incorporate the price negotiation and MLR regulation in this paper, using a similar but richer Nash bargaining model.

From the theoretical perspective, Aghadadashli, Dertwinkel-Kalt and Wey (2016) shows how bargaining power and demand elasticity affect the profit share in vertical relations if upstream and downstream firms bargain over linear input prices. This setting is very similar to the scenario where no regulation is imposed on the MLR. Despite the deep and broad discussion of the rate-of-return regulation and the bargaining model, very few studies discuss the consequences when such regulation is implemented in a bargaining setting. Hendricks (1975) introduced the wage negotiation when the rate-of-return of capital is regulated. My model suggests that the division of profit between insurers and health care providers is distorted by MLR regulation.

The third strand of literature that this paper relates to is the health insurance exchange marketplace literature. Being a new market with new policies, the Marketplace attracts many research works. A large part of them focus on the demand estimation in this market. Abraham et al. (2017) found that demand was highly elastic in 2014-2015. Tebaldi (2017) studies how the subsidy policy affects demand in California. Saltzman (2019) estimates the demand for insurance plans in California and Washington. Drake (2019) estimates the demand in 2017 California's Marketplace. In this paper, I employ a discrete choice model with random coefficients to estimate the demand in all the Federally-Facilitated Marketplaces, from 2014 to 2017. My estimates fall within the range of previous estimates, including those from the Massachusetts pre-ACA marketplace (Ericson and Starc, 2015; Jaffe and Shepard, 2017).

3 Background

3.1 The Medical Loss Ratio Regulation

The Medical Loss Ratio regulation under the ACA requires each insurer to spend 80%—for individual and small group market—or 85%—for large group market—of the total premium revenue on medical claims and health care quality improvement. Insurers that do not reach the threshold must publicly disclose their non-compliance and refund to their enrollees the portion of premium that exceeds the limit. If insurers are not compliant for three years, they will not be allowed to enter the market.

More specifically, the MLR calculation includes a preliminary calculation of the ratio and a credibility-based adjustment. The measurement is implemented at the insurer-market level. That is, one insurer has one MLR for all the plans in one market. The market is defined by state, year, and client type—individual, small group, or large group. The preliminary MLR of an insurer in a market is

$$Preliminary\ MLR = \frac{Total\,Medical\,Care\,Claims + Quality\,Improvement\,Expenses}{Total\,Premium\,Revenue - Taxes,\ Licensing\,and\,Regulatory\,Fees}.$$

The core part and the most flexible part of MLR is the medical claims over premium revenue. On average, the quality improvement expenses are only one percent of the medical care claims, and the taxes and fees together count for 17% of premium revenue.[1] Although insurers have some degree of flexibility in the quality improvement expenses, it takes time for them to get approvals from the state commissioner.

Because of the uncertainty in medical claims, the regulation allows a credibility-based adjustment of MLRs for small insurers,

$$Adjusted\,MLR = Preliminary\,MLR + Base\,Credibility\,Factor * Deductible\,Factor.$$

The base credibility factor, as shown in Panel A of table 1, decreases in the number of enrollees. Insurers having less than 1000 enrollees in a market are exempted from the regulation. For insurers with 1,000 to 75,000 enrollees, adjusted MLRs are higher than their preliminary ones.

The other adjustment factor is the deductible factor. The deductible line is a threshold for enrollees below which enrollees need to pay 100% of the medical bills by themselves. The deductible factor is calculated based on the average deductible of all plans provided by the insurer, as shown in Panel B of table 1.

By the regulation, insurers need to provide rebates to their enrollees if their adjusted MLRs are above the 80% threshold in the individual market. Nationwide, average annual rebates in the individual market were $260 million from 2011 to 2018.[2]

3.2 The Health Insurance Exchange Marketplaces

The Health Insurance Exchange Marketplace is an online platform for individuals and small groups to shop for health insurance plans. It opened in October 2013 when people could enroll in health insurance plans for 2014. The exchange marketplace is an important market for the individual insurance market. Every year, around 10 million individuals purchased their insurance at the Marketplace. That is 55% to 72% of the total private individual market, depending on the year (Cox, Fehr and Levitt, 2019). Unlike in the large group markets, consumers and insurers in the Marketplace do not bargain on the premiums or plan design. When people go to the platform, they choose insurance plans by comparing predetermined plan characteristics listed on the website, such as premiums, coverage rates, etc.

To ease the cross-plan comparison, the ACA requires insurers to classify all the plans into five

[1]Calculated by author, based on the 2011-2018 MLR reports.
[2]Calculated based on the 2011 to 2018 data from the CMS.

categories (four metal categories plus one "catastrophic" category) based on plans' actuarial values. The table 2 shows the actuarial values for each category. The more precious the metal, the higher the fraction of medical bills the insurance plan will cover. Among all five categories, silver is the most commonly offered plan, no matter measured by the number of plans or the number of enrollees. Two factors contribute here. On the insurer side, by regulation, insurers must provide at least one silver plan to gain the entrance ticket. The second factor is that low-income silver plan enrollees are eligible for a premium subsidy (Tebaldi, 2017).

Plans in the same metal category have the same actuarial values but could be differentiated by other features such as premiums, deductibles, out-of-pocket maximums, and cost-sharing, as well as provider networks. Unfortunately, restricted by the data, I can not observe the provider network. However, premiums, metal categories, and cost-sharing rates are much more salient than the network from consumers' view. Therefore, I leave the network feature for future research.

The marketplaces are state-level markets. Every state could choose between the Federally-Facilitated Marketplace (FFM) and the state-based Marketplace. The FFM is operated by the U.S. Department of Health and Human Services (HHS). States choosing FFM share similar marketplace design and regulatory environments. From 2014 to 2017, 40 states participated in the FFM for at least one year. Therefore, this paper focuses on the FFMs.

4 Theoretical Framework

This section presents the model of insurance plan demand and insurers' pricing with MLR regulation. The model consists of three parts. In the first part, insurers and health care providers bargain on health service prices. Following that, insurers determine premiums of the insurance plans and sell them in the market. Finally, consumers shop for insurance plans based on premiums and plan characteristics. If a consumer visits a health care provider, the insurer will pay part of the medical bill according to the plan, and the consumer will pay the other part. The health care provider treats the patient and gets payments from the insurer and the patient. In the following subsections, I solve the model by backward induction.

4.1 Demand for insurance plans

To model the demand for insurance plans, I adopt a methodology set out by Berry, Levinsohn and Pakes (1995) that has been used in both health (Ho, 2009) and non-health sectors (Nevo, 2001). I assume that the utility of individual i from choosing plan j in state s and year t is

$$u_{ijst} = X_{jst}\beta_i + \alpha_i\phi_{jst} + \xi_s^s + \xi_t^t + \varepsilon_{ijst}, \tag{1}$$

where X_{jst} is a vector of plan characteristics such as deductible and maximum OOP allowed by the plan. ϕ_{jst} is the premium of plan j. ξ_s^s and ξ_t^t are state fixed effects and year fixed effects, respectively. ε_{ijst} is the idiosyncratic error term, which follows EV Type I. α_i and β_i are random coefficients both of which consist of a constant part and a random part:

$$\begin{pmatrix}\alpha_i \\ \beta_i\end{pmatrix} = \begin{pmatrix}\alpha \\ \beta\end{pmatrix} + \Pi D_{ist} + \Sigma\nu_i,$$

where D_{ist} is a random draw of demographic characteristics in market t, and ν_i follows a i.i.d. standard normal distribution. Π and Σ are the matrices of random coefficients.

Then the utility individual i receives from choosing plan j can be written as

$$u_{ijst} = X_{jst}\beta + \alpha\phi_{jst} + \xi_s^s + \xi_t^t + \sum_k x_{jkst}\pi_k^\beta d_{ikst}^\beta + \pi^\alpha d_{ist}^\alpha \phi_{jst} + \sum_k x_{jkst}\sigma_k^\beta \nu_{ik}^\beta + \sigma^\alpha \nu_i^\alpha \phi_{jst} + \varepsilon_{ijst}$$

where the sum of first four terms—$X_{jst}\beta + \alpha\phi_{jst} + \xi_s^s + \xi_t^t$—represents the mean utility in market st. The following four terms, including the two summation terms, have all the random coefficients.

The market share of plan j in market t is the probability that plan j bringing the highest utility to individuals. More specifically, based on the utility function, the market share of plan j in state s, year t is

$$s_{jst} = \int \frac{e^{u_{ijst}(X_{jst},\phi_{jst},\xi_{jst},D_{ist},\nu_i;\alpha,\beta,\Pi,\Sigma)}}{1 + \sum_k e^{u_{ikst}(X_{kst},\phi_{kst},\xi_{kst},D_{ist},\nu_i;\alpha,\beta,\Pi,\Sigma)}} \varphi(\nu_i) d\nu_i. \tag{2}$$

By multiplying the market share with the market size M_{st}, I obtain the demand function of plan j in market st

$$D_{jst}(\phi_{jst}, X_{jst}) = M_{st} s_{jst}.$$

4.2 Insurers' premium choices

Insurers choose premiums to maximize their profits given service prices and MLR regulation. Consider an insurer f that provides a set of insurance plans J_f.[3] The objective in this part is to choose a set of premiums $\{\phi_j\}_{j\in J}$ that maximizes the total profit Π_f^I with a MLR no lower than the threshold $\bar{R}$. Following the regulation, I introduce MLR regulation as a constraint imposed at insurer-level. Therefore, the constrained profit-maximization problem that insurer f needs to solve is

$$\max_{\{\phi_j\}_{j\in J_f}} \Pi_f^I = \sum_{j\in J_f} (\phi_j - \tilde{p_j}\kappa_j\theta) D_j(\boldsymbol{\phi}) - C^F$$

$$s.t. \quad \sum_{j\in J_f} \tilde{p_j}\kappa_j\theta D_j \geq \bar{R} \sum_{j\in J_f} \phi_j D_j,$$

where ϕ_j is the premium of plan j, $\tilde{p_j}$ is the health service price, κ is plan j's coverage rate, θ is the fraction of enrollees who seek care, and C^F is the fixed cost to the insurer.

[3] To simplify the notation, I omit the subscript s and t for the rest of theoretical model.

The insurers' optimal solution to the problem can be rewritten as

$$\max_{\{\phi_j\}_{j\in J_f}} \mathfrak{L}^I = \sum_{j\in J_f}(\phi_j - mc_j)D_j(\boldsymbol{\phi}) - C^F + \lambda(\sum_{j\in J_f} mc_j D_j - \bar{R}\sum_{j\in J_f}\phi_j D_j), \tag{3}$$

where λ is the Lagrangian multiplier, a measure of the shadow cost brought by MLR regulation. By the Kuhn-Tucker theorem, $\lambda = 0$ when issuers are compliant with MLR regulation, $\lambda > 0$ otherwise.

The first order condition yields the relation between the optimal premiums and the health service prices in the presence of MLR regulation. That is,

$$\boldsymbol{\phi} = \frac{1-\lambda}{1-\lambda\bar{R}}\tilde{p}\odot\boldsymbol{\kappa}\theta - \mathbf{J}^{-1}\mathbf{D} \tag{4}$$

where $\odot$ indicates element-wise multiplication and J is the Jacobian matrix of $\boldsymbol{D}$ with respect to $\boldsymbol{\phi}$. This best response function shows that for insurers with MLRs above the threshold required by the regulation, their optimal premiums equal to the medical cost plus a markup. Insurers that are non-compliant with the regulation will put less weight on the medical cost for the premium choices.

In the appendix section A, I prove that $\lambda \in (0,1)$ is the sufficient and necessary condition of $0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1$. Put the above discussion in a Averch-Johnson model. λ ranges between 0 and 1 is the crucial condition of the existence of the Averch-Johnson effect (Averch and Johnson, 1962; Takayama, 1969; Stein and Borts, 1972).

4.3 Price negotiation

In the first stage, insurers and health care providers negotiate on health service price $\tilde{\mathbf{p}}$. In practice, insurers usually bargain for a set of insurance plans at once. Thus, I assume that plans provided by the same insurer in the same market have the same service price, that is $\tilde{p}_j = \tilde{p}, \forall j \in J_f$. Following previous studies (Crawford and Yurukoglu, 2012; Grennan, 2013; Gowrisankaran, Nevo and Town, 2015; Ho and Lee, 2017), I adopt the bilateral Nash bargaining model proposed in Horn and Wolinsky (1988). I assume that each insurer-provider pair maximizes a bilateral Nash product, taking the outcomes of the others as given. One important difference between my model and previous ones is the constraint introduced by MLR regulation. This regulation is well known to all the insurers and providers. Therefore, I assume that the insurer's profit in the Nash product is constrained.

Due to data limitations, I do not observe provider networks or the demand for services for each provider. Thus, I use one provider to represent one market. This assumption is strong if the paper's focus is on network negotiation. It is less concerning for my question, which focuses on a regulation imposed on insurer profit. Including more providers will change the outside profit and consequently will give insurers more bargaining power. This will not affect the conclusion that MLR regulation rules out bargaining equilibrium with low prices.

