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EQUILIBRIA IN HEALTH EXCHANGES: ADVERSE SELECTION VERSUS RECLASSIFICATION RISK

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EQUILIBRIA IN HEALTH EXCHANGES: ADVERSE SELECTION VERSUS RECLASSIFICATION RISK

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This paper studies regulated health insurance markets known as exchanges, motivated by the increasingly important role they play in both public and private insurance provision. We develop a framework that combines data on health outcomes and insurance plan choices for a population of insured individuals with a model of a competitive insurance exchange to predict outcomes under different exchange designs. We apply this framework to examine the effects of regulations that govern insurers' ability to use health status information in pricing. We investigate the welfare implications of these regulations with an emphasis on two potential sources of inefficiency: (i) adverse selection and (ii) premium reclassification risk. We find substantial adverse selection leading to full unraveling of our simulated exchange, even when age can be priced. While the welfare cost of adverse selection is substantial when health status cannot be priced, that of reclassification risk is five times larger when insurers can price based on some health status information. We investigate several extensions including (i) contract design regulation, (ii) self-insurance through saving and borrowing, and (iii) insurer risk adjustment transfers.

KEYWORDS: Insurance exchanges, adverse selection, reclassification risk.

1. INTRODUCTION

HEALTH INSURANCE MARKETS ALMOST EVERYWHERE ARE subject to a variety of regulations designed to encourage the efficient provision of insurance. One such approach is known as "managed competition" (see, e.g., Enthoven (1993) or Enthoven, Garber, and Singer (2001)). Under managed competition, a regulator sets up an insurance market called an *exchange* in which insurers compete to attract consumers, subject to a set of regulations on insurance contract characteristics and pricing. There are many important examples of managed competition in practice. A leading case is the state-by-state insurance exchanges set up under the Affordable Care Act (ACA) in the United States that were required to begin offering insurance in 2014 (see, e.g., Kaiser Family Foundation (2010)). Other examples include the national insurance exchanges set up in the Netherlands, starting in 2006, and Switzerland, starting in 1996 (see van de Ven and Schut (2008) and Leu, Rutten, Brouwer, Matter, and Rutschi (2009)). In addition, large employers in the United States have been increasingly outsourcing their insurance provision responsibilities to private health exchanges that resemble these publicly regulated exchanges (see, e.g., Pauly and Harrington (2013)).

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This paper sets up and empirically investigates a model of insurer competition in a regulated marketplace, motivated by these exchanges. We develop a framework that combines data on health outcomes and insurance plan choices for a population of individuals with a model of a competitive insurance exchange to predict outcomes under different exchange designs. The challenges in conducting this analysis are both theoretical and empirical. From the theoretical perspective, the analysis of competitive markets under asymmetric information, specifically insurance markets, is delicate. Equilibria are difficult to characterize and are often fraught with nonexistence. On the empirical side, any prediction of exchange outcomes must naturally depend on the extent of information asymmetries, that is, on the distributions of risks and risk preferences, and the information that insurers can act on relative to that in the hands of insurees. Thus, a key empirical challenge is identifying these distributions.

As the main application of our framework, we analyze one of the core issues faced by exchange regulators: the extent to which they should allow insurers to vary their prices based on individual-level characteristics, and especially health status (i.e., "pre-existing conditions"). For example, under the ACA, insurers in each state exchange are allowed to vary prices for the same policy based only on age, geographic location, and whether the individual is a smoker. Prohibitions on pricing an individual's health status can directly impact two distinct determinants of consumer welfare: adverse selection and reclassification risk.[2] Adverse selection is present when there is individual-specific information that cannot be priced, and sicker individuals tend to select greater coverage.[3] Reclassification risk, on the other hand, arises when changes in health status lead to changes in premiums. Restrictions on the extent to which premiums can be based on health status are likely to increase the extent of adverse selection, but reduce the reclassification risk that insured individuals face. For example, when pricing based on health status is completely prohibited, reclassification risk is eliminated but adverse selection is likely to be present.[4] At the other extreme, were unrestricted pricing based on health status allowed, adverse selection would be completely eliminated when consumers and firms possess the same information. We would then expect efficient insurance provision conditional on the set of allowed contracts, although at a very high price for sick consumers.[5] Thus, in determining the degree to which pricing of health sta-

[2]Each of these phenomena is often cited as a key reason why market regulation is so prevalent in this sector in the first place.

[3]See Akerlof (1970) and Rothschild and Stiglitz (1976) for seminal theoretical work.

[4]Insurer risk adjustment is one policy that regulators typically consider to reduce the extent of adverse selection in an exchange, conditional on a given set of price regulations. We consider insurer risk adjustment, and its implications for equilibrium outcomes and welfare, in Section 6.

[5]This abstracts away from liquidity concerns that could be present in reality, especially for low income populations.

tus should be allowed, a regulator needs to consider the potential trade-off between adverse selection and reclassification risk.[6]

Our approach combines a model of a competitive insurance exchange with an empirical analysis aimed at uncovering the joint distribution of individuals' risks and risk preferences. To this end, we start by developing a stylized model of an insurance exchange that builds on work by Rothschild and Stiglitz (1976), Wilson (1977), Miyazaki (1977), Riley (1979), and Engers and Fernandez (1987) who all modeled competitive markets with asymmetric information. Our approach can be viewed as an extension of the model in Einav, Finkelstein, and Cullen (2010c) to the case of more than one privately supplied policy, each of which must break even in an equilibrium.[7] In the model, the population is characterized by a joint distribution of risk preferences and health risk, and there is free entry of insurers. We assume that all individuals buy insurance in the marketplace as a result of either a fully enforced individual mandate or participation subsidies. (We relax this assumption in an extension, presented in our Supplemental Material (Handel, Hendel, and Whinston (2015)).) Throughout the analysis, we fix two classes of insurance contracts that each insurer can offer. In our baseline analysis, the more comprehensive contract has 90% actuarial value and mimics the most generous coverage tier under the ACA, while the less comprehensive contract has 60% actuarial value and mimics the least generous coverage tier under the ACA.[8] (We also examine other actuarial values in Section 6.)

To deal with the Nash equilibrium existence problems highlighted by Rothschild and Stiglitz (1976), we focus on another concept developed in the theoretical literature: Riley equilibria (Riley (1979)). Under the Riley notion, firms consider the possibility that rivals may react to deviations by introducing new profitable policies so that deviations rendered unprofitable by such reactions are not undertaken. The main roles of our theoretical analysis are (i) to prove the existence and uniqueness of Riley equilibrium in our context and (ii) to develop algorithms to find both the Riley equilibrium and any Nash equilibria, should they exist.

As the second input into our analysis, we empirically estimate the joint distribution of risk preferences and ex ante health status for the employees of a large

[6]See, for example, Bhattacharya, Chandra, Chernew, Goldman, Jena, Lakdawalla, Malani, and Phillipson (2013) or Capretta and Miller (2010) for policy-oriented discussions that advocate relaxing the pricing restrictions present in the ACA (subject to some complementary market design changes).

[7]In contrast, in the Einav, Finkelstein, and Cullen (2010c) model, there is only one privately supplied policy that must break even. As we discuss in Section 2, this difference can lead to substantially different outcomes.

[8]Actuarial value reflects the proportion of total expenses that an insurance contract would cover if the entire population were enrolled. In addition to the contracts we study, the ACA permits insurers to offer two classes of intermediate contracts with 70% and 80% actuarial value, respectively. In the legislation, 90% is referred to as "platinum," 80% "gold," 70% "silver," and 60% "bronze."

self-insured employer. We estimate these consumer micro-foundations using proprietary data on employee health plan choices and individual-level health claims (including dependents) over a three-year time period. To do so, we develop a structural choice model that generalizes Handel (2013), leveraging the unusually detailed information in our data about individuals' health status. To model health risk perceived by employees at the time of plan choice, we use the methodology developed in Handel (2013), which characterizes both total cost health risk and plan-specific out-of-pocket expenditure risk. The model incorporates past diagnostic and cost information into individual-level and plan-specific expense projections using both (i) sophisticated predictive software developed at Johns Hopkins Medical School and (ii) a detailed model of how different types of medical claims translate into out-of-pocket expenditures in each plan.

We use these estimates, along with our theoretical model of an exchange, to simulate exchange equilibria under different pricing regulations. These regulations range from requiring pure community rating to allowing perfect risk rating (full pricing of health risk). Between these two extremes, we consider, for example, the case in which insurers can price based on health-status quartiles. Because we study a sample of consumers from a large self-insured employer, our analysis is most relevant for a counterfactual private exchange offered by this employer, or other similar large employers. While less externally valid for exchanges with different populations (such as the uninsured qualifying for the ACA exchanges), the depth and scale of the data we use here present an excellent opportunity to illustrate our framework at a general level and, more specifically, to study the interplay between adverse selection and reclassification risk as a function of regulation in such markets.

We use the outputs of this equilibrium market analysis (premiums and consumers' plan choices) to evaluate long-run welfare under the different pricing regulations. Our analysis measures the gain or loss from allowing health-based pricing from the perspective of a 25-year-old consumer, who anticipates participating in many consecutive one-year markets characterized by the static model, taking into account the underlying health transition process. We evaluate lifetime welfare under two different scenarios. On the one hand, we consider fixed income over time, which is a reasonable assumption when borrowing is feasible. Alternatively, to capture potential borrowing frictions, we also evaluate welfare under the observed income profile. One benefit of pricing health conditions is that the population is healthier at younger ages, when their income is lower. Health-based pricing, which results in lower premiums early in life, can therefore be beneficial for steep enough income profiles if borrowing is not possible.

In our baseline scenario with 90% and 60% plans, our results show substantial within-market adverse selection with pure community rating. The Riley equilibrium results in full unraveling, with all consumers purchasing a 60% plan at a premium equal to plan average cost for the entire population. The welfare cost of this unraveling is large: a consumer with fixed income over time would be willing to pay \$619 per year to be able to purchase instead the 90% plan at a premium equal to its average cost for the whole population. This amount is roughly 10% of the average medical expenses in the population. Health-based pricing reduces this unraveling: as insurers can price on more and more health-relevant information, the market share of consumers enrolled in the 90% policy increases due to reduced adverse selection.

Although greater ability to price health-status information reduces adverse selection, our long-run welfare results illustrate the extent to which such policies exacerbate reclassification risk. Under the case of fixed income from age 25 to 65, welfare is highest when health-status pricing is banned. For example, from an ex ante perspective, an individual with median risk aversion would be willing to pay \$3,082 each year from age 25 to 65 to be in a market with pure community rating rather than face pricing based on health-status quartiles, even though the latter yields greater within-year coverage. This is approximately five times the \$619 welfare loss that occurs from adverse selection under pure community rating, and roughly half of the average annual medical expenses in the population. Thus, the welfare losses due to reclassification risk, even for fairly limited pricing of health status, can be quantitatively large. Moreover, we show that as the ability to price on health status becomes greater, the welfare loss grows. Finally, when we change the fixed lifetime income assumption and allow for increasing income profiles the losses from reclassification risk are attenuated because health-status-based pricing decreases premiums earlier in life when income is lower and thus smooths consumption over time. (This beneficial effect of health-based pricing is eliminated, however, if age-based pricing is allowed.)

We also examine several extensions that address the robustness of our findings, or illustrate how our framework can be used to address other issues that arise in exchange design. We consider (i) the effects of altering the actuarial value of the low coverage policy, (ii) the implications of allowing age-based pricing, with and without health-based pricing, (iii) the possibilities for self-insurance through saving and borrowing to ameliorate the losses due to reclassification risk, and (iv) the effect of introducing insurer risk adjustment transfers to mitigate adverse selection (as seen in many insurance exchanges in practice).

This paper builds on related work that studies the welfare consequences of adverse selection in insurance markets by examining it in the setting of a competitive exchange in which more than one type of policy is privately supplied and by adding in a long-term dimension whereby price regulation induces a potential trade-off with reclassification risk. Relevant empirical work that focuses primarily on adverse selection includes Cutler and Reber (1998), Cardon and Hendel (2001), Carlin and Town (2009), Lustig (2010), Einav, Finkelstein, and Cullen (2010c), Bundorf, Levin, and Mahoney (2012), Handel (2013), and Einav, Finkelstein, Ryan, Schrimpf, and Cullen (2013).[9] Ericson and Starc (2013) and Kolstad and Kowalski (2012) studied plan selection and regulation in the Massachusetts Connector health insurance exchange. Perhaps the closest paper in spirit to ours is Finkelstein, Poterba, and Rothschild (2009) which examined the welfare consequences of allowing gender-based pricing of annuities in the United Kingdom.[10] These papers all focus on welfare in the context of a short-run or one-time marketplace.

There is more limited work studying reclassification risk and long-run welfare in insurance markets. Cochrane (1995) studied dynamic insurance from a purely theoretical perspective, showing that, in the absence of asymmetric information, first-best insurance can be achieved using single-period contracts that are priced based on a consumer's health status and that insure both current medical expenses and changes in health status, provided that both consumers and firms can commit to making the required payments (perhaps through bonding). Herring and Pauly (2006) studied guaranteed renewable premiums and the extent to which they effectively protect consumers from reclassification risk. Hendel and Lizzeri (2003) and Finkelstein, McGarry, and Sufi (2005) studied dynamic insurance contracts with one-sided commitment, while Koch (2011) studied pricing regulations based on age from an efficiency perspective. Bundorf, Levin, and Mahoney (2012), while focusing on a static marketplace, also analyzed reclassification risk in an employer setting using a two-year time horizon and subsidy and pricing regulations relevant to their large employer context.[11] Crocker and Moran (2003) studied the role that job immobility plays in committing employees to employer sponsored insurance contracts and showed that the quantity of employer provided insurance is larger in professions with greater employee commitment/longevity.

The rest of the paper proceeds as follows: In Section 2, we present our model of insurance exchanges, characterize Riley and Nash equilibria, and discuss the trade-off between adverse selection and reclassification risk. Section 3 describes our data and estimation. In Section 4, we analyze exchange equilibria

[9]See also Crocker and Snow (1986) and Hoy (1982) for theoretical analyses of discriminatory pricing in insurance markets. Both papers show the possibility for such pricing to generate Pareto improvements in the two-type Rothschild–Stiglitz model, with the former paper considering an equilibrium environment (focusing on "Wilson" equilibria) and the latter demonstrating an expansion of the second-best Pareto frontier.

[10]See also Shi (2013) who studied the impact of risk adjustment and premium discrimination in health exchanges, finding that premium discrimination (across age groups) need not increase trade in the absence of risk adjustment transfers.

[11]We find substantially larger welfare consequences of reclassification risk than Bundorf, Levin, and Mahoney (2012). This reflects the different contexts studied and modeling assumptions employed. First, their environment includes a cheap HMO option, which consumers can always switch to, that substantially lessens total expenditures for high risk consumers. Second, their model of risk-rated premiums truncates premiums at 2 times the spending of the population average health risk in each plan (for the HMO, this premium is quite low). Third, they study two sequential utilization years for a young and healthy population.

for a range of regulations on health-based pricing using our baseline case of 90% and 60% actuarial value policies. Section 5 analyzes the long-run welfare properties of these equilibria. Section 6 discusses a number of extensions including (i) alternative contract configurations, (ii) age-based pricing, (iii) self-insurance through saving and borrowing, and (iv) insurer risk adjustment. Finally, Section 7 concludes.

2. MODEL OF HEALTH EXCHANGES

Our model can be viewed as an extension of the model developed in Einav, Finkelstein, and Cullen (2010c) (henceforth, EFC) to the case in which competition occurs over more than one policy. (We discuss below the relation to their model.) Our results provide the algorithm for identifying equilibria using our data, which we do in Section 4.

Throughout the paper, we focus on a model of health exchanges in which two prescribed policies are traded, designated as H for "high coverage" and L for "low coverage." In our baseline specification in Section 4, these policies will cover roughly 90% and 60%, respectively, of an insured individual's costs. Within each exchange, the policies offered by different companies are regarded as perfectly homogeneous by consumers; only their premiums may differ. There is a set of consumers who differ in their likelihood of needing medical procedures and in their preferences (e.g., their risk aversion). We denote by $\theta \in [\underline{\theta}, \overline{\theta}] \subseteq \mathbb{R}_+$ a consumer's "type," which we take to be the price difference at which he is indifferent between the H policy and the L policy. That is, if P_H and P_L are the premiums (prices) of the two policies, then a consumer whose θ is below $P_H - P_L$ prefers the L policy, a consumer with θ above $P_H - P_L$ prefers the H policy, and one with $\theta = P_H - P_L$ is indifferent. We denote by F the distribution function of θ. Throughout our main specification, we assume that there is either an individual mandate or sufficient subsidies so that all individuals purchase one of the two policies. (See our Supplemental Material for an analysis of participation.)

Note that consumers with a given θ may have different underlying medical risks and/or preferences, but will make identical choices between policies for any prices. Hence, there is no reason to distinguish among them in the model. Keep in mind, as we define below the costs of insuring type θ consumers, that those costs represent the expected costs of insuring all of the—possibly heterogeneous—individuals characterized by a specific θ.

This setup involves two restrictions worth emphasizing. First, as in EFC, consumer choices depend only on price differences, not price levels; that is, there are no income effects. In our empirical work, we estimate constant absolute risk aversion preferences, which leads to this property. Second, we restrict attention to the case of an exchange with two policies. We do so because in this case we can derive a simple algorithm for identifying equilibria. With more than two policies, we would likely need to identify equilibria computationally.

