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Keywords: health insurance, health reform, ACA, age-rating, age bands

JEL Codes: I11, I13, I18, H51

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Regulated age-based pricing in subsidized health insurance: Evidence from the Affordable Care Act*

Joe Orsini and Pietro Tebaldi+

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Abstract. We study age-rating restrictions in the health insurance marketplaces introduced by the Affordable Care Act. Because most buyers are subsidized, although age-rating restrictions affect pre-subsidy premiums, participation is primarily driven by subsidy generosity rather than pricing decisions. Combining pre and post-reform data on prices and enrollment, we find that age-rating restrictions altered pre-subsidy premiums: +$230/year for under-50 buyers and -$900/year for over-50 buyers. Accounting for the ACA subsidy design, this regulation decreased federal spending by more than 10%, and reduced participation by 2% (-4% among under-50, +2% among over-50). These effects differ across regions, varying with the age-composition of the uninsured.

Keywords: health insurance, ACA, health reform, age-rating, age bands

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1 Introduction

Market design and regulation of private health insurance markets are one area of economic policy that is periodically object of public debate and legislative reforms. Theoretical and empirical results in economics point at welfare losses from adverse selection (Akerlof, 1970; Stiglitz, 1987; Einav, Finkelstein, and Cullen, 2010), premium reclassification risk (Handel, Hendel, and Whinston, 2015), and consumption externalities (Pauly, 1970; Summers, 1989; Mahoney, 2015), as justifications for an active role of the government in these markets (c.f. managed-competition, Einav and Levin, 2015). The Patient Protection and Affordable Care Act of 2010 (ACA) represented the largest US-wide policy intervention in the non-elderly health insurance market in many decades. One central provision was the introduction of state-based health insurance exchanges (or marketplaces), where insurers compete in a highly regulated environment to provide health insurance coverage to consumers. Similar exchanges also exist in the context of Medicare Advantage, Medicare Supplement, and Medicare Part D markets, and outside the United States in Switzerland, the Netherlands, Israel, and Chile.

Two regulations that often interact in these markets are limits to price discrimination across buyers with different observable risk factors (e.g. age, existing medical conditions), and the provision of means-tested government-funded premium subsidies.

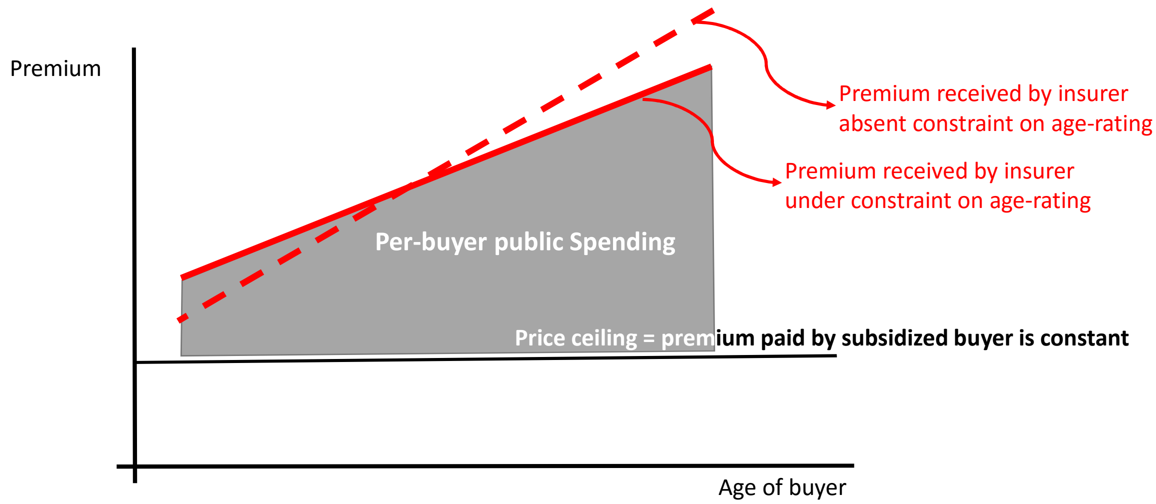
Under the ACA, insurers are subject to binding constraints on the way in which premiums can be adjusted with a buyer's age, and are banned from adjusting prices based on pre-existing medical conditions (including the extreme case of coverage denial). At the same time, the federal government provides subsidies (advanced tax credits) to all buyers whose income is less than four times the Federal Poverty Level. Over 10 million people per-year purchased coverage in these markets, and almost 90% of them are beneficiaries of federal subsidies, for a total government spending of approximately $40 billion per-year.[1] Understanding how age-rating regulations and premium subsidies interact is essential for a proper evaluation of the ACA, and critical for the design of alternative programs in the future.

In this article, we combine a simple theoretical framework (adapted from Ericson and Starc, 2015) with pre and post-ACA data (from 2008-2012 and 2014-2017, respectively) on market-level prices and 2015 ACA enrollment to study the effect of age-rating restrictions on prices, government spending, and participation in the exchanges. We show and quantify the extent to which, as theory predicts, age-rating restrictions lead insurers to charge higher prices for young buyers, while lowering prices for older buyers. Considering these price changes in combination with the federal subsidy program, we find that this policy had a significant impact on government spending and a more moderate impact on coverage. This differs from the effect that age-rating constraints would have without premium subsidies (this case is the main focus of Ericson and Starc, 2015).

[1] See e.g. https://aspe.hhs.gov/compilation-state-data-affordable-care-act .

The key intuition is illustrated in Figure 1, representing a stylized description of a marketplace environment. Age-rating restrictions change pre-subsidy premiums and insurers' revenues for any given selection of buyers in the market. However, most buyers are subsidized, and their premiums are capped at a given income-specific level.[2] Therefore, changes to pre-subsidy premiums induced by age-rating restrictions primarily impact public spending, increasing the subsidies to younger buyers and reducing the subsidies to older buyers. One main objective of this article is to measure these effects accounting for differences in participation across different age groups as directly observed in the ACA enrollment data.

Figure 1: **Age-rating restrictions under the ACA subsidy scheme**



Note:The figure illustrates the main insight on the effect of age-rating regulations in the presence of a mean tested subsidy program. The premium faced by buyers is the maximum afforable amount deremined by the government. The age-rating restrictions affect pre-subsidy premiums, increasing the ones of young buyers, decreasing the ones of old buyers. Since demand responds to the (fixed) subsidized premium, age-rating restrictions increase the public spending on younger buyers and decrease public spending on older buyers.

The contribution of the article is twofold. First, we use a novel combination of pre and post-ACA data to provide strong empirical evidence on the effect of age-rating restrictions on (pre-subsidy) premiums for young and old buyers in the context of ACA exchanges. This is related to, and consistent with, the findings of Ericson and Starc (2015) using pre-ACA Massachusetts data (although our institutional settings and research strategies are substantially different). It also adds to the literature on the effect of community-rating rules on premiums and market participation (see e.g. Clemens, 2015).

Second, we emphasize that, because age-rating restrictions are combined with a subsidy program in which the level of discounted premiums only varies with income, the primary effect of this policy

[2]Selection into the ACA marketplaces is largely determined by the generosity of subsidies, mandate penalties, and cost-sharing subsidies (Hackmann, Kolstad, and Kowalski, 2015; Tebaldi, 2017; DeLeire, Chappel, Finegold, and Gee, 2016) rather than insurers' rating decisions. This is discussed in details in Section 2.

is to reduce public spending by a significant amount (-10.76% annually). Using elasticities from the literature, we find that the effect on participation is mitigated (-4.2% for the younger buyers, +2.4% for the older ones), and much lower than what one would predict when studying age-rating alone without considering the interaction with premium subsidies.

Our analysis proceeds in four main steps. We start by arguing that, given the details of the regulations implemented under the ACA (Section 2), one would expect insurers to charge higher pre-subsidy premiums to all buyers in markets in which potential buyers are relatively older. The key reason is that under the ACA insurers are not free to adjust premium to a buyer's age, but rather only submit a unique base price equal to the premium for a 21-years-old. This price is then transformed in premiums for any given age following a standard age rating curve (SARC). As long as the unconstrained premiums would be steeper than the SARC — as we provide evidence for — insurers will raise prices when they expect to face an older population.

However, subsidized buyers are largely not affected by these price changes: the subsidized price is a function of a buyer's income, and subsidies increase with base prices to guarantee that post-subsidy premiums do not exceed a given "maximum affordable amount". This type of subsidy scheme (also called "price-linked", c.f. Jaffe and Shepard, 2016) loosens the link between the insurer-set premiums and the premiums that directly affect participation decisions of subsidized buyers.

After introducing our data, in Section 3 we show that the expected positive relationship between premium and age-composition of the uninsured is evident under the ACA, while not present before the reform. Under different specifications, we find that a 10% increase in the share of uninsured citizens who are older than 50 in a market corresponds to a $9/month increase in premium for a 21-year-old (approximately 5% of the mean); this is equivalent to $13/month for a 45-year-old, and $27/month for a 64-year-old. Importantly, the pre-ACA data does not show any significant relationship between the age of potential buyers and premiums. This is consistent with the simple theoretical insight by which, if age-rating is unconstrained, insurers can consider each age group within a geographic area as a separate market for pricing purposes. To corroborate further that age-rating restrictions are a binding constraint, we also show that the (unconstrained) age-adjustments adopted by insurers in the individual market before the ACA were steeper than the SARC. The growth of within-age average annual spending in the Medical Expenditure Panel Survey is also steeper.

In Section 4, we combine this evidence with a simple model of price-setting in a marketplace to provide estimates of the prices that would emerge if the ACA age-rating restrictions were removed. We consider a representative profit-maximizing insurer, or equivalently the competition between symmetric(ally differentiated) insurers; this is similar to Mahoney and Weyl (2014); Ericson and Starc (2015).[3] The insurer sets base prices to maximize total expected profits, which

[3] This approximation is an important limitation of our study. However, the ACA exchanges are highly concentrated markets, and most of them see less than two insurers participating in each geographic area. One could then argue

are a weighted average of profits across buyers of different age. Hence the first-order conditions for optimal pricing are a linear combination of marginal profit functions (whose parameters are to be estimated) across buyers of different age-groups, with weights equal to the age-composition of the uninsured in the market. Through this model we invert the reduced form relationship between regional age-composition and prices to estimate the parameters of marginal profit functions. With these estimates we solve the pricing first-order conditions age-by-age to calculate the unconstrained prices that would result if age-rating restrictions were lifted.

Our results indicate that, without the age-rating restrictions (and holding everything else constant), the unconstrained prices would be lower for younger buyers by, on average, \$229/year, while higher for older buyers by \$900/year. These differences can be explained by differences in expected cost *and* markups. This is one of the key insights of Ericson and Starc (2015): when age-rating is unrestricted, imperfectly competitive insurers not only charge higher premiums to older buyers because of higher cost, but also charge this group higher markups because of the lower demand elasticity to premium (see also Geruso, 2016; Tebaldi, 2017). Across markets, we also find that comparatively older markets see a larger price increase for young buyers while a smaller price decrease for the older group, and vice versa. This is consistent with the theoretical predictions of the simple model we adopt here, and it also suggests that — as is discussed for current policy reforms — there might be important gains from tailoring age-rating rules across geographic areas with different age-composition of consumers.

What are the effects of these price changes on market outcomes? In Section 5, we focus on this question considering the age-rating restrictions jointly with the subsidy program implemented under the ACA. For this we combine our estimates of unconstrained premiums with enrollment data from the 2015 ACA marketplace and estimates of age-income-specific extensive-margin elasticity from Ericson and Starc (2015), Tebaldi (2017) and Finkelstein, Hendren, and Shepard (2017). We find that the imposition of age-rating restrictions led to substantial savings for the government (-10.76% subsidy outlays per-year), discouraged the participation of young buyers by 4.2%, and increased the participation of older buyers by 2.4%.

