PRICING REGULATION AND IMPERFECT COMPETITION ON THE MASSACHUSETTS HEALTH INSURANCE EXCHANGE

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Abstract—We analyze insurance-pricing regulation under imperfect competition on the Massachusetts health insurance exchange. Differential markups lead to price variation apart from cost variation. Coarse insurer pricing strategies identify consumer demand. Younger consumers are twice as price sensitive as older consumers. Older consumers thus face higher markups over costs. Modified community rating links prices for consumers differing in both costs and preferences, and changes the marginal consumer firms face. Simpler regulations transfer resources from low-cost to high-cost consumers, reduce firm profits, and increase overall consumer surplus.

1. Introduction

HEALTH insurance exchanges (HIXs)—government-run marketplaces for private insurance—raise new questions about the regulation of insurance markets. On exchanges, consumers choose from a set of plans that vary not only in financial characteristics but also in brand, reputation, and provider network. As a result, insurance plans are imperfect substitutes, giving insurers market power that allows them to charge markups over costs. Insurance markets are also heavily regulated, and these regulations are controversial—for instance, the role of modified community rating and the effect of mandates to purchase a minimum level of insurance coverage. However, there is a lack of research that examines how insurance pricing regulation functions in imperfectly competitive, consumer choice-driven marketplaces.

HIXs are an ideal context to study these issues, as they offer a wide range of choice to consumers. HIXs are also interesting and important in themselves. The 2010 Affordable Care Act (ACA) set up HIXs to facilitate the purchase of insurance directly by consumers. A projected 20 million individuals will purchase through the exchanges (Congressional Budget Office, 2012). HIX are novel regulatory environments, and states and the federal government will have substantial latitude in designing and regulating them. Their choices will shape the market for individually purchased health insurance. For instance, HIXs can control what types of insurance plans are offered, how information about them is presented to consumers, how prices can vary across consumers, the defaults individuals face, and the frequency of the open enrollment period. However, little is known about the nature of demand for health insurance in such a setting. Understanding consumer demand and insurer incentives is important for both exchange design and the broader regulation of insurance markets.

The Massachusetts HIX provides an early look at a comprehensive HIX in action, as it is similar to the ACA’s exchanges but was created by the state’s own reforms and has been providing coverage since 2007. While regulation of HIXs is still in flux, HIXs differ importantly from the way most individuals in the United States currently obtain health insurance: employer-sponsored insurance or government-provided coverage (that is, Medicare or Medicaid). Other markets also offer insight into HIXs but have crucial differences. Medicare Part D’s insurance exchange has been a fruitful field of research, but offers a limited type of coverage (prescription drug insurance) to a narrow age range (the elderly). Employer-sponsored insurance typically offers a limited range of choice (see Dafny, Ho, & Varela, 2013, on the value of choice in these contexts), though some large employers may offer a range of choice akin to an HIX. However, employer-sponsored insurance differs from HIXs in how it is regulated (e.g., plans cannot price differentially by age in employer plans) and in the nature of competition (the employer negotiates directly with insurers). Finally, individual markets for direct purchase of insurance are currently small and decentralized, covering only about 5% of the population, with high search costs (Maestas, Schroeder, & Goldman, 2009) and limited public data.

Our analysis of consumer choice on the Massachusetts HIX provides the basis for counterfactual simulations that examine how modified community rating regulation interacts with insurer incentives under imperfect competition. We build on the existing literature that shows evidence of insurer market power in other contexts (for examples, see Dafny, Duggan, & Ramanarayan, 2012; Dafny, 2010; and Starc, 2014). We knit together this literature with the literature on community rating laws, which has examined the effect of community rating on coverage rates (Simon, 2005, Zuckerman & Rajan, 1999), and equilibrium outcomes assuming perfect competition (see Finkelstein, Poterba, & Rothschild, 2009, on gender-based pricing in annuities and Geruso (2011), on preference heterogeneity under perfect competition). Our work, however, emphasizes the importance of accounting for imperfect competition when analyzing these regulations.

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We focus on age-based pricing regulation, a particular type of modified community rating. This regulation can have a substantial effect on the prices individuals face in insurance markets, but researchers have generally neglected it. Under such regulation, older individuals may be charged higher prices than younger individuals, but only within a certain band, up to the maximum allowable price ratio. In Massachusetts, this ratio is 2, so the oldest enrollees cannot be charged more than twice the price charged the youngest. Because this regulation restricts how insurers can vary prices based on consumer characteristics, it is a form of modified community rating. Pure community rating, in which all consumers in a risk pool face the same price, creates a trade-off: welfare losses from adverse selection, against which are weighed welfare gains from insuring consumers against the possibility of being a bad risk by having higher expected medical spending. Modified community rating, in which insurers are allowed to vary premiums across consumers within limits, attempts to mitigate some of the welfare loss. The traditional analysis of community rating focuses on how the regulation links prices for consumers with different costs, and under the assumption of perfect competition, average prices will match average costs. However, community rating also links prices for consumers with different preferences—particularly how responsive consumers are to price. These preferences matter for price setting under imperfect competition.

We estimate a discrete choice model of consumer demand on the Massachusetts HIX, focusing on how price sensitivity varies by age. We use coarse firm pricing by age to overcome the endogeneity problem and identify consumers’ response to price. There is substantial variation by age in demand elasticities: younger consumers are more than twice as price sensitive as their older counterparts. Because price sensitivity varies by age, insurers would want to price-discriminate and charge higher prices to older enrollees, even if health costs did not vary by age. In contrast, existing work has assumed that insurers price differentially by age solely due to cost differentials (Blumberg, Buettgens, & Garrett, 2009), so assumes that regulations bind only to the extent the ratio of costs exceeds the maximum allowable ratio of prices by age. In general, though, profit-maximizing insurers will price-discriminate by responding to heterogeneity in consumer demand that is correlated with observable tags. Here we study age, but similar rationales apply to family size, gender, and geographic location.

Using our estimates, we simulate insurers’ optimal pricing under various models of market structure and examine the potential welfare effects of alternative pricing regulations.

We conduct a counterfactual exercise in which we estimate the distributional consequences of eliminating or tightening age-based pricing rules. Accounting for price discrimination is crucial in estimating the effect of such regulation. Compared to unconstrained insurer prices, the Massachusetts maximum allowable price ratio of 2 is estimated to raise prices on young consumers by 23%. However, setting the maximum allowable price ratio to the ratio of prices by age to the ratio of costs by age still leads to price increases on younger consumers of about 5%; these increases would not occur under perfect competition.

Despite these transfers, modified community rating improves surplus overall. The imperfectly competitive insurers price to the marginal, rather than the average, consumer. The marginal consumer in a plan is likely to be a young consumer with a relatively high price elasticity and relatively low medical expenditures. As a result, with binding-modified community rating, average prices, profits, and markups are lower than without regulation.

Finally, modified community rating can lead to severe welfare losses in the absence of an effective mandate. Even if risk adjustment were perfect, so that insurer costs did not differ by enrollee age, differences in preferences alone can lead this market to partially unravel. If consumers are allowed to opt out of coverage, modified community rating restrictions will lead the most price-sensitive consumers to opt out. As these consumers opt out, less price sensitive consumers are left in the market, leading to higher markups. This in turn leads more price-sensitive consumers to opt out of the market. If the participation elasticities are high enough, only price-insensitive consumers are left in the market. As a result, a weak or absent mandate may negate the consumer surplus gains achieved from modified community rating.

The preference heterogeneity that we identify is critical for analyzing policy, and this implies that choosing the set of consumers who form a risk pool is critical for determining the functioning of and allocation of surplus within insurance markets. When defining which segments of consumers to include in a health insurance exchange (e.g., subsidized enrollees, younger consumers eligible for catastrophic plans, or employees in small groups), understanding differences in preferences is as critical as understanding differences in cost.

The paper proceeds as follows. Section II describes the Massachusetts HIX, rating regulation, and some reduced-form results. Section III details our identification strategy and develops and estimates our model of consumer demand. Section IV derives optimal pricing behavior under imperfect competition and modified community rating regulation. Section V simulates insurance market outcomes under alternative age-based pricing regulations. Section VI examines how pricing regulation affects participation in the HIX in the absence of an effective mandate to purchase insurance. Section VII concludes.

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2 Existing estimates of price sensitivity for health insurance vary substantially by context, and most examine employer-sponsored health insurance. The only work addressing HIXs specifically is Ericson and Stare (2012a), whose measures of price sensitivity do not account for the endogeneity of premiums; instead, that paper focuses on the role of heuristics in choice. See also Carlin and Town (2008), Gruber and Washington (2005), Bundorf, Levin, and Mahoney (2012), and Einav, Finkelstein, and Cullen (2010).

