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 (ACA), several provisions, including risk adjustment and premium discrimination, will be implemented to contend with adverse selection. This paper develops a model to explore the effects of the two policies on consumer plan choices in the Exchanges. By selecting a population likely to participate in the Exchanges from five waves the Medical Expenditure Panel Survey (MEPS), I simulate consumer selection under different scenarios of policy implementation. The results show that both risk adjustment and premium discrimination improve efficiency of plan selection. I also construct two measures to estimate welfare loss of consumers, and the results indicate that the welfare losses are minimized when both risk adjustment and premium discrimination are implemented.

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

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1 Introduction

In the United States, the Patient Protection and Affordable Care Act (ACA) mandates the establishment of health insurance Exchanges in every state. Beginning in 2014, consumers who are not offered health insurance by their employers, or have no access to other private or public programs, can purchase policies through state and federal Exchanges. Exchange plans, designated by metal level (Bronze, Silver, Gold and Platinum), differ in actuarial value, i.e., the percent of health care costs for enrollees covered by insurance plans.

Adverse selection is commonly found in individual health insurance markets (see Cutler & Zeckhauser (2000) and McGuire (2012) for literature reviews). The sick tend to choose more generous plans than the healthy. Studies on the Massachusetts reform, implemented in 2006 and serving as a template of the national reform, confirm the presence of adverse selection on plan choice (Chan and Gruber (2010), Ericson and Starc (2011)). Adverse selection is likely to negatively affect the efficiency and sustainability of the Exchanges. It can cause a generous plan into a “death spiral” (Cutler & Reber (1998)), or even destroy a market. A previous Exchange, the California Health Insurance Purchasing Cooperative, collapsed largely due to adverse selection (Wicks and Hall (2000)).

Several provisions will be implemented in the Exchanges in order to mitigate the impact of adverse selection. One is risk adjustment, which means the use of information to calculate enrollees’ expected health expenditures and set subsidies or payments to health plans (Ellis & Van de Ven (2000)). Under risk adjustment, plans attracting low-risk enrollees subsidize plans attracting high-risk enrollees. It decreases financial risk plans bear and stabilizes premiums. Another provision to contend with adverse selection is premium discrimination. The ACA allows insurance plans to set premiums according to some enrollees’ individual characteristics, including age, family composition, residence, and smoking status. High-risk consumers are likely to face higher marginal costs than low-risk consumers. The outcome of plan selection becomes more efficient when consumers bear the marginal costs of their choices (Keeler et.al. (1998)[17]).

In this paper, I focus on how insurance plan choice is affected by risk adjustment and
premium discrimination in the Exchanges. I construct 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 the sense of actuarial value. The model predicts plan sorting in the equilibrium: consumers with high/low expected health expenditures enroll in the more/less generous plans. In order to understand how risk adjustment and premium discrimination work separately and jointly, the model includes 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.

The model is applied to a potential Exchange population drawn from five panels of the Medical Expenditure Panel Survey (MEPS). I simulate the equilibrium sorting and plan premiums in each case. Comparing to no policy intervention, I find that both risk adjustment and premium discrimination encourage consumers to enroll in the more generous plans, which in my model improve efficiency. I also construct two measures to assess welfare impact for consumers. One is the fraction of the population that enrolls in the more generous plans, and the other is the average “risk premium” for the population. I find that risk adjustment and premium discrimination increase consumer welfare separately and jointly, and consumer welfare is maximized when both provisions are implemented.

There is a large body of literature modeling selection in insurance markets. Cutler & Reber (1998) illustrate market equilibrium under adverse selection that the sick tends to choose more generous plans. Einav & Finkelstein (2011) show graphically adverse selection in insurance markets and its welfare consequence using demand and cost curves. Feldman & Dowd (1982) and Ellis & McGuire (1987) simulate consumer choice between fee-for-service plans and HMOs. My model consolidates their work by making specific assumptions about the market, and deriving explicit expressions for equilibrium sorting and welfare loss. It provides a way to quantitatively analyze adverse selection. My model incorporates risk adjustment, which is an extension of these studies. Including risk adjustment helps to predict consumer selection more accurately. The ACA mandates the implementation of risk adjustment in Exchanges, which will affect plan revenue and the premiums. Plan selection is also affected because
consumers therefore face different premiums from the case when there is no risk adjustment.

Two recent studies are close to my work. Bundorf et al. (2012) use data on small employers to explore market inefficiency when insurance premiums do not reflect individual differences in costs. They find that welfare loss will reduce when premiums are set based on people’s risk. In my paper, the model has the same prediction that the implementation of premium discrimination reduces consumer welfare loss. Handel et al. (2013) study the trade off between adverse selection and premium reclassification risk in Exchange plans. They simulate the welfare loss in the long-run, while my model focuses on the policy impacts in the short-run.

The paper is organized as follows. Section 2 briefly discusses policy implementation in Exchanges. Section 3 presents the theoretical model. Section 4 describes the data and how the Exchange-eligible population is selected. Section 5 shows the empirical simulation and results. Section 6 discusses the welfare impact. Section 7 concludes and discusses the next steps for research.

2 Health Insurance Exchanges

The ACA mandates insurance coverage, and starting in 2014 people who are not covered by an insurance policy will be charged a penalty. Individuals and small businesses will be able to purchase health insurance plans in state-level Exchanges. In Exchanges, four tiers of plans will be offered: Bronze, Silver, Gold, and Platinum, which will cover at least 60%, 70%, 80%, and 90% of a typical enrollee’s health care cost, respectively. There are also catastrophic plans available for those up to 30 years of age or with other conditions.

Risk adjustment is required to be implemented in Exchanges, in order to stabilize the premiums in the markets. The Exchange will collect money from plans with relatively healthy enrollees and subsidize plans with less healthy enrollees; ideally the premium reflects the differences in plan benefits and plan efficiency, not the health status or expected health care costs of the enrolled population.