These aggregate figures come from the combination of the effect of the age-rating rules on different subgroups. Subsidized buyers who are relatively young (under 50 in our main specification) receive, on aggregate, a premium support that is 134% larger (+\$670 million per-year in our sample). On the other hand, subsidy outlays to guarantee the affordability of premiums for older buyers are reduced by 15.25% (-\$2.46 billion per-year in our sample). In terms of coverage, buyers who are comparatively older and subsidized are not affected by age-rating rules, while the participation of younger subsidized buyers is estimated to be 3.7-3.9% lower. The effect on (much smaller) higher income groups is consistent with Ericson and Starc (2015): younger buyers participate less

that, given the focus of this article, the departure from the observed market structure is unlikely to be a first order concern.

(5.13-6.4% lower) and older buyers participate more (8-20.6% higher)

Related literature. Our work adds to the growing literature studying alternative policy designs in the context of government-sponsored health insurance. Hackmann, Kolstad, and Kowalski (2015); Tebaldi (2017); Jaffe and Shepard (2016) and Aizawa (2016) study, respectively, the welfare effect of a health insurance mandate, the impact of age-based subsidies, the impact of subsidies that are directly computed from market prices, and the interaction between ACA exchanges and labor markets. Adding to this, this article emphasizes the effect of age-rating rules on public spending and participation when these rules co-exist with a subsidy program. The key difference is that age-based subsidies (primarily) affect buyers' participation by determining the demand prices, while the age-rating restrictions affect insurers' revenue (and thus profit) functions by imposing constraints on the supply prices.

The paper that most closely relates to ours is the aforementioned work by Ericson and Starc (2015). They provide an equilibrium oligopoly model of a health insurance exchange, accounting for imperfect competition as well as heterogeneity in consumers' preferences and health risk. They estimate the model using individual data from the Massachusetts Health Connector, a state-level exchange that many see as a blueprint for the ACA exchanges. In their analysis, they also find that the age-rating restrictions are likely to alter prices across age groups, and — very importantly for our work — they provide the key insight that markups are affected by linking prices across different groups. What we add to their work from a conceptual standpoint is the analysis of how these price changes impact public spending when considered jointly with a price-linked subsidy scheme à la ACA. Empirically, we depart from the widely studied Massachusetts' context, and measure the impact of age-rating regulations on prices directly by combining pre and post-ACA data from 35 states during a long period of time (2008-2017).

Many other papers consider the interaction between regulations and imperfect competition in government-sponsored insurance, mostly focusing on different segments of the US health insurance markets. The cases of Medicare Advantage, Medicare Part D, Medigap, and Medicaid are the main focus of, among many others, Duggan and Hayford (2013); Curto et al. (2014); Duggan et al. (2014); Starc (2014); Clemens (2015); Decarolis et al. (2015). In a broad review of this literature Einav and Levin (2015) explicitly discuss the importance of properly accounting for the interaction between different rating rules and subsidy schemes in affecting market outcomes. We add to this literature by bringing in recent data from the US individual health insurance market before and after the ACA, and highlighting the channel through which rating rules can affect public spending when paired with a subsidy program.

2 ACA exchanges

2.1 Institutional context and federal regulations

In 2014, the ACA instituted health insurance marketplaces (or exchanges) in each of the fifty states. In these marketplaces, private insurers offer a variety of coverage options, and the federal government provides subsidies for low-income participants. Indeed, in the first two years of their operation, approximately 90 percent of buyers on these marketplaces received premium subsidies,[4] associated with annual government disbursements of approximately $40 billion (see Anthony et al., 2015).[5]

ACA marketplaces operate in each state separately, but they all follow similar institutions and regulations. Each state is divided into geographic rating regions — groups of counties or zipcodes — defining the level at which decisions by buyers and insurers take place. Every year, insurers must announce their interest in offering plans in each region in the subsequent calendar year. Entrants undergo a certification process, after which they offer different coverage options, classified into five coverage levels: Minimum Coverage, Bronze, Silver, Gold, and Platinum. Minimum Coverage indicates plans with very high deductible, which cannot be purchased by subsidized buyers, nor by buyers older than 35. The four metal tiers represent increasing coverage options, and are ordered by an estimate of the actuarial value of their coverage: 60% for Bronze, 70% for Silver, 80% for Gold, and 90% or more for Platinum plans. Products and prices are set (and made public) at the end of every summer, and individuals can then compare and purchase plans in their region during the "open enrollment" period in the late months of each year. Coverage starts the subsequent calendar year.

Age-rating regulations. One main provision of the ACA, and the main focus of this article, is that insurers are not allowed to arbitrarily vary prices depending on buyers' observable characteristics. One characteristic that affects annual premiums is the buyer's age, but this adjustment is done in a pre-specified way.[6] Each plan j offered in region r is associated with a single base price $b_{jr} > 0$, which is then translated to age-specific premiums using a standard age-rating curve (SARC). This specifies, for any given age τ, an adjustment factor A^τ, equal for all products. The

[4] See e.g. https://aspe.hhs.gov/sites/default/files/pdf/83656/ib_2015mar_enrollment.pdf.

[5] The ACA also contained a mandate for all households to purchase health insurance when not directly covered by other sources. However, in the early years of the reform, the enforcement of this mandate has been weak. In 2015, the tax penalty for a single individual was the maximum of 2 percent of income above the filing threshold and $325. For a single individual with $50,000 income (almost 75^{th} percentile of the income distribution), the tax penalty would be $794 per-year. This amount is much smaller than the $3,500 annual premium that, on average, a 35-years-old would have to pay for a plan in the ACA exchanges.

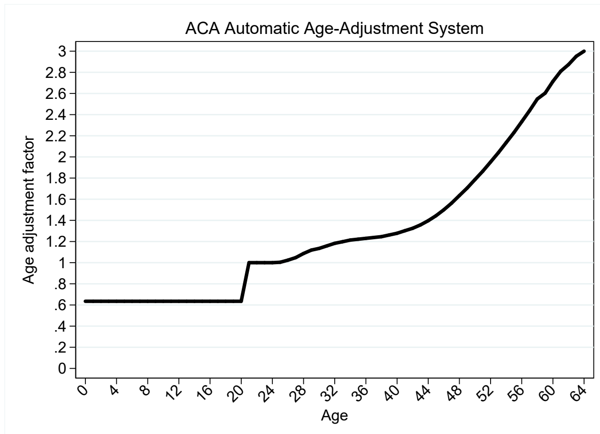
[6] In some states, a second characteristics that insurers can use is tobacco smoking. This adjustment is bounded to a factor of 5:1 from the baseline premium. As of today, analyses of this aspect of the ACA rating rules have been prevented by data limitations.

premium the insurer receives if a buyer of age τ chooses j is then:

$$P_{jr}^{\tau} = A^{\tau} \cdot b_{jr}. \tag{1}$$

Age adjustments vary between 0.635 (up to 20-year-olds), equal 1 for 21-years-old buyers, and increase smoothly up to 3 for 64-year-old buyers. Details for all ages are shown in Figure 2.

Figure 2: **Standardized age-rating curve in ACA exchanges**



Note: For every age τ, the line in the figure shows the corresponding factor A^{τ}, which is used to compute the price of a high-income, unsubsidized buyer (equation (1)). If the base price of the product is b_{jr}, $P_{jr}^{\tau} = A^{\tau} \cdot b_{jr}$. This is also equal to the total amount that the insurer receives when a subsidized buyer purchases the plan.

Premium subsidies. Although P_{jr}^{τ} is the premium received by the seller when a τ-year-old buyer enrolls in plan j in region r, subsidies are provided for all households with annual income below four times the federal poverty level (FPL; approximately $47,000 for a single individual). The law establishes a cap on the premium amount the household should pay for the second-cheapest Silver plan (benchmark plan) in each region. This cap is a function of the income of the household (see Table 1), ranging — for single buyers — from $684 per-year for the lowest income group to $4,368 for the highest income group. Importantly, given income this cap amount does not vary with the age of the buyers.[7]

Table 1: **Price caps for subsidy calculation in ACA marketplaces**

Income as % of FPL	up to 150%	150-200%	200-250%	250-400%
Max % of income to buy 2^{nd} cheapest Silver	4%	6.3%	8.05%	9.5%
Price cap of 2^{nd} cheapest Silver (single)	$684	$1,452	$2,416	$4,368
Price cap of 2^{nd} cheapest Silver (couple+1 child)	$1,164	$2,472	$4,008	$7,392

Note: The table shows, as a function of a buyer's income, the maximum amount that can be spent on the second cheapest Silver plan in the region. For each age-income pair, the subsidy is computed as the difference between the premium of this product (after age adjustment) and the corresponding share of annual income for the buyer. The bottom row shows the corresponding price cap on monthly price for the second cheapest Silver plan in the region for singles and households of three.

[7] The effect of allowing subsidized premiums to vary by age is the main focus of Tebaldi (2017).

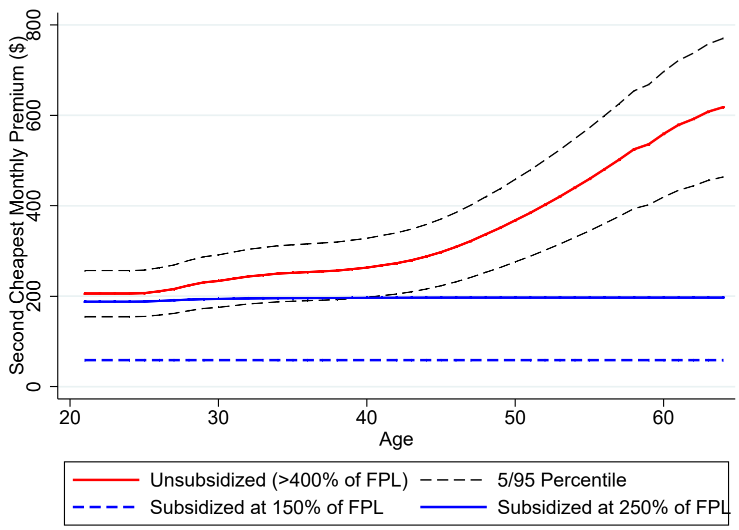
This subsidy scheme defines a premium discount for each age (τ; calculated as total age of the household adding up all members) and income (y) in region r equal to

$$S^{\tau,y}(b_r) = \max\left\{A^{\tau} \cdot b_r^* - \overline{P}^y, 0\right\}, \tag{2}$$

where $\overline{P}^y$ is the premium cap for households with income y, and b_r^* is the base price of the benchmark plan in the region. Since the law establishes that each buyer must pay at least \$1, the price of plan j for a household with total age τ and income y in region r is equal to

$$P_{jr}^{\tau,y} = \max\{P_{jr}^{\tau} - S^{\tau,y}(b_r), 1\}. \tag{3}$$

Figure 3: **Monthly premium by age, unsubsidized vs. subsidized**



Note: The figure shows, for 2015, the average premium of the second-cheapest Silver plan in a rating region (N=396) paid by buyers who are unsubsidized (red solid line), subsidized at 250% of the FPL (blue solid line), and subsidized at 150% of the FPL (blue dashed line), as a function of the buyer age. For the first group the thin dashed lines correspond to the 5th and 95th percentiles.

The formula shows that, even if the supply-price is increasing in age following the SARC, the demand-price of Silver plans for the (vast majority of) subsidized buyers is not. Indeed, Figure 3 shows that, when looking at data from the 2015 ACA exchanges (see below for details), the price for the unsubsidized (and received by the insurers) follows the SARC and displays a significant degree of dispersion across markets. On the other hand, however, the subsidized price of the benchmark plan for all buyers with annual income equal to 150% of the FPL is constant in age. For buyers with higher income equal to 250% of the FPL, the benchmark price is again almost flat. The only exception is for buyers younger than 30 who live in markets with very low base prices, who do not receive subsidies because the pre-subsidy premium of the benchmark plan is lower than the price-cap mandated by the subsidy program.