3 Plan prices are constant within five-year age blocks (e.g., ages 30 to 34), and then jump.

4 We note that it is not clear why one would want to transfer from younger to older consumers in this way.
II. The Massachusetts Connector: Context and Data

A. Massachusetts’s Health Reform

The commonwealth of Massachusetts signed its health care bill into law in April 2006 with the goal of providing universal coverage for its residents; the reform, in turn, served as a national model for health reform. This reform had many features, including expansions in public coverage, and individual and employer mandates. A key feature was the individual mandate, which required all Massachusetts residents to purchase a minimal level of health insurance coverage (minimum creditable coverage) or face a penalty equal to half of the premium of the lowest-cost health insurance plan offered through the exchange. To facilitate consumers purchasing insurance, the state required employers with eleven or more employees to make a fair and reasonable contribution to employees’ health insurance costs. It also established the Commonwealth Care Program, which provided free or subsidized coverage to lower-income residents, who earned up to 300% of the federal poverty level.5

Finally, the reform established an unsubsidized health insurance exchange that is the focus of this paper. The Massachusetts HIX (known as the Commonwealth Choice Program) was designed to facilitate nongroup coverage purchased directly by households and small group purchase of insurance. It has offered health insurance since May 1, 2007 (with the mandate taking effect July 1, 2007). Both the HIX and the Commonwealth Care Program are run by the Commonwealth Connector Authority, a quasi-public agency that shapes the market for individual coverage in Massachusetts in a number of ways. The Connector operates the exchange’s website, negotiates with insurers, and chooses which features of insurance plans are highlighted.

After the Massachusetts reform, the rate of uninsurance dropped. By 2009, 97.3% of the population was insured (Long & Phadera, 2009); the insurance rate for residents above 300% of the poverty line (i.e., those eligible for the exchange) was 99.1%. Increases in the insured came from individuals purchasing insurance through the Massachusetts HIX, increased offering of employer-provided health insurance, and expansions in subsidized coverage (Gruber, 2011). Kolstad and Kowalski (2010) show that the Massachusetts reform not only increased coverage but also decreased hospitalization for preventable conditions. However, the effect of the health reform and the HIX on the level and growth of inpatient for preventable conditions. However, the effect of the health reform and the HIX on the level and growth of
drate of premiums is a point of contention. By characterizing consumer demand and market structure in this paper, we provide a foundation for future analysis of the impact of the reform.6

5 The Commonwealth Care program is quite different from the HIXs established by the ACA, as enrollees do not choose among plans of different generosities but are assigned to a plan tier based on their income. In addition, prices in Commonwealth Care do not vary by age.

6 For an overview of the Massachusetts reform and its various components, see Ericson and Stare (2012b), Levy (2012), Miller (2012), and Long, Stockley, and Nordahl (2012).

B. Regulation of the Health Insurance Exchange

In addition to the individual mandate to purchase insurance, there are three other important regulations for the Massachusetts HIX that we consider.

Minimum creditable coverage (MCC). MCC is the least generous plan that is sufficient to comply with the mandate. The Connector is responsible for determining MCC for the state based on a combination of actuarial value, out-of-pocket maximum, deductibles, covered physician visits, and prescription coverage. In Massachusetts, MCC includes prescription drug coverage and three checkups, caps out-of-pocket expenditures at $5,000 for an individual and $10,000 for a family. A large number of policies just satisfying MCC are available, and they are quite popular. Therefore, regulation regarding the definition of MCC is likely to be important in a market with a mandate.7

Modified community rating. Modified community rating rules apply to pricing on the exchange. Prices for products can vary by age (and geography), but the ratio of a price for a given product for any two individuals cannot exceed the maximum allowable price ratio, which is 2 in Massachusetts. This establishes an age band within which prices can vary. In addition, no medical underwriting is allowed, and plans are guaranteed issue (no one can be denied coverage). These rating rules are critical in shaping premiums in the market. Age, in particular, is a critical feature of pricing.8

Figure 1 shows that age-based pricing regulations are binding: the average monthly premium for a 27-year-old is just

7 Finkelstein (2004) finds that minimum standards can reduce enrollment by potentially exacerbating adverse selection. However, in the presence of a mandate, such concerns are much less pressing.

8 Firms are constrained by age within rather than across postal codes. For example, the price for a 64-year-old in Boston may be related to the price of a 27-year-old in Boston, but not a 27-year-old in Worcester.
over $300, and the premiums for older consumers are just over $600. While the ACA specifies a three-to-one maximum allowable age rating band in the individual health insurance exchanges, states can impose stricter regulation. For example, Maryland has chosen a price ratio of 2.8. The choice of this ratio will alter both the size and division of surplus among young consumers, older consumers, and firms. We note that price discrimination through plan design is largely prohibited by the mechanisms in place by the regulator, especially minimum creditable coverage, which outlaws catastrophic plans with extremely high deductibles (e.g., $10,000 per year).

Minimum loss ratios. Minimum (medical) loss ratios require that insurers pay out a certain percentage of premiums in medical claims. The Massachusetts reforms did not contain minimum loss ratio regulation, and no such regulations were in effect during the time period we analyze. However, the ACA required a minimum loss ratio of 0.80 for individual and small group markets and 0.85 for large employers beginning in 2011.

C. Making Choices on the Exchange

The exchange offers a variety of health plans administered by the major private insurers in the state.9 Insurers had relatively wide latitude in designing these plans, which were grouped into tiers based on actuarial value: bronze, silver, and gold.10 Bronze plans are generally less generous (higher cost sharing) and therefore tend to be cheaper. Gold plans are the most generous, and hence most expensive, and silver plans forge a middle ground. In addition to this main market, there is a separate market for young adult consumers aged 18 to 26, in which plans tend to have more limited coverage, such as optional prescription drug coverage.

Plans are differentiated along a number of dimensions. Insurers vary in their network and perceived brand quality, and even within a tier, plans vary in their copayments, deductibles, and premiums. Table A.1 in the online appendix presents hedonic regressions that show substantial heterogeneity in price levels across insurers, even after accounting for tier and actuarial value of plans. Blue Cross Blue Shield and Harvard Pilgrim are the two most (and high-brand-quality) expensive insurers, and Neighborhood Health Plan is the cheapest. As a result, this environment looks similar to other imperfectly competitive insurance markets (e.g., as in Dafny, 2010, or Starc, 2014).

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The website itself, in addition to regulation, has the potential to shape consumer choices. (Screenshots from the purchasing process are included in the appendix.) Tiering can also affect how insurers design plans; for example, they may design plans to meet the minimum level of generosity in a tier. The way information is presented, plan features highlighted, and order in which plans are sorted may also affect consumer behavior. For instance, Ericson and Starc (2012a) finds a discontinuity in preference for the minimum choice plan. During the initial period, the website sorted plans according to price (as opposed to, for example, consumer satisfaction) so consumers may have inferred that price was the most important variable differentiating these plans.

D. Data and Descriptive Statistics

We use transaction-level data (purchase, cancelation, and payments) from the unsubsidized market, Commonwealth Choice, from its launch in July 2007 until December 2009 and observe approximately 50,000 transactions. There are large spikes in initial enrollment during the first month of the exchange’s operation, as well as just before the individual mandate’s financial penalties took effect in December 2007. Appendix figure A.1 plots a histogram of the number of individuals choosing single coverage joining the Connector for the first time, by month (the majority of purchases are for single coverage); it shows a steady-state enrollment rate of about 500 individuals per month.

Because we observe transaction-level data, we do not observe all the plan prices that individuals face. However, for November and December 2009, we collected an extensive set of price quotes from the exchange’s website using a Perl script, allowing us to create the plan menu that each enrollee faced. (The data appendix gives more details.) We have explored robustness checks on a subset of the data that extends back to July 2009 (see the data appendix). The choice of sample period does not have an effect on our results.

Table 1 describes the demographics of enrollees on the exchange, broken down into four samples. Column 1 shows descriptive statistics for the full time period, 2007 to 2009, and column 2 limits the sample to our time period, November and December 2009. These samples look similar. Our analysis sample is given in column 3, which includes ages 27 to 64 only; it excludes those 26 and under, since they are eligible for, and typically purchase in, a separate, young adult plan market. The sample includes only enrollees purchasing individual coverage (as compared to household coverage), since the majority of plans sold are of this type. Column 3 includes both new and repeat enrollees, but less than 10% of the sample is repeat enrollees. (For more detail on duration of enrollment in the exchange, see Ericson & Starc, 2012b.) Finally, column 4 describes enrollees joining the exchange for the first time in November and December.

