Evaluating Financial Risk in the Medicare Prospective Payment System

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The Medicare Prospective Payment System (PPS) is analogous to an insurance scheme in which financial risk is mitigated through experience rating. In addition, risk is also mitigated through reinsurance provisions. Although a provider may not want this reinsurance, participation is mandatory. We develop a framework for evaluating financial risk under the PPS. We use this framework to examine optional reinsurance as an alternative risk mitigation mechanism. We illustrate an application of optional reinsurance using data for Medicare psychiatric inpatient services. Our analysis indicates that viable schemes exist for implementing optional reinsurance as a prospective payment option.
(*Health Care; Hospitals; Medicare; Pricing; Psychiatric Services*)

1. Introduction

In 1983, in response to rapidly rising costs associated with retrospective cost-based reimbursement, Congress established the Medicare Prospective Payment System (PPS) to pay for inpatient services. In important respects, the PPS is analogous to an experience-rated insurance scheme with mandatory reinsurance. In exchange for assuming financial risk for caring for a patient during a hospital stay, the provider receives a prospectively determined payment. This payment may be thought of as an experience-rated "premium," determined on the basis of patient diagnosis at discharge, based on Diagnosis Related Groups (DRGs) and selected provider and geographic characteristics. Providers are also eligible for retrospective "outlier" payments based on the actual costs of caring for unusually costly patients.[1] These retrospective payments may be thought of as a form of reinsurance (Keeler et al. 1988) in which 1) participation is mandatory (i.e., opting out of reinsurance provisions is not an option); and 2) there is an implicit premium imposed on providers through a downward adjustment in PPS-based payments to finance outlier payments (Federal Register 1983, p. 39776).

The underlying notion in the PPS is that, by placing providers at financial risk for the cost of the services they provide, incentives can be created to increase efficiency across the board (Schliefer 1985). Two related problems exist with this approach. First, providers may respond strategically to financial risk in

[1] While only a small percentage of patient discharges are eligible for outlier payments (less than 3% in 1984) (HCFA 1987), currently there is a downward adjustment equal to 5.1% of total PPS-base operating payments to cover outliers and, in 1997, total payments for outliers exceeded 3 billion dollars. These payments are concentrated in large, urban, and teaching hospitals. In 1997, urban hospitals with 300 beds or more accounted for nearly 55% of outlier payments, but only 38% of PPS discharges. In contrast, rural hospitals with under 200 beds accounted for less than 7% of outlier payments, but 17% of PPS discharges (ProPAC 1997).

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addition to or in lieu of attempting to increase efficiency, for example, by manipulating quality and/or denying access to care for unprofitable patients. Second, providers' exposure to risk may vary for reasons beyond their control. Thus, there may be systematic differences in providers' expected costs of treating patients due to differences in input costs or inter-DRG case mix. Providers' costs may also vary because of nonsystematic (random) fluctuations in the treatment needs of patients within DRGs (see Dranove 1987, Allen and Gertler 1991, Ellis and McGuire 1988).

Outlier payments have been justified on the grounds that they mitigate incentives for providers to avoid unusually costly patients or to forego appropriate treatments, and that they systematically redistribute revenues to providers who face a greater risk of treating high-cost patients (ProPAC 1997). However, even with outlier payments and other existing adjustments, an important public policy issue remains: Can current PPS rules can be modified to make the distribution of financial risk more equitable and/or efficient? In the face of concerns regarding fairness and strategic behavior, two major types of modifications have been proposed in PPS payment rules to redistribute providers' exposure to financial risk. The first is refinements in experience rating; for instance, in DRG categories or in adjustments to payments on the basis of provider characteristics (see, for example, Edwards et al. 1994, Dada et al. 1992, HCFA 1987). The second is refinements and/or expansion of mandatory reinsurance provisions; for example, through use of "mixed" payment systems increasing the retrospective component of payments. (See, for example, Goodall 1990, McGuire et al. 1990, Pope 1990, Siegel et al. 1992.)

Both refinements in experience rating and in reinsurance provisions can simultaneously alter providers' exposure to financial risk associated with systematic and nonsystematic variations in costs. Efforts to evaluate the financial risk implications of proposed modifications have typically examined the impact on the mean and variance of patient profitability. Changes in expected profits provide a direct monetary measure of changes in systematic financial risk associated with alternative proposals. The mean and variance of profits do not, however, provide a comparable measure of either the impact on nonsystematic (random) risk or on the total risk faced by a provider in a given period (i.e., the combined financial risk associated with systematic and nonsystematic variations). In addition, it is important to consider implications of random variations for provider as well as patient-level profitability. This is because the provider, rather than the patient, is often the relevant unit for analysis. The impact of random variations at the provider level will depend not only on the degree of variation at the patient level, but also on total volume at the provider level; as the number of discharges increases, financial risk associated with random variations will approach zero.

This paper makes two contributions to the literature. First, drawing on an insurance analogy, we develop a general framework for characterizing financial risk associated with systematic and nonsystematic (random) variations. In particular, financial risk is characterized in terms of the reserve a provider must hold to avoid insolvency with a desired degree of certainty. Second, we illustrate how this framework may be used to assess an additional payment option for the PPS not previously considered in the literature: voluntary reinsurance (i.e., outlier provisions in which participation is optional). Other possible applications include analysis of the implications of newly emerging forms of payment, for example, capitated payment schemes for physicians discussed in the final section of the paper.

In §2 we develop a generic model of pricing under the Medicare PPS. We use this model to examine the reserve that is necessary for a provider to hold to assure solvency with a desired level of certainty as a result of systematic and random variations in patient treatment costs. In §3, we introduce voluntary reinsurance as a prospective payment option and model the market for it under the assumption that providers are risk-neutral, profit-maximizing firms, but are subject to insolvency constraints. In §4, we present several ways of computing reinsurance premiums for voluntary schemes.

