NBER WORKING PAPER SERIES

TRADEOFFS IN THE DESIGN OF HEALTH PLAN PAYMENT SYSTEMS: FIT, POWER AND BALANCE

Michael Geruso
Thomas G. McGuire

Working Paper 20359
http://www.nber.org/papers/w20359

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2014

The authors are grateful to Michael Chernew, Randy Ellis, Tim Layton, Julie Shi and Steve Trejo for comments on an earlier draft. Tim Layton also provided outstanding research assistance. Research for this paper was supported by the National Institute of Mental Health (R01 MH094290) and the National Institute of Aging (P01 AG032952). The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Tradeoffs in the Design of Health Plan Payment Systems: Fit, Power and Balance
Michael Geruso and Thomas G. McGuire
NBER Working Paper No. 20359
July 2014
JEL No. H42,H51,I13,I18

ABSTRACT

In many markets, including the new U.S. Exchanges, health plans are paid by risk-adjusted capitation, in some markets combined with reinsurance and other payment features. This paper proposes three metrics for grading these complex payment systems: fit, power and balance, each of which addresses a distinct market failure in health insurance. We implement these metrics in a study of Exchange payment systems with data similar to that used to develop the Exchange risk adjustment scheme and describe the tradeoffs among the metrics. We find that a simple reinsurance system scores better on fit, power and balance than the risk adjustment formula in use in the Exchanges.

Michael Geruso
University of Texas at Austin
Department of Economics
1 University Station C3100
Austin, TX 78712
and NBER
mike.geruso@austin.utexas.edu

Thomas G. McGuire
Department of Health Care Policy
Harvard Medical School
180 Longwood Avenue
Boston, MA 02115
and NBER
mcguire@hcp.med.harvard.edu

1. Introduction

Most health insurance markets implement an array of regulatory mechanisms designed to address the special market failures associated with health insurance. These problems include the long-recognized information asymmetries that lead to adverse selection and cream skimming, as well as the moral hazard problem of excessive healthcare utilization among consumers who face prices below the marginal cost of care. In this paper we show how several of the most prevalent regulatory mechanisms put in place to deal with these problems, such as reinsurance, capitation, and concurrent or prospective risk adjustment, can mutually interfere, so that one component of the regulation implicitly exacerbates the incentive or information problem that another component attempts to solve. Further, we argue that the *de facto* insurer incentives arising from the practical implementation of risk adjustment have been misunderstood.

Consider the combination of capitation and risk adjustment, a scheme used in the US Medicare program, many state Medicaid programs, the new state Exchanges created by the Affordable Care Act (ACA), and in regulated health insurance markets in Germany, Israel, Netherlands, Switzerland and elsewhere. Under pure capitation, the insurer receives the same premium payment regardless of the patient's realized healthcare spending. Contract theory (e.g. Laffont and Tirole 1993) applied to this context indicates that this type of payment mechanism incentivizes lower overall health spending by making the insurer the full claimant on savings from reduced utilization. When risk adjustment is added to capitation, these lump-sum payments are modified on an individual basis to account for the enrollee's expected costs, as predicted by diagnoses that are recorded during health care events like a doctor visit or hospital stay. Risk adjustment reduces incentives for insurers to cream-skim the healthiest among the insurance pool (Breyer, Bundorf and Pauly, 2012).

The tradeoff between the goals of limiting costs and limiting cream

skimming arises here because risk adjustment is, in fact, tied indirectly to realized costs. In practice the conditions used to determine risk adjustment are established during provider-patient interactions in which a bill (claim) is generated. For example, a single physician office visit at which a patient receives a new diagnosis of "diabetes without complications" changes a patient's relative risk score (normed around 1.0) in Medicare by 0.162, resulting in an additional payment of approximately $1,500 annually to a private health plan enrolling that individual. But the visit generating the diagnosis, and the follow-up events the visit triggers such as further diagnostic testing, are also components of cost to the plan, creating a correlation between payments a plan receives from risk adjustment and the plan's realized costs.

Real world payment systems are complex, often mixing capitation and "cost-based" payments that reimburse realized costs. Such complexities muddy the clear and independent theoretical aims of features like prospective capitation, risk adjustment, and reinsurance. Given the prominence of these regulatory mechanisms in both fully private and publicly subsidized US health insurance markets, the net effect of these insurer incentives is of tremendous practical importance. Nonetheless, the issue has been essentially unexplored, both theoretically and empirically, before now. The lack of prior work assessing incentives in the mechanisms used to control costs and mitigate adverse selection distortions is surprising, since cost control has attracted significant policy interest in recent years, and over the same period there has been a surge of empirical and theoretical work in economics on adverse selection in health insurance markets (see Chetty and Finkelstein 2013 for a comprehensive review).

In this paper we create a framework for evaluating the *de facto* insurer incentives embedded in the regulations and payment systems that govern health insurance markets, and apply this to the case of the ACA Exchanges. We first classify incentives for analyzing payment schemes along three dimensions that capture the main regulatory concerns in health insurance markets, including

correcting information problems, controlling costs, and eliminating margins of distortion across different types of services. Specifically, we study what we refer to as the fit, power and balance of payment systems.

"Fit" refers to how well variation across enrollees in plan costs is explained by variation in payments. The notion of fit is already well-established in the risk adjustment literature, where it is often operationalized as an R^2 in a regression of costs on risk adjuster variables and is implicitly or explicitly taken as the single objective to maximize. Conceptually, fit is tied to a payment scheme's ability to address adverse selection and cream skimming (Van de Ven and Ellis 2000). We generalize the measure to include the fit of the entire payment system, which consists not only of risk adjustment but of cost-sharing features such as reinsurance. In the context of ACA Exchanges, reinsurance is mandatory for the years 2014-2016 and partially reimburses an insurer's costs when the utilization of an individual enrollee exceeds a threshold.

"Power" is meant in the sense of the power of a contract (Laffont and Tirole 1993): it describes how the payer or regulator compensates expenditure by plans on the margin. A payment to an insurer that is independent of the insurer's realized costs is, in the language of contract theory, high-powered. Tying payments to costs indirectly through diagnostic coding or directly via supply-side cost sharing lowers power because it reimburses insurers for service provision. The design of high-powered payment systems can incentivize lower total spending because insurers are in a good position to constrain utilization--for example, by gatekeeping access to specialists or by negotiating lower prices from contracting providers. The tradeoff between fit and power of a payment system has been recognized before (e.g., Newhouse, 1996) though we know of no attempt to assess the tradeoff empirically in the context of plan payment systems.

