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

Julie Shi†

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 explores the impact of the two policies on the efficiency of consumer plan choice in the Exchanges. Selecting a population likely to participate in the Exchanges from the Medical Expenditure Panel Survey, I simulate consumer selection under different cases of policy implementation. The results show that risk adjustment always encourages more population to enroll in the more generous plans, which in my model improves the efficiency, while premium discrimination could in general improve or impair the efficiency, depending on the distribution of health care spending of the enrollees and the selected premium categories.

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

*I am grateful to my advisors Randall Ellis, Albert Ma, and Thomas McGuire for their continued guidance and support. I thank Jacob Glazer, Joseph Newhouse, Willard Manning, Micheal Sinkinson, Tim Layton, Aaron Schwartz, Daria Pelech, Qiang Wang, and the participants in the 12th International Industrial Organization Conference, Boston Summer Health Economics Workshop, and the Health Economics Seminar in Harvard Medical School for helpful comments. My research was supported by the National Institute of Mental Health (R01 MH094290) and the National Institute of Aging (P01 AG032932). All errors are my own.

†Department of Health Care Policy, Harvard Medical School, United States. 180 Longwood Ave. Boston, MA 02115. Tel: +1 617-470-2973. E-mail: shi@hcp.med.harvard.edu
1 Introduction

Adverse selection, which is a major concern in health insurance markets, induces two forms of inefficiency (see Cutler & Zeckhauser (2000) and McGuire (2012) for literature reviews). First, insurers may manipulate plan policies to attract profitable enrollees (Newhouse (1996), Ellis & McGuire (2007)). Second, consumers make inefficient choice among plans with different levels of generosity, when premiums do not reflect the marginal cost of consumer choice (Cutler & Reber (1998), Einav & Finkelstein (2011), and Glazer & McGuire (2011)).\footnote{In theory, the selection problem can be addressed by two payment system policies: risk adjustment and premium discrimination. The former contends with insurer actions to affect selection (Van de Ven & Ellis (2000)), and the latter improves the efficiency of consumer plan choice (Keefer et al. (1998), Bundorf et al. (2012)).} In theory, the selection problem can be addressed by two payment system policies: risk adjustment and premium discrimination. The former contends with insurer actions to affect selection (Van de Ven & Ellis (2000)), and the latter improves the efficiency of consumer plan choice (Keefer 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 three other individual characteristics in the Health Insurance Exchanges as part of the Affordable Care Act (ACA).\footnote{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 three other individual characteristics in the Health Insurance Exchanges as part of the Affordable Care Act (ACA).} Exchanges also mandate risk adjustment, so that plan payments are adjusted according to the risk of health care spending of enrollees. Thus, risk adjustment and premium discrimination, for the first time, work together through the new Exchange payment system.

In this paper, I analyze how efficiency of plan choice is affected by risk adjustment and premium discrimination in the Exchanges. 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 generous than the other in terms of 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. The revenue of plans comes from two sources: premium and risk adjustment payment. The cost of plans is the health care spending of the 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. In a competitive market where plans earn zero profits, insurance premiums are affected by the two policies through different mechanisms, and further 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 the enrollment in the two types of plans and premium levels based on the thresholds in the four cases.

In the model, case 1 is the baseline scenario where no policy is included. In case 2, the enrollment to the more generous plans increases when risk adjustment is implemented. Risk adjustment makes higher payments to the more generous plans in which high risk consumers have enrolled. In the competitive markets, 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 the two markets. In general, premium discrimination could result in more or less people enrolling in the more generous plans, depending on the distribution of health care spending for each group. With the specific assumption that the population in both subgroups are more homogenous in terms of expected costs than when pooling together, 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 adverse selection is less severe since the population are more homogeneous, and therefore 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. Case 1 is the baseline scenario, and the level of enrollment to each plan is calibrated from the Massachusetts health reform, which is implemented in 2006 and is a precursor of the national reform. In case 2, the premiums for the two types of plans are compressed by risk adjustment, and more people enroll in the more generous plans. In case 3, the fraction of the young who enroll in the more generous plans increases, but the fraction of the old decrease. The divergence comes from the distinct distributions of the expected spending for the two groups. The distribution is more homogenous for the young than that for the overall population, and is 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 I find 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 the young and the old markets, so a greater fraction enroll in the more generous plans compared to case 3. These results are robust, when I change the values of parameters in the simulation.

I also 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. For the overall population, 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.

Empirical studies find that age-based or risk-based premiums can improve efficiency (Geruso
(2013), Bundorf et al. (2012)), since consumers can efficiently self-select plans when they face the marginal costs of their choice. My paper contributes to the literature by providing a counterexample that charging premiums based on observed characteristics, even if they are highly related to health status, does not necessarily improve efficiency. In practice, premiums cannot base on ex post health care costs, but only on ex ante observable characteristics that are related to health status. People are sorted into subgroups by premium discrimination, but the heterogeneity on spending 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 can improve efficiency depends on the selection of premium categories and the distribution of the risk of the population. This analysis has important policy implications. Policymakers need carefully select premium categories, for example, age bands, in order to avoid impairing efficiency for some subgroups.