The HHS proposal (HHS Notice of Benefit of Payment Parameters for 2014) provides
details on how risk adjustment will be implemented. Concurrent models will be applied to predict cost, which means current year indicators are used to predict current year’s costs. Demographics and Hierarchical Condition Categories (HCCs) are included in the risk adjustment model. HHS proposes different age/gender categories for adults, children and infants. HHS also refines HCCs to meet the diagnosis condition of the Exchange population.

The HHS model makes adjustments for the fact that plans differ in their levels of cost-sharing, but does not make any adjustment for the plan-level reinsurance program, which is scheduled for the first three years of the program. Different risk adjustment formulas are applied to each metal level so as to capture the fact that plan payments will differ across metal levels, and these predictions reflect both the percentage of costs paid by the plan and the potential demand response to the enrollee cost-sharing.

The risk adjustment payment transfers for plans equal the difference between premiums with risk selection and premiums without risk selection. Premiums with risk selection are the state average premium adjusted by the normalized plan liability risk score (enrollee’s risk score), induced demand factor (the induced demand for enrollee due to subsidy of cost-sharing) and geographic cost factor. Premiums without risk selection is the state average premium adjusted by the normalized plan metal level actuarial value, allowable rating factor, induced demand, and geographic cost factor.

In Exchanges, plans are allowed to charge premiums differently by enrollees’ characteristics: age, premium rating area, family composition, and tobacco use. There are rating bands for some of the characteristics. The rating limit is 3:1 for age, which means that the premium setting for the oldest (most expensive) group can be no more than three times the premium for the youngest (least expensive) group. The rating limit is 1.5:1 for tobacco use, which means that smokers cannot be charged a premium that is more than 50% higher than the premium allowed for nonsmokers.
3 Model

In this section, a model is constructed to show consumer plan selection with and without risk adjustment and premium discrimination. I start with the model assumptions, and then from subsection 3.1 to subsection 3.4 analyze equilibriums in four cases: 1) No risk adjustment or premium discrimination is implemented; 2) Risk adjustment only; 3) Premium discrimination only; 4) Both risk adjustment and premium discrimination. In subsection 3.5 I show that the properties of the equilibrium still exists when one assumption of the model is relaxed.

There is a population of risk averse consumers. Consumer $i$ has the utility function

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

where $x_i$ is consumer $i$'s consumption and $\gamma$ is the risk aversion parameter. This utility displays Constant Absolute Risk Aversion.

She obtains wealth $W_i$, and purchases an insurance plan by paying premium $P$. When medical spending $m_i$ occurs, the insurance plan covers a fraction $v$. The cost-sharing for the consumer is $(1-v)m_i$. Hence, consumption is $x_i = W_i - P - (1-v)m_i$ and the utility function becomes

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

The consumer faces uncertainty in medical spending. I assume medical spending has the normal distribution, $m_i \sim N(\overline{m}_i, \sigma_i^2)$, with mean $\overline{m}_i$ and variance $\sigma_i^2$. I start with the assumption that the variance is constant, i.e., $\sigma_i^2 = \sigma^2$ for all consumers. The assumption is relaxed in section 3.5.

Her expected utility is

$$E[u(W_i - P - (1-v)m_i)] = u(W_i - P - (1-v)\overline{m}_i - \frac{1}{2} \gamma(1-v)^2 \sigma^2). \quad (1)$$

The term $(1-v)\overline{m}_i + \frac{1}{2} \gamma(1-v)^2 \sigma^2$ is the certainty equivalent of the cost-sharing $(1-v)m_i$.\footnote{The equation (1) holds because $E(u(t)) = u(\overline{m} - \frac{1}{2} \gamma \sigma^2)$ if a utility function has the form}
Therefore the total certainty equivalent generated from the uncertain medical spending is
\[ P + (1 - v)\bar{m}_i + \frac{1}{2}\gamma(1 - v)^2\sigma^2, \]
where the first part is plan’s premium \( P \), the second part \((1 - v)\bar{m}_i\) is the expected cost-sharing by the consumer, and the third part \(\frac{1}{2}\gamma(1 - v)^2\sigma^2\) is the risk premium from the uncertainty of cost-sharing. For simplicity, I define \( \delta \equiv \frac{1}{2}\gamma\sigma^2 \) in the following analysis.

Consumers differ in the risk of medical spending. The expected cost \( \bar{m}_i \) is drawn from a range \([M, \bar{M}]\), and has a cumulative distribution function of \( F(\bar{m}) \).

Two types of plans are provided, \( H \) and \( L \), and they are differ in actuarial value. Plan \( H \) covers fraction \( h \) of the consumer’s total cost, and plan \( L \) covers fraction \( l \) \((0 < l < h < 1)\). 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., the consumer’s health care cost is independent of plan coverage. Based on the assumption that consumers are risk averse, the efficient enrollment will be everyone enrolls plan \( H \), because plan \( H \) covers a greater portion of health spending risk for consumers than plan \( L \) does.

3.1 Case 1: No Risk Adjustment or Premium Discrimination is implemented

Consumer \( i \) chooses the plan that maximize her utility, which is equivalent to minimizes the total out-of-pocket costs plus risk premium. She will choose plan \( H \) if

\[ \frac{\text{OOP}_H}{OOP_H} + \frac{(1 - h)\bar{m}_i}{RP_H} + \frac{\delta(1 - h)^2}{RP_H} \leq \frac{\text{OOP}_L}{OOP_L} + \frac{(1 - l)\bar{m}_i}{RP_L} + \frac{\delta(1 - l)^2}{RP_L}. \quad (2) \]

In equation (2), \( \text{OOP}_H \) is the total out-of-pocket costs for plan \( H \), while \( P_H \) is the premium and \((1 - h)\bar{m}_i\) is the cost-sharing, \( RP_H \) is the risk premium for plan \( H \). \( \text{OOP}_L \) and \( RP_L \) are the total out-of-pocket costs and risk premium for plan \( L \).