Our introduction of "balance" is original. "Balance" assesses the differences in power across various types of medical services. If medical events in one area of

care impact the total risk score more than medical events in another area, the power of the payment system will be greater in the second area than in the first. Therefore, we show that even if risk adjustment succeeds in removing the incentive for insurers to distort benefits to attract a particular set of enrollees, it can create new incentives to distort benefits conditional on a fixed set of enrollees. To see how this might occur, consider the risk adjustment in the ACA Exchanges, which is concurrent, that is, based on diagnoses and procedures occurring during the contract period. If the risk score determining payments is differentially sensitive to a dollar unit of care spent in different clinical areas, such as circulatory conditions versus mental disorders, then even absent selection considerations, the insurer is incentivized to distort care away from clinical areas that will be less generously reimbursed on the margin *ex post*. The insurer can accomplish this, for example, by creating differentially stringent referral requirements for different types of specialists or choosing low quality providers in areas that are poorly reimbursed, in either case manipulating the shadow price of care across clinical areas (Frank et al. 2000)

The first main contribution of this paper is developing a clear, simple framework that can be used to characterize the relevant tradeoffs analytically. Our framework can compare and grade any type of existing or proposed payment system, from that used in traditional Medicare, to the private managed care plans in Medicare Advantage, to payments under the health insurance Exchanges created by the ACA, including several hypothetical variants on the Exchange payment system.

Our research builds on normative and empirical papers from health economics. The tradeoff first identified by Zeckhauser (1970) between the financial risk protection of insurance and its utilization incentives for consumers is analogous to the basic fit versus power question that we investigate here, from the perspective of insurer incentives. Balance in incentives to supply services in managed care has received attention as an issue of cream skimming, with "imbalance" in the structure of benefits being a way for plans to attract desirable sets of enrollees as in Glazer and

McGuire (2000).[1] We approach the matter differently here and consider whether the incentives in the payment system for a fixed population are balanced across service areas or are differentially reimbursed by the payment system. From this perspective, we show analytically that balance is best. We also develop an empirical welfare metric of the degree of imbalance that can be weighed along with measures of fit and power.

The second main contribution of this paper is to quantify for the first time the *de facto* incentives embedded in payment schemes that feature capitation with risk adjustment and reinsurance. Traditionally, diagnostic risk adjustment has been viewed as fitting payments to expected costs without sacrificing this cost-control incentive, under the premise that risk adjustment compensates for patient characteristics rather than services provided (Pope et al., 2011). But as is clear from the comments above, evaluation of the *de facto* properties of a capitation payment system is an empirical matter. We describe how power and balance can be measured with simulation methods that generate exogenous variation in healthcare utilization. Using two years of claims from the same database of insureds used to calibrate Exchange risk adjustment by the Department of Health and Human Services, we randomly eliminate healthcare events and measure the extent to which insurer payments and costs respond under various payment schemes. The exercise is not meant to analyze insurer response to incentives, but rather, for the first time, to illuminate the *de facto* incentives themselves. The Exchange payment system is particularly complex so we take it apart to assess the partial contribution of some of its key features, such as the decision to pay plans with a concurrent rather than prospective risk-adjustment formula.

[1] Glazer and McGuire (2000) apply the Rothschild-Stiglitz model of insurance markets with imperfect information to risk adjustment and managed health care. For empirical reviews see Cutler and Zeckhauser (2000), Ellis and McGuire (2007) and Breyer, Bundorf and Pauly (2012).

Past empirical work to describe payment system properties has focused on describing the fit of risk adjusted capitation payments.[2] Most papers in this literature report the R^2 of a regression underlying the risk adjustment system. For example, the system used in the Exchanges explains about 30% of the variance of costs (Department of Health and Human Services 2012). Simulation methods can be used to characterize fit in complex payment systems, as Zhu et al. (forthcoming) do for reinsurance in Exchanges. A "Payment system R-squared" describes this more generalized measure of fit, and we adopt this term and these methods here.

Power and balance are less frequently addressed in the empirical literature. We are aware of only a single a paper by McClellan (1997) which assessed the *de facto* power incentives in Medicare's Diagnosis-Related Group (DRG)-based Prospective Payment System (PPS) for paying hospitals. McClellan regressed payments on costs and showed that the "prospective" payment system included a large retrospective component, with approximately $.55 of each dollar in hospital costs recovered in higher payments on average. In our terms, McClellan showed that the power of the hospital DRG-PPS system was .45. We are unaware of any research applying McClellan's ideas to private health plan payments.

We find that, consistent with the expressed intentions of the Exchange regulators, concurrent risk adjustment confers dramatically better fit than would prospective risk adjustment in this setting. Concurrent risk adjustment in isolation more than doubles the fit to .40 compared to prospective risk adjustment. However, we show that it does so at the cost of reducing power—that is, the incentive to constrain spending—dramatically. Further, our simulations reveal that both forms of risk adjustment feature significant imbalance, meaning that the power of the payment systems varies considerably across clinical service areas. For example, the average power for inpatient services in the concurrent risk adjustment systems used in Exchanges is about .62, but power for the top ten major diagnostic categories

[2] For reviews see Van de ven and Ellis (2000) and Breyer, Bundorf and Pauly (2012).

ranges from .20 to .91, implying that the marginal reimbursement rate across these categories ranges from 80 cents on the dollar to 9 cents on the dollar. This is a margin of potential distortion that to our knowledge has been ignored in past treatments of risk adjustment.

The third main contribution of this paper is to challenge the conventional wisdom that risk adjustment should be the preferred mechanism for linking payments to expected costs without weakening insurer incentives to control costs. One of our most striking findings is that in terms of fit, power and balance, ACA reinsurance dominates ACA diagnosis-based risk adjustment. In other words, when considered singly, the (temporary) reinsurance feature of plan payment in the Exchanges provides a similar fit, is more powerful, and is better balanced than the concurrent risk adjustment system slated for indefinite continued use in the Exchanges. This finding that a simple reinsurance scheme dominates ACA risk adjustment exposes the extent to which the incentives created by risk adjustment have been widely misunderstood. The results stand in stark contrast to the near universal preference for diagnostic risk adjustment over reinsurance in health systems in the US and abroad.

These findings are important for the continued reform of US health insurance markets, which increasingly follow models of managed competition. Our framework and quantitative results present a clear set of considerations and benchmarks for regulators and policymakers aiming to simultaneously address concerns about selection and cost control. Most importantly, we illuminate and quantify a fundamental tradeoff between these concerns. Further, our simulation methodology is simple to adapt for regulatory agencies and researchers wishing to analyze insurer incentives in other payment systems.