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 (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 model consumer choice between different types of plans. 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 methodology to analyze adverse selection. My model also
incorporates risk adjustment, which is an extension of these studies. In the Exchanges, the ACA mandates the implementation of risk adjustment, which affects insurer premium setting, and further consumer plan selection. Including risk adjustment helps to predict consumer choice more accurately.

A few other papers also study risk adjustment and plan premiums in the Exchanges. McGuire et al. (2013) 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 assessing 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 shows that how the Exchange-eligible population is selected. Section 4 displays the simulation 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 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 \( \gamma \) is the CARA risk aversion parameter. I assume that the population is homogenous on risk aversion, but I allow the parameter to vary at different values to check the robustness of the results. 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 \( \sigma_i^2 \). 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. Consumers differ in the mean of medical spending. The expected (or mean of) medical spending, \( m_i \), is randomly drawn from a range \([\underline{M}, \bar{M}]\), and has a cumulative distribution \( F(m) \). The expected cost is public information and is known by both consumers and insurance 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

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

The term \((1 - v)m_i + \frac{1}{2} \gamma(1 - v)^2 \sigma^2\) is the certainty equivalent of the cost-sharing \((1 - v)c_i\).\(^3\)

The total cost of health care for the consumer is \( P + (1 - v)m_i + \frac{1}{2} \gamma(1 - v)^2 \sigma^2 \), where \( P \) is the plan premium, \((1 - v)m_i\) 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.

\(^3\)The equation (1) comes from the property that \( E(u(t)) = u(m - \frac{1}{2} \gamma \sigma^2) \) holds if the utility function has the form \( u(x) = -e^{-\gamma x} \) and the expected cost has a normal distribution \( t \sim N(m, \sigma^2) \). More details on risk premium are discussed by Pratt (1964).
Two types of plans are provided in the market, $H$ and $L$, which differ in fractions of health care spending covered by the insurance plans. Plan $H$ covers the fraction $h$, and plan $L$ covers the 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.

I assume no outside option for the consumers, and they are required to choose one plan between the two types of plans. I also assume no moral hazard in the model, i.e., consumers’ health care costs are independent on plan coverage. The assumption let the model focus primarily on adverse selection, and make equilibrium analysis tractable. The robustness of the conclusion under moral hazard is discussed later in section 6. Because consumers are risk averse, and enrolling in plan $H$ let the consumers bear less spending risk, the efficient enrollment is that everyone enrolls in plan $H$. The following efficiency analysis is based on the argument that it is more efficient if more people enroll in the more generous plans. The optimal policy therefore would be a mandate of enrollment in plan $H$. However, providing multiple choices provides other advantages such as satisfying consumers with heterogeneous preference, in practice the government only implements policies such as premium discrimination to affect consumer choice, but does not mandate the selection of a specific type of plan.

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

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

(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 cost of certainty equivalent. The two curves present the costs for consumers when they enroll in plan $H$ and plan $L$, which is the sum of plan premium, 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 increase with expected spending, so the curves are upward-sloping. Since plan $H$ provides a higher level of coverage than plan $L$ does, the curve for plan $H$ is flatter than that for plan $L$. The two curves intersect at point $m^*$. Consumers choose the plan with lower costs, so those with certainty equivalent less than $m^*$ enroll in plan $L$, and with certainty equivalent greater than or equal to $m^*$ enroll in plan $H$.

Rearrange equation (2) and it becomes

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

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 $\int_{m^*}^M m dF(m) / (1 - F(m^*))$. Plan $H$ covers a fraction $h$ of the spending, so the average cost is $\int_{m^*}^M m dF(m) h / (1 - F(m^*))$. For plan $L$, enrollees’ average spending is $\int_{m^*}^M m dF(m) / F(m^*)$, and the average cost for the plan is $\int_{m^*}^M m dF(m) / F(m^*) l$. Plans earn zero profits, so premiums are equal to the average costs:

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

$$P_L = \frac{\int_{m^*}^M m dF(m)}{F(m^*)} l. \quad (5)$$

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

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

Equation (6) defines the equilibrium. Low risk consumers enroll in plan $L$, high risk
consumers enroll in plan $H$, and the consumer with the expected spending $m^*$ is the marginal person who is indifferent between the two plans. The left-hand side illustrates the incremental benefit which consists of two components. The first is the direct benefit from more generous coverage: paying less cost-sharing of medical spending, $(h - l)m^*$. The second benefit is to bear less risk premium from the reduction of cost-sharing. The right-hand side shows the incremental cost, which is the premium difference between the two plans.

In order to make the equilibrium analysis tractable, I assume that expected cost has a uniform distribution, i.e., $F(m) = \frac{m - M}{M - M}$. 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 assumption of uniform distribution, the average costs of plan $H$ and plan $L$ are $\frac{M + m^*}{2}h$ and $\frac{M + m^*}{2}l$, so equation (6) becomes

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

(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. Both benefit and cost lines are linear to the spending, while the cost line is flatter.