\[ u(x) = -e^{-\gamma x} \] and the expected cost has normal distribution \( m \sim N(\bar{m}, \sigma^2) \). More details on risk premium are discussed by Pratt (1964).
Figure 1 illustrates the relation between plan selection and the expected spending of consumers. The two curves present the out-of-pocket costs plus risk premium for consumers when they enroll in plan $H$ and plan $L$. All consumers pay the plan premium and the risk premium, which are independent with the expected spending. Consumers also bear additional costs from risk-sharing when medical spending happens. The curves are upward-sloping because cost-sharing increases as the expected spending increases. Since plan $H$ provides a higher level of coverage than plan $L$ does, the costs for consumers who enroll in plan $H$ increase at a lower rate, and the curve for plan $H$ is flatter than the curve for plan $L$. The two curves intersect at the point $\bar{m}^*$. Consumers with expected spending less than $\bar{m}^*$ will enroll in plan $L$ and with spending more than $\bar{m}^*$ will enroll in plan $H$.

Rearrange equation (2) and it becomes

$$\frac{P_H - P_L}{h-l} - \delta \frac{(1-l)^2 - (1-h)^2}{h-l} \leq \bar{m}_i.$$  (3)

I define $\bar{m}^* = \frac{P_H - P_L}{h-l} - \delta \frac{(1-l)^2 - (1-h)^2}{h-l} \leq \bar{m}_i$ as the selection cutoff. Equation 3 shows that the consumers with expected health care costs that are larger than or equal to the cutoff $\bar{m}^*$ will choose plan $H$. Consumers with costs less than the cutoff $\bar{m}^*$ will choose plan $L$.

Plans charge premiums as revenue, and cover a fraction of health spending for their enrollees. For plan $H$, it attracts consumers with expected costs larger than or equal to $\bar{m}^*$. Those are enrollees with expected spending in the range $[\bar{m}^*, \bar{M}]$. The average spending for enrollees in plan $H$ is $\int_{\bar{m}^*}^{\bar{M}} mdF(m) / (1 - F(\bar{m}^*))$. Plan $H$ covers a fraction $h$ of the spending, so its average cost is $\int_{\bar{m}^*}^{\bar{M}} \frac{mdF(m)}{1 - F(\bar{m}^*)} h$. For plan $L$, it attracts consumers with expected costs less than $c^*$, so the average health care costs for plan $L$’s enrollees is $\int_{\bar{m}^*}^{\bar{M}} \frac{mdF(m)}{F(\bar{m}^*)}$ and its average cost is $\int_{\bar{M}^*}^{\bar{M}} \frac{mdF(m)}{F(\bar{m}^*)} l$. Plans earn zero profits, so premiums equal to the average costs:

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

$$P_L = \frac{\int_{\bar{M}^*}^{\bar{M}} mdF(m) l}{F(\bar{m}^*)}$$  (5)
Plug equations (4) and (5) into \( \bar{m}^* = \frac{P_H - P_l}{h - l} - \delta \frac{(1-l)^2}{h - l} - (1-h)^2 \), and rearrange it. The equation becomes

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

Equation 6 defines the equilibrium cutoff \( \bar{m}^* \). The left-hand side of equation (6) shows the incremental benefit for consumers from moving from plan \( L \) to plan \( H \). There are two benefits. One is the direct benefit from increased coverage. That is, consumers pay less cost-sharing for medical spending, \( (h - l)\bar{m}^* \). The other benefit is 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.

In the following analysis of this section, I assume that the expected cost has a uniform distribution. There are two benefits of making this assumption. One is that the condition for existence of equilibrium is presented, while it is much more complex to analyze under an arbitrary distribution. The other benefit is that a close-form solution of the equilibrium cutoff is derived under the uniform distribution, which provides an advantage of discussing the properties of equilibrium. It also provides a way to compare the equilibriums among the four cases. I only assume the uniform distribution in the theoretical model. In the empirical analysis, I use the real distribution for the Exchange-eligible population from the data.

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

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

There is an unique equilibrium \( \bar{m}^* \) since both benefit and cost are linear to the expected cost. An interior equilibrium exists only when \( \delta \) is within specific range of magnitude. The condition is

\[
\frac{l}{2[(1-l)^2 - (1-h)^2]} (M - M) \leq \delta \leq \frac{h}{2[(1-l)^2 - (1-h)^2]} (M - M).
\]
Figure 2 shows the situation. The solid line displays the incremental benefit, and the dashed line displays the incremental cost. The solid line is steeper than the dashed line, since the slope of the solid line is \( h - l \) and the slope of the dashed line is \( \frac{1}{2}(h - l) \). The line “Benefit (\( \delta \) is intermediate)” shows the condition when interior solution exists. This equilibrium is stable. Consumers with expected costs less than \( \hat{m}^* \) enroll in plan \( L \), and do not have incentive to move to plan \( H \), since their incremental costs are larger than the incremental benefit of moving to plan \( H \).

When \( \delta \) is sufficiently small, the risk aversion of the consumers is small and/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, and everyone prefers plan \( L \). In figure 2, the benefit line of “Benefit (\( \delta \) is intermediate)” shifts down to “Benefit (\( \delta \) is small)”, and the optimal cutoff is larger than the upper bound of the distribution.

When \( \delta \) is sufficiently large, the risk aversion is large and/or the uncertainty is large. The incremental benefit of moving from plan \( L \) to plan \( H \) is large, and everyone prefers plan \( H \). In figure 2, the benefit line of “Benefit (\( \delta \) is intermediate)” shifts up to “Benefit (\( \delta \) is large)”, and the optimal cutoff is smaller than the lower bound of the distribution.

Re-arranging equation (7), the cutoff becomes

\[
\frac{\hat{m}^* - M}{M - \hat{M}} = \frac{h}{h - l} - \frac{2\delta(2 - h - l)}{M - \hat{M}}. \tag{9}
\]

Equation (9) shows the fraction of consumers that enroll in plan \( L \). There are two properties of the fraction. The first is that the fraction is increasing in plan \( L \)’s actuarial value, \( l \). This is because when plan \( L \)’s coverage increases, the incremental benefit from moving from plan \( L \) to plan \( H \) decreases. The incentive for changing plans decreases, so more consumers will stay in plan \( L \). The second is that the fraction is decreasing in \( \delta \). A smaller fraction of population who has a higher level of risk aversion and/or faces a larger uncertainty of health costs will enroll in plan \( L \).