The remainder of the paper proceeds as follows. Section 2 defines fit, power and balance, and develops the rationale for these measures as grades of a payment system. Section 3 describes our data and how we operationalize the payment

schemes in the context of Exchanges. Results are in Section 4. Section 5 discusses the implications of our analysis for plan payment policy and research, and Section 6 contains some brief conclusions.

2. Fit, Power and Balance of a Payment System

This section develops the rationale and explicit definitions for our three measures of payment systems: fit, power and balance. Sections 2.1 and 2.2 begin by defining fit and power and then describing the tradeoff between the two. Health plans supply more than one service and the power of a payment system can differ across services, introducing the issue of balance in incentives. Section 2.3 extends the power analysis to more than one service by defining balance, and shows that a balanced system is (second) best. We derive an empirically operational expression for the inefficiency associated with imbalance in a payment system.

2.1 Fit

There are N individuals in a market indexed by i, i = 1,…,N. Cost for individual i is x_i, and the average cost in the population is $\bar{x}$. The payment system (which could be composed of diagnostic, demographic, and cost-related elements) leads to a payment of p_i for person i. We define the *fit* of the payment system as:

$$\text{Fit} \equiv 1 - \frac{\sum_i (x_i - p_i)^2}{\sum_i (x_i - \bar{x})^2} \qquad (1)$$

The fit measure in (1), analogous to an R^2, is the portion of the variance in costs explained by the payment system. An R^2 measure has been widely applied as a criterion for evaluating risk-adjustment algorithms (Breyer, Bundorf and Pauly, 2012). Improved fit reduces the variance of profits to health plans. The more important motivation for pursuing fit is that matching payments to costs mitigates incentives for insurers to cream-skim the healthiest, lowest-cost consumers among the insurance pool, perhaps by distorting the benefits package (Breyer, Bundorf and Pauly, 2012). An age-gender only risk adjustment system would underpay for the sick and overpay for the healthy enrollees. A plan would then have strong incentives

to skimp on quality or coverage to deter demand from the sicker enrollees. By more accurately tying revenues to expected costs, risk adjustment can mitigate these incentives. Better fit also reduces the adverse selection problem identified by Akerlof (1970): At the extreme, perfect fit fully compensates plans for enrolling high cost individuals, so that no *net* differences in the plan's cost can arise from selection. In the framework of Einav, Finkelstein, and Cullen (2010), better fit implies that a plan's (net) marginal cost curve flattens. While the literature has not yet produced an explicit formula translating fit to economic welfare, we follow the widely accepted intuition that higher fit reduces welfare loss from the selection problems described above.

A capitation payment system that just returns the population mean spending as the payment for each person, $p_i = \bar{x}$, covers costs on average but explains none of the variance in cost and so would have a fit of zero. A cost-based payment system in which $p_i = x_i$ explains all of the variance in cost and has a fit equal to one. In a pure capitation system with risk-adjusted payments but no other payment mechanisms, p_i is the fitted value from the risk-adjustment regression and (1) approaches the R^2 from that regression.[3]

The generalization in (1) accommodates other types of payment mechanisms, including reinsurance, capitation with risk adjustment, and "mixed systems" which blend together capitation and cost-based reimbursement by setting payments equal to a weighted average of individual costs and population average costs. A mixed system is a simple way to improve the fit of a payment system, and as we will see, can be easily characterized in terms of power and balance. A mixed system therefore serves as a convenient and relevant standard against which to compare the

[3] Eq (1) is exactly equal to the R^2 from the regression that determines risk adjustment coefficients (aka weights) when payments and risk adjustment weights are calculated within the same sample. Our measure of fit recognizes that a risk adjustment formula may have been estimated on a sample different from the population on which it is applied. This is true for both Medicare Advantage, in which the risk adjustment formula is estimated on beneficiaries who chose not to join Medicare Advantage, and in the Exchanges, in which claims from an employed population from predominantly large employers are used to estimate the risk adjustment weights.

performance of the more complex alternatives involving risk adjustment. A 50/50 mixed system setting payment equal to the half the population average plus half the cost that the individual incurs generates $p_i = .5\bar{x} + .5x_i$. For a 50/50 mixed system, fit is

$$\text{Fit (50/50 mix)} = 1 - \frac{\sum_i (x_i - .5\bar{x} - .5x_i)^2}{\sum_i (x_i - \bar{x})^2} = 1 - \frac{\sum_i (.5x_i - .5\bar{x})^2}{\sum_i (x_i - \bar{x})^2} = .75.$$

Since deviations are squared in the fit measure (as they are in an R^2 measure) cutting the deviations exactly in half with a mixed system always captures 75 percent of the variance in costs. Writing the mixed system in general form with a weight of r on the population mean cost and (1-r) on the individual's realized cost, the fit of a mixed system is

$$\text{Fit (r/1-r)} = 1 - \frac{\sum_i (x_i - r\bar{x} - (1-r)x_i)^2}{\sum_i (x_i - \bar{x})^2} = 1 - \frac{r^2 \sum_i (x_i - \bar{x})^2}{\sum_i (x_i - \bar{x})^2} = 1 - r^2. \quad (2)$$

Thus, if a mixed payment system weights the population mean at .8 and the realized costs at .2, the fit is equivalent to that of a regression explaining 36% of the variance in health care costs.

The fit of payment systems combining risk adjustment and a mixed system can be calculated analytically if the fit of the risk adjustment system is known. Suppose a risk adjustment system on its own has an R^2 equal to R^2_{RA}. If the risk adjusted capitation gets a weight r and a person's realized cost gets a weight (1-r) in the payment system, then fit is:

$$\text{Fit (RA,r/1-r)} = 1 - \frac{\sum_i (x_i - rx_i^{RA} - (1-r)x_i)^2}{\sum_i (x_i - \bar{x})^2} = 1 - \frac{r^2 \sum_i (x_i - x_i^{RA})^2}{\sum_i (x_i - \bar{x})^2} = 1 - r^2(1 - R^2_{RA}) \quad (3)$$

For example, if the risk adjustment explains 10 percent of the variance and the mixed system is 50/50, the fit of the payment system is 1 - .25(.90) = 77.5 percent.

When reinsurance combines with risk adjustment, fit will need to be evaluated empirically. Below in Section 3.2, we measure fit defined in (1) by the R^2 of a regression of payments on costs.