We denote the costs of insuring an individual of type θ under policy k by $C_k(\theta)$ for $k = H, L$ and define $\Delta P = P_H - P_L$. Given this, we define the average costs of serving the populations who choose each policy for a given ΔP to be

$$AC_H(\Delta P) \equiv E\big[C_H(\theta)|\theta \geq \Delta P\big]$$

and

$$AC_L(\Delta P) \equiv E\big[C_L(\theta)|\theta \leq \Delta P\big].$$

We also define the difference in average costs between the two policies, conditional on a price difference $\Delta P \in [\underline{\theta}, \overline{\theta}]$, to be

$$\Delta AC(\Delta P) \equiv AC_H(\Delta P) - AC_L(\Delta P).$$

Our characterization results hinge on the following assumption (which we verify in Section 4 holds in our data):

ADVERSE SELECTION PROPERTY: $AC_H(\cdot)$ and $AC_L(\cdot)$ are continuous functions that are strictly increasing at all $\Delta P \in (\underline{\theta}, \overline{\theta})$, with $AC_H(\theta) > AC_L(\theta)$ for all θ.

This Adverse Selection Property will hold, for example, if $C_H(\theta)$ and $C_L(\theta)$ are continuous increasing functions, with $C_H(\theta) > C_L(\theta)$ for all θ, and if the distribution function F is continuous. In that case, a small increase in ΔP shifts the consumers who were the best risks in policy H to being the worst risks in policy L, raising the average costs of both policies. We denote the lowest possible levels of average costs by $\underline{AC}_H \equiv AC_H(\underline{\theta})$ and $\underline{AC}_L \equiv AC_L(\underline{\theta})$, and the highest ones by $\overline{AC}_H \equiv AC_H(\overline{\theta})$ and $\overline{AC}_L \equiv AC_L(\overline{\theta})$.

We refer to the lowest prices offered for the H and L policies as a *price configuration*. We next define the profits earned by the firms offering those prices. Specifically, for any price configuration (P_H, P_L), define

$$\Pi_H(P_H, P_L) \equiv \big[P_H - AC_H(\Delta P)\big]\big[1 - F(\Delta P)\big]$$

and

$$\Pi_L(P_H, P_L) \equiv \big[P_L - AC_L(\Delta P)\big]F(\Delta P)$$

as the aggregate profit from consumers who choose each of the two policies. Let

$$\Pi(P_H, P_L) \equiv \Pi_H(P_H, P_L) + \Pi_L(P_H, P_L)$$

be aggregate profit from the entire population.

The set of *break-even price configurations*, which lead each policy to earn zero profits, is $\mathcal{P} \equiv \{(P_H, P_L) : \Pi_H(P_H, P_L) = \Pi_L(P_H, P_L) = 0\}$. Note that the price configuration $(P_H, P_L) = (\overline{AC}_L + \overline{\theta}, \overline{AC}_L)$, which results in all consumers purchasing policy L, is a break-even price configuration (i.e., it is in set $\mathcal{P}$), as is the "all-in-H" price configuration $(P_H, P_L) = (\underline{AC}_H, \underline{AC}_H - \underline{\theta})$. There may also be "interior" break-even price configurations, at which both policies have a positive market share. We let $\underline{\Delta P}^{\mathrm{BE}}$ denote the *lowest break-even* ΔP *with positive sales of policy* L, defined formally as[12]

$$\underline{\Delta P}^{\mathrm{BE}} \equiv \min\{\Delta P : \text{there is a } (P_H, P_L) \in \mathcal{P} \text{ with } \Delta P = P_H - P_L > \underline{\theta}\}. \tag{1}$$

The price difference $\underline{\Delta P}^{\mathrm{BE}}$ will play a significant role in our equilibrium characterizations below.

2.1. *Equilibrium Characterization*

The literature on equilibria in insurance markets with adverse selection started with Rothschild and Stiglitz (1976). Motivated by the possibility of nonexistence of equilibrium in their model, follow-on work by Riley (1979) (see also Engers and Fernandez (1987)) and Wilson (1977) proposed alternative notions of equilibrium in which existence was assured in the Rothschild–Stiglitz model. These alternative equilibrium notions each incorporated some kind of dynamic reaction to deviations (introduction of additional profitable policies in Riley (1979), and dropping of unprofitable policies in Wilson (1977)), in contrast to the Nash assumption made by Rothschild and Stiglitz. In addition, follow-on work also allowed for multi-policy firms (Miyazaki (1977), Riley (1979)), in contrast to Rothschild and Stiglitz's assumption that each firm offers at most one policy.

Our health exchange model differs from the Rothschild–Stiglitz setting in four basic ways. First, the prescription of two standardized policies limits the set of allowed policies. Second, in our model, consumers face many possible health states. Third, while the Rothschild–Stiglitz model contemplated just two consumer types, we assume there is a continuum of consumer types. Finally, we allow for multi-policy firms.

In our main analysis, we focus on the Riley equilibrium ("RE") notion, which we show always exists and is (generically) unique in our model. We also discuss how these compare to Nash equilibria ("NE"), which need not exist. (In addition, we consider Wilson equilibria in our Supplemental Material.) In what follows, the phrase *equilibrium outcome* refers to the equilibrium price configuration and the shares of the two policies.

We present a formal definition of Riley equilibrium in Appendix A. In words, a price configuration is a RE if there is no profitable deviation that would remain profitable regardless of reactions by rivals that introduce new "safe" policy offers, where a safe policy offer is one that will not lose money regardless of any additional contracts that enter the market after it.

[12]The price difference $\underline{\Delta P}^{\mathrm{BE}}$ is well-defined provided that $\Delta AC(\underline{\theta}) \neq \underline{\theta}$.

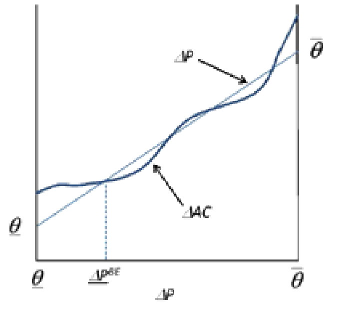

FIGURE 1.—The figure shows $\underline{\Delta P}^{\mathrm{BE}}$, the lowest price difference in any break-even price configuration that has positive sales of the policy L. It also shows a situation in which all consumers purchasing policy H is not an equilibrium outcome, because $\Delta AC(\underline{\theta}) > \underline{\theta}$. The unique Riley equilibrium outcome has price difference $\Delta P^* = \underline{\Delta P}^{\mathrm{BE}}$.

Our result for RE is as follows:

PROPOSITION 1: *A Riley equilibrium always exists and results in a unique outcome whenever* $\Delta AC(\underline{\theta}) \neq \underline{\theta}$.

(i) *If* $\Delta AC(\underline{\theta}) < \underline{\theta}$, *then it involves all consumers purchasing policy H at price* $P_H^* = \underline{AC}_H$.

(ii) *If* $\Delta AC(\underline{\theta}) > \underline{\theta}$, *then it involves the break-even price configuration* (P_H^*, P_L^*) *with price difference* $\Delta P^* = \underline{\Delta P}^{\mathrm{BE}}$, *the lowest break-even* ΔP *with positive sales of policy L.*

We prove Proposition 1 in Appendix A. Here we discuss the result, contrast RE with Nash equilibria, and discuss the relation of our result to EFC and Hendren (2013).

Figure 1 illustrates the result. The figure shows a situation in which $\Delta AC(\underline{\theta}) > \underline{\theta}$ and there are multiple price differences at which both policies break even (including price differences at which all consumers buy policy H, and price differences at which all consumers buy policy L). In this case, our result tells us that the unique RE involves positive sales of policy L and price difference $\underline{\Delta P}^{\mathrm{BE}}$. In contrast, if instead we had $\Delta AC(\underline{\theta}) < \underline{\theta}$, then all consumers purchasing policy H would have been the unique RE outcome. Finally, if instead $\Delta AC(\theta) > \theta$ for all θ, then $\underline{\Delta P}^{\mathrm{BE}} = \overline{\theta}$ and all consumers purchase policy L.

To understand the result, consider first when there is an all-in-H RE. (Readers not interested in the details of why the RE take the form described in Proposition 1 can skip this and the next two paragraphs.) In Appendix A, we first show that any RE must involve both policies breaking even. Given this fact, suppose, first, that $\Delta AC(\underline{\theta}) > \underline{\theta}$, so that the consumer with the lowest willingness to pay for extra coverage is willing to pay less than the difference in the two policies' average costs when (nearly) all consumers buy policy H, $\Delta AC(\underline{\theta}) = \underline{AC}_H - \underline{AC}_L$. In that case, starting from a situation in which all consumers buy policy H and $P_H^* = \underline{AC}_H$, a deviation offering price $\widehat{P}_L = \underline{AC}_H - \underline{\theta} - \varepsilon$ for small $\varepsilon > 0$ would cream-skim the lowest risk consumers into policy L at a price above $\underline{AC}_L$, the average cost of serving them. Moreover, no safe reaction to that deviation can cause the firm offering it to lose money: any reduction in P_H can only lower the deviator's average cost, while any undercutting in P_L cannot result in losses for the deviator. On the other hand, when $\Delta AC(\underline{\theta}) < \underline{\theta}$, a deviation from this all-in-H outcome that attempts to cream-skim must lose money, since then the deviation price satisfies $\widehat{P}_L \leq \underline{AC}_H - \underline{\theta} < \underline{AC}_L$, the lowest possible average cost for policy L. Thus, in that case, all-in-H is a RE.

Now consider break-even price configurations with $\Delta P \in (\underline{\Delta P}^{\mathrm{BE}}, \overline{\theta}]$ (and hence positive sales of policy L). Starting from such a configuration, a deviation to $\widehat{P}_H = AC_H(\underline{\Delta P}^{\mathrm{BE}})$ earns strictly positive profits (it results in a price difference lower than $\underline{\Delta P}^{\mathrm{BE}}$, attracting a positive share of consumers to policy H at an average cost below $AC_H(\underline{\Delta P}^{\mathrm{BE}})$). Moreover, we show in Appendix A that the worst possible safe reaction to this deviation would involve a reduction in P_L to $AC_L(\underline{\Delta P}^{\mathrm{BE}})$ (a reaction that leads to zero profits for the reactor), which makes the deviator earn zero, rather than incur losses. Thus, no such price configuration can be a RE.

Finally, consider the price configuration $P^* = (AC_H(\underline{\Delta P}^{\mathrm{BE}}), AC_L(\underline{\Delta P}^{\mathrm{BE}}))$ that results in price difference $\underline{\Delta P}^{\mathrm{BE}}$. When $\Delta AC(\underline{\theta}) < \underline{\theta}$, this is not a RE. To see this, observe that a deviation offering price $\widehat{P}_H = AC_L(\underline{\Delta P}^{\mathrm{BE}}) + \underline{\theta}$ attracts all consumers to policy H at a price above the cost of serving them, since

$$\widehat{P}_H = AC_L(\underline{\Delta P}^{\mathrm{BE}}) + \underline{\theta} \geq \underline{AC}_L + \underline{\theta} > \underline{AC}_H,$$

where the last inequality holds because $\Delta AC(\underline{\theta}) = \underline{AC}_H - \underline{AC}_L < \underline{\theta}$. Moreover, we show in Appendix A that the worst possible safe reaction to this deviation is an offer of policy L at a price that breaks even given $\widehat{P}_H$; that is, a $\underline{P}_L = AC_L(\widehat{P}_H - \underline{P}_L)$. Since we have $\Delta AC(\Delta P) < \Delta P$ for all $\Delta P \in [\underline{\theta}, \underline{\Delta P}^{\mathrm{BE}})$ when $\Delta AC(\underline{\theta}) < \underline{\theta}$, this implies that $\widehat{P}_H > AC_H(\widehat{P}_H - \underline{P}_L)$, so the reaction cannot make the deviator incur losses. On the other hand, when $\Delta AC(\underline{\theta}) > \underline{\theta}$, the worst safe reaction makes the deviator lose money for any deviation that offers a lower P_H (and we show that only such deviations need be considered), so P^* is a RE.

Note that any Nash equilibrium (NE) must be a RE since the set of deviations that are considered profitable under NE contains the set of Riley profitable deviations. Thus, Proposition 1 also describes NE, should they exist. However, while RE always exists in our model, NE need not. When $\Delta AC(\underline{\theta}) < \underline{\theta}$, the all-in-H RE outcome is also a NE (in fact, the unique one) since, as noted above, no cream-skimming deviation is then profitable. However, when $\Delta AC(\underline{\theta}) > \underline{\theta}$, the RE—which has positive sales of policy L—need not be a NE. In particular, we show in Appendix A that it will be a NE if and only if there is no profitable entry opportunity that slightly undercuts P_L^* and undercuts P_H^*, that is, if $\max_{\widehat{P}_H \leq P_H^*} \Pi(\widehat{P}_H, P_L^*) = 0$. In our empirical work, NE often fail to exist.[13]

Our characterization differs in several respects from that in EFC. EFC considers a model in which there is only one privately supplied policy over which competition occurs. This yields a Nash equilibrium at the lowest price P at which $P = AC$, where AC is the average cost of those consumers who purchase the policy.[14] Their model can apply when there is only one possible type of insurance coverage, or when a higher coverage level is achieved through purchase of a privately supplied add-on to a government-provided policy (such as Medigap coverage). In the latter case, P is the price of the add-on policy, while AC is the average cost of those consumers who purchase the extra coverage.[15] EFC's equilibrium always exists, and always involves a positive share of consumers purchasing insurance provided that all consumers are strictly risk averse and have a strictly positive probability of a loss (in the sense that their preferences are bounded away from risk neutrality, and their probability of a loss is bounded away from zero).

In contrast, in our model, competition occurs over two policies, and equilibrium when both policies are purchased involves both breaking even, yielding the lowest ΔP at which $\Delta P = \Delta AC$, where ΔAC is the difference in the average costs of the two plans, given the consumers who purchase each plan. In contrast to EFC, in this setting a NE may fail to exist, a fact that is driven by the possibility of cream skimming by low coverage plans, a possibility which is absent in their model.[16] Moreover, while RE always exist, they may involve full unraveling, with all consumers purchasing the lowest coverage plan, even when all consumers are strictly risk averse and have a positive probability of a loss. Intuitively, unraveling is more likely here than in the EFC model because the price of policy L reflects the lower costs of the consumers who choose it, leading even the consumers with the highest willingness to pay for higher coverage to pool with better risks in policy L.[17]

[13]We also discuss, in Appendix A, Nash equilibria when firms can offer only a single policy, as in Rothschild and Stiglitz (1976). In our empirical work, these always coincide with the RE.

[14]While EFC do not prove that the lowest break-even price with positive insurance sales is the unique Nash equilibrium, the argument is straightforward (see Mas-Colell, Whinston, and Green (1995, pp. 443–444) for a similar argument).

[15]The EFC model can also be used to derive equilibria when consumers must opt out of government-provided insurance if they purchase a higher coverage private plan. (In that case, AC would be the cost of the private plan for consumers who opt out.) However, in this scenario, EFC's welfare analysis would not apply, as there would be externalities on the government's budget.

[16]Note that profitable cream-skimming deviations that reduce P_L involve *increases* in ΔP, while in the EFC model only reductions in P can attract consumers.

[17]Specifically, in the case of an add-on policy (so policy H is then the combined add-on and government policies), the EFC equilibrium condition is $\Delta P = AC_H(\Delta P) - \widehat{AC}_L(\Delta P)$, where

Our results are also related to Hendren (2013). Hendren derived a sufficient condition for unsubsidized insurance provision to be impossible in a model with two states ("loss" and "no loss") and asymmetric information about the probability of a loss by characterizing when the endowment is the only incentive-feasible allocation. As he noted, his condition cannot hold when all consumers are strictly risk averse and have a strictly positive probability of a loss (bounded away from zero). Consistent with this result, in our model, when the low coverage involves no insurance, some consumers must purchase high coverage in the RE.[18] However, our results also show that when the lowest coverage policy in an exchange provides some coverage, the market can fully unravel even when all consumers are strictly risk averse and have a strictly positive probability of a loss.

2.2. *Adverse Selection versus Reclassification Risk*

In the main application of our framework, we examine the trade-off between adverse selection and reclassification risk that arises with health-based pricing. In that empirical application, we study the welfare effects of health-based pricing over an individual's lifetime. Here, to illustrate the main forces at work, we discuss this trade-off in a simpler static context.[19]

Consider a single-period setting, in which a consumer's medical expenses are $\widetilde{m} = \phi\widetilde{\varepsilon}_b + (1-\phi)\widetilde{\varepsilon}_a$, where $\widetilde{\varepsilon}_b$ and $\widetilde{\varepsilon}_a$ are both independently drawn from some distribution H, and $\phi \in [0, 1]$. The realization of ε_b occurs before contracting, while that of ε_a occurs after. With pure community rating, health status—the realization of ε_b—cannot be priced, while with health-based pricing it can. The parameter ϕ captures how much information about health status is known at the time of contracting. (As we will see in the next section, in our data this ranges between 0.18 and 0.29, depending on the age cohort.) With community rating, there is an adverse selection problem, as consumers know their ε_b realization. In contrast, under perfect health-based pricing, a consumer faces insurance prices that perfectly reflect the realization of ε_b. Consumers are therefore able to perfectly insure the risk in ε_a, but end up bearing all of the risk in ε_b. For example, if the market with community rating fully unravels

$\widehat{AC}_L(\Delta P)$ is the average cost of policy L for the population who chooses policy H given ΔP. In contrast, our (interior) equilibrium condition is $\Delta P = AC_H(\Delta P) - AC_L(\Delta P)$. Since adverse selection implies that $\widehat{AC}_L(\Delta P) > AC_L(\Delta P)$, when $\Delta AC(\underline{\theta}) > \underline{\theta}$ the lowest ΔP satisfying our equilibrium condition is above the lowest satisfying the EFC condition, implying more unraveling in our setting of two privately provided policies. In fact, Weyl and Veiga (2014) showed that the equilibrium in the EFC data using our condition involves complete unraveling.