Figure 3 presents the comparison of the equilibria in the four cases. The expected costs of the population range in \([\hat{M}, \bar{M}]\), and the grey 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 more than $c^*$ will enroll in plan $H$.

### 3.2 Case 2: Model with Risk Adjustment

In this case risk adjustment is implemented. There is a regulator who makes a risk adjustment transfer between plans. I assume that there are health status signals $S$ that are perfectly informative about consumers’ risk type, and the signals are available for all agents (consumers, health plans and the regulator). The regulator makes the risk-adjusted payments to plans according to the enrollees’ costs. Define the risk adjuster as $r$. For a consumer with expected spending $c$, the regulator will pay $rc$ to the plan she enrolls in, where $0 < r < l$. In order to balance the budget, the regulator charges a capitation fee $R$ for each enrollee.

Consumers pay premiums and receive reimbursement from plans. They may or may not be aware of the intervention of risk adjustment. They choose plans that minimize the costs of certainty equivalent. The condition is the same as that in case 1 when no risk adjustment is implemented:

$$\frac{P_H - P_L}{h - l} - \delta \frac{(1 - l)^2 - (1 - h)^2}{h - l} \leq m_i.$$  \hspace{1cm} (10)

The cutoff is defined as $\hat{m} = \frac{P_H - P_L}{h - l} - \delta \frac{(1 - l)^2 - (1 - h)^2}{h - l}$.

Plans charge premiums, submit a capitation fee $R$ for each enrollee to the regulator, and receive the risk-adjusted payments $rc$ from the regulator. It is equivalent to the condition that plans bear a capitation fee $R$ for each enrollee, and pay a less fraction of enrollees’ spending. For plan $H$, the fraction is $h - r$, instead of $h$. For plan $L$, the fraction is $l - r$.

Plans earn zero profit, so premiums equal to the average costs:

\footnote{The information assumption in risk adjustment is discussed more in Ellis (2008), Ellis (2011), and Ellis & Van De Ven (2000).}

\footnote{As is reviewed in section 2, the implementation of risk adjustment in Exchanges will be more complex than what I assume in the model. However, since the assumption captures the principle of risk adjustment that plans attracting low-risk enrollees will subsidize plans attracting high-risk enrollees, it is sufficient to illustrate the impact of risk adjustment on plan sorting in Exchanges.}
\[ PH = \frac{\int_{\hat{m}} \hat{m}dF(\hat{m})}{1 - F(\hat{m})}(h - r) + R \]  

\[ PL = \frac{\int_{\hat{m}} \hat{m}dF(\hat{m})}{F(\hat{m})}(l - r) + R \]  

Plugging equations (11) and (12) into \( \hat{m} = \frac{PH - PL}{h - l} - \frac{\delta(1 - l)^2 - (1 - h)^2}{h - l} \), it becomes

\[(h - l)\hat{m} + \delta[(1 - l)^2 - (1 - h)^2] = \frac{\int_{\hat{m}} \hat{m}dF(\hat{m})}{1 - F(\hat{m})}(h - r) - \frac{\int_{\hat{m}} \hat{m}dF(\hat{m})}{F(\hat{m})}(l - r) \]  

Equation 13 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 fee is the same for both plans, so it is cancelled out. The premium difference only reflects part of the difference of enrollees’ average spending plans actually cover. Comparing equation 6 to equation 13, case 1 is a special case of case 2 when the risk adjuster \( r = 0 \).

Under uniform distribution, equation (13) becomes

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

Equation 13 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 fee is the same for both plans, so it is cancelled out. The premium difference only reflects part of the difference of enrollees’ average spending plans actually cover. Comparing equation 6 to equation 13, case 1 is a special case of case 2 when the risk adjuster \( r = 0 \).

Under uniform distribution, equation (13) becomes

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

A unique equilibrium \( \hat{m} \) exists since both benefit and cost are linear to the expected cost. An interior equilibrium exits only when \( \delta \) satisfies the condition

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

There is a corner solution when \( \delta \) is sufficiently large, or sufficiently small. The analysis is the same as in case 1.

Figure (4) shows the equilibrium cutoffs in case 1 and case 2. The incremental benefits are the same in both cases, but the incremental costs are different. The incremental cost is smaller in case 2. The curve for incremental cost shifts down, so the equilibrium cutoff \( \hat{m} \) in case 2 is smaller than the cutoff \( \hat{m}^* \) in case 1. Comparing to case 1, more people enroll in
plan $H$ in case 2. The equilibrium allocation is shown in figure 3.

Re-arranging equation (14), the equilibrium cutoff becomes

$$\frac{m^* - \bar{M}}{\bar{M} - \bar{M}} = \frac{h - r}{h - l} - \frac{2\delta(2 - h - l)}{\bar{M} - \bar{M}}$$

(16)

Equation (16) shows the fraction of consumers enrolling in plan $L$ under risk adjustment. The fraction is decreasing in $r$, which means that the increase of the magnitude 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 not affected by the shift of the cost distribution, is decreasing in $\delta$, and is decreasing in plan $L$’s coverage $l$.

3.3 Case 3: Model with Premium Discrimination

In this case premium discrimination is implemented. I assume that consumers differ in another dimension of characteristics: age. There are two groups of consumers, young and old. They are separated into two markets: the market for the young, and the market for the old. Plans provide the same plan in different markets, and charge different premiums. In each market, the analysis is similar as in case 1.