2.2 Power

We use the term *power* as it is used in contract theory, to describe the share of costs at the margin born by the health plan.[4] Power in health insurance contracts is tightly linked to the goal of cost control, as it describes the insurer's marginal incentive to limit healthcare spending. Insurers are in a position to materially affect healthcare spending--for example by limiting quantity via patient cost sharing and gatekeeping, by increasing the patient's shadow price of care in certain clinical areas via long waits or limited networks, and by lowering prices paid to providers via selective contracting.

In health insurance markets, contracts are generally less than full-powered; for example, in many settings, including the ACA Exchanges, insurers reinsure against large losses. Therefore, for insured individuals already above some threshold level of claims, there are weakened incentives for the insurer to limit claims. Further, as we show below, any risk adjustment system in health insurance which uses diagnoses linked to claims will have less than full power.[5] Power is therefore likely to be considerably away from full (i.e., 1.0) in this setting, with potentially substantial impact on plan incentives for healthcare spending.

If an insurer's payment p_i is invariant to changes in costs x_i, as it would be in a plan paid by an age-gender only risk adjustment system, the power of the payment system would be at the maximum of 1.0. Conversely, in a cost-based system where payment tracked costs exactly, the power would be 0. Away from these polar cases of payment systems, the change in payment for a person with respect to a change in cost for a person could vary over people and vary over ranges of cost. For example, the first health care event in a diagnostic area will trigger higher payment, but

[4] Power is maximized with a fixed price contract and decreases as the price is tied to realized costs. See Laffont and Tirole (1993, p. 11).

[5] The risk corridor feature of Exchanges in which the regulator shares gains and losses beyond certain thresholds also reduces the power of ACA plan payments. Assessing the effect of risk corridors would require simulating plans, and would be affected by the size of the plan and adverse selection among plans.

subsequent ones may not. In general, the derivative, dp_i/dx_i, will depend on various factors, including levels of spending, and differ for different categories of spending.

At the population level, characterizing a payment system as applied to a group of N enrollees, we define power (ρ) as:

$$\text{Power} \equiv \rho = 1 - \frac{1}{N}\sum_i \frac{dp_i}{dx_i} \qquad (4)$$

Power in (4) is an inverse measure of the change in payments for a marginal change in costs. In some cases, power can be determined from the design of the payment system itself. For a pure mixed system, power is simply r, the weight put on the prospective portion of payment, i.e. $\rho = r$. For a reinsurance-only scheme, power can be computed analytically as a function of the reinsurance threshold if the empirical distribution of enrollee claims costs is known. In general, however, (4) will vary over ranges of spending and will need to be assessed empirically. We explain how we use simulation methods to do so in Section 3.2 below.

With explicit definitions of fit and power we can begin to characterize the tradeoff between the two. Figure 1 graphs the fit and power of several payment systems. Point A is a cost-based payment system, with fit equal to 1 and power equal to 0. Point B is a fully prospective system paying average cost with no risk adjustment with fit equal to 0 and power equal to 1. A simple mixed system combines the two, and from above we know that both fit and power can be expressed as a function of the weight r put on the prospective payment. The combinations of fit and power achievable by a mixed system can be described by the solid curve in Figure 1, which traces Fit = 1 – (Power)^2.

Note that the terms of the tradeoff in a mixed system are the same for any distribution of cost (the x_i); in other words, independent of the population under study. A feature of the tradeoff is that a small decrease in power away from power = 1, i.e., moving r up from 0, buys a good deal of fit. Lowering power from 1.00 to .9 (putting a 10% weight on costs, x_i) lifts fit from 0 to 19%. Similarly, a small decrease

in fit from 1 can be yields a large increase in power. Lowering fit from 100% to 90% lifts power from 0 to .32.

Other points can be added to Figure 1 after empirical analysis. A capitation system that uses only age and gender could improve fit at no sacrifice in power at a point like C. As noted above, a risk-adjusted system could be combined with a mixed system. A mixed system with weight 1-r on costs and weight r on a hypothetical demographic risk adjustment system could produce the set of possibilities traced by the dotted line in Figure 1. Adding diagnoses from claims to the payment system would improve fit compared to point C but degrade power, and therefore lie above and to the left of C, in a region like D. Such points may or may not be outside the mixed system curves.

Before moving to balance, we note that more power in a payment system is not necessarily preferred. While a fully cost-based system (r = 1) gives too much incentive to supply care, a fully prospective system, asking the provider/plan to bear all costs at the margin (r = 0), may create the opposite problem and lead to underservice (Ellis and McGuire 1986; Newhouse 1996). Our goal in this paper is to quantify the power, fit, and balance of payment systems, not to find the constrained optimal combination, which will vary across markets, and is always relative to a regulator's objective function. Nonetheless, the focus in the current policy environment on more tightly constraining healthcare costs or healthcare cost growth suggests that the status quo power in the healthcare system overall is lower than the social optimum, at least as evaluated by proponents of spending reductions. Furthermore, optimal power on the supply side would depend on the demand-side incentives in the overall payment system in consideration.

2.3 Balance

Payment systems partly based on costs may create incentives to distort the distribution of resources devoted to particular types of services, one of the efficiency concerns that risk adjustment was introduced to address. A payment system with

identical marginal reimbursement incentives across services is said to have *balance*. If costs across clinical areas are reimbursed differentially, then insurers may over-provide care in some areas and under-provide it in others, relative to the social optimum. We propose to measure *imbalance* in the incentives in a payment system.

From (4), we can recognize that power could depend on the service, s:

$$\rho(s) = 1 - \frac{1}{N}\sum_i \frac{dp_i}{dx_{si}} \qquad (5)$$

The power of the payment system could differ according to whether it was assessed with respect to spending on office-based care or hospital care, for example, or across various diagnostic categories.

We show in Appendix A that balance in power is efficient in a second-best sense: If average power in the payment system is $\bar{\rho}$, the best way to attain that power is $\bar{\rho} = \rho(s)$, for all s. Furthermore, Appendix A shows that a metric for the inefficiency caused by imbalance in power, L, is

$$L(\text{payment system}) \sim \sum_s \bar{x}_s(\rho(s) - \bar{\rho})^2 \qquad (6)$$

In (6), $\bar{x}_s$ is the mean spending on service s in the population. The metric indicates that the distortions caused by imbalance for a service area are proportional to the square of deviations of power across service areas from the average power, weighted by spending in each area. Obviously, when the power is the same for every service area, the loss in (6) equals zero.

