Cost–Minimizing Risk Adjustment †

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Abstract

Conventional risk adjustment, which sets capitation payments equal to the average cost of individuals with similar observable characteristics, is not optimal if health plans can use private information to select low–cost enrollees. "Cost–minimizing risk adjustment" minimizes the sum of capitated HMO premiums plus FFS costs by balancing the gains from HMO cost efficiency against the overpayments that result from HMO selection. Estimations using privately–insured data suggest that cost–minimizing risk-adjusted premiums reduce total sponsor costs as much as 25.6% below conventional risk-adjustment premiums.

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1 Introduction

While capitation payments to health plans create incentives for efficiency and cost containment, such payments also create incentives for plans to attempt to attract low cost enrollees. Cutler and Zeckhauser (2000) convincingly summarize the literature on selection as showing that managed care plans are successful at attracting a favorable selection of enrollees, even when plans are largely prohibited from using demand side incentives to do so. While the mechanism that health plans use to do this are not well understood, one hypothesis is that health plans directly influence who enrolls by discouraging enrollment (or encouraging disenrollment) of high expected cost enrollees or focusing recruitment on those who are expected to be profitable. In this paper we explore the optimal design of risk adjustment models under the assumption that managed care plans are able to selectively "dump" unprofitable enrollees using private information that is not available to the regulator setting capitation rates.

Risk adjustment is a frequently recommended strategy for offsetting selection incentives. Conventional risk adjustment sets capitation rates so as to reflect the expected cost of individual enrollees, thereby reducing the potential financial gains from selection. Various studies have found that potential profit from selection under conventional risk adjustment mechanisms are still substantial (van Vliet and van de Ven 1992; Newhouse et al. 1989; van de Ven et al. 2000). Shen and Ellis (forthcoming) confirms that even recent models of risk adjustment such as Ambulatory Cost Group (ACG) and Diagnostic Cost Group (DCG) models do not reduce the profits of selection to negligible levels.

Given the impossibility of fully eliminating selection incentives when capitation payments are set so as to equal expected costs, a recent line of research has examined how best to accommodate selection or other problems when designing a risk adjustment model. Glazer and McGuire (2000) call this "optimal risk adjustment." The appropriate capitation strategy depends on the mechanism that health plans use to affect selection. The regulatory problem that Glazer and McGuire solve is that health plans are able to distort services in ways that tend to attract low cost and repel high cost enrollees. Encinosa (2000) solves a different regulatory problem in which risk adjustment is used to offset problems of imperfect competition.

This study contributes to the literature on optimal risk adjustment while focusing on a different regulatory problem than those of Glazer and McGuire (2000) and Encinosa (2000). We develop the concept of "cost–minimizing risk adjustment" which solves the problem of explicit dumping of enrollees who are expected to be unprofitable. We examine how risk adjusted premiums can be adapted to reduce the selection incentive for plans to dump, while still encouraging capitated health plans to exist so as to control costs. The cost-minimizing capitation payments balance the gains of cost containment and the losses of health plan selection.

We model a world in which a single sponsor purchases health care services for its beneficiaries from health plans. The sponsor optimally chooses premiums to capitated plans, which we call HMOs, and noncapitated, cost-based reimbursement plans, which we call fee-for-service (FFS) plans[1]. To keep the model simple, we assume there are no quality differences between capitated and noncapitated plans. Hence the sponsor appropriately cares only about the sum of total payments to the two plan types. We assume that the HMO sector can perfectly select enrollees so as to include only those who are *ex ante* expected to be profitable. Enrollees are indifferent between joining the

[1] Many studies have suggested a mix of capitation payment and cost–based reimbursement payment systems to reduce the incentives for selection. Ma (1994), and Lewis and Sappington (1996) present models in which a mixture of fully cost–based and fully prospective payment systems is optimal in the presence of risk selection. Newhouse et al.(1997) conclude that a portion of reimbursement of a health plan should be based on actual use. van Barneveld, van Vliet, and van de Ven (1996) propose a mandatory high–risk pooling method. In their paper, payers allow plans to pool a certain proportion of enrollees into the traditional cost–based reimbursement payment system. The rest are paid for based on the conventional risk–adjustment capitation payment system. In their study, the percentage of pooling is determined by payers. Plans only have the flexibility to determine which individuals are to be placed in the pooling. Their proposal cannot prevent plans from dumping high–cost individuals, especially when the number of the expected unprofitable individuals is larger than that of the mandatory pooling. A mixture of capitation and cost-based payment may also have favorable incentive properties (Ellis and McGuire, 1986; Newhouse, 1996).

HMO or the FFS; and the HMO decides who to take. Such an assumption is appropriate if the HMO is able to directly or indirectly influence plan choice according to the costliness of enrollees. For instance, HMO providers may encourage high expected cost enrollees to disenroll or remain in the FFS, or the HMO may focus marketing efforts on the healthy. Alternatively, if the unattractiveness of enrolling in an HMO is directly proportional to the level of future expected costs, then individuals may sort themselves in their intensity of desire to join the HMO by their expected future use, and the HMO may be able to choose a level of attractiveness for each risk adjustment group that enrolls profitable and dumps unprofitable enrollees, achieving the same result.