In the young market, plan $H$ charges premium $P_H^{\text{Young}}$ and plan $L$ charges premium $P_L^{\text{Young}}$. The young make choice between plan $H$ and plan $L$, and minimize the costs of certainty equivalent. The cutoff is defined as $m^{\text{Young}} = \frac{P_H^{\text{Young}} - P_L^{\text{Young}}}{h - l} - \frac{\delta(1-l)^2 - (1-h)^2}{h - l}$. The cumulative distribution of enrollees’ expected costs is $F^{\text{Young}}(c)$. Plans earn zero profits in this market, so premiums equal to average costs:

$$P_H^{\text{Young}} = \int_{m^{\text{Young}}} \frac{m dF^{\text{Young}}(m)}{1 - F^{\text{Young}}(m^{\text{Young}})} h$$

$$P_L^{\text{Young}} = \int_{m^{\text{Young}}} \frac{m dF^{\text{Young}}(m)}{F^{\text{Young}}(m^{\text{Young}})} l$$

(17)

(18)

The equilibrium condition for the young is
\[(h - l)\bar{m}\text{Young} + \delta[(1 - l)^2 - (1 - h)^2] = \frac{\int_{\bar{m}\text{Young}}^{M\text{Young}} \bar{m} dF\text{Young}(\bar{m})}{1 - F\text{Young}(\bar{m}\text{Young})} h - \frac{\int_{\bar{m}\text{Young}}^{M\text{Young}} \bar{m} dF\text{Young}(\bar{m})}{F\text{Young}(\bar{m}\text{Young})} l \] (19)

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

\[(h - l)\bar{m}\text{Old} + \delta[(1 - l)^2 - (1 - h)^2] = \frac{\int_{\bar{m}\text{Old}}^{M\text{Old}} \bar{m} dF\text{Old}(\bar{m})}{1 - F\text{Old}(\bar{m}\text{Old})} h - \frac{\int_{\bar{m}\text{Old}}^{M\text{Old}} \bar{m} dF\text{Old}(\bar{m})}{F\text{Old}(\bar{m}\text{Old})} l \] (20)

The left-hand side of equation 19 and equation 20 show the incremental benefit for consumers from moving from plan \(L\) to plan \(H\), and the right-hand side show the incremental cost.

I assume that the young has the cost distribution \(\bar{m}\text{young} \sim U[M, \tilde{m}]\), and the old has the cost distribution \(\bar{m}\text{old} \sim U[\tilde{m}, M]\) where \(\tilde{m} \in [M, \bar{M}]\). This is an extreme assumption that all young people have low costs and all old people have high costs. The two distributions of the expected costs do not overlap.

The cutoffs are

\[\bar{m}\text{young} = M + \frac{h}{h - l}(\tilde{m} - M) - 2\delta(2 - h - l)\] (21)

and

\[\bar{m}\text{old} = \tilde{m} + \frac{h}{h - l}(\bar{M} - \tilde{m}) - 2\delta(2 - h - l).\] (22)

With premium discrimination, the fraction of people who enroll in plan \(L\) equals the sum of the fractions for the young and the old:
\[
\begin{align*}
\frac{(\bar{m}_{\text{young}} - M) + (\bar{m}_{\text{old}} - \bar{m})}{M - M} &= \frac{[\frac{h}{h-l}(\bar{m} - M) - 2\delta(2-h-l)] + [\frac{h}{h-l}(\bar{M} - \bar{m}) - 2\delta(2-h-l)]}{M - M} \\
\frac{h}{h-l} &= 2\cdot \frac{2\delta(2-h-l)}{M - M}
\end{align*}
\] (23)

From equation (9), the fraction of people who enroll in plan \( L \) without premium discrimination is
\[
\frac{M - M}{M - M} = \frac{h}{h-l} = 2\frac{2\delta(2-h-l)}{M - M}
\]
Comparing equation (9) to equation (23), the fraction decreases. The intuition is that the cost ranges are compressed for each group. The population becomes more homogenous so the premium difference decreases. In each market fewer consumers enroll in plan \( L \), and overall fewer consumers enroll in plan \( L \).

Figure 3 shows the equilibrium allocation. \( \bar{m} \) 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.

### 3.4 Case 4: Model with 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 pays back the plans according to their enrollees’ expected spending. Consumers choose the plans that minimize the costs of certainty equivalent. Plans charge enrollees premiums, pay the regulator a capitation fee for each enrollee, and receive risk-adjusted payments from the regulator.

Define \( \bar{m}_{\text{young}} \) and \( \bar{m}_{\text{old}} \) are the equilibrium cutoff, the equilibrium conditions are
\[
(h-l)\hat{m}_\text{young}^+ \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{m}^{M} \hat{m} dF_{\text{Young}}(\hat{m})}{1 - F_{\text{Young}}(\hat{m})} (h-r) - \frac{\int_{M}^{\hat{m}_\text{young}} \hat{m} dF_{\text{Young}}(\hat{m})}{F_{\text{Young}}(\hat{m})} (l-r) 
\]  
(24)

\[
(h-l)\hat{m}_\text{old}^+ \delta[(1-l)^2 - (1-h)^2] = \frac{\int_{m}^{M} \hat{m} dF_{\text{Old}}(\hat{m})}{1 - F_{\text{Old}}(\hat{m})} (h-r) - \frac{\int_{M}^{\hat{m}_\text{old}} \hat{m} dF_{\text{Old}}(\hat{m})}{F_{\text{Old}}(\hat{m})} (l-r) 
\]  
(25)

I keep the assumption that the young has the cost distribution \( c_{\text{young}} \sim U[M, \hat{m}] \), and the old has the cost distribution \( c_{\text{old}} \sim U[\hat{m}, M] \) where \( \hat{m} \in [M, M] \). The equilibrium cutoffs are

\[
\hat{m}_\text{young} = M + \frac{h-r}{h-l} (\hat{m} - M) - 2\delta(2-h-l) 
\]  
(26)

and

\[
\hat{m}_\text{old} = \hat{m} + \frac{h-r}{h-l} (M - \hat{m}) - 2\delta(2-h-l). 
\]  
(27)