Other regulations. There are other regulations that we do not consider directly in our analysis. One is the provision of cost-sharing subsidies, available for households purchasing a Silver plan and whose income is lower than 250% of the FPL. For this group, the federal government covers part of deductible and out-of-pocket expenses, increasing the actuarial value of Silver plans from 70% to 95% for income levels between 100-150% of the FPL, 88% for income levels between 150-200% of the FPL, and 74% for income levels between 200-250% of the FPL. Cost-sharing reductions do not directly affect prices, yet make Silver plans extremely attractive for subsidized buyers, and the dominant options when compared to Gold and Platinum plans (see also DeLeire et al., 2016). Indeed, the data we introduce next shows that, in 2015, the share of buyers choosing either Bronze or Silver coverage is equal to 90%. For this reason, we will focus on these plans when studying the impact of age-rating on market outcomes.

Lastly, the ACA also introduced three programs to mitigate insurers' incentives to cream skim healthy patients, and to facilitate the stabilization of the new markets. The programs are called risk-adjustment (permanent), re-insurance (2014-2016 only), and risk-corridors (2014-2016 only), often referred to as "the three R's".[8] What is important for our analysis is that, under these regulations, insurers still have incentives to charge higher prices when expecting older buyers in a market. Risk-adjustment does not compensate aggregate, market-level increases in expected cost. Re-insurance primarily covers right-tail risk but does not make young and old buyers equally costly. Risk-corridors (with highly uncertain payoffs, see previous footnote) are only intended to facilitate insurers to hit a profitability target, without being explicitly linked to buyers' age.

2.2 Age-rating restrictions and subsidies in a simple oligopoly model

Consider a given geographic market in which symmetric(ally differentiated) insurers offer health insurance plans. As in Akerlof (1970); Einav, Finkelstein, and Cullen (2010), insurers only set premiums (or prices), while other contract characteristics are treated as exogenous throughout. Because of symmetry we can omit insurer-specific notation without loss of generality; profit functions, best-replies, and equilibrium prices will be symmetric (this is similar to Mahoney and Weyl, 2014; Ericson and Starc, 2015).

[8] See e.g. http://kff.org/health-reform/issue-brief/explaining-health-care-reform-risk-adjustment-reinsurance-and-risk-corridors/. Risk-adjustment under the ACA determines monetary transfers from insurers with ex-ante relatively less risky enrollees to those who enroll ex-ante relatively more risky enrollees. Re-insurance and risk-corridors are instead temporary programs facilitating market stabilization in the early years, reimbursing insurers for the ex-post realized riskiness of their pools independently from the one of their competitors. Re-insurance collects a fixed amount for every health insurance policy sold by any issuer in any market in the US, and it compensates every insurer for individual claims exceeding an attachment point ($45,000 in 2014-15, and $90,000 in 2016) until a cap of $250,000. The coinsurance rates were 100% in 2014, and 50% in 2015-16. Risk-corridors are instead intended to facilitate the targeting of a 20% (variable) profit margin, imposing transfers from "overly" profitable carriers to their competitors. Importantly, this program is not guaranteed to pay out, since it is possible that the payments due to less profitable insurers are larger than the dues of the more profitable ones. For example, in 2014 insurers were due a total of $2.8 billion while only owing $362 million. Therefore the program paid only 12.5% of what was due to insurers who realized lower-than-expected variable margins.

Buyers can be one of two types: young buyers, who are low-risk and low-demand (L), or old buyers, who are high-risk and high-demand (H). Let $\mu_L = \mu$ denote the fraction of L buyers in the market, and $\mu_H = 1-\mu$ the fraction of H buyers. The function $\sigma_L(P)$ denotes the demand function (probability of purchase) for L buyers as a function of price, and similarly for $\sigma_H(P)$. Assume that

$$\sigma_L(P) < \sigma_H(P) \quad \text{and} \quad \frac{\mathrm{d}\sigma_L(P)}{\mathrm{d}P} < \frac{\mathrm{d}\sigma_H(P)}{\mathrm{d}P} < 0. \tag{4}$$

Also let C_L be the expected cost for the insurer of covering a L buyer, and **similarly for** C_H *(and the same for H buyers)*, with

$$C_L < C_H. \tag{5}$$

Equations (4) and (5) combined summarize "adverse selection" in this simple environment: buyers who are more willing to pay and less price sensitive are more costly to cover.

As a function of prices (P_L, P_H) insurers' profits are

$$\Pi(P_L, P_H) = \mu\sigma_L(P_L)\,(P_L - C_L) + (1-\mu)\sigma_H(P_H)\,(P_H - C_H)\,. \tag{6}$$

Regulations and pricing incentives. We consider three policy environments: no rating regulations and no subsidies (or unconstrained), rating regulations without subsidies (c.f. Ericson and Starc, 2015, ES), and rating regulations with subsidies (ACA).

Simple algebra implies that unconstrained equilibrium prices (P_L^*, P_H^*) are equal to:

$$P_L^* = C_L - \frac{\sigma_L(P_L^*)}{\frac{\mathrm{d}\sigma_L(P_L^*)}{\mathrm{d}P}} \quad \text{and} \quad P_H^* = C_H - \frac{\sigma_H(P_H^*)}{\frac{\mathrm{d}\sigma_H(P_H^*)}{\mathrm{d}P}}. \tag{7}$$

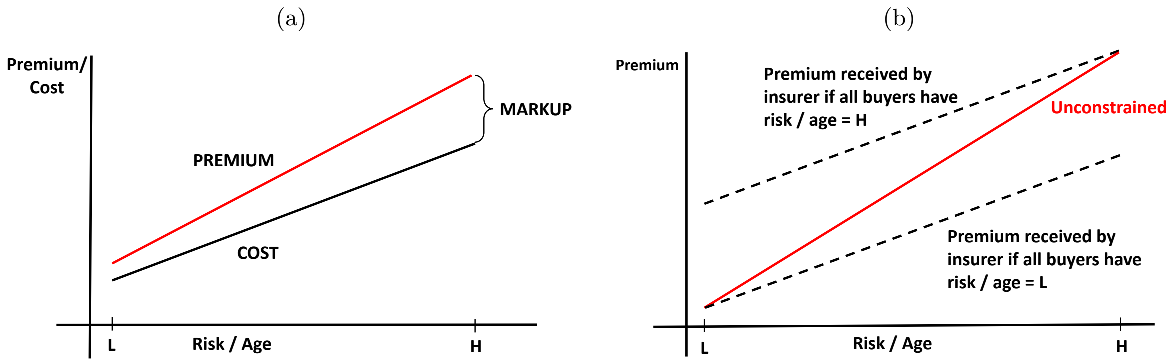
The premium faced by L buyers is lower for two reasons: first, they are cheaper to cover, and second, they are charged a lower markup because they are more price sensitive. This is also illustrated in panel (a) of Figure 4.

To model age-rating restrictions, suppose there is an age-adjustment factor $A > 1$ such that prices must satisfy $P_H \leq A \times P_L$. Without loss of generality, we assume that the regulation is binding (as is the case under the ACA) and $P_H = A \times P_L$. In this case the insurer solves:

$$\max_{P_L} \Pi(P_L, A \times P_L). \tag{8}$$

To analyze this problem we follow closely the approach of ES. Define the modified (or weighted)

Figure 4: **Unconstrained and constrained pricing in the simple model**



Note: The figure illustrates two predictions of the simple oligopoly model. Panel (a) shows that, as in equation (7), unconstrained premiums for older buyers are higher due to higher cost *and* higher markups. Panel (b) shows that, as in equation (9) following Ericson and Starc (2015), the constrained premiums vary with the age-composition of the market. The more (less) older buyers, the higher (lower) the premium for *all* buyers.

demand $\overline{Q}^A$ as $\overline{Q}^A = \mu\sigma_L + (1-\mu)A\sigma_H$.[9] With this, the equilibrium prices (P_L^*, P_H^*) satisfy

$$P_L^* = \left(\frac{\mu\sigma'_L(P_L^*)C_L}{\frac{\mathrm{d}\overline{Q}^A(P_L^*)}{\mathrm{d}P_L}} + \frac{(1-\mu)A\sigma'_H(P_H^*)C_H}{\frac{\mathrm{d}\overline{Q}^A(P_L^*)}{\mathrm{d}P_L}} \right) - \frac{\overline{Q}^A(P_L^*)}{\frac{\mathrm{d}\overline{Q}^A(P_L^*)}{\mathrm{d}P_L}} \quad \text{and} \quad P_H^* = A \times P_L^*. \tag{9}$$

The expression in equation (9) highlights two important effects of age-rating restrictions. First, the price for L buyers is higher than the unconstrained one, and vice versa the price for H buyers is lower. These differences are not only due to the regulatory link between the prices charged to buyers with different cost. As emphasized by ES, the markups charged by insurers are also different. The reason is that the regulation alters the set of marginal buyers who would respond to a price increase, since a Δ increase in P_H must correspond to a Δ/A increase in P_L. Therefore, the markup charged to H buyers is lower, and the markup charged to L buyers is higher.

A second important consequence of the rating regulation is evident from equation (9) and highlighted in panel (b) of Figure 4. If all buyers in a market are L ($\mu = 1$), the equilibrium P_L^* is not affected by the constraint. Symmetrically, if all buyers are H, the equilibrium P_H^* is not affected by the constraint. Across markets, differences in the age-composition of the population move the equilibrium prices from one extreme to the other, so that in markets with comparatively more H buyers *all* buyers face higher prices, and vice versa. This relationship between age-composition of the population and price conditional on age is entirely driven by rating regulations. Documenting this in the ACA context, and inverting the relationship between constrained prices and market composition to back out unconstrained prices represent the core of our empirical exercise later on.

Without subsidies, ES show how rating regulations would impact participation decisions and consumer surplus, penalizing L buyers to favor H buyers. Here, however, we consider an ACA-type

[9] This should be seen as a function of P_L only, so that $\mathrm{d}\overline{Q}^A/\mathrm{d}P_L = \mu\sigma'_L + A^2(1-\mu)\sigma'_H$.

situation in which the government provides premium subsidies to guarantee that buyers can find coverage for a given "maximum affordable amount" $\overline{P}$, typically a fraction of the buyer's income. For any given price vector, the government provides discounts so that buyers can buy the cheapest plan in the market paying $\overline{P}$. After applying this discount, buyers still pay price differences (if any) across different plans, so that insurers still compete in prices (see Jaffe and Shepard, 2016, for a rich discussion of this).

Without rating restrictions, the equilibrium prices satisfy:

$$P_L^* = C_L - \frac{\sigma_L(\overline{P})}{\frac{\mathrm{d}\sigma_L(\overline{P})}{\mathrm{d}P}} \quad \text{and} \quad P_H^* = C_H - \frac{\sigma_H(\overline{P})}{\frac{\mathrm{d}\sigma_H(\overline{P})}{\mathrm{d}P}}. \tag{10}$$

When rating restrictions coexist with premium subsidies the equilibrium prices (P_L^*, P_H^*) satisfy

$$P_L^* = \left(\frac{\mu\sigma'_L(\overline{P})C_L}{\frac{\mathrm{d}\overline{Q}^A(\overline{P})}{\mathrm{d}P_L}} + \frac{(1-\mu)A\sigma'_H(\overline{P})C_H}{\frac{\mathrm{d}\overline{Q}^A(\overline{P})}{\mathrm{d}P_L}} \right) - \frac{\overline{Q}^A(\overline{P})}{\frac{\mathrm{d}\overline{Q}^A(\overline{P})}{\mathrm{d}P_L}} \quad \text{and} \quad P_H^* = A \times P_L^*. \tag{11}$$

In this situation, again, insurers' incentives are altered so that markups are lowered, pre-subsidy price for L buyers is higher than in (10), and price for H is lower. However, the post-subsidy price is now unchanged, and therefore the rating regulation does not affect participation, nor does it imply a transfer of consumer surplus from L to H. Instead, the subsidy for L buyers increases, and the subsidy for H buyers decreases. In this simple setting, when subsidies are provided, age-rating restrictions have a direct effect on public spending rather than consumer surplus.

Empirical predictions. To summarize, the simple model delivers the following three empirical predictions:

P1. Without age-rating regulations, prices for a given age-group do not depend on the share of old buyers in a market.