The principal assumptions behind (6) are first, that there are no other margins of distortion aside from those directly embedded in the payment system itself, and second, that the welfare loss from a deviation of actual power from desired power in a service area is approximately proportional to the square of the deviation — a common feature of welfare metrics of the "Harberger triangle" variety. Importantly, it is not necessary to know the desired average power to derive the result in (6). Appendix A shows that the welfare loss can be decomposed into a loss from the deviation of the average power from the desired, plus the loss from the

variation around the average. Even if we do not know the desired power (and therefore the loss from the gap between the desired and the average) we can still compute the welfare loss from the variation around the average. Thus, expression (6) should be understood as measuring the loss from imbalance, not the loss from the deviation of the average from the optimal power.[6] We return in the discussion below to the issue of whether other margins of distortion across clinical areas or types of service would affect the optimality of balance.

As before, it is possible to characterize some payment systems analytically. Notably, a mixed system has an average power of r, and the power is the same for any category of spending. A mixed system is thus perfectly balanced and has no welfare loss from imbalance. A reinsurance system can only be evaluated empirically, but will generally have some imbalance because spending for different services will not fall equally among people for whom reinsurance is activated. An age-gender only capitation system has a uniform power of 1.0 and no loss from imbalance. Power in a risk-adjusted system conditioning payments on medical events will vary by clinical area and feature some loss from imbalance.

3. Data and Empirical Framework

In order to empirically assess fit, power, and balance in payment systems, we use claims from large, self-insured plans to compare the actual costs of insuring enrollees to the simulated payments made to plans under each payment system. We focus on illuminating the incentives embedded in the concurrent risk adjustment and reinsurance regulations governing the ACA Exchanges. Concurrent risk adjustment links payments in a plan year to diagnoses entered in a patient's claims records during

[6] The first assumption might not hold if some services areas should be encouraged/discouraged differentially. For example, it might be desirable to encourage preventive care or discourage low-value care. While this is plausible, design of risk adjustment is not usually based on such considerations. The second assumption might not hold if plan response to incentives differs across service areas; for example if plan/providers find it easier to adjust to incentives in outpatient rather than inpatient care. Such differences also may exist but as far as we know there are no data on which to base differential estimates of such responses. See Appendix A.

that same year. We also apply our model to an alternative policy of prospective risk adjustment, using diagnoses contained in claims from the previous year of enrollment. Prospective risk adjustment is a particularly important alternative, being the most common implementation of risk adjustment, and the form used in Medicare.

3.1 Data

Our claims data come from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database, which compiles health insurance claims from consumers insured by dozens of large employers across the US. Each claim lists the payment to the healthcare provider, and the portions of the bill paid by the insurer and by the consumer. Each claim also lists any associated procedures and diagnoses codes. These diagnoses codes determine the risk scores on which risk-adjusted payments are based. Claims are linked to individuals, and individuals are linked across time. The same data source was used by US Department of Health and Human Services (HHS) for estimating the coefficients used in the risk adjustment model applied in the Exchanges.[7]

We take claims from 2008 and 2009—the most recent years available to us—and restrict attention to individuals aged 21 to 64, who are observed in both years and enrolled in an HMO, PPO, or POS plan.[8] The age range 21 to 64 corresponds to the definition of adult in the Exchanges. Because our simulations require observing the actual cost to the plan of each claim, we keep only those individuals for whom care was paid for on a non-capitated basis. From this sampling frame, we take a random sample of 2 million covered lives as our analysis and simulation sample, which we use to evaluate fit, power and balance. We take advantage of the

[7] The HHS estimation of risk adjustment weights used Truven MarketScan claims from 2010, and included individuals aged 0-64 with the following restrictions: "(1) The enrollee had to be enrolled in a FFS plan; (2) the enrollee must not have incurred any claims paid on a capitated basis, and (3) the enrollee must have been enrolled in a plan with drug benefits and mental health and substance abuse coverage." Separate models were estimated for children and adults. See Federal Register Vol. 78, No. 231 for full details of the HHS sample restrictions and estimation procedure.

[8] Data access was through the National Bureau of Economic Research.

large sample and use the roughly 15 million remaining individuals in the sampling frame to estimate risk adjustment coefficients for the hypothetical prospective risk adjustment scheme we consider. We thus avoid any overfitting problem caused by estimating and evaluating a payment system on the same sample.

Concurrent risk adjustment in the exchange system is based on a Hierarchical Condition Categories (HCC) model. These HCCs are comprised of indicators for particular conditions, with each condition determined by the presence of a diagnosis or diagnoses in the patient's claims record.[9] The set of conditions represented in the HCCs were chosen by HHS. The risk adjustment coefficients, commonly called "risk adjustment weights," come from a regression of costs on HCCs at the individual level, and reflect the dollar value association between a health condition and expected costs. A person with several HCC conditions would have a risk score equal to the sum of the coefficients associated with each condition. Details about the risk adjustment system along with our empirical estimates of the parameters are reported in Appendix B.

The weights are scaled so that a person with mean expected costs would generate a risk score of 1.0. Actual payment for a person is the product of the risk score and the average cost in the population. For example, an enrollee with a risk score of 2.0 generates a net plan payment that is twice as large as the payment for an enrollee of average expected cost. Plans are compensated by the regulator averaging risk scores within plans and then transferring a risk-adjustment payment from plans with lower than average risk enrollees to plans with higher than average risk enrollees.

As a precursor to analysis, we must estimate prospective risk adjustment weights to simulate payments under that counterfactual payment system. HHS publishes a mapping of diagnoses to HCCs as well as HCC weights for use in the

[9] These conditions are referred to as "hierarchical" because the most severe condition within a clinical area determines the classification.

Exchanges for concurrent risk adjustment, but does not publish weights for (counterfactual) prospective risk adjustment, forcing us to estimate our own weight coefficients. In order to fairly compare the prospective and concurrent models, we re-estimate the weights for the concurrent model on the same 15 million person sample used to estimate prospective weights, in all cases using the mapping of diagnoses to HCCs defined by HHS. Our main results are not sensitive to using the concurrent risk adjustment weights as estimated by HHS in place of those we estimate ourselves. Simulation results using the HHS weights in place of those we estimate are provided in Appendix C. The dependent variable in our risk adjustment regression is the total payments (insurer plus patient) in claims to service providers.[10]

HHS attempts to set the risk adjustment coefficients so that the mean risk score in the population is approximately one, and final payments are based on a re-normed relative risk score for which the mean is exactly one. We follow the same procedure, re-norming all risk scores by the average risk score, so that the average risk score in our sample is equal to one. Below, we generally report in terms of payments to plans, which are simply risk scores multiplied by the average cost in the population.