In our sample, the following firms sold insurance using the Connector: Blue Cross Blue Shield of Massachusetts, Fallon Community Health Plan, Harvard Pilgrim Health Care, Health New England, Neighborhood Health Plan, and Tufts Health Plan. All of these insurers are nonprofit, but Dafny and Ramanarayanan (2012) show that for-profit and nonprofit insurers behave similarly.

Note the ACA establishes four tiers in the HIXs (it adds platinum), with slightly different definitions for the tiers. Also, beginning in 2010 (after our sample), the Connector required plans to take one of six standardized forms (e.g., bronze low, bronze high), though plans may still differentiate themselves based on their provider networks. See Ericson and Starc (2013) for an analysis of plan standardization.
Our analysis sample uses one observation per enrollee who purchased during November or December 2009. This sample includes repeat enrollees who purchased previously (in November and December 2008, because contracts are annual), since they comprise part of the demand curve that firms face and thus affect optimal pricing. However, repeat enrollees may display inertia (Ericson, 2014; Handel, 2013), and their choices may not reflect their underlying preferences. Since tenure on the exchange is so short, approximately 90% of our enrollees are first-time choosers. Thus, even if we estimate preferences of of first-time choosers only, we find substantially similar results (see the appendix; for more on dynamics, see Ericson & Starc 2012b).

### III. Estimating Consumer Demand

#### A. Theoretical Model of Demand

The utility a person attaches to a plan is a function of his or her fundamental preferences (risk aversion and valuation of brand, network, and quality) and perceived risk of making a claim. We infer the utility that consumers attach to a plan based on consumers’ choices (a revealed preference approach), since we are modeling the demand curve that firms face. This approach is flexible; for instance, it accounts for adverse selection motives by allowing consumers to vary in the utility they attach to plans of different generosities.

A discrete choice model of plan is important in our context, as consumers are already clustered at the cheapest plans (about 25% choose the cheapest plan available to them in our sample period) and have little ability to reduce insurance spending in response to price increases. Reduced-form analyses (available in the appendix) misleadingly suggest little consumer response to price, but the discrete choice model accounts for consumers’ limited potential range of substitution.

The model we use to estimate consumer demand is a standard discrete choice logit model (Train, 2003). In this model, consumer i’s utility of plan j in market m is given by

\[ u_{ijm} = \delta_{jm} + \mu_{ijm} + \epsilon_{ijm}, \]

where \( \delta_{jm} \) is the mean utility of a plan in market m, \( \mu_{ijm} \) represents the (mean-zero) component of a plan’s utility that varies based on observed individual characteristics (e.g., age), and \( \epsilon_{ijm} \) is an error term that is independently and identically distributed (i.i.d.) extreme value. This implies shares can be written as

\[ s_{ijm} = \frac{\exp(\delta_{jm} + \mu_{ijm})}{1 + \sum \exp(\delta_{jm} + \mu_{ijm})}, \]

where \( s_{ijm} \) represents the probability that consumer i purchases product j in market m. In the absence of individual heterogeneity \( \mu_{ijm} \), the \( \delta_{jm} \) parameters simply represent an inversion of the observed market shares for each plan. The mean utility \( \delta_{jm} \) can be decomposed into price and plan characteristics, where \( \delta_{jm} = a p_{jm} + X_j \beta + \zeta_{jm} \), with \( X_j \) being either a vector of plan fixed effects or a vector of plan characteristics, such as insurer (brand), deductibles, and

#### Table 1.—Demographics of the Exchange

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of coverage</td>
<td>All</td>
<td>Single</td>
<td>Single</td>
<td>Single</td>
</tr>
<tr>
<td>Includes repeat enrollees</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Age</td>
<td>36.1</td>
<td>34.1</td>
<td>41.2</td>
<td>42.5</td>
</tr>
<tr>
<td>% Female</td>
<td>47.6</td>
<td>50.8</td>
<td>50.9</td>
<td>51.9</td>
</tr>
<tr>
<td>% single coverage</td>
<td>84.4</td>
<td>89.0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Premium paid</td>
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<td>$361</td>
<td>$364</td>
<td>$374</td>
</tr>
<tr>
<td>Percent in tier</td>
<td>41.5</td>
<td>39.9</td>
<td>63.9</td>
<td>60.8</td>
</tr>
<tr>
<td>Bronze</td>
<td>21.3</td>
<td>20.5</td>
<td>28.1</td>
<td>30.5</td>
</tr>
<tr>
<td>Silver</td>
<td>7.4</td>
<td>5.5</td>
<td>8.0</td>
<td>8.7</td>
</tr>
<tr>
<td>Young Adult Plan</td>
<td>29.9</td>
<td>34.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Percent with insurer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue Cross Blue Shield</td>
<td>31.5</td>
<td>21.8</td>
<td>15.4</td>
<td>12.9</td>
</tr>
<tr>
<td>Fallon</td>
<td>15.4</td>
<td>21.1</td>
<td>20.3</td>
<td>21.1</td>
</tr>
<tr>
<td>Harvard Pilgrim</td>
<td>22.7</td>
<td>24.3</td>
<td>17.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Health New England</td>
<td>2.8</td>
<td>3.8</td>
<td>5.6</td>
<td>6.1</td>
</tr>
<tr>
<td>Neighborhood</td>
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<td>24.8</td>
<td>36.7</td>
<td>38.7</td>
</tr>
<tr>
<td>Tufts</td>
<td>7.2</td>
<td>4.2</td>
<td>4.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Number</td>
<td>47,158</td>
<td>2,289</td>
<td>1,075</td>
<td>982</td>
</tr>
</tbody>
</table>

Numbers represent simple averages from the raw HIX enrollment data. Column 2 is limited to enrollees who selected a plan in November and December 2009. Columns 3 and 4 further limit the sample to enrollees who entered the exchange for the first time in November and December 2009.
copayments or, alternatively, plan fixed effects, \( p_{jm} \) is the price, and \( \zeta_{jm} \) is any unobserved product characteristic. A given insurance plan (e.g., HMO Blue Basic Value) is offered to all, ages 27 to 65, and in multiple (but not necessarily all) geographical markets.

In our main specifications, we use choices from all tiers to identify consumer preference parameters. We argue this is the best specification, as consumers can substitute across tiers. For example, the closest substitute to a bronze plan from a high-reputation insurance firm may be an actuarily more generous silver plan from a lower-reputation firm. (Indeed, some bronze plans are more expensive than some silver plans, even though the silver plans are actuarily more generous.) However, we also conduct specifications using other models of choice. In nested logit specifications, we assume consumers first pick a tier, then a plan. In other specifications, we identify off the variation in bronze plans alone and treat silver and gold plans as the outside option. In each case, the results are very similar to our main specifications.

B. Identification Strategy: Coarse Firm Pricing by Age

The degree of consumer price sensitivity affects insurer price-setting behavior and has implications for policy design. Estimates of price sensitivity are difficult to identify because unobserved plan characteristics may be correlated with price. Our identification strategy makes use of the coarseness in how firms set prices. While firms may vary prices continuously by age, they do not in fact set a different price for each age: they price more coarsely, in five-year age bins. Figure 1 shows that age, they do not in fact set a different price for each age: they price more coarsely, in five-year age bins. Figure 1 shows that firms do not perceive a discontinuity in preference or cost discrimination firm using coarse pricing rules.) Moreover, there are age trends in preferences, which we account for. We allow for \( \mu_j \) to evolve continuously over ages, but limited data require that we place some structure on how it does so. Estimating a separate linear spline in age for each of the 21 plans would allow a great deal flexibility but is infeasible in our data. We allow for preferences for plan tier (bronze, silver, gold) to evolve flexibly with age. Further, we allow different plans within a tier to have different qualities. In other specifications, we allow a linear trend in the age-plan fixed effect interaction. Ultimately the assumption that identifies the price coefficient in these specifications is that age-specific deviations in preference for plans within a given tier are not correlated with prices. This seems a reasonable assumption, and our results do not change substantially when we allow for more variability in age-specific preference for plans.

We use coarse geographical pricing to define markets. Instead of varying prices for each postal code, firms set prices for larger geographic regions that roughly correspond to hospital referral networks; these may be a good proxy for underlying insurer costs. For example, Blue Cross Blue Shield charges three sets of premiums: one for western Massachusetts, one for the greater Boston area, and one for Cape Cod. We use this variation to define a geographical region that is a set of postal codes in which prices do not vary within a plan-age cell. (See the online data appendix for details.) Within a market, prices for individual consumers vary based on age alone: it is this age variation that we use to identify price sensitivity.