P2. When binding age-rating regulations are imposed, prices for all buyers are higher in markets with a higher share of old buyers.

P3. When binding age-rating regulations coexist with subsidies that are set to guarantee a maximum affordable amount the primary effect of rating regulations is to alter public spending.

3 Age-rating and pricing: before and after the ACA

3.1 Data

Our analysis combines several data sources. We use prices and product information from before (2008-2012) and after (2014-2017) the ACA to study the relationship between premiums and age-composition of the market. To assess the effect of the age-rating restrictions jointly with the subsidy program implemented under the ACA, we also use 2015 county-level ACA enrollment information for different demographic groups. Part of our analysis combines these sources with information from the Small Area Health Insurance Estimates, the Dartmouth Atlas, the Area Health Resources File, and the Medical Expenditure Panel Survey. Details on data sources and definitions of specific variables used in our analysis can be found in the Online Appendix.

2008-2012 Pre-ACA data. This dataset is provided by a large online health insurance broker which requires anonymity and with whom one of the authors has a confidential data-use agreement. The data contains information on premiums, plan characteristics, and consumer demographics (age and gender) for approximately 1.5 million applications for individual health insurance during the 2008-2012 period. Application-weighted, county-level price and deductible information are summarized in the top section of Table 2.

Importantly, in the states covered in this dataset,[10] insurers could deny coverage based on pre-existing medical conditions of the applicant before the ACA. This major institutional difference, and the numerous other policy changes introduced by the ACA, are the reason why we do not directly compare prices before and after the ACA to investigate the effect of age-rating restrictions. Instead, as in a pseudo placebo test, we use this data to provide evidence for prediction P1 above, that the age-composition of a geographic area did not have any impact on health insurance prices before the age-rating constraints.

Table 2: **Premium for a 21-years-old and deductible before and after the ACA**

		Monthly Premium for 21 y.o. ($)					Annual Deductible ($000s)				
	Year	Mean	Std Dev.	Min.	Max.	N	Mean	Std Dev.	Min.	Max.	N
Pre-ACA	2008	90.69	30.36	24.34	247.65	760	3.11	2.01	0.00	20.00	760
	2009	86.66	28.34	26.11	209.52	820	3.85	2.53	0.00	20.00	820
	2010	89.50	35.76	27.22	309.00	810	4.43	2.84	0.00	20.00	810
	2011	84.42	35.88	2.00	405.72	628	4.77	2.69	0.00	25.00	628
	2012	88.57	36.20	26.00	260.94	445	5.12	3.42	0.00	25.00	445
ACA	2014	207.48	33.81	116.79	360.61	385	3.87	1.53	0.00	6.25	385
	2015	214.24	34.37	130.88	344.20	396	3.80	1.34	1.30	6.50	396
	2016	234.40	38.25	141.48	366.02	396	4.55	1.78	1.30	8.50	396
	2017	290.75	70.21	155.94	590.56	396	5.08	1.76	0.00	8.70	396

Note: For 2008-2012 the level of observation is the county and the premium/deductible relates to the county average (where price information exists). For 2014-2017 the level of observation is the ACA rating region and the premium is the 2^{nd} cheapest silver plan and deductible is the corresponding deductible.

[10] These are Alabama, Arkansas, Arizona, Delaware, Florida, Georgia, Iowa, Illinois, Indiana, Kansas, Louisiana, Missouri, Mississippi, Montana, North Carolina, North Dakota, Nebraska, New Hampshire, New Mexico, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Wisconsin, and Wyoming.

2014-2017 Post-ACA data. The main dataset for our analysis consists of prices and deductible information in 35 Federally Facilitated marketplaces in the first four years of the ACA, 2014-2017.[11] This data is available through the website of the Center for Medicare and Medicaid Services (CMS.gov). The dataset contains 385 rating regions in 2014, and 396 in 2015-2017; the summary of (pre-subsidy) premium and deductible for the second-cheapest Silver plan in each region is provided in the bottom of Table 2.

Since plan-level enrollment information is not available, we focus primarily on the second-cheapest Bronze and Silver plans in each region as proxies for a demand-weighted average price in each market. The second-cheapest Silver plan is the benchmark product in each market: this is used to determine the level of subsidies received by each household, and it is also bundled with the cost-sharing subsidy for a large number of buyers. This is also the plan for which, given income, subsidized buyers pay the exact same amount independently from their age. Indeed, Silver plans represent approximately 70% of enrollment in the exchanges. When adding the less generous, and cheaper, Bronze plans, these two product categories add up to 90% of ACA marketplace enrollment in 2015.[12]

Market characteristics. Several parts of our analysis rely on comparing prices across markets with different composition of (potential) buyers. To describe how these markets differ, we focus primarily on age and income of the uninsured. These are key variables affecting (post-subsidy) premiums and participation before and after the ACA. We derive information on the share of uninsured younger than 50 (out of those aged 21-64) at the county level from the Small Area Health Insurance File (SAHIE). The same source also provides information on the income composition of the uninsured, and allows us to construct the share of households who are subsidy eligible under the ACA.[13]

We also include other variables to control for heterogeneity in market characteristics that could affect prices through differences in demand and cost of healthcare services. Combining the Area Health Resources File and the Dartmouth Atlas we consider the number of primary-care physicians (per 100,000 people), the share of residents declaring to be in fair/poor health, the wage index used by Medicare to adjust payments to physicians, and other controls.[14]

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[11]The 35 states are: Alabama, Arkansas, Arizona, Delaware, Florida, Georgia, Iowa, Illinois, Indiana, Kansas, Louisiana, Maine, Michigan, Missouri, Mississippi, Montana, North Carolina, North Dakota, Nebraska, New Hampshire, New Jersey, New Mexico, Nevada, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Wisconsin, West Virginia, and Wyoming. Data for Oregon and Nevada are only available for the 2015-2017 period.

[12]Our analysis leads to similar results when using the cheapest plan price in each tier, the median plan price in each tier, or excluding Bronze plans from the analysis.

[13]This is the total number of households with income between 138-400% of the FPL, divided by the total number of uninsured households.

[14]These include the share of African-American residents, the average household size, the birth rate among

Table 3: **Characteristics of geographic markets before and after the ACA**

Variable	**Counties (Pre-ACA)** Mean	Std Dev.	Min.	Max.	N	**ACA Rating Regions** Mean	Std Dev.	Min.	Max.	N
Aged 50-64 Share	0.24	0.04	0.07	0.39	1270	0.23	0.04	0.14	0.42	396
Subsidized Share	0.82	0.03	0.69	0.91	1270	0.82	0.03	0.71	0.87	396
PCPs (per 100,000 people)	52.49	27.15	0.00	195.23	1249	60.18	20.83	0.00	137.02	396
Fair/Poor Health Share	0.17	0.05	0.05	0.40	1138	0.17	0.04	0.07	0.32	396
IPPS OPPS Wage Index	0.86	0.09	0.71	1.20	1270	0.88	0.08	0.71	1.18	396
African American Share	0.12	0.16	0.00	0.84	1270	0.14	0.14	0.00	0.72	396
Average Household Size	2.55	0.22	2.01	4.05	1270	2.57	0.20	2.05	3.74	396
Teen Birth Rate	0.05	0.02	0.01	0.12	1253	0.05	0.02	0.01	0.10	396
Chlamydia Rate	0.04	0.03	0.00	0.18	1267	0.04	0.02	0.01	0.14	396

The market characteristics are summarized in Table 3. Importantly, while insurers set prices at county level in the pre-ACA period, we construct market covariates at the rating region level at which premiums are set since 2014. This is the level of participation and pricing in the ACA marketplaces (see also Dickstein et al., 2015). Every region-level variable in our analysis is a population-weighted average of the county-level variable across the counties in the region. Table 3 shows how the market-level characteristics do not show relevant differences when comparing the pre-ACA pricing level to the one mandated under the ACA.

Table 4: **2015 ACA region-level enrollment**

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Total Enrollment (1,000)	21.291	43.621	0.193	392.442	396
Aged 50-64 Share	0.398	0.064	0.159	0.617	396
Silver & Bronze Share	0.899	0.05	0.603	0.984	396
100-150% of FPL Share	0.355	0.143	0.067	0.661	396
150-250% of FPL Share	0.392	0.082	0.22	0.582	396
250-400% of FPL Share	0.16	0.06	0	0.303	396

Note: The level of observation is the ACA pricing region.

ACA enrollment. To calculate the impact of the age-rating restrictions on public spending and enrollment, we use the ACA county-level 2015 enrollment published by ASPE.gov.[15] This shows total enrollment in each county by age-group, metal tier, and income-bin. For consistency with the market definition adopted under the reform, this county-level information is again aggregated at the rating-region level. This dataset is summarized in Table 4. 90% of buyers are subsidized, and the vast majority of them have income below 250% of the FPL. The share of buyers older than 50 is almost 40%. When compared to the share of uninsured in the same age group (24%), this shows that — consistently with other studies, e.g. Ericson and Starc (2015); Geruso (2016); Tebaldi (2017)

teenagers, and the incidence of Chlamydia.

[15]See https://aspe.hhs.gov/affordable-care-act-research.

— older buyers are more willing to purchase coverage at the income-specific affordable amount compared to their younger counterparts.

3.2 Age-rating before the ACA and in the MEPS

We start by documenting how the SARC adopted under the ACA mandates that premiums grow less in age than what is observed in the pre-ACA data, and less than health expenditure in the MEPS.

We do this through two simple linear regressions. First we use pre-ACA plan-level data. Let $Y^{\tau}_{c,t,j}$ be the ratio of the the premium charged to a τ-year-old to the premium charged to a 21-year-old for insurance plan j in county-year (c,t). We regress $Y^{\tau}_{c,t,j}$ on a full set of age dummies:

$$Y^{\tau}_{c,t,j} = \sum_{\tau'=21}^{64} \mathbf{1}[\tau = \tau']\delta^{\tau'} + \varepsilon^{\tau}_{c,t,j}. \tag{12}$$

In the MEPS, we consider the set of privately insured, and for every individual i of age τ_i, we let Y_i be the ratio between i's annual medical expenditure covered by the carrier and the average of this variable for buyers with $\tau_i = 21$. We then run:

$$Y_i = \sum_{\tau'=21}^{64} \mathbf{1}[\tau_i = \tau']\delta^{\tau'} + \varepsilon_i. \tag{13}$$

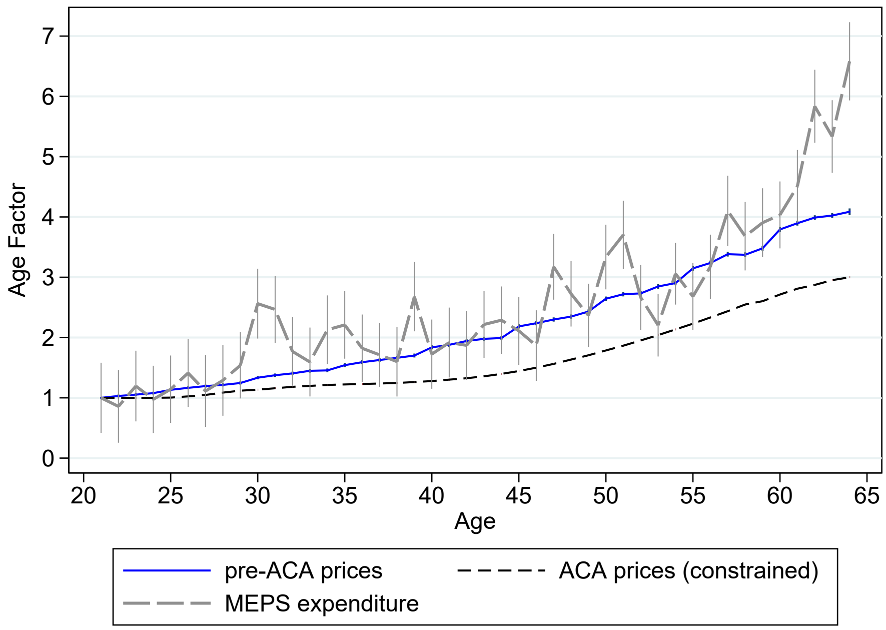
In both specifications (12) and (13) the coefficient δ^{21} is mechanically equal to 1. The other coefficients can be simply interpreted as (average) age-adjustment factors based on, respectively, pre-ACA insurers' behavior, or a nationally-representative health expenditure survey.

