Efficiency in Plan Choice with Risk Adjustment and Premium Discrimination in Health Insurance Exchanges*

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Abstract

In the new state-level Health Insurance Exchanges created by the Affordable Care Act, risk adjustment and premium discrimination are for the first time implemented together to contend with adverse selection. This paper develops a model to explore the impact of the two policies on the efficiency of consumer plan choice in the Exchanges. Premium discrimination could improve or impair efficiency in general, while risk adjustment always improves efficiency. Selecting a population likely to participate in the Exchanges from five waves of the Medical Expenditure Panel Survey, I simulate consumer selection under different cases of policy implementation. The results show that both policies improve efficiency of plan selection for the overall population in the context of Exchanges. I also construct two measures to assess the welfare impact. The results indicate that the welfare loss is minimized when risk adjustment and premium discrimination are implemented together.

Keywords: Health Insurance Exchanges; Adverse selection; Risk adjustment; Premium discrimination

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1 Introduction

Adverse selection, a major concern in health insurance markets (see Cutler & Zeckhauser (2000) and McGuire (2012) for literature reviews), induces two forms of inefficiency. First, insurers may manipulate plan policies to attract profitable enrollees (Newhouse (1996), Ellis & McGuire (2007)). Second, when premiums do not reflect the marginal cost of consumer choice, consumers make inefficient choice among plans with different levels of generosity (Cutler & Reber (1998), Einav & Finkelstein (2011), and Glazer & McGuire (2011)).[1] In theory, two payment system policies address selection: risk adjustment contends with insurer actions to affect selection (Van de Ven & Ellis (2000)), and risk-based premiums can improve the efficiency of consumer plan choice (Keeler et al. (1998), Bundorf et al. (2012)).

While risk adjustment has long been implemented in practice, such as in the U.S. Medicare program, and the national health care systems of the Netherlands and Germany, premiums are not commonly adjusted for risk. For example, in the U.S. insurers cannot charge premiums based on enrollees' health-related characteristics in employer-sponsored health insurance, Medicare Part C (Medicare Advantage) or Part D (prescription drug). One recent change is that premiums may be based on enrollees' age, which is highly related to health status, along with a few other individual characteristics in the Health Insurance Exchanges as part of the Affordable Care Act (ACA).[2] Exchanges also mandate risk adjustment so that plan payments will be adjusted according to the risk of enrollees. Thus, risk adjustment and premium discrimination, for the first time, will work together through the new Exchange payment system.

In this paper, I analyze how the efficiency of plan choice is affected by risk adjustment and premium discrimination in a model of the Exchanges, and find that overall both policies encourage consumers to enroll in the more generous plans, which in my model improves efficiency. I begin by constructing a model in which consumers are risk adverse, differ in expected health expenditures, and choose between two types of plans. One type is more

[1] There is a related inefficiency on the level of cost-sharing. The spending risk for consumers is shared less by insurers when adverse selection exists (Rothschild & Stiglitz (1976), Cutler & Zeckhauser (1998)).

[2] Other three characteristics that could be used for premium discrimination are family structure, residence, and smoking status.

generous than the other in terms of actuarial value, the percent of enrollees' health care costs covered by insurance plans. Plans charge premiums, receive risk adjustment payments from the Exchanges, and provide benefit to their enrollees. Risk adjustment payments affect plans' revenue, and premium discrimination changes the characteristics of potential enrollees by splitting them into separate markets, which affect plans cost. The two policies affect insurance premiums through different mechanisms, and together influence consumer plan choice.

In order to understand how risk adjustment and premium discrimination work separately and jointly, I study four cases: 1) No risk adjustment or premium discrimination is implemented; 2) Only risk adjustment is implemented; 3) Only premium discrimination is implemented; 4) Both are implemented. In each case the model describes plan sorting in equilibrium: consumers with expected health care expenditures greater than or equal to a threshold enroll in the more generous plans, and with expenditures smaller than the threshold enroll in the less generous plans. Policy impacts on plan choice are characterized by comparing plan enrollments and premium levels based on the thresholds in the four cases.

In the model, case 1 provides the baseline enrollments when no policy is incorporated. In case 2 the enrollments to the more generous plans increase when risk adjustment is implemented. Risk adjustment makes higher payments to the more generous plans in which high risk consumers have enrolled. Competition causes the more generous plans charge lower premiums in comparison to case 1, and therefore attract more enrollees. In case 3 the population is split into two subgroups: the young and the old. The same plan can charge different premiums in these different markets. The model predicts that a larger fraction of people will enroll in the more generous plans in each market, and the overall fraction increases. The intuition is that the population in both subgroups are more homogenous in terms of expected costs than when pooling together, so the incremental premiums they face when moving from the less generous plans to the more generous plans decrease. In case 4 when both polices are implemented, premium discrimination generate separate market for the young and the old, and in each market risk adjustment has similar impact on plan choice that sending more people to the more generous plans.

I then apply the model to a potential Exchange population drawn from five waves of the Medical Expenditure Panel Survey (MEPS), and simulate the equilibrium in each case. The results are consistent with the theoretical analysis that more people enroll in the more generous plans when risk adjustment and premium discrimination are implemented. In case 2, the premiums for the two types of plans compress so more people enroll in the more generous plans. In case 3, the fraction of the young who enroll in the more generous plans increases, while the fraction of the old decrease. The divergence comes from the different distributions of expected costs for the two groups in MEPS data. The expected cost is more homogenous for the young than that for the overall population, and more disperse for the old. Adverse selection is mitigated in the young group, and becomes more severe in the old group. More young people and less old people enroll in the more generous plans, and overall a larger fraction of the population enroll in the more generous plans compared to case 1. In case 4, risk adjustment subsidizes high risk people and compresses the premiums in both markets, so a even larger fraction enroll in the more generous plans. These results are robust when I change the values of parameters used in the simulation.

Consumers will efficiently self-select plans when they face the marginal costs of their choice, and empirical studies find that age-based or risk-based premiums can improve efficiency (Geruso (2013), Bundorf et al. (2012)). My paper provides a counterexample that charging premiums based on observed characteristics, even if they are highly related to health status, does not necessarily improve efficiency. In reality, the number of premium categories is limited. People are sorted into premium subgroups by their characteristics, but heterogeneity on risk remains within each premium category. Efficiency in selection improves only when the consumers in a subgroup become more homogenous, like the young group in my analysis. Adverse selection worsens if the subgroups are more heterogeneous than the overall population, like the old group in my empirical analysis. Whether premium discrimination will improve efficiency or not depends on the selection of premium category and the distribution of the risk of the population.

I construct two measures to assess welfare impact for consumers. One is the fraction of the population enrolling in the more generous plans, and the other is the average "risk premium" borne by the population. In general, welfare could increase or decrease when premium discrimination is implemented, depending on the distribution of the expected costs and the structure of premium categories. In this analysis, based on potential Exchange population and the illustrative young-old premium category, I find that risk adjustment and premium discrimination increase consumer welfare separately and jointly, and welfare loss of consumers is minimized when both policies are implemented.

A large literature has established the presence of adverse selection in individual health insurance markets. Cutler & Reber (1998) illustrate a notable example of how a generous plan is pushed into a "death spiral" in a employer-sponsored insurance market. A previous Exchange, the California Health Insurance Purchasing Cooperative, failed largely due to adverse selection (Wicks and Hall (2000)). Studies confirm the existence of adverse selection in plan choice in the Massachusetts health reform, which is implemented in 2006 and served as a template of the national reform (Chan and Gruber (2010), Ericson and Starc (2012)).

My analysis is based on the Einav-Finkelstein framework (Einav & Finkelstein (2011), Einav, Finkelstein & Levin (2010), and Einav, Finkelstein & Cullen (2010)) which models selection in insurance markets, and is closely related to Feldman & Dowd (1982), Ellis & McGuire (1987) and Cutler & Reber (1998) in which they simulate consumer choice between fee-for-service plans and HMOs. In relation to these papers, my model makes specific assumptions about the market, and derives explicit expressions for equilibrium sorting and welfare loss, which provides a quantitative method to analyze adverse selection. My model also incorporates risk adjustment, which is an extension of these studies. Including risk adjustment helps to predict consumer selection more accurately. In the Exchanges the ACA mandates the implementation of risk adjustment, which will affect insurer premium setting, and further consumer plan selection.

A few other papers also study risk adjustment and plan premiums in the Exchanges. McGuire et al. (forthcoming) illustrate how to find the best-fitting risk adjustment weights when plan premiums also do some "risk-adjusting" with premium categories. Glazer et al. (2013) suggest a statistical methodology for how to use risk adjustment to hit program target to improve sorting of enrollees between plans. Handel et al. (2013) study the trade-off between adverse selection and premium reclassification risk in Exchange plans. Comparing to these studies, my paper characterizes explicitly how risk adjustment and premium discrimination affect consumer plan choice in the Exchanges, and accessing the impacts in terms of welfare measures.

The paper is organized as follows. Section 2 presents the theoretical model. Section 3 describes the data and how the Exchange-eligible population is selected. Section 4 displays the empirical simulation and results. Section 5 discusses the welfare impact. Section 6 concludes.

2 Model

This section presents a model of how consumer plan choice is affected by the implementation of risk adjustment and premium discrimination. It starts with model assumptions, and then analyzes equilibria in four cases: 1) No risk adjustment or premium discrimination; 2) Risk adjustment only; 3) Premium discrimination only; 4) Both risk adjustment and premium discrimination are implemented.

There is a population of risk averse consumers. Consumer i has the Constant Absolute Risk Aversion (CARA) utility function

$$u(x_i) = -e^{-\gamma x_i},$$

where x_i is her consumption and γ is the CARA risk aversion parameter. The consumer has wealth W_i, and purchases an insurance plan by paying premium P. The insurance plan covers a fraction v of her medical spending c_i. The cost-sharing for the consumer is $(1-v)c_i$, and her consumption is $x_i = W_i - P - (1-v)c_i$. The utility function becomes

$$u(W_i - P - (1-v)c_i) = -e^{-\gamma(W_i - P - (1-v)c_i)}.$$

The consumer faces uncertainty in medical spending, which I assume has a normal distribution, $c_i \sim N(m_i, \sigma_i^2)$, with mean m_i and variance σ_i^2.[3]Consumers differ in the mean of medical spending. I assume that the *expected (or mean of)* medical spending, m_i, is randomly drawn from a range $[\underline{M}, \overline{M}]$, and has a cumulative distribution $F(m)$. The expected cost is public information and is known by both consumers and plans. I start with the assumption that the variance is constant, i.e., $\sigma_i^2 = \sigma^2$, for all consumers, and relax it later.