In our discrete choice model, we identify the premium coefficient \( \alpha \) under the assumption that preferences evolve continuously with age. As described above, observed market shares allow us to infer mean utilities for each plan. We compute mean utility of plans by age from market shares by age. Under our assumption of continuous preferences, discontinuities in mean utilities at round-numbered ages are solely attributable to discontinuous changes in premiums, which then allows us to back out \( \alpha \).

For example, let \( \delta_j + \mu_{j30} \) be the mean utility of product \( j \) offered to consumers who are age 30 and \( \delta_j + \mu_{j29} \) be the mean utility of product \( j \) offered to a consumer who is age 29. From the choice model, we get consistent estimates of both mean utilities. In the absence of age trends, the price coefficient can be simply written as

\[
\alpha = E_j \left[ \frac{\mu_{j30} - \mu_{j29}}{p_{j30} - p_{j29}} \right].
\]

Of course, there are age trends in preferences, which we account for. We allow for \( \mu_j \) to evolve continuously over ages, but limited data require that we place some structure on how it does so. Estimating a separate linear spline in age for each of the 21 plans would allow a great deal flexibility but is infeasible in our data. We allow for preferences for plan tier (bronze, silver, gold) to evolve flexibly with age. Further, we allow different plans within a tier to have different qualities. In other specifications, we allow a linear trend in the age-plan fixed effect interaction. Ultimately the assumption that identifies the price coefficient in these specifications is that age-specific deviations in preference for plans within a given tier are not correlated with prices. This seems a reasonable assumption, and our results do not change substantially when we allow for more variability in age-specific preference for plans.

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13 When plan fixed effects are included, this is the market-specific deviation from the mean, as in Nevo (2001).

14 The marginal cost of choosing a more generous plan jumps correspondingly, as shown by appendix figure A.2. The ratio of the cost of the average gold plan to that of the average bronze plan varies slightly within each age category but stays between 1.8 and 2. Further details on price changes are included in appendix section A.2.

15 Without assuming that preferences evolve smoothly, the premium coefficient is not separately, nonparametrically identified from variation in preferences over plans. This is because the premium is itself a (highly nonlinear) function of demographic characteristics, such as age, that may also affect preference for plans or benefit designs. This is why allowing flexible preferences over plans is crucial for correctly identifying price sensitivity.
C. Estimating Consumer Demand

The model is estimated using the conditional logit approach in table 2. This allows us to interact consumer characteristics, such as age, with plan characteristics, such as price. Specification A, column 1 estimates the model without allowing consumer heterogeneity, while column 2 allows price sensitivity to vary linearly by age. The data strongly reject constant price sensitivity by age. Furthermore, by comparing columns 2 and 3, we see that accounting for variation in preferences is important to estimating the level of price sensitivity as well. The estimates in column 3 indicate that the oldest consumer in our sample (64) is roughly half as price sensitive as the youngest consumer in our sample. For each specification, we report the sample size (number of unique consumers making a purchase).

Alternative specifications confirm the pattern of lower price sensitivity by age. Panel B of table 2 separately estimates the model by five-year age bands. These results for each ten-year age bin still show the variation in price sensitivity by age, indicating our structural assumptions are not too restrictive. For use in some counterfactual exercises, panel C of table 2 divides the age span in the exchange in half and runs the model separately for those under age 45, and age 45 and older. The younger consumers are substantially more price sensitive, and the difference is statistically significant. The results show that distribution is shifted toward 0 (less price sensitive).

We run a number of additional robustness checks that confirm our main result. To identify price sensitivity from variation in choice and price across insurers only (as opposed to variation between insurers and tiers), we run specifications in appendix table A.3, panel D that identify off variation in the bronze tier only and treat other tiers as the outside option. The exact definition of the outside option does not substantially change our results. Panel E in appendix table A.3 allows for unobserved consumer heterogeneity and more flexible substitution patterns, and again finds that older individuals are less price sensitive.

Additional specifications in table A.4 tell the same story. The first two columns of table A.4 break out price sensitivity into five-year age bands and show a pattern of declining price sensitivity with age. Column 3 estimates a nested logit in which consumers first choose a plan tier (gold, silver, or bronze) and then choose a policy from within that tier. The dissimilarity parameter is an inverse measure of the correlation between error terms in each nest, and a dissimilarity parameter of 1 would indicate the model collapses to the conditional logit. The low dissimilarity parameter for bronze and silver plans indicates that consumers see these types of plans as closer substitutes than gold plans, which have an estimated dissimilarity parameter near 1. However, since most consumers are in the bronze tier, we believe panel D’s results are more reliable. Column 4 includes additional mixed logit results, in which the price coefficient α is allowed to take on a log-normal distribution, shifted by age category. The results show that distribution is shifted toward 0 (less price sensitive) for older consumers. Nonetheless, because of data limitations and the flexibility the specifications provide, these results are somewhat noisy. Additional robustness checks that replicate the results for a smaller “bandwidth” around each pricing discontinuity are available in appendix table A.5.
Overall, the results are striking and tell a consistent story. The elasticities of the youngest group, those age 27 to 35, are nearly twice as large in magnitude as those of the oldest group. These results are consistent with the raw data. Even before accounting for the endogeneity of premiums, we observe that the marginal cost of gold plans relative to bronze plans increases substantially with age, while the fraction of consumers purchasing bronze plans stays relatively flat with age (appendix figure A.2). This suggests that older consumers have a lower distaste for price. However, in our specifications, we account for continuous age trends in preferences: because of coarse firm pricing, we have demographically similar groups facing different prices. This identification strategy finds that individuals are more price sensitive than if we ignored the endogeneity of premiums (e.g., compare these estimates to Ericson & Starc, 2012a). Note, however, that our claim that older individuals are less price sensitive does not rely on choice between tier, as we also estimate models of demand off bronze plans alone in appendix table A.3 and find a similar result: the marginal cost of high-brand-quality insurers increases with age, but again, the fraction choosing these insurers does not decline sharply with age.

Various demographic factors could be driving the preference heterogeneity that we see in the data. For the pricing exercise in the next section, it does not necessarily matter whether age is simply a signal for another demographic factor correlated with preferences; insurers can price differently by age but not on other factors correlated with age (such as income). We note that younger consumers are not from lower-income postal codes in our data. However, because older individuals are more likely to be married, the selection of older consumers into the exchange may differ because some married consumers have access to insurance through a spouse. In addition, older consumers are less likely to report that they are in excellent health. Strombom, Buchmueller, and Feldstein (2002) report that older and sicker consumers tend to be less price sensitive. Finally, the relatively older consumers in our sample might be more financially sophisticated, leading them to more heavily weigh characteristics other than price when making decisions. Differences in the marginal utility of wealth, due to either consumption levels or different levels of risk aversion, would lead older consumers to have a higher willingness to pay than younger consumers. In our model, the assumption that premiums enter the utility function linearly is an approximation. The curvature in the utility function implies a smaller disutility from premiums for older consumers.

However, specific investments can also rationalize the results. Imagine that younger consumers are not loyal to any physician, but older consumers are patients of doctors in a limited number of networks. Assuming no other heterogeneity in plan attributes, insurers are closer substitutes for younger consumers than older consumers. Empirically this generates different estimates of price sensitivity. Alternatively, we could allow for heterogeneous brand preferences or differential variances in the idiosyncratic error term. These alternative approaches would not alter firm incentives (or premiums) but would have slightly different implications for consumer welfare, strengthening our results.

D. Identification Validity

While firms could price in discrete age blocks if the cost of an insured individual changed dramatically at each age cutoff, this alternative explanation for the jump in prices is not supported by the data. While diagnostic tests (such as mammograms) are recommended for patients beginning at the age cutoffs, observed medical spending in the Medical Expenditure Panel Survey (MEPS) rises smoothly and shows no systematic discontinuities in health expenditures at round numbered ages. Thus, differences in spending are unlikely to account for such large price jumps.

Appendix table A.8 supports our identification strategy by showing that characteristics of enrollees’ postal codes do not change discontinuously between age categories, with the exception that enrollees over age 55 seem to be slightly more employed and white and they are wealthier. This may lead us to slightly underestimate the price sensitivity of this age category. Similarly, the density of individuals enrolling in the exchange does not change at the various age cutoffs. Figure A.3 shows the number of enrollees in each one-year age bin (we do not have exact birthdate, only age in years). There is no pattern of densities dropping at round numbered ages, though there is perhaps anomalously low enrollment for individuals aged exactly 50 years. The final column of appendix table A.8 shows that the density does not change discontinuously at any break points, with the potential exception of the age 50 break point.