The fraction of consumers who enroll in plan \( L \) is

\[
\frac{(\hat{m}_\text{young}^+ - M) + (\hat{m}_\text{old}^+ - \hat{m})}{\hat{m} - \hat{m}} = \frac{\frac{h-r}{h-l} (\hat{m} - M) - 2\delta(2-h-l) + \frac{h-r}{h-l} (M - \hat{m}) - 2\delta(2-h-l)}{\hat{m} - \hat{m}} 
\]  
(28)

Comparing equation (23) to equation (28), less consumers enroll in plan \( L \) under risk adjustment. The larger the magnitude of the risk adjustment, the less people enroll in plan \( L \). The intuition is the same as in case 2: in each market the risk adjustment decreases the premium difference 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.
3.5 The case with heterogeneous variance

In this case I relax the assumption that the variance of medical spending is constant. Instead, I assume the variance is linear to the mean, i.e., $\sigma_i^2 = \beta m_i$, which is closer to the practice.\footnote{In general, I can assume $\sigma_i^2 = \alpha + \beta m_i$. However, the assumption $\sigma_i^2 = \beta m_i$ has the advantage that the coefficient $\beta$ 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).}

There are a large number of studies discussing the correlation between mean and variance of health care expenditures ((Basu (2005), Buntin & Zaslavsky (2004), Manning et al. (2005) and McGuire et al. (2013)). McGuire et al. (2013) suggests a linear relationship for the potential Exchange population.

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

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

(29)

Under uniform distribution, the equilibrium cutoff is

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

(30)

Equation (30) shows the equilibrium cutoff when the variance of consumer’s spending is heterogeneous. The existence and uniqueness of equilibrium provide foundation of the simulation in the empirical analysis. The properties of equilibrium still hold. $\bar{m}^*$ is increasing in $l$, which means the fraction of the population enrolls in plan $L$ is increasing in plan $L$’s actuarial value. $\bar{m}^*$ decreases in $\gamma$ and $\beta$, which means a smaller fraction of population who has a higher level of risk aversion and/or faces a larger uncertainty of health costs will enroll in plan $L$.

I omit the equilibrium discussion for the other three cases, since they are similar as the analysis discussed here.
4 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 who are followed for two years. Data is collected in five rounds of interviews covering the two-year period. The Household Component is the source for personal and household characteristics, including insurance coverage and self-reported health conditions. The MEPS collects data in a similar fashion for respondents in all types of health insurance coverage. Panels 9 (2004/05) through 13 (2008/09) are used in this analysis, requiring participation in both years of the panel (dropping those who die during their first survey year.) Year 1’s individual characteristics are used to predict year 2’s spending.

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) on the methodology of the selection. People who are selected are adult, non-elderly individuals (aged 18-64) in 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 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, and most information is taken from McGuire et al. (2013). The young group includes people younger than or equal to 40, and 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.

As stated in McGuire et al. (2013), the major limitation of using the MEPS data is that the
observed health care expenditures are affected by the household’s insurance coverage, whereas for the plan sorting in an Exchange I would ideally like to observe spending conditional on the insurance the household would buy in the Exchange. This limitation is endemic to simulation research on the ACA, and indeed in the empirical risk adjustment field generally, where models are often fit on “outside” data. Presumably, participants gaining insurance with Exchange coverage would increase utilization over what is observed in our data, and these increases are likely to be larger for the enrollment of more generous plans.

5 Empirical Simulation and Results

Subsection 5.1 shows how parameters in the model are chosen, subsection 5.2 presents the simulation results in all four cases, and subsection 5.3 discusses the robustness of the results.

5.1 Parameter Set Up

The following equation is used for the simulation:

\[(h - l)\bar{m}^* + \frac{1}{2} \gamma \beta [(1 - l)^2 - (1 - h)^2]\bar{m}^* = \frac{\int_{\bar{m}_M}^{\bar{m}} \bar{m} dF(\bar{m})}{1 - F(\bar{m}^*)} (h - r) - \frac{\int_{\bar{m}_M}^{\bar{m}^*} \bar{m} dF(\bar{m})}{F(\bar{m}^*)} (l - r). \] (31)

A group of parameters are included in equation (31): the actuarial values of plan H and plan L, the risk adjuster r, the risk aversion parameter γ, the correlation between the mean and the variance of expected spending β, and the distribution of expected spending F(\bar{m}). I assume h = 0.9 and l = 0.6, which are the regulated levels of coverage for Platinum plans and Bronze plans. I assume r = 0.2 in all four cases. I also vary r to other values in case 4, in order to compare the impacts on sorting between different levels of risk adjustment.

I use the real distribution of the expected spending from the 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 year 1’s information: age-gender combination, self-reported
health status and mental health status, indicators of total spending, and 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 frequency on 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 of them has low predicted costs, while some in the middle range and a few of them have extremely high costs. Most of the young population concentrates on the low cost range. The distribution for the old is more dispersive than that for the young.

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

The coefficient $\gamma$ is calibrated as $1.5 \times 10^{-3}$ using the plan selection information in Massachusetts reform. There are three categories of plans provided: Bronze, Silver, and Gold. In Ericson & Starc (2012), they describe that 60.6% of the population enrolled in the least generous plans (Bronze plans) in 2009. In this analysis I set the fraction 60% as a start point of the simulation. when $\gamma = 1.5 \times 10^{-3}$, 60% of the population enrolls in plan $L$ in case 1 when no risk adjustment or premium discrimination is implemented. This magnitude of the parameter is consistent with the estimation in the literature (Handel et al. (2013); Cohen & Einav (2007); Gertner (1993); and Sydnor (2006)).

In Handel et al. (2013), the estimation of the mean risk aversion parameter in a CARA utility function is $4.28 \times 10^{-4}$ for the pseudo-sample for 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) the estimation is $2.0 \times 10^{-3}$. 