Based on the assumption of normal distribution of the medical spending, her expected utility is

$$E[u(W_i - P - (1-v)c_i)] = u(W_i - P - ((1-v)m_i + \frac{1}{2}\gamma(1-v)^2\sigma^2)). \tag{1}$$

The term $(1-v)m_i + \frac{1}{2}\gamma(1-v)^2\sigma^2$ is the certainty equivalent of the cost-sharing $(1-v)c_i$.[4] The total cost for a consumer is $P + (1-v)m_i + \frac{1}{2}\gamma(1-v)^2\sigma^2$, where P is plan premium , the $(1-v)m_i$ is the expected cost-sharing by the consumer, and $\frac{1}{2}\gamma(1-v)^2\sigma^2$ is the risk premium from the uncertainty of cost-sharing. For simplicity in notation, I define $\delta \equiv \frac{1}{2}\gamma\sigma^2$ in the following analysis.

Two types of plans are provided in the market, H and L, which differ in actuarial value. Plan H covers a fraction h of consumers' total costs, and plan L covers a fraction l. Plan H is more generous than plan L, i.e., $h > l$. Plan H charges premium P_H and plan L charges premium P_L. The market is competitive so both plans earn zero profit.

There is no outside option for consumers, and they are required to choose one plan between the two types of plans. There is no moral hazard, i.e., consumers' health care costs are independent on plan coverage. Based on the assumption that consumers are risk averse, the

[3]In reality, health care spending has approximately log-normal distribution (Manning (1998), Manning et al. (2005)). I assume normal distribution to have the advantage of deriving an explicit form of expected utility.

[4]The equation (1) comes from the property that $E(u(t)) = u(m - \frac{1}{2}\gamma\sigma^2)$ holds if a utility function has the form $u(x) = -e^{-\gamma x}$ and the expected cost has a normal distribution $c \sim N(m, \sigma^2)$. More details on risk premium are discussed by Pratt (1964).

efficient enrollment in the model is that everyone enrolls in plan H, because plan H shares with consumers a greater risk of medical spending than plan L does.

2.1 Case 1: No Risk Adjustment or Premium Discrimination

Consumer i chooses the plan that maximizes her utility, which is equivalent to minimizing the sum of out-of-pocket costs and risk premium. She will choose plan H if

$$\underbrace{P_H + (1-h)m_i}_{OOP_H} + \underbrace{\delta(1-h)^2}_{RP_H} \leq \underbrace{P_L + (1-l)m_i}_{OOP_L} + \underbrace{\delta(1-l)^2}_{RP_L}. \tag{2}$$

In equation (2), OOP_H is the total out-of-pocket costs for plan H, where P_H is the plan premium and $(1-h)m_i$ is the cost-sharing. RP_H is the risk premium borne by the consumer in plan H. OOP_L and RP_L are the total out-of-pocket costs and risk premium for plan L.

Figure 1 illustrates the relation between plan selection and the expected medical spending of consumers. The two curves present the costs for consumers when they enroll in plan H and plan L, which is the sum of plan premiums, risk premium, and cost-sharing. The first two terms are independent of the expected spending, and are illustrated by the intersections of the two curves with the horizontal axis. The last term is increasing with the expected spending, so the curves are upward-sloping. Since plan H provides a higher level of coverage than plan L does, the slope of the curve for plan H is flatter than that for plan L. The two curves intersect at point m^*. Consumers with expected spending less than m^* will enroll in plan L, while those with spending greater than or equal to m^* will enroll in plan H.

Rearrange equation (2) and it becomes

$$m_i \geq \frac{P_H - P_L}{h-l} - \delta\frac{(1-l)^2-(1-h)^2}{h-l} \equiv m^*, \tag{3}$$

which defines the selection cutoff m^*.

Plans charge premiums, and cover a fraction of health spending of their enrollees. Plan H attracts consumers with expected costs greater than or equal to m^*, so enrollees' average spending in plan H is $\frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}$. Plan H covers a fraction h of the spending, so the average cost is $\frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}h$. For plan L, the average cost is $\frac{\int_{\underline{M}}^{m^*} mdF(m)}{F(m^*)}l$. Plans earn zero profits, so premiums are equal to the average costs:

$$P_H = \frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}h, \tag{4}$$

$$P_L = \frac{\int_{\underline{M}}^{m^*} mdF(m)}{F(m^*)}l. \tag{5}$$

Plugging equations (4) and (5) into $m^* = \frac{P_H - P_L}{h-l} - \delta\frac{(1-l)^2-(1-h)^2}{h-l}$ yields

$$(h-l)m^* + \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}h - \frac{\int_{\underline{M}}^{m^*} mdF(m)}{F(m^*)}l. \tag{6}$$

Equation (6) defines the equilibrium cutoff m^*. The left-hand side shows the incremental benefit for consumers from moving from plan L to plan H. There are two types of benefit. The first is the direct benefit from increased coverage: consumers pay less cost-sharing for medical spending, $(h-l)m^*$. The second benefit is that they bear less risk premium from the decrease of the cost-sharing. The right-hand side shows the incremental cost, which is the premium difference between the two plans.

I assume that expected cost has a uniform distribution, i.e., $F(m) = \frac{m-\underline{M}}{\overline{M}-\underline{M}}$. The existence of equilibrium can be explicitly described under a uniform distribution, while it is more complex under an arbitrary distribution. This uniform assumption is made only in the theoretical model. In the empirical analysis, I use the real distribution of the expected spending from the data.

Under the uniform distribution assumption, the average costs of plan H and plan L are $\frac{\overline{M}+m^*}{2}h$ and $\frac{\underline{M}+m^*}{2}l$, so equation (6) becomes

$$(h-l)m^* + \delta[(1-l)^2 - (1-h)^2] = \frac{\overline{M}+m^*}{2}h - \frac{\underline{M}+m^*}{2}l. \tag{7}$$

Figure 2 illustrates the relation between the incremental benefit and the incremental cost, and the condition when an interior equilibrium exists. The horizontal axis represents the expected spending m, and the vertical axis represents consumers valuation in switching plans from L to H. The solid line displays the incremental benefit, and the dashed line displays the incremental cost, with a flatter slope.

An interior equilibrium exists only when δ is within a specific range, which is defined in equation (8).

$$\frac{l}{2[(1-l)^2-(1-h)^2]}(\overline{M}-\underline{M}) \leq \delta \leq \frac{h}{2[(1-l)^2-(1-h)^2]}(\overline{M}-\underline{M}). \tag{8}$$

The line "Benefit (δ is intermediate)" illustrates the situation. Consumers with expected costs less than m^* enroll in plan L, and others enroll in plan H. The equilibrium is stable because consumers do not have incentives to switch. For example, enrollees in plan L do not want to switch to plan H since their incremental costs are larger than the incremental benefits.

A corner solution occurs when δ is sufficiently small or large. When δ is sufficiently small, either because the risk aversion of the consumers is small or the uncertainty of health care spending is small (note that $\delta \equiv \frac{1}{2}\gamma\sigma^2$), the incremental benefit of moving from plan L to plan H is small. In Figure 2, the line "Benefit (δ is intermediate)" shifts down to "Benefit (δ is small)" and everyone prefers plan L. When δ is sufficiently large, the line "Benefit (δ is intermediate)" shifts up to "Benefit (δ is large)" , and everyone prefers plan H.

Re-arranging equation (7) yields

$$\frac{m^*-\underline{M}}{\overline{M}-\underline{M}} = \frac{h}{h-l} - \frac{2\delta(2-h-l)}{\overline{M}-\underline{M}}, \tag{9}$$

which characterizes the fraction of consumers that enroll in plan L. There are two properties of the fraction. First, it is increasing in plan L's actuarial value, l, because the incremental benefit from moving from plan L to plan H decreases when plan L's coverage increases. Second, it is decreasing in δ, because a smaller fraction of population will enroll in plan L when they either have a higher level of risk aversion or face a larger uncertainty of health costs.

Consumer plan choice is decided by the incremental premiums between plan L and plan H. High incremental premiums drive more consumers to enroll in less generous plans, and low incremental premiums drive them to enroll in more generous plans. The incremental premium can be derived from equation (7). The equilibrium cutoff m^* is defined by the equation and equals $\underline{M} + \frac{h}{h-l}(\overline{M} - \underline{M}) - 2\delta(2-h-l)$. Plugging it back into the right-hand side of the equation yields the incremental premium:

$$\Delta P^* = h\overline{M} - l\underline{M} - \delta(2-h-l)(h-l). \tag{10}$$

The incremental premium is increasing in the upper bound of expected cost $\overline{M}$, and decreasing in the lower bound $\underline{M}$. It means that the more disperse are the expected costs of the population, the higher the equilibrium incremental premium will be.

This section has developed the first of four cases, and the equilibria are summarized in Figure 3. Over the range of expected costs $[\underline{M}, \overline{M}]$, the shadow area displays the fraction of people enrolled in plan H. Since I assume consumers are risk averse and there is no moral hazard, the efficient selection is that everyone enrolls in plan H. In case 1, only consumers with expected costs greater than or equal to m^* will enroll in plan H.

2.2 Case 2: Risk Adjustment

I next expand the framework to incorporate risk adjustment. The principle of risk adjustment is that plans attracting enrollees with high health risk will receive greater payments than plans attracting enrollees with low risk. In the model, the process is implemented through a regulator. The regulator observes consumers' expected costs, and makes payment to plans consumers enroll in according to the costs.[5] A plan will receive a higher amount of payment if it attracts a sicker consumer. The regulator also charges the plans a capitation fee per enrollee in order to balance the budget. Consumers pay premiums and receive benefits from plans. Plans charge premiums, pay capitation fees, receive risk adjustment payments, and

[5]The observability of consumers' expected spending in risk adjustment is discussed in Ellis (2008), Ellis (2011), and Van de Ven & Ellis (2000).

provide benefits to enrollees.[6]

Consumers may or may not be aware of the intervention of risk adjustment. They choose plans that minimize the out-of-pocket costs and the risk premiums. The condition is the same as that in case 1 when no risk adjustment is implemented:

$$m_i \geq \frac{P_H - P_L}{h-l} - \delta\frac{(1-l)^2-(1-h)^2}{h-l} \equiv \widehat{m}. \tag{11}$$

Equation (11) defines $\widehat{m}$ as the selection cutoff.