Consider one insurer-provider pair. They seek to find the service price $\tilde{p}$ that maximizes the Nash product of their profits below

$$\Pi^{Nash} = \left(\Pi^I - \Pi_0^I\right)^\tau \left(\Pi^H - \Pi_0^H\right)^{(1-\tau)},$$

where τ is the bargaining parameter which measure insurer's bargaining power. Π^I and Π^H are insurer's constrained profit and health care provider's profit, respectively, when they agree on price $\tilde{p}$. In the case of no agreement is reached, the insurer will not enter this market, receiving Π_0^I and health care providers will see patients covered by other insurance plans and receiving Π_0^H. Therefore, the four relevant profit functions in the bargaining problem are

$$\begin{aligned}
&\Pi^I = \textstyle\sum_{j\in J_f} \left(\phi_j - \tilde{p}_j\kappa_j\theta\right) D_j(\boldsymbol{\phi}) - C^F + \lambda\left(\sum_{j\in J_f} \tilde{p}_j\kappa_j\theta D_j - \bar{R}\sum_{j\in J_f} \phi_j D_j\right),\\
&\Pi^H = \textstyle\sum_{j\in J_f} (\tilde{p} - \tilde{c_h})\theta D_j,\\
&\Pi_0^I = 0,\\
&\Pi_0^H = \textstyle\sum_{j\in J_f} (\tilde{p}_0 - \tilde{c_h})\theta D_j.
\end{aligned} \tag{5}$$

$\tilde{c_h}$ is the service cost per patient to the health care provider, which assumed to be the same for patients covered by different insurance plans. $\tilde{p}_0$ is the alternative price of service.

In the following subsections, I solve the Nash product maximization problem defined above and obtain the expression of negotiated prices. To better illustrate the intuition of the equations, I start with a single-product scenario and provide the multi-product solution after that. It is important to note that one insurer could and usually does offer multiple plans in a market. It is important because when the regulation is imposed at the insurer-level, insurers could make a large profit from one plan and sacrifice a small portion of the profit to another plan.

4.3.1 Single-product scenario

When the insurer provides only one insurance plan in the market, the objective function of the bargaining model could be simplified as

$$\Pi^{Nash} = \left[(\phi - \tilde{p}\kappa\theta)D - C^F + \lambda(\tilde{p}\kappa\theta D - \bar{R}\phi D)\right]^\tau \left[(\tilde{p} - \tilde{p}_0)\theta D\right]^{(1-\tau)}.$$

By the envelope theorem and the relation in the equation (4), the F.O.C. of the objective function above w.r.t p yields,

$$\tilde{p} = \tilde{p}_0 - \frac{(1-\lambda\bar{R})\frac{D^2}{D'} + C^F}{\frac{\tau}{1-\tau}(1-\lambda)\kappa\theta D + \frac{D'}{D}\phi'\left[(1-\lambda\bar{R})\frac{D^2}{D'} + C^F\right]}. \tag{6}$$

As shown by the equation above, the equilibrium price consists of two parts—the opportunity cost to health care provider $\tilde{p}_0$ and a unit markup for the provider. The latter part depends on the bargaining power τ, the effect of MLR regulation measured by λ, and the demand function $D(\cdot)$. The negotiated price $\tilde{p}$ is decreasing in insurers' bargaining power τ. Intuitively, insurers with larger bargaining power could push the negotiated price lower and leave smaller profit to health care providers. The extreme case is when an insurer has all the bargaining power, then the negotiated price will equal to $\tilde{p}_0$, and the provider will obtain zero profit from having an agreement with this insurer. The relation between the negotiated price and MLR regulation depends on insurers' best response function $\phi(\cdot)$ and demand function $D(\cdot)$. From previous section, I obtain the best response function $\phi(\tilde{p})$. It allows me to solve out the ϕ' in the denominator, details are in the appendix section B.1. Applying the implicit function theorem to the equation (4), I obtain

$$\phi' = \frac{(1-\lambda)\kappa}{(1-\lambda\bar{R})A}, \text{ with } A = 2 - \frac{DD''}{(D')^2}. \tag{7}$$

The above equation shows that both the curvature of demand function and MLR regulation affect how optimal premium responds to changes in serve price. Essentially, the MLR regulation magnifies the sensitivity of premium to the service price. As proved in the Appendix section A, $0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1$. Then premiums will be less responsive to changes in price, no matter an increase or a reduction, if insurers are affected by MLR regulation.

4.3.2 Multi-product scenario

In the real world, insurers provide more than one plan and strategically select premiums to maximize the total profit. Thus, it is needed to generalize previous analysis to a multi-product scenario. Similar to the single-product case, I apply the envelope theorem and use the relation in the equation (4) to obtain the equation below, which is analogue to equation (6),

$$\tilde{p} = \tilde{p}_0 - \frac{\mathbf{1}^T\boldsymbol{D}}{\frac{\tau}{(1-\tau)}\frac{(1-\lambda)\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\boldsymbol{J}^{-1}\boldsymbol{D}]^T\boldsymbol{D}+C^F} + \mathbf{1}^T\boldsymbol{J}\frac{\partial\boldsymbol{\phi}}{\partial p}}. \tag{8}$$

The equation above explicitly shows the effect of the regulation (λ) and the bargaining power (τ) on the service price. The difference between single-product and multi-product solutions is the Jacobian matrix $\boldsymbol{J}$. When this matrix degenerates to a diagonal matrix, solutions are the same regardless of the number of plans offered by an insurer. When the off-diagonal entries in the Jacobian matrix are not zero, plans subsidize each other and achieve the MLR requirement as a whole.

For the $\frac{\partial\boldsymbol{\phi}}{\partial p}$, I again use the implicit function theorem and derive the following equation from equation (4),

$$\left(\begin{bmatrix}[\mathbf{J}^{-1}\mathbf{D}]^T H^1\\ \vdots \\ [\mathbf{J}^{-1}\mathbf{D}]^T H^J\end{bmatrix} - 2\mathbf{J}\right)\frac{\partial\boldsymbol{\phi}}{\partial p} = -\frac{1-\lambda}{1-\lambda\bar{R}}\mathbf{J}\boldsymbol{\kappa}. \tag{9}$$

H^j is the Hessian matrix of plan j's demand function with respect to premiums of plans offered by the same insurer. The term in the large parentheses corresponds to the A in equation (7). The technical details are in the appendix section B.

4.4 Graphical illustration

I use the framework sketched above to provide a graphical representation of the effect of MLR regulation. The graph shows a simplified situation where the insurer provides only one plan. This simplification affects the estimation but does not change the general conclusion that MLR regulation rules out bargaining equilibria with low negotiated service prices. In addition, I assume that the profit will be zero for both the insurer and the provider if they do not reach any agreement on the service price.

4.4.1 Setup

Consider an insurer I that offers one insurance plan, and a health care provider H offers one medical service. In the absence of MLR regulation, both the profit maximization problem and the Nash product maximization problem are unconstrained.

More specifically, at the first stage, the insurer and the provider maximize the Nash product of their profits with respect to the service price p. The Nash product is defined as

$$\Pi^{Nash} = \left[\phi D(\phi) - p\kappa\theta D(\phi) - C^F\right]^{\tau} \left[(p - c_h)\theta D(\phi)\right]^{(1-\tau)}.$$

At the second stage, the insurer maximizes the profit by setting the premium

$$\phi = arg\max_{\phi} \left[\phi D(\phi) - p\kappa\theta D(\phi) - C^F\right].$$

4.4.2 Price negotiation and premium choice

As shown in the previous sections, I solve this simplified model by backward induction. The solution from the second stage is the best response function of insurer,

$$\phi(p) = p\kappa\theta - \frac{D}{D'}. \tag{10}$$

This is a special version of the equation (4)—when MLR regulation is not effective. The second term on the right-hand-side is positive as I assumed the demand decreases in the premium. The optimal premium is increasing in service price if and only if $2(D')^2 - DD'' > 0$. This condition is satisfied when the demand function is concave or mildly convex, such as a linear demand function and a logit form demand function. Appendix section C discusses the conditions for an increasing best response function.

Having the best response in mind, the insurer negotiates the service price with the health care provider. The negotiated price solution in this simplified scenario is

$$p = c_h - \frac{\frac{D^2}{D'} + C^F}{\frac{\tau}{1-\tau}\kappa D + \frac{D'}{D}\phi'(\frac{D^2}{D'} + C^F)}. \tag{11}$$

When the insurer has all of the bargaining power, $\tau \to 1$, the service price is equal to the cost of the provider. In this case, the provider does not enjoy any profit while the insurer takes all the profit. When the health care provider has all the bargaining power, $\tau = 0$, the equilibrium price is $\bar{p} = c_h - \frac{D(\phi(\bar{p}))}{D'(\phi(\bar{p}))\phi'(\bar{p})}$. This is the highest price that the insurer would accept. Any price higher than $\bar{p}$ means negative profit for the insurer.

Figure 1 shows the insurer's best response and the corresponding profit. On the right half-plane, the x-axis represents the negotiated price; the y-axis represents the premium. When the insurer and the provider bargain on the price, the equilibrium price moves between c_h and $\bar{p}$ along the x-axis. The location of the negotiated price depends on the bargaining power τ. When $\tau = 1$, $p = c_h$. When $\tau = 0$, $p = \bar{p}$. For each possible negotiated price, the blue curve shows the insurer's best response. Along the best response curve, points A and C correspond to the equilibria when the insurer has all the bargaining power and none bargaining power, respectively. The dashed line $p\kappa\theta$ represents the marginal cost to the insurer. On the left half-plane, the black curve is the demand function for insurance plans. Then the profit could be represented by a rectangle below the demand curve. The real profit equals the premium revenue minus the medical cost minus the fixed cost. To simplify the figure, I show the raw profit—real profit plus fixed costs—rather than the real profit. In other words, the raw profit is the product of demand and the difference between the premium and marginal cost. This simplification does not affect the comparison between profits corresponding to different (p, ϕ) pairs within a firm. For example, as shown in the figure, the green shaded area represents the raw profit corresponding to the point A where the insurer has all the bargaining power.

4.4.3 Effect of MLR regulation

When MLR regulation takes effect, the insurance firm maximizes its profit subject to a minimal ratio $\bar{R}$ for medical loss. That is, for the insurer,

$$p\kappa\theta \geq \bar{R}\phi(D).$$

Figure 2 shows how the regulation affects the bargaining equilibrium and insurer's optimal premium choice. The orange line represents the MLR threshold, and the area underneath the line, the orange shared area, indicates all the eligible (p, ϕ) pairs under the regulation. In other words, if the insurer has little bargaining power so that the optimal solution without MLR regulation locates between points B and C, then the insurer will not be affected by the regulation. However, when the optimal premium choice without MLR regulation is between points A and B, that is when the insurer has large bargaining power and low negotiated price, the insurer has to either lower the premium and/or concede part of her profit to the provider. Continue using the example in the Figure 1. The MLR at point A is below the regulatory threshold. If the service price is fixed, the insurer will have no choice other than moving to the point A' and gain the profit $\Pi_{A'}$ indicated by the green shaded area. When the service price is negotiated, the insurer could move to other locations between points A' and B. For example, the insurer could move to point A'' and gain the profit $\Pi_{A''}$ indicated by the blue shaded area. Where locates the new optimal choice is an empirical question. It depends on the profit corresponding to each point, which is related to the curvature of the demand function. As for the premium, it could become lower or higher than ϕ_A. Again, it depends on the relation between the regulation threshold and the curvature of the demand function.

This simple model shows that if an insurer has little bargaining power and a high negotiated price, MLR regulation will not affect the price. For an insurer with large bargaining power and a low negotiated price, MLR regulation will rule out the (p, ϕ) combination that the insurer initially chooses. Consequently, the service price increases under the above condition. Whether the premium increases or decreases depends on the relative concavity of the demand function to the regulation threshold.

5 Data

To empirically estimate the effect of MLR regulation, I apply the model developed in the previous section to the Health Insurance Exchange Marketplaces. I use data from multiple sources to construct my sample. The two primary data sources this paper relies on are healthcare.gov and the Center for Consumer Information & Insurance Oversight (CCIIO). The former is the website where consumers shop for their insurance plans. From the website, I gather data on premiums and other plan characteristics. In this dataset, each plan has a state-specific plan ID, which is uniquely defined by state, insurer, and plan.

From the CCIIO, I obtain the enrollment data and insurers' MLR reports. The unit of observation in the enrollment data is state-plan. I merge the enrollment data with the plan characteristics by plan IDs and generate a dataset of demand, premium, and plan characteristics. A caveat with the enrollment data is that the number of enrollees is aggregated to the state level, not at county or rating area level. Therefore, I use the average premium as the state-level premium. Insurers' MLR reports are filed annually and contain financial information such as MLR, total revenue, total cost, and other insurer-level information such as the Employer Identification Number (EIN), whether it is for-profit, etc. These data are merged to the main dataset by state-specific issuer IDs. In the following analysis, I use this state-specific issuer ID as the insurer ID. The EIN is used for generating instruments, described in section 6.1.

To complete the dataset, I obtain the market and population demographics data from the Area Health Resources Files (AHRF). More specifically, I estimate the income distribution in each state using the statistics of uninsured people's income groups and use the number of uninsured people as the market size.

The final sample has 7,570 unique plan IDs offered by 306 insurers (238 EINs) in 149 state-year markets. That is 12,384 plan-year observations. Table 3 shows the descriptive statistics of key variables in the sample.

As mentioned earlier, plan features could vary within the same metal category. In this paper, I include the following plan characteristics. The *Deductible* is the amount an enrollee pays for health care services before the insurance plan starts to pay. After reaching the deductible line, the enrollee will pay either a fixed amount—*copayment*—for the health care service or a fixed fraction—*coinsurance*—of the total spending. When the total out-of-pocket payment—the sum of deductibles, copayments, and coinsurance—reaches the Out-Of-Pocket maximum (*OOP max*), the insurance plan will cover all spendings after that.

Figure 3 shows the average of premiums and other plan characteristics by metal category and year. Panel A shows that, on average, premium increases from catastrophic plans to platinum plans. It also increases significantly over the years. For the deductible and OOP max, the difference across metal categories is significant, but the over-year changes are much smaller than those in premiums. Panel D and E present the copayment and coinsurance, respectively. Because only 52.35% of plans have copayment and 38.53% have coinsurance, the variation of these two plan characteristics is much larger. As Parys (2018) shows, premiums increased significantly from year to year. The time trend of other plan characteristics is relatively flat. This variation in premiums and plan characteristics is one of the key identification sources in my analysis.