In §5, we apply the methodological framework developed in the previous sections to examine the feasibility and possible effects on financial risk of offering optional reinsurance as an option using data for Medicare psychiatric inpatient discharges for 1985. We find in §6 that viable individually- and group-rated optional reinsurance schemes exist that would reduce the reserves necessary for providers to hold in response to random variations. However, our analysis suggests that for psychiatric inpatient services, risk associated with random variations is limited and that participation in voluntary reinsurance would be low. We close with a discussion of possible policy implications of our findings in §7.

2. An Insurance Analogy

In this section we use an insurance analogy to model financial risk under the PPS. We draw on this analogy to present a general pricing scheme which can be specialized to show its equivalence to current Medicare PPS payment rules and proposed changes in these rules. We then develop a framework for characterizing the financial risk associated with pricing schemes in terms of the reserves necessary for a provider to hold to avoid insolvency with a desired level of certainty.

2.1. Reimbursement Under the Prospective Payment System

Let the subscript j, $j = 1, \ldots, J$, denote a provider and the subscript i any one of its n_j inpatients treated in a given fiscal period, usually a year. (Note that n_j can also be modeled as a random variable drawn from an appropriate distribution without affecting the results.) Let C_{ij} be the cost of treating patient i, which is an independently, identically distributed random variable drawn from a given distribution. Let R_{ij} denote the total reimbursement received by provider j for treatment of patient i. Treating prospective payment as an insurance/reinsurance scheme, R_{ij} may be written as a function of three components:

$$R_{ij} = B_{ij} - RP_{ij} + RE_{ij}. \qquad (2.1)$$

The three functions, B_{ij}, RP_{ij}, and RE_{ij}, have i and j as subscripts to denote any adjustments that are specific to the patient and the provider or its geographic locale, respectively. In this way, as in insurance contracts, aspects of experience rating can be incorporated to adjust for differential risk characteristics.

B_{ij} represents the base prospective payment received by the provider. RE_{ij} represents the retrospective payment, if any, based on realized resource use received by the provider. Thus, it represents any reinsurance payment. RP_{ij} represents the premium, if any, paid prospectively by the provider, to become eligible for reinsurance. Thus, (2.1) is a hybrid scheme in which the difference, $B_{ij} - RP_{ij}$, is the effective prospective payment, and RE_{ij} is the effective reinsurance payment. Equation (2.1) subsumes, as a special case, the current PPS pricing rules, i.e., base DRG payments plus retrospective reimbursement for patients who are "outliers," where both DRG payments and outlier thresholds are adjusted (experience rated) to reflect provider characteristics. Equation (2.1) also subsumes proposed modifications of the PPS, for example, proposals for further experience rating and proposals for "mixed" payment systems combining fixed DRG payments with payments based on providers' incurred costs (Goodall 1990, McGuire et al. 1990, Pope 1990, Siegel et al. 1992). Consequently, the risk implications developed below apply to a wide class of pricing schemes that represent virtually all proposed modifications to the PPS.

2.2. Risk Implications of the PPS

To evaluate the risk implications of the Medicare PPS, it is necessary to relate (2.1) to profitability. Let π_{ij} be the profit from treating the ith patient of provider j, which is the difference between revenue given by (2.1) and treatment cost C_{ij}:

$$\pi_{ij} = B_{ij} - RP_{ij} + RE_{ij} - C_{ij}. \qquad (2.2)$$

Since (2.1) and (2.2) depend on the actual treatment pattern of the patient, variations in treatment patterns directly result in variations in revenue and profit. If the analysis is focused on the patient level, then (2.2) immediately suggests that, to manage risk, tradeoffs can be made between the expected value of patient-profit and its variation around the expected value. In many studies, such as Keeler et al. (1988) and Freiman et al. (1988), uncertainty is represented by the standard deviation of patient-profitability. As pointed out by Siegel et al. (1992), C_{ij} can be quite skewed. The skewness in treatment cost also exacerbates the skewness of reinsurance payment RE_{ij} when it represents an outlier payment, in which case RE_{ij} is a random variable that takes the value zero if the cost is below the outlier threshold and a fraction of the cost in excess of the threshold. Since these two factors work together to make π_{ij} skewed, using the standard deviation only to represent the uncertainty in patient-profitability may not be appropriate since it does not fully capture the shape of the distribution in such cases. Further, tradeoffs between the expected profit and the variability of patient-profit around its expected value do not directly indicate how the overall performance of the provider is affected. For instance, what is the probability that the provider will break even? And what reserve must be kept to assure solvency with some desired level of certainty? Such questions can only be addressed by explicitly looking at profitability at the provider level. By (2.1) the expected profit for provider j is merely the sum of the profit of its n_j patients. As with patient-profitability, variations in treatment patterns also result in variations in total profit for the provider.

A provider's expected profit gives a measure of its long-run profitability. The standard deviation (variance) of profit around its expected value provides a measure of the variability of a provider's profits in any given period, say a year. But, as noted above, it can have important shortcomings. These can be addressed by drawing on an alternative financial measure from the insurance literature for evaluating risk for any given period: the total reserve required to assure that the provider will be protected from insolvency with some desired level of certainty. This measure provides a more direct way of measuring risk, because, unlike the standard deviation, it represents a particular fractile of the distribution. In other words, it directly takes the shape of the distribution of provider profit into account.