In our framework, all plans have identical ex ante cost functions, but because capitated plans have incentives to expend effort reducing costs, HMOs are more efficient providers than FFS plans. If this is not true, then there is no reason in our model for the sponsor to offer the HMO[2]. The sponsor can take advantage of HMO cost efficiency by encouraging enrollment into the HMO sector. However, given the selection by capitated health plans, the sponsor has to increase HMO premium payments above average costs in order to expand the HMO market share, which increases the total cost. In our framework, costs would be minimized if the sponsor could offer only the HMO with no FFS, and prevent any dumping. This might be achieved by a contract to the HMO that required them to accept everyone. But if true, it would be the ability to prevent dumping, and not just the use of capitated HMOs that would be responsible for the cost savings. Because we do observe many sponsors offering both HMOs and FFS, and selection is a problem, we believe that our model has application to various real world situations.

Our assumption, that the sponsor's objective is to minimize total payments, is also made in the simulation models of Feldman and Dowd (1982), Ellis and McGuire (1987), and Newhouse et al. (1989). Given plans' selection behavior, simply expanding the cost–efficient HMO sector does not ensure payment savings. An alternative sponsor objective would be to minimize the social cost of

[2]Another reason to offer both HMOs and the FFS is taste heterogeneity among employees. We choose not to model this variation, which could soften the ability of plans to perfectly select.

treatment (i. e., the sum of plan costs, not sponsor costs). In our model, the social cost-minimizing solution is that all consumers enroll in the cost–efficient HMO sector. This result is straightforward but relatively uninteresting, since it neglects the potentially large HMO profits needed to get HMOs to enroll everyone. We focus instead on the more interesting case of the private cost to the sponsor, not the social cost, and briefly discuss how the results differ from the social optimum in a concluding section.

After deriving some results analytically in Section 2, we examine cost–minimizing risk adjustment empirically in Section 3 using a privately–insured dataset from William M. Mercer, Inc. Our simulations show conventional risk adjustment can significantly overpays HMOs in the presence of biased selection. Cost–minimizing risk adjustment makes better use of the information contained in signals by balancing the trade-off between cost containment and selection. Total payments by the sponsor can be reduced by switching from conventional to cost minimizing risk adjustment.

Before describing our model and results, we would like to anticipate criticisms and rationalize the focus of our approach. We focus here on risk adjustment, an *ex ante* mechanism for calculating payments rather than risk sharing, which is an *ex post* payment mechanism. We make no claims that cost-minimizing risk adjustment is necessarily superior to risk sharing or other *ex post* payment formulas. As already noted, we focus on modeling health plan risk selection using private information. We do not attempt to model consumer choice and how it might be influenced by enrollee premiums, plan benefit features, or individual private information not observed by the plans. We focus on risk adjustment in the context of a price–setting sponsor, which may not be applicable to a market with competitively determined premiums. An interesting extension would be to consider risk adjustment and how it might be implemented in a competitive setting. Finally, we assume away the supply-side behavior that is the focus of Glazer and McGuire (2000) in their optimal risk adjustment paper not because we think it is unimportant, but rather so as to focus on the new insights of this framework.

2 The Model

2.1 Cost–Minimizing Model

Consider a single sponsor using different payment mechanisms for two types of health plans: capitated and noncapitated. Capitated HMOs receive a fixed premium for each enrollee in a given risk class, while noncapitated FFS plans are paid for the cost of health services actually provided. Total costs to the sponsor are the sum of HMO premiums plus FFS actual costs.

The HMO sector is assumed to be more cost efficient than the FFS sector. For generality, we model the cost advantage of HMOs using two parameters: a proportional advantage and a per-person fixed cost advantage over the FFS sector. If a person's health cost is C in the FFS sector, we assume that the cost in the HMO sector to deliver the same services to the same person is $\lambda C - b$ (≥ 0) , where $0 < \lambda \leq 1$ and $b \geq 0$. Miller and Luft (1994), among others, estimate that HMO costs 10% less than FFS, i. e. $\lambda = 90\%$. The cost efficiency of the HMO sector may be for a variety of reasons. For example, plans may be able to influence costs through pricing discounts, selection of lower cost providers or lower claims processing costs, all of which cause $\lambda \leq 1$. Or perhaps HMOs avoid the fixed costs per enrollee needed for claims processing so that $b \geq 0$. The FFS sector passively accepts any people not enrolled by the HMOs and is always reimbursed its cost.

We realize that in the real world, HMO and FFS plans tend to differ systematically in the benefits that they offer, or the quantity and quality of care they provide. In principle, differences in these factors could be estimated by actuaries or as part of the risk adjustment formula, and adjustments could be made in the payments to HMOs. Since we do not have the information that would permit us to make these adjustments (and indeed they seem to be rarely done in practice using conventional risk adjustment models), we ignore the benefit and quality differences in calculating the value of the services provided by HMO and FFS health plans. Also relevant is that consumers do not pay any premiums directly to the health plan. Instead, consumers pay the same amount of premiums to the sponsor regardless of which sector they are in. Hence, the consumers are indifferent between the HMO and FFS sectors. Consumers are completely passive in our model: they apply to be in the HMO sector, but the plan alone decides who to enroll. Given the absence of any quality or quantity differences between the capitated and noncapitated plans, the sponsor cares only about minimizing the sum of payments to the two types of health plans.