There is also important variation arising from different insurer MLRs. Figure 4 shows the MLRs reported by insurers from 2014-2017. Grey bars and red contour bars present the preliminary MLR and credibility-adjusted MLR, respectively. Most of the insurers have MLRs between 0.8 and 1. Those after the credibility-adjustment are higher than the preliminary ones overall. Callaghan, Plummer and Wempe (2020) find that, all markets pooled together from 2011-2015, MLRs of both non-compliant and compliant plans move towards to the threshold over years. In the Marketplace, from 2014-2017, the width of MLR distribution does not shrink and it is relatively continuous at threshold 0.8, as shown in the appendix figure A1.

This study grapples with the same two major data limitations as in other studies. The first one is that I do not observe negotiated prices. To address this problem, I structurally introduce insurer premium choices into the bargaining solution. Second, because the marketplace started in 2014, three years later than the regulation, pre-regulation data do not exist. Therefore, reduced-form approaches are not applicable in this case.

6 Empirical Strategy

In this section, I present the empirical estimation strategy which is based on the theoretical model developed in section 4.

6.1 Demand for insurance plans

In the discrete choice model for the insurance plan demand, a couple of variables and distributions need to be further specified. First, the plan characteristics X_j includes plan j's deductible, OOP max, copayment, coinsurance, metal category, and plan type. These are the most salient plan characteristics that consumers could observe in the marketplace. [4] Second, for the demographic distribution, I use the income group measured by the federal poverty level. Another important variable for the demand estimation is the market size M_t. Following previous studies (Tebaldi, 2017; Drake, 2019; Saltzman, 2019), I assume that the outside option is uninsured. The uninsured population under age 65 represents the "demand" of outside option.

The premium is endogenous in the model. Therefore, I use three sets of instrument variables together to mitigate the endogeneity problem. The first set contains the average plan characteristics of plans offered by the rivals in the same market. Those instruments are missing in single-insurer markets. Therefore, I use an indicator of single-insurer markets and replace missing values by zero in the average plan characteristics. The second set of instruments includes the average premiums and the average plan characteristics of plans offered by the same insurer in other markets. The same insurer is identified by the EIN. Because there are local insurers that only participated in one market (i.e., one year in one state), I use a similar method to deal with missing values— add an indicator of single-market insurer and assign zero to those missing values in the average instruments. The last set of instruments includes cost shifters. It includes the average Medicare wage index across all core-based statistical areas where the plan was provided.

6.2 Effect of MLR regulation on marginal cost

Before estimating the full model, I examine the effect of MLR regulation on insurers' marginal cost, without including the price negotiation.

Insurers' best response function, the equation (4), establishes the relation between marginal cost and marginal revenue under MLR regulation. That is

$$mc = \left(\bar{R} + \frac{1 - \bar{R}}{1 - \lambda} \right) mr,$$

with $mc = \tilde{p}\kappa\theta$ and $mr = \phi + \boldsymbol{J}^{-1}\boldsymbol{D}$. From the demand estimation, the marginal revenue mr_j is calculable. However, the marginal cost is unobservable. Therefore, I adopt a widely used assump-

[4] Due to the potential collinearity issue, the main specification leaves OOP max out. I choose OOP max because this is the last feature that enrollees will use.

tion about marginal cost–that the log of marginal cost is a linear function of product characteristics. With this assumption, I estimate the effect of MLR regulation by the following equation

$$ln(mr_j) = Const - ln\left(\bar{R} + \frac{1-\bar{R}}{1-\lambda\mathbb{1}(Rebate_{f(j)})}\right) + w_j\gamma + \omega_j, \tag{12}$$

where $\mathbb{1}(Rebate_{f(j)})$ is an indicator of whether the insurer f needs to rebate, w_j is a vector of plan characteristics including same variables as in X_j, λ measures the effect of MLR regulation on non-compliant insurers. From the discussion in the section 4, I expect that $\lambda > 0$. A positive λ implies that MLR regulation breaks the efficient equality–$marginal\,cost = marginal\,revenue$. Affected by the MLR, marginal cost is higher than the marginal revenue.

6.3 Effect of MLR regulation and price negotiation

Using the model developed in section 4, I derive a set of moments for the estimation. I start by adapting my model to the available data. The heterogeneity in the service prices is an interesting topic but requires a high-quality dataset. As this paper focuses on the essence of price negotiation, I use one representative price for all the health services. More specifically, I use the average spending as a proxy of the service price. Moreover, due to data availability, I use the average spending per enrollee instead of the average spending per patient. In this way, θ is not identifiable, thus, I use p and p_0 instead of $\tilde{p}\theta$ and $\tilde{p}_0\theta$, respectively. For the alternative price p_0, I use the average Medicaid spending per enrollee as a proxy and denote it as p^{MCD}. This payment can be considered as the lowest payment a provider receives.

One big challenge for the estimation is that negotiated prices are not observed. In this part of estimation, instead of making an assumption about marginal cost, I combine equation (4) and equation (8) to eliminate service price in the final estimation equation.

After those changes, I am able to jointly estimate λ, τ, and C^F using two-step GMM under the assumption that $E[Z'\xi] = 0$. The error term ξ is defined as

$$\begin{aligned}\xi = \quad & \frac{\tau(1-\lambda\bar{R})(\boldsymbol{\phi} + \boldsymbol{J}^{-1}\boldsymbol{D})^T\boldsymbol{D}}{(1-\lambda\bar{R})[\boldsymbol{J}^{-1}\boldsymbol{D}]^T\boldsymbol{D} + C^F} - \frac{\tau(1-\lambda)p^{MCD}\boldsymbol{\kappa}^T\boldsymbol{D}}{(1-\lambda\bar{R})[\boldsymbol{J}^{-1}\boldsymbol{D}]^T\boldsymbol{D} + C^F} \\ & - \frac{(1-\tau)(1-\lambda)}{1-\lambda\bar{R}} p^{MCD} \frac{\boldsymbol{1}^T\boldsymbol{J}\boldsymbol{A}^{-1}\boldsymbol{J}\boldsymbol{\kappa}}{\boldsymbol{1}^T\boldsymbol{D}} - (1-\tau)(\frac{\boldsymbol{1}^T\boldsymbol{J}\boldsymbol{A}^{-1}\boldsymbol{J}(\boldsymbol{\phi} + \boldsymbol{J}^{-1}\boldsymbol{D})}{\boldsymbol{1}^T\boldsymbol{D}} - 1). \end{aligned} \tag{13}$$

In the equation, $\boldsymbol{\phi}$ and $\boldsymbol{D}$ are observed, $\boldsymbol{J}$ and $\boldsymbol{H}$ are calculated based on the demand estimates. Appendix section B.2 shows how $\boldsymbol{J}$ and $\boldsymbol{H}$ are calculated. For the instruments in Z, I use the number of firms in the market, year dummies, and state dummies.

7 Empirical Results

7.1 Demand for insurance plans

Before estimating the demand with random coefficients, I explore the relation between demand and plan characteristics by nested-logit regressions.

$$ln(s_{jst}) - ln(s_{0st}) = \alpha ln\phi_{jst} + X'_{jst}\beta + \sigma ln s_{j/g} + \gamma^s_s + \gamma^t_t + \gamma^f_{f(j)} + \xi_j \tag{14}$$

In the equation, s_{jst} and s_{0st} are market shares of plan j and outside option in state s and year t, respectively. ϕ_{jst} is plan j's average premium. X_{jst} is a vector of plan characteristics. $s_{j/g}$ is the nested market share where g represents the metal category that plan j belongs to. γ^s and γ^t are state fixed effects and year fixed effects, respectively. $\gamma^f_{f(j)}$ is insurer fixed effect, $f(j)$ indicates the insurer who provides plan j. Since the conditional market share $s_{j/g}$ is also endogenous, I use the number of plans in the nest as an additional instrument.

Table 4 presents the estimates of demand for insurance plans in the exchange marketplace. The first two columns show the results of nested-logit regressions while the followings show the results with random coefficients. In columns (1) and (3), plan characteristics include deductible and OOP max. In the other columns, I replace OOP max with copayment and coinsurance. Across all the specifications, higher premiums lower consumer utility. After controlling for the copayment and coinsurance rates, consumers significantly prefer low deductible. It is interesting to note that consumers significantly prefer the copayment feature and do not care much about the amount of copayment. As for the coinsurance, consumers do not like this feature and are very sensitive to the coinsurance level. This finding echoes what Loewenstein et al. (2013) find—consumers understand copayment the best among all the four plan features. In other words, consumers prefer insurance plans that they know how it works.

In the following study, I use the model and estimates in column (5) as the demand for insurance plans. More specifically, I use those estimates to calculate Jacobian and Hessian matrices of demand as well as the derivatives of the best response function with respect to the health service price.

Based on the selected specification, the average own-price elasticity is -2.23 (SD 0.51), which locates well in the range of estimates in previous studies (-5.2, -1.1) (Abraham et al., 2017; Saltzman, 2019; Drake, 2019). Figure 5 shows the kernel density of own-price elasticity by metal category. From the least to the most generous category, mean elasticity does not move much while the width of distribution shrinks.

7.2 Effect of MLR regulation

From the demand estimation, I obtain plan-level marginal revenue $mr_j = \phi_j + [\boldsymbol{J}^{-1}\boldsymbol{D}]_{jj}$. Figure 6 shows the distribution of marginal revenue for compliant and non-compliant insurers. In the figure, the marginal revenue of plans provided by non-compliant insurers are higher than that of plans provided by compliant insurers. Using these calculated marginal revenues, I estimate equation (12) to tease out the effect of MLR regulation on marginal cost by non-linear least squares.

As shown in the table 5, λ is significantly different from zero, regardless of model specifications. From column (1) to (4), I add year fixed effects, state fixed effects, and firm characteristics one by one. Inspired by previous studies (Dafny, 2019; McCue, Hall and Liu, 2013), I include a not-for-profit indicator and the number of counties the insurer enters as firm characteristics. With more controls, the magnitude of the effect reduces. Column (5) includes the same control variables as column (4) except using OOP max instead of copayment and coinsurance. My estimate of λ is robust to this change of plan characteristics. In the setting of column (4), $\lambda = 0.0568$ means that, compared to compliant insurers, 9.7% of non-compliant insurers' marginal cost is induced by the regulation given plan design. In other words, the ratio of marginal cost to marginal revenue equals one when there is no regulation. When the MLR regulation is effective, this ratio increases to 1.097, which suggests an inefficiency. That increase could be driven by an increase of marginal cost and/or a decrease of the marginal revenue at equilibrium.

Among all the plan characteristics, the most significant contributor is copayment. As expected, higher copayment relates to lower marginal cost and, therefore, lower marginal revenue. The constant term estimates, shown in the last row in the table, implying that the marginal cost of the base plan—a plan without any cost-sharing in the catastrophic category—is about \$1700, on average.

7.3 Effect of MLR regulation and price negotiation

Combining the demand estimates with the full model, I jointly estimate the bargaining parameter, the effect of MLR regulation, and insurers' fixed cost. Table 6 presents the results with different specifications. Because the estimation in this part relies on the demand estimation discussed in section 7.1. I use a parametric bootstrap method to calculate the standard errors (Efron and Tibshirani, 1986). More specifically, I assume that the demand parameters follow the distributions estimated by the demand model, and bootstrap based on those estimated distributions to evaluate the accuracy of the point estimates in this section.

Column (1) in Table 6 shows the baseline estimates, where I assume that insurers have the same bargaining parameter and same fixed cost. Following that, I allow non-compliant insurers to have a different bargaining parameter where τ_1 measures the difference. Results displayed in column (2) suggest that non-compliant insurers have an insignificantly lower bargaining power although the magnitude is large—28% less powerful than compliant insurers on average. In column (3), all insurers have the same bargaining parameter, and not-for-profit insurers could have a different fixed cost. The estimates suggest that, compared to for-profit insurers, non-for-profit insurers have higher fixed cost. The last column combines the specification of columns (2) and (3).

The first row presents the estimates of λ—a measure of the effect of MLR regulation. The results are relatively robust to changes in the specifications. To interpret λ, I use estimates in column (4) to calculate the negotiated service prices with and without the MLR regulation, assuming all other settings are unchanged. Table 7 shows a summary of the calculated negotiated prices. The average negotiated price of compliant insurers does not change when there is the MLR regulation. For non-compliant insurers, the MLR regulation raises the negotiated price by \$86.62. Those changes in negotiated price translate into \$21.3 million and \$62.8 million more OOP payment for patients enrolled in compliant plans and non-compliant plans every year, respectively. This extra OOP payment is for health care services, excluding any changes in the premiums. To answer what would premiums be and what is the total welfare effect, I conduct the following counterfactual analysis.

8 Counterfactual Analysis

To disentangle the effect of MLR regulation and that of price negotiation, I compare price and premiums at equilibrium in the following three scenarios:

1. No regulation on profit and prices are negotiated;
2. MLR regulation is effective, but health service prices are fixed at pre-regulation negotiated level;
3. MLR regulation is effective, and prices are negotiated.

In all the three scenarios, I constructed a synthetic market of 100,000 individuals and three insurers. Each insurer provides one silver plan with different plan characteristics shown in the table below.

	Insurer1 (plan A)	Insurer2 (plan B)	Insurer3 (plan C)
Deductible (\$)	2000	3000	5000
Copayment (\$)	10	25	30

In the first scenario, there is no regulation on insurer profit. Insurers and health care providers negotiate service prices, and insurers set the premium to maximize the profit. This setting would mimic the market if the Marketplace existed before the MLR regulation. When there is no regulation on the profit, insurers will exploit the demand and pricing as much as possible. The top panel in Table 8 shows the solution at equilibrium in this scenario. The negotiated service prices are around \$2700, and the optimal premiums are around \$2600. Of the 100 thousand individuals in the market, about 52 thousand purchased insurance plans. The uninsurance rate is higher in this constructed market than in the real market because I eliminate cheap plans for simplification. Together, it means around \$45 million of premium revenue and \$33 million of medical loss for one insurer.