We also do a number of additional checks to confirm the validity of our identification assumption. In contexts where prices do not change by age (i.e., employer-sponsored insurance), probability of take-up and plan choice conditional on take-up do not show discontinuities by age (authors’ analysis of the Current Population Survey and National Health Interview Survey), suggesting no widespread discontinuities in preference.

Another potential concern is that some diagnostic tests become recommended at round-numbered ages. It is possible that these tests could discontinuously affect price sensitivity, even despite the smooth rise in health care spending. Two important recommendations affect consumers in our sample: mammograms for women beginning at age 40 and colorectal screening for all consumers beginning at age 50. When we exclude these consumers and redo our analyses using only the

However, reduced-form analyses cannot allow us to identify differential price sensitivity by age, as individuals are constrained in different ways, there is no single outcome variable (as consumers choose a plan from a menu), and there is no single price change (the relative prices of many plans change at round number ages).

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18 The results using the expanded July–December 2009 robustness check sample are similar and, in fact, do not contain any significant differences in postal code characteristics at age 55.
youngest (under 35) and oldest (over 50) consumers, we replicate the premium differentials in the main text (see appendix table A.9).

Finally, we can directly test whether diagnostic tests affect price sensitivity by examining men and women at age 40. The recommendations for mammography at age 40 affect only women, and our sample consists only of single individuals. If this discontinuity affected preferences, we would expect a different pattern in price coefficients for men and women. In appendix table A.5, we allow for different price coefficients for men and women. While women are typically less sensitive to price than their male counterparts (the effect is not statistically significant), there is no difference using the age 40 discontinuity relative to other age groups. These analyses provide support for our identification strategy and results.

E. Robustness: Selection into the HIX

We perform robustness checks that address potential selection both between plans within the exchange and into the exchange itself. While our data describe purchase conditional on participation in the exchange, we know very little about the behavior of consumers outside the exchange. We address selection in a number of ways. First, we discuss in detail what alternative options consumers have besides the exchange and how this may affect our estimates. Second, we run robustness checks in our model of consumer demand to ensure that our results are not sensitive to the exact definition of the outside good. Furthermore, section VI examines the impact of nonparticipation in the HIX through additional simulations.

Potential enrollees (those above 300% of the poverty line) in the HIX have few close substitutes. If they (or their spouse) are offered employer-sponsored insurance, they are not eligible to enroll in the exchange. Their alternatives to the exchange plans are either to remain uninsured or purchase an individual plan from a broker or directly from the insurer. Uninsurance among this group is extremely low (compliance with the mandate is extremely high). The uninsurance rate is only 0.9% for Massachusetts residents above 300% of the poverty line (calculated from Long and Phadera’s, 2009, detailed tabulations of 2010 Massachusetts Health Insurance Survey), suggesting very limited scope for consumers to substitute into the HIX if insurer prices were lowered.

The second alternative is individual plans not purchased from the exchange. This market is regulated similarly to the HIX. While we do not have data on choices in this market, we can examine whether there is differential selection based on age into the exchange versus the individual market. The American Community Survey (ACS) provides information on the number of individuals who purchase insurance directly from the insurance company. The 2008–2010 ACS for Massachusetts shows that the age distribution of people who directly purchase is relatively flat with respect to age (see appendix table A.6), with slightly more under 30 years old. This pattern is quite similar to the age distribution of individuals in the exchange (see figure A.3), indicating that there is no systematic selection into the HIX by age.

F. Robustness: Accounting for Dynamics

Recall that our sample includes both first-time and repeat enrollees because both are relevant for describing firm pricing incentives. However, the differential price sensitivity of the young versus old is not due to inertia alone. In appendix table A.7 we run the same specifications as in table 2, but now on a sample of enrollees who are entering the HIX for the first time; inertia will not affect this new sample’s choices. We find the same pattern of price sensitivity by age, which is to be expected: approximately 90% of our sample are first-time enrollees. (We also run counterfactual exercises using only first-time enrollees, which are also similar.) The estimates in table 2 best describe the demand curve firms face, but appendix table A.7 can be used to generalize our results to other contexts with more or less inertia.

IV. Firm Pricing and Age-Based Pricing Regulation

A. Motivation

In this section, we model how age-based pricing regulation affects markets in the presence of imperfect competition and age-based heterogeneity in price sensitivity. We develop the model in the context of age, but the same logic would apply to any observable tag by which costs and preferences varied.

We analyze the effect of three types of age-based pricing regulations:

- Age pooling. Firms cannot vary prices by age.
- Age bands. Firms can vary prices by age, but with a maximum allowable price ratio of $\theta$ (the ratio of the highest price to lowest price).
- Age unconstrained. Firms can vary prices by age.

In all cases, we assume that if a plan is offered, it must be offered to all ages. Note further that pooling and unconstrained prices are simply special cases of age bands (where $\theta = 1$ and $\theta = \infty$, respectively). On the Massachusetts HIX, $\theta = 2$, while the ACA requires states to set $\eta \leq 3$.

B. Model and Theoretical Predictions

Consider two types of consumers, old and young, who are purchasing an insurance plan. Costs rise with age, so the old have an average cost (to the insurer) of $c_H$, greater than the cost of the young $c_L$. Let fraction $\sigma$ of the population be old and fraction $1 - \sigma$ be young. There are $N \geq 2$ risk-neutral profit-maximizing insurers, each offering a single plan that is available to the young and the old (we generalize to multiplan

\[ \theta = \frac{c_H}{c_L} \]

Here, we assume both groups have a high enough willingness to pay to purchase insurance, so that selection out of the market is not an issue (i.e., that the mandate is effective). Section VI examines the consequences of selection with a weak or absent mandate.
firms later. Insurers can determine whether an individual is old or young but cannot further determine the expected cost of the individual. Hence, each insurer can set two prices: one for old and one for young individuals, \( p_H \) and \( p_L \), respectively.

We first examine how regulation affects pricing in perfectly competitive markets, in which products are identical and firms make zero profits. Stricter limitations on age-based pricing transfers resources from old individuals to young individuals in addition to changing the level of prices. Age bands are binding only up to the ratio of costs between the two groups. Prices under perfect competition are summarized below:

- Under the age-pooling regulation, prices are equal to population average cost: \( \bar{p} = \bar{c}_H + (1-\sigma)\bar{c}_L \).
- Under the age-unconstrained regulation, prices are equal to each type’s average cost: \( p_H = c_H \) and \( p_L = c_L \).
- Under the age-bands regulation with \( \theta \leq \frac{c_H}{c_L} \), prices for the young are above their cost and for the old below their cost: \( p_H^L = \theta p_L^L \) and \( p_L^H = \frac{1}{(1-(1-\theta))}\left[\sigma \bar{c}_H + (1-\sigma)\bar{c}_L\right] \). When \( \theta > \frac{c_H}{c_L} \), the regulation does not bind, and so \( p_H^L = c_H \) and \( p_L^H = c_L \).

However, in an imperfectly competitive market, the prices insurers set for each group are determined not only by costs but also by that group’s elasticity of demand. Hence, prices for old and young consumers may differ due to a price discrimination motive as well as a cost differential motive. Thus, we must consider how characteristics other than cost affect prices when modeling age-based pricing regulations. Price discrimination can amplify price differences if high-cost consumers have lower price sensitivities, and it can reduce (or even reverse the direction of) price differences if low-cost consumers are less price sensitive (the “worried-well”; see Starc, 2014).

Now let the market be imperfectly competitive. Let \( \bar{s}_L \) reflect the share of age group \( \bar{s}_L \) that purchases insurance at firm \( j \), and let \( s_H = \sigma \bar{s}_H \) and \( s_L = (1-\sigma)\bar{s}_L \) be the number of each group purchasing insurance at firm \( j \). Then we can write the profits of firm \( j \) as

\[
\Pi_j = s_H(p_H - c_H) + s_L(p_L - c_L).
\]

Firms set prices based on their first-order conditions (which we assume are unique), subject to the age-based pricing regulations they face. We drop the \( j \) subscripts below. We define a few terms. Let \( s_H \) and \( s_L \) be functions of \( p_H \) and \( p_L \), respectively, so that \( s' \) gives the change in type \( i \)’s enrollment as \( p_i \) changes. Let total enrollment be \( S = s_H + s_L \). For use in the age-bands pricing, define weighted demand \( \bar{S} = \theta s_H + s_L \).