The HMO seeks to maximize current period profit by enrolling only those expected to be profitable. Individuals not enrolled are dumped into the FFS sector. Following van Vliet and van de Ven (1992), Newhouse et al. (1989), and van Barneveld (1996), we assume that there is no cost incurred in selection. In the concluding section we discuss the implications of selection costs to our model.

In order to select profitable enrollees, the HMO must have information that differentiates profitable from unprofitable enrollees. Suppose that the sponsor adjusts premiums by the risk adjustors K and that premiums are assumed to be linear combinations of these adjustors. Hence, for any K and weights β the premium for an individual i is $\beta' K_i$. Under the asymmetric information structure, the plan employs information L in addition to K to obtain its own expectation about enrollees' expenditure. For example, if the sponsor uses age and sex as risk adjustors to set up premiums, the plan can employ prior utilization in addition to age and sex to form their own expenditure prediction. The asymmetric information may arise from several possibilities: compared to the sponsor, the plan has more access to enrollees' information; even when the sponsor has the same information, some information may not be appropriate or feasible to use in the capitation formula.[3]

Let $EC_i(K, L)$ be the plan's expectation about an individual i's health cost when i is in the FFS sector. $\lambda EC_i(K, L) - b$ is the expected cost when the individual receives the same service from the HMO sector. Then the expected profit the plan can gain by enrolling individual i into the HMO sector is $\beta' K_i - \lambda EC_i(K, L) + b$. Being a profit maximizer, the plan only keeps individuals with non-negative expected profit in the HMO sector. Therefore, i is in the HMO

[3] van de Ven and van Vliet (1992) summarize the considerations for using various signals as risk adjustors.

sector if $i \in I = \{j \mid \beta' K_j - \lambda EC_j(K, L) + b \geq 0\}$, otherwise the individual is dumped to the FFS sector.

The total cost that the sponsor has to pay for the whole population conditional on the plan's selection strategy is:

$$\int_I \beta' K_i di + \int_{\tilde{I}} C_i di$$

where $I = \{j \mid \beta' K_j - \lambda EC_j(K, L) \geq 0\}$ and $\tilde{I}$ is the complementary set of I.

For a given set of risk adjustors K, the optimal weights β are determined by minimizing the total cost. The objective function is as follows:

$$\min_{\beta} \int_I \beta' K_i di + \int_{\tilde{I}} C_i di$$
$$\text{s. t.} \quad \begin{cases} I = \{j \mid \beta' K_j - \lambda EC_j(K, L) + b \geq 0\}; \\ \tilde{I} = \{j \mid \beta' K_j - \lambda EC_j(K, L) + b < 0\}. \end{cases} \tag{1}$$

It is clear that the vector of optimal cost-minimizing weights β^* is a function of risk adjustors K. Of greater interest is that the optimal β^* also depends on the distribution of health care expenditure C, the structure of the plan's expected expenditure EC, and λ and b which measure the cost efficiency difference between the HMO and FFS sectors. The HMO market share, the ratio of number of individuals in the HMO sector over the total defined population, can be calculated once the vector of optimal weights β^* is determined.

Under conventional risk–adjustment using the set of risk adjustors K, the weights on K are calculated by minimizing the prediction error of health care expenditure. For example, they can be obtained by running the OLS regression of the expenditure in the subsequent year on K.

2.2 Mutually Exclusive Risk Groups

Before we estimate optimal premiums and market shares for one empirical application, we illustrate how the vector of optimal weights β^* is determined for the case where the population can be segmented into mutually exclusive subgroups according to signal K. For example, if sex is the only adjustor, the premiums for female and male would be determined within female and male populations respectively. Suppose that for a representative subgroup, the cost C in the FFS sector has $f(C)$ and $F(C)$ as probability density and distribution functions respectively, both defined over $[0, \infty)$. The optimal cost-minimizing premium for each subgroup minimizes the total payment for that subgroup. The minimization problem becomes:

$$\min_{\beta} L = \min_{\beta} \left[\int_0^{(\beta+b)/\lambda} \beta f(C) dC + \int_{(\beta+b)/\lambda}^{\infty} C f(C) dC \right]. \tag{2}$$

$$\text{s. t. } \beta \geq 0$$

The first part of L measures the total premiums paid to the HMO sector. For a given β, the HMO selects only individuals with $\lambda C - b \leq \beta$, since the plan knows that each enrollee in the HMO sector costs $\lambda C - b$. The second part of L is the total payment for individuals with $\lambda C - b > \beta$ who are dumped to the FFS sector. $\beta = 0$, i. e. paying zero premium for the HMO sector, simply means that the sponsor only offers the FFS sector and its total cost over the defined population is $\int_0^{\infty} C f(C) dC$.