Results are shown in Figure 5, which compares the resulting age-rating schedules (each coefficient plotted with 95% confidence intervals, where we use robust standard errors in both specifications) to the SARC mandated by the ACA.

The SARC adopted under the ACA lays below both the estimated pre-ACA age-rating schedule, and the cost-based age-rating curve implied by the MEPS. Both curves show a ratio of 64:21 larger than the 3:1 mandated by the ACA, with $\delta^{64}/\delta^{21} \approx 4$ in the pre-ACA data, and $\delta^{64}/\delta^{21} \approx 5$ in the MEPS.

When interpreting these coefficients, it is important to recall that —in our sample of states— insurers could deny coverage based on pre-existing medical conditions before the ACA. However, the vast majority of individuals in the MEPS subsample we consider here — the privately insured — are covered by employer-sponsored insurance, for which pre-existing medical conditions do not affect access to coverage. It is therefore not surprising that the pre-ACA pricing data shows a slower growth of premium in age than the MEPS data, which is based solely on ex-post realized medical spending. The ratio of $\delta^{64}/\delta^{21} \approx 5$ from the MEPS is also in line with the 5:1 ratio that is

Figure 5: **Age-rating adjustments: pre-ACA, MEPS, and ACA**



Note: The figure plots the ACA SARC, and the estimates of $\delta^{21}, \ldots, \delta^{64}$ from specifications (12) and (13). The solid line shows the δ^{τ} estimated from pre-ACA premiums (equation (12)), with 95% (robust) confidence intervals. The long-dashed line shows the δ^{τ} estimated from the MEPS (equation (13)), with 95% (robust) confidence intervals. The short-dashed line is the SARC applied across all state-level health insurance marketplaces except for MA and UT. The coefficient show that, in the pre-ACA, when pre-existing medical conditions could be used for underwriting purposes, $\delta^{64}/\delta^{21} \approx 4$. In the MEPS, largely representative of employer-sponsored insurance, medical spending would imply that $\delta^{64}/\delta^{21} \approx 5$. The ACA mandates that $\delta^{64}/\delta^{21} = 3$.

often discussed by industry experts as "actuarially fair" when underwriting on pre-existing medical conditions is prohibited (see e.g. Blumberg and Buettgens, 2013).

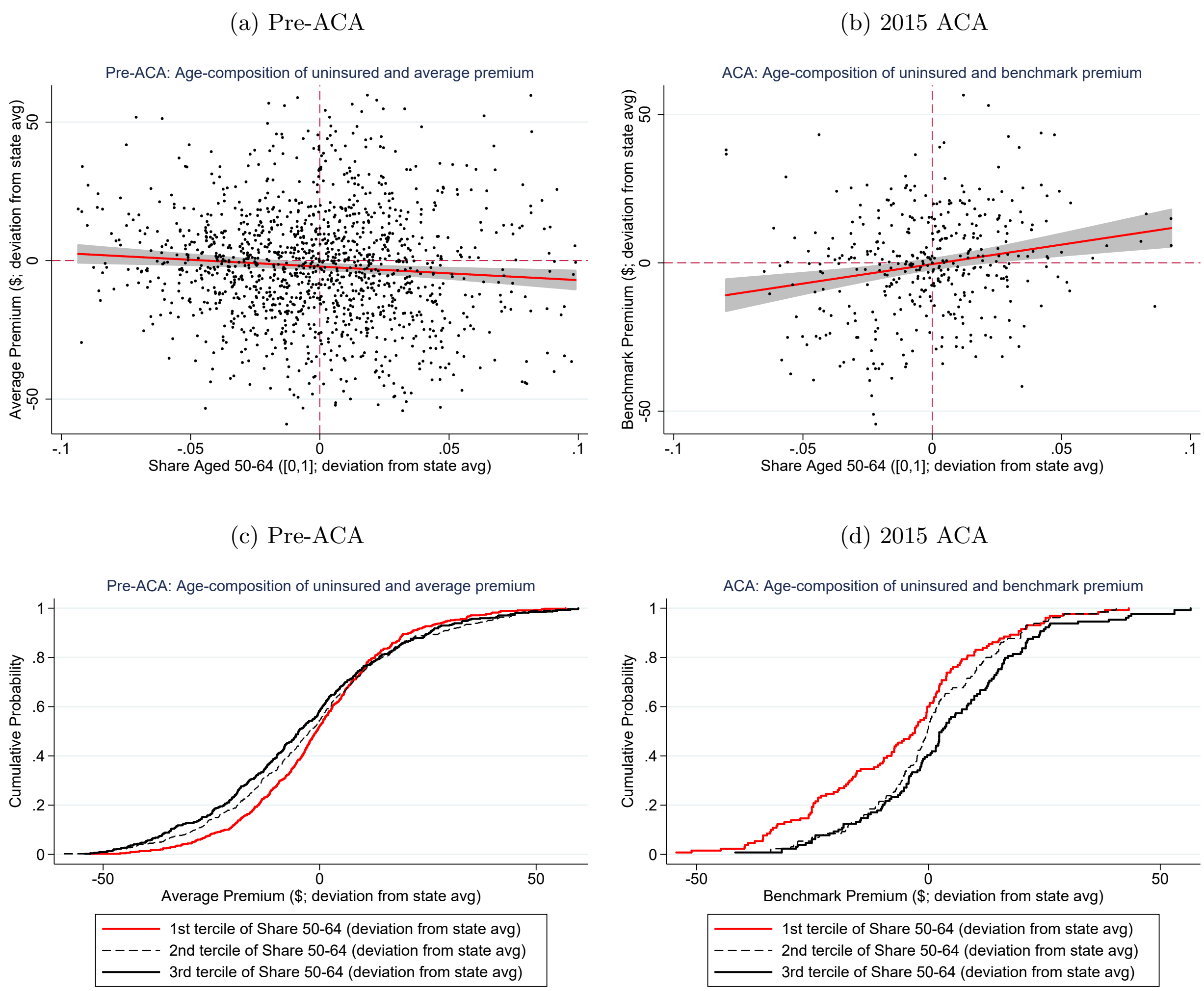
3.3 Market composition and prices before and after the ACA

The above evidence strongly suggests that the unconstrained slope of age-based prices would be steeper than the SARC. Hence, the age-rating restriction should induce a positive relationship between the share of old buyers in a market and the (pre-subsidy) premium for a young buyer (prediction P2 above). Without restrictions to age-rating, this should not be the case: insurers can simply price age-by-age in any given market, and the share of market participants of other ages should not affect the price of a given age-group (prediction P1 above). We go on to show evidence for both facts by exploring the relationship between price and age-composition of the uninsured across markets, before and after the reform.

Graphical analysis. In Figure 6, we study the relationship between age-composition of a geographic market (as of 2013, in deviation from state-average) and the premium for 21-year-old buyers (also in deviation from state average). We compare pre-ACA premiums, pooled across years, to ACA premiums in 2015, the year for which county-level enrollment data is also available.

In panels (a) and (b) we plot the premium for 21-year-old buyers in a market (Y-axis) against the share of uninsured in the market who are older than 50 (X-axis). In the pre-ACA a market is a county, while in the post-ACA a market is a rating region. In panels (c) and (d) we plot the empirical CDF of 21-year-old premiums, distinguishing between markets in the first, second, and third tercile of share of uninsured older than 50.

Figure 6: **21-years-old premium, young vs. old markets before and after the ACA**



Note: The figure plots the relationship between market-level premium for 21-year-olds and age-composition of the uninsured before and after the ACA. In panels (a) and (c) each observation is a county (N=1,270), the premium is the demand-weighted average premium for 21-year-olds, pooling across the years in the pre-ACA sample (2008-2012). In panels (b) and (d) each observation is a region (N=397), the premium is the second-cheapest Silver (benchmark) premium for 21-year-olds in the region. The share of uninsured aged 50-64 is computed from the 2013 Small Area Health Insurance Estimates (Census.gov). For the ACA data, this measure is calculated at the region level as a weighted average across the counties in the rating region, with weights equal to the total number of uninsured in each county.

These figures support the theoretical implications of age-rating restrictions discussed in Section 2.2. There is no clear relationship between the share of relatively old potential buyers in a county and the premium charged to 21-year-olds before the ACA. On the other hand, this relationship appears in the 2015 ACA data, with (pre-subsidy) 21-year-old premium increasing in the share of potential buyers who are older than 50. In particular, the ACA data shows a clean, almost complete, (first-order stochastic) ordering of the three CDFs of premium of young buyers by the three terciles of share of over-50 buyers in a market. This is completely absent in the pre-reform data.

Pre and post-ACA cross-sectional analysis. To support the previous evidence controlling for market characteristics other than age, and for non-premium product characteristics that could vary systematically across different markets, we run a set of OLS regressions to document with more precision the effect of the ACA on the relationship between premium for young (21-year-olds) buyers and age-composition of a market.

A caveat for our analysis is that the level of pricing differs across the two periods, changing from county-level to the (coarser) region-level pricing mandated by the reform. Therefore, we first show results from a simple cross-sectional specification that is consistent with the institutional details underlying the data generating process. The main findings and magnitudes of estimated coefficient are robust across different specifications, including county-level and region-level panel regressions that we will consider next.

In the pre-ACA period, we regress county-level, demand-weighted, average premium (summarized in Table 2, pooling across the 2008-2012 years) on the average annual deductible, share of uninsured adults aged between 50-64 as of 2013, share of households with income between 100-400% of the FPL, state fixed-effects, and additional controls. In the post-ACA period we regress region-level premium of the second cheapest Silver and the second cheapest Bronze plans (two observations per region) on annual deductible, an indicator for the metal tier of the product, and the same set of market-level covariates including state fixed-effects.

Formally, in each dataset we run:

$$P_{mj}^{21} = \alpha^{age} Share5064_m + \beta X_{mj} + \gamma Z_m + \varepsilon_{mj}, \tag{14}$$

where j is a plan (average plan in the pre-ACA, second-cheapest Silver and Bronze in the ACA). m is a county in the pre-ACA data, and a rating region (group of counties within the same state) in the ACA data. $Share5064_m$ is the share of (2013) uninsured aged 50-64 over the uninsured aged 21-64 in market m, X_{mj} contains product characteristics (deductible and, in the ACA data, a flag for metal tier), and Z_m contains additional market covariates, including state fixed-effects.

Results are summarized in Table 5, where our main focus is on the coefficient α^{age} on the share of uninsured aged 50-64.