An interior equilibrium exists only when $\delta$ is within a specific range, which is defined in equation (8):

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

(8)

The line “Benefit ($\delta$ 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
since 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 of enrolling in plan H are greater than the incremental benefits.

A corner solution occurs when $\delta$ is sufficiently small or sufficiently large. When $\delta$ is sufficiently small, either because the consumers are less risk averse 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 ($\delta$ is intermediate)” shifts down to “Benefit ($\delta$ is small)”, and everyone prefers plan L. When $\delta$ is sufficiently large, the line “Benefit ($\delta$ is intermediate)” shifts up to “Benefit ($\delta$ is large)”, and everyone prefers plan H.

Re-arranging equation (7) yields
\[
\frac{m^* - M}{M - \overline{M}} = \frac{h}{h-l} - \frac{2\delta(2-h-l)}{M - \overline{M}},
\] (9)
which characterizes the fraction of consumers that enroll in plan L. There are three properties of the fraction. First, it is increasing in plan L’s coverage $l$. The incremental benefit from moving from plan L to plan H decreases, when plan L’s coverage increases. Second, it decreases in $\delta$. 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. Third, it increases in the upper bound of expected cost $\overline{M}$, and decreases in the lower bound $\underline{M}$, which means that the more disperse are the expected costs of the population, the more/less population will enroll in the less/more generous plans.

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). Plugging $m^*$ into the right-hand side of the equation yields the incremental premium:
\[
\Delta P^* = h\overline{M} - l\underline{M} - \delta(2-h-l)(h-l).
\] (10)
The incremental premium is increasing in the upper bound of expected cost $M$, and decreasing in the lower bound $M$. Similar as the enrollment, it means that the more disperse are the expected costs of the population, the higher the equilibrium incremental premium is.

This section has developed the first of four cases, and the equilibria are summarized in Figure 3. Over the range of expected costs $[M, M]$, the shadow area displays the fraction of people enrolled in plan $H$. As is stated above, 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 high-risk enrollees receive greater payments from a third party, usually the government, than plans attracting low-risk enrollees. In the model, risk adjustment is implemented through a regulator. The regulator observes consumers’ plan enrollment and expected costs, and makes payments, which are proportional to the enrollees’ costs, to the corresponding plans consumers enroll in.\(^4\) 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 provide benefits to enrollees.\(^5\)

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 where no risk adjustment is implemented:

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

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

---

\(^4\)The observability of consumers’ expected spending in risk adjustment is discussed in Ellis (2008), Ellis (2011), and Van de Ven & Ellis (2000).

\(^5\)The implementation of risk adjustment in Exchanges is more complex than what I assume in the model. The Department of Health and Human Services (HHS) (2013b) proposed details on how risk adjustment is 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 illustrate the impact of risk adjustment on plan sorting.
Define the risk adjuster as $r \ (0 < r < l)$ and the capitation fee as $R$. The assumption $0 < r < l$ is to avoid negative premiums in the following analysis. For an 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 $vm \ (v = h \ or \ l)$. Plans receive $rm$ and pay $vm$, and an equivalent payment schedule is to provide the coverage $(v - r)m$ and receive 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 to the average costs:

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

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

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

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

Equation (14) defines the equilibrium cutoff $\hat{m}$. 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 premium only reflects a fraction of the difference of enrollees’ costs that plans cover. Comparing equation (6) with equation (14), case 1 is a special case of case 2 when risk adjuster $r = 0$.

Under uniform distribution, equation (14) becomes

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

A unique equilibrium $\hat{m}$ exists, since both benefit and costs are linear to the expected costs. An interior equilibrium exists only when $\delta$ satisfies the condition:
\[
\frac{l - r}{2[(1 - l)^2 - (1 - h)^2]}(\bar{M} - M) \leq \delta \leq \frac{h - r}{2[(1 - l)^2 - (1 - h)^2]}(\bar{M} - M). \tag{16}
\]

There is a corner solution when \( \delta \) is sufficiently large or sufficiently small. The range for \( \delta \) 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

\[
\frac{\hat{m} - M}{\bar{M} - M} = \frac{h - r}{h - l} - \frac{2\delta(2 - h - l)}{\bar{M} - M}. \tag{17}
\]

Equation (17) describes the fraction of consumers enrolling in plan \( L \) when risk adjustment is implemented. Compared to equation (9), the fraction decreases. In addition, the fraction is decreasing in \( r \), which means that the increase of the power of risk adjustment causes 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 decreases in \( \delta \) and plan \( L \)'s coverage \( l \), and more disperse distribution of costs, i.e., a larger \( \bar{M} - M \), leads to less enrollment in the more generous plans.