Although useful in assessing short-term risk, the required total reserve does not provide a direct measure of the financial risk of incurring a loss as a result of random variations. Consider a provider that expected a loss. It would need, at a minimum, a reserve equal to its expected loss; we refer to this reserve as the *systematic reserve*. The residual reserve, the difference between the total reserve and the systematic reserve, is the *diversifiable reserve*, and it would approach zero as the number of discharges increases for a provider. In this sense, the diversifiable reserve provides a surrogate for measuring the risk from random variations. Interestingly, the decomposition has different properties for a provider that expects a profit. In this case, the systematic reserve is zero, so the total reserve is identified with the residual or the diversifiable reserve. It then follows that, since the diversifiable reserve would approach zero as the number of discharges increases, so does the total reserve because both have the same value. In contrast, using the standard deviation as a surrogate for short-term financial risk for a provider due to random variations, as used by Keeler et al. (1988), does not capture this effect.

Using the reserve as a measure of short-term risk can provide additional insight into tradeoffs associated with PPS pricing schemes. Consider the impact of a proposal to increase the generosity of outlier benefits, leading to an increase in the expected value of RE_{ij}. To facilitate comparison with a benchmark case, it is usually assumed that the expected total level of reimbursement is the same in both schemes, which leads, in this case, to a compensating reduction in $B_{ij} - RP_{ij}$, the effective prospective payment.[2] Under these conditions, increasing the generosity of reinsurance provisions under current PPS rules will reduce risk as measured by a decrease in the mean variance of provider-profitability (Keeler et al. 1988) and the mean reserve ratio (Dada et al. 1992), suggesting that risk from random variations is falling. However, increasing reinsurance payments necessitates a compensating reduction in base prospective payments. Consequently, some providers, especially those who have few or no eligible outliers, may find a net reduction in expected profit leading to a net increase in the required reserve. This is because the required increase in their systematic reserve is only partially compensated for by the decrease in their diversifiable reserve. In short, mandatory reinsurance may result in systematic forced transfers of revenue, for example from

[2] Whether budget-neutral changes in PPS payment rules are politically feasible is a separate issue we do not attempt to address here.

low-cost, low-variance providers to high-cost, high-variance providers.

Forced transfers may be justified directly as a means of correcting inequities in the distribution of systematic risk and redistributing revenues to providers who are more likely to serve unusually costly patients. They may also be justified as a necessary, albeit not necessarily desirable, consequence of using outlier payments to mitigate strategic behavior (e.g., avoidance or undertreatment of unusually costly patients). Finally, mandatory reinsurance and associated forced transfers may be justified as a means of assuring access to reinsurance against nonsystematic variations in costs.

As discussed, refinements in experience rating, for example through refinements of DRG classifications, offer an alternative means of redistributing systematic and nonsystematic risk and mitigating financial incentives. We show next that voluntary reinsurance may also be a viable alternative for mitigating financial risk associated with nonsystematic cost variations. Policy makers need to weigh carefully the use of mandatory reinsurance against these alternatives. In particular, to the extent policy makers are specifically concerned about mitigating risk associated with nonsystematic variations, voluntary reinsurance avoids any forced transfers.

2.3. Applications

The analysis developed here has several possible applications useful for both individual providers and public policy makers. Individual providers may use it to assess their exposure to financial risk under the PPS. They may also use this framework to estimate the level of reserves, if any, which they may wish to carry to avoid insolvency. Finally, decomposing reserves into systematic and diversifiable components may be useful to individual providers in developing risk management strategies. One possible strategy for managing risk is to increase volume to reduce the diversifiable reserve through risk pooling. This strategy may be of particular interest if the diversifiable component of reserves is large and opportunities exist for expanding volume, for instance by more aggressive marketing or a joint venture. Note that benefits from possible reductions in financial risk from expanding volume may complement possible economies of scale in the production process in meeting peak-load problems, which have been discussed as a motivation for hospital mergers, especially in low-volume markets (Lynk 1995). A second strategy is to drop selected product lines. For example, this approach may be used if variations are low (e.g. a provider faces a population in a DRG with systematically higher severity) or opportunities to expand volume are limited.

This analysis may be used by public policy makers to consider the implications of alternative policy options for the overall distribution of financial risk in payment systems. Specifically, in the sections that follow, we use our framework to consider voluntary reinsurance as a prospective payment option under the assumption that providers are risk-neutral, profit-maximizing firms subject to insolvency constraints, for example as a result of creditor concerns and/or government regulation.[3]

3. Modeling Optional Reinsurance

Adapting the pricing rule (2.1), there are many possible types of reinsurance policies which could be implemented under the Medicare PPS. We develop a framework for evaluating whether offering such insurance schemes on an optional basis is financially viable. Our test for viability is that the scheme be self-financing so that premiums from participating providers can exceed expected reimbursement. For the model presented here, the only additional assumption required is that premiums are determined prospectively. In evaluating the financial risk implications of possible schemes, it is useful to establish a benchmark. In this analysis, we use as a benchmark a PPS with no reinsurance in which a provider simply receives a base payment (i.e., a "pure" PPS in which all payments are prospective).

We compare our benchmark case to a second case in which, in addition to receiving a base payment, a provider may elect optional reinsurance coverage (i.e.,

[3] Alternative behavioral assumptions are also possible. We consider the case of a risk-averse firm in the companion Addendum, available from the authors.

retrospective reimbursement based on actual treatment costs for patients under some predetermined set of rules). To qualify for this reinsurance benefit, the provider must pay a prospective premium, reducing the effective base payment. But no reduction will occur if they do not participate. For ease of exposition, we assume that RP_{ij}, the reinsurance premium per patient, is the same for all patients for a given provider and denote it RP_j.