The second scenario is when the MLR regulation is effective, and prices are fixed at the pre-regulation level. The pre-regulation level is the negotiated result when there is no MLR regulation.

That is the level in the first scenario. The middle panel in Table 8 presents the results at equilibrium in this setting. With the same level of service prices, because of the MLR regulation, insurers have to lower premiums to achieve the requirement. Therefore, premiums in this scenario are lower than those in the first scenario. Consequently, demands and medical loss are higher than in the previous case. Despite the increase in demands, the reduction in premiums drives to lower premium revenues for all three insurers.

The last scenario is the real world scenario described in the previous sections—the MLR regulation is effective, and service prices are negotiated by insurers and health care providers. In the constructed market, as shown by the bottom panel in Table 8, the negotiated prices increase to $4200, and the premiums increase to $3700. Although the demands reduce by more than one thousand for each plan, the premium revenues are higher than the other scenarios.

Comparing scenarios 1 and 2 suggests that, if service prices were fixed, the MLR regulation would limit insurer profit and make the insurance plans more affordable for more people. The average enrollee would spend $224 less on insurance plans. With lower premiums, 1.6% of individuals would become insured. For the whole market, consumers save $7.9 million from insurance plans and spend $4.4 million more on health care services. Together, the consumer welfare increases by $3.6 million.

Changing from scenario 1 to 3 illustrates the effect of MLR regulation in the real market setting—a market where service prices are negotiated by insurers and health care providers. The results imply that insurers will allow higher service prices, concede part of the profit to health care providers, and increase premiums. Although the demand drops, the total profit remains at the same level as before regulation. From the consumers' perspective, they will need to pay $144 million more out of pocket—$ 47 million for the insurance plans and the other $67 million for health care services.

9 Conclusion

This paper builds a structural model of the effects of Medical Loss Ratio regulation on health service prices and insurance premiums. The model incorporates the regulation and insurer-provider price negotiation. This constrained bargaining model reveals how MLR regulation leads to higher health service prices via price negotiation. I also provide a graphical representation of the effect, which illustrates the intuition that MLR regulation rules out bargaining equilibria with low service prices. It rings the bell for policy-makers that vertical relation—e.g., negotiation relation—could open a channel through which the effect of regulations passes from the regulated side to the other side. Particularly, in markets where the private provision of public service is essential, a successful regulation needs to align private firms' incentives with the social optimum.

Applying this model to the ACA's Health Insurance Exchange Marketplace, I estimate the effect of ACA MLR regulation on prices, premiums, and patient welfare. My estimates imply that, along with the increase in MLRs, the MLR regulation results in higher health service prices and higher patient OOP payments. If MLR regulation were implemented in a market where health care service prices were fixed, consumers would spend less out of pocket. However, because of the insurer-provider price negotiation, consumers need to spend more when MLR regulation is effective.

This paper examines pricing behavior in a static and partial equilibrium framework, assuming that demand for health care services only varies proportionally to the demand for insurance plans, without adjusting for any preemptive behavior among insurers. Therefore, the conclusion from this paper should be interpreted as short-run effects. As data availability increases over time, future work could extend my model by adding dynamic components.

I also do not consider any heterogeneity among health care providers in a market. Estimates in this paper provide an average estimation of the effect of MLR regulation on health service prices. Both the heterogeneity in the negotiation—e.g., hospitals and independent practice groups might have different bargaining parameters—and the heterogeneity in the menu of service prices—e.g., effects on low-value services and high-value services might be different—could help understand the impact of this regulation on the provider market. However, I argue that this heterogeneity is a second-order concern relative to the direct effects of MLR regulation on insurer pricing, as it does not significantly alter insurer behavior. Future work could build this heterogeneity into the model; alternatively, future work might integrate provider networks into estimation. Ho and Lee (2017) and Ho and Lee (2019) model the bargaining on network formation before the ACA. More data of the provider market is needed to introduce this into the model empirically.

From the perspective of patients, a better health outcome could be more important than the OOP payment. It is still unclear whether the higher medical spending translates into better health status. To answer this question, researchers will need good measurements of service utilization and health outcomes.

Besides its MLR regulation, there are many other provisions under the ACA. Some of them—such as risk-corridor, reinsurance, and individual mandate—could affect this paper's estimates. For example, the individual mandate could affect insurer pricing because the penalty level affects the outside option for consumers and, therefore, the curvature of demand function. It is an exciting agenda to incorporate those related provisions and tease out the effect of each provision and how they interact with each other.

Lastly, the year 2020 is very different. The COVID-19 pandemic brings exogenous shocks to the demand for health care services and the cost to insurers. In the coming year(s), the pandemic could also affect the demand for insurance plans and price negotiation. Examining the consequences following the pandemic is another meaningful direction.

References

Abraham, Jean, Coleman Drake, Daniel W. Sacks, and Kosali Simon. 2017. "Demand for health insurance marketplace plans was highly elastic in 2014–2015." *Economics Letters*, 159: 69–73.

Abraham, Jean M, Pinar Karaca-Mandic, and Kosali Simon. 2014. "How has the Affordable Care Act's medical loss ratio regulation affected insurer behavior?" *Medical Care*, 370–377.

Acemoglu, Daron, and Amy Finkelstein. 2008. "Input and technology choices in regulated industries: Evidence from the health care sector." *Journal of Political Economy*, 116(5): 837–880.

Aghadadashli, Hamid, Markus Dertwinkel-Kalt, and Christian Wey. 2016. "The Nash bargaining solution in vertical relations with linear input prices." *Economics Letters*, 145: 291–294.

Averch, Harvey, and Leland L Johnson. 1962. "Behavior of the firm under regulatory constraint." *The American Economic Review*, 52(5): 1052–1069.

Barrette, Eric, Gautam Gowrisankaran, and Robert Town. 2020. "Countervailing Market Power and Hospital Competition." National Bureau of Economic Research.

Berry, Steven, James Levinsohn, and Ariel Pakes. 1995. "Automobile Prices in Market Equilibrium." *Econometrica*, 63(4): 841–890.

Callaghan, Sandra Renfro, Elizabeth Plummer, and William F Wempe. 2020. "Health Insurers' Claims and Premiums Under the Affordable Care Act: Evidence on the Effects of Bright Line Regulations." *Journal of Risk and Insurance*, 87(1): 67–93.

CCIIO. 2017. "Summary of 2016 Medical Loss Ratio Results." Center for Consumer Information and Insurance Oversight.

Cicala, Steve, Ethan M. J. Lieber, and Victoria Marone. 2019. "Regulating Markups in US Health Insurance." *American Economic Journal: Applied Economics*, 11(4): 71–104.

Cooper, Zack, Stuart V Craig, Martin Gaynor, and John Van Reenen. 2019. "The price ain't right? Hospital prices and health spending on the privately insured." *The Quarterly Journal of Economics*, 134(1): 51–107.

Cox, Cynthia, Rachel Fehr, and Larry Levitt. 2019. "Individual Insurance Market Performance in 2018." Kaiser Family Foundation.

Craig, Stuart V, Keith Marzilli Ericson, and Amanda Starc. 2018. "How Important Is Price Variation Between Health Insurers?" National Bureau of Economic Research.

Crawford, Gregory S, and Ali Yurukoglu. 2012. "The welfare effects of bundling in multichannel television markets." *American Economic Review*, 102(2): 643–85.

Curto, Vilsa, Liran Einav, Amy Finkelstein, Jonathan Levin, and Jay Bhattacharya. 2019. "Health care spending and utilization in public and private Medicare." *American Economic Journal: Applied Economics*, 11(2): 302–32.

Dafny, Leemore. 2019. "Does It Matter if Your Health Insurer Is For Profit? Effects of Ownership on Premiums, Insurance Coverage, and Medical Spending." *American Economic Journal: Economic Policy*, 11(1): 222–65.

Dafny, Leemore, Mark Duggan, and Subramaniam Ramanarayanan. 2012. "Paying a premium on your premium? Consolidation in the US health insurance industry." *American Economic Review*, 102(2): 1161–85.

Drake, Coleman. 2019. "What are consumers willing to pay for a broad network health plan?: Evidence from covered California." *Journal of Health Economics*, 65: 63–77.

Duggan, Mark, Amanda Starc, and Boris Vabson. 2016. "Who benefits when the government pays more? Pass-through in the Medicare Advantage program." *Journal of Public Economics*, 141: 50–67.

Efron, Bradley, and Robert Tibshirani. 1986. "Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy." *Statistical Science*, 54–75.

Einav, Liran, Amy Finkelstein, and Maria Polyakova. 2018. "Private provision of social insurance: drug-specific price elasticities and cost sharing in Medicare Part D." *American Economic Journal: Economic Policy*, 10(3): 122–53.

Ericson, Keith M Marzilli, and Amanda Starc. 2015. "Pricing regulation and imperfect competition on the massachusetts health insurance exchange." *Review of Economics and Statistics*, 97(3): 667–682.

Fehr, Rachel, Cynthia Cox, and Larry Levitt. 2019. "Data Note: Changes in Enrollment in the Individual Health Insurance Market through Early 2019." Kaiser Family Foundation.

Fehr, Rachel, Daniel McDermott, and Cynthia Cox. 2020. "Individual Insurance Market Performance in 2019." Kaiser Family Foundation.

Gaynor, Martin, Kate Ho, and Robert J Town. 2015. "The industrial organization of health-care markets." *Journal of Economic Literature*, 53(2): 235–84.

Gowrisankaran, Gautam, Aviv Nevo, and Robert Town. 2015. "Mergers when prices are negotiated: Evidence from the hospital industry." *American Economic Review*, 105(1): 172–203.

Grennan, Matthew. 2013. "Price discrimination and bargaining: Empirical evidence from medical devices." *American Economic Review*, 103(1): 145–77.

Grennan, Matthew. 2014. "Bargaining ability and competitive advantage: Empirical evidence from medical devices." *Management Science*, 60(12): 3011–3025.

Hendricks, Wallace. 1975. "The effect of regulation on collective bargaining in electric utilities." *The Bell Journal of Economics*, 451–465.

Ho, Kate, and Robin S. Lee. 2017. "Insurer Competition in Health Care Markets." *Econometrica*, 85(2): 379–417.

Ho, Kate, and Robin S Lee. 2019. "Equilibrium provider networks: Bargaining and exclusion in health care markets." *American Economic Review*, 109(2): 473–522.

Ho, Katherine. 2009. "Insurer-provider networks in the medical care market." *American Economic Review*, 99(1): 393–430.

Horn, Henrick, and Asher Wolinsky. 1988. "Bilateral monopolies and incentives for merger." *The RAND Journal of Economics*, 408–419.

Jaffe, Sonia, and Mark Shepard. 2017. "Price-linked subsidies and health insurance markups." *HKS Working Paper No. RWP17-002*.

Karaca-Mandic, Pinar, Jean M Abraham, and Kosali Simon. 2015. "Is the medical loss ratio a good target measure for regulation in the individual market for health insurance?" *Health Economics*, 24(1): 55–74.

Loewenstein, George, Joelle Y Friedman, Barbara McGill, Sarah Ahmad, Suzanne Linck, Stacey Sinkula, John Beshears, James J Choi, Jonathan Kolstad, David Laibson, et al. 2013. "Consumers' misunderstanding of health insurance." *Journal of Health Economics*, 32(5): 850–862.

McCue, Michael J, and Mark Hall. 2015. "Health insurers' financial performance and quality improvement expenditures in the affordable care act's second year." *Medical Care Research and Review*, 72(1): 113–122.

McCue, Michael, Mark Hall, and Xinliang Liu. 2013. "Impact of medical loss regulation on the financial performance of health insurers." *Health Affairs*, 32(9): 1546–1551.

Nevo, Aviv. 2001. "Measuring Market Power in the Ready-to-Eat Cereal Industry." *Econometrica*, 69(2): 307–342.

Parys, Jessica Van. 2018. "ACA marketplace premiums grew more rapidly in areas with monopoly insurers than in areas with more competition." *Health Affairs*, 37(8): 1243–1251.

Roberts, Eric T, Michael E Chernew, and J Michael McWilliams. 2017. "Market share matters: evidence of insurer and provider bargaining over prices." *Health Affairs*, 36(1): 141–148.

Saltzman, Evan. 2019. "Demand for health insurance: Evidence from the California and Washington ACA exchanges." *Journal of Health Economics*, 63: 197–222.