3.2 Measuring Fit, Power, and Balance

Applying the definition in Section 2, we measure fit of the payment system as the R^2 from a regression of payments on costs; specifically, $p_i = \beta x_i$.[11] The cost variable, x_i, is the total cost of the claims filed by person *i*, and p_i is the payment for

[10] Restricting analysis to only the insurer-paid portion of claims, more closely aligns with the HHS process for estimating weights, but is less transparent and the makes little difference to results. HHS estimated separate models for plans with different degrees of coverage, the metal levels in the Exchanges. We are estimating a single model so do not have to be concerned with different plan shares of covered costs. We disregard plan differences in share of covered expenses, referred to as "actuarial value."

[11] While this equation ($p_i = \beta x_i$) appears similar to part of the payment formula used in mixed systems, the interpretation is different. In the case of the mixed systems payment formula, the parameter r determining the mix of cost based and prospective payment is chosen, not estimated.

person i, recognizing risk adjustment and other payment system features. The estimated R^2 reflects the fraction of the variance in costs explained by the payment.[12]

While fit can be found using the same simple regression regardless of the form of the payment system, figuring power requires different methods. There is no generalized closed-form expression for power in a risk-adjusted payment system and power cannot be determined by examination of the payment formula.

As we explain above, power is related to the derivative of payments with respect to cost (dp/dx) summed over the population. We perform a simulation exercise that corresponds to a thought experiment of exogenously reducing utilization in order to trace the resulting change in payment. To do so, we simulate changes in utilization by drawing, for our fixed population of enrollees, a random sample of the observed medical events. We define a medical event separately for outpatient and inpatient services, which both makes sense clinically and allows us to characterize power differently for these two major sectors of care. We define an outpatient event as all services during a single day and randomly eliminate all services that correspond to a particular patient-day pair. We define an inpatient event as a hospital stay, and we randomly eliminate hospital stays.[13]

Unlike the measurement of fit, which simply describes how well payments track costs in the cross-section, the variation used to measure power in this simulation is generated by reducing events within the medical histories of individual

[12] In the case of a pure capitated, risk-adjustment payment scheme, this R^2 would exactly equal the R^2 from the regression used to estimate the risk adjustment weights if both regressions were estimated over the same population.

[13] The obvious alternative to this approach would be to randomly eliminate "claims" from the MarketScan data. We thought this made less sense conceptually. An inpatient stay typically involves ten claims or more. One of these will be the large room and board claim for the stay itself, and this will be accompanied by claims for lab tests and other procedures associated with the stay. The "thought experiment" of eliminating the room and board charge but not the ancillary services made little sense. Eliminating one of the many minor claims associated with a hospital stay would by definition have no effect on risk adjustment because the diagnoses associated with the stay would be on the room and board charge. Analogous issues arise on the outpatient side.

enrollees.[14] We ask, for example: If a plan succeeds in randomly reducing outpatient medical events by 10%, by how much does the payment for that enrollee change? And, how does this average out over an entire population of enrollees?[15] When we come to balance, we repeat this question, but for targeted, rather than random, reductions in medical events.

Such simulations allow us to incorporate several complexities of real-world payment systems that are unwieldy to model algebraically. First, they can be used to study reinsurance and other payment features tied to cost/events. Second, they offer more flexibility in evaluating payment systems in which the claims generated in one year are used to determine payments in the next, such as in the prospective risk adjustment used in Medicare Advantage. Third, the method adapts naturally to the measure of balance, the basis of which is an analogous simulation performed separately within clinical areas. And finally, the simulation, by reducing larger and larger shares of medical events, allows us to check whether the power of the same payment system varies over a range of potential cost reductions.

Specifically, we simulate reduced utilization by randomly sampling without replacement medical events as defined above from individuals in our baseline sample of 2M adults. Call F the fraction of events drawn and removed. We conduct separate simulations for four values of F (.05, .10, .15, .20). When F = .05, 5% of medical events are eliminated. At maximum we take away 20% of claims, which

[14] Thus we take a different approach than McClellan (1997), where the goal was to decompose the variance in payments to hospitals in terms of the contributions of diagnosis-based risk adjustment, procedure reimbursement, and outlier payments. Here, we aim more explicitly to analyze implicit power of the risk-adjustment system. Determining power via regression is problematic because doing so requires invoking the identifying assumption that variation in cost across individuals is exogenous to the determination of payments. This wouldn't be true in a risk-adjusted system, for example, because health differences across individuals would affect both payment (due to risk adjustment) and costs, generating an omitted variable bias.

[15] An alternative scheme for estimating power might rely on variation in utilization arising from changes in cost-sharing arrangements, and track the response of insurer payments and total costs to the utilization changes. Doing so would result in power estimates local to the source of utilization variation, and would reflect both the power of the payment incentives and service-specific price elasticity of demand. Our intention is to estimate power in a global sense and isolate only the plan incentives.

seems a reasonable upper bound for how much reduction might be possible. For each value of F, we repeat the simulation five times and report mean payment and mean cost for the insured sample.[16]

Each event removed decreases the plan's costs by the dollar amount of the claims associated with the event. In our large sample, a random F share of events will be very closely approximated by the share F of total costs associated with that type of event. Each event removed also affects the risk score with some probability because the diagnoses on the claims associated with the event are also removed. Claims pivotal in establishing a diagnosis defining an HCC have a direct effect on payment. Claims containing no "new information" used in risk adjustment, for example, claims associated with the second visit to a doctor during a year for the same condition, have no effect on the risk adjustment score. Removing events can affect payment in other ways, however, if the payment system involves cost-related features such as reinsurance. If a person's spending is in the range in which reinsurance payments kick in, reducing an event will reduce payments for that person even if the risk score does not change.

To calculate power, for each individual we generate a counterfactual relative risk score based on the claims retained, and scale this score by the average cost in the original population. We also take into account any change in reinsurance payments to calculate a new simulated payment for the individual.[17] We then directly apply equation (4) to summarize power for the entire population, substituting discrete "deltas" (.05, .10, .15, .20) for derivatives.