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 \( \hat{m} \) in case 2 is smaller than the cutoff \( m^* \) in case 1. Compared to case 1, more people enroll in plan \( H \), and risk adjustment improves efficiency in plan choice. The equilibrium allocation along with equilibria in other cases are shown in Figure 3.

Equation (15) defines the equilibrium cutoff \( \hat{m} \), and plugging the cutoff into the right-hand side of equation (14) yields the incremental premium:

\[
\Delta \hat{P} = h\bar{M} - l\bar{M} - r(\bar{M} - M) - \delta(2 - h - l)(h - l). \tag{18}
\]

Equation (18) incorporates the risk adjuster \( r \). Case 1 is a special case of case 2 when \( r = 0 \). 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 $H$. 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, and they construct separate market. The same plan can charge consumers different premiums in different markets. 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 $m_{young} = \frac{P_{H^{young}} - P_{L^{young}}}{h-l} - \delta(1-l)^2/(1-h)^2$. 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:

\[ P_{H^{young}} = \frac{\int_{m_{young}} m \, dF_{young}(m)}{1 - F_{young}(m_{young})} h, \]  
\[ P_{L^{young}} = \frac{\int_{m_{young}} m \, dF_{young}(m)}{F_{young}(m_{young})} l. \] (19) (20)

The equilibrium condition for the young is:

\[ (h-l)m_{young} + \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{m_{young}} m \, dF_{young}(m)}{1 - F_{young}(m_{young})} h - \frac{\int_{m_{young}} m \, dF_{young}(m)}{F_{young}(m_{young})} l. \] (21)

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

\[ (h-l)m_{old} + \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{m_{old}} m \, dF_{old}(m)}{1 - F_{old}(m_{old})} h - \frac{\int_{m_{old}} m \, dF_{old}(m)}{F_{old}(m_{old})} l. \] (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 \( m_{\text{young}} \sim U[M, \tilde{m}] \), and for the old is \( m_{\text{old}} \sim U[\tilde{m}, M] \) where \( \tilde{m} \in [M, M] \). 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

\[
m_{\text{young}} = M + \frac{h}{h-l}(\tilde{m} - M) - 2\delta(2 - h - l),
\]

and

\[
m_{\text{old}} = \tilde{m} + \frac{h}{h-l}(M - \tilde{m}) - 2\delta(2 - h - l).
\]

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

\[
\frac{(m_{\text{young}} - M) + (m_{\text{old}} - \tilde{m})}{M - \tilde{m}} = \frac{\frac{h}{h-l}(\tilde{m} - M) - 2\delta(2 - h - l) + \frac{h}{h-l}(M - \tilde{m}) - 2\delta(2 - h - l)}{M - \tilde{m}}
\]

\[
= \frac{h}{h-l} - 2 \cdot \frac{2\delta(2 - h - l)}{M - \tilde{m}}.
\]

In case 1 the fraction of people who enroll in plan \( L \) without premium discrimination is

\[
\frac{m^* - M}{M - \tilde{m}} = \frac{h}{h-l} - \frac{2\delta(2 - h - l)}{M - \tilde{m}}.
\]

In this case, the fraction decreases comparing to equation (25). The result predicts that fewer people enroll in the less generous plans when premium discrimination is implemented.

The intuition is as follows. When the population becomes more homogenous within each
subgroup, the incremental premium they face decreases. The incremental premiums for the two groups are

$$\Delta P_{\text{young}} = h\tilde{m} - l\overline{M} - \delta(2 - h - l)(h - l),$$

(26)

and

$$\Delta P_{\text{old}} = h\overline{M} - l\tilde{m} - \delta(2 - h - l)(h - l).$$

(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 \([M, \overline{M}]\), while in this case the young distribute in \([M, \tilde{m}]\) and the old distribute in \([\tilde{m}, \overline{M}]\), where \(\tilde{m} \in [M, \overline{M}]\). In each market, fewer consumers enroll in plan \(L\), and overall, fewer consumers enroll in plan \(L\).

Figure 3 illustrates the equilibrium allocation. \(\tilde{m}\) is the cutoff of the expected costs between the young and the old. In each market, people with expected costs higher than the 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.

However, the prediction is based on the specific assumption on the distribution of expected costs for the young and the old. In both groups, the distributions are more homogeneous than the overall population, therefore the model predicts that a greater enrollment in the more generous plans. In the empirical analysis, I apply the real distribution of the expected spending from MEPS data, and find that less old people will enroll in plan \(H\), since the distribution of the spending for the old is actually more heterogeneous than the overall population. The theoretical and empirical analysis together suggests that in general premium discrimination can push more or less people enroll in the more generous plans, and can improve or impair efficiency in plan choice.
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 market, and risk adjustment is implemented in both markets. The mechanism of risk adjustment is the same as in case 2. The regulator charges a capitation fee $R$ for each enrollee and makes 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 $\hat{m}^{\text{young}}$ and $\hat{m}^{\text{old}}$ as the equilibrium cutoffs, and the equilibrium conditions are:

\begin{equation}
(h-l)\hat{m}^{\text{young}} + \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{\hat{m}^{\text{young}}}^{M} m dF^{\text{young}}(m)}{1 - F^{\text{young}}(\hat{m}^{\text{young}})} (h-r) - \frac{\int_{\hat{m}^{\text{young}}}^{\hat{m}^{\text{young}}} m dF^{\text{young}}(m)}{F^{\text{young}}(\hat{m}^{\text{young}})} (l-r),
\end{equation}

and

\begin{equation}
(h-l)\hat{m}^{\text{old}} + \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{\hat{m}^{\text{old}}}^{M} m dF^{\text{old}}(m)}{1 - F^{\text{old}}(\hat{m}^{\text{old}})} (h-r) - \frac{\int_{\hat{m}^{\text{old}}}^{\hat{m}^{\text{old}}} m dF^{\text{old}}(m)}{F^{\text{old}}(\hat{m}^{\text{old}})} (l-r).
\end{equation}

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

\begin{equation}
\hat{m}^{\text{young}} = M + \frac{h-r}{h-l} (\hat{m} - M) - 2\delta(2-h-l),
\end{equation}

and

\begin{equation}
\hat{m}^{\text{old}} = \tilde{m} + \frac{h-r}{h-l} (M - \tilde{m}) - 2\delta(2-h-l).
\end{equation}

The fraction of consumers who enroll in plan $L$ is:

18
\[
\frac{(\bar{m}_{\text{young}} - M) + (\bar{m}_{\text{old}} - \bar{m})}{M - M} = \frac{[\frac{h}{h-l}(\bar{m} - M) - 2\delta(2-h-l)] + [\frac{h}{h-l}(M - \bar{m}) - 2\delta(2-h-l)]}{M - M}
\]

\[
= \frac{h-r}{h-l} - 2 \cdot \frac{2\delta(2-h-l)}{M - M}.
\]

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 risk adjustment is, the smaller the number of people who enroll in plan \( L \). The intuition is the same as in case 2: in each market 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. In all the four cases, the model illustrates that risk adjustment always improve efficiency by encourage more people to enroll in the more generous plans, while premium discrimination could improve or impair efficiency. In section 4, I use data for the Exchange-eligible population to estimate the impacts of the two policies on plan selection.

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 population 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). 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 first relax the assumption on homogeneous variance of spending, and allow it vary by the mean of spending. Then I estimate consumers’ health care risk, set the values of parameters, and calibrate the baseline level of enrollment. Finally I present the simulation results of all four cases.

4.1 The case with heterogeneous variance

In the simulation, 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. A large number of studies discuss the correlation between mean

---

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.
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.\(^7\)

Recall that \(\delta\) is defined as \(\delta \equiv \frac{1}{2}\gamma\sigma^2\). Under the assumption \(\sigma^2_i = \beta m_i\), \(\delta\) becomes \(\delta_i \equiv \frac{1}{2}\gamma\beta m_i\). In case 1, equation (6) becomes

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

(33)

Under uniform distribution, the equilibrium cutoff is

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

(34)

Equation (34) defines the equilibrium cutoff when the variance of consumers’ spending is heterogeneous. The properties of equilibrium still hold. \(m^*\) increases in \(l\), which means the fraction of the population that enrolls in plan \(L\) is increasing in plan \(L\)’s coverage. \(m^*\) decreases in \(\gamma\) and \(\beta\), which means a smaller fraction of the population will enroll in plan \(L\) who either have a higher level of risk aversion or face greater uncertainty of health spending. I omit the equilibrium discussion for the other three cases, since they are similar to the analysis discussed in case 1.

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

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

(35)

The left-hand side of equation (35) illustrates the benefit for consumers of moving to more generous plans, which comes from less cost-sharing and less risk premium. The right-hand side illustrates the cost, which is the incremental premium. \(m^*\) is the equilibrium cutoff of spending, with which consumers are indifferent between the two types of plans. Consumers

\(^7\)In general, I can assume \(\sigma^2_i = \alpha + \beta m_i\). However, the assumption \(\sigma^2_i = \beta m_i\) has the advantage of estimating the coefficient \(\beta\) from a Poisson-like Generalized Linear Model (GLM). More details on modeling medical expenditure using GLM are discussed in Buntin & Zaslavsky (2004).
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.

4.2 Parameter Set Up

Five parameters are included in equation (35): the coverage of plan $H$ and plan $L$, $h$ & $l$, the risk adjuster $r$, the risk aversion parameter $\gamma$, and the correlation between the mean and the variance of expected spending $\beta$. 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 by 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 of the population who has positive spending. Figure 5 displays the distribution of predicted spending for three groups: the whole population, the young (age 18-40), and 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, or for the overall population.