Consistently with the previous graphical evidence and the theoretical insight of Section 2.2, we find no statistically significant relationship between age-composition of a market and premium of young buyers before the ACA, while the same relationship becomes positive, statistically significant,

Table 5: **Market characteristics and premium of 21-year-olds before and after the ACA**

	(1)	(2)	(3)	(4)	(5)
Pre-ACA: Average market premium for 21-year-olds					
Aged 50-64 Share	**-7.29**	**-5.84**	**-6.38**	**-5.26**	**4.05**
	(15.3)	(15.5)	(15.6)	(16.4)	(21.8)
Annual Deductible ($1,000)	-7.18***	-7.17***	-7.17***	-6.79***	-6.89***
	(0.51)	(0.51)	(0.52)	(0.53)	(0.54)
Subsidized Share		-11.5	-5.17	17.5	-11.6
		(22.8)	(23.8)	(27.0)	(31.3)
PCPs (per 100,000 people)			0.023	0.015	0.017
			(0.024)	(0.025)	(0.027)
Fair/Poor Health Share				-28.0	-43.4**
				(19.2)	(20.2)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	No	No	Yes
Observations	1270	1270	1249	1125	1115
Adjusted R-squared	0.46	0.46	0.46	0.46	0.47
ACA: Bronze and Silver premium for 21-year-olds					
Aged 50-64 Share	**120.6*****	**102.8*****	**97.4*****	**98.6*****	**90.4****
	(26.1)	(26.5)	(27.1)	(27.7)	(40.8)
Annual Deductible ($1,000)	-1.90***	-1.80**	-1.71**	-1.69**	-1.62**
	(0.71)	(0.72)	(0.72)	(0.72)	(0.71)
Silver	36.9***	37.1***	37.3***	37.3***	37.5***
	(1.95)	(1.94)	(1.96)	(1.96)	(1.95)
Subsidized Share		121.5***	83.8*	95.1**	24.2
		(41.7)	(44.9)	(47.3)	(53.0)
PCPs (per 100,000 people)			-0.089*	-0.092*	-0.055
			(0.047)	(0.047)	(0.051)
Fair/Poor Health Share				-14.6	-45.3
				(27.1)	(31.7)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	No	No	No	Yes
Observations	792	792	792	792	792
Adjusted R-squared	0.75	0.75	0.75	0.75	0.76

Note: The top panel shows the result of the OLS specification in equation (14) estimated from pre-ACA data, the bottom panel reports the estimates from 2015 ACA data. Robust standard errors are in parentheses. Additional controls include the wage index used by Medicare to adjust payments to physicians, share of African-American residents, the average household size, the birth rate among teenagers, and the incidence of Chlamydia.

and robust across specifications when looking at the 2015 ACA pricing data.

Quantitatively, these regressions imply that, under the ACA, a rating region in which the share of uninsured older than 50 is 10% higher — where this variable ranges between 10 and 40% — corresponds to a $10/month increase in base prices. Following the SARC, this corresponds to a $10/month increase in prices for 21-year-old buyers, $14/month for 40-year-olds, and $30/month for 64-year-olds.

Panel analysis. The geographic level of pricing under the ACA is different than the one adopted by insurers before the reform (see also Dickstein et al., 2015, where we study the effect of bundling rural counties in different rating regions). This represents a caveat for a panel analysis of the change in the relationship between age-composition of a market and premiums of young buyers brought about by the ACA regulations. Nevertheless, we believe that it is of interest to show how, at each geographic level — county and ACA rating region —, the main finding of the previous cross-sectional analysis still holds.

For this, using all the county-year (region-year) data from 2008-2017 (2013 is missing), we can show how there was no relationship between age-composition of a market and premiums before the reform, and how this relationship appears significantly at the onset of the ACA marketplaces. We consider both, a county-year level specification (for which the ACA pricing-level is inaccurate), and a region-year level specification (for which the pre-reform pricing level is inaccurate).

Formally, we specify

$$P^{21}_{mjt} = \alpha^t Share5064_m + \beta X_{mjt} + \gamma Z_{mt} + \varepsilon_{mjt} \tag{15}$$

where j is a plan, in county (region) m, year t. $Share5064_m$ is measured in the 2013 SAHIE as in Table 5, X_{mjt} collects the plan's characteristics, and Z_{mt} contains market characteristics including state-year fixed-effects. Our coefficients of interest, α^t, should be interpreted as year-specific variation from state-year specific average premium for 21-year-olds in a county (region) induced by the difference of the share of uninsured aged 50-64 from the state average.

Predictions P1 and P2 of Section 2.2 correspond to $\alpha^{2008} = \alpha^{2009} = ... = \alpha^{2012} = 0$, and $\alpha^{2014} > 0, \alpha^{2015} > 0, ..., \alpha^{2017} > 0$. In Figure 7, we show the estimates of α^t from specification (15) for both, county-level (left) and region-level (right) panel datasets; tabular results are presented in Appendix A.

As expected, with no statistically significant relationship between age-composition of the uninsured and premium of young buyers before the ACA, but a positive and significant relationship after the ACA marketplaces are introduced starting in 2014.

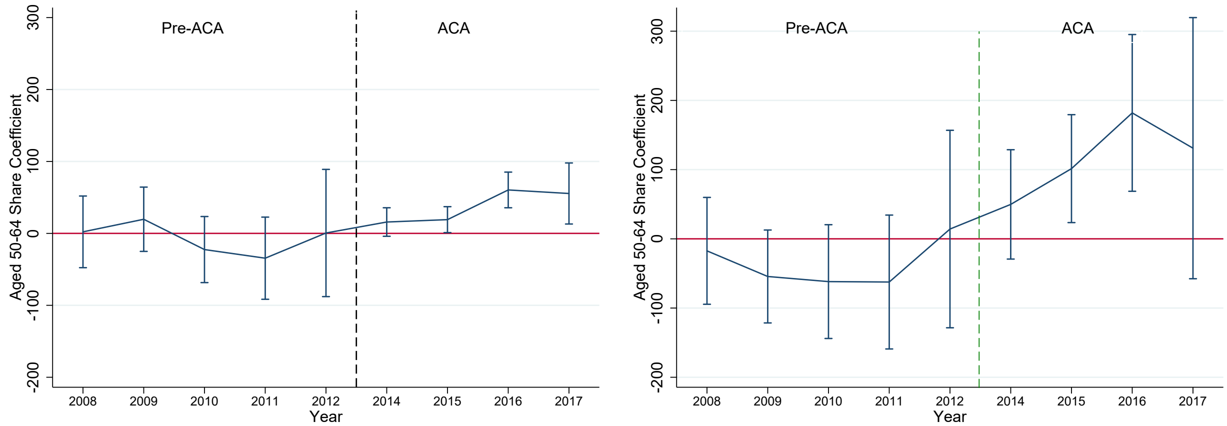
The left panel, using county-level data in both periods, departs from the institutional details of the ACA, since several counties (cross sectional observations) are not the relevant market for pricing purposes. This introduces important measurement error and it is therefore not surprising to see attenuated coefficients when compared to the region-level panel estimates.

A second observation is that, during the ACA period, the magnitude of the estimated α^t increases over time. This is consistent with a situation in which insurers are progressively learning how to price in the exchanges, or realize over time that — as evident from Tables 3 and 4 in Section

Figure 7: **Premiums and share of uninsured aged 50-64, year by year**

(a) County-level panel

(b) Region-level panel



Note: The figure shows the coefficients from the panel specification in equation (15). On the left we report the estimates of α^t (and 95% confidence intervals computed from robust standard errors) from the regression in which the cross-sectional unit is the county. On the right we report the same estimates when the cross-sectional unit is the ACA rating region. Additional controls include Deductible, Subsidized Share, PCP Rate, Fair/Poor Health Share and State-Year Fixed Effects. Tabular results are reported in Appendix A.

3, and showed in Ericson and Starc (2015); Geruso (2016); Tebaldi (2017) — older uninsured are much more likely to purchase coverage. A larger share of uninsured aged 50-64 generates then an even stronger incentive to set a higher premium for all buyers.

4 Pricing model and counterfactual unconstrained premiums

A natural question originating from the previous results is: how would prices have been set if age-rating had not been constrained while all other ACA regulations were applied?

The pre-post reform comparison does not provide an answer to this. Institutional changes introduced by the ACA (e.g. regulation on minimum insurance benefits, and the universal ban on underwriting on pre-existing medical conditions) would invalidate any assumption that insurers have similar pricing incentives in the two settings.

Instead, to back out information about unconstrained prices, we can combine the simple model of oligopoly pricing under age-rating restrictions with the (post-reform) joint variation in age-composition of the uninsured and pre-subsidy premiums. Intuitively, if we observed a region where *all* uninsured are 64 (21), the model would imply that the observed premium in this region is equal to the unconstrained price for 64-year-olds (21-year-olds) in all regions with the same characteristics other than premiums. (See Figure 4(b)) The data does not directly provide us with this extreme cases, but the same intuition applies: the increase in premium corresponding to a relative increase in the age of the uninsured is informative about the premiums that would result if age-rating was unconstrained.

4.1 Econometric model

Adapting the framework of Section 2.2, we consider a symmetric oligopoly pricing game, so that we only need to model one pricing decision per-market (this is similar to Mahoney and Weyl (2014), in a Nash-in-prices equilibrium symmetric insurers would set the same price). If plan-level enrollment was available, as in Ericson and Starc (2015) and Tebaldi (2017), one could instead model a full-blown oligopoly pricing game between differentiated insurers.[16]

An insurer selling plan j in region r must choose a base-price b_{jr}. This is transformed to the price for young (Y) buyers as $P_{jr}^{Y} = b_{jr} \cdot A^{Y} = b_{jr}$, while the price for old (O) buyers is $P_{jr}^{O} = b_{jr} \cdot A^{O} = 3 \cdot b_{jr}$.

Let $\pi_r^Y(P^Y)$ be the per-buyer profit function for Y buyers in region r, and similarly for O buyers. Let μ_r^O be the share of potential buyers who are O. In a symmetric pricing equilibrium in region r, the base price $b_{jr}^* = b_r^*$ for all j solves the FOC

$$0 = (1 - \mu_r^O)\frac{\partial \pi_r^Y(b_r^*)}{\partial P^Y} + \mu_r^O 3 \frac{\partial \pi_r^O(3b_r^*)}{\partial P^O}. \tag{16}$$

If age-based pricing was allowed, instead, insurers would simply set $P_r^{*,Y}$ and $P_r^{*,O}$ solving

$$\frac{\partial \pi_r^Y(P_r^{*,Y})}{\partial P^Y} = 0 \quad \text{and} \quad \frac{\partial \pi_r^O(P_r^{*,O})}{\partial P^O} = 0. \tag{17}$$

Knowing the functions $\partial \pi_r^Y$ and $\partial \pi_r^O$ one can then calculate unconstrained prices.

We proceed by making parametric assumptions on these functions, and assuming that observed prices satisfy the relationship in (16). This, taken in expectation, can then be used as a moment condition to back out the parameters necessary to determine the two solutions of (17).

We let

$$\frac{\partial \pi_r^Y}{\partial P^Y} = 1 - \alpha^Y P_r^Y + \beta X_r + \omega_r^Y; \tag{18}$$

$$\frac{\partial \pi_r^O}{\partial P^O} = 1 - \alpha^O P_r^O + \beta X_r + \omega_r^O. \tag{19}$$

In this expression, X_r contains region-level covariates: share of low-income, subsidy-eligible buyers, the product deductible, the number of primary-care physicians per-1,000 residents, the share of residents declaring to be in fair/poor health, and state dummies. The terms ω_r^Y, ω_r^O are idiosyncratic error terms, assumed to be independent from b_r^*, X_r, and μ_r^O.

[16] These data are not yet available for the vast majority of the state-based exchanges, limiting us here to using a much simpler framework. See also our discussion in Section 6.

One can then re-write (16), adding the region subscript, as

$$0 = (1-\mu_r^O)\left(1-\alpha^Y b_r^* + \beta X_r + \omega_r^Y\right) + \mu_r^O 3\left(1-\alpha^O 3 b_r^* + \beta X_r + \omega_r^O\right) \tag{20}$$

or

$$b_r^* = \frac{(1-\mu_r^O)\left(1+\beta X_r + \omega_r^Y\right) + \mu^O 3\left(1-\alpha^O 3 b_r^* + \beta X_r + \omega_r^O\right)}{(1-\mu_r^O)\alpha^Y + 9\mu^O\alpha^O} + \widetilde{\omega}_r, \tag{21}$$

and

$$E\left[\widetilde{\omega}_r \middle| X_r, b_r^*, \mu_r^O\right] = 0 \tag{22}$$

is a valid moment condition that can be used for estimation of $(\alpha^Y, \alpha^O, \beta)$. Once such estimates are obtained, the unconstrained prices will solve (in expectation)

$$E\left[P_r^{*,Y} \middle| X_r\right] = \frac{1+\beta X_r}{\alpha^Y}, \tag{23}$$

$$E\left[P_r^{*,O} \middle| X_r\right] = \frac{1+\beta X_r}{\alpha^O}. \tag{24}$$

Several comments are in order. First, the linearity of marginal profit functions would hold in the simple case in which the underlying demand-supply model features linear (in price) demand and quadratic (in quantity) average costs, where both functions depend (also linearly) on product and region characteristics.[17] Second, the normalization of the constant term to 1 is without loss of generality since all solutions to FOC conditions are invariant to scaling. Third, the restriction of β to be equal across Y and O may seem restrictive, which implies that insurers have equal benefit from increasing the premium by \$1 when prices are zero. This could be justified economically thinking that all buyers would buy at \$0 price, and that demand, for either age, would not change when the premium moves from \$0 to \$1. Hence total cost would be the same as well, and marginal profit around \$0 premiums would indeed be equal for Y and O buyers. In practice, this assumption cannot be relaxed without a more complex structure of the model or additional data. Indeed differences between the way in which X_r affects π^Y and π^O are not identified under moment condition (22) since the terms $(1-\mu_r^O)X_r$ and $3\mu_r^O X_r$ are perfectly collinear.