Define the risk adjuster as r $(0 < r < l)$ and the capitation fee as R. [7] For a enrollee with expected cost m, plan revenue comes from the premium P and risk adjustment payment rm, and plan cost is the sum of the capitation fee R and the coverage vm ($v = h$ or l) of enrollee's cost. Since plans receive rm and pay vm, it's equivalent to paying $(v-r)m$ and receiving no risk adjustment payment. The coverage is $h-r$ for plan H, and $l-r$ for plan L. Plans earn zero profit, so premiums are equal average costs:

$$P_H = \frac{\int_{\widehat{m}}^{\overline{M}} mdF(m)}{1-F(\widehat{m})}(h-r)+R, \tag{12}$$

$$P_L = \frac{\int_{\underline{M}}^{\widehat{m}} mdF(m)}{F(\widehat{m})}(l-r)+R. \tag{13}$$

Plugging equations (12) and (13) into equation (11) yields

$$(h-l)\widehat{m} + \delta[(1-l)^2-(1-h)^2] = \frac{\int_{\widehat{m}}^{\overline{M}} mdF(m)}{1-F(\widehat{m})}(h-r) - \frac{\int_{\underline{M}}^{\widehat{m}} mdF(m)}{F(\widehat{m})}(l-r). \tag{14}$$

Equation (14) defines the equilibrium cutoff $\widehat{m}$. The left-hand side shows the incremental benefit for consumers from moving from plan L to plan H, which is the same as case 1. The right-hand side shows the incremental cost, which is the premium difference. Capitation fees are the same for both plans, so they cancel out. Due to risk adjustment, the incremental

[6] The implementation of risk adjustment in Exchanges will be more complex than what I assume in the model. The Department of Health and Human Services (HHS) (2013b) proposed details on how risk adjustment will be implemented in the federal-run Exchanges. However, the assumption captures the principle of risk adjustment that plans attracting low-risk enrollees will subsidize plans attracting high-risk enrollees, and is appropriate to be made to illustrate the impact of risk adjustment on plan sorting.

[7] The assumption $0 < r < l$ is made to avoid negative premiums in the following analysis.

premium only reflects part of the difference of enrollees' costs that plans actually cover. Comparing equation (6) to equation (14), case 1 is a special case of case 2 when risk adjuster $r = 0$.

Under uniform distribution, equation (14) becomes

$$(h-l)\widehat{m} + \delta[(1-l)^2 - (1-h)^2] = \frac{\overline{M} + \widehat{m}}{2}(h-r) - \frac{\underline{M} + \widehat{m}}{2}(l-r). \tag{15}$$

A unique equilibrium $\widehat{m}$ exists since both benefit and costs are linear in expected costs. An interior equilibrium exists only when δ satisfies the condition

$$\frac{l-r}{2[(1-l)^2 - (1-h)^2]}(\overline{M} - \underline{M}) \leq \delta \leq \frac{h-r}{2[(1-l)^2 - (1-h)^2]}(\overline{M} - \underline{M}). \tag{16}$$

There is a corner solution when δ is sufficiently large or sufficiently small. The range for δ is the same to that in case 1, while the levels are shift down when risk adjuster r is incorporated.

Re-arranging equation (15) yields

$$\frac{\widehat{m} - \underline{M}}{\overline{M} - \underline{M}} = \frac{h-r}{h-l} - \frac{2\delta(2-h-l)}{\overline{M} - \underline{M}}. \tag{17}$$

Equation (17) describes the fraction of consumers enrolling in plan L with risk adjustment. Compared to equation (9), the fraction decreases when risk adjustment is implemented. In addition, the fraction is decreasing in r, which means that the increase of the power of risk adjustment will cause more people to enroll in the more generous plan. Other properties of the fraction that hold in case 1 still hold in case 2: the fraction is decreasing in δ, and is decreasing in plan L's coverage l.

Figure 4 illustrates the equilibria in case 1 and case 2. The incremental benefits are the same in both cases, but the incremental cost is smaller in case 2 than that in case 1. The curve for incremental cost shifts down, so the equilibrium cutoff $\widehat{m}$ in case 2 is smaller than the cutoff m^* in case 1. Compared to case 1, more people enroll in plan H in case 2. The equilibrium allocation along with equilibria in other cases are shown in Figure 3.

The incremental premium provides the intuition on increased enrollment in the more generous plans. The incremental premium decreases when risk adjustment is implemented, so more consumers choose to enroll in plan H. Equation (15) defines the equilibrium cutoff $\widehat{m}$, and plugging the cutoff into the right-hand side of equation (14) yields the incremental premium:

$$\Delta\widehat{P} = h\overline{M} - l\underline{M} - r(\overline{M} - \underline{M}) - \delta(2 - h - l)(h - l). \tag{18}$$

Equation (18) incorporates the risk adjuster r. Case 1 is a special case of case 2 when $r = 0$. Equation (18) shows that the incremental premium decreases with risk adjustment. The larger the risk adjuster r, the higher is the subsidy to sick people, and the lower the incremental premium consumers face.

2.3 Case 3: Premium Discrimination

For simplicity, I assume there are two groups of consumers, young and old, which construct separate markets. The same plan can charge different premiums to the young and the old. For each group, the analysis is similar to that in case 1.

In the young market, plan H charges premium P_H^{young} and plan L charges premium P_L^{young}. The young choose between plan H and plan L, and minimize the out-of-pocket costs and the risk premiums. The cutoff is defined as $m^{young} = \frac{P_H^{young} - P_L^{young}}{h-l} - \delta\frac{(1-l)^2-(1-h)^2}{h-l}$. The distribution of young enrollees' expected costs is denoted as $F^{young}(m)$. Plans earn zero profits in this market, so premiums are equal to the average costs:

$$P_H^{young} = \frac{\int_{m^{young}}^{\overline{M}} m dF^{young}(m)}{1 - F^{young}(m^{young})} h, \tag{19}$$

$$P_L^{young} = \frac{\int_{\underline{M}}^{m^{young}} m dF^{young}(m)}{F^{young}(m^{young})} l. \tag{20}$$

The equilibrium condition for the young is

$$(h-l)m^{young}+\delta[(1-l)^2-(1-h)^2]=\frac{\int_{m^{young}}^{\overline{M}} mdF^{young}(m)}{1-F^{young}(m^{young})}h-\frac{\int_{\underline{M}}^{m^{young}} mdF^{young}(m)}{F^{young}(m^{young})}l \quad (21)$$

In the old market, the analysis is similar as in the young market. Hence the equilibrium for the old is

$$(h-l)m^{old}+\delta[(1-l)^2-(1-h)^2]=\frac{\int_{m^{old}}^{\overline{M}} mdF^{old}(m)}{1-F^{old}(m^{old})}h-\frac{\int_{\underline{M}}^{m^{old}} mdF^{old}(m)}{F^{old}(m^{old})}l \quad (22)$$

The left-hand side of equation (21) and equation (22) shows the incremental benefit for consumers from moving from plan L to plan H, and the right-hand side shows the incremental cost.

I assume that the distribution of the expected costs for the young is $m^{young} \sim U[\underline{M}, \widetilde{m}]$, and for the old is $m^{old} \sim U[\widetilde{m}, \overline{M}]$ where $\widetilde{m} \in [\underline{M}, \overline{M}]$. Though this assumption is extreme that all young people have low costs, all old people have high costs and the two distributions do not overlap, it leads to interesting and analytically tractable results. In the empirical analysis I use the empirical distribution of expected costs in the data. Based on the cost distribution the cutoffs become

$$m^{young}=\underline{M}+\frac{h}{h-l}(\widetilde{m}-\underline{M})-2\delta(2-h-l) \quad (23)$$

and

$$m^{old}=\widetilde{m}+\frac{h}{h-l}(\overline{M}-\widetilde{m})-2\delta(2-h-l). \quad (24)$$

With premium discrimination, the fraction of people who enroll in plan L equals the sum of the fractions for the young and the old who enroll in plan L:

$$\frac{(m^{young}-\underline{M})+(m^{old}-\widetilde{m})}{\overline{M}-\underline{M}}$$

$$= \frac{[\frac{h}{h-l}(\widetilde{m}-\underline{M})-2\delta(2-h-l)]+[\frac{h}{h-l}(\overline{M}-\widetilde{m})-2\delta(2-h-l)]}{\overline{M}-\underline{M}} \tag{25}$$

$$= \frac{h}{h-l} - 2 \cdot \frac{2\delta(2-h-l)}{\overline{M}-\underline{M}}.$$

The fraction of people who enroll in plan L without premium discrimination is $\frac{m^*-\underline{M}}{\overline{M}-\underline{M}} = \frac{h}{h-l} - \frac{2\delta(2-h-l)}{\overline{M}-\underline{M}}$. This fraction decreases comparing to equation (25). The result predicts that fewer people will enroll in the less generous plans when premium discrimination is implemented.

The intuition is that the population becomes more homogenous within each subgroup so the incremental premium they face decreases. The incremental premiums for the two groups are

$$\Delta P^{young} = h\widetilde{m} - l\underline{M} - \delta(2-h-l)(h-l) \tag{26}$$

$$\Delta P^{old} = h\overline{M} - l\widetilde{m} - \delta(2-h-l)(h-l). \tag{27}$$

Compared to equation (10) which shows the incremental premium without premium discrimination, the incremental premiums for both groups decrease, since their expected costs distribute in a narrower range. In case 1, the expected costs for the whole population distribute in $[\underline{M}, \overline{M}]$, while in this case the young distribute in $[\underline{M}, \widetilde{m}]$ and the old distribute in $[\widetilde{m}, \overline{M}]$, where $\widetilde{m} \in [\underline{M}, \overline{M}]$. In each market, fewer consumers enroll in plan L, and overall, fewer consumers enroll in plan L.

Figure 3 illustrates the equilibrium allocation. $\widetilde{m}$ is the cutoff of the expected costs between the young and the old. In each market, people with expected costs higher than a cutoff enroll in plan H. In total, the fraction of people who enroll in plan H is higher in case 3 than that in case 1.

2.4 Case 4: Premium Discrimination and Risk Adjustment

In this case, both risk adjustment and premium discrimination are implemented. The young and the old select plans in separate markets, and risk adjustment is implemented in both of them. The mechanism of risk adjustment is the same as in case 2. The regulator charges a capitation fee R for each enrollee and make payments to plans according to their enrollees' expected spending. Consumers choose the plans that minimize their out-of-pocket costs plus risk premiums. Plans charge enrollees premiums, pay the regulator a capitation fee for each enrollee, and receive risk-adjusted payments from the regulator.