Random deletion of medical events disregards the relative ease with which a plan could reduce utilization in particular clinical areas. Our purpose is not to predict what a plan would do, but rather to characterize the underlying incentives

[16] In practice with our sample of 2 million individuals, five repetitions yields very precise estimates.
[17] Scaling risk scores by the original population average costs corresponds to the experiment of perturbing utilization for a single individual or for a small plan that does not affect the regulator's normalization of the population-level risk scoring parameters.

embedded in the HHS payment schemes. In practice, plans would choose the level of service provision weighing these payment incentives against competitive pressures and would also take into account the relative costliness of reducing utilization, for example, via more stringent gatekeeping.[18]

Finally, when evaluating the prospective risk adjustment payment system, we account for the fact that payments only impact utilization with a one-year lag and only for enrollees who remain in the same plan in the year after the diagnoses are recorded. Otherwise, another insurer bears the payment response to a reduction in utilization. Exchanges are too new to have data on turnover, but recent research on non-group health insurance markets in the years 2008-2011 just preceding the ACA finds very high turnover rates (Sommers, 2014). In our Exchange simulations, we characterize two cases, assuming 100% and then 50% of persons enrolled in a plan in one year stay in that plan the next.[19] This parameter could be made more precise when applying our framework to a setting like Medicare Advantage, where the retention of elderly beneficiaries in plans year-to-year has been well-measured.[20]

To characterize balance, we build on the power simulations, but divide events according to their primary diagnosis across the 25 Major Diagnostic Categories (MDCs), which are broad clinical groupings based on the five-digit ICD9 codes used in claims. For the 10 MDCs associated with the highest total dollar value of payments in our sample, plus the MDC for mental disorders, we replicate the simulation procedure we used to estimate power, but apply the sampling only to events associated with the MDC of interest. We have inpatient and outpatient events for 11 clinical areas for a total of 22 power calculations on which to figure

[18] We are also not attempting to assess the empirical importance of this incentive as it opposes the competition incentive, which would tend restrain plans' ability to reduce services while retaining market share.

[19] Sommers (2014) found somewhat higher turnover rates, on average 58%. We assume in effect that turnover will be reduced slightly in the Exchanges.

[20] In Medicare Advantage, turnover can occur because of plan exit as well as individual disenrollment. For plans remaining year-to-year, reenrollment rates are 90 percent or higher among the 65+ population. (Newhouse and McGuire, 2014).

balance. The results of the exercise highlight heterogeneity in how costs across different clinical areas are differentially reimbursed on the margin. In principle, one could evaluate balance by applying our equation (5) across finer diagnostic categories; across places of service; or across primary, secondary, and tertiary care.

To illustrate our balance analysis, for MDC 5 (Diseases and Disorders of Circulatory System), we randomly remove 10% of events associated with that MDC and recalculate all risk scores. We also calculate the new cost of insuring the individual for purposes of figuring reinsurance payments.[21] This yields a category-specific power. We show power for each clinical area and summarize balance by assessing squared deviations of power across categories from the system-level power, as called for in equation (6).

4. Results

4.1 Fit and Power

Column (1) of Table 1 grades payment systems according to fit. We consider several versions of the ACA payment system. The first row, which includes only concurrent risk adjustment, corresponds to the payment system planned for the Exchanges for 2017 and beyond. The second row adds the temporary feature of the Exchange payment scheme—reinsurance. From 2014 to 2016, a transitional reinsurance program in the individual market will compensate plans for covering individuals with realized costs above an attachment point. Insurers will receive a reimbursement of 80% of the individual claims that exceed an attachment point of $60,000 and fall below a cap of $250,000. This reinsurance operates separately from, and in addition to, the risk adjustment payment. For purposes of comparison, the Row (3)

[21] Unlike the case for randomly sampling among all types of events, when sampling by MDC the reduction in overall cost of an enrollee is not equal to the reduction in events. It is approximated however by the percentage reduction (e.g., 5%) in events we simulate times the share of total costs represented by the MDC in question.

corresponds to a hypothetical Exchange payment system that included only reinsurance.

Concurrent risk adjustment in Row (1), which has not been previously tried in a large health insurance system, achieves a fit of 0.40, substantially higher than what is typically achieved under prospective risk adjustment.[22] Hypothetical prospective risk adjustment in Row (4) yields a fit of 0.11, similar to estimates of fit in other prospectively adjusted payment systems, such as Medicare Advantage. Fit under reinsurance alone reported in Row (3) is remarkably high. This is intentional -- or at least implicit in the goal of shielding insurers from financial risk in the early years of the Exchanges. Even though reinsurance activates for only about 1% of individuals in our simulations, more than half of the variance in insurer costs is eliminated by reinsurance.

Fit under the 2014-2016 ACA scheme that includes concurrent risk adjustment and reinsurance in Row (2) achieves the highest fit of the options considered. This is not surprising. What is surprising is the small incremental contribution (.03) of concurrent risk adjustment when added to ACA reinsurance. Also in contrast to the conventional wisdom, reinsurance with prospective risk adjustment (Row (5)) fits nearly as well as reinsurance with concurrent risk adjustment.[23]

With regard to power, columns (2) and (3) in Table 1 characterize the power for inpatient and outpatient events for each of the five payment systems. Table 1 reports power for F = .1 only; i.e., in each simulation, we subtract 10% of medical events at random. Results for the other values of F, not reported, differed very little, implying that the power of the payment systems was uniform over the range of 0 <

[22] This compares to the 0.29-0.36 fit reported by regulators in Federal Register Vol. 78, No. 231.
[23] Note that the retention assumption is not important for the fit column. To study the fit of prospective risk adjustment we only need to observe the person in the previous year, irrespective of what plan they were in. The retention assumption matters only for power.

$F \leq .20$.[24] Consistent with our discussion above about the *de facto* linking of expected and realized costs via healthcare events, power for concurrent risk adjustment shown in the first row deviates considerably away from 1.0. The .62 in the first row and second column means that for each dollar of cost removed when 10% of inpatient events are eliminated, payment falls on average by $.38. The power of concurrent risk adjustment is greater for outpatient care, at .77, implying that the diagnoses lost as outpatient events are removed are less likely to be unique, i.e., appearing in other medical events, and thus having a smaller average effect on risk-adjusted payments.

Row (3) shows power for reinsurance only. Payments fall with reinsurance for medical events for persons whose total costs exceed the reinsurance threshold of $60,000. Persons with an inpatient event are more likely to be above this threshold so the power reduction from 1.0 is naturally greater for inpatient than for outpatient. Interestingly, however, the power reduction for ACA reinsurance alone is less than the power reduction from concurrent risk adjustment alone.