4.2 Estimates of marginal profits and unconstrained premiums

Marginal profits. We estimate the model using the 2015 ACA pricing data. The estimates of $(\alpha^Y, \alpha^O, \beta)$ are displayed in Table 6, with analytical robust standard errors in parentheses.

We find that a \$1 increase in premium reduces marginal profits from a young buyer by \$0.32,

[17]For example, demand from a young buyer could take the form $\sigma_{young} = A - B \times p_{young} + C \times X_r$, with σ_{young} being the probability that the buyer purchases upon entering the exchange, and X_r collecting region demographics and the financial characteristics of the benchmark plan. Expected costs from the same buyer could take the form $C_{young}(\sigma_{young}) = D \times \sigma_{young} + E^2 \times \sigma^2_{young}$.

Table 6: **Estimated Marginal Profit Function Parameters**

Notation	Variable	Point Estimate
α^{young}	Young Premium (\$1,000)	0.323***
		(0.069)
α^{old}	Old Premium (\$1,000)	0.088***
		(0.020)
β_1	Deductible (\$1,000)	-0.010**
		(0.004)
β_2	Subsidized Share	-0.078
		(0.247)
β_3	PCPs (per 100,000 people)	-0.0006**
		(0.0002)
β_4	Fair/Poor Health Rate	0.065
		(0.156)

Note: Non-linear Least Squares estimates of equation (21), with state FE, using 2015 rating data. Analytical robust standard errors in parentheses.

while the same premium increase for an older buyer reduces marginal profits by less than \$0.10. The fact that our estimates imply a smaller decrease in marginal profits for older consumers is consistent with an underlying demand-supply model in which older buyers have either higher per-person expected cost, lower sensitivity to increases in premiums, or both. These features of the underlying model are relatively uncontroversial, and are consistent with results in — among others — Bundorf, Levin, and Mahoney (2012); Handel, Hendel, and Whinston (2015); Ericson and Starc (2015); Geruso (2016); Tebaldi (2017).

The remaining parameters capture heterogeneity in per-person marginal profits across products and regions. In particular, we find that deductible reduces per-person marginal profits, consistent with a demand model in which less generous coverage increases the sensitivity of demand to premium increases, and/or a cost model in which marginal costs are lower for products with a high deductible.

Unconstrained prices. Solving equations (23) and (24), we obtain the unconstrained prices that would have been set, ceteris paribus, if age-rating restrictions were not applied. The results are summarized in Table 7.

We report both constrained and unconstrained premiums for each age, averaged across regions. The difference between these values corresponds to the average increase (decrease) in premiums faced by young (old) consumers as a result of the age-rating restrictions. The estimated impact of the regulation is to reduce the benchmark premium for buyers between 50 and 64 by \$930/year, a 10.7% premium-reduction, and to increase premiums for younger buyers by \$230, corresponding to a 9.8% premium-increase.

The effect of the age-rating regulation is highly heterogeneous across regions, varying with the age-composition of the market. The youngest regions (1st quartile of share of uninsured older

Table 7: **Comparison between constrained and unconstrained premiums**

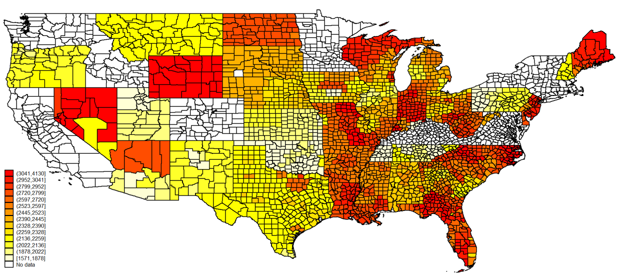
	Young Buyers (20-49)	Old Buyers (50-64)
Unconstrained Premium ($1,000)	2.341	8.642
	(0.140)	(0.690)
Constrained Premium ($1,000)	2.571	7.713
	(0.014)	(0.125)
Difference ($1,000)	0.230	-0.930
	(0.139)	(0.689)
(%) Premium Change (Q1 of Share Aged 50-64)	8.349	-11.964
(%) Premium Change (Q2 of Share Aged 50-64)	9.001	-11.434
(%) Premium Change (Q3 of Share Aged 50-64)	10.694	-10.058
(%) Premium Change (Q4 of Share Aged 50-64)	11.205	-9.643

Note: Counterfactual premiums are computed solving equations (23) and (24) using the estimates from Table 6. Standard errors in parentheses, computed analytically via Delta-method.

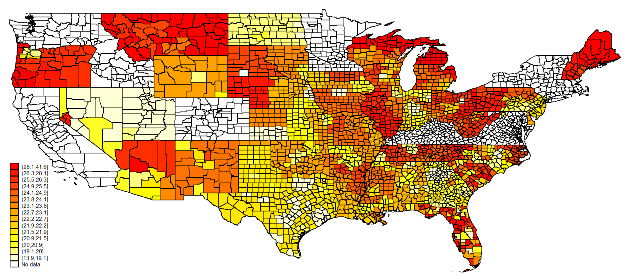
than 50) see a 8% premium increase for young buyers, and a 12% decrease of the premium for old buyers. On the other hand, the oldest regions (4th quartile) see an 11% increase in premium for young buyers and a 9.6% decrease in the premium for those older than 50.

Figure 8: **Premiums, share aged 50-64, and effect of age-rating restrictions**

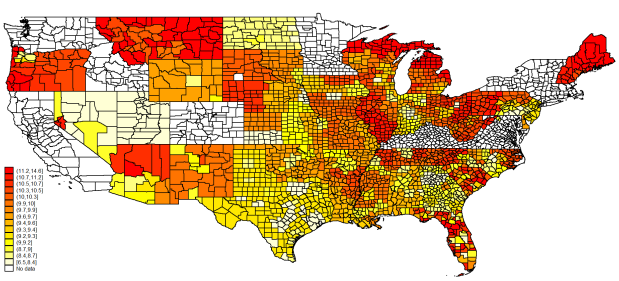
(a) 2015 ACA annual premium for 21-year-olds



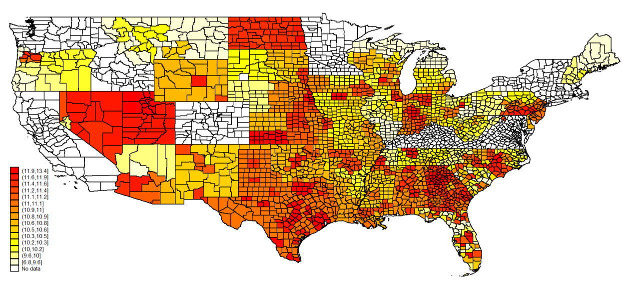
(b) Share of 2013 uninsured aged 50-64 in the region



(c) Effect of SARC: % Increase of under-50 premiums



(d) Effect of SARC: % Decrease of over-50 premiums



Note: Heterogeneity across counties in base prices (panel (a)), share of uninsured older than 50 (panel (b)), increase of under-50 premiums due to age-rating restrictions (panel (c)), and decrease of over-50 premiums due to age-rating restrictions.

To illustrate this heterogeneity across the entire estimation sample, Figure 8 shows how premiums vary across counties in the 35 state exchanges we observe in our data (panel (a)), the variation in the share of uninsured older than 50 (panel (b)), and the percentage change in premium for the two age groups (panel (c) and (d)) induced by the age-rating restrictions.

The differences in the effect of age-rating both across and within states are as large as 7% premium increase (decrease). This suggests that the adoption of a unique SARC for the entire U.S. leads — ceteris paribus — to important cross-market differences in market outcomes. Therefore consumers, insurers, and the government could benefit from a tailored premium age bands properly accounting for the age-composition of different geographic markets.

5 Effect of ACA age-rating on demand and public spending

The last step of our analysis amounts to provide a back-of-the-envelope measure of how the effect of age-rating on premiums impacted public spending and enrollment in the exchanges.

To answer this question, we use the 2015 enrollment data together with estimates of semi-elasticity of insurance demand to premium from three different sources: Tebaldi (2017), providing semi-elasticities for all four groups (young and old, subsidized and unsubsidized), Ericson and Starc (2015), providing elasticity for the unsubsidized, distinguishing between young and old, and Finkelstein, Hendren, and Shepard (2017), providing elasticities for the subsidized, without distinction of age. These semi-elasticities are summarized in Table 8.

To measure the effect of the age-rating restriction on demand and spending, using the subsidy formulas in (2) and (3) we calculate the size of the subsidy and the post-subsidy premium faced by buyers of different ages if the premiums were equal to the unconstrained one calculated above. For old, subsidized buyers, who would face higher pre-subsidy premium without age-rating, the subsidized premium is unchanged, while the subsidy increases by the exact same amount as the pre-subsidy premium. This is also true for the vast majority of young, subsidized buyers; the exception are those living in markets with particularly low benchmark prices (see Figure 3), who do not receive subsidies and would then benefit fully from lower premiums if age-rating restrictions were relaxed. Lastly, for (the small group of) unsubsidized buyers who are fully exposed to price changes, we calculate the effect of age-rating restrictions on their participation.

Table 9 summarizes our results, where numbers in each column are calculated using the cor-

Table 8: **Semi-elasticities by age and income from the literature**

Group:		Source:		
Income	Age	Tebaldi (2017)	Ericson and Starc (2015)	Finkelstein, Hendren, and Shepard (2017)
		Change in total demand if prices increase by $100/year		
High-Income	21-49	-3.02%	-2.79%	n/a
(>400% FPL)	50-64	-1.91%	-0.77%	n/a
Low-Income	21-49	-5.75%	n/a	-5.34%
(100-400% FPL)	50-64	-2.10%	n/a	-5.34%

Table 9: **Effect of age-rating restrictions on enrollment and public spending**

	Source of semi-elasticity estimates		
	Tebaldi (2017) (All Groups)	Finkelstein, Hendren, and Shepard (2017) (Subsidized Only)	Ericson and Starc (2015) (Unsubsidized Only)
Unconstrained Subsidized Enrollment 21-49 (mn)	4.88	4.86	n/a
Effect of age-rating restrictions	*-0.19 (-3.89%)*	*-0.18 (-3.70%)*	n/a
Unconstrained Subsidized Enrollment 50-64 (mn)	2.61	2.61	2.61
Effect of age-rating restrictions	*0.00*	*0.00*	*0.00*
Unconstrained Unsubsidized Enrollment 21-49 (mn)	0.78	n/a	0.78
Effect of age-rating restrictions	*-0.05 (-6.4%)*	n/a	*-0.04 (-5.13%)*
Unconstrained Unsubsidized Enrollment 50-64 (mn)	0.34	n/a	0.38
Effect of age-rating restrictions	*0.07 (+20.58%)*	n/a	*0.03 (+7.9%)*
Unconstrained Subsidy Spending 21-49 ($bn)		0.50	
Effect of age-rating restrictions		*0.67 (+134%)*	
Unconstrained Subsidy Spending 50-64 ($bn)		16.13	
Effect of age-rating restrictions		*-2.46 (-15.25%)*	
Total Unconstrained Subsidy Spending ($bn)		16.63	
Effect of age-rating restrictions		*-1.79 (-10.76%)*	

Note: Subsidized Enrollment/Subsidy calculated using 250% of FPL as a representative subsidized enrollee (mid-point of 100-400%)

responding semi-elasticities, when available. These calculations imply that, in our sample of 35 federally facilitated exchanges, the adoption of the SARC led to a decrease in subsidy spending of $1.79 billion (-11%) in 2015. This is the difference between the extra spending for subsidies to young buyers ($670 million) and the large decrease in spending for old buyers ($2.45 billion).