Define $\widehat{m}^{young}$ and $\widehat{m}^{old}$ as the equilibrium cutoffs, and the equilibrium conditions are

$$(h-l)\widehat{m}^{young}+\delta[(1-l)^2-(1-h)^2] = \frac{\int_{\widehat{m}^{young}}^{\overline{M}} mdF^{young}(m)}{1-F^{young}(\widehat{m}^{young})}(h-r)-\frac{\int_{\underline{M}}^{\widehat{m}^{young}} mdF^{young}(m)}{F^{young}(\widehat{m}^{young})}(l-r) \tag{28}$$

$$(h-l)\widehat{m}^{old}+\delta[(1-l)^2-(1-h)^2] = \frac{\int_{\widehat{m}^{old}}^{\overline{M}} mdF^{old}(m)}{1-F^{old}(\widehat{m}^{old})}(h-r)-\frac{\int_{\underline{M}}^{\widehat{m}^{old}} mdF^{old}(m)}{F^{old}(\widehat{m}^{old})}(l-r). \tag{29}$$

Maintaining the assumption that the young have the cost distribution $m^{young} \sim U[\underline{M}, \widetilde{m}]$, and the old have the cost distribution $m^{old} \sim U[\widetilde{m}, \overline{M}]$ where $\widetilde{m} \in [\underline{M}, \overline{M}]$, the equilibrium cutoffs are

$$\widehat{m}^{young} = \underline{M} + \frac{h-r}{h-l}(\widetilde{m} - \underline{M}) - 2\delta(2-h-l) \tag{30}$$

and

$$\widehat{m}^{old} = \widetilde{m} + \frac{h-r}{h-l}(\overline{M} - \widetilde{m}) - 2\delta(2-h-l). \tag{31}$$

The fraction of consumers who enroll in plan L is:

$$\frac{(\widehat{m}^{young} - \underline{M}) + (\widehat{m}^{old} - \widetilde{m})}{\overline{M} - \underline{M}}$$

$$= \frac{[\frac{h-r}{h-l}(\widetilde{m} - \underline{M}) - 2\delta(2-h-l)] + [\frac{h-r}{h-l}(\overline{M} - \widetilde{m}) - 2\delta(2-h-l)]}{\overline{M} - \underline{M}} \quad (32)$$

$$= \frac{h-r}{h-l} - 2 \cdot \frac{2\delta(2-h-l)}{\overline{M} - \underline{M}}.$$

Equation (32) incorporate risk adjuster r and case 3 is a special case of case 4 when $r = 0$. Comparing equation (25) to equation (32), fewer consumers enroll in plan L with risk adjustment. The more powerful is risk adjustment, the smaller the number of people who enroll in plan L. The intuition is the same as in case 2: in each market the risk adjustment decreases the incremental premiums so consumers' incentive to move from plan L to plan H increases.

Figure 3 shows the equilibrium allocation. Compared to case 3, the fraction of people enrolling in plan H is larger in case 4 in both markets.

2.5 The case with heterogeneous variance

In this case I relax the assumption that the variance of medical spending is the same for all enrollees. Instead, I assume the variance is proportion to the mean, i.e., $\sigma_i^2 = \beta m_i$, which is closer to reality. There are a large number of studies discussing the correlation between mean and variance of health care expenditures (McGuire et al. (2013), Basu (2005), Buntin & Zaslavsky (2004) and Manning et al. (2005)). McGuire et al. (2013) find a roughly linear relationship for the potential Exchange population.[8]

Recall that δ is defined as $\delta \equiv \frac{1}{2}\gamma\sigma^2$. Under the assumption $\sigma_i^2 = \beta m_i$, δ becomes

[8] In general, I can assume $\sigma_i^2 = \alpha + \beta m_i$. However, the assumption $\sigma_i^2 = \beta m_i$ has the advantage of the fact that the coefficient β can be estimated by a Poisson-like Generalized Linear Model (GLM). More details on modeling medical expenditure using GLM are discussed in Buntin & Zaslavsky (2004).

$\delta_i \equiv \frac{1}{2}\gamma\beta m_i$. In case 1, equation (6) becomes

$$(h-l)m^* + \frac{1}{2}\gamma\beta[(1-l)^2 - (1-h)^2]m^* = \frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}h - \frac{\int_{\underline{M}}^{m^*} mdF(m)}{F(m^*)}l. \tag{33}$$

Under uniform distribution, the equilibrium cutoff is

$$m^* = \frac{1}{1+\gamma\beta(2-h-l)}[\underline{M} + \frac{h}{h-l}(\overline{M} - \underline{M})]. \tag{34}$$

Equation (34) defines the equilibrium cutoff when the variance of consumers' spending is heterogeneous. The properties of equilibrium still hold. m^* is increasing in l, which means the fraction of the population that enrolls in plan L is increasing in plan L's actuarial value. m^* decreases in γ and β, which means a smaller fraction of the population will enroll in plan L who either have a higher level of risk aversion or face a larger uncertainty of health costs. I omit the equilibrium discussion for the other three cases, since they are similar to the analysis discussed in case 1. The existence and uniqueness of equilibrium in the model allows me to simulate plan selection empirically.

3 Data

This analysis uses data from the Medical Expenditure Panel Survey (MEPS), a nationally representative survey of the civilian, non-institutionalized U.S. population conducted annually since 1996. Each year MEPS collects information on approximately 33,000 individuals, enlisting a new panel of respondents each year who are followed for two years. Data are collected in five rounds of interviews covering the two-year period. The Household Component (HC) is the source for personal and household characteristics, including insurance coverage and self-reported health and health conditions. The HC is also the source of data on medical "events" (e.g. an inpatient stay or office visit) including information about diagnoses, procedures, and payments from various sources. I use data from panel 9 (2004/05) to panel 13 (2008/09).

A population of individuals and families is selected who would be eligible to enroll in state-level Exchanges under current law based on their income, insurance, and employment status. I follow McGuire et al. (2013) in selection of the sample. People who are selected are adult, non-elderly individuals (aged 18-64) with households earning at least 138% of the federal poverty level (FPL) and children in households with income of at least 205% of the FPL. The selected people also satisfy at least one of the following conditions: ever uninsured, a holder of a non-group insurance policy, self-employed, employed by a small employer, or paying an out-of-pocket premium for their employer-sponsored health insurance (ESI) plan that is deemed to be unaffordable (as defined in the ACA).[9] In total, there are 20,865 individuals from MEPS, each with two years of data.

Table 1 summarizes some statistics on this group. The young group includes people 40 or younger, and the old group includes people older than 40. The population contains a relatively high proportion of Hispanics and lives disproportionately in the South. The income range is large because of the various qualification criteria for Exchange participation.

4 Empirical Simulation and Results

In this section, I calibrate the model, estimate expected health care spending of consumers, and present the simulation results on consumer choice in all four cases.

The following equation, which is the same as equation (33) except that risk adjuster r is incorporated, is used for the simulation:

$$(h-l)m^* + \frac{1}{2}\gamma\beta[(1-l)^2-(1-h)^2]m^* = \frac{\int_{m^*}^{\overline{M}} mdF(m)}{1-F(m^*)}(h-r) - \frac{\int_{\underline{M}}^{m^*} mdF(m)}{F(m^*)}(l-r). \quad (35)$$

The left-hand side of equation (35) illustrates the benefit for consumers of moving to more generous plans, which is less cost-sharing and less risk premium. The right-hand side illustrates the cost, which is the incremental premium. m^* is the equilibrium cutoff with which

[9]Small employers are either (1) those with fewer than 50 employees or (2) those with fewer than 100 employees who report only one business location. The ACA states that individuals whose out-of-pocket premiums for employer-sponsored insurance exceed 9.5% of family income will be eligible to purchase health insurance through an Exchange.

consumers are indifferent between the two types of plans. Consumers with expected costs less than m^* enroll in the less generous plans, and others enroll in the more generous plans.

This equation complies the simulation for all the four cases. The risk adjuster r is set to zero in case 1 and case 3 when risk adjustment is not incorporated. Equilibria for the young and the old are simulated separately in case 3 and case 4 when premium discrimination is implemented.

4.1 Parameter Set Up

Five parameters are included in equation (35): the actuarial values of plan H and plan L, h & l, the risk adjuster r, the risk aversion parameter γ, and the correlation between the mean and the variance of expected spending β. I assume $h = 0.9$ and $l = 0.6$, which are the regulated levels of coverage for Platinum plans and Bronze plans in the Exchanges. I start by assuming $r = 0.2$ and vary this assumption later in case 4, in order to compare the impacts on sorting between different levels of risk adjustment.

I use the empirical distribution of the expected spending from the MEPS data. I follow the approach developed by McGuire et al. (2013) to predict the spending. In McGuire et al. (2013), year 2's spending is predicted using a group of year 1's individual characteristics: age-gender combination, self-reported health status, self-reported mental health status, indicators of total spending, and indicators of spending by services. A two-part model is used for the estimation. The first part is a logistic model predicting the probability of spending for the whole population. The second part is a quasi-GLM model predicting the spending for the population who has positive spending. Figure 5 displays the distribution of predicted spending separately for the whole population, for the young (age 18-40), and for the old (age 41-64). For the whole population, the majority has low predicted costs, some are in the middle range, and a few have extremely high costs. Most of the young population concentrates on the low cost range. The spending for the old is more dispersed than that for the young.

Each individual has an observed spending m_i, from the data, and expected spending $\hat{m}_i$ which is predicted by the two-part model. The square of the error of spending for each individual is $\hat{\epsilon}_i^2 = (m_i - \hat{m}_i)^2$, and β is estimated by regressing $\hat{\epsilon}_i^2 = \beta * \hat{m}_i$. Table 2 displays the estimation results. $\hat{\beta} = 12,654$ with a p-value less than 0.0001. R-square for the regression is 0.055.

I use the plan selection information in Massachusetts reform to calibrate the risk aversion parameter γ. In the Massachusetts reform, there are three levels of plans provided: Bronze, Silver, and Gold. Ericson & Starc (2012) report that about 60% of the population enrolled in the least generous plans (Bronze plans) in 2009. In this analysis, therefore, I use this fraction to calibrate γ. I find that when $\gamma = 1.5 * 10^{-3}$, 60% of the population enrolls in plan L in case 1 when no risk adjustment or premium discrimination is implemented. This magnitude of risk aversion is consistent with the estimation in the literature (Handel et al. (2013); Cohen & Einav (2007); Gertner (1993); and Sydnor (2006)).[10] I also vary the values of γ to check the robustness of the results.

4.2 Simulation Results

Figure 6 displays the simulation results on equilibria in case 1 and case 2. Figure 6A includes the whole range of expected costs, and Figure 6B includes the range around the equilibrium cutoffs in order to show them more clearly. The solid line represents the incremental benefit, which is the same in both cases. The dashed lines represent the incremental cost. The red (darker) line is for case 1, and the green (lighter) line is for case 2. Risk adjustment decreases the incremental premium consumers face, so the green (lighter) line is a downward shift of the red (darker) line. In case 1 the equilibrium cutoff is \$1,790. Consumers with expected spending less than \$1,790 enroll in plan L, and others enroll in plan H. The equilibrium is stable that enrollees in plan L do not have incentives to switch to plan H, and vice versa. In case 2, the equilibrium cutoff is \$1,160, which is smaller than that in case 1, and means that more consumers enroll in plan H.