5
5.2 Simulation Results

Figure ?? displays the simulation results on equilibriums in case 1 and case 2. Figure 6A includes the whole range of expected costs, and figure ??B includes part of the range in order to show the cutoffs 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 line is for case 1, and the green line is for case 2. Risk adjustment decrease the premium difference consumers face, so the green line is just a down-shift of the red 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. For consumers who enroll in plan L, the incremental cost is larger than the incremental benefit of changing from plan L to plan H, so they have no incentive to change plans. 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 separate markets: the young and the old. In each market the analysis is similar as case 1 and case 2. Figure 7 shows the results. Figure 7A shows the equilibriums with and without risk adjustment for the young. The cutoff is $1,020 without risk adjustment, and is $660 with risk adjustment. Figure 7B shows the equilibriums for the old. The cutoffs are $1,920 and $1,400. In both markets more consumers enroll in plan H when risk adjustment is implemented.

Table 3 summarizes the equilibriums for the four cases. Column (1) indicates the market, i.e., whether it is 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) shows the simulated equilibrium cutoffs from figure 6 and figure 7. Column (4) shows 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 share of enrollment in plan $H$, which is calculated from column (2) and column (4). In case 1, as the basic case calibrated from the condition in Massachusetts reform, 39.4% of the population enrolls in plan $H$, the more generous plan. In case 2, when risk adjustment is implemented, the fraction increases to 56.4%. In case 3, when 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 case. The simulation results are consistent with the model prediction.

Table 4 shows the premiums of plan $L$ and plan $H$ in all four cases in each market. Column (1) indicates the market and column (2) shows the equilibrium cutoffs. Column (3) and column (4) displays premiums for plan $L$ and plan $H$ calculated from equilibrium cutoffs and the distribution of expected spending of enrollees. Column (5) shows the premium difference between the two plans, which is derived by subtracting column (3) from column (4).

There are two findings from the premium results. First is that premium difference is compressed when risk adjustment is implemented. In case 1, the premium difference consumers face between plan $L$ and plan $H$ is $3,082, and it becomes $2,396 in case 2. It is the same for the young and for the old in case 3 and case 4. This is because high risk people who enroll in plan $H$ are subsidized by low risk people, so premium of plan $L$ decreases and premium of plan $H$ increases under risk adjustment.

Second is that high risk people face a higher premium difference than low risk people when premium discrimination is implemented. In case 1 the premium difference is $3,082 for the whole population, while it becomes $1,762 for the young and $3,310 for the old in case 3. Everyone faces the same premium without premium discrimination, so high risk people are subsidized by low risk people. With premium discrimination, the two groups are separated, so the premium differences are closer to their own marginal costs of plan selection. The trend of divergence is similar between case 2 and case 4.
Since concurrent models will be used for risk adjustment, the predictive power on enrollees’ costs could be large. Table 5 shows the equilibrium results in case 4 under different levels of risk adjusters. $r = 0.2$ is the original assumption, 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.

In table 5, column (1) indicates the market and column (2) provides the size of the population in each market. Column (3) shows the simulated equilibrium cutoffs. The cutoffs decreases as the risk adjuster increase in both the young and the old markets. Number of enrollees in plan $H$ is calculated according to the cutoff, which is shown in column (4). Column (5) shows the share of enrollment in plan $H$ for the whole population. When $r = 0.2$, the value of the share is 67.6%. As the risk adjuster increases, more people will enroll in plan $H$, which is consistent with the model prediction. When $r = 0.5$, the share increases to 87.7%.

5.3 Robustness Analysis

In this subsection 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 less enrollees in plan $H$ in each case. The reason is that the coverage of plan $H$ decreases, and the incremental benefit of changing plans decreases too. The conclusion still holds that both risk adjustment and premium discrimination encourage people to enroll in the more generous plans.

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. Plan $H$ is less attractive for people when they are less risk averse, so the share of enrollment in plan $H$ is less than that in the main results. When people are more risk averse, the shares are larger. The conclusion that both risk adjustment and premium discrimination encourage people to enroll in the more generous plans holds in both scenarios.
6 Welfare Analysis

Two measures are used to discuss the welfare impact on consumers. The first is the share of enrollment in plan $L$, which is already shown in table 3, and the second is the average risk premium the population bears. A single enrollee’s risk premium is $\frac{1}{2}\gamma\beta\overline{m}(1-h)^2$ if she enrolls in plan $H$ and $\frac{1}{2}\gamma\beta\overline{m}(1-l)^2$ if she enrolls in plan $L$. In the first-best case when all consumers enroll in plan $H$, the average risk premium is

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

(32)

Re-arrange equation (32) and it becomes

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

(33)

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

The two measures are positively correlated. If a consumer move from plan $L$ to plan $H$, both measures show welfare improvement. However, enrollees have the same weight in the first measure, but are treated differently by their expected costs 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 high expected spending moves using the second measure.

Table 6 summarizes the results of two measures on welfare loss. Column (1) shows the share of enrollment in plan $L$ and column (2) shows 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 consumer still shares 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. In all other three cases, both the share of enrollment and the average risk premium are lower. Consumer welfare is increased when risk adjustment and premium discrimination are implemented. In case 4, the share of enrollment is 32.4% and the risk premium is $470$. Welfare loss of consumers reaches the minimum in the four cases when both risk adjustment and premium discrimination are implemented.

When comparing case 3 to case 1, although the share of enrollment increases by 12.2%, the average risk premium almost remains the same. This is because all of the 39.4% of population enrolling in plan $H$ are with high expected costs in case 1, while not every high costs enrollees enroll in plan $H$ 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 former can have lower costs than the latter. The measure of risk premium puts greater weight on enrollees with high expected costs, so it does not change as the same amount as the first measure in case 3.

7 Discussion

The primary purpose of the paper is to analyze the impact of risk adjustment and premium discrimination on plan sorting in health insurance Exchanges. The result supports the ACA that both policies are helpful to counter the problem of adverse selection. It also suggests the magnitude of impacts on plan sorting at different levels of risk adjustment.