[18]To see this, observe that in that case the average cost of policy L is always zero, so $\Delta AC(\Delta P) = AC_H(\Delta P)$. Thus, since $\overline{\theta} > C_H(\overline{\theta}) = AC_H(\overline{\theta})$ when type $\overline{\theta}$ is strictly risk averse and has a positive probability of a loss, we then have $\Delta AC(\overline{\theta}) < \overline{\theta}$, which implies that the RE has some consumers purchasing policy H.

[19]The lifetime calculation we do later can be viewed as a sequence of static markets.

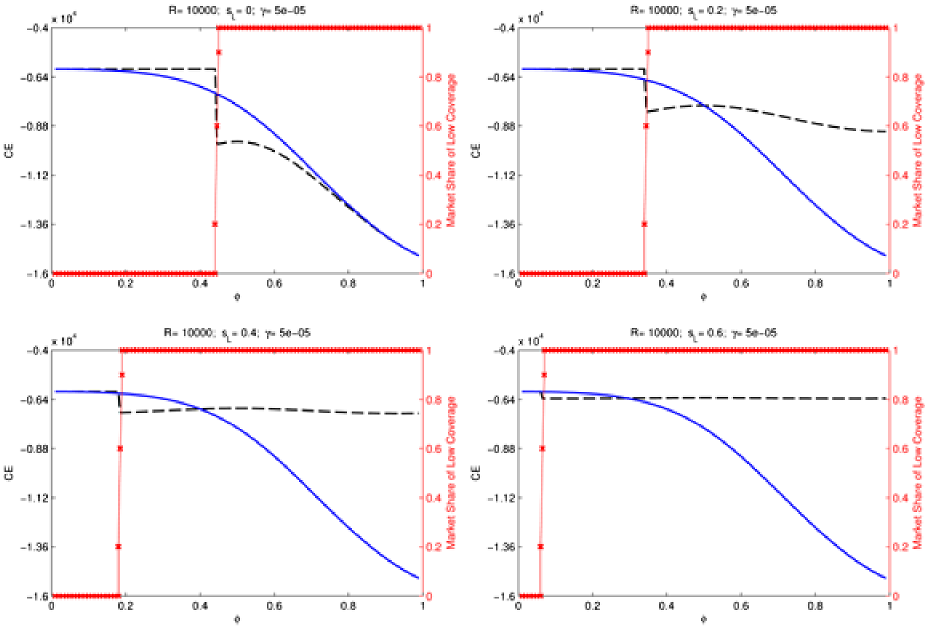

FIGURE 2.—Adverse selection versus reclassification risk, $R = 10{,}000$. X curve: market share of low coverage plan with pure community rating; dashed curve: certainty equivalent with pure community rating; solid curve: certainty equivalent with perfect health-based pricing.

so that all consumers end up with insurance covering share s_L of their medical expenses, then, roughly speaking, they pay for share $(1 - s_L)$ of their medical expenses with community rating and share ϕ with perfect health-based pricing.[20]

Figure 2 shows the results of a simulation in which the distribution of medical expenses H is log-normal, truncated at \$200,000. Its parameters are set so that the mean of total medical expenditures is \$6,000 and the ratio of the variance of total medical expenses to this mean is $R = 10{,}000$. The constant absolute risk aversion (CARA) coefficient is $\gamma = 0.00005$. The policies in each panel are simple linear contracts, with the high coverage plan in each panel covering 90% and the low coverage plan covering share s_L, which takes values of 0, 0.2, 0.4, and 0.6 in the four panels.[21] Each panel plots three curves. The horizontal axis measures the share ϕ of medical risk that is realized before contracting.

[20]This is only a rough statement, because $\tilde{\varepsilon}_a$ and $\tilde{\varepsilon}_b$ are drawn independently, which reduces the risk under community rating relative to that in health-based pricing.

[21]Our aim here is to illustrate the main forces at work in a simple setting. Note that these policies involve the possibility of consumers having much more extreme out-of-pocket expenses than the actual policies we explore later (which have caps on an individual's total out-of-pocket spending), and the risk aversion coefficient is lower than what we estimate. Our analysis later also

For each ϕ, the curve marked with X's shows the market share of the low coverage plan in the RE with pure community rating, the dashed curve shows a consumer's (ex ante, before any medical realizations) certainty equivalent under pure community rating, and the gradually declining solid curve shows the certainty equivalent arising with perfect health-based pricing.

Comparing the four panels in Figure 2, we see that the greater is s_L (the coverage in the low coverage policy), the more unraveling there is—specifically, for larger s_L the market unravels to all consumers in the low coverage plan at lower levels of ϕ.[22] This reflects the fact that cream skimming is easier when the low coverage plan does not expose consumers to too much more risk. In each panel, the welfare of community rating and perfect health-based pricing is the same when $\phi = 0$ (there is then neither adverse selection nor reclassification risk). When $s_L = 0$, welfare in these two regimes is also the same when $\phi = 1$: in that case, the market fully unravels to zero coverage with community rating (consumers know exactly their medical expenses when contracting) and there is nothing left to insure once health status ε_b is priced with perfect health-based pricing. Between these two extremes for ϕ, when $s_L = 0$ health-based pricing is better at high ϕ at which the market nearly fully unravels with community rating, but worse at low ϕ where all consumers get high coverage. A similar pattern emerges at higher levels of s_L except that full unraveling (which happens with pure community rating at $\phi = 1$) is now much more attractive than no coverage (which happens with health-based pricing when $\phi = 1$). Whether there is a range over which health-based pricing is better than community rating then depends on the level of ϕ at which the market unravels.[23] Our empirical work, which we now turn to, explicitly quantifies ϕ, R, and the other key parameters described here and uses these inputs to study the trade-off between adverse selection and reclassification risk induced by different pricing and contract regulations.

3. DATA AND ESTIMATION

3.1. *Data*

Our analysis uses detailed administrative data on the health insurance choices and medical utilization of employees (and their dependents) at a large U.S.-based firm over the period 2004 to 2009. These proprietary panel data include the health insurance options available in each year, employee plan

allows for a nondegenerate distribution of risk aversion levels, risk aversion that is correlated with health status, and partial pricing of health status.

[22] Although it cannot be detected in the figures, when $s_L = 0$, there are some consumers in the high coverage 90 policy at all $\phi < 1$.

[23] In Appendix D of the Supplemental Material, we show a similar figure for a case with greater medical risk ($R = 30{,}000$). Unraveling happens at higher ϕ in that case, reflecting consumers' greater reluctance to choose a low coverage plan.

choices, and detailed, claim-level employee (and dependent) medical expenditure and utilization information. We describe the data at a high level in this section; for a more in-depth description of different dimensions, see Handel (2013).

The first column of Table I describes the demographic profile of the 11,253 employees who work at the firm for some period of time within 2004–2009 (the firm employs approximately 9,000 at one time). These employees cover 9,710 dependents, implying a total of 20,963 covered lives. Forty-six point seven percent of the employees are male and the mean employee age is 40.1 (median

TABLE I
SUMMARY DEMOGRAPHIC STATISTICS[a]

Sample Demographics	All Employees	PPO Ever	Final Sample
N—Employee Only	11,253	5,667	2,023
N—All Family Members	20,963	10,713	4,544
Mean Employee Age (Median)	40.1	40.0	42.3
	(37)	(37)	(44)
Gender (Male %)	46.7%	46.3%	46.7%
Income			
Tier 1 (<\$41K)	33.9%	31.9%	19.0%
Tier 2 (\$41K–\$72K)	39.5%	39.7%	40.5%
Tier 3 (\$72K–\$124K)	17.9%	18.6%	25.0%
Tier 4 (\$124K–\$176K)	5.2%	5.4%	7.8%
Tier 5 (>\$176K)	3.5%	4.4%	7.7%
Family Size			
1	58.0%	56.1%	41.3%
2	16.9%	18.8%	22.3%
3	11.0%	11.0%	14.1%
4+	14.1%	14.1%	22.3%
Staff Grouping			
Manager (%)	23.2%	25.1%	37.5%
White-Collar (%)	47.9%	47.5%	41.3%
Blue-Collar (%)	28.9%	27.3%	21.1%
Additional Demographics			
Quantitative Manager	12.8%	13.3%	20.7%
Job Tenure Mean Years (Median)	7.2	7.1	10.1
	(4)	(3)	(6)

[a]This table presents summary demographic statistics for the population we study. The first column describes demographics for the entire sample whether or not they ever enroll in insurance with the firm. The second column summarizes these variables for the sample of individuals who ever enroll in a PPO option, the choices we focus on in the empirical analysis. The third column describes our final estimation sample, which includes those employees who (i) enroll in the PPO option at the firm in t_{-1} and (ii) remain enrolled in one of the three new PPO options at the firm through at least t_1.

of 37). The table also presents statistics on income, family composition, and employment characteristics.

Our analysis focuses on a three-year period in the data beginning with a year we denote t_0. For t_0, which is in the middle of the sample period, the firm substantially changed the menu of health plans that it offered to employees. At the time of this change, the firm forced all employees to leave their prior plan and actively re-enroll in one of five options from the new menu, with no default option. These five options were composed of three PPOs and two HMOs. Our analysis focuses on choice among the three PPO options, which approximately 60% of health plan enrollees chose. We focus on this subset of the overall option set because (i) we have detailed claims data for PPO enrollees but not for HMO enrollees and (ii) the PPO options share the same doctors/cover the same treatments, eliminating a dimension of heterogeneity that would have to be identified separately from risk preferences. Analysis in Handel (2013) reveals, reassuringly, that while there is substitution across options within the set of PPO options, and across the set of HMO options, there is little substitution between these two subsets of plans, implying there is little loss of internal validity when considering choice between just the set of PPO options.

Within the nest of PPO options, consumers chose between three nonlinear insurance contracts that differed on financial dimensions only. We denote the plans by their individual-level deductibles: PPO_{250}, PPO_{500}, and PPO_{1200}. Post-deductible, the plans have coinsurance rates ranging from 10% to 20%, and out-of-pocket maximums at the family level. In terms of actuarial equivalence value (the proportion of expenditures covered for a representative population), PPO_{250} is approximately a 90% actuarial equivalence value plan (for our sample) while PPO_{1200} is approximately a 73% actuarial equivalence value plan (PPO_{500} is about halfway between PPO_{250} and PPO_{1200}). Over the three-year period that we study, t_0 to t_2, there is substantial variation in the premiums for these plans as well as for different income levels and family structure; this variation is helpful for identifying risk preferences separately from consumer inertia. See Figure 2 in Handel (2013) for specific detail on the within-sample premium variation, which primarily reflects (i) variation in the average costs of the pool enrolling in each plan, (ii) number of dependents covered, (iii) employee income, and (iv) the firm's rule for subsidizing coverage.

We restrict the final sample used in choice model estimation to those individuals/families that (i) enroll in a PPO option at the firm and (ii) are present in all years from t_{-1}, the year before the menu change, through at least t_1. The reasons for the first restriction are discussed above. The second restriction, to more permanent employees, is made to leverage the panel nature of the data, especially the temporal variation in premiums and health risk, to more precisely identify risk preferences. The second column in Table I presents the summary statistics for the families that choose one of the PPO options, while the third column presents the summary statistics for the final estimation sample, incorporating the additional restriction of being present from t_{-1} to at least t_1.

Comparing the second column to the first column reveals little selection on demographic dimensions into the PPO options, while comparing the third column to the others reveals some selection based on family size and age into the final sample, as expected given the restriction to longer tenure.

3.2. *Health Status and Cost Model*

We use detailed medical and demographic information together with the "ACG" software developed at Johns Hopkins Medical School to create individual-level measures of predicted expected medical expenses for the upcoming year at each point in time.[24] We denote these ex ante predictions of the next year's expected medical expenditures by λ and compute these measures for each individual in the sample (including dependents as well as employees). We refer to λ_{it} as individual i's "health status" at time t. Figure D.1 in Appendix D of the Supplemental Material presents the distribution of λ for individuals in the data, as predicted for year t_1, for any individuals in the data (including dependents) present at both t_0 and t_1. The average predicted yearly expenditures for an individual are \$4,878, and as is typical in the health care literature, the distribution is skewed with a large right tail. See Table III later in this section and Table D.I in Appendix D of the Supplemental Material for additional detailed information on the distribution of health spending for our primary sample of interest.

The health status variable λ measures expected total health expenses. However, to evaluate the expected utility for consumers from different coverage options, we need to estimate an ex ante distribution of out-of-pocket expenses for each family j choosing a given health plan k (not just their mean out-of-pocket expense). We utilize the cost model developed in Handel (2013) to estimate these distributions, denoted $H_k(X_{jt}|\boldsymbol{\lambda}_{jt}, \mathbf{Z}_{jt})$. Here, $\boldsymbol{\lambda}_{jt}$ is the vector of λ_{it} for all i in family j, $\mathbf{Z}_{jt}$ are family demographics, and X_{jt} are out-of-pocket medical expenditure realizations for family j in plan k at time t.

The cost model is described in our Supplemental Material; here we provide a broad overview. The model has the following primary components:

1. For each individual and time period, we compute expected expenditure, λ_{it}, for four medical categories: (i) hospital/inpatient, (ii) physician office visits, (iii) mental health, and (iv) pharmacy.

2. We next group individuals into cells based on λ_{it}. For each expenditure type and risk cell, we estimate an expenditure distribution for the upcoming year based on ex post cost realizations. Then we combine the marginal distri-

[24]The program, known as the Johns Hopkins ACG (Adjusted Clinical Groups) Case-Mix System, is one of the most widely used and respected risk adjustment and predictive modeling packages in the health care sector. It was specifically designed to use diagnostic claims data to predict future medical expenditures.

butions across expenditure categories into joint distributions using empirical correlations and copula methods.

3. Finally, for each plan k, we construct the detailed mappings from the vector of category-specific medical expenditures to plan out-of-pocket costs.

The output from this process, $H_k(X_{jt}|\boldsymbol{\lambda}_{jt}, \mathbf{Z}_{jt})$, represents the distribution of out-of-pocket expenses associated with plan k used to compute expected utility in the choice model (and counterfactuals).

The cost model assumes both that there is no individual-level private information and no moral hazard (total expenditures do not vary with k). While both of these phenomena have the potential to be important in health care markets, and are studied extensively in other research, we believe that these assumptions do not materially impact our estimates. Because our cost model combines detailed individual-level prior medical utilization data with sophisticated medical diagnostic software, there is less room for private information (and selection based on that information) than in prior work that uses coarser information to measure health risk.[25] To support these assumptions, we run a "correlation test" in the spirit of Chiappori and Salanie (2000) that investigates whether the choice of higher coverage predicts higher ex post total spending (due to either moral hazard or selection on private information). The test reveals that choice of more comprehensive coverage does not predict higher ex post expenditures, controlling for other observable information used in our choice model.[26]

3.3. *Risk Preferences: Choice Model*

We estimate risk preferences with a panel discrete choice model where choices are made by each household j at time t, conditional on their household-

[25]Pregnancies, genetic predispositions, and noncoded disease severity are possible examples of private information that could still exist. Cardon and Hendel (2001) found no evidence of selection based on private information with coarser data, while Carlin and Town (2009) used claims data that are similarly detailed to ours and also argued that significant residual selection is unlikely.

[26]We perform this analysis for the set of families in our estimation sample for the year t_0, when all of these families make an active plan choice. We estimate a robust standard-error OLS specification with total family spending during t_0 as the dependent variable, and indicator variables for choice of PPO_{250} and PPO_{500} for t_0 on the right-hand side, which also contains observable information such as ex ante predicted family mean spending, past costs, age, income, and other factors that enter our predictive cost model. The coefficient on PPO_{250} is \$839 ($T = 0.78$) and on PPO_{500} is $-$\$531 ($T = -0.52$), implying that family plan choice is not predictive of residual spending at t_0 above and beyond our rich observable measures (though because of the noise inherent to medical spending, a medium-sized effect of private information cannot be ruled out).

plan specific ex ante out-of-pocket cost distributions $H_k(X_{jt}|\boldsymbol{\lambda}_{jt}, \mathbf{Z}_{jt})$. Specifically, the utility of plan k for household j at time t is

$$U_{jkt} = \int_0^\infty u_j\big(M_{jkt}(X_{jt}, \mathbf{Z}_{jt})\big)\, dH_k(X_{jt}|\boldsymbol{\lambda}_{jt}, \mathbf{Z}_{jt}), \tag{2}$$

where u_j is the v-NM or "Bernoulli" expected utility index that measures utility conditional on a given ex post realized state X_{jt} from the expenditure distribution H_k. $\mathbf{Z}_{jt}$ are individual-level observables (described shortly) and M_{jkt} is the effective household consumption, given by

$$\begin{aligned} M_{jkt} = {} & W_j - P_{jkt} - X_{jt} + \eta\big(\mathbf{Z}_j^B\big)\mathbf{1}_{jk,t-1} + \delta_j(A_j)\mathbf{1}_{1200} \\ & + \alpha HTC_{j,t-1}\mathbf{1}_{250} + \varepsilon_{jkt}(A_j), \end{aligned} \tag{3}$$

where W_j denotes household wealth, P_{jkt} is the premium contribution for plan k at time t, and $\mathbf{1}_{jk,t-1}$ is an indicator that equals 1 if plan k is the incumbent plan (default option) at choice year t. This variable captures consumer inertia, which may be present for years with a default option (when the consumer may incur cost η to switch).[27] $\delta_j(A_j)$ is a random coefficient, with distribution estimated conditional on family status A_j (single or covering dependents), that captures permanent horizontal preferences for PPO_{1200} arising from the Health Savings Account linked to this plan option. Parameter α captures preferences for very high-expenditure consumers, who almost exclusively choose PPO_{250} even when that option is not attractive financially ($HTC_{j,t-1} = 1$ for the top 10% of the distribution of expected total costs). The utility of each option k for family j at t is also affected by a mean zero idiosyncratic preference shock ε_{jkt} known to the decision-maker, with variance σ_ε to be estimated conditional on family status A_j.