Let π_{ij}^1 be the profit from treating the ith patient of provider j in the benchmark case (i.e., prospective payment only). Then, applying (2.2):

$$\pi_{ij}^1 = B_{ij} - C_{ij}. \quad (3.1)$$

Let π_{ij}^2 be the profit from treating the ith patient of provider j in the second case when there is reinsurance. Then, applying (2.2) and (3.1):

$$\pi_{ij}^2 = \pi_{ij}^1 - RP_j + RE_{ij}. \quad (3.2)$$

Thus, Δ_{ij}, the incremental benefit of opting for reinsurance, will be:

$$\Delta_{ij} = -RP_j + RE_{ij}. \quad (3.3)$$

Since the reinsurance payments are received for eligible patients only, the typical provider may find that Δ_{ij} is negative for most patients. Hence, there is an incremental loss on most patients. To motivate why reinsurance may be attractive to a provider, we begin by considering a profit-maximizing provider who is risk neutral and is not constrained by the insolvency constraint and, hence, has no reason to hold a reserve. Such a provider will undertake optional reinsurance if and only if the expected value of RE_{ij} exceeds the premium RP_j:

$$E(\Delta_{ij}) = -RP_j + E(RE_{ij}) > 0. \quad (3.4)$$

Since a provider will undertake optional reinsurance only if the premium is less than the expected reinsurance benefit, this benefit is the reservation price of the provider for purchasing optional reinsurance. The reservation prices given by (3.4) assume that providers are risk-neutral and maximize expected profit. When this is the case, at most it will be possible to recover a premium equal to the expected benefit, which leaves no room to recover administrative costs.[4]

A provider's reservation price may exceed its expected pay-out from reinsurance for at least two reasons. First, although risk-neutral, a provider may be subject to an insolvency constraint. This may occur, for example, because of concern by regulators or risk-averse debt holders. Second, the provider itself may be risk-averse. In this analysis we assume that providers are risk-neutral but are subject to an insolvency constraint. That is, each provider must carry a reserve to protect itself from the risk of insolvency with some prespecified degree of uncertainty. (An alternative formulation assuming providers are risk-averse is available as an addendum from the authors by request.)

The key idea is that holding a reserve is expensive because of the opportunity cost of capital. We assume without loss of generality that the cost of capital to a provider and the desired probability with which it wishes to avoid insolvency are given and are the same for each provider. This permits us to calculate a provider's required reserve and, given its cost of capital, its cost of holding this reserve. Next, we modify (3.1) to include the cost of holding a reserve, which then can lead to a reservation price that is greater than the expected reinsurance benefit, suggesting that viable self-financing schemes for optional reinsurance schemes can exist.

First consider the benchmark case of a "pure" PPS in which there is no reinsurance. Let R_j^1 be the reserve per patient that provider j must hold to satisfy its reserve requirement. This is computed by determining the total reserve for the provider and then dividing it by the number of inpatients. Let β be the cost of capital to the provider. Then, $\tilde{\pi}_{ij}^1$, the adjusted profit for patient i in this case is:

[4] This is immediately apparent for an individually-rated scheme, since a risk-neutral provider will at most be willing to pay a premium equal to the expected reinsurance benefit and no administrative costs can be recovered. In the case of a group-rated scheme for risk-neutral providers, adverse selection will drive up the premium to the reservation price of the provider with the highest expected pay-out. Hence, in this case also, it will not be possible to recover any administrative costs.

$$\tilde{\pi}^1_{ij} = \pi^1_{ij} - \beta R^1_j. \qquad (3.5)$$

In the second case, where reinsurance is offered in exchange for a premium, let $R^2_j(RP_j)$ be the reserve per patient required if the provider participates in reinsurance. In this case, adjusted profit for patient i, $\tilde{\pi}^2_{ij}$ is:

$$\tilde{\pi}^2_{ij} = \pi^1_{ij} - RP_j + RE_{ij} - \beta R^2_j(RP_j). \qquad (3.6)$$

Including reinsurance benefits changes the location and shape of the distribution of provider profitability. Since the premium uniformly lowers revenue for each patient, in the absence of any reinsurance benefits this would result in a uniform shift in the distribution of provider profitability that decreases its expected value and increases the reserve per patient (by up to the premium). However, receiving reinsurance benefits mitigates this effect by increasing revenue on some patients so that the probability of a large loss is decreased. This may reduce the reserve, and, because revenue is increased, the expected value of profitability may improve.

Let $\tilde{\Delta}_{ij}$ be the adjusted benefit of optional reinsurance, defined by the difference of (3.6) and (3.5). A provider will undertake optional reinsurance if and only if the expectation of $\tilde{\Delta}_{ij}$ is positive. Taking its expectation yields:

$$E(\tilde{\Delta}_{ij}) = -RP_j + E(RE_{ij}) - \beta(R^2_j(RP_j) - R^1_j) > 0. \qquad (3.7)$$

By analogy to (3.4), (3.7) also yields a reservation price. Finding this reservation price would appear difficult because the reserve $R^2_j(RP_j)$ is an explicit function of the premium. As is shown below, however, the reservation price can be found by utilizing the assumption that the reinsurance premiums are determined prospectively. As is also shown, given reservation prices for all providers, we can evaluate whether viable schemes for optional reinsurance can be devised that are self-financing and that can recover administrative costs if deemed appropriate.

4. Pricing Optional Reinsurance

A provider will participate in optional reinsurance if the premium is less than the reservation price and not participate in optional reinsurance if the premium is greater than the reservation price. For the reinsurance scheme to be self-financing, the premium must be greater than or equal to the weighted average of the expected reinsurance payment per patient for participating providers. Thus any viable pricing scheme must satisfy these two sets of conditions.