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 $\beta$ 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 $\gamma$. The Massachusetts reform is implemented in 2006, and served as a template of the national reform. In the Massachusetts reform, three levels of plans are 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 as a baseline enrollment in case 1, and to calibrate $\gamma$. I find that when $\gamma = 1.5 \times 10^{-3}$, 60% of the population enrolls in plan $L$ when no risk adjustment or premium discrimination is implemented. This magnitude of risk aversion is consistent with the estimation results in the literature (Handel et al. (2013); Cohen & Einav (2007); Gertner (1993); and Sydnor (2006)).\footnote{In Handel et al. (2013), the estimation of the mean risk aversion parameter in a CARA utility function is $4.3 \times 10^{-4}$ for the pseudo-sample of the Exchanges. In Cohen & Einav (2007), the estimation is $3.1 \times 10^{-3}$. In Gertner (1993), the estimation is $3.1 \times 10^{-4}$, and in Sydnor (2006) it is $2.0 \times 10^{-3}$.

4.3 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 from 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 with higher costs 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 more consumers enroll in plan $H$.

In case 3 and case 4, there are two segmented markets: the young and the old. In each 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 greater than the cutoffs in the young markets. In both markets, more consumers enroll in plan $H$ under 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, while 12,058 of them are young, and 8,807 are old. Column (3) illustrates the simulated equilibrium cutoffs shown in Figure 6 and Figure 7. Column (4) displays the number of enrollees in plan $H$. The enrollment of the young and the old are provided in each case, even they are pooled together in case 1 and case 2. Column (5) of Table 3 shows the fraction of enrollment in plan $H$, which is the ratio between Column (4) and Column (2).

The simulation results are consistent with the model prediction. In case 1, there are 2,838 young individuals and 5,382 old individuals enrolling in plan $H$. There are 8,216 enrollees in plan $H$, which is about 39.4% of the overall population. In case 2, when risk adjustment is implemented, the enrollment for both groups increase, and the fraction for the entire population increases as well. In case 3, when premium discrimination is implemented, the enrollment of plan $H$ increases from 23.5% to 45.0% for the young, but decreases from 61.1% to 60.6% for the old. In the young market, the distribution of spending is more homogeneous, and more young individuals enroll in plan $H$. In the old market, the expected spending is more heterogeneous, as is shown in figure 5. Adverse selection is more severe, so a less fraction of the population enroll in the more generous plans. In total, more people enroll in plan $H$ when premium discrimination is implemented. In case 4, when risk adjustment is implemented in additional to premium discrimination, the enrollment in plan $H$ increases in
both markets, and the total enrollment fraction is the greatest among the four cases.

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) shows 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 between case 3 and case 4. High-risk consumers enroll in plan H and low-risk consumers enroll in plan L. The enrollees in plan H are subsidized by enrollees in plan L, 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. When two groups are separated by premium categories, 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, and the incremental premium increases. The trends 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 are implemented in the 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 $H$ 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 coverage 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 $\gamma$ from $1.5 \times 10^{-3}$ to $1 \times 10^{-3}$ and $2 \times 10^{-3}$. The results are shown in Table A2. The fraction of enrollment in plan $H$ decreases when $\gamma$ 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 in the context of Exchanges. Though recent literature has found risk aversion is correlated with individual characteristics (for example, Einav et al. (2013)), such as health status, I do not incorporate heterogeneity in this analysis, in the purpose of keeping the model clean and only focusing on the key policies. This analysis can be viewed as the investigation of the policy impacts for a subgroup of population with homogenous risk aversion.

5 Welfare Analysis

As I assume no moral hazard, there is always welfare improvement when consumers switch from plan $L$ to plan $H$, since they bear less risk of spending. 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. The second is the average risk premium the population bear. In my model, 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 entire population is

\[
L^{FB} = \frac{1}{2} \gamma \beta m (1 - h)^2 dF(m). \tag{36}
\]

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 is the weighted sum of risk premium borne by enrollees in plan \( L \) and in 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 increases in \( \gamma \) and \( \beta \), which means welfare loss is greater for a population with either greater 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 weighted equally in the first measure, but differently in the second measure. 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 when using the first measure, but different for the second. The welfare improvement in the second measure is larger, when a consumer with higher expected spending moves.

Table 6 summarizes the results of two measures on welfare loss. Column (1) displays the fraction of enrollment in plan \( H \) and Column (2) displays the average risk premium consumers bear. In the optimal case where everyone enrolls in plan \( H \), 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.
Comparing case 3 with case 1, although the fraction of enrollment increases by 12.2%, the average risk premium almost remains the same. 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 the old consumers with relatively low costs enroll in plan $L$. Some of the young enrollees in plan $H$ have lower costs than the old enrollees 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 could be affected positively or negatively by the two policies, and how large the impacts are on welfare measures. I find that risk adjustment always improve efficiency of consumer plan choice, while premium discrimination could improve or impair efficiency in general. Using a nationally representative data, I find that both risk adjustment and premium discrimination encourage the overall population to enroll in the more generous plans, which positively affect consumer choice in terms of bearing less financial risk. While the impact of the risk adjustment is in the same direction for the young and the old population, efficiency is only improved by premium discrimination for the young, but not for the old. Consumer welfare loss is minimized when both policies are implemented.