Now, let's consider the case of an interior solution. In order to guarantee existence of an interior solution, the following second order condition (SOC) must be satisfied:

$$SOC = -\frac{f[(\beta+b)/\lambda]}{\lambda^2} + \frac{2}{\lambda} f[(\beta+b)/\lambda] + \frac{\beta}{\lambda^2} f'[(\beta+b)/\lambda] - \frac{\beta+b}{\lambda^3} f'[(\beta+b)/\lambda] \geq 0. \tag{3}$$

Differentiating Eq. 2 and rearranging terms, the optimal cost-minimizing premium β^* is given by:

$$\beta^* = \frac{\beta^* + b}{\lambda} - \frac{\lambda F[(\beta^* + b)/\lambda]}{f[(\beta^* + b)/\lambda]} = C^* - \frac{\lambda F(C^*)}{f(C^*)}, \tag{4}$$

where $C^* = \frac{\beta^* + b}{\lambda}$. Thus, cost-minimizing payment pays the FFS costs of the marginal HMO enrollee (C^*) minus a discount that is based on λ and the hazard rate at C^*. The conventional risk–adjusted premium, β^{con}, simply equals the average cost of the population under the HMO sector. If μ is the average cost in the FFS sector (the mean of $f(C)$), then $\beta^{con} = \lambda\mu - b$.

By differentiating Eq. 4, one can derive the following relationships between β^* and λ, and between β^* and b:

$$\frac{d\beta^*}{d\lambda} = \frac{\beta^* + b}{\lambda} - \frac{\beta^* + b + b\lambda}{\lambda^3 SOC} f[(\beta^* + b)/\lambda]. \tag{5}$$

and

$$\frac{d\beta^*}{db} = \frac{f[(\beta^* + b)/\lambda]}{\lambda SOC} - 1. \tag{6}$$

Each of these equations decomposes the optimal cost-minimizing premium change induced by the HMO cost efficiency change into two separate effects: a cost efficiency effect and a selection effect.

- $\frac{\beta^*+b}{\lambda}$ (> 0) in Eq. 5 and "-1" in Eq. 6 capture the cost efficiency effect. When the HMO sector becomes more cost efficient, i.e. λ decreases or b increases, the optimal cost-minimizing premium decreases.

- $-\frac{\beta^*+b+b\lambda}{\lambda^3 SOC} f[(\beta^* + b)/\lambda]$ (< 0) in Eq. 5 and $\frac{f[(\beta^*+b)/\lambda]}{\lambda SOC}$ (> 0) in Eq. 6 measure the selection effect. As the HMO sector is more cost efficient, the sponsor can reduce the total cost if more people are enrolled in the HMO sector. Given the selection behavior of the plan, the sponsor has to offer higher premiums in order to encourage higher HMO enrollment. Therefore, the optimal cost-minimizing premium increases when λ decreases or b increases.

In the following section, we find the optimal solutions for our model employing a privately–insured dataset.

3 Empirical Study

We use a privately–insured dataset from William Mercer Inc. for the years 1992-93 to estimate cost-minimizing payments and contrast them with conventional risk–adjustment payments. The data contain information on diagnoses, individuals' demographic characteristics, and the total covered charge. We do not have full information about their insurance coverage, but we know that most of the individuals are in the FFS sector. For our estimation, we assume that the total covered charge equals the real cost under the FFS regime. We use prospective adjustors which means that information set K from Year 1 (1992) is used to risk adjust premiums for Year 2 (1993). We restrict our analysis to people eligible for the entire twenty–four months. There are 827,536 non-elderly people, all under age of 65 who qualify using this criterion. Since by construction all individuals were enrolled for all twenty–four months, no weight is required to account for partial year enrollment in our estimations.

We specify the relevant variables as follows:

- In terms of risk adjustors K, three sets of risk adjustors are considered here: age–sex, DCGs, and ACGs. All these risk adjustors segment the total population into exclusive subgroups. There are 16 age-sex cells, 23 DCGs, and 82 ACGs. For the sake of comparison, we also present the case in which no risk adjustor is used at all, and the sponsor pays the same premium for every enrollee in the HMO sector.

- For the two parameters in the HMO cost efficiency function, we consider the following values. In terms of λ, they are 95% and 90% which means that the HMO sector costs 5% and 10% less than the FFS sector, respectively. b takes various values: 0, 100, 150, 200, 250 and 300.

- For any given set of risk adjustors, we assume that the additional information the plan employs is the prior usage in 1992, i.e. $L = C_{-1}$. We regress the cost in 1993, C, on independent variables C_{-1} and K by running OLS regressions. Let $\hat{C}(C_{-1}, K)$ be the predicted level of expenditure in the FFS sector based on OLS regressions, then $EC = \hat{C}(C_{-1}, K)$. The expected cost in the HMO sector for the same individual always equals $\lambda EC - b$. When there is no risk adjustor, we examine all three plan's prediction models: $EC = \hat{C}(C_{-1}, age-sex)$, $EC = \hat{C}(C_{-1}, ACG)$ and $EC = \hat{C}(C_{-1}, DCG)$.

3.1 No Risk Adjustors

First, we investigate the case with no risk adjustment where the sponsor pays the plan the same premium for every enrollee in the HMO sector. Conventional policy will set the premium equal to the average cost under the HMO sector. We have assumed that the cost in 1993 represents the health expenditure when the whole population is covered in the FFS sector. The average cost is \$1556.30. Hence, the conventional premium is $\$1556.30 \times \lambda - b$ which reflects the cost–efficiency of the HMO sector.

Based on Eq. 1, we note that the cost-minimizing premium must be either zero (i. e., everyone is in the FFS sector) or one of the values of the plan's expected cost $\lambda \times EC - b$. We used a grid search algorithm to find the cost-minimizing premium. For each possible value of the payment premiums, we identify whether an individual is in the HMO sector (who has non-negative expected profit) or in the FFS sector. Then we calculate the sponsor's total payment by summing up the total premium payments for HMO enrollees and the total health care expenditure in 1993 for individuals kept in the FFS sector. Finally we choose the cost minimizing risk adjustment formula from among all those considered.