If the participating providers are known, then the minimum premium is easy to compute. However, identifying participating providers is predicated on knowing each provider's reservation price, which, in our model, requires solving (3.7) with the inequality replaced with an equality. This solution requires determining, for each provider, the reserve per patient for the benchmark case; and for the reinsurance case, the reserve per patient for any premium.

Assume that the distribution of provider profitability is known or has been empirically estimated. Let $F^1_j(\alpha)$ be the α'th fractile of the distribution of provider profitability per patient in the benchmark case. Then R_1, the reserve per patient required to assure solvency with probability $(1 - \alpha)$ is

$$R_1 = -\min(0, F^1_j(\alpha)). \qquad (4.1)$$

The "0" in the minimum operator ensures that the reserve is nonnegative and the "−" converts a loss into the reserve requirement. Thus, when the α'th fractile is positive no reserve is necessary. Note that R_1 is always positive for providers that expect a loss because each of them must carry a systematic reserve.

Analogously, in the case of reinsurance, assume that the distribution of profitability per patient is known. Let $F^2_j(\alpha, RP_j)$ be the α'th fractile of provider profitability per patient. Then the reserve per patient required to assure solvency with probability $(1 - \alpha)$ is:

$$R_2(RP_j) = -\min(0, F^2_j(\alpha, RP_j)). \qquad (4.2)$$

Thus, using (4.2) in (3.7), P_j, the reservation price for provider j is the solution to:

$$-RP_j + E(RE_{ij}) + \beta R^1_j + \beta(\min(0, F^2_j(\alpha, RP_j))) = 0. \qquad (4.3)$$

Observe that while $F^2_j(\alpha, RP_j)$ depends on RP_j in a complex way, because reinsurance payments in our model are independent of the premium, (4.3) can be simplified using the following proposition:

PROPOSITION 1. *Given a reinsurance function RE_{ij}, the α'th fractile for premium RP_j satisfies:*

$$F_j^2(\alpha, RP_j) = F_j^2(\alpha, 0) - RP_j. \quad (4.4)$$

The proof is trivial and omitted. The intuition behind this proposition is that the reinsurance policy determines the shape of the distribution and it and the premium together determine the location of any fractile in the distribution.

Using this result the reservation price is given by the following:

PROPOSITION 2. *For provider j, $j = 1, \ldots, J$, the reservation price, P_j, is given by:*

$$P_j = \min[E(RE_{ij}) + \beta R_j^1, (E(RE_{ij}) + \beta R_j^1 + \beta F_2(\alpha, 0))/(1 + \beta)]. \quad (4.5)$$

PROOF. Start from

$$P_j = E(RE_{ij}) + \beta R_j^1 + \beta \min(0, F^2(\alpha, 0) - P_j).$$

This implies that $P_j \leq E(RE_{ij}) + \beta R_j^1 \equiv P_j^1$. Also, $P_j \leq E(RE_{ij}) + \beta R_j^1 + \beta \min(0, F^2(\alpha.0) - P_j)$. Rearranging terms gives: $P_j \leq (E(RE_{ij}) + \beta R_j^1 + \beta F^2(\alpha, 0))/(1 + \beta) \equiv P_j^2$. From this it follows that

$$P_j = \min(P_j^1, P_j^2) = \min[E(RE_{ij}) + \beta R_j^1, (E(RE_{ij}) + \beta R_j^1 + \beta F^2(\alpha, 0))/(1 + \beta)]. \quad \square$$

Note that calculating P_j only required information on provider j. Therefore, it can be calculated for any provider-specific values for α and β.

Proposition 2 gives a simple computational approach to finding the reservation prices for all providers of any optional policy. It requires evaluation of a fractile of the distribution of provider profitability for the benchmark case and evaluation of the same fractile under the reinsurance case with a premium of zero dollars.

Once these reservation prices are known, it is easy to price the premium for this optional pricing scheme. Assume without loss of generality that the providers are ordered such that $P_1 \geq P_2 \geq \cdots \geq P_J$. Then, for a given premium P, providers 1 to k will participate, such that:

$$P_1 \geq P_2 \geq \cdots \geq P_k > P \geq P_{k+1} \geq \cdots \geq P_J. \quad (4.6)$$

If the first k, $k = 1, \ldots, J$, providers participate, then, $PO(k)$, the expected payout per patient is the weighted average of the expected reinsurance reimbursement to the first k providers:

$$PO(k) = \sum_{j=1}^{k} n_j^*(RE_{ij})/[\sum_{j=1}^{k} n_j]. \quad (4.7)$$

The premium P can be chosen in a variety of ways. For example, if there are no administrative costs and the reinsurance scheme must be self-financing, then the premium equals the expected payout, so that

$$P(k) = PO(k). \quad (4.8)$$

Conditions (4.6) and (4.8) and Proposition 2 together imply that:

PROPOSITION 3. *If the reinsurance scheme is self-financing and there are no administrative costs, then the first k^* providers participate and the premium P^* satisfies* (4.6) *and* (4.8).

Finding all solutions satisfying Proposition 3 requires systematically going through the sorted providers once to find all premiums that satisfy Proposition 3. It is easy to show that at least one solution exists. Examples can be generated such that there are multiple solutions. However, in the empirical work examining potential equilibrium in the market for optional reinsurance reported in the next two sections, there were unique solutions satisfying Proposition 3 for all scenarios that were examined. Proposition 3 assumes that all providers are offered the same premium. It can be easily generalized to provide an experience-rated premium by making appropriate changes in (4.6) and (4.8). For example, fixed costs may be included by modifying (4.8) by adding a term to its right-hand-side that allocated this cost on a per-discharge basis. Experience rating requires adding appropriate weights to correct the nominal premium for the realized premium paid per discharge by each provider.