In order to have the model concentrate on the policy impacts, I have made the assumption that premium discrimination only segments the population into two groups. In practice, however, premiums are conditioned on many categories. 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. Premiums can
also be based on family structure, residence, and smoking status. Consumer choice is affected by the structure of premium categories. Finer categories may or may not improve efficiency in consumer choice, which can be tested using the model constructed in this analysis. 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. This analysis can incorporate these variations, and states can evaluate the impacts by using their own data on consumer characteristics, risk adjustment formula, and premium categories.

Premium discrimination induces 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 getting old, which can be regarded as unfair. Premium discrimination in the one hand improves efficiency, but in the other hand may generate other social costs. 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. Rating bands constrain the unfairness within specific ranges, but does not completely eliminate it. In the model I only sort the population into young and old, while in practice finer age categories are implemented. When the age band is binding, the incremental premium would change for the youngest and/or the oldest groups, and then it is unclear how premium discrimination would affect sorting among different plans.

In the Exchanges, the government also provides premium subsidies to low- and middle-income families to purchase insurance. The subsidy is positively correlated with the premium, and the old would receive higher subsidy than the young. The subsidy would largely decrease the out-of-pocket premium the consumers face, and is helpful to mitigate the fairness problem induced by premium discrimination. The results would not be affected in my model in the sense that it is the premium difference, i.e., the incremental premium between the two plans, decides consumers’ choice, not the absolute value of premium for each plan.

---

9 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.
The Exchange system has implemented a lot of regulations to make sure it functions properly. In order to make the model tractable, I only incorporate the key features in my analysis but ignore other factors. I discuss briefly on how the other policies potentially affect my conclusion. In general, this study should be viewed as an illustration of the policy impacts on plan sorting, but not a simulation prediction of the premiums and enrollments of the Exchange plans.

I assume individual completely comply with the insurance mandate. In reality, people with low risk may choose to be uninsured and pay the penalty. However, the compliance rate is expected to be high with insurance mandate and the subsidy schedule for premiums and cost-sharing, especially in later years. A support evidence of 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)). 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 $60,000.10 The two features will change the distribution of enrollees’ costs, so the results would likely be affected.

Three factors I have not incorporated in my model 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 expenditures will probably increase, when the uninsured population get insured and when they enroll in the more generous plans. Moral hazard will affect the incremental premium between plans and further affect plan selection. It is not necessarily optimal that everyone enrolls in the more generous plans. When incorporating moral hazard in my model, there is a tradeoff between excess care and risk sharing. An optimal plan still exists for the population, if the moral hazard is homogenous, though it could be either a more generous plan or a less generous plan, depending on the magnitude of moral hazard.

Second is multiple plan options. Five types of plans (Young adults plan, Bronze, silver,
gold, and platinum), rather than two, are provided in the Exchanges. When consumers face more than two options, the analysis becomes very complex. Most other related research has relied on the assumption of two plans, such as Handel et al. (2013), and it is reasonable to assume that consumers have the two-plan options. In general, it is an important and interesting topic on the existence of equilibrium on plan selection, when consumers have more than two options.

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 financial coverage, for example provider network. In that situation, adverse selection still exists on the network dimension, when the two plans have the same level of generosity.
References


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

Out-of-pocket costs plus risk premium

$P_H + \delta (1 - h)^2$

$P_L + \delta (1 - l)^2$

$m^*$ Expected spending $m$

Figure 2. Equilibrium in Case 1

Valuation

Benefit ($\delta$ is large)

Benefit ($\delta$ is intermediate)

Incremental cost

Benefit ($\delta$ is small)

$m^*$ Expected spending $m$
Figure 3. Comparison of Equilibrium in Four Cases

First-best

Case 1

Case 2

Case 3

Case 4

Figure 4. Equilibria in Case 1 and Case 2
Figure 5. Distribution of Predicted Spending for the Whole Population, the Young and the Old

The Whole Population

The Young (Age 18-40)
Figure 5. Continued.