Looking at quantity changes, this exercise suggests that age-rating did not affect participation of old, subsidized buyers, since their (benchmark) prices do not change as the base-prices decrease due to the age-rating rules. For young subsidized, the fraction of those affected is non-zero, and we calculate that the age-rating restrictions decreased participation among this group by 3.7-3.9%.

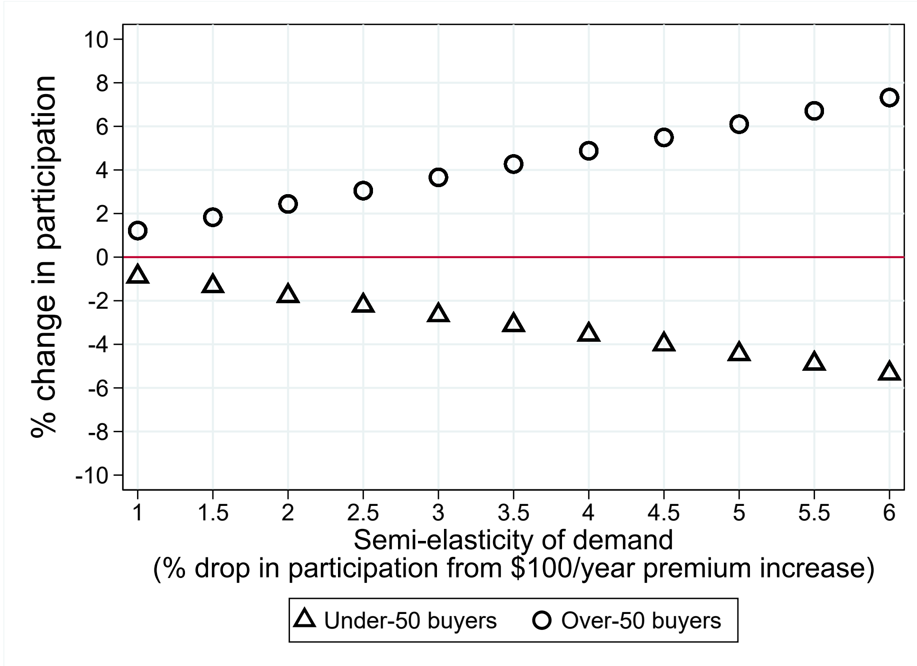
The non-subsidized buyers are fully exposed to the price changes induced by the age-rating restrictions. Older buyers are better off, and younger buyers are worse off; this is the main point of Ericson and Starc (2015) and we find the same in our context. For the younger, for which Ericson and Starc (2015) and Tebaldi (2017) estimate similar semi-elasticities, we find that the SARC discouraged participation of 5-6.5% of buyers. For the older, we find a 20% increase in participation using the semi-elasticity from Tebaldi (2017), while a smaller increase (8%) using the lower semi-elasticity from Ericson and Starc (2015).

As a last exercise, Figure 9 considers a wide range of semi-elasticities, and for each age-group we plot (on the Y-axis) the corresponding effect of age-rating restrictions on participation.

Going from low price sensitivity (1% semi-elasticity) to high price sensitivity (6% semi-elasticity), the effect of age-rating restrictions on the participation of under-50 buyers, without distinguishing between high and low-income, goes from a decrease of less than 1% to a decrease of less than 6%.

For the older group, going from a 1% semi-elasticity to a 6% semi-elasticity implies that the increase in participation generated by the age-rating restrictions goes from slightly more than 1%

Figure 9: **Effect of age-rating regulations on enrollment, different semi-elasticities**



Note: The graph shows for over-50 (circles) and under-50 (triangles) the effect of age-rating restrictions on participation in the exchanges, as a function of the corresponding semi-elasticity of demand.

to almost 8%.

Both of these effects are smaller, in relative terms, to the 11% reduction in public spending due to differences in subsidies necessary to guarantee affordability of premiums at the federally set maximum affordable amounts.

6 Conclusion

In this paper we combined pre- and post-ACA data to provide evidence that the age-rating rules mandated by the ACA are binding, imposing a lower slope of the age-rating schedule than the one insurers would have set without the regulation, ceteris paribus. As a consequence, we also find that markets with a larger share of uninsured who are relatively older face higher pre-subsidy premiums. This relationship between premium and age-composition of a market was not present before the ACA.

Using a stylized model of regional price-setting under the ACA age-rating rule, we calculated the prices that would have resulted in the same regions if age-rating was unconstrained. We find that the regulation led, on average, to a $230/year price increase for young buyers and a $930/year decrease for old buyers. This effect is highly heterogeneous across regions, varying by up to 7% of average annual premiums between relatively young and relatively old markets.

Using elasticities from the literature, enrollment data from the 2015 ACA exchanges, and applying the formula underlying the ACA subsidy scheme, we find that the age-rating restrictions led to large savings for the government (11%), discouraged participation of young buyers (4% decrease), and encouraged participation of older buyers (2% increase).

A richer empirical framework combined with richer plan-level enrollment and/or claims data could be used to extend this analysis. First, one could estimate a model of multi-plan, horizontally differentiated insurers, allowing for richer heterogeneity across buyers. This would allow our framework to provide more precise measures of the effects of specific policies, including age-rating rules and subsidy schemes. These measures could then be mapped directly to more precise normative statements than the very limited ones that we are able to provide with this article.

Second, additional data could help distinguish between demand and cost curves rather than estimating highly parametrized marginal profit functions. It would then be possible, and desirable, to find the welfare-maximizing combination of age-rating and subsidies as a function of the characteristics of a state (or region) in terms of uninsured population and structure of the health insurance market. This is an important agenda for future work, considering the growing role of state authorities in the calibration of the policy parameters to be used in the health insurance marketplaces for the individual insurance market.

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Appendix A: Panel Regressions

This appendix reports in tabular format the estimates of specifications (15) in the paper, used to produced Figure 7. County-level panel estimates are in Table 10, while region-level panel estimates are in Table 11.

Table 10: Panel Regression - County-level

	(1)	(2)	(3)	(4)
	Premium for 21-year-old (county-year level)			
Aged 50-64 Share 2008	14.9	6.87	12.8	2.06
	(24.6)	(24.7)	(25.0)	(25.4)
Aged 50-64 Share 2009	26.6	19.0	19.7	19.6
	(21.8)	(22.0)	(22.0)	(22.8)
Aged 50-64 Share 2010	-3.53	-11.2	-9.64	-22.6
	(23.7)	(23.7)	(23.3)	(23.4)
Aged 50-64 Share 2011	-49.8*	-57.4**	-56.0**	-34.6
	(26.7)	(26.8)	(27.2)	(29.1)
Aged 50-64 Share 2012	4.21	-4.40	-1.53	0.38
	(41.1)	(41.0)	(42.0)	(45.1)
Aged 50-64 Share 2014	21.9**	17.2*	19.6*	18.1*
	(10.2)	(10.2)	(10.2)	(9.99)
Aged 50-64 Share 2015	23.6***	19.1**	21.1**	19.2**
	(8.74)	(8.74)	(8.77)	(9.21)
Aged 50-64 Share 2016	67.7***	63.2***	64.7***	60.5***
	(11.6)	(11.6)	(11.8)	(12.6)
Aged 50-64 Share 2017	63.9***	59.4***	63.4***	55.4**
	(19.9)	(19.9)	(20.3)	(21.6)
Deductible	-7.65***	-7.67***	-7.62***	-7.18***
	(0.29)	(0.29)	(0.29)	(0.29)
Subsidized Share		48.9***	49.5***	38.3***
		(9.28)	(9.60)	(11.0)
PCPs (per 100,000 people)			0.016**	0.023***
			(0.0076)	(0.0080)
Fair/Poor Health Share				20.4***
				(6.82)
State-Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	13150	13150	12690	11330
Adjusted R-squared	0.91	0.91	0.91	0.91

The level of observation is the county-year.
Robust standard errors are in parentheses.
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 11: Panel Regression - Region-level

	(1)	(2)	(3)	(4)
Aged 50-64 Share 2008	-3.31	-12.2	-20.9	-17.3
	(39.0)	(39.3)	(39.0)	(39.4)
Aged 50-64 Share 2009	-41.2	-52.2	-56.5*	-54.4
	(32.6)	(33.7)	(33.9)	(34.2)
Aged 50-64 Share 2010	-51.4	-59.1	-63.9	-61.8
	(39.9)	(40.6)	(41.6)	(41.9)
Aged 50-64 Share 2011	-45.7	-53.5	-64.2	-62.4
	(48.2)	(49.2)	(49.0)	(49.3)
Aged 50-64 Share 2012	40.7	27.3	12.7	14.2
	(71.6)	(71.2)	(73.1)	(72.7)
Aged 50-64 Share 2014	63.9	54.9	48.0	49.8
	(40.7)	(39.5)	(40.0)	(40.3)
Aged 50-64 Share 2015	115.4***	106.5***	99.7**	101.4**
	(39.9)	(39.1)	(39.5)	(39.8)
Aged 50-64 Share 2016	196.2***	187.4***	180.2***	182.0***
	(57.8)	(57.1)	(57.5)	(57.7)
Aged 50-64 Share 2017	144.9	136.0	129.2	131.0
	(96.1)	(95.7)	(95.9)	(96.2)
Deductible	-6.65***	-6.67***	-6.60***	-6.59***
	(0.49)	(0.49)	(0.50)	(0.50)
Subsidized Share		59.8**	21.8	39.3
		(26.9)	(28.5)	(31.1)
PCPs (per 100,000 people)			-0.10***	-0.11***
			(0.027)	(0.027)
Fair/Poor Health Share				-22.0
				(19.7)
State-Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	2885	2885	2885	2885
Adjusted R-squared	0.91	0.91	0.92	0.92

The level of observation is the region-year. Robust standard errors are in parentheses.
* $p < .1$, ** $p < .05$, *** $p < .01$

Regulated age-based pricing under the ACA

ONLINE APPENDIX I:

Data Sources and Variables

Variable(s)	Description	Source
1. Pre-ACA Premium/Deductible	Application-weighted average	Proprietary Dataset
2. ACA Premium/Deductible	Second cheapest (benchmark) plan in region and associated deductible	CMS.gov
3. Uninsured Population	Total Uninsured Population	SAHIE
4. Aged 50-64 Share	Share of uninsured population aged 50-64	SAHIE
5. Subsidized Share	Share of uninsured population with household income >138% & <400% of FPL	SAHIE
6. Primary Care Physicians (per 100,000 people)	Amount of PCPs per 100,000 population	AHRF
7. Fair/Poor Health Share	Share of population reporting fair or poor health	Dartmouth
8. IPPS OPPS Wage Index	Medicare Advantage FFS payment based on IPPS & OPPS	CMS
9. African American Share	Non-hispanic African-American share of population	Dartmouth
10. Teen Birth Rate	Teen birth rate (per 100 females aged 15-19)	Dartmouth
11. Chlamydia Rate	Chlamydia rate (per 100 population)	Dartmouth
12. Average Household Size	Average Household Size	USDA
13. ACA 2015 Enrollment	ACA enrollment by age and income sub-categories	ASPE.gov
14. Private Insurance Claims paid by Insurer	2013 average healthcare costs	MEPS

Note: When collapsing to the regional level 2013 Total Uninsured Population was used to weight the different counties
Sources:
Dartmouth - http://www.countyhealthrankings.org/
SAHIE - http://www.census.gov/did/www/sahie/data/20082014/index.html/
AHRF - Area Health Resource Files
CMS - http://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/Downloads/ffs2013.zip
USDA - https://www.ers.usda.gov/data-products/atlas-of-rural-and-small-town-america/documentation/
MEPS - MEPS HC-163