Table 1, shows the results of when the HMO uses age, sex and prior year spending to select enrollees, while the sponsor makes a payment that is not risk adjusted.[4] When the cost difference between the HMO sector and the FFS sector is small (for example, b=0), the sponsor can minimize its payment by simply offering only FFS sector (i. e., premium=0). As the HMO sector becomes more cost efficient (i. e., λ decreases or b increases), the cost-minimizing premiums are not zero anymore, but are significantly smaller than the conventional premiums. The HMO market share under cost-minimizing risk adjustment is always smaller than the one under conventional risk adjustment. For example, the optimal HMO market share with no risk adjustment is 16.4% when HMOs have a 10% proportional cost advantage and a \$300 per person fixed cost advantage. This

[4]We examined similar tables for the case where the HMO uses the information contained in age, sex, and either DCGs or ACGs for selection, and the results were similar. Hence we present only one table here.

is to be contrasted with an HMO market share of 65.8% under conventional risk adjustment. These results indicate that if no information is used to adjust the premiums and the cost-efficiency of HMO is relatively small, conventional risk adjustment tends to overpay the plan and leads to too large of an HMO market share.

Conventional risk–adjusted premiums reflect any known cost savings of HMOs, but do not take into account plan selection. Hence, if the HMO becomes more cost efficient, say b decreases by $50, the conventional premiums will decrease by $50 as well. Consequently, the HMO market rates under conventional risk adjustment are constant across various values of λ and b. However, with cost–minimizing risk adjustment, there are two opposite effects induced by the improved HMO cost efficiency. On the one hand, the efficiency effect decreases premiums, as with conventional premiums. On the other hand, because HMOs are now less expensive, the sponsor will want to encourage the HMO sector to take more enrollees. This is achieved by offering higher HMO premiums relative to HMO costs. Depending on the distribution of costs of individuals, in some cases the selection effect can dominate the cost reduction effect, and hence cost decreases in the HMO sector may actually require increasing the cost-minimizing premiums.[5]

This tradeoff is illustrated in our estimations. Consider the example where there is no risk adjustment, and one is interested in the cost-minimizing premium when the plan uses age-sex and prior usage for cost prediction. Suppose λ is fixed at 0.9 (Tables 1). If everyone in the HMO sector costs $200 less (instead of $150) than everyone in the FFS sector (b moves from 150 to 200), the conventional premium will decrease exactly by $50. However, the cost-minimizing premium *increases* by $15. Here the selection effect dominates the efficiency effect and the HMO market share increases significantly. When b moves from $200 to $250, the cost-minimizing premium

[5] A specific example might illustrate. Suppose that the HMO premium is currently $1000, and that there are a large number of FFS enrollees currently costing $1001. If HMO costs are reduced further even slightly, then it will be attractive to increase the HMO market share so as to cover these marginal people costing $1001. If there are sufficient large number of them at this cost, then the actual premium paid to the HMO may need to increase. We find this pattern regularly in our sample given the sharp mode to the distribution.

decreases exactly by \$50. This reveals that the selection effect is zero and the HMO market share remains the same as before. When b moves from \$250 to \$300, the cost-minimizing premium decreases by \$23. This represents the case when the selection effect is non-zero but it is smaller than the efficiency effect and there is a small increase in the HMO market share.

The estimation results also show that the sponsor can save significantly by switching from conventional to cost–minimizing risk adjustment. Although we have shown it here for using only prior year spending, even greater savings are possible when plans are able to use diagnosis–based information as well. The less cost–efficient the HMO sector is compared to the FFS sector, the more the sponsor can save by using cost-minimizing risk adjustment.

Table 1: No Risk Adjustors

(Plan's cost prediction based on age-sex and prior usage)

	Cost–minimizing Models						Conventional Models
b=	0	100	150	200	250	300	
1. Premiums							
$\lambda = 0.95$	\$0	\$0	\$121	\$111	\$101	\$51	++
$\lambda = 0.9$	\$0	\$0	\$117	\$132	\$83	\$60	++
2. HMO Market Share							
$\lambda = 0.95$	0%	0%	3.7%	12.1%	15.5%	15.5%	65.8%
$\lambda = 0.9$	0%	0%	7.2%	15.5%	15.5%	16.4%	65.8%
3. Cost Saving by Switching From Conventional to Cost–minimizing Risk Adjustment							
$\lambda = 0.95$	25.6%	23.1%	21.9%	20.8%	19.8%	18.9%	—
$\lambda = 0.9$	23.8%	21.1%	19.9%	18.8%	17.8%	16.8%	—

Notes:
++ Conventional premium: $\lambda \times$ \$1556.3 (Average Cost)-b.

3.2 Risk Adjustors

When the sponsor uses age-sex, DCGs or ACGs to adjust premiums, these risk adjustors can group consumers into exclusive categories. In our data, there are 16 subgroups in age-sex, 23 subgroups in DCGs, and 82 subgroups in ACGs. Within each subgroup, the same procedure mentioned above can be used to search for the cost-minimizing premium. For these three risk adjustment models, the plan's expected cost functions for individuals under the FFS sector are $EC = \hat{C}(C_{-1}, age - sex)$, $EC = \hat{C}(C_{-1}, DCG)$, and $EC = \hat{C}(C_{-1}, ACG)$, respectively.