We assume that households have constant absolute risk aversion (CARA) preferences:

$$u_j(M_{jkt}) = -\frac{1}{\gamma_j}e^{-\gamma_j M_{jkt}}. \tag{4}$$

Parameter γ_j is a household-specific CARA risk preference parameter unobserved by the econometrician. We estimate a random-coefficient distribution of γ_j that is assumed to have mean $\mu_\gamma(\mathbf{Z}_j^A, \boldsymbol{\lambda}_j)$ and be normally distributed with variance σ_γ^2.[28] Note that observable heterogeneity impacts risk preference estimates through a shift in μ_γ, while the level of unobserved heterogeneity

[27] η depends on $\mathbf{Z}_j^B$, a subset of demographic variables and linked choices. See Table B.I in Appendix B of the Supplemental Material for a list of the variables included in $\mathbf{Z}_j^B$ and Handel (2013) for a discussion of heterogeneity in inertia.

[28] The left tail of this normal distribution is truncated at a value just above 0, as is required in the CARA model. This truncation has a very minimal impact empirically.

measured by σ_γ^2 is assumed constant for the entire population. We use the following specification for $\mu_\gamma(\mathbf{Z}_j^A, \boldsymbol{\lambda}_j)$:

$$\mu_\gamma(\mathbf{Z}_j^A, \boldsymbol{\lambda}_j) = \beta_0 + \beta_1 \log\left(\sum_{i\in j} \lambda_i\right) + \beta_2 \text{age}_j + \beta_3 \log\left(\sum_{i\in j} \lambda_i\right) * \text{age}_j + \beta_4 1_{mj} + \beta_5 1_{mj}\widehat{\upsilon}_{mj} + \beta_6 1_{nmj}\widehat{\upsilon}_{nmj}. \tag{5}$$

In addition to expected household health expenditures ($\sum_{i\in j} \lambda_i$), risk preferences depend on the maximum household age, denoted age_j, and the interaction between health risk and age. 1_{mj} is an indicator variable that denotes whether the employee associated with the household is a "manager" (i.e., a high-level employee) at the firm. 1_{nmj} is the complement of 1_{mj}. $\widehat{\upsilon}_{mj}$ is a measure of ability, and is computed as the residual to the following regression, run only on the sample of managers in the population:

$$\text{Income}_j = \alpha_0 + \alpha_1 \text{age}_j + \alpha_2 \text{age}_j^2 + \upsilon_j. \tag{6}$$

The residual $\widehat{\upsilon}_{nmj}$ is computed from the corresponding regression for nonmanagers.

Regarding identification, risk preferences are identified separately from inertia by leveraging the firm's insurance menu redesign for year t_0, together with the assumption that risk preferences are constant within family over time. Households in that year chose plans from a new menu of options with no default option, while in subsequent years they did have their previously chosen option as a default option. Conditional on this choice environment, changing prices and health status over time separately identify inertia from risk preference levels and risk preference heterogeneity. The different components of risk preference heterogeneity are identified using the price variation that exists across income tiers, coverage tiers (number of family members covered), and over time, combined with the changes to household expected medical spending over time (see Figure 2 in Handel (2013), and the related discussion in the text for further discussion of this variation). Finally, consumer preference heterogeneity for the high-deductible plan option with the linked health savings account (HSA) is distinguished from risk preference heterogeneity by comparing choices between the two other plans to those between either of those plans and the high-deductible plan.

We estimate the choice model using a random coefficients simulated maximum likelihood approach similar to Train (2009). The likelihood function at the household level is computed for a sequence of choices from t_0 to t_2, since inertia implies that the likelihood of a choice made in the current period depends on the previous choice. Since the estimation algorithm is similar to a standard approach, we describe the remainder of the details, including the specification for heterogeneity in inertia, in Appendix B of the Supplemental Material.

3.4. *Preference Estimates*

Table II presents our choice model estimates. Column 1 presents the estimates of our primary specification, while Columns 2–4 present robustness analyses to assess the impact of linking different types of observable heterogeneity to risk preferences. The table presents detailed risk preference estimates, including the links to observable and unobservable heterogeneity. Since we only use these parameters in the upcoming exchange equilibrium analyses (plus σ_ε), for simplicity we present and discuss the rest of the estimated parameters in Appendix B of the Supplemental Material (e.g., inertia estimates, PPO_{1200} random coefficients, ε_{jkt} standard deviations, and income regressions). Parameter standard errors, which are generally quite small, are also presented in Appendix B of the Supplemental Material.

TABLE II

CHOICE MODEL ESTIMATES[a]

Empirical Model Results Parameter/Model	(1) Primary Model	(2) Robustness 1	(3) Robustness 2	(4) Robustness 3
Risk Preference Estimates				
μ_γ—Intercept, β_0	$1.21 * 10^{-3}$	$1.63 * 10^{-4}$	$1.06 * 10^{-3}$	$2.54 * 10^{-4}$
μ_γ—$\log(\sum_{i\in j} \lambda_i)$, β_1	$-1.14 * 10^{-4}$	–	$-1.21 * 10^{-4}$	–
μ_γ—age, β_2	$-5.21 * 10^{-6}$	$3.60 * 10^{-6}$	$-4.69 * 10^{-6}$	$3.99 * 10^{-6}$
μ_γ—$\log(\sum_{i\in j} \lambda_i) *$ age, β_3	$1.10 * 10^{-6}$	–	$1.01 * 10^{-6}$	–
μ_γ—Manager, β_4	$4.3 * 10^{-5}$	$7.45 * 10^{-5}$	$5.3 * 10^{-5}$	$5.4 * 10^{-5}$
μ_γ—Manager Ability, β_5	$1.4 * 10^{-5}$	$4.49 * 10^{-5}$	–	–
μ_γ—Nonmanager Ability, β_6	$7.5 * 10^{-6}$	$3.24 * 10^{-5}$	–	–
μ_γ—Nominal Income, β_7	–	–	$3.0 * 10^{-5}$	–
μ_γ—Population Mean	$4.39 * 10^{-4}$	$3.71 * 10^{-4}$	$4.33 * 10^{-4}$	$4.73 * 10^{-4}$
μ_γ—Population σ	$6.63 * 10^{-5}$	$7.45 * 10^{-5}$	$8.27 * 10^{-5}$	$6.30 * 10^{-5}$
σ_γ—γ Standard Deviation	$1.24 * 10^{-4}$	$1.14 * 10^{-4}$	$1.40 * 10^{-4}$	$1.20 * 10^{-4}$
Gamble Interp.:				
μ_γ Mean	693	728	696	676
μ_γ Mean + 25th Quantile σ_γ	736	772	748	717
μ_γ Mean + 75th Quantile σ_γ	653	688	651	640
μ_γ Mean + 95th Quantile σ_γ	604	638	596	593

[a]Column 1 presents the results from our primary specification described in Section 3. Columns 2–4 present robustness analyses that assess the impact of linking preferences to health status and our measure of income earning ability. For each model, we present the detailed risk preference estimates, including the links to observable and unobservable heterogeneity. The rest of the parameters (inertia estimates, PPO_{1200} random coefficients, and ε_{jkt} standard errors) and the standard errors for all parameters are provided in Appendix B of the Supplemental Material. The bottom of the table interprets the population mean risk preference estimates: it provides the value X that would make someone indifferent about accepting a 50–50 gamble where you win $1,000 and lose X versus a status quo where nothing happens. The population distributions of risk preferences are similar across the specifications, even though the additional links between health risk/ability and risk preferences add richness.

For the primary specification, the population mean for μ_γ, the household mean risk aversion level, is $4.39 * 10^{-4}$. The standard deviation for μ_γ (or the standard deviation in risk preferences based on observable heterogeneity) equals $6.63 * 10^{-5}$. The standard deviation of unobservable heterogeneity in risk preferences, σ_γ, equals $1.24 * 10^{-4}$. See the results in the bottom section of Table II for interpretations of these risk preference estimates in the context of simple hypothetical gambles.[29]

In terms of observable heterogeneity, risk preferences are negatively correlated with mean health risk: a one point increase in $\log(\sum_{i\in j} \lambda_i)$ reduces μ_γ by $8.10 * 10^{-5}$ for a 30-year old.[30] While a negative correlation between mean risk (expected total medical expenses) and risk aversion may suggest less adverse selection than when these factors are independent, Veiga and Weyl (2013) showed the opposite is the case in our application. Using our simulated sample, they computed the product of risk aversion times the variance of the risk faced, which is the appropriate measure of insurance value under some assumptions. In our case, the correlation between insurance value and mean expected risk is positive, exacerbating adverse selection. Managers and those with higher ability are slightly more risk averse. With a log expected total health spending value of 9 (around the median for a household), risk aversion is increasing in age by $4.69 * 10^{-6}$ per year. The specifications in Columns 2–4 in Table II, which investigate robustness with respect to the inclusion of and specification for health status/ability in risk preferences, estimate similar means and variances for risk preferences relative to our primary specification. While the estimates in the literature span a wide range, and should be interpreted differently depending on the different contexts being studied, our estimates generally fall in the middle of the range of prior work on insurance choice, while the extent of heterogeneity we estimate is somewhat lower in magnitude (see, e.g., Cohen and Einav (2007)). The negative estimated correlation between expected health risk and risk preferences is consistent with that association in Finkelstein and McGarry (2006) but the opposite sign of the effect found in Cohen and Einav (2007).

[29]The bottom rows in Table II interpret the mean of the average estimated risk aversion μ_γ, as well as several quantiles surrounding that average μ_γ. We present the value X that would make a household with our candidate risk aversion estimate indifferent between inaction and accepting a simple hypothetical gamble with a 50% chance of gaining \$1,000 and a 50% chance of losing \$$X$. Thus, a risk-neutral individual will have $X = \$1{,}000$, while an infinitely risk averse individual will have X close to zero. For the population mean of μ_γ from the primary model we have $X = \$693$, while for the 25th, 75th, and 95th quantiles of unobserved heterogeneity around that mean, X is \$736, \$653, and \$604, respectively (these values are decreasing because they decrease as γ increases).

[30]The coefficient on health risk is more negative than this, while the interaction between age and risk preferences has a positive coefficient, indicating some reduction in the negative relationship between risk preferences and health risk as one becomes older.

3.5. *Simulation Sample*

We estimate the choice model at the family level because that is the unit that actually makes choices in the data. For our counterfactual insurance exchange simulations, we focus on individuals to simplify exposition.

The sample used in the simulations contains individuals between the ages of 25 and 65. Thus, our simulations include both individuals with single coverage in the data, and individuals who are members of families with family coverage in our data. To ensure that the data for a given individual are complete, we require a given simulated individual to be present for at least eight months in each of two consecutive years.[31] The data from the first year are used to predict health status, while the presence in the second year is used to ensure the individual was a relevant potential participant in the firm's benefit program for that year. This ensures that the simulation sample reflects to some extent the presence/longevity of the choice model estimation sample. For risk preferences, some of the variables used in estimation are defined at the family level rather than the individual level (e.g., ability, manager status of the employee in the family). Every individual that comes from a given family is assigned the relevant family value for these variables when simulating risk preferences for that individual in the exchange counterfactuals. Table D.I in Appendix D of the Supplemental Material describes some key descriptive variables for this pseudo-sample of 10,372 individuals used for the insurance exchange simulations. Importantly, the distributions of income and health expenditures are similar to those of the main estimation sample and the population overall. The proportion female is also similar. Finally, similarly to what we see in the data overall, the simulation sample covers the range of ages from 25 to 65 fairly evenly: this is relevant to our upcoming welfare analysis, which assumes that the population is in a steady state.

Table III shows the distribution of expenses for the simulation sample. The first two columns show the mean and standard deviation of expenditure by age group. The next column represents the standard deviation within each group of the expected expenditure, followed by the standard deviation of expenses around the expectation (i.e., the mean of squared deviations from the individual means). The last two columns show what we denoted as R and ϕ in Section 2.2. R is defined as the variance of health expenses divided by the mean expenses, while ϕ represents the proportion of the variance of expenses that is revealed prior to contracting, namely, that is known at the time of purchasing coverage. Interestingly, ϕ decreases in age. Namely, a lower proportion of

[31] For individuals whose past year of cost data is less than one year (between eight months and one year), we assume that this past data represent one full year of health claims for the purposes of constructing their health status λ. We assume in all of the simulations that individuals buy a plan expecting to be in that plan for the full year (this is not an issue in choice model estimation, where the sample is restricted to those present for full years). The cost model estimation is done only for individuals with full years of cost data and these full-year distributions are the ones used in our analysis.

TABLE III

EXCHANGE SAMPLE: SUMMARY STATISTICS

Final Sample Total Health Expenditure Statistics						
Ages	Mean	S.D.	S.D. of Mean	S.D. Around Mean	R	ϕ
All	6,099	13,859	6,798	9,228	31,369	0.24
25–30	3,112	9,069	4,918	5,017	26,429	0.29
30–35	3,766	10,186	5,473	5,806	27,550	0.29
35–40	4,219	10,753	5,304	6,751	27,407	0.24
40–45	5,076	12,008	5,942	7,789	28,407	0.25
45–50	6,370	14,095	6,874	9,670	31,149	0.24
50–55	7,394	15,315	7,116	11,092	31,722	0.22
55–60	9,175	17,165	7,414	13,393	32,113	0.19
60–65	10,236	18,057	7,619	14,366	31,854	0.18

the uncertainty is revealed prior to contracting for older groups.[32] Moreover, the majority of the variance in expenses remains to be resolved after contracting. Viewed in the context of the model in Section 2.2, these quantities have direct implications for the empirical trade-off between adverse selection and reclassification risk as a function of the different pricing, contract, and market regulations that we investigate for the remainder of the paper.

4. EQUILIBRIUM EFFECTS OF RISK-RATING

We use the estimates from our choice and cost models to study the effects of pricing and contract regulations. As in Section 2, we study exchanges in which insurers can offer two policies. We assume here that the two policies cover either 90% or 60% of expenditures in the population, on average. While there are a variety of potential nonlinear contract designs that would imply these coverage levels, following the discussion of such policies in Consumers Union (2009) we assume that the 90% policy has no deductible, a 20% coinsurance rate post-deductible, and a \$1,500 out-of-pocket maximum (all at the individual level we study here) and the 60% policy has a \$3,000 deductible, a 20% coinsurance rate post-deductible, and a \$5,950 out-of-pocket maximum. In Section 6, we study other contract configurations.

The estimated model contains three sources of heterogeneity that we use in this analysis: risk type, risk aversion, and an idiosyncratic preference shock.

[32]However, comparing R (the ratio of the variance to mean medical expenses) and mean medical expenses, we see that the overall variance of medical expenses is roughly four times larger in age group 60–65 than in age group 25–30. Thus, the total amount of information known prior to contracting (measured by its variance) is larger in the former group, despite the fact that ϕ is decreasing in age.

For each individual in the population we compute, based on their demographics and prior diagnostics, the risk type λ discussed in the previous section. For a given λ, we take 100 draws from the estimated distribution of γ (conditional on λ and the other demographics modeled in equation (5)), creating 100 "pseudo-individuals" for each actual individual in our sample. Doing so generates a joint distribution of risk preferences and risk type. For each of the two plan designs, we compute the distribution of out-of-pocket expenses $H_k(\cdot|\lambda_{it}, Z_{it})$. With these objects, we compute the expected utility of each (pseudo) individual for each plan, and use them to find CE_{90} and CE_{60} (gross of premiums), as described in Section 2. Willingness to pay for the extra coverage of the 90% plan is $\theta = CE_{90} - CE_{60} + \varepsilon$, where ε is distributed $N(0, \sigma_\varepsilon^2)$. Thus, as in equation (3), there is a random shock to a consumer's preference between the two plans. For the simulations that follow, we use $\sigma_\varepsilon = 525$, which is the estimated standard deviation of ε for the single population for PPO_{1200} relative to PPO_{250}. As we report below, our results are robust to medium-sized changes in σ_ε.

The sample population and the estimated distributions determine $F(\theta)$. Costs to each plan k, $C_k(\theta)$ for $k = 90$ and 60, are computed using expected plan costs $\lambda_{it} - E[X_{it}|\lambda_{it}, Z_{it}]$, aggregating over all individuals associated with each θ, while $AC_{90}(\theta)$ and $AC_{60}(\theta)$ are determined by aggregating these costs over the θ that select a given plan.

The Adverse Selection Property introduced in Section 2, upon which our theoretical results hinge, can be verified in our sample: Figure 3 shows that AC_{90} and AC_{60} are increasing in ΔP for each policy, and that AC_{90} exceeds AC_{60} at all ΔP.

4.1. *Pure Community Rating*

We start by considering the case of pure community rating, where insurers must price everyone in the whole population identically. We follow the theoretical results of Section 2 as a roadmap to finding equilibria.

The first step toward finding equilibria involves checking whether all consumers pooling in the 90 plan is an equilibrium. Figure 4, which plots $\Delta AC(\Delta P)$, shows that $\Delta AC(\underline{\theta}) > \underline{\theta}$, which implies that there is a profitable cream-skimming deviation from all-in-90 that attracts the healthiest customers to the 60 policy.[33] Thus, in our population, all-in-90 is not an equilibrium. The equilibrium must involve purchases of the 60 policy.

The second step toward finding equilibrium involves finding the lowest break-even ΔP, $\underline{\Delta P}^{\text{BE}}$; that is, the lowest interior ΔP at which $\Delta P = AC_{90}(\Delta P) - AC_{60}(\Delta P)$, if any exist, or $\Delta P = \overline{\theta}$ otherwise. This is then the RE ΔP.

[33]Figures 4 and 5 present $\Delta AC(\Delta P)$ for only $\Delta P > 0$, even though empirically a very small proportion of consumers have $\theta < 0$ because they are both healthy and have negative draws of the idiosyncratic preference shock ε. The values for $\Delta AC(\underline{\theta})$ are essentially identical to those for $\Delta AC(0)$ depicted in both figures.