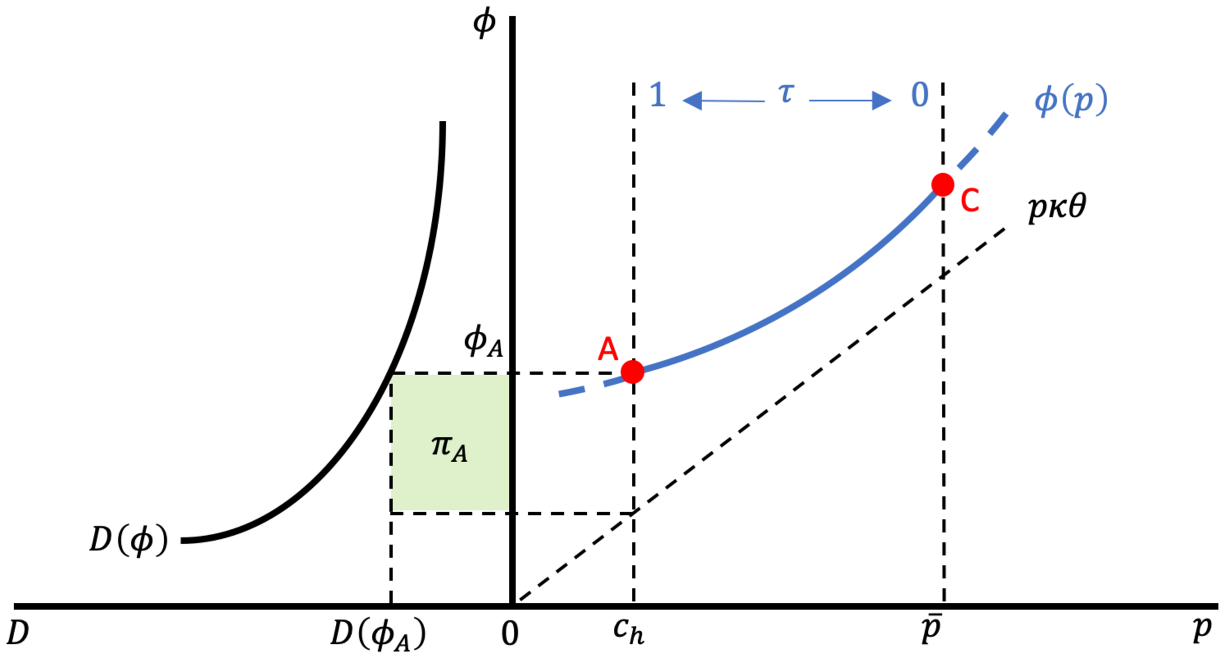
Stein, Jerome L, and George H Borts. 1972. "Behavior of the firm under regulatory constraint." *The American Economic Review*, 62(5): 964–970.

Takayama, Akira. 1969. "Behavior of the firm under regulatory constraint." *The American Economic Review*, 59(3): 255–260.

Tebaldi, Pietro. 2017. "Estimating equilibrium in health insurance exchanges: Price competition and subsidy design under the aca." *Becker Friedman Institute for Research in Economics Working Paper*, , (2017-05).

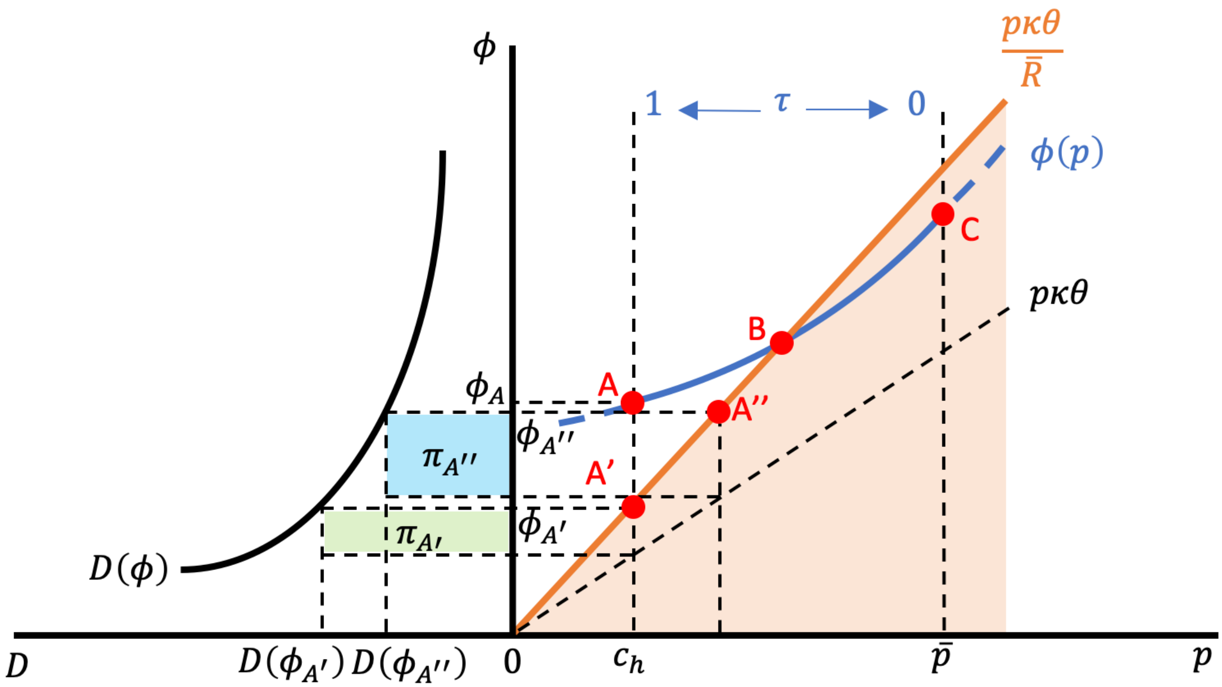
Trish, Erin E, and Bradley J Herring. 2015. "How do health insurer market concentration and bargaining power with hospitals affect health insurance premiums?" *Journal of Health Economics*, 42: 104–114.

Figure 1: Insurer's best response and the negotiated health service price



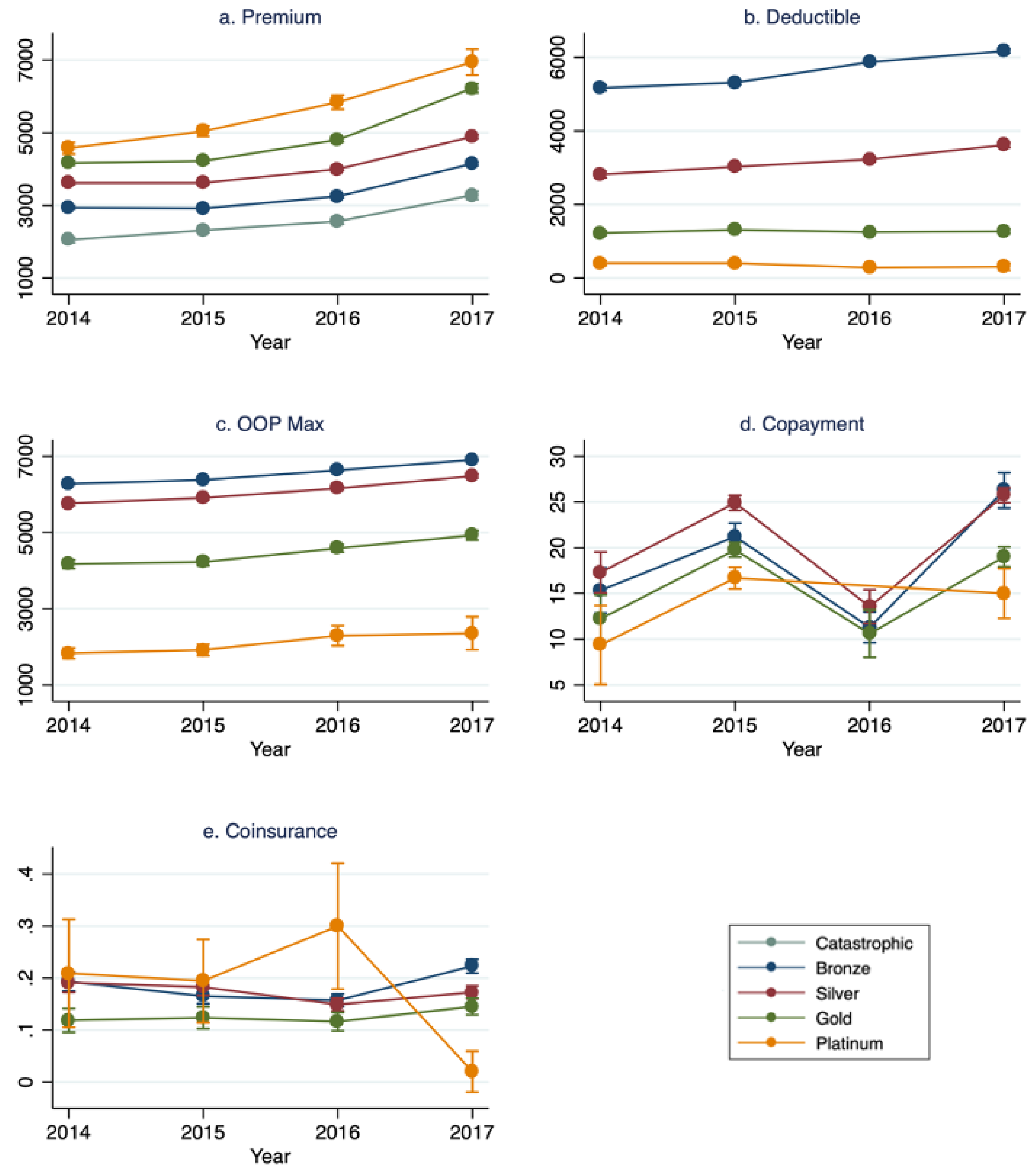
Notes: This figure represents the negotiated prices and insurer's premium choice when the insurer only provides one insurance plan without MLR regulation. The negotiated price varies along the x-axis in the right half plane. Insurer's bargaining power τ affects where the negotiated price locates between c_h and $\bar{p}$. The blue curve depicts insurer's best response of premium to price. Points A and C indicates what are the negotiated price and premium when insurer has all bargaining power or none bargaining power, respectively. In the left half plane, the black curve is the demand for insurance plan. The green shaded area show the profit (including fixed cost) if the insurer has the max bargaining power.

Figure 2: Impact of MLR regulation



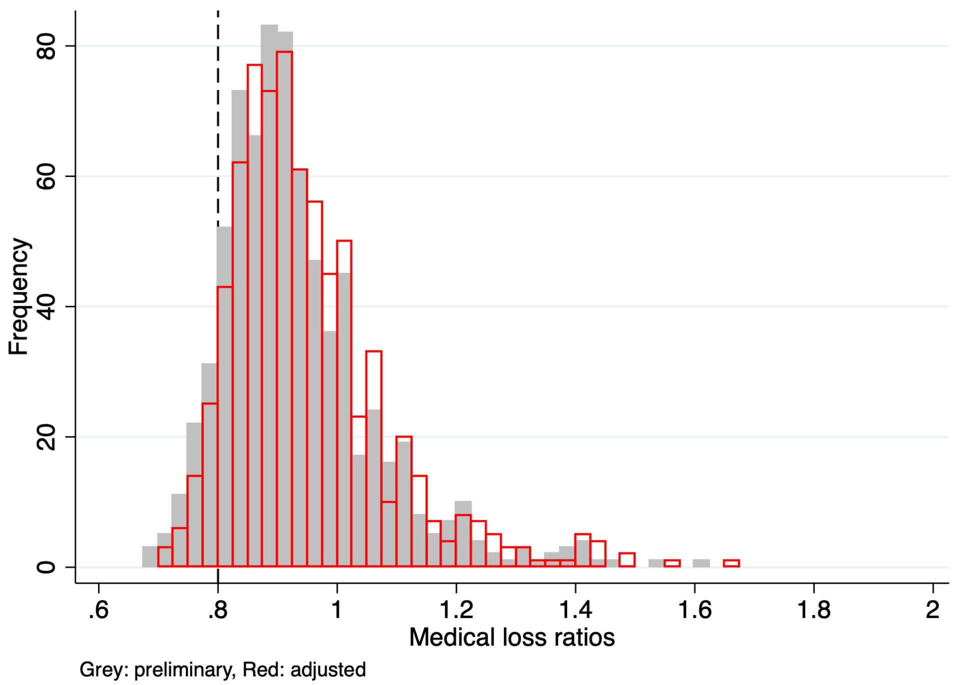
Notes: This figure presents how the MLR regulation affects the choice of negotiated price and premium. The orange line represents MLR regulation threshold and the orange shaded area below that curve indicates all the eligible choices of price and premiums under MLR regulation.

Figure 3: Variation in premium and plan characteristics, by metal category and year



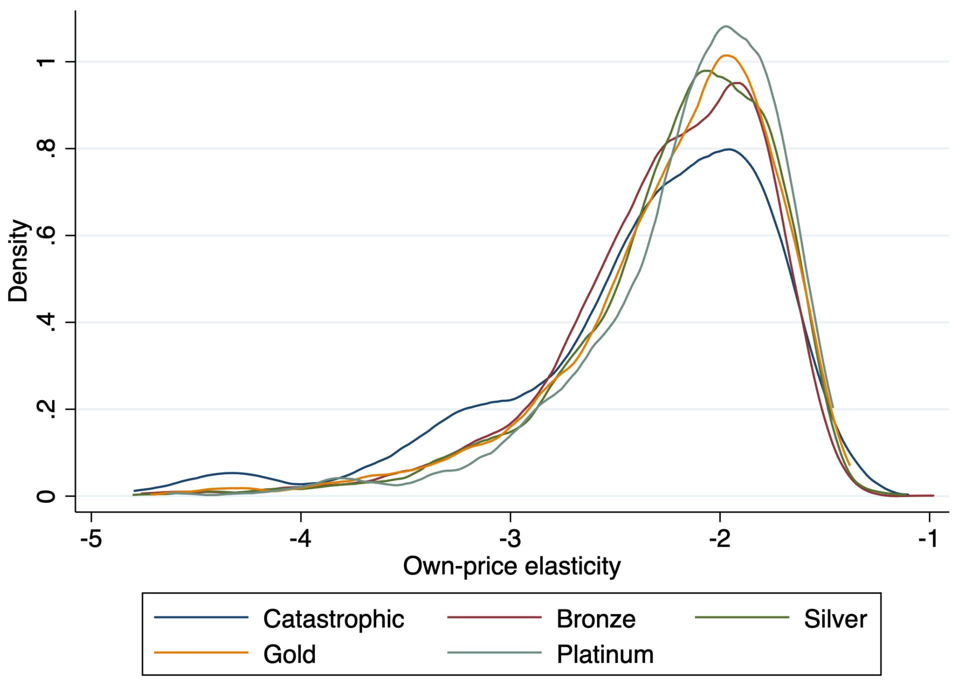
Notes: This figure shows the variation of premium, deductible, Out-Of-Pocket maximum, copayment, and coinsurance, by metal category and year. The bars show the 95% confidence interval of the means.