Since the distribution of costs varies across subgroups, the cost-minimizing premium and consequently the HMO market share differ by subgroups. The results in Table 2 demonstrate the variations across subgroups when DCG is used for risk adjustment and cost saving takes the value of $\lambda = 0.95$ and $b = 300$. The average FFS cost differs across DCG subgroups, ranging from $285 to $64,787. Consequently, the conventional premiums which equal the assumed average HMO cost in each subgroup vary from $0 to $61,248. For subpopulation with low average cost (DCG0.2 to DCG2.5), the gains from HMO cost-efficiency dominates the overpayments that result from HMO selection. As a result a payer can save its total cost to encourage more enrollees into HMO by offering premiums higher than conventional ones. For other subgroups with high average cost, HMO selection effect dominates cost-efficiency effect and the payer can save its total cost by discouraging HMO enrollment. As a matter of fact, in seven DCG subgroups of those, the overpayment resulting from HMO selection is so significant that the payer can save total cost by simply keeping only FFS sector (cost-minimizing premium = $0). Overall, the average HMO market share under cost-minimizing adjustment (74.7%) is slightly smaller than the one under conventional adjustmemnt (78.3%) (Table 3).

Similar to the no adjustor model, as the HMO becomes more cost efficient, three scenarios are observed in the subgroups of the three risk adjustment models: the selection effect dominates the efficiency effect which results in the increase of the cost-minimizing premium, the selection effect can be zero which leads cost-minimizing premium decreases by the same amount of HMO cost saving, and the selection effect can be smaller than the efficiency effect and hence the degree of cost-minimizing premium decreasing is smaller that the degree of HMO cost saving.[6]

[6]Complete results are available upon request.

Table 3 presents the average market share for each risk adjustment model. In general, as the HMO efficiency increases, HMO market share of cost-minimizing risk adjustment goes up. When age-sex is used for risk adjustment, the HMO market share of cost-minimizing risk adjustment ranges from 0% to 36.7%, well below 82.5% of the market share under the age-sex conventional risk adjustment. ACG and DCG cost-minimizing risk adjustments encourage higher level of HMO market share compared to the age-sex cost-minimizing risk adjustment. When the HMO improves its cost efficiency, HMO market share under ACG/DCG cost-minimizing risk adjustment is close to the market share under conventional ones. As a matter of fact, when $\lambda = 0.9$ and $b = 300$, the DCG cost-minimizing risk adjustment encourages the plan to extend the HMO market share compared to the DCG conventional risk adjustment.

Table 4 presents how much the sponsor can save by adopting the cost-minimizing risk adjustment instead of conventional risk adjustment. Generally, regardless of risk adjustors, the cost-saving rates decrease as the HMO sector becomes more cost efficient. If age-sex is the risk adjustors used, the sponsor can save significantly by switching from conventional to cost-minimizing risk adjustment. When DCG/ACG are used as adjustors, the savings are relatively small.

Overall, we have considered cost-minimizing risk–adjustment models in the market where the plan has additional information to select enrollees into the HMO sector and the sponsor's goal is to minimize the total cost that includes the premiums for HMO enrollees and the real cost for individuals who are dumped to the FFS sector by the plan. When capitation of the HMO sector improves cost efficiency relative to the FFS sector, HMO selection behavior eventually overshadows the cost–efficiency effect. At some point, encouraging more people to join the HMO increases the total cost to the sponsor even though the HMO sector is more efficient than the FFS sector. For most of the specifications we have examined here, cost–minimizing risk adjustment leads to a smaller HMO market share than conventional risk adjustment. Given the evidence suggesting that in practice HMOs may be only 10% more efficient than the FFS sector, our analysis suggests adds another reason for why sponsors are potentially overpaying the health plan using conventional

Table 2: Risk Adjustors: DCGs

(HMO cost = 0.95* FFS cost - 300, where HMO cost>=0)

DCG	Empirical Data		Premiums		HMO Shares	
	Avg. cost	#individuals	I	II	I	II
DCG0.2	$285	107,476	$0	$8	79.4%	88.5%
DCG0.3	$342	50,354	$25	$55	80.9%	86.5%
DCG0.4	$494	70,394	$169	$213	81.4%	88.5%
DCG0.5	$547	69,553	$220	$226	81.7%	82.9%
DCG0.7	$786	67,235	$447	$515	81.7%	88.6%
DCG1	$1,167	234,676	$808	$865	78.7%	84.6%
DCG1.5	$1,719	45,296	$1,333	$1,361	76.4%	77.8%
DCG2	$2,124	53,613	$1,718	$1,750	76.7%	78.9%
DCG2.5	$2,645	21,144	$2,213	$2,219	72.6%	73.0%
DCG3	$3,198	36,084	$2,738	$0	72.4%	0.0%
DCG4	$4,094	25,268	$3,589	$0	72.0%	0.0%
DCG5	$4,840	15,047	$4,298	$3,929	71.2%	57.6%
DCG6	$5,692	11,606	$5,108	$3,885	70.4%	0.4%
DCG7.5	$7,365	8,679	$6,697	$4,956	69.5%	0.0%
DCG10	$9,672	5,875	$8,888	$0	68.3%	0.0%
DCG15	$14,996	1,967	$13,946	$0	68.6%	0.0%
DCG20	$17,739	1,430	$16,552	$0	66.9%	0.0%
DCG25	$24,011	837	$22,510	$16,711	67.0%	3.9%
DCG30	$33,202	613	$31,242	$22,582	68.0%	7.2%
DCG40	$45,170	249	$42,611	$0	67.5%	0.0%
DCG50	$48,816	73	$46,075	$42,458	69.9%	64.4%
DCG60	$62,117	34	$58,711	$0	58.8%	0.0%
DCG70	$64,787	33	$61,248	$52,529	69.7%	54.5%