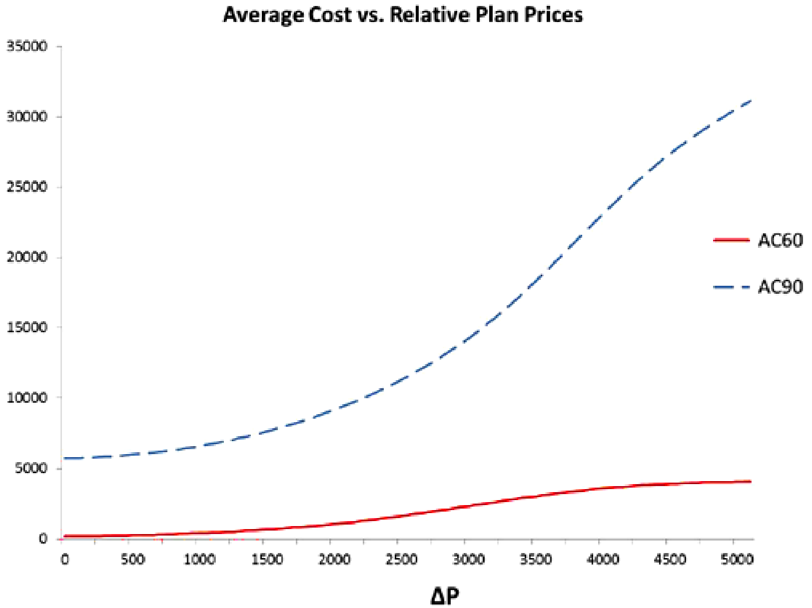

FIGURE 3.—Plot of average costs versus the price difference ΔP. Average costs are increasing in this price difference, and are larger for the 90 policy at each ΔP, consistent with the Adverse Selection Property maintained to derive our theoretical results.

Figure 4 shows that, for the case of pure community rating, there is no interior equilibrium. Namely, there is no pair of premiums at which both policies have positive market shares and both break even: for any premium gap between 60 and 90 coverage, the gap in average costs is larger than the gap in premiums. The market must fully unravel. Thus, by Proposition 1, all-in-60 must be the RE.

All-in-60 is not a Nash equilibrium, as a price cut in P_{90} in conjunction with an infinitesimal reduction of P_{60} is profitable.[34] The top section of Table IV summarizes these findings for the case of a pure community rating pricing regulation.

4.2. *Health-Based Pricing*

We now investigate the effects of allowing pricing of some health status information. Specifically, we first consider the case in which consumers are classified into quartiles based on their ex ante predicted total expenditures λ; for

[34]This type of deviation is profitable in every all-in-60 RE we report throughout in the paper. Appendix A also discusses Nash equilibria when firms can only offer single policies (sp-NE). All the RE we found are sp-NE (they need not be, as the existence of sp-NE, unlike RE, is not guaranteed).

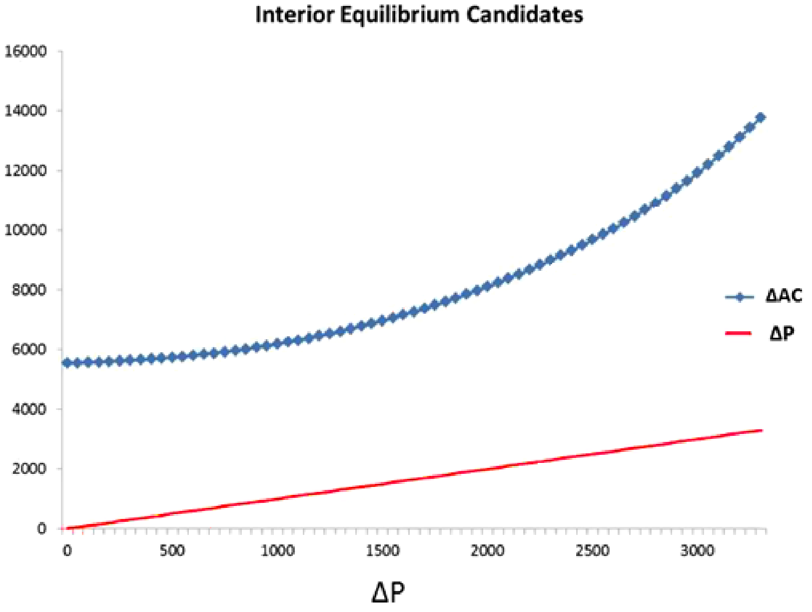

FIGURE 4.—Plot of the average cost difference $\Delta AC(\Delta P)$ and the price difference ΔP.

TABLE IV

EXCHANGE EQUILIBRIA: COMMUNITY RATING AND HEALTH-STATUS QUARTILE PRICING[a]

Equilibria Without Pre-Existing Conditions							
	Equilibrium Type	P_{60}	S_{60}	AC_{60}	P_{90}	S_{90}	AC_{90}
	RE	4,051	100.0	4,051	–	0	–
	NE			Does not exist			

Equilibria With Health Status-Based Pricing							
Market	Equilibrium Type	P_{60}	S_{60}	AC_{60}	P_{90}	S_{90}	AC_{90}
Quartile 1	RE/NE	289	64.8	289	1,550	35.2	1,550
Quartile 2	RE	1,467	100.0	1,467	–	0	–
Quartile 3	RE	4,577	100.0	4,577	–	0	–
Quartile 4	RE	9,802	100.0	9,802	–	0	–

[a]The top section of this table presents the equilibrium results for the case of pure community rating (no pricing of pre-existing conditions). The bottom section presents the equilibrium results for the case in which insurers can price based on health status information in the form of health status quartiles. The equilibrium results are presented for each health status quartile, which act as separate markets under this regulation.

example, the first quartile contains the healthiest consumers, while the last contains the sickest consumers. Insurers can target each quartile with different prices as they see fit. We later present results that vary the fineness of information insurers can price on, ranging from pure community rating all the way up to the case of unrestricted risk rating/price discrimination. These stylized regulations are meant to be illustrative of potentially more subtle regulations seen in real-world insurance markets that vary the ability of insurers to price discriminate based on health status. We follow the same steps as in the previous subsection to find equilibria, but now for each market segment separately.

The implications of this pricing regulation for adverse selection are seen directly when examining the pricing equilibrium for quartile 1, the healthiest quartile of consumers. For quartile 1, there is an interior equilibrium. The first step, as described above, is to check whether all-in-90 is an equilibrium. Figure 5 shows that, as in the pure community rating case, $\Delta AC(\underline{\theta}) > \underline{\theta}$, implying that all-in-90 is not an equilibrium.

The second step is to look for interior equilibrium candidates. Figure 5 shows two interior break-even ΔP's. By Proposition 1, the lowest ΔP, the one with the largest share of customers in the 90 policy, is the RE. In this equilibrium, 35.2 percent of quartile 1 consumers obtain high coverage.

In contrast, equilibria in quartiles 2, 3, and 4 are qualitatively identical to the equilibrium under pure community rating. We omit the graphs, which look similar to Figure 4. The bottom section of Table IV summarizes the findings for the

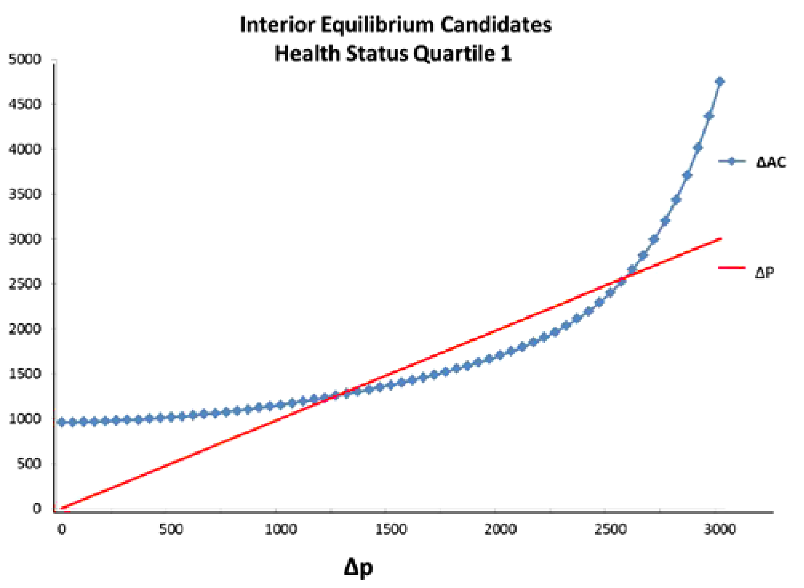

FIGURE 5.—Plot of the average cost difference $\Delta AC(\Delta P)$ and price difference ΔP for the healthiest quartile.

four quartiles under health status-based pricing. The table also highlights the potential for reclassification risk when moving from the static equilibrium analysis to the analysis of long-run consumer welfare: if insurers can price based on health status quartiles, consumers will find themselves paying premiums as low as $289 or as high as $9,802, corresponding to the different quartiles, as their health evolves over time. However, under these pricing regulations, many of the healthiest consumers in the population obtain a greater level of insurance coverage, and thus are less impacted by adverse selection.

To more completely analyze the trade-off between adverse selection and reclassification risk, we also consider a range of pricing regulations that allow insurers to price based on health status information with varying degrees of specificity. The second column in Table V describes the RE share in the 60 policy when insurers instead can price based on 2, 4, 6, 8, 10, 20, or 50 health status partitions, as well as the case of full risk-rating (labeled ∞). Adverse selection is reduced as the insurers are able to price on finer information: with 4, 10, and 50 partitions, the 60 plan has 90%, 83%, and 63% market shares, respectively, while with full risk-rating, 73% of consumers choose to enroll in the 90 plan.[35] (The welfare numbers in the third through fifth columns of Table V will be discussed in Section 5.)

TABLE V

EXCHANGE OUTCOMES ACROSS HEALTH-STATUS PRICING REGIMES[a]

Equilibria Welfare Loss From Health Status-Based Pricing: Varying Regulation				
# of Health Buckets	S_{60}	$y_{\mathrm{HB}x,\mathrm{PCR}}$ Fixed Income	$y_{\mathrm{HB}x,\mathrm{PCR}}$ Non-Manager Income Path	$y_{\mathrm{HB}x,\mathrm{PCR}}$ Manager Income Path
2	100.0	1,920	710	−102
4	90.0	3,082	1,821	−886
6	82.0	3,951	2,377	−232
8	85.1	4,649	2,084	−1,510
10	83.2	5,357	2,269	−1,364
20	81.4	8.590	4,621	−393
50	63.2	11,578	7,302	2,359
∞	27.0	14,733	9,944	2,399

[a]Equilibria and long-run welfare comparison between the pricing regulations that allow some pricing based on health status and the case in which no pricing on health status is allowed. The table shows the share of consumers choosing the 60 policy for each pricing regime. It also presents the values for $y_{\mathrm{HB}x,\mathrm{PCR}}$, the annual payment required under regulation that allows pricing of x evenly sized health risk buckets that makes consumers indifferent between that regulation and the case of pure community rating (PCR). The regimes x listed in the first column correspond to how targeted pricing can be over the range of health status; for example, 4 corresponds to the case of quartile pricing, while ∞ is full risk-rating. The results presented are for Riley equilibria and $\gamma = 0.0004$.

[35]With no ε preference shock, with full risk-rating, all consumers would enroll in the 90% plan. Here, with the estimated ε standard deviation incorporated, the first-best allocation has 73% of consumers in the 90% plan, since some choose the 60% plan due to this preference shock.

5. WELFARE EFFECTS

Our aim in this section is to evaluate the expected utility of an individual starting at age 25 from an ex ante ("unborn") perspective, that is, before he knows the evolution of his health. The unborn individual faces uncertainty about how his health status will transition from one year to the next, and thus what policies he will purchase and what premiums he will pay. Since individuals differ in their risk aversion, we will calculate this expected utility separately for different risk aversion levels.

To be more specific, for any pricing rule x (e.g., pure community rating), the analysis in the previous section tells us what policy each individual will choose as a function of their health status (λ) and risk aversion (γ), and the premium they will pay. Given this information, we can compute the certainty equivalent $CE_x(\lambda, \gamma)$ of the uncertain consumption that this individual of type (λ, γ) will face within a year because of uncertainty over his health realization.

To measure the welfare difference for an individual with age-25 risk aversion level γ between any two regimes x and x', we define the fixed yearly payment $y_{x,x'}(\gamma)$ added to income in regime x that makes the individual have the same expected utility starting at age 25 under regime x and as under regime x':

$$\sum_{t=25}^{65} \delta^t E\big[-e^{-\gamma\{I_t - CE_x(\lambda_t,\gamma)+y_{x,x'}(\gamma)\}}\big] = \sum_{t=25}^{65} \delta^t E\big[-e^{-\gamma\{I_t - CE_{x'}(\lambda_t,\gamma)\}}\big],$$

or

$$y_{x,x'}(\gamma) = -\frac{1}{\gamma}\ln\left(\frac{\sum_{t=25}^{65} \delta^t E\big[-e^{-\gamma\{I_t - CE_{x'}(\lambda_t,\gamma)\}}\big]}{\sum_{t=25}^{65} \delta^t E\big[-e^{-\gamma\{I_t - CE_{x}(\lambda_t,\gamma)\}}\big]}\right). \tag{7}$$

To compute expected utility starting at age 25 from an ex ante perspective, we need to know how health status will transition over time for an individual with a given risk aversion γ at age 25. If risk was independent of risk aversion, the computation would be straightforward. In a steady state, the observed health realization of the whole population (at different ages) would be representative of the expected realization of any individual as he ages. Assuming that our sample represents a steady state population, we would just draw from the realized cost distribution to capture the ex ante distribution that any (unborn) individual faces.[36]

[36]Recall that the age distribution in our sample is close to uniform, as it should be in a steady state population.

However, our estimates imply that health and risk aversion are correlated, with more risk averse individuals being healthier on average. Table D.II in Appendix D of the Supplemental Material shows, for various risk aversion levels γ, the average costs of the individuals selected in this manner at ages 25–30, 45–50, and 60–65. The pattern of costs reflects the positive correlation between health status and risk aversion, as well as the attenuation of this positive relationship with increases in age. The correlation makes the population as a whole not representative of the health costs faced by individuals after they draw their own γ.

To identify the stochastic health outcomes a 25-year old with a given risk aversion γ foresees at any given future age t, we isolate those individuals in our simulation sample of age t whose risk aversion γ_t falls into a band around the level expected based on our estimates of equation (5), for individuals with risk aversion level γ at age 25.[37] For a given discount factor $\delta \leq 1$ and regime x, we calculate $\sum_t \delta^t E[-e^{-\gamma\{I_t - CE_x(acg_t,\gamma)\}}]$ as follows: first, we generate the value of $e^{-\gamma\{I_t - CE_x(\lambda_t,\gamma)\}}$ that each individual of age t in the band associated with γ would have if he chose between the 60 and 90 policies facing the equilibrium prices in regime x and having risk aversion parameter γ.[38] The income level I_t is either held fixed (in which case, with CARA preferences, its level does not matter) or comes from the regression in equation (6) and is estimated separately for managers and nonmanagers.[39] We then derive $E_{x_t}[-e^{-\gamma\{I_t - CE_x(\lambda_t,\gamma)\}}]$ by calculating the sample mean of those values for age t individuals in the γ band. We then discount and add these values over t to get $\sum_t \delta^t E_{x_t}[-e^{-\gamma\{I_t - CE_x(\lambda_t,\gamma)\}}]$. We proceed similarly for regime x'.

In our primary analysis, we do not allow consumers to borrow and save over the course of their lifetimes to self-insure against health shocks. We assume this because (i) we do not observe the extent to which agents are able to save and borrow in practice, and (ii) integrating borrowing and saving into our full welfare model introduces substantial computational complexity. Our main analysis allows for two types of consumer income paths. The first assumes that income is fixed at the same level over time (perfect income smoothing prior to health spending), while the second allows for increasing income paths (as observed in our data) without the possibility of borrowing or saving. In the latter case, we provide a calculation separately for managers and nonmanagers, whose expected incomes paths differ. We note that, since self-insurance

[37]We use a band radius of 0.00005.

[38]Thus, we evaluate the welfare of an individual who at age 25 does not foresee his risk aversion changing.

[39]For managers, the mean income level I_t starts near income tier 1 at age 25 (\$0–\$40,000) and is near tier 4 at age 65 (\$124,000–\$176,000). Maximum income for managers occurs at age 66. For nonmanagers, mean income also starts near income tier 1 at age 25 and is halfway between tiers 2 (\$40,000–\$80,000) and 3 (\$80,000–\$124,000) at age 65. Income peaks at age 56 for nonmanagers, with an average near income tier 3. See the discussion of the estimates of equation (6) in Appendix B of the Supplemental Material for more details.

TABLE VI

WELFARE ANALYSIS: COMMUNITY RATING VS. HEALTH-STATUS QUARTILE PRICING[a]

Welfare Loss From Health Status-Based Pricing in RE/sp-NE ($/Year)			
γ	$y_{\mathrm{HB4,PCR}}(\gamma)$ Fixed Income	$y_{\mathrm{HB4,PCR}}(\gamma)$ Non-Manager Income Path	$y_{\mathrm{HB4,PCR}}(\gamma)$ Manager Income Path
0.0002	2,220	1,499	−384
0.0003	2,693	1,688	−613
0.0004	3,082	1,821	−886
0.0005	3,399	1,764	−973
0.0006	3,626	2,115	−891

[a] Long-run welfare comparison between the two pricing regulations of (i) pricing based on health status quartiles ($x =$ "HB4") and (ii) pure community rating ($x' =$ "PCR"). The table presents the values for $y_{\mathrm{HB4,PCR}}(\gamma)$, the annual payment required under regime HB4 to make consumers indifferent between HB4 and PCR. The results presented are based on the RE outcomes presented in Table IV. We present results for the differing cases of (i) fixed income, (ii) the nonmanager income path, and (iii) the manager income path. The assumed discount rate is $\delta = 0.975$.

through borrowing and/or saving has the potential to impact our main conclusions, in Section 6.3 we study a simplified extension of our primary welfare model that allows for dynamic borrowing and saving decisions over the course of a consumer's lifetime.