When the bands are binding, write \( p_H \) as an implicit function of \( p_L \) and \( \bar{S} \) as a function of \( p_L \), so that \( \frac{d \bar{S}}{dp_L} = \theta^2 s''_H + s'_L \).

**Proposition 1.** Assume markets are imperfectly competitive. Then, under the age-pooling regime, \( p_{\text{Pool}} = \frac{1}{N} \left( s'Hc_H + s'Lc_L \right) - \frac{\bar{S}}{N} \). Under age-unconstrained, \( p_{\text{Un}}^H = c_H - \frac{s_H}{s} \) and \( p_{\text{Un}}^L = c_L - \frac{s_L}{s} \). If age-bands are binding, \( p_{\text{Band}}^L = \left( \frac{\theta}{s_L} \bar{c}_H + \frac{s_H}{s} c_L \right) - \frac{\bar{S}}{s} \) and \( p_{\text{Band}}^H = \theta p_{\text{Band}}^L \).

**Proof.** Immediate from first-order condition.

Proposition 1 shows that under the age-unconstrained policy, firms simply set prices for each group equal to cost, plus a markup inversely proportional to the elasticity of that group’s demand. An insurer can set only one price under age-pooling, which is equal to a markup term inversely related to the elasticity of population demand, plus a cost term, where the relative weight on each cost term is that group’s share of the marginal change in demand. Note that firms price to marginal cost; not average cost; more weight will be put on the costs of the group that is more price sensitive.

The optimal price under binding age bands is similar to that under age pooling, except the markup term is now inversely related to weighted demand \( \bar{S} \) and the weight on each cost term is given by \( \theta \). The first-order condition thus takes into account that the price for the high-cost group is \( \theta \) times that for the low-cost group. If the low-cost group (young) is more price sensitive than the high-cost group (old), there are two reasons for the high-cost group to prefer a pooling or pseudo-pooling arrangement. First, as always, more low-risk types have lower costs. However, more price-sensitive individuals also lower the optimal markup of the insurer. We use these first-order conditions for price setting in the counterfactual exercise that follows.

We then adapt this pricing rule to account for the multiple products firms offer, as firms take into account the effect that changing price on one plan has on their other plans’ enrollment. Let firms offer \( N \) plans, and let \( \bar{p}_i, \bar{c}_i, \bar{s}_i \) be the \( 1 \times N \) vectors of prices, costs, and enrollment for age group \( i \) (\( i = L \) or \( H \)). Denoting the \( N \times N \) matrix of cross-price derivatives for consumers of type \( i \) as \( \mathbf{M}_i \), the optimal price for the young group for any \( \theta \) is given by

\[
\bar{p}_{L}^{\text{Band}} = \left( \theta^2 \mathbf{M}_H + \mathbf{M}_L \right)^{-1} \left( \theta \mathbf{M}_L \bar{c}_H + \mathbf{M}_L \bar{c}_L \right) - \left( \theta^2 \mathbf{M}_H + \mathbf{M}_L \right)^{-1} \left( \bar{s}_L + \theta \bar{s}_H \right).
\]

The first-order condition implies that the prices are related to both the mix of cost-type and preferences across different groups of consumers.
V. Effect of Alternative Regulations

A. Simulation Method and Assumptions

In this section, we examine how alternative age-based pricing regulations would affect prices and welfare on the Massachusetts HIX. We first examine how age-based pricing interacts with imperfect competition and compare the predicted prices to those we would expect under perfect competition. Then we examine how changes in the maximum allowable price ratio ($\theta$) affect transfers between the young and old, as well as between consumers and firms.

Simulating firm prices requires that we specify firms’ demand curve, costs, and pricing rule. Consumer demand is derived from the preferences estimated in table 2.22 We use the multiproduct pricing rule developed in the previous section and simultaneously solve the system of optimal pricing equations for a new vector of prices under each set of regulations. We infer costs from the Medical Expenditure Panel Survey (MEPS), as described below.23 However, we also present counterfactuals with a number of other cost assumptions, methods of addressing adverse selection, and alternative models of consumer demand; results are similar (see appendix tables A.9, A.10, and A.12).

Insurer costs are an important component of our simulations, but they are not directly observed. To estimate insurer costs, we rely on data from the 2008 MEPS on the health costs of different groups. To construct the table, we restrict the sample to individuals age 27 to 64 and with moderate to high incomes and private insurance, to mimic the population in the Massachusetts Commonwealth Choice program. In the MEPS data, older consumers have higher medical expenditures but also pay a higher percentage of those medical expenditures out of pocket. Therefore, as a measure of relative costs to the insurer, we form the ratio of insured costs of older groups to the insured costs of the average insured costs of 27- to 30-year-old consumers.24 For our simulations, we assume that the insurer’s cost for a bronze plans is 60% of the total age-specific health costs, 70% for silver, and 90% for gold plans. These correspond to the approximate actuarial values of each type of plan as set by the Connector.

Based on the MEPS data, the ratio of insured expenditure for the oldest consumer group (55- to 64-year-olds) relative to those 30 and under is 2.7, implying that insurers would be constrained by a $\theta$ of 2 even in the absence of price discrimination motives. Yet the data show that the cost ratios for slightly younger consumers (50 to 54 or 45 to 49) are much lower (about 1.5). In contrast, premium ratios for these consumers are not much lower.

The combination of the cost and price data suggests that price discrimination explains part of the pricing pattern in the data. Specifically, consider 45- to 49-year-old consumers. Cost estimates indicate that these consumers cost only slightly more (20%) to the insurer than consumers age 27 to 30, yet premiums are 40% higher. This is easily rationalized by differences in elasticities: consumers age 27 to 30 have an elasticity that is over twice the elasticity for the older group.

B. Unconstrained Prices with Perfect and Imperfect Competition

Figure 2 shows our estimate of what prices would be if firms did not face age-based pricing regulation. It plots premiums by age under both perfect and imperfect competition, assuming the costs in the MEPS data, the preferences in the demand system, and no regulation. While in our full equilibrium simulations we limit the analysis to two groups of consumers, it is useful to examine the impact of preference heterogeneity on the entire distribution of premiums. Therefore, in figure 2, we plot partial equilibrium markups $\gamma$ as a function of $\alpha$, age group-specific price sensitivity as estimated in table 2, panel B. We then add these markups to the insurer’s average cost for each group, as listed in table 3.

Differences in preferences amplify the age-based difference in costs, leading older consumers to have a much larger gap between prices under perfect and imperfect competition. The simulated prices under imperfect competition are more extreme than actually observed in the market (the prices for older consumers are higher than observed, and the prices for younger consumers are lower than observed) because the prices are unconstrained by age-based pricing regulation in this simulation. Note that margins on the oldest consumers can be quite large, at around $100 per month, or 20% of the purchase price. By contrast, the margins on the youngest consumers are quite slim.

C. Effects of Alternative Age-Band Regulations

Main specifications. Here, we examine the effect of alternative age bands (value of $\theta$), and consider maximum allowable price ratios that range from full pooling ($\theta = 1$) to those of the cost ratio ($\theta = 2.75$). To conduct our simulation of alternative age bands, we split the sample at age 45 into young and older consumers and use the parameter $\gamma$ to indicate the relative cost of older consumers, such that $c_H = \gamma c_L$. Following the MEPS, we set $\gamma = 2.75$, with average total medical expenditures of $2,500 per year for younger consumers.

22 For simplicity, this specification does not allow for any unobserved heterogeneity, though the results are robust to alternative specifications.

23 We do not directly observe costs. An alternative method would be to infer insurer costs from observed prices under the assumption of profit maximization. That route is problematic for two reasons. First, the prices we observe are constrained by age-pricing regulation, limiting our ability to identify the relative costs of young and old. Second, since insurers are using coarse pricing rules, the assumption of perfect profit maximization is problematic. However, if the researcher is willing to assume a ratio of costs between the oldest and youngest consumers, costs can then be estimated. If we assume an actual cost ratio between old and young of 2.75 to 1, the cost-level estimates and counterfactuals we run are very similar to those we get when we use the MEPS. Results are available in the online appendix.

24 A limitation of this analysis is that it does not account for differential selection into the exchange: the consumers who lacked coverage in the employer-based market are not representative of the population. However, in the absence of better cost data, it provides a useful baseline.
Figure 2.—Simulated Monthly Premiums with Unconstrained Pricing under Perfect and Imperfect Competition

Premiums under perfect competition are age-based average insurer costs from the MEPS, as listed in Table 3. Premiums under imperfect competition add a markup term for a plan with average market share: \[ \alpha_i (1 - \bar{s}_j) \].