Figure 4: Distribution of MLRs



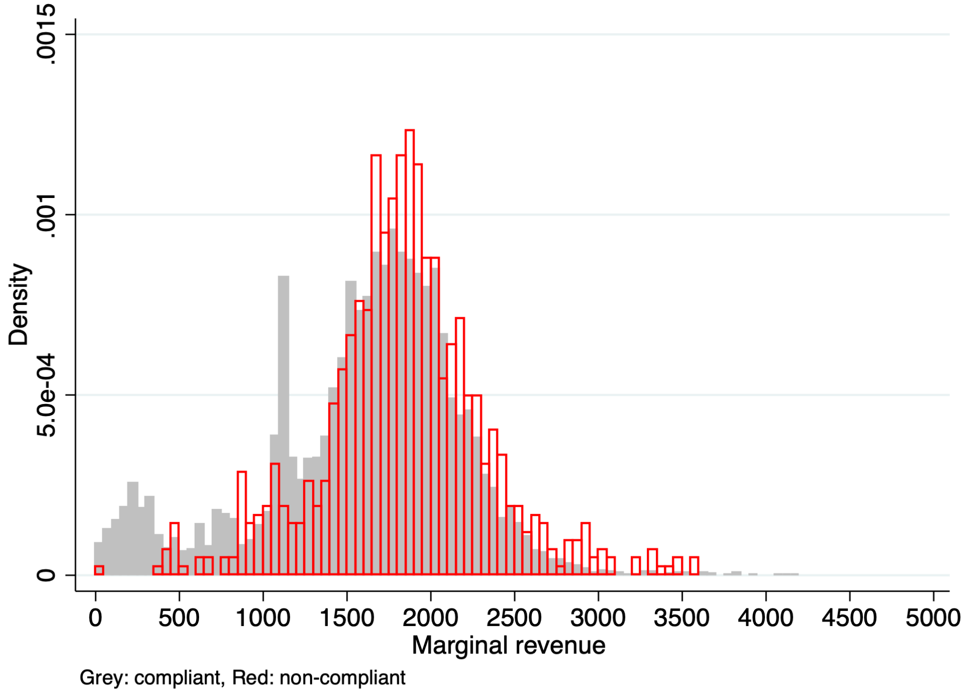
Notes: This figure presents the distribution of medical loss ratios. Data is from the MLR reports. The sample includes insurers in the Federally-Facilitated Marketplace from 2014-2017.

Figure 5: Distribution of own-price elasticity of demand



Notes: This figure presents the empirical density distribution of own-price elasticity of demand for insurance plan. The elasticities are calculated based on the demand estimation. Unit observation is plan.

Figure 6: Empirical density of estimated marginal revenue



Notes: This figure presents the density distribution of marginal revenues at plan-year level. The marginal revenues are calculated based on the demand estimation. The compliance status are at insurer-year level.

Table 1: Adjustment factors of medical loss ratio

Panel A. Base credibility factor

Life Years	Base Credibility Factor
<1,000	Not Credible
1,000	8.3%
2,500	5.2%
5,000	3.7%
10,000	2.6%
25,000	1.6%
50,000	1.2%
75,000	0.0%

Panel B. Deductible factor

Deductible	Deductible Factor
$0	1.000
$2,500	1.164
$5,000	1.402
$10,000	1.736

Notes: This table presents the two adjustment factors used in the ACA MLR regulation.

Table 2: Actuarial value of metal category

Category	Actuarial value
Catastrophic	NA
Bronze	60%
Silver	70%
Gold	80%
Platinum	90%

Notes: This table presents the actuarial value of each category in the Marketplace.

Table 3: Summary statistics of key variables

Panel A. Continuous variables

	Mean	Std. Dev.	Min	Max
N enrollees	2663	9953	11	274,497
Premium ($)	3939.08	1189.48	1008	13,087
Deductible ($)	3645.06	2153.96	0	7150
Copayment ($)	20.54	17.09	0	150
Coinsurance (percent)	16.6	16.65	0	80
OOP max ($)	5773.81	1443.86	500	7150
Plan market share (percent)	0.308	0.906	0.00019	28.445

Panel B. Category variables

	Freq.	Percent
Metal category		
Bronze	3751	30.29
Silver	4803	38.78
Glod	2596	20.96
Platinum	494	3.99
Catastrophic	740	5.98
Plan type		
EPO	986	7.96
HMO	6320	51.03
POS	1369	11.05
PPO	3709	29.95
Year		
2014	2296	18.54
2015	3511	28.35
2016	3698	29.86
2017	2879	23.25

Notes: This table shows the summary statistics of key variables. Full name of plan type: Exclusive provider organization (EPO), Health maintenance organization (HMO), Point-of-service (POS), Preferred provider organization (PPO)

Table 4: Results of demand estimation

	Nested-logit		Random Coefficients		
	(1)	(2)	(3)	(4)	(5)
log(premium)	-0.565	-0.713	-2.32	-2.19	-0.615
	(0.101)	(0.086)	(0.416)	(0.34)	(0.803)
log(deductible)	0.002	-0.008	0.01	-0.031	-0.028
	(0.005)	(0.004)	(0.014)	(0.013)	(0.013)
log(OOP max)	0.099		0.475		
	(0.027)		(0.073)		
Copayment		0.0003		0.0004	0.0004
		(0.0005)		(0.0017)	(0.0018)
Coinsurance		-0.225		-0.956	-0.99
		(0.058)		(0.193)	(0.216)
Having copayment		0.00071		0.199	0.196
		(0.017)		(0.056)	(0.067)
Having coinsurance		-0.052		-0.336	-0.359
		(0.017)		(0.054)	(0.059)
ρ	0.768	0.808			
	(0.013)	(0.011)			
Metal Category FE	X	X	X	X	X
Plan Type FE	X	X	X	X	X
State FE	X	X	X	X	X
Year FE	X	X	X	X	X
RC premium			X	X	X
RC premium (interact with demo)					X

Notes: This table presents the results of demand estimation. The first two columns are from nested-logit regressions with metal category being nest. The following three columns report estimates of discrete choice model with random coefficients. Columns (3) and (4) allow for random coefficients for the premium. Column (5) additionally includes individual income level and allows it to interact with the premium.

Table 5: Effect of MLR regulation on marginal cost

	(1)	(2)	(3)	(4)	(5)
λ	0.120	0.119	0.0832	0.0568	0.0554
	(0.00725)	(0.00742)	(0.00830)	(0.00821)	(0.00821)
log(deductible)	0.00909	0.00749	0.00472	0.00889	0.00972
	(0.00490)	(0.00485)	(0.00436)	(0.00432)	(0.00425)
Copayment	-0.000724	-0.00132	-0.00254	-0.00191	
	(0.000618)	(0.000621)	(0.000553)	(0.000549)	
Coinsurance rate	-0.0488	-0.0861	0.140	0.131	
	(0.0630)	(0.0622)	(0.0593)	(0.0597)	
Having copayment	-0.0166	-0.0109	0.0430	0.0215	
	(0.0177)	(0.0182)	(0.0171)	(0.0171)	
Having coinsurance	0.0765	0.0652	-0.0248	0.0116	
	(0.0196)	(0.0191)	(0.0168)	(0.0171)	
log(OOP max)					0.0431
					(0.0220)
Constant	7.257	7.341	7.471	7.441	7.051
	(0.0537)	(0.0532)	(0.0803)	(0.0731)	(0.201)
Year FE		Yes	Yes	Yes	Yes
State FE			Yes	Yes	Yes
Firm characteristics				Yes	Yes
N	10,859	10,859	10,859	10,859	10,859
R^2	0.022	0.035	0.278	0.302	0.300

Notes: This table show the estimates of the effect of MLR regulation on marginal cost, without structurally including the price negotiation. Column (1) shows the baseline estimates, which include metal level fixed effects and plan type fixed effects. From column (2) to column (4), I add year fixed effects, state fixed effects, and firm characteristics one-by-one. Column (5) has same control variables as column (4) except that column (5) use OOP max instead of copayment and coinsurance as plan characteristics. λ is the measure of the effect of MLR regulation.

Table 6: Effect of MLR regulation and bargaining

		(1)	(2)	(3)	(4)
Effect of MLR Regulation	λ	0.133	0.143	0.145	0.152
		(0.01)	(0.007)	(0.01)	(0.009)
Nash Bargaining Parameters	τ_0	0.498	0.428	0.31	0.403
		(0.028)	(0.591)	(0.03)	(0.041)
	τ_1		-0.1		-0.035
			(0.089)		(0.216)
Insurer Fixed Cost	C^F	1.285	1.227	0.255	1.226
		(0.041)	(1.366)	(0.065)	(0.035)
	C^F_{NFP}			0.047	0.063
				(0.02)	(0.015)
N observations		796	796	796	796

Notes: This table shows the estimates of the full model. In columns (2) and (4), I allow non-compliant insurers having a different bargaining parameter. τ_1 is the difference. In column (3) and (4), not-for-profit insurers could have different level of fixed costs. Standard errors are calculated by the parametric bootstrapping.

Table 7: Changes in price due to MLR regulation

	(1) Compliant	(2) Non-compliant	(3) Pooled
Price w/o MLR regulation			
Mean	2659.5	2952.56	2680.42
Std. Dev.	5152.09	6312.45	5243.65
Price w/ MLR regulation			
Mean	2659.31	3039.17	2686.42
Std. Dev.	5138.87	6828.58	5277.97
Change in price			
Mean	-0.20	86.62	6.00
Std. Dev.	39.53	561.54	156.31
N Observations	10,629	817	11,446

Notes: This table shows the changes in negotiated price due to the MLR regulation, assuming premium and demand unchanged.

Table 8: Statistics of the counterfactual scenarios

	Insurer 1	Insurer 2	Insurer 3
Scenario 1. No regulation, with bargaining			
Service price (in thousands)	2.73	2.72	2.71
Premium (in thousands)	2.61	2.61	2.6
Demand (in thousands)	17.61	17.54	17.39
Premium revenue (in millions)	45.95	45.72	45.23
Medical loss (in millions)	33.68	33.45	32.96
Scenario 2. With regulation, no bargaining			
Service price (in thousands)	2.73	2.72	2.71
Premium (in thousands)	2.39	2.38	2.37
Demand (in thousands)	18.06	18.05	18.03
Premium revenue (in millions)	43.19	43.03	42.72
Medical loss (in millions)	34.55	34.43	34.18
Scenario 3. With regulation, with bargaining			
Service price (in thousands)	4.29	4.27	4.23
Premium (in thousands)	3.76	3.74	3.7
Demand (in thousands)	16.33	16.4	16.56
Premium revenue (in millions)	61.33	61.3	61.3
Medical loss (in millions)	49.07	49.04	49.04

Notes: This table characterizes the market in three scenarios. In the first scenario, there is no regulation and insurers and providers negotiate the service price. In the second scenario, service prices are fixed at the pre-regulation level and the regulation is effective. The settings of the third scenario is the same as in the ACA health exchange marketplaces.

The Effect of Medical Loss Ratio Regulation on Insurer Pricing Appendix

Xiaoxi Zhao

November 2, 2020

A Conditions for $0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1$

In this section, I prove that $0 < \lambda < 1$ and $0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1$ are equivalent.

By definition, $0 < \bar{R} < 1$ and the Lagrangian multiplier $\lambda > 0$ when the constraint is binding. Therefore,

$$0 < \lambda < 1 \quad \Leftrightarrow \quad 0 < 1 - \lambda < 1 - \lambda\bar{R}.$$

It is not hard to prove that

$$0 < 1 - \lambda < 1 - \lambda\bar{R} \quad \Rightarrow \quad 0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1.$$

For the other direction,

$$0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1 \quad \Rightarrow \quad 0 < 1 - \lambda < 1 - \lambda\bar{R} \text{ or } 0 > 1 - \lambda > 1 - \lambda\bar{R}$$

Because $0 > 1 - \lambda > 1 - \lambda\bar{R} \Rightarrow \lambda < \lambda\bar{R}$, which contradict to $0 < \bar{R} < 1$ and $\lambda > 0$. Only the first case is possible, that is

$$0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1 \quad \Rightarrow \quad 0 < 1 - \lambda < 1 - \lambda\bar{R}.$$

Therefore, $0 < \lambda < 1$ is a sufficient and necessary condition for $0 < \frac{1-\lambda}{1-\lambda\bar{R}} < 1$.

B Premium choice

- Single-product case

At the second stage, each insurer chooses the premium ϕ to maximize its profit given the service price p and under the MLR regulation constraint. Based on the model built up in section **??**, each insurer solves the following constrained profit-maximization problem

$$\max_{\phi} \Pi^I = (\phi - p\kappa\theta)D(\phi) - C^F(p)$$

$$s.t. \quad p\kappa\theta \geq \bar{R}\phi$$

Using the method of Lagrangian multiplier,

$$\max_{\phi}(\phi - p\kappa\theta)D(\phi) - C^F(p) + \lambda(p\kappa\theta - \bar{R}\phi)$$

Then the F.O.C. w.r.t. ϕ is

$$(\phi - p\kappa\theta)D'(\phi) + D(\phi) - \lambda\bar{R} = 0$$

Denoting the $p\kappa\theta$ as marginal cost mc, the above equation turns to

$$mc = \phi + \frac{D}{D'} - \frac{\lambda\bar{R}}{D'} \tag{15}$$

In the above equation, the first two terms represent insurer's marginal revenue. The equation shows that insurer's marginal cost is higher than the marginal revenue when the constraint is binding. In an unconstrained scenario, marginal cost equals to marginal revenue.