We first compare two regimes: ACG-quartile pricing and pure community rating. The latter eliminates reclassification risk but exacerbates adverse selection. Health-based pricing also involves some intertemporal redistribution, as the young tend to face lower premiums. To the extent that this regime smooths consumption over time (given the fact that income generally rises with age), this creates some welfare gain as well if agents cannot otherwise borrow to smooth their consumption over time. Table VI shows the values of $y_{x,x'}(\gamma)$ comparing pricing based on ACG-quartiles ($x =$ "HB4") and community rating ($x' =$ "PCR") for $\delta = 0.975$.

With a fixed income, the welfare gains from eliminating reclassification through community rating greatly exceed any losses this rule introduces due to adverse selection. The loss from health-based pricing on quartiles ranges from \$2,220 to \$3,626 per year depending on risk aversion level. Losses are larger for those with greater risk aversion. The annual loss with health status quartile pricing at a risk aversion level of 0.0004, approximately the mean in our sample, is \$3,082, which is about 51% of the \$6,099 annual average total expenses in the population (see Table D.I in Appendix D of the Supplemental Material). We can compare this to the welfare implications of just adverse selection: with fixed income and risk aversion 0.0004, a consumer would be willing to pay \$619 per year to face a regime in which everyone receives the 90 policy at price $P_{90} = \underline{AC}_{90}$ rather than the community rating regime in which pre-existing conditions cannot be priced and everyone ends up buying the 60 policy at price $P_{60} = \overline{AC}_{60}$. Thus, the welfare loss from reclassification risk is at least 5 times as large as the welfare loss from adverse selection under pure community rating.

When individuals cannot borrow, health-based pricing confers an additional benefit by moving consumption forward in life. For nonmanagers, the losses from health-based pricing now range from \$1,499 to \$2,115 per year. For managers, however, whose income is higher and rises more steeply with age (see footnote 39), and therefore benefit more from moving consumption forward in time, health-based pricing is actually preferred to community rating. For this group, the benefits of smoothing income over time outweigh the costs of reclassification risk. Section 6.3 investigates a model where consumers can self-insure via dynamic borrowing and saving, and reveals that our main conclusions about the importance of reclassification risk relative to adverse selection are unchanged once self-insurance is possible.

We revisit Table V to examine the welfare implications of varying the extent to which insurers can price health status information. The third through fifth columns illustrate the impact of finer pricing on long-run welfare for risk aversion value $\gamma = 0.0004$. With fixed income (the third column), and for nonmanagers' income paths (the fourth column), the welfare loss from increased reclassification risk swamps the welfare gain from reduced adverse selection: the welfare loss from pricing 20 health status categories is almost 3 times that from pricing quartiles. For managers' income paths, the effect is not monotone, because of the benefits of income smoothing, but fine enough pricing does lead to a welfare loss relative to community rating (e.g., with 50 health status groups). Overall, the results highlight the trade-off between adverse selection and reclassification risk, and suggest that reclassification risk is likely to be more important from a welfare perspective.[40,41]

6. EXTENSIONS

In this section, we study several extensions to our primary analysis. First, we investigate how market equilibria and the welfare trade-off between adverse selection and reclassification risk depend on the actuarial values of the contracts the regulator allows insurers to offer. Second, we allow for age-based pricing.[42] Third, we incorporate self-insurance through saving and borrowing

[40]In addition to considering the fixed income case here, in the next section we consider the same comparison between community rating and pricing based on health status when there is also age-based pricing which eliminates the intertemporal consumption-shifting effect of health-status-based pricing. When we do so, managers also prefer community rating.

[41]One caveat to these results is that they rely on our estimated risk preferences being appropriate for evaluating reclassification risk. With fine pricing of health status, consumers can face very large monetary losses from reclassification, and the implied certainty equivalents for risk averse consumers can become implausibly large in magnitude for the reasons noted by Rabin (2000).

[42]Age-based pricing is commonly found in health exchanges in practice, including the state exchanges set up under the ACA. We note that age-based pricing will not impact the extent of reclassification risk, since age is deterministic over one's lifetime.

into the analysis. The ability to borrow after a health shock, or save in anticipation of future shocks, could in theory alter our conclusions by substantially reducing the costs of reclassification risk. Fourth, we study the impact of insurer risk adjustment transfers, whereby insurers are at least partially compensated when enrolling ex ante sicker consumers. Finally, in our Supplemental Material, we present two additional extensions: (i) endogenous consumer exchange participation, and (ii) an alternative weighting of our sample designed to reflect representative U.S. demographics.

6.1. *Alternative Contracts and Contract Design*

So far we have studied pricing regulation for a given set of contracts. In practice, exchange designers also regulate contract configuration. In this section, we replicate our analysis of adverse selection and reclassification risk for a range of alternative contract configurations. Specifically, we investigate configurations that hold the high coverage contract at an actuarial value of 90, and set the low coverage contract at 80, 40, and 20, respectively.

Table VII shows market equilibrium results for these alternative contract configurations. Consider first pure community rating. Under both the 90–80 and 90–40 configurations, community rating results in full unraveling just as it does for 90–60. However, under 90–20, less than a third of the market ends up with the lower coverage. The unattractiveness of the low option pushes more consumers to purchase 90, making it cheaper, spiraling into a high share of high coverage. The welfare consequence of having a less attractive low contract is not immediate. While over 70% of the population end up with high coverage, the rest has very little coverage.

The top row in each subsection of Table VIII shows welfare numbers under community rating, relative to all-in-60 (the RE under pure community rating in the 90–60 configuration) for each pair of alternative contracts. Consider first the entry for pure community rating under fixed income. It compares ex ante welfare relative to the equilibrium of community rating pricing in the configuration 90–60. Naturally, welfare for fixed income pooling in 80 is better than pooling in 60 ($278 better), which in turn is $4,472 better than pooling in 40. Interestingly, the Riley equilibrium in the 90–20 configuration, while $3,900 (= 4,472 − 572) better than pooling in 40, is $572 worse than pooling in 60. Trade increases quite a bit by lowering the minimal coverage from 60 to 20, but welfare goes down.

From the community rating row, we also see that managers (who have a steeper income growth), but not nonmanagers, may prefer to pool at 60 rather than at 80 in order to reduce premiums earlier in life when income is lower. In addition, under community rating, only managers prefer the RE in 90–20 to pooling in 60 specifically because enrolling in the 20 plan is relatively less costly for them due to their steeper income profile. Both nonmanagers and managers prefer pooling in 60 to pooling in 40 (the RE outcome for the 90–40 configuration).

TABLE VII

RILEY EQUILIBRIA UNDER ALTERNATIVE CONTRACT DESIGNS

	Equilibrium for Alternative Insurance Contract Designs								
	90% and 80%			90% and 40%			90% and 20%		
Contracts	P_{90}	P_{80}	S_{80}	P_{90}	P_{40}	S_{40}	P_{90}	P_{20}	S_{20}
All	–	4,800	100	–	2,413	100	7,345	31	28
Q1	1,434	652	71	1,253	4	21	1,252	0	20
Q2	–	2,114	100	2,855	76	10	2,840	6	9
Q3	–	5,491	100	7,519	895	26	6,794	142	8
Q4	–	10,945	100	–	6,224	100	13,343	685	12

Next, we look at the impact of allowing health-based pricing for different contract configurations. The first column of each configuration in Table VIII shows the market share of low coverage in each pricing regime. While it takes a lot of discrimination to get anyone in the 90 policy under the 90–80 configuration (with 50 categories, only 15% of the population gets high coverage), in the 90–40 configuration even health quartile pricing gets more than 54% of consumers to choose the 90 policy. However, as trade increases with more partitions, only managers benefit. Namely, as in Section 5, if income growth is not steep, the gains from reducing adverse selection are smaller than the additional losses from reclassification risk. This is also true, in most cases, for managers, who are most likely to prefer discrimination because of their relatively steep income paths.

6.2. *Age-Based Pricing*

Age-based pricing is one of the few exceptions to pure community rating typically allowed by health insurance regulation. In this section, we use our framework to study whether age-based pricing reduces adverse selection, and how the presence of age-based pricing affects the welfare impact of allowing health-based pricing (see, e.g., Ericson and Starc (2013) for a lengthier discussion).

We group consumers into five-year age bins as usually done in practice, for example in the Massachusetts Connector. Table III (in Section 3) describes each age bucket. The first column shows mean total medical expenses by age in our sample: those age 30–35 have a mean of $3,766, while those age 60–65 have a mean of $10,236.

We first consider whether age-based pricing ameliorates the extent of adverse selection. As we saw in Section 4, by allowing some health-status-based pricing, additional trade was generated for the healthiest quartile of the population. Because age—as shown in the first column—is a proxy for health type, we may expect more trade in equilibrium.

TABLE VIII

WELFARE UNDER ALTERNATIVE CONTRACT DESIGNS[a]

Welfare Losses From Health-Based Pricing: Varying Contract Designs				
		90% and 80%		
# of Health Buckets	S_{80}	Fixed Income	Non-Manager Income Path	Manager Income Path
Community Rating	100.0	−278	−83	194
4	92.2	3,265	1,987	−896
10	90.8	5,585	2,974	−1,343
20	87.4	8,920	5,280	−491
50	85.1	11,895	7,409	2,323
500 (∞)	31.0	18,166	13,035	4,940
		90% and 40%		
# of Health Buckets	S_{40}	Fixed Income	Non-Manager Income Path	Manager Income Path
Community Rating	100.0	4,472	3,243	2,098
4	45.2	6,664	4,790	953
10	42.5	8,552	5,640	429
20	32.8	11,317	7,396	1,538
50	36.6	14,010	9,491	4,247
500 (∞)	3.0	19,986	16,022	9,112
		90% and 20%		
# of Health Buckets	S_{20}	Fixed Income	Non-Manager Income Path	Manager Income Path
Community Rating	28.0	572	573	−45
4	11.8	3,635	2,404	−487
10	18.3	14,885	11,355	3,487
20	13.4	17,125	12,749	6,075
50	12.4	19,399	14,715	9,957
500 (∞)	2.0	20,893	17,550	11,861

[a]The welfare numbers presented are the yearly values that make a consumer indifferent between the contract/price regulatory regime and the baseline case of community rating where 90% and 60% contracts can be offered.

Surprisingly perhaps, allowing for age-based pricing does not prevent full unraveling. For each age group, the Riley equilibrium involves all-in-60. Age-based pricing undoes some of the transfers from the younger, healthier age groups to the older groups that occur in pure community rating. However, the distributions of health risk and risk preferences still imply that, even for the younger age groups, full unraveling occurs in equilibrium.[43]

Finally, we consider the simultaneous pricing of age and health status. The exercise is interesting for at least two reasons. First, health-based pricing may have a different impact on equilibrium in a more homogeneous population,

[43]We note that these results are robust to medium-sized changes in σ_ε, even though this shock to preferences introduces a source of willingness to pay for coverage unrelated to risk type.

TABLE IX

RE FOR PRICING REGULATION THAT ALLOWS INSURERS TO PRICE BASED ON HEALTH STATUS QUARTILES AND AGE

Joint Health Status Quartile and Age Pricing Regulation: Equilibrium Results											
	Q1 (Healthy)			Q2			Q3		Q4 (Sick)		Avg.
Ages	S_{60}	P_{60}	P_{90}	S_{60}	P_{60}	P_{90}	S_{60}	P_{60}	S_{60}	P_{60}	S_{60}
25–30	37	126	616	75	375	1,935	100	930	100	5,520	78
30–35	37	156	676	58	337	1,597	100	1,411	100	6,855	74
35–40	48	189	966	50	608	2,028	100	1,867	100	7,246	75
40–45	62	299	1,489	100	1,257	–	100	3,180	100	8,141	90
45–50	37	492	1,592	82	1,574	4,044	100	3,891	100	10,138	80
50–55	73	946	2,936	100	2,304	–	100	5,847	100	10,858	93
55–60	67	1,477	3,617	100	5,159	–	100	6,733	100	11,702	92
60–65	100	2,200	–	100	5,824	–	100	7,666	100	13,321	100

grouped by age, than it has in the whole population. Second, when evaluating the welfare impact of health-based pricing, age-based pricing may neutralize the benefits associated with consumption smoothing, by reducing the transfer from young to old that health-based pricing otherwise induces.

Table IX shows the equilibrium when insurers can separate each age group into health status quartiles. Unlike pure age-based pricing, which involved full unraveling to all-in-60 for every age group, we now have a positive share in 90 for all of the healthiest quartiles except in the oldest cohort, as well as for the second quartile for the younger groups. The interaction of age and health-based pricing thus reduces adverse selection, relative to each priced separately. Table D.III in Appendix D of the Supplemental Material shows the compensation required to make an individual indifferent between a regime with health status quartile pricing for each age group, and another in which all individuals in each age band receive the 60 policy at its average cost for their age band (the result of pure age-based pricing). Once age is priced, health-based pricing, which appealed to individuals with steeply increasing income, is no longer preferred by those consumers. The benefit of health-based pricing is the reduction in adverse selection, and the postponement of premiums until later in life. With age-based pricing, the latter benefit is eliminated. The cost associated with reclassification risk then dominates the benefits of reducing adverse selection across the range of risk aversion types and for the different income path models studied.[44]

[44]Although we do not do so here, one can also examine the welfare effects of allowing age-based pricing versus pure community rating. Age-based pricing may, in general, affect the extent of unraveling. Even when it does not, it may generate intertemporal gains. This is true even when consumers can borrow and lend (as in the next subsection) because it effectively allows borrowing at a zero interest rate (given the break-even condition).

6.3. *Self Insurance: Saving and Borrowing*

Our core analysis investigates several models for consumer lifetime income paths, but does not allow for consumers to either borrow when they receive negative health shocks or save in advance of such shocks. Such precautionary savings and borrowing could, in theory, mitigate the welfare losses from risky health shocks, especially in environments in which they lead to significant reclassification risk. To illustrate the potential impact of savings and borrowing, and study the robustness of our main findings, we study an extension that embeds our basic model into a stylized life-cycle model with capital markets. As in our main analysis, the consumer has an income flow, and stochastic health expenses (including premiums) that may depend on age and health status. We add on top of this a model of health status transitions, which we estimate with our data, and a model for borrowing and saving that allows consumers to insulate themselves from health shocks. We describe the important aspects of this model here, and present the full model in Appendix C of the Supplemental Material.

Specifically, we modify the model as follows. First, we make the simplifying assumption that each period in the model corresponds to a five-year age bin (25–30, 30–35, . . . , 60–65). This is done both to simplify the dynamic computation and to have large enough sample sizes for age-specific health transition matrices.[45] In each period, the consumer chooses an insurance policy based on their ex ante information, and then during the period realizes their in-period health expenses and updated health status. Their updated health status determines (i) the distribution of their health expenses for the next period, (ii) premiums for the next period (if health status can be priced), and (iii) the future evolution of their health status. We assume that period t saving or borrowing is decided after observing health expenses for that period. This assumption represents a fluid financial market where, for example, individuals can take a last-minute loan if they were unlucky during the period.[46] We note that within each period, consumers experience five years of identical health claims in the insurance contract they chose for that period, appropriately discounted. For each age bin, health status, and regulatory pricing regime, we use the static market equilibrium outcomes from our primary analysis and determine the actual choice each individual makes in each period, yielding her premiums and out of pocket expenses.[47] We assume consumers have flat income profiles over

[45] As seen in the results below, this simplified framework yields welfare results that are similar in magnitude to the model without borrowing or saving presented in our primary analysis.

[46] Access to capital, especially when a health condition develops, may not be this fluid in practice. To the extent that true credit markets have frictions we do not capture, we likely overstate the positive impact of borrowing in mitigating the welfare loss from reclassification risk.

[47] Market outcomes are assumed to be the same as those in our primary equilibrium analysis. They thus do not account for the potential effect that borrowing and saving could have on consumer insurance choices. Accounting for these dynamic effects would likely push consumers

time (as in the first column of Table VI) in order to neutralize the other channels through which savings could impact welfare. We consider a consumer with risk aversion coefficient $\gamma = 0.0004$.

Solving the dynamic life-cycle savings problem requires modeling transitions across health states, which we estimate from our sample using empirical year-to-year transitions in consumers' ACG indices λ_{it}. To this end, we divide the population into 7 cells reflecting different health status levels based on ACG index, and non parametrically estimate a 7-by-7 transition matrix. We estimate a separate transition matrix for each of 8 five-year age groups. Using these ingredients, we solve an 8-period dynamic optimization problem where individuals transition over 7 health types as they age and can save and borrow in each period. We solve the consumer's dynamic problem using backwards induction, determine each consumer's lifetime value for each possible starting state in period 1, and then compute the ex ante certainty equivalent of regulatory pricing regime x for an unborn individual who does not yet know her type (as in Section 5).

We use this framework to compare three regimes: (i) all-in-90, (ii) the Riley equilibrium with pure community rating (PCR), and (iii) the Riley equilibrium under pricing health quartiles (HB4).[48] The welfare results are presented in Table X. The first column shows the welfare loss from adverse selection for the case of pure community rating relative to all-in-90. The second column shows the relative welfare loss from (i) reduced adverse selection but (ii) increased reclassification risk moving from pure community rating to health status quartile pricing (analogous to Table VI). The results show that, as expected, access to capital markets lowers the welfare losses for both of these comparisons. Without the possibility of saving or borrowing ("$S = 0$"), the welfare loss from health status quartile-based pricing relative to community rating is \$3,352 per person per year, while when full borrowing and saving are allowed ("*Any S*"), the loss is reduced to \$1,540 per person per year. The corresponding losses from community rating relative to all-in-90 are \$765 and \$269, respectively. Thus, while allowing for saving and borrowing improves consumer welfare in all pricing regimes, the welfare losses from reclassification risk in health status quartile-based pricing still far outweigh the welfare gains from reduced adverse selection, relative to the case of pure community rating.