The age-based premium coefficient \( \alpha_i \) is taken from Table 2, panel B.

Table 3.—Comparison of Costs across Age Groups

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Total $ 3,992</th>
<th>18.5</th>
<th>76.5</th>
<th>$ 3,054</th>
</tr>
</thead>
<tbody>
<tr>
<td>27–30</td>
<td>$ 2,401</td>
<td>17.4</td>
<td>79.7</td>
<td>$ 1,914</td>
</tr>
<tr>
<td>31–34</td>
<td>$ 2,509</td>
<td>18.3</td>
<td>77.5</td>
<td>$ 1,945</td>
</tr>
<tr>
<td>35–39</td>
<td>$ 2,723</td>
<td>23.3</td>
<td>73.9</td>
<td>$ 2,012</td>
</tr>
<tr>
<td>40–44</td>
<td>$ 3,279</td>
<td>18.7</td>
<td>76.6</td>
<td>$ 2,512</td>
</tr>
<tr>
<td>45–49</td>
<td>$ 3,241</td>
<td>19.6</td>
<td>71.6</td>
<td>$ 2,320</td>
</tr>
<tr>
<td>50–54</td>
<td>$ 4,046</td>
<td>18.9</td>
<td>75.9</td>
<td>$ 3,071</td>
</tr>
<tr>
<td>55–64</td>
<td>$ 6,627</td>
<td>17.2</td>
<td>78.1</td>
<td>$ 5,175</td>
</tr>
</tbody>
</table>

Data taken from 2008 MEPS, with authors’ calculations. Sample selection: people age 27 to 64 with middle or high incomes with any private insurance. Average insurer cost is mean private insurer expenditure for this sample. The final column is the ratio of each age group’s average insurer cost to that of the 27- to 30-year-olds.

Table 4 describes the simulation results, presenting the change in premiums relative to the baseline of age-unconstrained (\( \theta = \infty \)) prices.\(^\text{25}\) We find that conditional on the age band being set at the cost ratio (\( \theta = \gamma = 2.75 \)), the prices for the younger group are 5% higher than they would be under age-unconstrained pricing. The Massachusetts age band of 2 leads to 24% higher premiums for younger consumers conditional on a cost ratio of 2.75.

Changes in age-based pricing do not merely lead to transfers between consumers; they alter total consumer surplus as well. Table 4 compares consumer surplus under bands of 1 (full pooling), 2, and 2.75 (cost-ratio) to unregulated pricing to capture the welfare impact of regulation. In each case, consumer welfare is higher with the pricing regulation in place than it would be in the absence of regulation; the positive compensating variation for the older consumers is larger in magnitude that the negative compensating variation for younger consumers, who must be paid to be made whole.

Table 4.—Change in Prices, Surplus, and Profits Relative to No Age-Based Pricing Regulation

<table>
<thead>
<tr>
<th>Regulation</th>
<th>( \theta = 1 )</th>
<th>( \theta = 2 )</th>
<th>( \theta = 2.75 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Change in premium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Older consumers</td>
<td>-49.9%</td>
<td>-14.6%</td>
<td>-2.2%</td>
</tr>
<tr>
<td>Younger consumers</td>
<td>39.8%</td>
<td>23.4%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Consumer surplus change ($ per enrollee-month)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Older consumers</td>
<td>308</td>
<td>89</td>
<td>15</td>
</tr>
<tr>
<td>Younger consumers</td>
<td>-62</td>
<td>-41</td>
<td>-7</td>
</tr>
<tr>
<td>Total</td>
<td>246</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td>Change in Firm’s profits ($ per enrollee-month)</td>
<td>-123</td>
<td>-24</td>
<td>-4</td>
</tr>
</tbody>
</table>

Data and authors’ calculations. Taken from a series of counterfactuals in which \( \theta \), the maximum allowable price ratio, is altered, as described in the text. Surplus change represents the compensating variation required to provide consumers with the same level of utility relative to unconstrained premiums. Percentage increase or decrease in each age group’s premium is taken as a percent of their premium under \( \theta = \infty \). Estimates used are from Table 2, panel C.

\(^{25}\) We run parallel simulations using just the oldest and youngest groups and find very similar results (appendix table A.9).
prices fall when age bands are narrower than the cost differentials. Recall that in the equation for prices under age bands in proposition 1, the cost term represents the (weighted) cost of the marginal consumer. It is less than a simple average cost whenever the ratio of the price sensitivity of the younger, more price-sensitive group to the older, less price-sensitive group is sufficiently large.26 (Note that our simulations use the more complex multiproduct first-order condition derived below the proposition.)

Premiums for the older consumers fall more than the premiums of the younger consumers rise (even though the older consumers value the reductions less). In our simulations, the unconstrained average prices are around $200 per month for the younger consumers and $600 per month for older consumers. If you were simply to take an average in the age-pooling case, you would expect a $200 per month increase in the premiums of younger consumers. But because insurers price to the marginal consumer, the increase in premiums on younger consumers is about $100 per month, for an average premium of only $300 per month in the full pooling case.

The regulation affects firm profits as well. The bottom row of table 4 shows that firm profits fall (compared to unconstrained pricing) as the maximum allowable price ratio is lowered. The 2-to-1 age bands allow consumers to capture more of the surplus generated without leading to negative profits on the part of insurers. Total surplus (consumer surplus plus firm profits) increases as the maximum allowable price ratio is lowered because the price vector in equilibrium more closely reflects prices based on the cost of the marginal consumer. This allows consumers to sort more efficiently across plans.27 The regulations implicitly transfer money to consumers with a lower marginal utility of income, as evidenced by older consumers’ lower price sensitivity.28 Therefore, the surplus gains come from more efficient allocation of consumers to plans because firms’ prices reflect the costs of the marginal rather than average consumer.29

In the final two columns, we also present simulations for $\theta = 1$ using alternative demand estimates from panels D and E of appendix Table 2. These simulations show the same pattern of results with slightly different magnitudes: prices on older consumers’ decline, firm profits decline, and consumer surplus increases.

26 Specifically, larger than $\theta - \theta^2$, which is true in all our simulations in which the maximum allowable price ratio binds. In fact, in the community rating case, the insurers would lose money. This provides a rationale for why community rating arrangements that would be possible under perfect competition may be more likely to fail under imperfect competition.

27 Section VI also shows that age-based pricing regulation can have an effect on efficiency when the mandate is dropped or ineffective.

28 How transfers are valued in the welfare model can affect the welfare conclusions but will not affect our simulations of insurer pricing.

29 Note that our welfare analysis takes product characteristics as fixed, which is reasonable since the products are highly regulated by the HIX. In this time period, plans needed to meet a tier-specific actuarial value and other design restrictions. Beginning in 2010, the financial characteristics of plans were standardized across all firms by the HIX.

Alternative cost assumptions. Because the HIX does not link enrollment data to claims data, our simulations must rely on cost data from the MEPS. While imperfect, they provide a useful benchmark for this analysis. Furthermore, because HIX populations depend on policy decisions and state demographics, the exact cost figures will vary from state to state. Therefore, we provide a number of robustness checks using alternative cost assumptions. We conduct counterfactual estimates in which the relative costs of old to young range from the 2.75-to-1 found in the MEPS and other studies (Handel, Hendel, & Whinston, forthcoming) to the 5 to 1 estimates provided by industry-funded actuaries. In table A.11, we conduct robustness checks in which we experiment with different ratios of costs between older and younger consumers. In the rows using MEPS costs, we maintain the assumption that the young group spends the true amount in the MEPS, but vary the costs of the older group to test different ratios. When the cost ratio between groups is 3 to 1, a maximum allowable price ratio of 3 binds (and raises premiums for younger consumers by 3% to 4%) because of differences in preferences. Similarly, in the equilibrium pricing rows, we infer costs under the assumptions that insurers are optimally pricing and that the ratio of costs is as listed. The results are similar to those using the MEPS assumption. The central intuition of the model—that prices depend not only on costs but on consumer preferences across groups—generalizes regardless of the exact assumption on costs.

Accounting for dynamic pricing. Our primary simulations account for inertia by using a demand curve that is estimated off both first-time and repeat enrollees. However, these simulations do not account for the future value of inertial enrollees captured in this period. Our primary simulations are likely to be reasonably accurate, as we see few repeat enrollees (less than 10%) in this time. Substantial policy uncertainty may have caused firms to discount the future benefit of inertial enrollees, since potential regulatory changes in the HIX plan menu could lead individuals to switch plans and reoptimize and impending federal health reform would have unclear effects on the HIX. Nonetheless, we present a model of how firms value future enrollees in appendix section A.3 and simulate the effect of age-based pricing limits. Our model indicates that markup implied by the dynamic model would be about 91% of the markup implied by our primary simulations. We simulate premiums implied by the dynamic model in appendix table A.12 and show that dynamic pricing considerations do not have a substantial effect on our analysis.