In case 3 and case 4, there are two separate markets: the young and the old. In each

[10] In Handel et al. (2013), the estimation of the mean risk aversion parameter in a CARA utility function is $4.3 * 10^{-4}$ for the pseudo-sample for the Exchanges. In Cohen & Einav (2007), the estimation is $3.1 * 10^{-3}$. In Gertner (1993), the estimation is $3.1 * 10^{-4}$ and in Sydnor (2006) the estimation is $2.0 * 10^{-3}$.

market the analysis is similar to that of case 1 and case 2. Figure 7 shows the results. Figure 7A describes the equilibria with and without risk adjustment for the young. The cutoff is \$1,020 without risk adjustment, and is \$660 with risk adjustment. Figure 7B describes the equilibria for the old. The cutoffs are \$1,920 and \$1,400, which are both higher than the cutoffs in the young markets. In both markets, more consumers enroll in plan H with risk adjustment.

Table 3 summarizes the equilibria for the four cases. Column (1) indicates whether results are for the whole population, for the young or for the old. Column (2) provides the size of the population in each market. There are 20,865 consumers in the sample size, while 12,058 of them are young, and 8,807 are old. Column (3) illustrates the simulated equilibrium cutoffs from Figure 6 and Figure 7. Column (4) displays the number of enrollees in plan H in each market based on the distribution of expected spending and the cutoff. In case 3 and case 4, the number for the whole population is the sum of the numbers for the young and for the old. For example, in case 3 there are 5,423 young enrollees and 5,335 old enrollees in plan H, so in total there are 10,758 enrollees in plan H.

Column (5) of Table 3 shows the fraction of enrollment in plan H, which is the ratio between Column (4) and Column (2). Since case 1 is calibrated from the Massachusetts reform, 39.4% of the population enrolls in plan H, the more generous plan. In case 2, when only risk adjustment is implemented, the fraction increases to 56.4%. In case 3, when only premium discrimination is implemented, the fraction increases to 51.6%. It shows that both risk adjustment and premium discrimination encourage people to enroll in the more generous plan. In case 4, when both policies are implemented, the fraction is 67.6%, which is the largest among the four cases. The simulation results are consistent with the theoretical analysis.

Table 4 illustrates the premium levels of plan L and plan H in all four cases in each market. Column (1) indicates the market and Column (2) displays the equilibrium cutoffs. Column (3) and Column (4) display the premiums for plan L and plan H, and Column (5) displays the incremental premium between the two plans, which is derived by subtracting Column (3) from Column (4). There are two findings from the premium results.

First, the incremental premium is compressed when risk adjustment is implemented, which is consistent with the theoretical analysis. In case 1, the incremental premium consumers face between plan L and plan H is \$3,082, and it decreases to \$2,396 in case 2. The trend is the same for the young and for the old in case 3 and case 4. This is because high risk consumers who enroll in plan H are subsidized by low risk consumers, so the premium of plan H decreases and the premium of plan L increases.

Second, the old face a higher incremental premium than the young when premium discrimination is implemented. In case 1 the incremental premium is \$3,082 for the whole population, while it becomes \$1,762 for the young and \$3,310 for the old in case 3. Without premium discrimination, high-risk consumers are subsidized by low-risk consumers in a way that everyone faces the same premium. The two groups are separated according to premium categories, so the incremental premiums are closer to their own marginal costs of plan selection. As is shown in Figure 5, the expected costs for the young is more homogenous than the whole population, so the incremental premium decreases. The costs for the old disperse more than the whole population, so the incremental premium increases. Premium discrimination pushes more young consumers but fewer old consumers enrolling in plan H. In total, a larger fraction of the population enroll in plan H. The conditions are similar between case 2 and case 4.

Table 5 characterizes the equilibrium results in case 4 with different levels of risk adjustment. 0.2 is the baseline of risk adjuster r, and other three values are also selected: 0.3, 0.4 and 0.5. I only simulate the equilibrium in case 4 since in practice both risk adjustment and premium discrimination will be implemented in Exchanges. The model predicts that more consumers will enroll in more generous plans when the power of risk adjustment increases. The fraction of the population that enroll in plan H is 67.6% when $r = 0.2$, and it increases to 75.0%, 81.8% and 87.7% when risk adjuster r increases to 0.3, 0.4 and 0.5, respectively.

I select other values of parameters in order to check the robustness of the results. First I change the actuarial value of plan H, h, from 0.9 to 0.8, while keeping all other parameters unchanged. The results are shown in Table A1. Comparing to the main results when $h = 0.9$, there are fewer enrollees in plan H in each case. This is because the incremental benefit of changing plans decreases when the coverage of plan H decreases. Second I vary the risk aversion parameter γ from $1.5 * 10^{-3}$ to $1 * 10^{-3}$ and $2 * 10^{-3}$. The results are shown in Table A2. The fraction of enrollment in plan H decreases when γ decreases, and vice versa. This is because the more generous plan is less attractive for people when they are less risk averse, and more attractive when they are more risk averse. The conclusion holds in both robustness checks that both risk adjustment and premium discrimination encourage people to enroll in the more generous plans.

5 Welfare Analysis

Two measures are presented to analyze the welfare impact on consumers. The first is the fraction of enrollment in plan H, which is already illustrated in Table 3, and the second is the average risk premium the population bear. Based on the model setup, an enrollee's risk premium is $\frac{1}{2}\gamma\beta m(1-h)^2$ if she enrolls in plan H and $\frac{1}{2}\gamma\beta m(1-l)^2$ if she enrolls in plan L. In the first-best case when all consumers enroll in plan H, the average risk premium for the population is

$$L^{FB} = \int_{\underline{M}}^{\overline{M}} \frac{1}{2}\gamma\beta m(1-h)^2 dF(m). \tag{36}$$

Integrating equation (36) yields

$$L^{FB} = \frac{1}{2}\gamma\beta(1-h)^2 E(m). \tag{37}$$

In the four cases, the average risk premium for the whole population is the weighted sum of risk premium for plan L and plan H. For example, in case 1, it is $\frac{1}{2}\gamma\beta(1-l)^2 E(m|m \leq m^*)F(m^*) + \frac{1}{2}\gamma\beta(1-h)^2 E(m|m > m^*)(1-F(m^*))$ where m^* is the equilibrium cutoff. The measure is increasing in γ and β, which means welfare loss is greater for a population with either larger risk aversion or larger uncertainty of medical spending.

The two welfare measures are positively correlated. If a consumer moves from plan L to plan H, both measures show welfare improvement. However, enrollees are treated the same in the first measure, but differently in the second measure. If two consumers, one with high expected spending and the other with low expected spending, both move from plan L to plan H, the welfare impacts are the same for the first measure, but different for the second. The welfare improvement is larger when a consumer with higher expected spending moves in the second measure.

Table 6 summarizes the results of two measures of welfare loss. Column (1) displays the fraction of enrollment in plan H and Column (2) displays the average risk premium consumers bear. In the first-best case, everyone enrolls in plan H, and the average risk premium is \$199 per person since the population still bear 10% of the costs. In case 1, 60.6% of the population enrolls in plan L and the average risk premium is \$782 per person. The fraction increases and the risk premium decreases when risk adjustment and premium discrimination are implemented. In case 4, the fraction of enrollment in plan H is 67.6% and the risk premium is \$470. Welfare loss of consumers reaches the minimum in the case 4 when both risk adjustment and premium discrimination are implemented.

When comparing case 3 to case 1, although the fraction of enrollment increases by 12.2%, the average risk premium almost remains the same. This is because all of the 39.4% of the population enrolling in plan H in case 1 have high expected costs, while it is not the situation in case 3. Since there are separate markets in case 3, those young consumers with relatively high costs enroll in plan H and old consumers with relatively low costs enroll in plan L. The young who are in plan H can have lower costs than the old in plan L. The measure of risk premium puts greater weights on enrollees with high expected costs, so the change of risk premium is less than the change of fraction from case 1 to case 3.

6 Discussion

Risk adjustment and premium discrimination work together for the first time in the Health Insurance Exchanges to contend with adverse selection. The primary contribution of this study is to provide an analytical framework illustrating how consumer plan choice is affected by the two policies, and how large the impacts are on welfare measures. By using a nationally representative data set, I find that both risk adjustment and premium discrimination encourage the overall population to enroll in the more generous plans, which improves efficiency in terms of having consumers bear less financial risk. While the impact of the risk adjustment is the same for the young and the old population, efficiency is only improved by premium discrimination for the young, not the old. Consumer welfare loss is minimized when both policies are implemented.

My analysis studies how the two policies work together in the context of Exchanges. In practice, premiums will be conditioned on many categories. For example, in the federally-run Exchanges, HHS (2013a) proposed a single premium for children with age 0-20, one-year age bands for adults aged 21-63, and a single premium for the old with age 64 and above. Consumer choice is affected by the structure of premium categories. Finer categories may improve efficiency in consumer choice, and this hypothesis can be tested with the methods here using a larger dataset. In addition, my results are based on a national sample, while the Exchanges are implemented at the state level. Individual characteristics vary across states, and the rules of risk adjustment and premium discrimination also vary. The model proposed in this paper can incorporate these variations, and states can apply it to evaluate the impacts by using their own data on consumer characteristics, risk adjustment formula, and premium categories.

Premium discrimination brings a trade-off between efficiency and fairness. It improves efficiency by having consumers bearing less risk, but with a cost of increasing the premiums the high-risk population faces. People pay more when they are old and sick, which can be regarded as unfair. Premium discrimination in the one hand improves efficiency, but in the other hand may generate other social costs. Rating bands constrain the unfairness within specific ranges, but does not completely eliminate it.[11] The optimal premium categories that

[11]In the federally-run Exchanges, the rating band for age is 3:1, which means that the premium charged to the oldest (most expensive) group can be no more than three times the premium to the youngest (least expensive) group. The rating band for tobacco use is 1.5:1, which means that smokers cannot be charged premiums that are 50% higher than the premium charged for non-smokers.

balance efficiency and fairness could be an area for future work.

I assume individual completely comply with the insurance mandate in the analysis. In reality, people with low risk may choose to be uninsured and pay the penalty. [12] My model also does not incorporate the reinsurance program in the Exchanges. In the first three years of Exchanges, plans will be forced to participate in a federally run system of reinsurance. Plans are only responsible for 20% of costs after the amount reaches $60,000.[13] The two features will change the distribution of enrollees' costs, so the results would likely be affected.