We also examine the two cases where consumers are only allowed to borrow ("$S \leq 0$") or only allowed to save ("$S \geq 0$") in order to decompose their effects.

more toward lower insurance, and would therefore likely not have a large impact on equilibrium outcomes.

[48]The welfare loss from pricing health status quartiles, relative to pure community rating, under flat income is \$3,082 per consumer per year, in our primary analysis (see Table VI). Here, this value is slightly larger, equal to \$3,352, because our model with saving and borrowing makes some necessary simplifications relative to our primary specification. The primary simplification is modeling health status transitions across seven possible health states (and for five-year age bins) rather than assuming a continuous health state and steady state population.

TABLE X

LONG-RUN WELFARE UNDER BORROWING AND SAVING[a]

Welfare Loss With Borrowing and Saving ($/Year)		
Savings Case	$y_{\text{PCR},90}$	$y_{\text{HB4,PCR}}$
Any S	269	1,540
$S \geq 0$	391	1,977
$S \leq 0$	337	2,480
$S = 0$	765	3,352

[a]This table presents the long-run welfare results when consumers are allowed to (i) borrow ($S \leq 0$), (ii) save ($S \geq 0$), or (iii) borrow and save (*Any S*). We investigate these models for the cases of (i) pure community rating and (ii) health status quartile-based pricing examined in our primary analysis ($S = 0$). The results presented are based on the RE outcomes for each of the two pricing regulations. The assumed discount rate is $\delta = 0.975$ and the consumer's risk aversion coefficient is $\gamma = 0.0004$.

While both cases are clearly preferred by the consumer to the case where neither borrowing nor saving is allowed, borrowing is less helpful in contending with reclassification risk under health status quartile pricing.

6.4. *Risk Adjustment*

Risk adjustment transfers are a key policy implemented in many health insurance markets in order to ameliorate adverse selection. It is tempting to think that risk adjustment can solve the adverse selection problem entirely, by simply providing a transfer to each firm that gives that firm an expected cost from each enrollee in each plan equal to the average cost of the plan if there was no selection (i.e., equal to the population average cost in that plan), thereby eliminating the impact of selection on cost. However, even if the government were to accomplish this, so that $\Delta P = \underline{AC}_H - \overline{AC}_L$, an efficient outcome will result only if $\underline{\theta} \leq \underline{AC}_H - \overline{AC}_L$, as otherwise the consumers with willingness to pay below $\underline{AC}_H - \overline{AC}_L$ will still choose to purchase policy L. Moreover, doing so can result in the government running a deficit. Still, risk adjustment can reduce the losses from adverse selection.

In this subsection, to illustrate how our framework can incorporate risk adjustment transfers, and the impact of these transfers on equilibrium, we use the risk adjustment formula proposed by the Federal government (see, e.g., Department of Health and Human Services (2012a, 2012b)) for the ACA.[49] In

[49]See the concurrent work of Glazer, McGuire, and Shi (2014) and Mahoney and Weyl (2014) for further discussions of insurer risk adjustment transfers and their impact on equilibria in insurance markets.

practice, risk adjustment can lead to a number of problems, such as insurers up-coding enrollees to qualify for larger transfers. We will abstract from such issues and assume that the regulator can perfectly observe the health status of each enrollee.

The HHS risk adjustment policy is designed to always break even. It provides a transfer payment per member to each plan i equal to

$$T_i = \left\{ \left(\frac{R_i}{\sum_i s_i R_i} \right) - \left(\frac{AV_i}{\sum_i s_i AV_i} \right) \right\} \overline{P}, \tag{8}$$

where R_i is plan i's "risk score" (equal to plan i's average cost divided by the average cost of all plans in the market), AV_i is plan i's actuarial value (i.e., 0.60 or 0.90 in our model), s_i is plan i's market share, and $\overline{P}$ is the average premium in the market. Intuitively, if the average cost of the 90 policy was 50% more than that of the 60 policy, as it would be if each had a random sample of consumers, transfers would be zero. When the average cost in the 90 policy is more than 50% greater than that of the 60 policy, transfers flow to the 90 plan. Note that $\sum_i T_i = 0$, so the transfers are balanced. These transfers alter insurers' average costs, which are now $AC_{90} - T_{90}$ and $AC_{60} - T_{60}$ in the 90 and 60 policy, respectively.

Since in a RE all policies break even and the transfers are balanced, the market average premium must equal the market average cost:[50]

$$\overline{P} = \overline{AC}(\Delta P) \equiv s_{90}(\Delta P) AC_{90}(\Delta P) + s_{60}(\Delta P) AC_{60}(\Delta P).$$

Plan i's risk score is $R_i = AC_{90}(\Delta P)/\overline{AC}(\Delta P)$. Substituting into (8), we get

$$\begin{aligned} T_{90}(\Delta P) &= \left\{ \left(\frac{AC_{90}(\Delta P)}{\overline{AC}(\Delta P)} \right) - \left(\frac{0.9}{\overline{AV}(\Delta P)} \right) \right\} \overline{AC}(\Delta P) \\ &= AC_{90}(\Delta P) - \overline{AC}(\Delta P) \left(\frac{0.9}{\overline{AV}(\Delta P)} \right), \end{aligned}$$

where $\overline{AV}(\Delta P) \equiv s_{90}(\Delta P)(0.9) + s_{60}(\Delta P)(0.6)$.

[50]Formally, in equilibrium each policy will break even given its post-transfer average cost. Thus, recalling that T_i is a per member transfer, we have $P_{90} = AC_{90}(\Delta P) - T_{90}(\Delta P)$ and $P_{60} = AC_{60}(\Delta P) + T_{90}(\Delta P)(\frac{s_{90}(\Delta P)}{s_{60}(\Delta P)})$. The market average premium is therefore $\overline{P} = s_{90}(\Delta P) P_{90} + s_{60}(\Delta P) P_{60} = \overline{AC}(\Delta P)$.

Observe that the transfers depend on the market prices (through ΔP), while the market prices depend on the transfer rule. Thus, the equilibrium prices are determined as a fixed point. Specifically, the prices will be

$$P_{90}(\Delta P) = AC_{90}(\Delta P) - T_{90}(\Delta P) = \overline{AC}(\Delta P)\left(\frac{0.9}{\overline{AV}(\Delta P)}\right)$$

and

$$P_{60}(\Delta P) = \overline{AC}(\Delta P)\left(\frac{0.6}{\overline{AV}(\Delta P)}\right).$$

This leads to a fixed point condition for ΔP:

$$\Delta P = \overline{AC}(\Delta P)\left(\frac{0.3}{\overline{AV}(\Delta P)}\right). \tag{9}$$

Applying formula (9) to our data, we find that with pure community rating, the equilibrium with risk adjustment has prices $P_{90} = 6{,}189$ and $P_{60} = 4{,}139$ (so $\Delta P = 2{,}050$), and the 90 policy capturing a 49% market share for the whole population.[51]

To study the welfare implications, we compare the long-run implications of equilibrium outcomes with and without insurer risk adjustment, for the case of pure community rating. Table D.IV in Appendix D of the Supplemental Material shows the yearly amount $y_{\text{PCR,risk-adj}}$ an individual would need to receive with pure community rating to be as well off as when risk adjustment occurs. The risk adjustment outcome is preferred, reflecting the reduction in adverse selection compared to the case with no insurer transfers. For example, an individual with fixed income and $\gamma = 0.0004$ would need to receive \$349 per year under pure community rating to be as well off as when risk adjustment occurs.

7. CONCLUSION

In this paper, we have developed a framework to study equilibrium and welfare for a class of regulated health insurance markets known as exchanges. The framework combines a theoretical model of an exchange (and results characterizing equilibria) with estimates of the joint distribution of health risk and risk aversion in a population of interest, allowing us to analyze exchange outcomes under various possible regulations. In our main application of the framework, we study the effects of health-based pricing on market outcomes

[51] In contrast, if the government were to instead implement risk adjustment transfers that result in price difference $\Delta P = \underline{AC_H} - \overline{AC}_L = 1{,}571$ in this market, 66% of consumers would purchase the 90 policy and the government would run a deficit of \$274 per consumer (on average), losing \$2,139 per consumer in the 90 policy and gaining \$3,348 per consumer in the 60 policy.

and welfare for a population of employees at a large employer. While allowing even partial health-based pricing increases coverage compared to the full unraveling that arises under pure community rating, if consumers can smooth their income over time or if pricing based on age is also allowed (eliminating any consumption smoothing benefit of health-based pricing), the welfare loss from the reclassification risk it induces far outweighs the welfare gain from reduced adverse selection. (For a more detailed summary of our results, refer back to the Introduction.) We have also illustrated how our framework can be applied to study other related issues, such as the effect of varying the coverage levels of available plans, age-based pricing, self-insurance through consumer saving and borrowing, and insurer risk adjustment transfers.

There are a number of dimensions on which our stylized model could be extended to more closely model most exchange environments. In our setting, products are differentiated only on financial dimensions. While in some settings (e.g., the Netherlands and Germany) this is essentially true in reality, in the U.S. context, exchanges include insurers that offer products that are differentiated in terms of medical care and the network of available physicians. Incorporating product differentiation, and, additionally, the possibility of imperfect competition, could enrich both our equilibrium predictions and understanding of long-run welfare. In addition, it would be interesting to model more subtle consumer micro-foundations such as inertia, limited consumer information, or issues of consumer choice adequacy, all of which prior research has demonstrated may be important factors in insurance markets.

Finally, the exchanges analyzed here (and those operating in reality) have short-term annual policies. An interesting question is the extent to which longer-term contracts can serve to reduce reclassification risk. While these kinds of contracts have been discussed to some extent (Hendel and Lizzeri (2003), Crocker and Moran (2003), Herring and Pauly (2006)), there has been little to no empirical analysis of the benefits of such contracts. This seems an interesting direction for future research.

APPENDIX A: PROOFS

We use (a slightly modified version of) the definition provided in Engers and Fernandez (1987):

DEFINITION 1: A *Riley equilibrium* (RE) is a profitable market offering S, such that for any nonempty set S' (the deviation), where $S \cup S'$ is closed and $S \cap S' = \emptyset$, if S' is strictly profitable when $S \cup S'$ is offered, then there exists a set S'' (the reaction), disjoint from $S \cup S'$ with $S \cup S' \cup S''$ closed, such that:

(i) S' incurs losses when $S \cup S' \cup S''$ is tendered;

(ii) S'' does not incur losses when any market offering $\widehat{S}$ containing $S \cup S' \cup S''$ is tendered (we then say S'' is "*safe*" or a "*safe reaction*").

A deviation S' that is strictly profitable when $S \cup S'$ is offered, and for which there is no safe reaction S'' that makes S' incur losses (with market offering $S \cup S' \cup S''$), is a *profitable Riley deviation*.

In our setting, a market offering is simply a collection of prices offered for the two policies. Definition 1 says that a set of offered prices is a Riley equilibrium if no firm, including potential entrants, has a profitable deviation that also never leads it to incur losses should other firms introduce additional "safe" price offers (where a "safe" price offer is one that would never incur losses were any *further* price offers introduced).[52]

A.1. *Safe Price Offers*

We begin by considering which price offers are "safe" in the sense that they do not incur losses regardless of any additional offers being introduced.

LEMMA 1: *Given price configuration (P_H, P_L), single-policy offer $P_L'' < P_L$ is safe if and only if $\Pi_L(P_H, P_L'') \geq 0$.*

PROOF: If $\Pi_L(P_H, P_L'') < 0$, then P_L'' makes losses absent any reaction, and hence is not safe. So suppose that $\Pi_L(P_H, P_L'') \geq 0$. Any price offers $\widehat{P} = (\widehat{P}_H, \widehat{P}_L)$ with a $\widehat{P}_L < P_L''$ gives the firm offering P_L'' a profit of zero. Any price offers $\widehat{P}$ with $\widehat{P}_H \geq P_H$ and $\widehat{P}_L \geq P_L''$ cannot make the firm offering P_L'' incur losses. Finally, any price offers $\widehat{P}$ with $\widehat{P}_H < P_H$ and $\widehat{P}_L \geq P_L''$ weakly lowers the sales of the firm offering P_L''. If that firm makes no sales at $(\widehat{P}_H, P_L'')$, then its profit is zero. If it has positive sales at $(\widehat{P}_H, P_L'')$, then it must also at (P_H, P_L''). This implies that $\Pi_L(\widehat{P}_H, P_L'') \geq 0$ since then $AC_L(\widehat{P}_H - P_L'') \leq AC_L(P_H - P_L'') \leq P_L''$. *Q.E.D.*

DEFINITION 2: The *lowest safe policy L price given P_H* is $\underline{P}_L(P_H) \equiv \min\{P_L'' : \Pi_L(P_H, P_L'') \geq 0\}$.

REMARK 1: The lowest safe price given P_H is given by

$$\underline{P}_L(P_H) = \left\{ \begin{array}{ll} P_H - \underline{\theta}, & \text{if } P_H \leq \underline{AC}_L + \underline{\theta} \\ \widetilde{P}_L(P_H), & \text{if } P_H \in (\underline{AC}_L + \underline{\theta}, \overline{AC}_L + \overline{\theta}) \\ \overline{AC}_L, & \text{if } P_H \geq \overline{AC}_L + \overline{\theta} \end{array} \right\},$$

where $\widetilde{P}_L(P_H) \equiv \{\widetilde{P}_L : \widetilde{P}_L = AC_L(P_H - \widetilde{P}_L)\}$. When $P_H \leq \underline{AC}_L + \underline{\theta}$, all consumers buy policy H at prices $(P_H, \underline{P}_L(P_H))$; when $P_H \in (\underline{AC}_L + \underline{\theta}, \overline{AC}_L + \overline{\theta})$,

[52]In fact, it suffices to restrict attention to deviations by potential entrants.

there are positive sales of both policies at prices $(P_H, \underline{P}_L(P_H))$; and when $P_H \geq \overline{AC}_L + \overline{\theta}$, all consumers buy policy L at prices $(P_H, \underline{P}_L(P_H))$. Note that for $P_H \in (\underline{AC}_L + \underline{\theta}, \overline{AC}_L + \overline{\theta})$, the price $\underline{P}_L(P_H)$ and price difference $P_H - \underline{P}_L(P_H)$ are both continuous and strictly increasing in P_H. (The price difference $P_H - \underline{P}_L(P_H)$ must increase if $\underline{P}_L(P_H)$ does since $\underline{P}_L(P_H) = AC_L(P_H - \underline{P}_L(P_H))$ for P_H in this range.)

REMARK 2: Observe that if a two-policy reaction (P''_H, P''_L) is safe and causes the profitable single-policy deviation P'_H to instead make losses, then the single-policy reaction P''_L is also safe and causes the single-policy deviation P'_H to make losses. To see why, note first that it cannot be that $P''_H < P'_H$ (otherwise the deviator's profit would not be strictly negative). The result is immediate if $P''_H > P'_H$. So suppose that $P''_H = P'_H$. Since the firms make losses on policy H and the reaction is safe, we must have $\Pi_L(P'_H, P''_L) \geq 0$. But then Lemma 1 implies that the single-policy reaction P''_L is safe and clearly also causes the deviating firm to make losses. Hence, in looking at safe reactions to single-policy deviations in P_H, we can restrict attention to single-policy safe reactions in P_L.

LEMMA 2: *If at $(P_H, \underline{P}_L(P_H))$ we have positive sales of policy H and $\Pi_H(P_H, \underline{P}_L(P_H)) \geq 0$, then $\Pi_H(P_H, P_L) \geq 0$ at all $P_L > \underline{P}_L(P_H)$.*

PROOF: Since there are positive sales of policy H, it follows that $P_H \geq AC_H(P_H - \underline{P}_L(P_H)) \geq AC_H(P_H - P_L)$ for any $P_L > \underline{P}_L(P_H)$, where the second inequality follows from the fact that increases in P_L weakly lower AC_H. *Q.E.D.*

REMARK 3: In light of Remark 2, Lemma 2 implies that a profitable single-policy deviation to P'_H can be rendered unprofitable by a safe reaction if and only if it is rendered unprofitable by a single-policy reaction to $\underline{P}_L(P'_H)$.

A.2. *RE and NE Characterizations*

We first establish three properties shared by RE and NE: (i) both policies break even; (ii) all-in-H is an equilibrium if and only if $\Delta AC(\underline{\theta}) \leq \underline{\theta}$; (iii) if $\Delta AC(\underline{\theta}) > \underline{\theta}$, then the equilibrium price difference must be $\underline{\Delta P}_{\text{BE}}$.

LEMMA 3: *If (P^*_H, P^*_L) is a RE (resp. NE), then*

$$\Pi_H(P^*_H, P^*_L) = \Pi_L(P^*_H, P^*_L) = 0.$$

PROOF: Since any NE is a RE, we establish the result by showing it for RE. We first show that $\Pi_L(P^*_H, P^*_L) \leq 0$. Suppose otherwise, so that $\Pi_L(P^*_H, P^*_L) > 0$. Then for small $\varepsilon > 0$, we would have $\Pi_L(P^*_H, P^*_L - \varepsilon) > 0$. By Lemma 1, a single-policy deviation that offers $P^*_L - \varepsilon$ would then be safe, and there would therefore be no reaction that could render it unprofitable. But then (P_H^*, P_L^*) would not be a RE, a contradiction.