Notes:

I: Conventional Models; II: Cost-Minimizing Models.

risk–adjustment: conventional risk adjustment typically results in too large of an HMO market share.

Table 3: Comparison of HMO Market Shares

	Cost–minimizing Models						Conventional
b=	0	100	150	200	250	300	Models
1. Risk Adjustors: Age-sex							
$\lambda = 0.95$	0%	0%	10.6%	14.8%	27.6%	30.9%	82.5%
$\lambda = 0.9$	0%	0%	10.8%	23.9%	33.6%	36.7%	82.5%
2. Risk Adjustors: DCG							
$\lambda = 0.95$	0.4%	0.4%	30.6%	42.1%	48.6%	74.7%	78.3%
$\lambda = 0.9$	1.0%	28.2%	50.4%	79.7%	80.1%	82.3%	78.3%
3. Risk Adjustors: ACG							
$\lambda = 0.95$	1.1%	54.5%	62.2%	68.7%	71.2%	72.2%	83.5%
$\lambda = 0.9$	1.8%	66.8%	70.4%	71.8%	73.3%	79.8%	83.5%

Table 4: Cost Savings by Switching from Conventional to Cost-minimizing Risk Adjustment

	Cost–minimizing Models					
b=	0	100	150	200	250	300
1. Risk Adjustors: Age-sex						
$\lambda = 0.95$	20.5%	17.0%	15.2%	13.5%	12.2%	10.9%
$\lambda = 0.9$	17.8%	14.1%	12.2%	10.6%	9.3%	8.1%
2. Risk Adjustors: DCG						
$\lambda = 0.95$	11.3%	7.2%	5.5%	4.2%	3.2%	3.0%
$\lambda = 0.9$	8.2%	3.9%	2.6%	2.0%	2.1%	2.3%
3. Risk Adjustors: ACG						
$\lambda = 0.95$	10.3%	7.2%	6.6%	6.1%	5.9%	5.6%
$\lambda = 0.9$	7.1%	5.0%	4.7%	4.4%	4.1%	4.1%

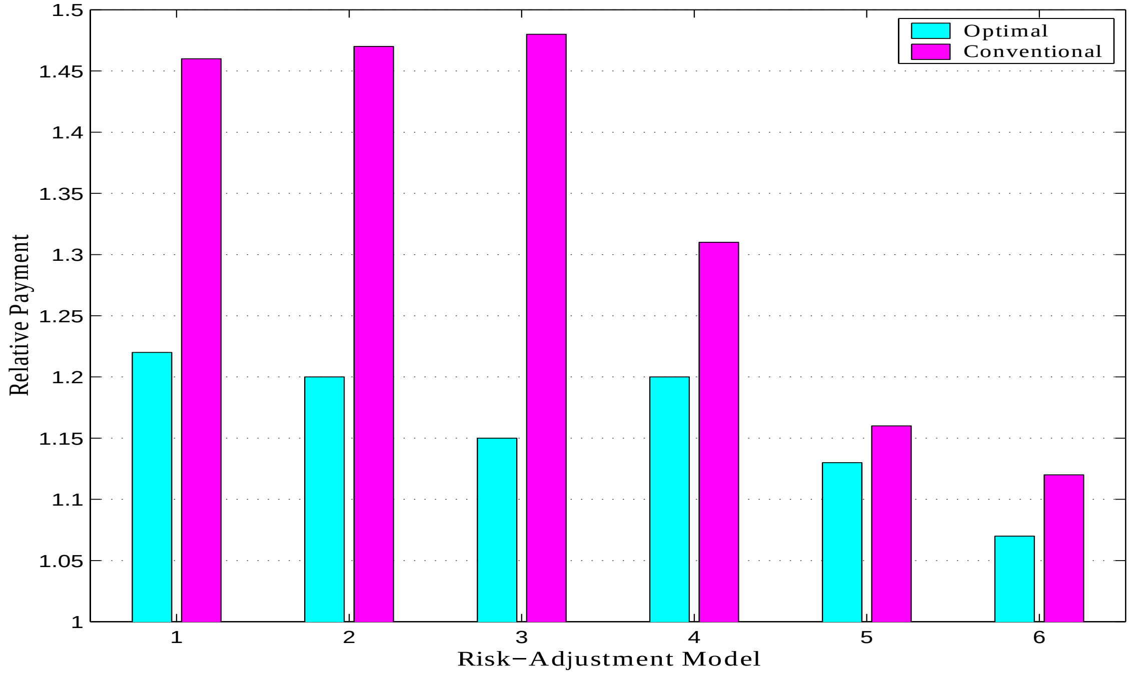
3.3 Comparison of Total Costs

We can also compare total payments under different specifications to the optimal social cost, which is the theoretical minimum payment. As we have already mentioned, the cost–minimizing premium from the sponsor's point of view is different from that which minimizes social costs, since the first best is not achievable. The solution for minimizing social costs is that everyone joins the HMO sector. In this scenario the optimal social cost is calculated by applying cost discount value of λ and b to real expenditure in 1993 (the cost in FFS). The ratio of the sponsor's total payments to the optimal social cost provides a measure of the degrees of overpayment compared to the optimal social cost. We demonstrate the pattern of cost comparisons using the results when the HMO sector has the largest cost saving advantage compared to the FFS sector, where $\lambda = 0.9$ and $b = 300$ (see Figure 1).