This study makes some simplifications, and three factors could be considered for future research in order to make the analysis more practical. First is moral hazard. The demand for health care is affected by insurance coverage, and the enrollees' costs will probably increase when they enroll in more generous plans. Moral hazard will affect the incremental premium between plans and further affect plan selection. The first-best case will not in general be when everyone enrolls in the more generous plans when incorporating moral hazard in the model. Second is more than two plans. Four types of plans (Bronze, silver, gold and platinum), rather than two, will be provided in the Exchanges. When consumers face more than two options, additional conditions are required to guarantee the existence of equilibrium. The sorting situation and welfare analysis will also change. Third is plan differentiation. Health insurance is a complex product, and plans can easily be designed differently from one to another. It is likely that insurers will differentiate plans on features other than actuarial value, for example, provider network, therefore attract consumers with different characteristics.

[12] However, the compliance rate is expected to be high with insurance mandate and the subsidy schedule for premiums and cost-sharing. One evidence to support the high compliance rate is that in the Massachusetts reform, 95% of the tax filers claimed full insurance in 2008 (Massachusetts Health Connector and Department of Revenue (2010)).

[13] Zhu et al. (2013) study the reinsurance in the Exchanges, and evaluate the power of reinsurance to improve the payment system.

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Figure 1. The Relation between Plan Selection and the Cost of Certainty Equivalent