Following widely used assumption about marginal cost–log of marginal cost is a linear function of product characteristics (will add an additional term for demand) w.

$$ln(mc) = w\gamma + D\gamma^D + \omega$$

Note that, unlike traditional commodities, marginal cost for health insurance plans may increase in demand due to adverse selection. This term is NOT YET included in the regression. Then I linearize $ln(mc)$ at $mr = \phi + \frac{D}{D'}$. That is,

$$ln(mc) = ln(mr) + \frac{mc - mr}{mr} + O((mc - mr)^2) \approx ln(mr) - \lambda\bar{R}\frac{1/D'}{mr} \tag{16}$$

Combine equation (15) and (16),

$$ln(mr_j) = \lambda_{f(j)}\mathbb{1}(Rebate_{f(j)})\frac{\bar{R}}{\phi_j D' + D} + w_j\gamma + D_j\gamma^D + \omega_j \tag{17}$$

where $\mathbb{1}(Rebate_{f(j)})$ is an indicator of whether the firm need to rebate due to MLR regulation. λ measures the shadow cost due to the regulation. Since the MLR is evaluated at firm-level, I assume that the impact of regulation is same for all the plans provided by the same firm.

- Multi-product case

When an insurer providers more than one products, she could strategically select premiums to maximize the overall profit. In such case, the Nash product function for a insurer providing J plans could be written as

$$f^{Nash} = \tau ln\left[\sum_j(\phi_j - p\kappa_j)D_j - C^F + \lambda(\sum_j p\kappa_j D_j - \bar{R}\sum_j \phi_j D_j)\right] + (1-\tau)ln\left[(p - p^{MCD})\sum_j Dj\right].$$

The F.O.C. w.r.t. p is

$$\frac{\partial f^{Nash}}{\partial p} = \frac{\tau}{\mathfrak{L}^I}(\frac{\partial \mathfrak{L}^I}{\partial p} + \sum_j \frac{\partial \mathfrak{L}^I}{\phi_j}\frac{\partial \phi}{\partial p}) + \frac{(1-\tau)}{(p-p^{MCD})\sum_j D_j}\left[\sum_j D_j + (p-p^{MCD})\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}\right] = 0.$$

Similar to the single-product case, I apply the envelope theorem and use the relation in the equation (4) to obtain the equation below

$$\frac{\partial f^{Nash}}{\partial p} = \frac{\tau}{\mathfrak{L}^I}(\frac{\partial \mathfrak{L}^I}{\partial p}) + \frac{(1-\tau)}{(p-p^{MCD})\sum_j D_j}\sum_j\left[D_j + (p-p^{MCD})\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}\right] = 0$$

$$-\frac{\tau(1-\lambda)\sum_j \kappa_j D_j}{(1-\lambda\bar{R})\sum_j \phi_j D_j - (1-\lambda)p\sum_j \kappa_j D_j - C^F} + \frac{(1-\tau)}{p-p^{MCD}} + (1-\tau)\frac{\sum_j\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}}{\sum_j D_j} = 0$$

$$\Rightarrow \quad -\frac{\tau(1-\lambda)\sum_j \kappa_j D_j}{\sum_j\left[(1-\lambda\bar{R})\phi_j - (1-\lambda)p\kappa_j\right]D_j - C^F} + \frac{(1-\tau)}{p-p^{MCD}} + (1-\tau)\frac{\sum_j\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}}{\sum_j D_j} = 0 \quad (18)$$

Rearrange the red term as

$$[(1-\lambda\bar{R})\boldsymbol{\phi} - (1-\lambda)p\boldsymbol{\kappa}]^T\mathbf{D}$$

Rearrange the equation (4),

$$(1-\lambda)p\boldsymbol{\kappa} - (1-\lambda\bar{R})\boldsymbol{\phi} = (1-\lambda\bar{R})\mathbf{J}^{-1}\mathbf{D}$$

By plugging the above equations to equation (18),

$$\Rightarrow \quad \frac{\tau(1-\lambda)\sum_j \kappa_j D_j}{(1-\lambda\bar{R})[J^{-1}D]^T D + C^F} + \frac{(1-\tau)}{p-p^{MCD}} + (1-\tau)\frac{\sum_j\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}}{\sum_j D_j} = 0$$

$$\Rightarrow \quad (p-p^{MCD})\left[\frac{\tau(1-\lambda)\sum_j \kappa_j D_j}{(1-\lambda\bar{R})[J^{-1}D]^T D + C^F} + (1-\tau)\frac{\sum_j\sum_k \frac{\partial D_j}{\partial \phi_k}\frac{\partial \phi_k}{\partial p}}{\sum_j D_j}\right] = -(1-\tau)$$

$$\Rightarrow \quad (p-p^{MCD})\left[\frac{\tau(1-\lambda)\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{\mathbf{1}^T\mathbf{J}\frac{\partial \phi}{\partial p}}{\mathbf{1}^T\mathbf{D}}\right] = -(1-\tau) \quad (19)$$

where $\mathbf{1}$ is a $J \times 1$ vector of ones.

B.1 Calculation of ϕ'

One important variable in the expression of optimal price, equation(6) and equation (8), is $\frac{\partial \phi}{\partial p}$. This

- Single product case

Starting from the equation (4), in the single-product case,

$$(1-\lambda)p\kappa = (1-\lambda\bar{R})(\phi + \frac{D}{D'})$$

Then, the total derivative w.r.t. p when $\phi = \phi(p)$ yields

$$(1-\lambda)p\kappa = (1-\lambda\bar{R})\phi' \left[2 - \frac{DD''}{(D')^2}\right]$$

Rearrange to get the equation(7)

$$\phi' = \frac{(1-\lambda)\kappa}{(1-\lambda\bar{R})A}$$

where $A = 2 - \frac{DD''}{(D')^2}$.

- Multi-product case

When each insurers provide more than one plans, ϕ' could be derived as following. For each plan $j \in \{1, ..., J\}$,

$$\frac{1-\lambda}{1-\lambda\bar{R}}\, p \sum_{k=1}^{J} \frac{\partial D_j}{\partial \phi_k}\kappa_k = \sum_{k=1}^{J} \frac{\partial D_j}{\partial \phi_k}\phi_k + D_j$$

As $\phi_k, \forall k \in \{1, ..., J\}$ is a function of p, by taking derivative w.r.t. p, I obtain,

$$\frac{1-\lambda}{1-\lambda\bar{R}} \sum_{k=1}^{J} \frac{\partial D_j}{\partial \phi_k}\kappa_k + \frac{1-\lambda}{1-\lambda\bar{R}}\, p \sum_{k=1}^{J} \kappa_k \sum_{l=1}^{J} \frac{\partial^2 D_j}{\partial \phi_k \partial \phi_l}\frac{d\phi_l}{dp} = \sum_{k=1}^{J} \phi_k \sum_{l=1}^{J} \frac{\partial^2 D_j}{\partial \phi_k \partial \phi_l}\frac{d\phi_l}{dp} + \sum_{k=1}^{J} \frac{\partial D_j}{\partial \phi_k}\frac{d\phi_k}{dp} + \sum_{k=1}^{J} \frac{\partial D_j}{\partial \phi_k}\frac{d\phi_k}{dp}$$

in matrix form

$$\Rightarrow \quad \frac{1-\lambda}{1-\lambda\bar{R}}\mathbf{J}_{j:}\boldsymbol{\kappa} + \frac{1-\lambda}{1-\lambda\bar{R}}\, p\boldsymbol{\kappa}^T\mathbf{H^j}\frac{\partial \boldsymbol{\phi}}{\partial p} = \boldsymbol{\phi}^T\mathbf{H}^j\frac{\partial \boldsymbol{\phi}}{\partial p} + 2\mathbf{J}_{j:}\frac{\partial \boldsymbol{\phi}}{\partial p}$$

where $\mathbf{J}_{j:}$ is the j^{th} row of the Jacobian matrix of demand function, $\mathbf{H^j}$ is the Hessian matrix of plan j's demand function.

$$\Rightarrow \quad \frac{1-\lambda}{1-\lambda\bar{R}}\mathbf{J}_{j:}\boldsymbol{\kappa} + (\frac{1-\lambda}{1-\lambda\bar{R}}\, p\boldsymbol{\kappa}^T - \boldsymbol{\phi}^T)\mathbf{H^j}\frac{\partial \boldsymbol{\phi}}{\partial p} = 2\mathbf{J}_{j:}\frac{\partial \boldsymbol{\phi}}{\partial p}$$

Plug in the matrix form of equation (**??**),

$$\frac{1-\lambda}{1-\lambda\bar{R}}p\boldsymbol{\kappa}^T - \boldsymbol{\phi}^T = [\mathbf{J}^{-1}\mathbf{D}]^T,$$

the equation becomes

$$\frac{1-\lambda}{1-\lambda\bar{R}}\mathbf{J}_{j:}\boldsymbol{\kappa} + [\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{H^j}\frac{\partial \boldsymbol{\phi}}{\partial p} = 2\mathbf{J}_{j:}\frac{\partial \boldsymbol{\phi}}{\partial p}$$

After a rearrangement, the equation used to calculate $\frac{\partial \phi_j}{\partial p}, \forall j$ is

$$[\mathbf{J}^{-1}\mathbf{D}]^T \mathbf{H}^{\mathbf{j}} \frac{\partial \boldsymbol{\phi}}{\partial p} = \mathbf{J}_{j:}(2\frac{\partial \boldsymbol{\phi}}{\partial p} - \frac{1-\lambda}{1-\lambda \bar{R}}\boldsymbol{\kappa}),\ \forall j \tag{20}$$

$$([\mathbf{J}^{-1}\mathbf{D}]^T \mathbf{H}^{\mathbf{j}} - 2\mathbf{J}_{j:})\frac{\partial \boldsymbol{\phi}}{\partial p} = -\frac{1-\lambda}{1-\lambda \bar{R}}\mathbf{J}_{j:}\boldsymbol{\kappa},\ \forall j$$

Finally, the equation (9)

$$\left(\begin{bmatrix} [\mathbf{J}^{-1}\mathbf{D}]^T H^1 \\ \vdots \\ [\mathbf{J}^{-1}\mathbf{D}]^T H^J \end{bmatrix} - 2\mathbf{J} \right) \frac{\partial \boldsymbol{\phi}}{\partial p} = -\frac{1-\lambda}{1-\lambda \bar{R}}\mathbf{J}\boldsymbol{\kappa}$$

B.2 Calculation of derivatives of demand

The next step is to get D'' from demand estimation. Based on the market share function specified by equation(2), the demand of insurance plan j is

$$D_j \equiv M_t s_{jt} = M_t \int \frac{e^{\delta_j + \mu_{ij}(X_j,\phi_j,D_i,\nu_i;\Pi,\Sigma)}}{1+\sum_k e^{\delta_k+\mu_{ik}(X_k,p_k,D_i,\nu_i;\Pi,\Sigma)}} \varphi(\nu_i) d\nu_i$$

where M_t is the market size of market t. Then, by the Leibniz integral rule,

$$\frac{\partial D_j}{\partial \phi_j} = M \int (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha) s_{ij}(1-s_{ij})\varphi(\nu_i) d\nu_i$$

$$\frac{\partial D_j}{\partial \phi_k} = -M \int (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha) s_{ij} s_{ik}\varphi(\nu_i) d\nu_i$$

and

$$\frac{\partial^2 D_j}{\partial \phi_j^2} = M \int (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 (1-2s_{ij}) s_{ij}(1-s_{ij})\varphi(\nu_i) d\nu_i$$

$$\frac{\partial^2 D_j}{\partial \phi_j \partial \phi_k} = -M \int (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 (1-2s_{ij}) s_{ij} s_{ik}\varphi(\nu_i) d\nu_i$$

$$\frac{\partial^2 D_j}{\partial \phi_k \partial \phi_l} = M \int 2(\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 s_{ij} s_{ik} s_{il}\varphi(\nu_i) d\nu_i$$

The above terms could be approximated numerically by simulation, as in the demand estimation. That is changing integral to summation–sum up all the simulated individuals in the market. Note that the size of Jacobian and Hessian matrices varies across markets.

$$\mathbf{J}_{jj} = \frac{\partial D_j}{\partial \phi_j} \approx M \frac{1}{N}\sum_{i=1}^{N} (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha) s_{ij}(1-s_{ij}) \tag{21}$$

$$\mathbf{J}_{jk} = \frac{\partial D_j}{\partial \phi_k} \approx -M \frac{1}{N} \sum_{i=1}^{N} (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha) s_{ij} s_{ik} \tag{22}$$

and

$$\mathbf{H^j}_{jj} = \frac{\partial^2 D_j}{\partial \phi_j^2} \approx M \frac{1}{N} \sum_{i=1}^{N} (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 (1 - 2s_{ij}) s_{ij} (1 - s_{ij}) \tag{23}$$

$$\mathbf{H^j}_{jk} = \frac{\partial^2 D_j}{\partial \phi_j \partial \phi_k} \approx -M \frac{1}{N} \sum_{i=1}^{N} (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 (1 - 2s_{ij}) s_{ij} s_{ik} \tag{24}$$

$$\mathbf{H^j}_{kl} = \frac{\partial^2 D_j}{\partial \phi_k \partial \phi_l} \approx M \frac{1}{N} \sum_{i=1}^{N} (\alpha + \pi^\alpha d_i^\alpha + \sigma^\alpha \nu_i^\alpha)^2 s_{ij} s_{ik} s_{il} \tag{25}$$

By plugging equation(21) to (25) into the equation (20), I obtain $\frac{\partial \boldsymbol{\phi}}{\partial p}$ as functions of λ–a parameter to estimate.

In the demand estimation, because I use log of premium instead of premium, I need to divide the derivatives by the premium when I implement this approximation.

B.3 Elimination of p

From previous section, we know that insurers choose premiums to maximize their profit under the MLR regulation, according the equation (4).

$$p\boldsymbol{\kappa} = \frac{1 - \lambda \bar{R}}{1 - \lambda} (\boldsymbol{\phi} + \mathbf{J}^{-1} \mathbf{D}) \tag{26}$$

Following the Kuhn-Tucker condition, $\lambda > 0$ for insurers triggered the rebate and $\lambda = 0$ otherwise.