5. Illustration

In this paper we have developed an approach to evaluating the efficacy of proposed modifications in

Medicare PPS pricing formulas. We now provide, using data on Medicare psychiatric inpatient discharges for 1985, an empirical illustration of our methodology. In this analysis, we consider a hypothetical self-contained PPS for these services and evaluate the potential effects of offering existing PPS outlier provisions on an optional basis. We focus on two questions. First, how many providers would participate in optional reinsurance under alternative payment rules? Second, what impact does provision of optional reinsurance have on overall risk exposure of providers as a group and on risk exposure of participating providers?

5.1. Data

Psychiatric inpatient services are provided in three major settings: scatter beds in general hospitals, psychiatric specialty units in general hospitals, and psychiatric specialty hospitals. Patients treated in approved psychiatric units in general hospitals and in psychiatric specialty hospitals, who make up the majority of Medicare psychiatric discharges, are currently exempt from the PPS and are reimbursed instead on a retrospective cost basis under provisions of the Tax Equity and Responsibility Act of 1982 (TEFRA). Examining psychiatric inpatient services is of interest for two reasons. First, exemptions for these patients have been justified on the grounds that the PPS would impose unusually high levels of financial risk on psychiatric providers (for example see English et al. 1986, Frank and Lave 1985, Jencks et al. 1987, Taube et al. 1984). Psychiatric services therefore offer an opportunity to study the risk mitigating effects of alternative payment rules under conditions identified as unusually severe. Second, Congress has mandated regular review of alternative payment options for exempt services (U.S. DHHS 1988). Hence, there is interest in possible modifications of prospective payment rules to integrate presently exempt psychiatric services into the PPS.

Data for this illustration are drawn from the NIMH 1985 ADM PATBILL data files constructed by Freiman et al. (1988). Files contain patient-level data on all Medicare inpatient psychiatric discharges from general and psychiatric specialty hospitals in 1985 and selected hospital level information. These data allow us to calculate estimates of individual patient treatment costs and to emulate standard Medicare adjustments in PPS prospective and retrospective payments reflecting providers' geographic location and individual characteristics. Because Medicare is primarily intended to reimburse for acute rather than chronic care, patients with lengths-of-stay exceeding 150 days were eliminated from the sample.[5] Data for states with Medicare waivers (Maryland, Massachusetts, New Jersey, New York) were also excluded because these states' payment rules are different from those of other states and because of possible issues regarding data reporting. The final sample used in this research contained 235,740 patient discharge records drawn from 5,374 providers.

5.2. Methods

We simulated, following Dada et al. (1992), a hypothetical self-contained prospective payment system for psychiatric inpatient services including not only those services currently covered by the PPS, but also currently exempt services. As discussed in Dada et al. (1992), including exempt and non-exempt services together in a single PPS raises important public policy issues. However, for the purposes of the present analysis, in which our primary interest is illustrating the implications of alternative policies towards reinsurance for providers who may have significant risk exposure, we do not distinguish between exempt and non-exempt providers.

As a first step in our analysis, we calculated DRG prospective payment weights for psychiatric DRGs from our data using the basic methodology employed by the PPS. Second, we calculated expected outlier payments for each provider under PPS outlier payment rules. We then solved for total reimbursement to providers if outlier reinsurance was mandatory or was offered on a voluntary basis under one of several

[5] Medicare has a 150-day general limit on reimbursement under outlier payments for a "spell" of illness. In addition, in the case of psychiatric care, Medicare has, at least in theory, a 190-day lifetime limit on reimbursement for inpatient services. If the distribution of very long length-of-stay patients (greater than 150 days) is random, excluding them will not bias our analysis. At the same time, to the extent special issues exist for these patients regarding behavioral responses by hospitals, including them could introduce problems.

selected schemes subject to the constraint that total expected reimbursement for providers as a group equal their total expected costs (i.e., that expected profits per patient for providers as a group equal zero).

A wide range of strategic behaviors are possible by providers in response to financial risk under the PPS; for example, avoidance of high cost patients, delay in discharging patients in order to qualify for outlier benefits, etc. There is no consensus on how to model such responses. Since our interest here is in the impact of reinsurance on financial risk, rather than introduce arbitrary assumptions about behavior into our analysis, we assumed behavior was fixed (i.e., that observed provider admission and treatment patterns were not affected by the level of financial risk).

Possible optional outlier reinsurance schemes were compared to a benchmark PPS in which there was no reinsurance. Current PPS outlier provisions retrospectively reimburse providers for 60% of a patient's actual treatment costs above some threshold level for up to 150 days of care for patients who are deemed to be "outliers" (i.e., are unusually costly or have unusually long lengths of stay). These provisions thus serve as an implicit form of reinsurance with a deductible (the threshold), a coinsurance rate of 40%, and a stop-loss provision (the 150 day limit). Congress has set a target level for outlier payments equal to 5% to 6% of total PPS reimbursement and directed that outlier thresholds and base prospective payments be adjusted to achieve this target (*Federal Register* 1983, p. 39776). To the extent that base prospective payments are lower than they otherwise would be as a result, this implies an implicit premium for reinsurance whose payment by providers is mandatory for participation in the PPS. A simplified version of current PPS outlier payment rules is examined in which only cost outliers were eligible for reimbursement, and the outlier threshold was $12,000 adjusted for certain provider characteristics.[6] We only report on findings for the representative case in which providers sought to hold a reserve sufficient to limit the probability of insolvency to 5% (i.e., to be sufficient to assure insolvency would not occur with a probability of 95%). The results for other probabilities of insolvency are similar and so are not reported here. To estimate reserves, we used the statistically robust technique of bootstrapping following Efron and Tibshirani (1986). First, a simulated distribution of provider profitability was computed for each provider. Then, the appropriate fractile was determined from which the reserve could be determined.[7] The cost of carrying a reserve was evaluated for capital costs of 5%, 10%, 15%, 20%, and 25% per year.