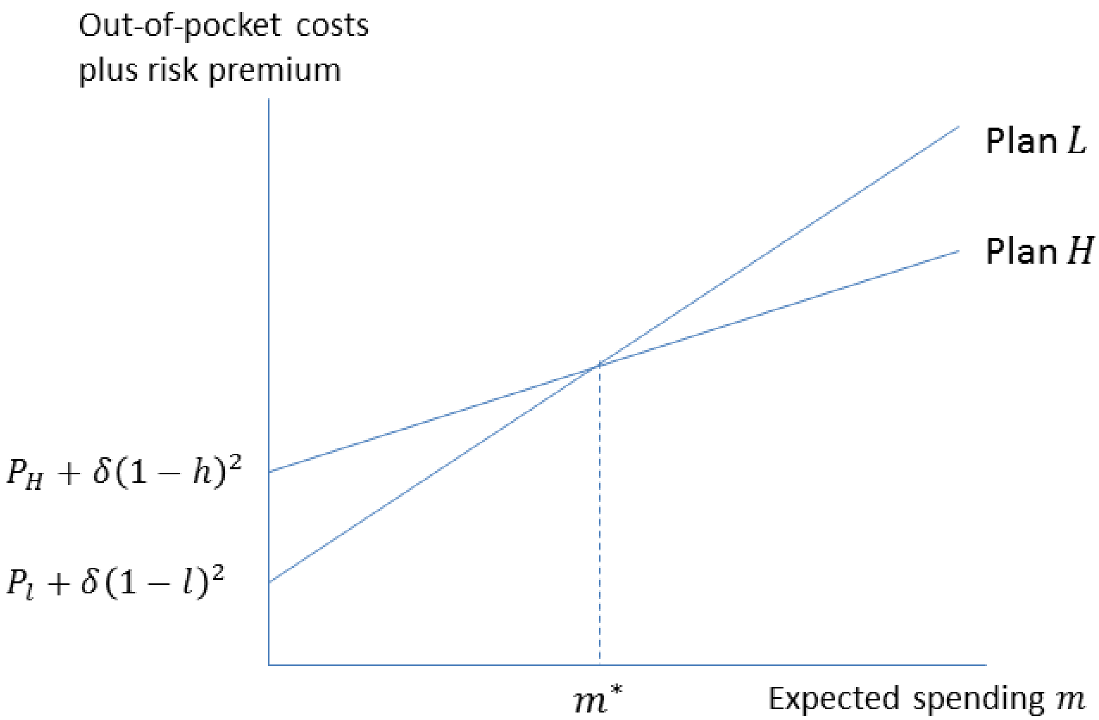


Figure 2. Equilibrium in Case 1

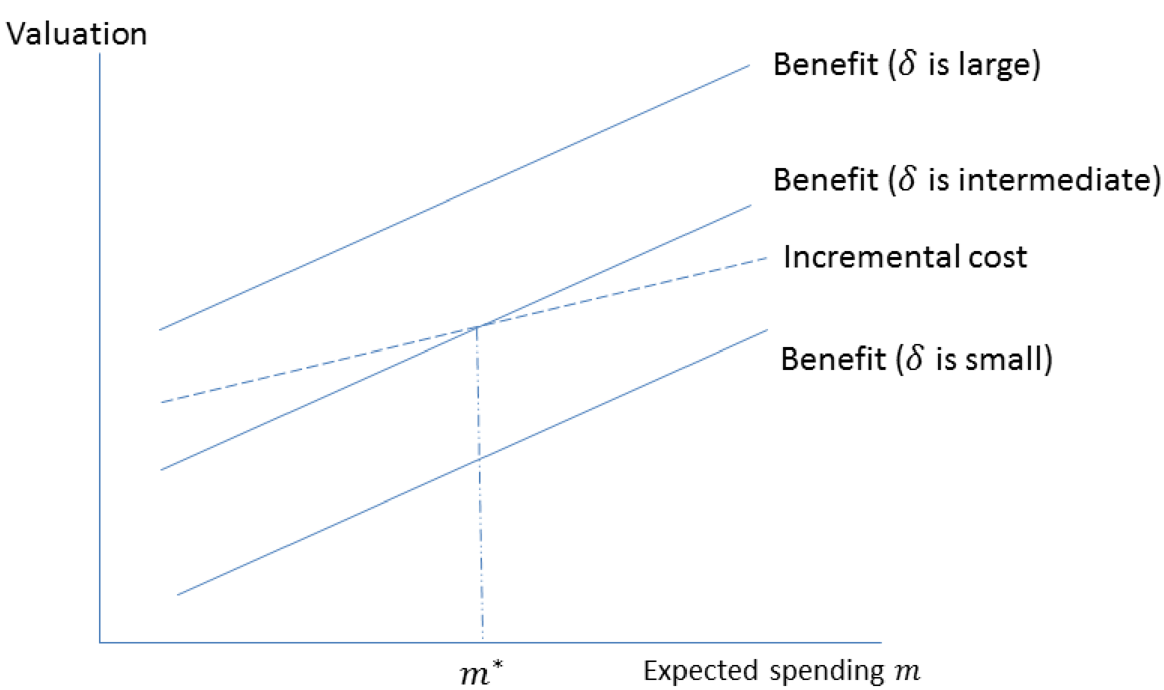


Figure 3. Comparison of Equilibrium in Four Cases

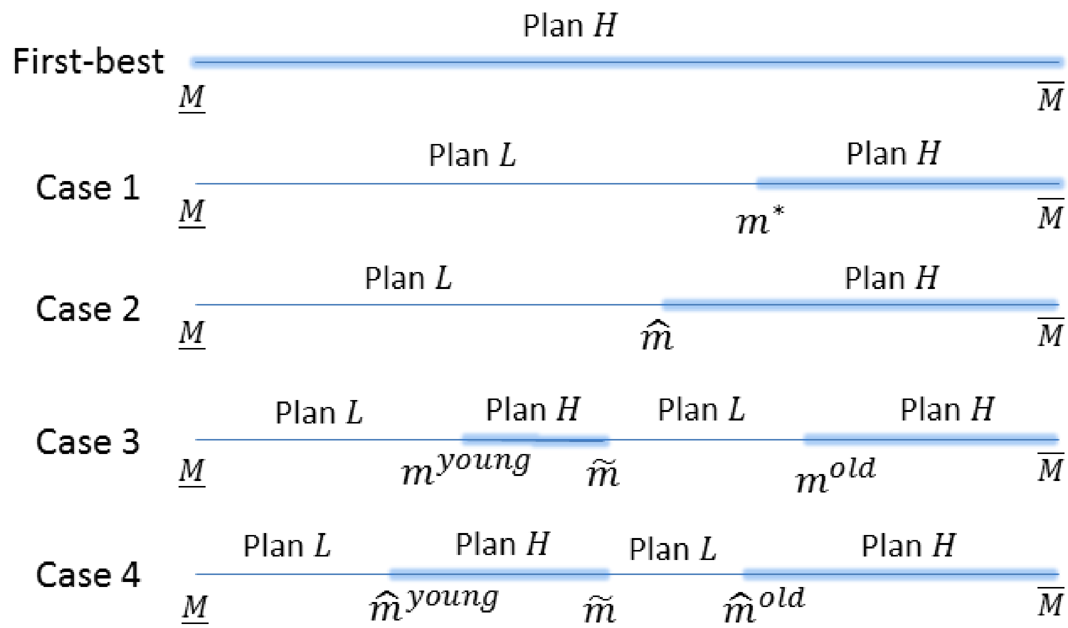


Figure 4. Equilibria in Case 1 and Case 2

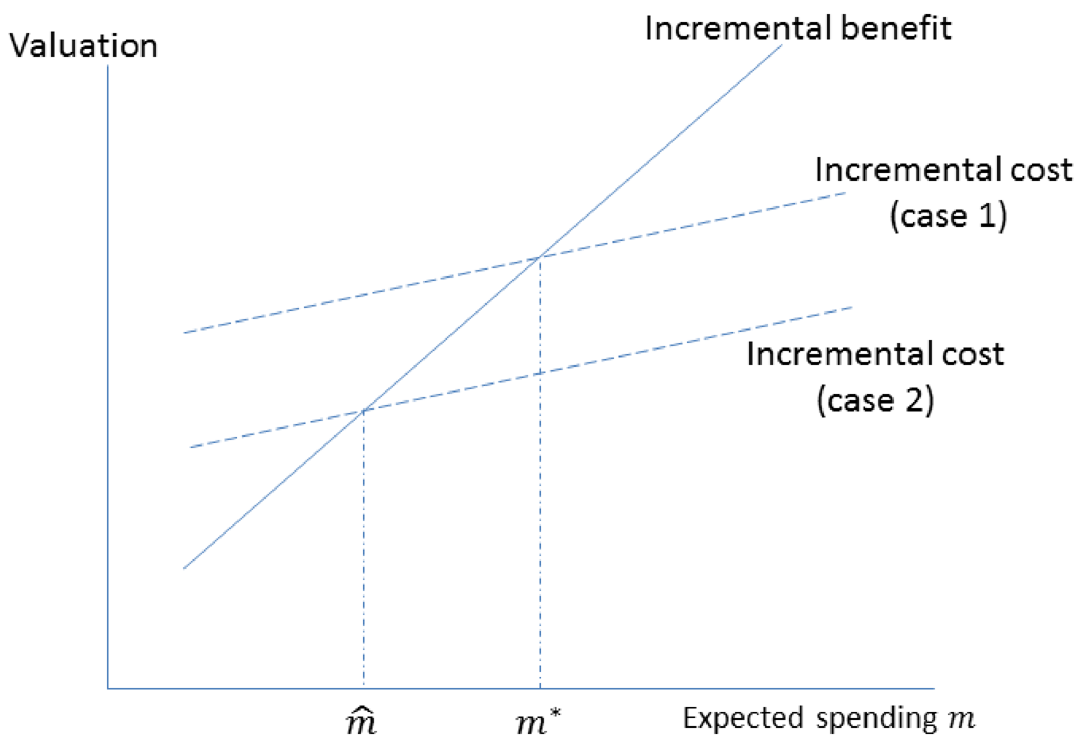
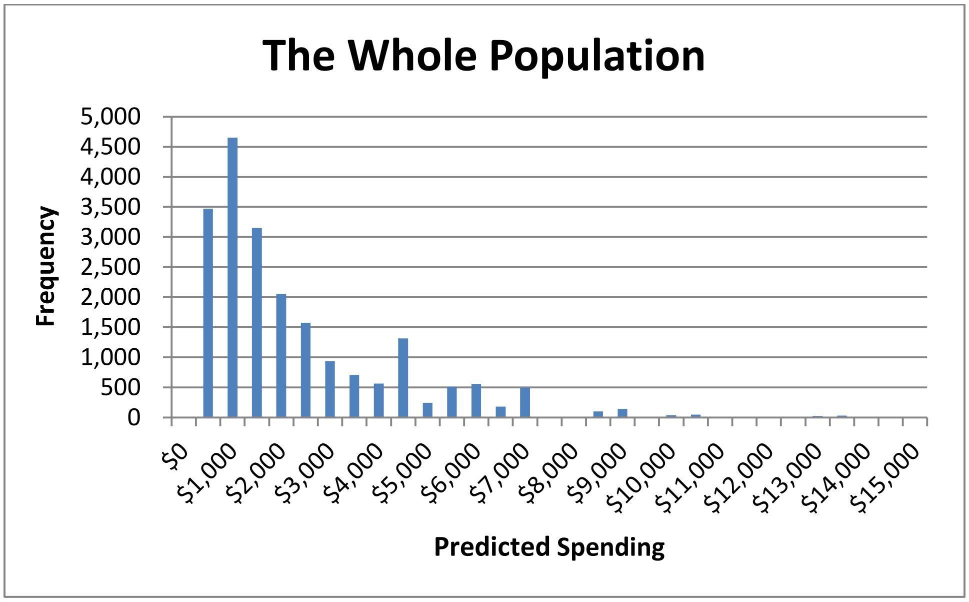


Figure 5. Distribution of Predicted Spending for the Whole Population, the Young and the Old



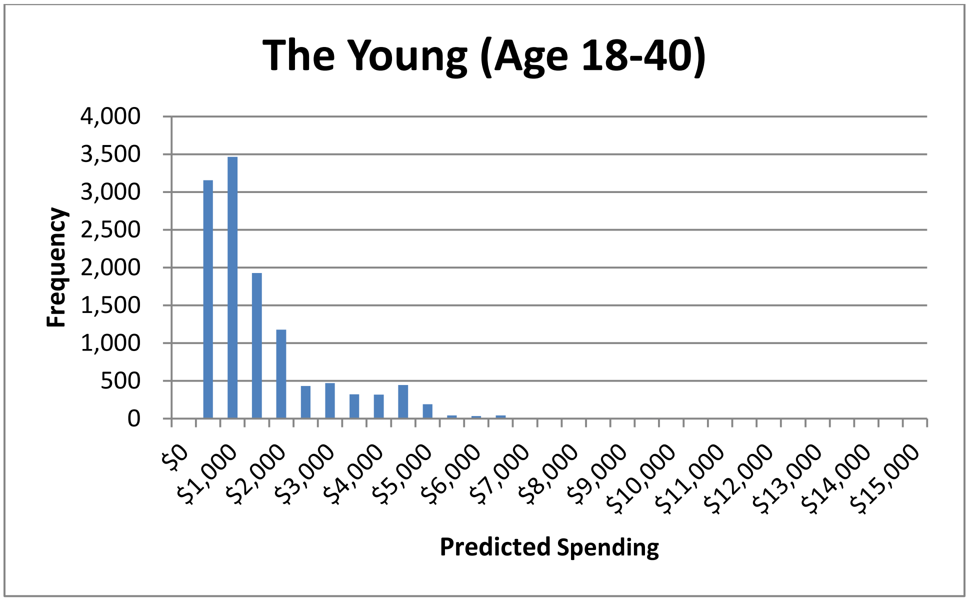


Figure 5. Continued.