In practice, the Exchanges will be implemented at state level. Individual characteristics can vary across states, and the rules of risk adjustment and premium discrimination can also vary a great deal. The model in this paper is easy to apply and incorporates some of those variations. States can use their own data to simulate the equilibrium. They can use their own risk adjustment model to predict spending. They can also analyze the impacts under their own premium categories.
Some simplifications are made in this analysis, which are necessary for deduction of the results but derive from the situation in practice. A number of factors could be considered for future research in order to make the model more complete.

**Moral Hazard.** The demand of 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 premium difference between plans and further affect plan selection. The first-best case will not be everyone enrolls in the more generous plans when incorporating moral hazard in the model.

**Multiple plan types.** In Exchanges there will be four types of plans provided. When consumers face more than two options, additional conditions will be required to guarantee the existence of equilibrium. The sorting situation and welfare analysis will be more complex when there are multiple plans.

**Imperfect competition.** Insurance plans are complex products, and one plan can easily be designed differently from another. When only a few insurers participate in Exchanges, it is likely that they can make profits. Premiums will no longer equal to the average costs, when markets are not perfectly competitive, and this feature could affect consumer’s plan selection and equilibrium sorting.
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URL: http://www.ingentaconnect.com/content/aea/aer/2012/000000102/00000003/art00086


URL: http://www.ncbi.nlm.nih.gov/pubmed/10180920

URL: http://www.ncbi.nlm.nih.gov/pubmed/15811539


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

\[ P_H + \delta (1 - h)^2 \]
\[ P_L + \delta (1 - l)^2 \]

Figure 2. Equilibrium in Case 1

Valuation

Benefit (\( \delta \) is large)
Benefit (\( \delta \) is intermediate)
Incremental cost
Benefit (\( \delta \) is small)
Figure 3. Comparison of equilibrium in Four Cases

Figure 4. Equilibriums 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>
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<tbody>
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<td>Male</td>
<td>50.8%</td>
</tr>
<tr>
<td>Age</td>
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</tr>
<tr>
<td>Young (Age ≤ 40)</td>
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<tr>
<td>Old (Age &gt; 40)</td>
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**Table 2. OLS Regression for the Correlation between Mean and Variance of Expected Spending**

<table>
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<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. Equilibriums in the Four Cases**

<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>Share of enrollment in Plan H (5) = (4)/(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Whole 20,865</td>
<td>$1,790</td>
<td>8,216</td>
<td>39.4%</td>
</tr>
<tr>
<td>Case 2</td>
<td>Whole 20,865</td>
<td>$1,160</td>
<td>11,762</td>
<td>56.4%</td>
</tr>
<tr>
<td>Case 3</td>
<td>Young 12,058</td>
<td>$1,020</td>
<td>5,423</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>$1,920</td>
<td>5,335</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865</td>
<td>$1,790</td>
<td>10,758</td>
<td>51.6%</td>
</tr>
<tr>
<td>Case 4</td>
<td>Young 12,058</td>
<td>$660</td>
<td>7,766</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old 8,807</td>
<td>$1,400</td>
<td>6,333</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole 20,865</td>
<td></td>
<td>14,099</td>
<td>67.6%</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 (1)</th>
<th>Cutoff (2)</th>
<th>Premium L (3)</th>
<th>Premium H (4)</th>
<th>Premium Difference (5) = (4) - (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Whole</td>
<td>$1,790</td>
<td>$514</td>
<td>$3,596</td>
</tr>
<tr>
<td>Case 2</td>
<td>Whole</td>
<td>$1,160</td>
<td>$761</td>
<td>$3,125</td>
</tr>
<tr>
<td>Case 3</td>
<td>Young</td>
<td>$1,020</td>
<td>$326</td>
<td>$2,088</td>
</tr>
<tr>
<td></td>
<td>Old</td>
<td>$1,920</td>
<td>$670</td>
<td>$3,980</td>
</tr>
<tr>
<td>Case 4</td>
<td>Young</td>
<td>$660</td>
<td>$636</td>
<td>$2,042</td>
</tr>
<tr>
<td></td>
<td>Old</td>
<td>$1,400</td>
<td>$865</td>
<td>$3,514</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. Equilibriums in Case 4 under 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>Share 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></td>
<td>14,099</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></td>
<td>15,657</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></td>
<td>17,072</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></td>
<td>18,303</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>Share of enrollment in Plan H (1)</th>
<th>Average risk premium (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-best</td>
<td>100%</td>
</tr>
<tr>
<td>Case 1</td>
<td>39.4%</td>
</tr>
<tr>
<td>Case 2</td>
<td>56.4%</td>
</tr>
<tr>
<td>Case 3</td>
<td>51.6%</td>
</tr>
<tr>
<td>Case 4</td>
<td>67.6%</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.
### Table A1. Equilibriums 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>Share 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</td>
<td>8,807</td>
<td>$2,350</td>
<td>4,399</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>8,216</td>
<td>39.4%</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</td>
<td>8,807</td>
<td>$1,560</td>
<td>5,921</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>12,454</td>
<td>59.7%</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;  
$h$: Plan H's actuarial value;  
$l$: Plan L’s actuarial value.

### Table A2. Equilibriums in the Four Cases when $\gamma=1\times10^{-3}$ & $\gamma=2\times10^{-3}$

<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>Share of enrollment in Plan H (5) = (4)/(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma=1\times10^{-3}$</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</td>
<td>8,807</td>
<td>$3,350</td>
<td>3,210</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>5,329</td>
<td>25.5%</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</td>
<td>8,807</td>
<td>$2,340</td>
<td>4,399</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>8,229</td>
<td>39.4%</td>
</tr>
<tr>
<td>$\gamma=2\times10^{-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</td>
<td>8,807</td>
<td>$1,380</td>
<td>6,346</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>13,732</td>
<td>65.8%</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</td>
<td>8,807</td>
<td>$1,020</td>
<td>7,310</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20,865</td>
<td></td>
<td>16,826</td>
<td>80.6%</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;  
$\gamma$: risk aversion parameter.