Table 1 **Financial Risk Under Various Pricing Options**

Payment Option	Total Reserve Per Discharge ($)	Systematic Reserve Per Discharge ($)	Diversifiable Reserve Per Discharge ($)
No Outlier	786.03	533.52	252.51
Mandatory 60% Outlier Reinsurance	736.64	507.68	228.96
Individual Optional 60% Outlier Reinsurance	758.37	533.52	224.85

6. Results

We begin with the benchmark case of a "pure" PPS with no outlier payments. The mean cost per discharge under this system is $3,390.36. Since the system is designed to be budget-neutral in the sense that total payments equal total costs, the expected profit per discharge is zero. As shown in the first row of Table 1, assuming that each provider wishes to assure solvency with a probability of 95%, the total required reserve is $786.03 per discharge or a total reserve for patients as a group of about 185 million dollars. Of this reserve, $532.52 per discharge, or a total of about 126 million dollars, is the systematic reserve and represents that component which cannot be diversified. The

[6] Actual outlier rules include provisions for length-of-stay outliers, and, with some adjustments, the cost threshold is $12,000 or 1.5 times the average cost of treatment in a DRG nationwide, whichever is greater.

[7] For each provider, calculating the reserves required generating two empirical distributions of profitability: without reinsurance and with reinsurance but no premium. Using 500 replications with replacement generated each empirical distribution. From each distribution, the total reserve was first determined; then, the systematic reserve was calculated as the expected loss, if any. The diversifiable reserve was then set as the difference of these two quantities.

Table 2 Comparison of No Outlier and 60% Mandatory Reinsurance Payment Options

	Increase in Expected Profit	Decrease in Expected Profit	Number of Providers
Increase in	14	4,821	4,835
Required Reserve	(.26)	(89.74)	(90)
Decrease in	449	90	539
Required Reserve	(8.4)	(1.7)	(10)
Number of	463	4,911	5,374
Providers	(8.6)	(91.4)	(100)

remaining reserve of $252.51 per discharge, or a total of 59 million dollars, is the diversifiable reserve (i.e., that portion of the reserve that approaches zero for a provider as the number of its discharges increases).

This decomposition shows that the impact of random variations as measured by diversifiable reserve is relatively modest; it is about 32% of the total reserve and is about 7.4% of mean treatment cost. This suggests that the financial cost of the reserve is 2% or less, even when the cost of capital is *as high* as 25% per annum. We examine next the impact of mandatory reinsurance on financial risk.

6.1. Mandatory Reinsurance

To mitigate financial risk, the current PPS and many proposed modifications include mandatory reinsurance provisions. As discussed earlier, mandatory reinsurance can make some providers strictly worse off. We demonstrate the extent of this effect by examining the financial risk impact of implementing the current outlier provision compared to the benchmark case.

These provisions are compared to the benchmark case in the second row of Table 1: The *total* systematic and diversifiable *reserves* decrease. However, there are transfers between providers that make most of them strictly worse off. This is demonstrated in Table 2, where we have broken down hospitals into those whose risk profile compared to the benchmark case is strictly better and worse under mandatory reinsurance. There are four cases: 1) expected profit increases and reserve decreases; 2) expected profit increases and reserve increases; 3) expected profit decreases and reserve decreases; and, 4) expected profit decreases and reserve increases.

The most significant finding, reflecting the effect of forced transfers, is that a total of 4,821 providers, nearly 90%, had a decrease in expected profit and an increase in required total reserve, increasing both short-term and long-term financial risk. Consequently, if the goal of mandatory outlier reinsurance is to mitigate risk from random variations, it is appropriate to ask whether alternative outlier provisions have the potential to substantially mitigate such risk, and whether this can be achieved without making any providers strictly worse off. As we show next, insight into both issues can be developed by making outlier reinsurance optional.

6.2. Optional Reinsurance

Since the outlier provision of the current Medicare PPS only reimburses providers for very expensive cases, it is obvious that the many providers with no outlier-eligible discharges would prefer not to elect coverage under PPS outlier provisions if it were offered on a voluntary basis. Potential participants under any voluntary reinsurance scheme consist of those providers who have positive reservation prices as computed using Proposition 2. Not surprisingly, only a relatively small fraction are potential participants. We find that 16.8% or 903 of the 5,374 providers in the data set have positive reservation prices.

A direct way of measuring the maximum benefit from risk mitigation from random variations is by compelling participation of all 903 providers in an individually-rated scheme in which the expected premium for each provider equals its expected reimbursement from outlier payments. This leaves expected profit and systematic reserve *unchanged* compared to the benchmark case; consequently, any reduction in reserves must be the result of reducing the impact of risk associated with random variations. In the individually-rated case, shown in row three of Table 1, the systematic reserve per discharge remains unchanged compared to the benchmark case at $533.52 per discharge; but the diversifiable reserve is $224.85 per discharge, and the total diversifiable reserve is about 52.9 million dollars. Compared to a diversifiable reserve of $252.51 per discharge in the benchmark case, this represents a reduction in diversifiable reserve of $27.66 per discharge or about 6.6

million dollars in total reserve. It also represents a reduction in diversifiable reserve of $4.11 per discharge compared to $228.96 per discharge in the case of mandatory reinsurance. Thus, although participation and the effects on risk would be modest, individually-rated optional reinsurance could reduce risk associated with random variations not only compared to the benchmark case of a "pure" PPS, but also compared to the case in which participation in reinsurance is mandatory.