Minimum loss ratio regulation. Minimum loss ratios (MLRs) require that insurers pay out a certain percentage of premiums in health costs or refund the difference to consumers, creating a pseudo-price cap.30 While the

30 The ACA requires that medical costs plus quality improvement expenditures exceed a percentage of “adjusted premiums,” which are net of taxes,
Massachusetts insurers were not subject to minimum loss ratios during our time period, we simulate the effect of the ACA’s 80% MLR and how it interacts with age-based pricing regulation. Appendix table A.13 shows how premiums change for younger consumers with and without MLRs under different levels of the maximum allowable price ratio. With the ACA’s maximum allowable price ratio and minimum loss ratios, consumer surplus is increased relative to unconstrained age pricing. However, MLRs also mitigate the transfers from younger consumers to older consumers that would otherwise occur under binding age-based pricing regulation. Intuitively, the MLR regulation dampens the incentive for insurers to set higher prices for younger consumers to gain slack against the age-rating regulation, while retaining the incentive for insurers to price to the marginal rather than average consumer.

**Risk adjustment.** While there is no risk adjustment in the Massachusetts HIX during our time period, the ACA contains a risk adjustment provision. The extent to which risk adjustment will reduce cost differences between age groups is unknown; however, we can examine the extreme case. Suppose risk adjustment by age were perfect, so enrollees had the same expected cost to insurers regardless of age. Then prices would differ only due to a price discrimination rationale. In this case, our model predicts that moving from age-unconstrained pricing (θ = ∞) to full community rating (θ = 1) would increase prices on the young 22% with perfect risk adjustment; recall that without any risk adjustment, the increase was 49.9%. Maximum allowable price ratios greater than 2 do not bind under perfect risk adjustment. Under unconstrained pricing and risk adjustment, prices for younger consumers are 30% lower than price for older consumers as a result of price discrimination. Finally, we run robustness checks using our bronze-only specifications, which duplicate the qualitative pattern of the results for the full sample. The discussion in section VI highlights the potential for selection in the absence of perfect risk adjustment.

**VI. Pricing Regulation and Market Participation**

**A. Participation Model**

Thus far, we have assumed that nonparticipation in the HIX is unimportant—that the mandate to purchase is effective. However, in the absence of a mandate, consumers may opt out of coverage. Indeed, just as the market can unravel when costs differ, the market can also unravel when preferences differ. This section shows how allowing nonparticipation in the market changes the impact of modified community rating regulations.

In this simulation, we show how age-band pricing regulation can lead to selection on age and health status into and out of the exchange. The relative share of young and old participants affects average costs in the market, which is well known. Importantly, under imperfect competition, the relative share of young and old also affects optimal markups. Maximum allowable price ratios lead insurers to raise prices on younger consumers. As a result, some younger consumers opt out of the insurance market, leading prices to adjust and exacerbating the transfers from the younger consumers left in the market to older consumers.

We expand the model to allow consumers to opt out of the market. Participation rates depend on a group’s take-up elasticity and the prices they face. Denote the participation rate of consumer group $i$ under a maximum allowable price ratio of $\theta$ by $\rho_i$, and their take-up elasticity by $\varepsilon_i$. Further, let $p_0^i$ represent the price (or price index) under unconstrained pricing and $p^*_{io}$ represent the optimal price (or price index) for consumer group $i$ under a maximum allowable price ratio of $\theta$. We assume full participation under unconstrained pricing as a benchmark. The participation rate can then be written as

$$\rho_{i} = 1 - \varepsilon_{i} \frac{(p_{0}^{i} - p^{*}_{io})}{p_{0}^{i}}.$$

We allow participation to vary by health status and allow health status to vary by age. In our pricing counterfactuals, we were able to account for selection by letting insurers’ marginal costs vary, but we now need to separately model the participation decision. We split the sample by age again as young or old (under versus over age 45). We then split by good or bad health status as taken from the MEPS, and group individuals in “excellent,” “very good,” or “good” health together as one group and those in “fair” or “poor” health as another. There are thus four demographic groups, each an age–health status cell.

We need a number of additional assumptions for this simulation as well. First, we take extensive margin elasticities for both relatively healthy and relatively sick (in fair or poor self-reported health) from the Congressional Budget Office (2005): they are $- .57$ and $- .34$, respectively. In addition, we assume that younger consumers in fair or poor health are 3.75 times more costly to insure than consumers in excellent, very good, or good health, again following MEPS estimates. We continue to assume that average costs of older versus younger individuals are given as in the MEPS.

**B. Participation and Pricing Regulation without a Mandate**

Table 5 describes results of removing the mandate and allowing nonparticipation. Selection into the exchange leads to prices that are dramatically higher regardless of the maximum allowable price ratio considered. In addition, we see

31 The relative costs of the healthy older individuals versus sick older individuals does not play a role in our simulations, as the older individuals continue to participate in the market.
that healthy, young consumers are likely to leave the market. Under the age-pooling regulation, approximately 60% of healthy, young consumers opt out of the market, along with 45% of the sicker consumers. In addition, there is significant unraveling with a maximum allowable price ratio of 2.75; since this price ratio would allow prices to reflect cost differences, the unraveling comes from differences in preferences.

While full unraveling does not occur given these parameter estimates, consumers are made worse off by the higher prices and there is an inefficiency resulting from uninsurance. Hence, without a mandate, there is a trade-off between the welfare benefits of pooling (as in the previous section) and the costs of uninsurance. Finally, we note that a statutory penalty can reduce or eliminate opting out of insurance. For example, a statutory penalty equal to half of the cheapest bronze premium (as it is set in Massachusetts) leads to no uninsurance in the simulation above.

The optimal price tends to increase when the mandate is removed for three reasons. First, in our simulation, the consumers who leave the market are younger ones, who are both less expensive to insure and more price sensitive: prices for older consumers are always lower under age-based pricing regulation than with unconstrained pricing. In addition, with the larger exit of healthy consumers from the market, average cost to insure goes up even further. Finally, the marginal consumer changes. Since there are simply fewer younger consumers in the market, the marginal consumer is more likely to be older and more expensive to insure. This further increases prices.

The exact magnitudes of rate shock due to modified community rating depend on the underlying costs, demographics, and preferences of consumers in the exchange. However, our results suggest that without an effective mandate, noncompliance is likely to be problematic, as modified community rating leads to higher markups on young, healthy consumers, who may then exit the exchange. This holds true even with a very successful risk adjustment system, as prices vary due to both differences in costs and differences in preferences.

### VII. Conclusion

This paper has analyzed consumer behavior and pricing regulation using a novel data set in a health insurance exchange that serves as a model for the national health reform. We find strong evidence of heterogeneity in preferences: younger consumers who are more than twice as price sensitive compared to their older counterparts. Price discrimination amplifies variation in insurance prices as insurers have a motive, in addition to costs, to increase premiums on older consumers.

Our theory shows that age-based pricing restrictions do not merely lead to transfers from young to old consumers, but also change firms’ profits and market efficiency. Our simulations show that these restrictions lead insurers to price to marginal, young, inexpensive consumers, lowering overall markups. By bringing price closer to marginal cost, this improves market efficiency. Our model of consumer welfare shows that these regulations increase consumer surplus and total surplus. Finally, note that pricing regulation can also lead to partial unraveling and dramatic premium increases in the absence of an effective mandate: not only do average costs in the market go up when young people opt out of coverage, but average markups also increase.

Our pricing and enrollment data are ideal for analyzing the impact of price regulation in exchanges. Yet the lack of linked claims data prevents us from examining selection within the exchange. Moreover, caution is needed in generalizing from Massachusetts to other states, as they may differ in demographics and preferences for insurers and providers. An analysis of subsidies, an important component of federal health reform, is outside the scope of this paper since the HIX did not offer subsidies during this time period. Future work should consider these issues; our theoretical results provide a useful framework for such analyses.

To understand the impact of pricing regulation, assuming a perfectly competitive market is misleading and incorrect. Insurance market regulations must consider not only the nature of consumer demand but also strategic insurer pricing in the face of consumer demand. Our results from Massachusetts provide a starting point for researchers who study HIXs and related markets, as well as for regulators designing the exchanges.

### REFERENCES