The Old (Age 41-64)
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*

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>50.8%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Young (Age &lt;= 40)</td>
<td>57.8%</td>
</tr>
<tr>
<td>Old (Age &gt; 40)</td>
<td>42.2%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>Non-hispanic white</td>
<td>51.1%</td>
</tr>
<tr>
<td>Non-hispanic black</td>
<td>12.5%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>28.8%</td>
</tr>
<tr>
<td>Asian</td>
<td>5.2%</td>
</tr>
<tr>
<td>Other</td>
<td>2.4%</td>
</tr>
<tr>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>13.9%</td>
</tr>
<tr>
<td>Midwest</td>
<td>19.1%</td>
</tr>
<tr>
<td>South</td>
<td>38.7%</td>
</tr>
<tr>
<td>West</td>
<td>28.3%</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
</tr>
<tr>
<td>Less than high school degree</td>
<td>19.4%</td>
</tr>
<tr>
<td>High school degree</td>
<td>29.5%</td>
</tr>
<tr>
<td>Some college</td>
<td>14.7%</td>
</tr>
<tr>
<td>College degree or more</td>
<td>25.7%</td>
</tr>
<tr>
<td>Mean Individual Income ($2009) [Standard Deviation]</td>
<td>$33,300 [$31,500]</td>
</tr>
<tr>
<td>Poverty Status (based on family income)</td>
<td></td>
</tr>
<tr>
<td>&lt;138% FPL</td>
<td>2.8%</td>
</tr>
<tr>
<td>139% - 200% FPL</td>
<td>18.2%</td>
</tr>
<tr>
<td>201% - 300% FPL</td>
<td>28.0%</td>
</tr>
<tr>
<td>301% - 400% FPL</td>
<td>17.5%</td>
</tr>
<tr>
<td>400% FPL or higher</td>
<td>33.5%</td>
</tr>
<tr>
<td>Employment Status</td>
<td></td>
</tr>
<tr>
<td>Continuously employed</td>
<td>70.5%</td>
</tr>
<tr>
<td>Continuously unemployed</td>
<td>10.2%</td>
</tr>
<tr>
<td>Self-reported Health Status</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>30.6%</td>
</tr>
<tr>
<td>Very Good</td>
<td>33.3%</td>
</tr>
<tr>
<td>Good</td>
<td>27.4%</td>
</tr>
<tr>
<td>Fair</td>
<td>7.3%</td>
</tr>
<tr>
<td>Poor</td>
<td>1.4%</td>
</tr>
</tbody>
</table>
### Table 2. OLS Regression for the Correlation between Mean and Variance of Expected Spending

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Spending</td>
<td>12,654</td>
<td>363.9</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>R-Square</td>
<td>0.055</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Equilibria in the Four Cases

<table>
<thead>
<tr>
<th>Market</th>
<th>Size of population (1)</th>
<th>Cutoff (2)</th>
<th># of enrollees in plan H (3)</th>
<th>% of enrollment in plan H (5) = (4)/(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Young 12,058</td>
<td>2,834</td>
<td>23.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>5,382</td>
<td>61.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865 $1,790</td>
<td>8,216</td>
<td>39.4%</td>
<td></td>
</tr>
<tr>
<td>Case 2</td>
<td>Young 12,058</td>
<td>4,785</td>
<td>39.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>6,987</td>
<td>79.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865 $1,160</td>
<td>11,773</td>
<td>56.4%</td>
<td></td>
</tr>
<tr>
<td>Case 3</td>
<td>Young 12,058</td>
<td>5,423</td>
<td>45.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>5,335</td>
<td>60.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865 $1,920</td>
<td>10,758</td>
<td>51.6%</td>
<td></td>
</tr>
<tr>
<td>Case 4</td>
<td>Young 12,058</td>
<td>7,766</td>
<td>64.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>6,333</td>
<td>71.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865 $1,400</td>
<td>14,099</td>
<td>67.6%</td>
<td></td>
</tr>
</tbody>
</table>

Case 1: 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

<table>
<thead>
<tr>
<th>Market</th>
<th>Cutoff (1)</th>
<th>Premium L (3)</th>
<th>Premium H (4)</th>
<th>Incremental Premium (5) = (4) - (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Whole</td>
<td>$1,790</td>
<td>$3,596</td>
<td>$3,082</td>
</tr>
<tr>
<td>Case 2</td>
<td>Whole</td>
<td>$1,160</td>
<td>$3,125</td>
<td>$2,396</td>
</tr>
<tr>
<td>Case 3</td>
<td>Young</td>
<td>$1,020</td>
<td>$2,088</td>
<td>$1,762</td>
</tr>
<tr>
<td></td>
<td>Old</td>
<td>$1,920</td>
<td>$3,980</td>
<td>$3,310</td>
</tr>
<tr>
<td>Case 4</td>
<td>Young</td>
<td>$660</td>
<td>$2,042</td>
<td>$1,407</td>
</tr>
<tr>
<td></td>
<td>Old</td>
<td>$1,400</td>
<td>$3,514</td>
<td>$2,649</td>
</tr>
</tbody>
</table>

Case 1: 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**

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

Case 4: Both risk adjustment and premium discrimination.

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

<table>
<thead>
<tr>
<th></th>
<th>% of enrollment in plan H (1)</th>
<th>Average risk premium (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal</td>
<td>100%</td>
<td>$199</td>
</tr>
<tr>
<td>Case 1</td>
<td>39.4%</td>
<td>$782</td>
</tr>
<tr>
<td>Case 2</td>
<td>56.4%</td>
<td>$550</td>
</tr>
<tr>
<td>Case 3</td>
<td>51.6%</td>
<td>$780</td>
</tr>
<tr>
<td>Case 4</td>
<td>67.6%</td>
<td>$470</td>
</tr>
</tbody>
</table>

Case 1: 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**

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

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**

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

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.