We next show that $\Pi_H(P_H^*, P_L^*) \leq 0$. The result is immediate if policy H makes no sales at (P_H^*, P_L^*). So suppose that $\Delta P^* < \overline{\theta}$ and that, contrary to the claim, (P_H^*, P_L^*) is a RE with $\Pi_H(P_H^*, P_L^*) > 0$. If $\underline{P}_L(P_H^*) > P_L^*$, then a single-policy deviation to $P_H^* - \varepsilon$ for small enough $\varepsilon > 0$ would be a profitable Riley deviation, as no safe reaction in P_L could render it unprofitable. So we must have $\underline{P}_L(P_H^*) \leq P_L^*$. Now if $\underline{P}_L(P_H^*) < P_L^*$, then there can be no policy L sales at (P_H^*, P_L') for any $P_L' \in [\underline{P}_L(P_H^*), P_L^*)$, since otherwise a single-policy deviation to $P_L' + \varepsilon$ for sufficiently small $\varepsilon > 0$ would be strictly profitable and safe. Thus, $\underline{P}_L(P_H^*) \leq P_L^*$ implies that $\Pi_H(P_H^*, \underline{P}_L(P_H^*)) = \Pi_H(P_H^*, P_L^*) > 0$. By continuity, we then have that $\Pi_H(P_H^* - \varepsilon, \underline{P}_L(P_H^* - \varepsilon)) > 0$ for small enough $\varepsilon > 0$, so a single-policy deviation to such a $P_H^* - \varepsilon$ cannot be rendered unprofitable by any safe reaction, yielding a contradiction.

Thus, we have $\Pi_L(P_H^*, P_L^*) \leq 0$ and $\Pi_H(P_H^*, P_L^*) \leq 0$. But if either is strictly negative, then some firm must be earning strictly negative profits, and would do better by dropping all of its policies. The result follows. *Q.E.D.*

LEMMA 4: *There is a RE* (*resp. NE*) *in which all consumers buy policy H if and only if* $\Delta AC(\underline{\theta}) \leq \underline{\theta}$.

PROOF: By Lemma 3, $P_H^* = \underline{AC}_H$ in any all-in-H equilibrium. Suppose that $\Delta AC(\underline{\theta}) > \underline{\theta}$, so that $\underline{AC}_H - \underline{\theta} > \underline{AC}_L$. Then a single-policy deviation offering $\widehat{P}_L = \underline{AC}_H - \underline{\theta} - \varepsilon$ for small enough $\varepsilon > 0$ attracts a positive measure of consumers at an average cost close to $\underline{AC}_L$ and thus makes positive profits; that is, $\Pi_L(\underline{AC}_H, \underline{AC}_H - \underline{\theta} - \varepsilon) > 0$. Moreover, this deviation is safe, so cannot be made unprofitable by any reactions. Hence, all-in-H is not an RE, and hence not a NE.

Now suppose that $\Delta AC(\underline{\theta}) \leq \underline{\theta}$. Let $P_H^* = \underline{AC}_H$ and $P_L^* \geq \underline{AC}_H - \underline{\theta}$ be offered by more than one firm. We show that there are then no profitable deviations, even before considering any reactions, implying that all-in-H is a RE and NE. Consider any deviation $(\widehat{P}_H, \widehat{P}_L) \leq (\underline{AC}_H, P_L^*)$. To be profitable, some consumers must buy policy L in the deviation, so $\widehat{P}_L < \underline{AC}_H - \underline{\theta}$ and $\Delta \widehat{P} > \Delta P^*$. But the most profitable such deviation has $\widehat{P}_H$ equal to or arbitrarily close to P_H^*. (Otherwise, both $\widehat{P}_H$ and $\widehat{P}_L$ could be raised by a small and equal amount.) But, since the reduction in P_L makes policy H at price P_H^* either strictly unprofitable or have no sales, this deviation is weakly less profitable than a single-policy deviation to $\widehat{P}_L$. But since $\widehat{P}_L < \underline{AC}_H - \underline{\theta} \leq \underline{AC}_L$, this single-policy deviation is unprofitable. *Q.E.D.*

LEMMA 5: *Among all price pairs* (P_H, P_L) *at which both policies break even and there are positive sales of policy L, only the one with the lowest sales of policy L* (*i.e., having* $\Delta P = \underline{\Delta P}^{\mathrm{BE}}$) *can be a RE* (*resp. NE*).

PROOF: Suppose that at price configurations $P' = (P'_H, P'_L)$ and $P'' = (P''_H, P''_L)$ both policies break even, $\min\{\Delta P', \Delta P''\} > \underline{\theta}$, and there is a larger share for policy L in P'' than in P'. Then $\Delta P' < \Delta P''$ and there are positive sales of policy H at P'.[53] In addition, $P'_L = AC_L(\Delta P') < AC_L(\Delta P'') = P''_L$. Starting at price configuration P'', consider an entrant deviation offering price $P'_H = AC_H(\Delta P') < AC_H(\Delta P'') = P''_H$. Since $P'_H - P''_L < \Delta P'$, after the deviation the share of policy H is positive and, moreover, $P'_H - AC_H(P'_H - P''_L) > 0$. Thus, the deviation is profitable. Now, observe that the lowest safe policy L price given P'_H is P'_L, that is, $\underline{P}_L(P'_H) = P'_L$, so $\Pi_H(P'_H, \underline{P}_L(P'_H)) = 0$. Hence, there are no safe reactions that make the deviator incur a loss (Remark 3). This implies that (P''_H, P''_L) is not a RE, which is a contradiction. Since it is not a RE, it also cannot be a NE. *Q.E.D.*

REMARK 4: Note that in the proofs of the above results, all profitable deviations were single-policy deviations. Thus, the same properties hold for NE in which firms can offer only a single policy.

We now separately complete the characterization of RE and NE. We first note the following fact about RE:

LEMMA 6: *Suppose that at $P^* = (P^*_H, P^*_L)$, there are positive sales of policy L (so $\Delta P^* \in (\underline{\theta}, \overline{\theta}]$) and both policies break even. Then P^* is a RE if and only if there are no single-policy Riley profitable deviations in P_H.*

PROOF: Consider a multi-policy profitable Riley deviation $P' = (P'_H, P'_L)$. We will show that we necessarily have $\Pi_H(P'_H, P^*_L) > 0$ and $\Pi_H(P'_H, \widetilde{P}_L) \geq 0$ for all $\widetilde{P}_L \in [\underline{P}_L(P'_H), P^*_L]$. Thus, a single-policy deviation to P'_H would be a profitable Riley deviation.

The claim is immediate if $P'_L > P^*_L$, since then dropping offer P'_L would affect neither the deviation profit, nor the deviator's profit after any reaction. So henceforth we shall assume that $P'_L \leq P^*_L$. Moreover, we must have $P'_H \leq P^*_H$; otherwise, the deviator can sell only policy L at price $P'_L \leq P^*_L = AC_L(\Delta P^*) \leq AC_L(\Delta P')$, contradicting P' being a profitable Riley deviation. So $P' \leq P^*$.

Next, observe that we must have $\Delta P' < \Delta P^*$ and an increased share of policy H being purchased. If not, then since the average costs of both policies would be no lower than they were before the deviation, and both deviation prices would be weakly lower, the deviation could not generate a strictly positive profit. Note that this also implies that we must have $P'_H < P^*_H$.

Suppose, first, that $\underline{P}_L(P'_H) < P'_L$. If $\Pi_H(P'_H, \underline{P}_L(P'_H)) < 0$, then the safe single-policy reaction to $\underline{P}_L(P'_H)$ makes the deviator incur losses, in contra-

[53]Note that we may have $\Delta P'' = \overline{\theta}$.

diction to the assumption that P' is a profitable Riley deviation. So in this case we must have $\Pi_H(P'_H, \underline{P}_L(P'_H)) \geq 0$. Moreover, there must be positive sales of policy H at prices $(P'_H, \underline{P}_L(P'_H))$ because, if not, then (see Remark 1) $\underline{P}_L(P'_H) = \overline{AC}_L \geq P^*_L \geq P'_L$. Thus, $\Pi_H(P'_H, \widetilde{P}_L) > 0$ for all $\widetilde{P}_L \in (\underline{P}_L(P'_H), P^*_L]$, implying that the single-policy deviation to P'_H is a profitable Riley deviation.

On the other hand, if $\underline{P}_L(P'_H) \geq P'_L$, then $\Pi_L(P'_H, P'_L) \leq 0$, which implies that $\Pi_H(P'_H, P'_L) > 0$ (since the deviation to P' is profitable). This, in turn, implies that $\Pi_H(P'_H, \widetilde{P}_L) > 0$ for all $\widetilde{P}_L \in [\underline{P}_L(P'_H), P^*_L]$, which establishes the result. *Q.E.D.*

With these results in hand, we now prove Proposition 1:

PROOF OF PROPOSITION 1: Suppose, first, that $\Delta AC(\underline{\theta}) \leq \underline{\theta}$. By Lemma 4, we know that there is an all-in-H RE (and any such RE has a unique outcome, with $P^*_H = \underline{AC}_H$). We now show that if $\Delta AC(\underline{\theta}) < \underline{\theta}$, then this is the unique RE outcome. By Lemma 5, we know that any RE involving positive sales of policy L must involve the lowest break-even price difference, $\underline{\Delta P}^{\mathrm{BE}}$. Let $(P^{**}_H, P^{**}_L) = (AC_H(\underline{\Delta P}^{\mathrm{BE}}), AC_L(\underline{\Delta P}^{\mathrm{BE}}))$ denote the corresponding break-even prices. Consider a single-policy deviation to $\widehat{P}_H = P^{**}_L + \underline{\theta}$, which will attract all consumers to policy H. Since $\widehat{P}_H > \underline{AC}_L + \underline{\theta} > \underline{AC}_H$, this is a profitable deviation absent any reaction. Since $\widehat{P}_H \in (\underline{AC}_L + \underline{\theta}, \overline{AC}_L + \overline{\theta})$, we know that $\underline{P}_L(\widehat{P}_H) = AC_L(\widehat{P}_H - \underline{P}_L(\widehat{P}_H))$ (see Remark 1). Since $\Delta AC(\Delta P) \leq \Delta P$ for all $\Delta P \in [\underline{\theta}, \underline{\Delta P}^{\mathrm{BE}})$, this implies that $\widehat{P}_H > AC_H(\widehat{P}_H - \underline{P}_L(\widehat{P}_H))$, so by Remark 3 no safe reaction can make the deviation unprofitable.

Suppose, instead, that $\Delta AC(\underline{\theta}) > \underline{\theta}$. By Lemma 5, we know that the only candidate for a RE involves the lowest break-even price difference with positive sales of policy L, $\underline{\Delta P}^{\mathrm{BE}}$. Again, let $(P^{**}_H, P^{**}_L) = (AC_H(\underline{\Delta P}^{\mathrm{BE}}), AC_L(\underline{\Delta P}^{\mathrm{BE}}))$ denote the corresponding break-even prices. By Lemma 6, we need only consider single-policy deviations in P_H to verify that this is an equilibrium. Any such deviation $\widehat{P}_H$ that is strictly profitable must have $\widehat{P}_H < \min\{P^{**}_H, P^{**}_L + \underline{\theta}\}$ and $\widehat{P}_H > AC_H(\widehat{P}_H - P^{**}_L)$. By the latter inequality, $\widehat{P}_H > \underline{AC}_H > \underline{AC}_L + \underline{\theta}$. Then, by Remark 1, the lowest safe reaction in P_L has $\underline{P}_L(\widehat{P}_H) = AC_L(\widehat{P}_H - \underline{P}_L(\widehat{P}_H))$ and results in positive sales of policy H. Since $\Delta AC(\Delta P) > \Delta P$ for all $\Delta P \in [\underline{\theta}, \underline{\Delta P}^{\mathrm{BE}})$, this implies that $\widehat{P}_H < AC_H(\widehat{P}_H - \underline{P}_L(\widehat{P}_H))$, so the deviation is unprofitable. *Q.E.D.*

We now turn to NE:

LEMMA 7: *If $\Delta AC(\underline{\theta}) < \underline{\theta}$, there is a unique NE outcome and it involves all consumers purchasing policy H. If $\Delta AC(\underline{\theta}) > \underline{\theta}$, there is a unique NE outcome and it involves the break-even prices $(\underline{P}^{\mathrm{BE}}_H, \underline{P}^{\mathrm{BE}}_L)$ corresponding to the lowest break-even price difference with positive sales of policy L ($\underline{\Delta P}^{\mathrm{BE}}$), iff $\Pi(\underline{P}^{\mathrm{BE}}_H, \underline{P}^{\mathrm{BE}}_L) = 0 =$*

$\max_{\widehat{P}_H \le P_H^*} \Pi(\widehat{P}_H, \underline{P}_L^{\mathrm{BE}})$, *that is, if there is no profitable multi-policy deviation by an entrant that reduces* P_H *and lowers* P_L *slightly to capture all consumers*.

PROOF: Since any NE is a RE, the uniqueness result for $\Delta AC(\underline{\theta}) < \underline{\theta}$ follows directly from Proposition 1. Suppose, instead, that $\Delta AC(\underline{\theta}) > \underline{\theta}$. By our previous results for RE, any NE outcome must involve price configuration $(\underline{P}_H^{\mathrm{BE}}, \underline{P}_L^{\mathrm{BE}})$. Observe, first, that no deviation from $(\underline{P}_H^{\mathrm{BE}}, \underline{P}_L^{\mathrm{BE}})$ that raises ΔP (including single-policy deviations in P_L) can be profitable, as this raises the average costs of both policies.

Now consider deviations that lower ΔP. A single-policy deviation offering policy H at price $\widehat{P}_H < \underline{P}_H^{\mathrm{BE}}$, since it makes policy L at price $\underline{P}_L^{\mathrm{BE}}$ earn strictly positive profits, is less profitable than the multi-policy deviation $(\widehat{P}_H, \underline{P}_L^{\mathrm{BE}} - \varepsilon)$ for sufficiently small $\varepsilon > 0$, as this captures the entire market. However, any multi-policy deviation $(\widehat{P}_H, \widehat{P}_L) \ll (\underline{P}_H^{\mathrm{BE}}, \underline{P}_L^{\mathrm{BE}})$ is dominated by a deviation $(\widehat{P}_H + \delta, \widehat{P}_L + \delta)$ for some $\delta > 0$. As $\Delta \widehat{P} < \underline{\Delta P}^{\mathrm{BE}}$, the supremum of deviation profits is therefore $\max_{\widehat{P}_H \le \underline{P}_H^{\mathrm{BE}}} \Pi(\widehat{P}_H, \underline{P}_L^{\mathrm{BE}})$. *Q.E.D.*

REMARK 5: If firms can only offer one policy, the only change to Lemma 7 would be that if $\Delta AC(\underline{\theta}) > \underline{\theta}$, then there is a NE at the break-even prices $(\underline{P}_H^{\mathrm{BE}}, \underline{P}_L^{\mathrm{BE}})$ corresponding to the lowest break-even price difference with positive sales of policy L ($\underline{\Delta P}^{\mathrm{BE}}$), if and only if $\Pi(\underline{P}_H^{\mathrm{BE}}, \underline{P}_L^{\mathrm{BE}}) = 0 = \max_{\widehat{P}_H \le \underline{P}_H^{\mathrm{BE}}} \Pi_H(\widehat{P}_H, \underline{P}_L^{\mathrm{BE}})$, that is, if there is no profitable single-policy deviation in P_H by an entrant.

Although it will not play a role in our analysis, we note the following result:

LEMMA 8: *If* $\theta > C_H(\theta) - C_L(\theta)$ *for all* $\theta \in [\underline{\theta}, \overline{\theta}]$, *then some consumers must be buying policy H in any NE*.

PROOF: Suppose all consumers are purchasing policy L. Then, by Lemma 3, $P_L^* = \overline{AC}_L$ and (without loss of generality) $P_H^* = P_L^* + \overline{\theta}$. Now consider a deviation to $(P_H^* - \varepsilon, P_L^*)$. We will show that for small $\varepsilon > 0$, aggregate profits are strictly positive. Aggregate profits equal

$$\begin{aligned} \psi(\varepsilon) &\equiv \Pi\big(P_H^* - \varepsilon, P_L^*\big) \\ &= \int_{\overline{\theta}-\varepsilon}^{\overline{\theta}} \big[P_H^* - \varepsilon - C_H(\theta)\big] f(\theta)\, d\theta + \int_{\underline{\theta}}^{\overline{\theta}-\varepsilon} \big[P_L^* - C_L(\theta)\big] f(\theta)\, d\theta. \end{aligned}$$

Now

$$\begin{aligned} \psi'(\varepsilon) = {} & \big[P_H^* - \varepsilon - C_H(\overline{\theta} - \varepsilon)\big] f(\overline{\theta} - \varepsilon) - \big[P_L^* - C_L(\overline{\theta} - \varepsilon)\big] f(\overline{\theta} - \varepsilon) \\ & - \big[1 - F(\overline{\theta} - \varepsilon)\big], \end{aligned}$$

so

$$\begin{aligned}\psi'(0) &= \left[P_H^* - C_H(\overline{\theta})\right]f(\overline{\theta}) - \left[P_L^* - C_L(\overline{\theta})\right]f(\overline{\theta}) \\ &= f(\overline{\theta})\left\{\overline{\theta} - \left[C_H(\overline{\theta}) - C_L(\overline{\theta})\right]\right\} > 0.\end{aligned}$$

Since, by Lemma 3, $\psi(0) = \Pi(P_H^*, P_L^*) = 0$, this implies that, for small $\varepsilon > 0$, aggregate profit is strictly positive. As a result, there is a $\delta > 0$ such that $(P_H^* - \varepsilon, P_L^* - \delta)$ is a profitable deviation. *Q.E.D.*

The assumption that $\theta > C_H(\theta) - C_L(\theta)$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$ is an implication of risk aversion; it says that all consumers prefer the greater coverage of policy H if it is priced at fair odds (for that consumer). However, in our analysis, the presence of a (behavioral) idiosyncratic preference shock for each policy could mean that consumers do not satisfy this condition.

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