Then from the above equation, we could obtain the expression of $\frac{\partial \boldsymbol{\phi}}{\partial p}$, i.e. the equation (9)

$$\left(\begin{bmatrix} [\mathbf{J}^{-1}\mathbf{D}]^T H^1 \\ \vdots \\ [\mathbf{J}^{-1}\mathbf{D}]^T H^J \end{bmatrix} - 2\mathbf{J} \right) \frac{\partial \boldsymbol{\phi}}{\partial p} = -\frac{1 - \lambda}{1 - \lambda \bar{R}} \mathbf{J} \boldsymbol{\kappa}$$

To simplify notation, denote

$$\mathbf{A} = \left(\begin{bmatrix} [\mathbf{J}^{-1}\mathbf{D}]^T H^1 \\ \vdots \\ [\mathbf{J}^{-1}\mathbf{D}]^T H^J \end{bmatrix} - 2\mathbf{J} \right)$$

Then the expression of $\frac{\partial \boldsymbol{\phi}}{\partial p}$ is more explicit,

$$\frac{\partial \boldsymbol{\phi}}{\partial p} = -\frac{1 - \lambda}{1 - \lambda \bar{R}} \mathbf{A}^{-1} \mathbf{J} \boldsymbol{\kappa} \tag{27}$$

From the bargaining model, the service price p is selected according to the equation(19), one per each market-insurer. After plugged the equation(26) into the equation(19),

$$(p - p^{MCD})\left[\frac{\tau(1-\lambda)\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{1-\lambda}{1-\lambda\bar{R}}\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}\boldsymbol{\kappa}}{\mathbf{1}^T\mathbf{D}}\right] = -(1-\tau)$$

Rearrange

$$\frac{\tau(1-\lambda)(p\boldsymbol{\kappa})^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{1-\lambda}{1-\lambda\bar{R}}\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}(p\boldsymbol{\kappa})}{\mathbf{1}^T\mathbf{D}}$$

$$-p^{MCD}\left[\frac{\tau(1-\lambda)\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{1-\lambda}{1-\lambda\bar{R}}\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}\boldsymbol{\kappa}}{\mathbf{1}^T\mathbf{D}}\right] = -(1-\tau)$$

Then plug the equation(26) into the equation

$$\frac{\tau(1-\lambda\bar{R})(\boldsymbol{\phi} + \mathbf{J}^{-1}\mathbf{D})^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}(\boldsymbol{\phi} + \mathbf{J}^{-1}\mathbf{D})}{\mathbf{1}^T\mathbf{D}}$$

$$-p^{MCD}\left[\frac{\tau(1-\lambda)\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} + (1-\tau)\frac{1-\lambda}{1-\lambda\bar{R}}\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}\boldsymbol{\kappa}}{\mathbf{1}^T\mathbf{D}}\right] = -(1-\tau)$$

Finally,

$$\frac{\tau(1-\lambda\bar{R})(\boldsymbol{\phi} + \mathbf{J}^{-1}\mathbf{D})^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} - \frac{\tau(1-\lambda)p^{MCD}\boldsymbol{\kappa}^T\mathbf{D}}{(1-\lambda\bar{R})[\mathbf{J}^{-1}\mathbf{D}]^T\mathbf{D} + C^F} - \frac{(1-\tau)(1-\lambda)}{1-\lambda\bar{R}}p^{MCD}\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}\boldsymbol{\kappa}}{\mathbf{1}^T\mathbf{D}}$$

$$= (1-\tau)(\frac{\mathbf{1}^T\mathbf{J}\mathbf{A}^{-1}\mathbf{J}(\boldsymbol{\phi} + \mathbf{J}^{-1}\mathbf{D})}{\mathbf{1}^T\mathbf{D}} - 1)$$

C Conditions for increasing best response function $\phi(p)$

In this section, I am going to discuss the conditions for $\phi(p)$ being increasing in p.

D Optimal price in different scenarios

D.1 Price-taker insurers

In this scenario, health care providers set the price and insurers are simply price-takers. Therefore, the price p is set by

$$\max_p \Pi^H = (p - c_h)\theta D$$

The F.O.C. w.r.t. p is

$$\frac{\partial \Pi_H}{\partial p} = \theta D + (p - c_h)\theta D'\phi' = 0$$

Then the optimal price is

$$p^* = c_h - \frac{D}{D'\phi'} \tag{28}$$

D.2 Bargaining without regulation

This time, health care providers and insurers bargaining over price in a context without any constraint. The optimization problem in this scenario is (log of the Nash product)

$$\max_p f^{Nash} = \tau ln[(\phi - p\kappa\theta)D - C^F] + (1-\tau)ln[(p - c_h)\theta D].$$

The F.O.C. w.r.t. p is

$$\frac{\partial f^{Nash}}{\partial p} = \tau\frac{(\phi' - \kappa\theta)D + (\phi - p\kappa\theta)D'\phi'}{(\phi - p\kappa\theta)D - C^F} + (1-\tau)\frac{\theta D + (p - c_h)\theta D'\phi'}{(p - c_h)\theta D}$$

By envelope theorem, $D + (\phi - p\kappa\theta)D' = 0$,

$$\frac{\partial F}{\partial p} = \tau\frac{-\kappa\theta D}{(\phi - p\kappa\theta)D - C^F} + (1-\tau)\frac{\theta D + (p - c_h)\theta D'\phi'}{(p - c_h)\theta D} = 0$$

$$\Rightarrow \tau\frac{\kappa\theta D}{\frac{D^2}{D'} + C^F} + \frac{1-\tau}{p - c_h} + \frac{(1-\tau)D'\phi'}{D} = 0$$

$$\Rightarrow \frac{\tau}{1-\tau}\frac{\kappa\theta D}{\frac{D^2}{D'} + C^F} + \frac{1}{p - c_h} + \frac{D'\phi'}{D} = 0$$

$$\Rightarrow (p - c_h)\left[\frac{\tau}{1-\tau}\kappa\theta D^2 + D'\phi'(\frac{D^2}{D'} + C^F)\right] = -D(\frac{D^2}{D'} + C^F)$$

Therefore, the optimal price in this scenario is

$$\begin{aligned} p^{**} &= c_h - \frac{D(\frac{D}{D'} + \frac{C^F}{D})}{\frac{\tau}{1-\tau}\kappa\theta D + \phi'(D + \frac{D'C^F}{D})} \\ &= c_h - \frac{D}{D'\phi' + \frac{\frac{\tau}{1-\tau}\kappa\theta D}{\frac{D}{D'} + \frac{C^F}{D}}} \end{aligned} \tag{29}$$

Compare to p^*, the red term is the extra term and its impact on p^{**} depends on the bargaining power. When $\tau = 0$–insurers have no power at all, it degenerates to price-taker scenario. The red term could be rearranged to

$$\frac{\frac{\tau}{1-\tau}\kappa\theta D}{\frac{D}{D'} + \frac{C^F}{D}} = \frac{\tau}{1-\tau}\frac{\kappa\theta D}{\phi(-1/\eta_\phi + C^F/(\phi D))}$$

where $\eta_\phi = -\frac{D'\phi}{D}$. Then the sign of this red term depends only on the tradeoff between premium elasticity and the fraction of fixed cost over premium revenue.

Table A1: Optimal price

	$\nexists$ regulation	$\exists$ regulation
Price-maker ($\tau = 1$)	$p_1 = c_h$	$p_2 = c_h$
Price-taker ($\tau = 0$)	$p_3 = c_h - \frac{D}{D'\phi'}$	$p_4 = c_h - \frac{D}{D'\phi'}$
Bargain	$p_5 = c_h - \frac{D}{D'\phi' + \frac{\frac{\tau}{1-\tau}\kappa\theta D}{\frac{D}{D'} + \frac{C^F}{D}}}$	$p_6 = c_h - \frac{D}{D'\phi' + \frac{\frac{\tau}{1-\tau}(1-\lambda)\kappa\theta D}{(1-\lambda\bar{R})\frac{D}{D'} + \frac{C^F}{D}}}$
Function of ϕ	$\phi = p\kappa\theta - \frac{D}{D'}$	$\phi = \frac{1-\lambda}{1-\lambda\bar{R}} p\kappa\theta - \frac{D}{D'}$

D.3 Bargaining with MLR regulation

This is the scenario in the main text, to make things more comparable, I rearrange the equation (6) and get

$$
\begin{aligned}
p^{***} &= c_h - \frac{(1-\lambda\bar{R})\frac{D^2}{D'} + C^F}{\frac{\tau}{1-\tau}(1-\lambda)\kappa\theta D + (1-\lambda\bar{R})D\phi' + \frac{D'\phi'}{D}C^F} \\
&= c_h - \frac{D\left[(1-\lambda\bar{R})\frac{D}{D'} + \frac{C^F}{D}\right]}{\frac{\tau}{1-\tau}(1-\lambda)\kappa\theta D + D'\phi'\left[(1-\lambda\bar{R})\frac{D}{D'} + \frac{C^F}{D}\right]} \\
&= c_h - \frac{D}{D'\phi' + \frac{\frac{\tau}{1-\tau}(1-\lambda)\kappa\theta D}{(1-\lambda\bar{R})\frac{D}{D'} + \frac{C^F}{D}}} \qquad (30)
\end{aligned}
$$

Again the blue term will equal to zero if insurers do not have any bargaining power. Moreover, when the constraint is not binding, i.e. $\lambda = 0$, then the red term will degenerate to the one in the previous subsection.

D.4 Summary

Table A1 summarizes the optimal prices in all six possible scenarios. From equation 7,

$$
\phi' = \frac{(1-\lambda)\kappa\theta}{(1-\lambda\bar{R})\frac{(D')^2 - DD''}{(D')^2}}
$$

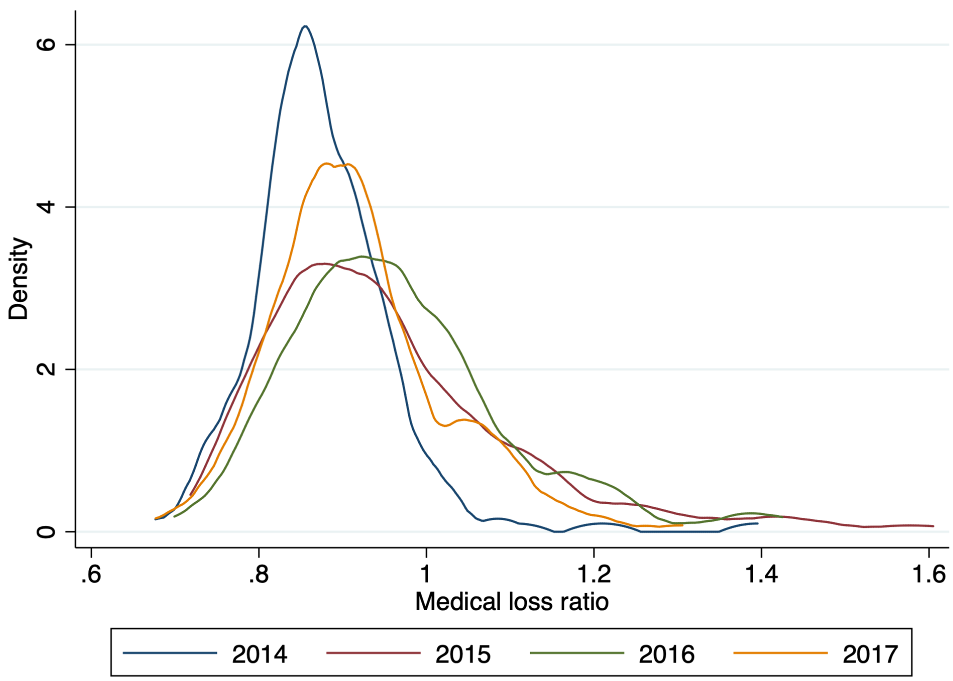
Additional Tables and Figures

Table A2: Effect of MLR regulation on marginal cost

	(1)	(2)	(3)	(4)	(5)
λ	0.132***	0.125***	0.0413***	0.0298***	0.0288**
	(0.00878)	(0.00900)	(0.00895)	(0.00898)	(0.00886)
ln(deductible)	0.00851	0.00715	0.00454	0.00884*	0.00968*
	(0.00473)	(0.00477)	(0.00449)	(0.00441)	(0.00442)
Copayment	-0.000594	-0.00117	-0.00237***	-0.00179**	
	(0.000601)	(0.000603)	(0.000552)	(0.000549)	
Coinsurance rate	-0.0482	-0.0908	0.136*	0.128*	
	(0.0644)	(0.0624)	(0.0627)	(0.0616)	
Having copayment	-0.0174	-0.0151	0.0389*	0.0184	
	(0.0200)	(0.0198)	(0.0191)	(0.0190)	
Having coinsurance	0.0770***	0.0676***	-0.0223	0.0142	
	(0.0197)	(0.0194)	(0.0176)	(0.0178)	
ln(OOP max)					0.0453*
					(0.0219)
Constant	7.257***	7.344***	7.479***	7.446***	7.036***
	(0.0516)	(0.0538)	(0.0845)	(0.0755)	(0.206)
Year FE		Yes	Yes	Yes	Yes
State FE			Yes	Yes	Yes
Firm characteristics				Yes	Yes
N	10859	10859	10859	10859	10859
R^2	0.022	0.035	0.278	0.302	0.300

Notes: The compliance status is identified by the credibility-adjusted MLR.

Figure A1: Distribution of Medical Loss Ratio in the Marketplace, by year



Notes: This figure shows the Kernel density of MLR of insurers in the Marketplace from 2014-2017. The unit of observation is insurer-year.