As a practical matter, it may be difficult to offer optional reinsurance on an individually-rated basis, and group-rated schemes may be preferred. In such cases Proposition 3 can be used to calculate premiums for a rich set of reinsurance schemes. Such schemes can be shown to be viable in the sense that they are self-financing, and lead to participation of a significant number of the potential providers identified using Proposition 2.

The most direct implementation of Proposition 3 is to offer a single premium to all providers. Not surprisingly, given a high level of heterogeneity in providers' expected treatment costs, we found that exactly one provider opts to participate in this reinsurance scheme. We then considered simple variants of Proposition 3. We first used the standard technique of introducing an explicit stop-loss provision to cap the reinsurance benefit per patient. Only nine providers participated even when the cap was as low as $500. A second alternative considered was to experience-rate premiums adjusting for provider characteristics. We specifically examined the use of experience rating based on the proportion of a provider's patients who were eligible for outlier reimbursement. Our experience-rated reinsurance premium was determined by multiplying the base premium by the expected proportion of outlier eligible patients for that provider. No more than ten providers participated.

Using a combination of caps and experience rating resulted in substantially more participation, depending on the cost of capital, on the order of 500 to 600 providers when the cap was $500. Table 3 shows the number of participants for different values of β, the cost of capital, and the cap value. As β increases, the incentive to decrease reserves increases so that the number of participants increases. However, as the cap value increases, the benefit to providers with fewer high-cost patients decreases, because the premium is increasing, so that participation decreases.

Table 3 **Provider Participation in Experience-rated Optional Reinsurance**

Cost of Capital	5%	10%	15%	20%	25%
Benefit Cap of $500	503	534	570	600	626
Benefit Cap of $1,000	352	373	392	438	477
Benefit Cap of $2,000	193	202	214	223	279
Benefit Cap of $3,000	125	129	134	147	164
Benefit Cap of $4,000	91	96	107	115	124

These findings suggest that although the current outlier reinsurance provision can be viable when offered on a voluntary basis, its impact on reducing the required reserve is limited. Can other provisions do better?

6.3. Alternative Optional Reinsurance Provisions

Current outlier provision have high eligibility thresholds—for example, costs above $12,000—that limit benefits for most providers. If reinsurance is offered on a voluntary basis, with a premium for participating providers, eligibility thresholds can be reduced to make the scheme more attractive while making participants better off. We do not provide details here, but we examined a variety of such outlier provisions with thresholds as low as $1,000. Not surprisingly, participation increases. However, there is only modest reduction in the diversifiable reserve. Optional outlier provisions with low thresholds can be used to approximate "mixed" schemes (since "mixed" systems can be easily shown to have an outlier threshold of zero dollars). In this context, our findings suggest that offering schemes analogous to "mixed" schemes on a voluntary basis will also have limited total impact on diversifiable reserves.[8]

[8] While we find elsewhere (Dada et al. 1992) that "mixed" schemes could have a substantial impact on the total exposure of psychiatric providers to financial risk, this is primarily due to forced transfers that reduce reserves associated with systematic differences in costs between hospitals, rather than reductions in risk associated with random variations.

7. Discussion

In this paper, we have developed a framework for evaluating financial risk under the Medicare PPS and its proposed modifications. Using this approach may be useful for individual providers as well as for public policy making. The framework's potential use in a public policy setting is illustrated using data on Medicare inpatient psychiatric discharges for 1985. In our empirical analysis we examined the feasibility and risk impact of offering reinsurance under existing PPS outlier provisions on an optional basis for a hypothetical self-contained PPS for these services. We find that even in a PPS without any reinsurance provisions, the financial risk from random variations in treatment costs, as measured by the diversifiable reserve, is modest. Further, when we compare a PPS with no reinsurance with one with mandatory participation in outlier provisions, we find that while there is a reduction of diversifiable reserve for a small number of providers, most providers are left with lower profits and higher reserves. Finally, under the behavioral assumptions of our model, we find that feasible group-rated optional reinsurance schemes exist. These schemes would reduce diversifiable reserve while not imposing forced transfers on providers. However, the magnitude of their impact on diversifiable reserves is small and when reinsurance is optional, relatively few providers may participate.

Our findings suggest several conclusions. Regarding the Medicare PPS specifically, to the extent nonsystematic random variations in costs are a concern, optional reinsurance appears to be a feasible option and reduces financial risk associated with random variations. But for the services examined, the size of this reduction is small and relatively few providers may participate. This raises questions about the importance of financial risk associated with random variations under the PPS from a public policy perspective. Likewise, our findings raise questions about the importance of random variations as problem from the perspective of individual providers.

More generally, the issues of diversifiable risk raised in this paper are ubiquitous to prospective payment schemes. Since the mid-1980s, such schemes have become increasingly common for healthcare providers as a cost containment mechanism. This includes not only prospective payment of hospitals, but capitation of physician fees, in which a physician or physician group accepts a flat payment per enrollee from a health insurance plan in exchange for providing services as needed in specified categories of medical care. For example, in 1995, 15% of physician revenues from managed care contracts came from capitated contracts; an additional 19% came from bonuses drawn from risk-pool withholds (Emmons and Simon 1996) This in turn is leading to the emergence of markets for reinsurance for providers (Kreig 1995). The analysis developed in this paper offers a framework for evaluating financial risk under these emerging payment systems and assessing the feasibility of possible reinsurance schemes. This framework may be useful not only from a policy perspective, but also from the perspective of providers seeking to assess their own risk exposure. One important empirical issue is the extent to which our behavioral assumptions regarding providers (risk-neutral subject to an insolvency constraint) are appropriate. In an Addendum available from the authors, we demonstrate that our general analytical framework is not specific to these assumptions and can also be readily applied assuming providers are risk averse.[9]

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