It is not surprising that when constrained to use the same risk adjustors, cost-minimizing models always reduce payments compared to the conventional risk adjustment. For example, DCG cost-minimizing risk adjustment costs 13% more than the optimal social cost (relative payment:1.13), compared to 16% under the DCG conventional adjustment. Figure 1 also highlights that that any of the cost-minimizing payment systems save costs relative to all conventional payment systems with one exception: conventional risk adjustment using ACGs has the smallest payment among all the conventional risk adjustment models. As a matter of fact, it can work almost as well as cost-minimizing risk adjustments or even slightly better, depending on the specifications of λ and b.

Across various cost-minimizing risk adjustments, the ACG model is the most effective at minimizing total payments, improving cost-saving. The relative payment under the ACG cost-minimizing risk adjustment is 1.07, which means that the sponsor's payment is only 7% higher than the optimal social cost. A relative payment of 1.13 is the best result that can be achieved under other cost-minimizing risk adjustment.

Figure 1: Comparison of Total Costs ($\lambda = 0.9$, $b = 300$)



NOTES:

Payment: Value relative to the optimal social cost.

Model 1: Risk adjustor: none. Cost prediction is based on age–sex, and prior usage.

Model 2: Risk adjustor: none. Cost prediction is based on DCG and prior usage.

Model 3: Risk adjustor: none. Cost prediction is based on ACG and prior usage.

Model 4: Risk adjustor: age–sex. Cost prediction is based on age–sex, and prior usage.

Model 5: Risk adjustor: DCG. Cost prediction is based on DCG and prior usage.

Model 6: Risk adjustor: ACG. Cost prediction is based on ACG and prior usage.

4 Conclusions

How to mitigate selection is a challenge faced by every sponsor using capitation payment. Conventional risk adjustment has tried to refine the set of risk adjustors in order to bring capitation payment close to each individual's expected expenditure. However, due to the potential profit gain, a health plan may still engage in the selection behavior by using private information to identify and select enrollees with non-negative expected profit into the HMO sector. If HMOs are able to select in this manner, conventional risk adjustment models which set premiums on adjustors to minimize a loss function equal to the sum of the squared deviations of predicted and actual health care cost are not optimal. Instead, we have proposed cost–minimizing risk adjustment, whereby the weights assigned to risk adjustor signals are determined by minimizing a new loss function: total health care payment conditional on health plan selection behavior. The optimal premiums balance the consequences of HMO cost efficiency against the overpayments due to selection.

Our analysis is based on a special and simple model. For a more comprehensive understanding of cost-minimizing premiums, our framework could be extended in several areas.

- We have considered a simple model of dumping where an HMO can enroll everyone it wants, and the FFS is a "risk sink" where all the unprofitable consumers go. However, consumers may have their own preferences over the FFS or HMO sector. A more complete model would include demand side considerations as well as supply side dumping.

- We postulate that HMOs are able to perfectly select the profitable and dump the unprofitable enrollees, such as by selectively marketing or selective enrollment and disenrollment. Clearly, HMOs will be able to do this less perfectly than our estimations suggest. It may be informative to model and simulate alternative mechanisms for selecting enrollees, if such selection can be understood.

- A related point is that HMO effort to select profitable enrollees will be costly, which we have not explicitly modeled. We believe that without any loss in generality, selection costs can be subsumed into the fixed or proportional cost parameters that we do model, and hence selection costs would change parameter values but not the predictions of our model.

- In this study, we assume that the cost efficiency difference between HMO and FFS sectors, λ and b, are exogenous variables. It is possible that the efficiency of the HMO sector has a spill–over effect on the FFS sector. When more and more individuals enroll in the HMO sector, the cost difference between HMO and FFS sectors could decrease. Hence, one possible extension would be to assume that λ (or b) itself is a choice variable, and potentially a function of the

HMO market share. λ may also be viewed as the discount the sponsor can get from the health plan. In this case, λ endogeneity may stem from the sponsor's bargaining power with the health plan. The more potential enrollees there are, the more bargaining power the sponsor may have, leading to a larger discount. Under this circumstance, we would expect λ to have a negative correlation with the HMO market share.

- We have not tried to model risk adjustment in a competitively–priced

  HMO market. It could be fruitful to explore cost minimizing risk adjustment in a setting where health plans competitively bid on risk adjusted premiums, where risk adjustment information is used only to standardize payments or adjust for differences in riskiness between projected and actual enrollments.

- Since our estimations are based on one non–elderly population dataset, it would be desirable to apply our method to other datasets to test the robustness of our findings.

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