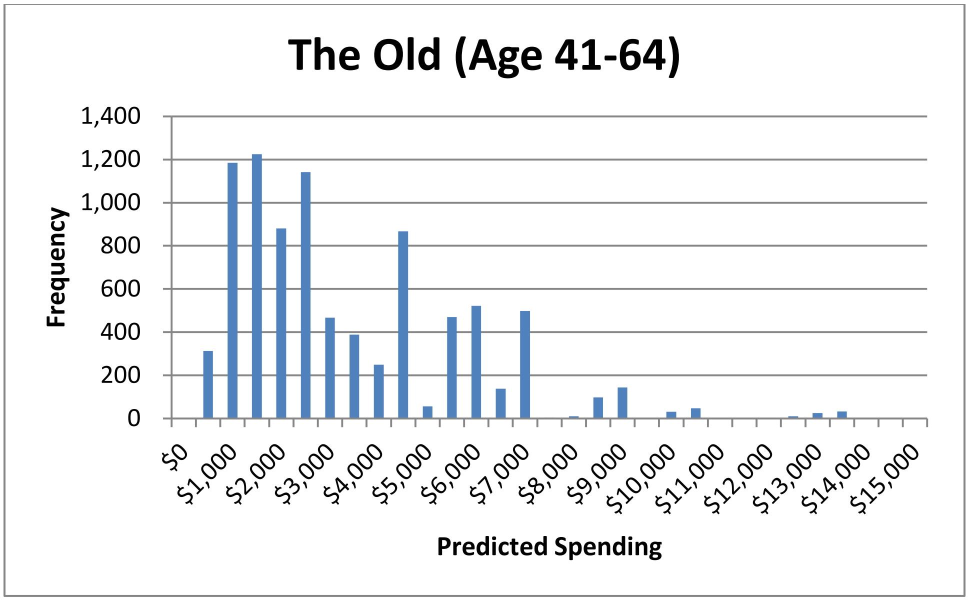


Figure 6. Simulation Results in Case 1 and Case 2

Figure 6A

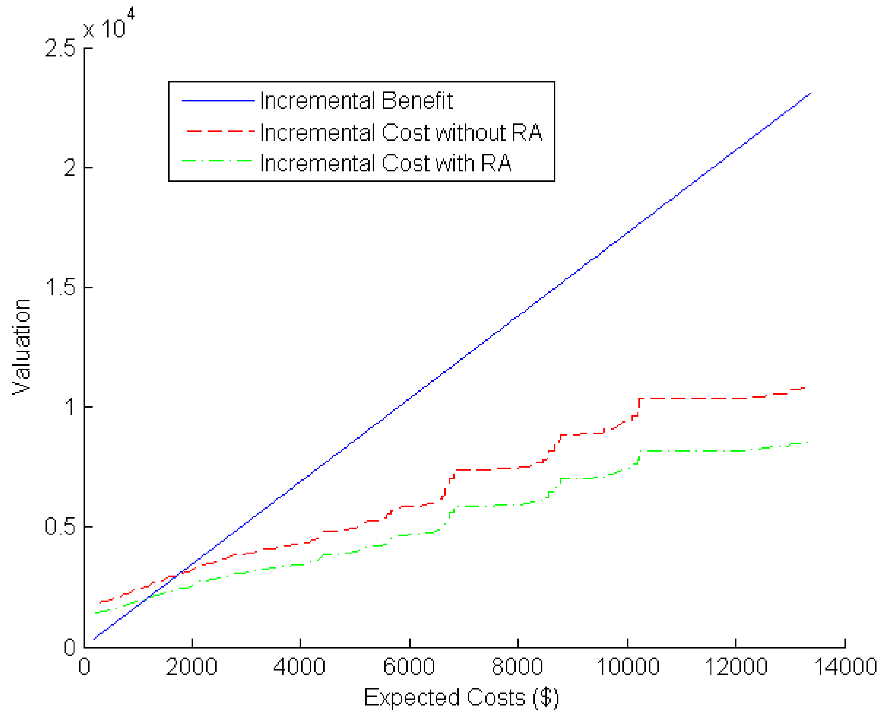


Figure 6B

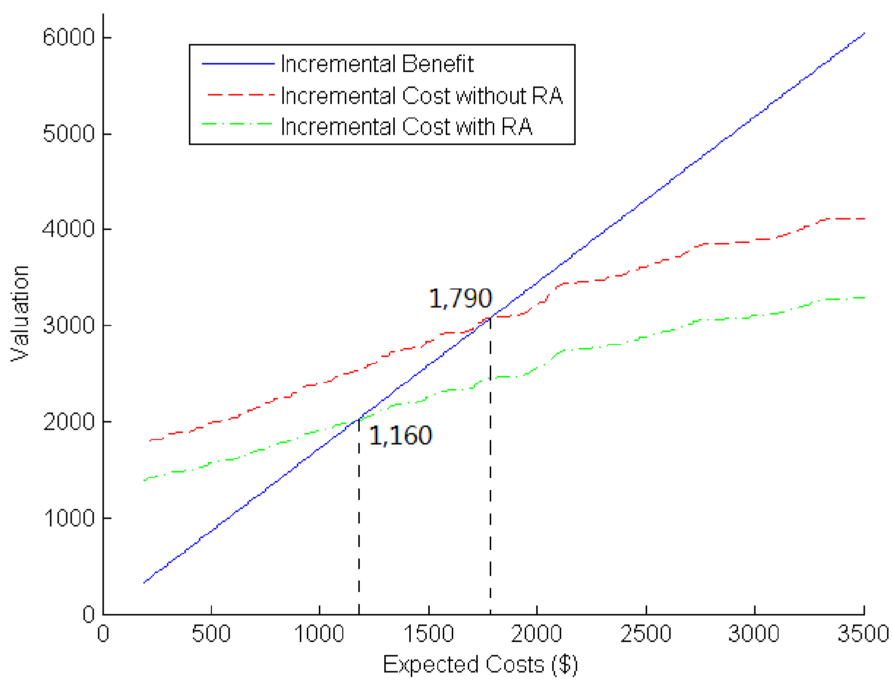


Figure 7. Simulation Results in Case 3 and Case 4

Figure 7A For the Young Population

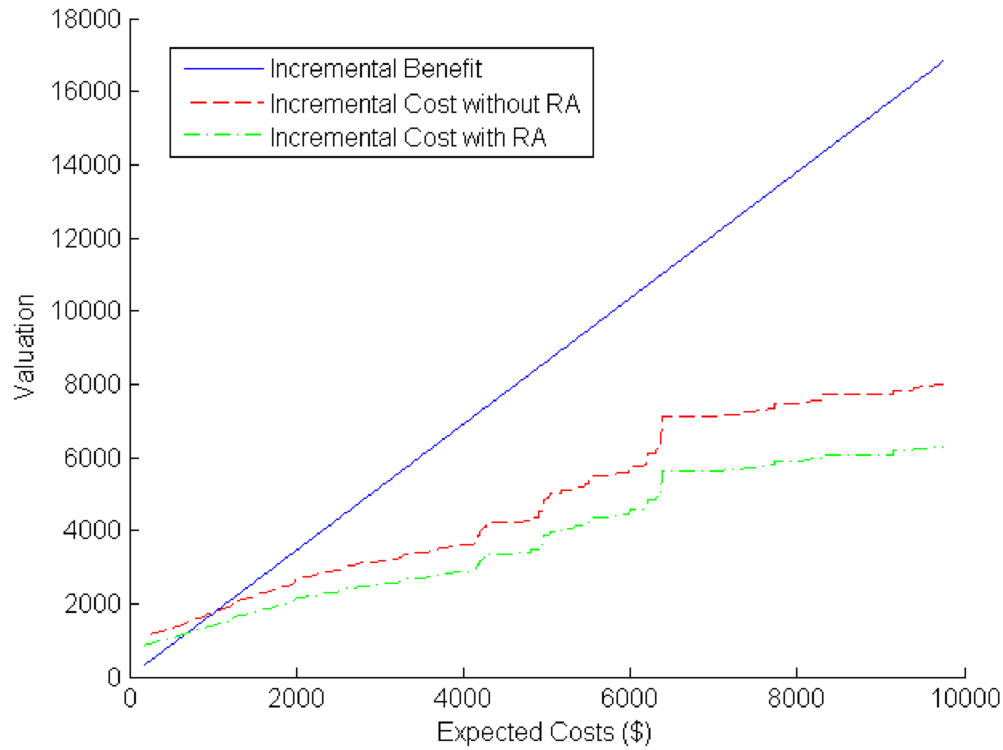


Figure 7B For the Old Population

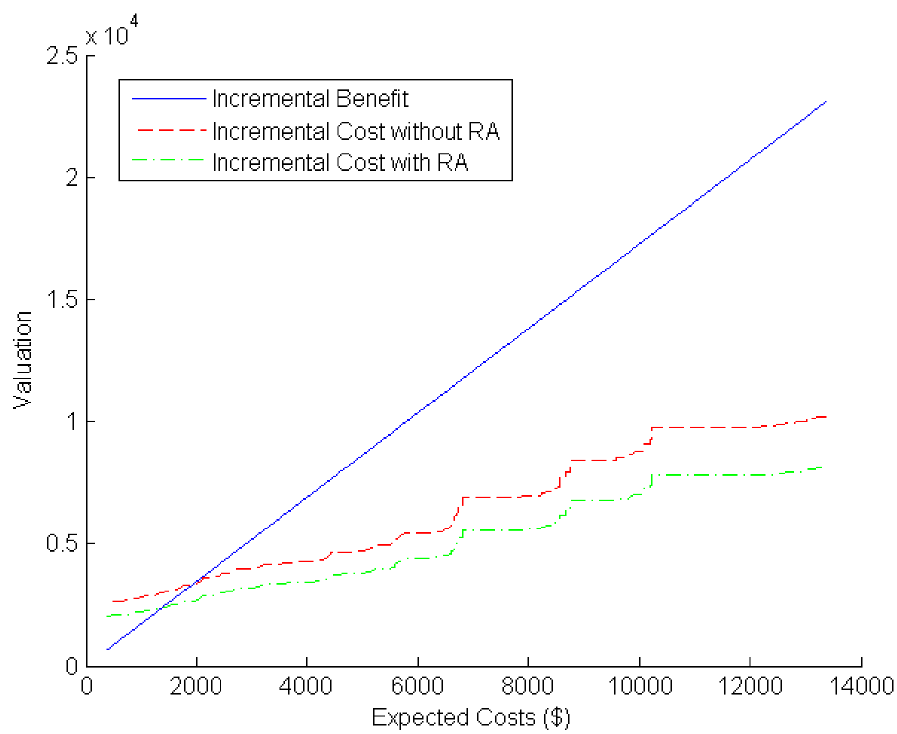


Table 1. Descriptive Statistics of Exchange Population, MEPS 2005-2009, N=20,865

Data reported as percentages, unless noted	
Male	50.8%
Age	
Young (Age <= 40)	57.8%
Old (Age > 40)	42.2%
Race	
Non-hispanic white	51.1%
Non-hispanic black	12.5%
Hispanic	28.8%
Asian	5.2%
Other	2.4%
Region	
Northeast	13.9%
Midwest	19.1%
South	38.7%
West	28.3%
Education Level	
Less than high school degree	19.4%
High school degree	29.5%
Some college	14.7%
College degree or more	25.7%
Mean Individual Income ($2009) [Standard Deviation]	$33,300 [$31,500]
Poverty Status (based on family income)	
<138% FPL	2.8%
139% - 200% FPL	18.2%
201% - 300% FPL	28.0%
301% - 400% FPL	17.5%
400% FPL or higher	33.5%
Employment Status	
Continuously employed	70.5%
Continuously unemployed	10.2%
Self-reported Health Status	
Excellent	30.6%
Very Good	33.3%
Good	27.4%
Fair	7.3%
Poor	1.4%

Table 2. OLS Regression for the Correlation between Mean and Variance of Expected Spending

Dependent Variable	Coefficient	Standard error	P Value
Mean Spending	12,654	363.9	<.0001
R-Square	0.055		

Table 3. Equilibria in the Four Cases

	Market (1)	Size of population (2)	Cutoff (3)	# of enrollees in plan H (4)	% of enrollment in plan H (5) = (4)/(2)
Case 1	Whole	20,865	$1,790	8,216	39.4%
Case 2	Whole	20,865	$1,160	11,762	56.4%
Case 3	Young	12,058	$1,020	5,423	
	Old	8,807	$1,920	5,335	
	Whole	20,865		10,758	51.6%
Case 4	Young	12,058	$660	7,766	
	Old	8,807	$1,400	6,333	
	Whole	20,865		14,099	67.6%

Case1: No risk adjustment or premium discrimination;
Case 2: Risk adjustment only;
Case 3: Premium discrimination only;
Case 4: Both risk adjustment and premium discrimination.

Table 4. Premiums for Plan L and Plan H in the Four Cases

	Market (1)	Cutoff (2)	Premium L (3)	Premium H (4)	Incremental Premium (5)=(4)-(3)
Case 1	Whole	$1,790	$514	$3,596	$3,082
Case 2	Whole	$1,160	$761	$3,125	$2,396
Case 3	Young	$1,020	$326	$2,088	$1,762
	Old	$1,920	$670	$3,980	$3,310
Case 4	Young	$660	$636	$2,042	$1,407
	Old	$1,400	$865	$3,514	$2,649

Case1: No risk adjustment or premium discrimination;
Case 2: Risk adjustment only;
Case 3: Premium discrimination only;
Case 4: Both risk adjustment and premium discrimination.

Table 5. Equilibria in Case 4 with Different Levels of Risk Adjusters

	Market (1)	Size of population (2)	Cutoff (3)	# of enrollees in plan H (4)	% of enrollment in plan H (5) = (4)/(2)
r=0.2	Young	12,058	$660	7,766	
	Old	8,807	$1,400	6,333	
	Total	20,865		14,099	67.6%
r=0.3	Young	12,058	$540	8,680	
	Old	8,807	$1,160	6,977	
	Total	20,865		15,657	75.0%
r=0.4	Young	12,058	$430	9,586	
	Old	8,807	$950	7,486	
	Total	20,865		17,072	81.8%
r=0.5	Young	12,058	$340	10,260	
	Old	8,807	$750	8,043	
	Total	20,865		18,303	87.7%

Case 4: Both risk adjustment and premium discrimination.

Table 6. Two Welfare Measures in the First-best Case and the Four Cases

	% of enrollment in plan H (1)	Average risk premium (2)
First-bset	100%	$199
Case 1	39.4%	$782
Case 2	56.4%	$550
Case 3	51.6%	$780
Case 4	67.6%	$470

Case1: No risk adjustment or premium discrimination;
Case 2: Risk adjustment only;
Case 3: Premium discrimination only;
Case 4: Both risk adjustment and premium discrimination.

Table A1. Equilibria in the Four Cases when h=0.8 & l=0.6

	Market (1)	Size of population (2)	Cutoff (3)	# of enrollees in plan H (4)	% of enrollment in plan H (5) = (4)/(2)
Case 1	Total	20,865	$2,250	6,518	31.2%
Case 2	Total	20,865	$1,360	10,210	48.9%
Case 3	Young	12,058	$1,370	3,817	
	Old	8,807	$2,350	4,399	
	Total	20,865		8,216	39.4%
Case 4	Young	12,058	$790	6,533	
	Old	8,807	$1,560	5,921	
	Total	20,865		12,454	59.7%

Case1: No risk adjustment or premium discrimination;
Case 2: Risk adjustment only;
Case 3: Premium discrimination only;
Case 4: Both risk adjustment and premium discrimination;
h: Plan H's actuarial value;
l: Plan L's actuarial value.

Table A2. Equilibria in the Four Cases when γ=1*10^-3 & γ=2*10^-3

	Market (1)	Size of population (2)	Cutoff (3)	# of enrollees in plan H (4)	% of enrollment in plan H (5) = (4)/(2)
γ=1*10^-3					
Case 1	Total	20,865	$3,260	4,461	21.4%
Case 2	Total	20,865	$2,210	6,548	31.4%
Case 3	Young	12,058	$2,220	2,119	
	Old	8,807	$3,350	3,210	
	Total	20,865		5,329	25.5%
Case 4	Young	12,058	$1,350	3,830	
	Old	8,807	$2,340	4,399	
	Total	20,865		8,229	39.4%
γ=2*10^-3					
Case 1	Total	20,865	$1,150	11,777	56.4%
Case 2	Total	20,865	$810	14,305	68.6%
Case 3	Young	12,058	$670	7,386	
	Old	8,807	$1,380	6,346	
	Total	20,865		13,732	65.8%
Case 4	Young	12,058	$460	9,516	
	Old	8,807	$1,020	7,310	
	Total	20,865		16,826	80.6%

Case1: No risk adjustment or premium discrimination;
Case 2: Risk adjustment only;
Case 3: Premium discrimination only;
Case 4: Both risk adjustment and premium discrimination;
γ: risk aversion parameter.