Combining concurrent risk adjustment and reinsurance degrades power considerably, as shown in Row (2). Looking first at inpatient, the power loss from concurrent risk adjustment of .38 plus the power loss from reinsurance of .28 sum to the power loss from their combination (1-.34 =) .66, implying that the margins on which these two payment features are reducing payments as events are removed are essentially independent. This "adding up" of power loss is also approximately true for events on the outpatient side where the power losses in the first two rows just sum to the power loss in the third row. Comparing Rows (2) and (3), the fit gain of adding concurrent risk adjustment to reinsurance is small, but the power loss is considerable.

Rows (4) through (7) show power for prospective risk adjustment alone and for prospective risk adjustment with reinsurance on realized costs (the same

[24] The power for any of the systems studied for both settings of care differed by at most .01 across the range of F studied. Differences this small are not economically meaningful and are probably due to some randomness in the drawing of events.

reinsurance modeled alone in Row (3)). When calculating power for prospective risk adjustment, we recognize the dynamic nature of the payment system. Rows (4) and (5) assume 100% retention, meaning everyone stays in the plan year-to-year. Under this assumption, the inpatient and outpatient power are .91 and .85 respectively.

The power of prospective risk adjustment exceeds that of concurrent risk adjustment because the diagnoses from the dropped events from the previous year predict current cost less well than diagnoses from similar events drawn from the current year. This is not surprising. Appendix B reports the risk adjustment model estimates for concurrent and prospective models. Dropping an HCC designation has a bigger impact in the concurrent than the prospective model as indicated by the generally larger estimated regression coefficients in the concurrent model.[25]

Rows (6) and (7) assume a more realistic retention rate of 50%. The reduction in power from 1.0 applies only to the share of people retained. Under 50% retention, inpatient prospective risk adjustment power is reduced from 1 by only by (.09)*(.50) = .045, resulting in power of (1-.045) = .96. Obviously, if retention were zero, there would be no sacrifice in power for prospective risk adjustment.[26] The impact of retention on power is small here precisely because power is already high under prospective risk adjustment.

---

[25] Note that for prospective risk adjustment power is lower for outpatient events than inpatient events, the opposite of the pattern for concurrent risk adjustment shown in Row (1). This implies that at the margin of F = .10, the diagnoses coming from the outpatient side in a prospective system are more predictive of next year's spending than are the diagnoses coming from inpatient events. This finding is sensible if diagnoses recorded in outpatient events are more likely to capture chronic, persistent conditions, whereas diagnoses recorded on inpatient events are more skewed to acute medical events that may be less predictive of future costs. Compared to reinsurance alone, prospective risk adjustment alone has similar power for outpatient events, but higher power for inpatient events. The tradeoff is that fit is significantly sacrificed under prospective risk adjustment.

[26] The fit numbers do not need to be adjusted for retention if we assume an Exchange has data on people as they change plans and can use the overall Exchange data base for purposes of risk adjustment. A refinement on this approach would be to do something like what Medicare does for persons just becoming eligible at age 65, and use only demographics as risk adjusters in the first year of MA plan payment. In this case the retained share could be paid by the full risk adjustment system and the share not retained would be paid by the stripped-down formula.

To characterize power of prospective risk adjustment and reinsurance combined, we restore the additional power from partial retention for inpatient and outpatient events.[27] Unlike the case of combining concurrent risk adjustment and reinsurance, in which the power incentive is only approximately independent and additive, for prospective risk adjustment with reinsurance, the power of prospective risk adjustment is completely independent from reinsurance, which operates over claims in a different plan year from the year generating the risk adjustment diagnoses. Clearly, reinsurance reduces power much more than does prospective risk adjustment.

4.2 Balance

We report results on balance in Table 2 for the same payment systems studied in Table 1. We list the 10 Major Diagnostic Categories (MDCs) associated with the largest total claims, as well as the MDC for Mental Health (MDC 19). We added the mental health category because it has been found previously to be subject to incentives to be underprovided in capitation-based managed care plans in both Medicare and Exchange payment systems.[28] Other diagnostic areas with similar characteristics are already included in the "top-ten" list.

Table 2 contains the power estimate for inpatient and outpatient services for each MDC, as well as the summary measure for imbalance from (6). Each entry in Table 2 is the result of a separate simulation. For example, for inpatient care associated with MDC 8 (Musculoskeletal System and Connective Tissue) under concurrent risk adjustment (in the upper left of the table), .91 is the average of 5 simulations in which 10% of the inpatient admissions with MDC 8 are removed at random. Payments in this category are reduced by 0.9% on average, yielding a power estimate of $1 - .009/.10 = .91$.

[27] For inpatient power in Row (5), we add back the (.96-.91) difference and for outpatient power we add back the (.92-.85) to get power of .68 and .79 respectively for Row (5) with 50% retention.
[28] Results for Exchanges are described in McGuire et al. (2014). Results for Medicare are in Ellis and McGuire (2007). Both papers contain a review and references to related literature.

Row (1) corresponds to concurrent risk adjustment. Comparison across clinical areas reveals significant heterogeneity in the power of reimbursement incentives. Under concurrent risk adjustment, the category with the lowest power (Respiratory Systems – outpatient) reimburses insurers 88 cents on the dollar of their costs (power = .12), whereas the category with the highest power (Musculosketal Systems – inpatient) pays insurers just 9 cents on the dollar. The balance criterion introduced above indicates that the marginal incentives to provide care should be equalized across clinical areas. For the concurrent risk-adjustment only payment scheme, this implies the optimal power within each MDC is equal to the overall average, which is 0.62 for inpatient and 0.77 for outpatient in Table 1, though even this inpatient/outpatient disparity is itself a margin of balance distortion.[29] Equation (6) summarizes imbalance as the sum of squares of the difference between clinical-area power and the average power weighted by spending in the clinical area. This summary measure is shown in the last columns of Table 2.[30]

What leads to some conditions being reimbursed at a higher rate than others on the margin under risk adjustment? Conceptually, the marginal reimbursement of a claim is a function of two factors. First is the probability that a claim is pivotal in establishing a diagnosis—conditions generating many individual claims with identical diagnoses tend to be associated with higher power. Second is the relative generosity with which a diagnosis is reimbursed in relation to the cost of the condition. The estimated coefficient in a risk adjustment model picks up the additional total costs associated with the appearance of a diagnosis, not the direct cost of actually treating that condition. When we eliminate an event, we lose the direct costs of treatment.

[29] We also note that MDCs are a natural unit of division for analyzing balance, but finer levels of aggregation—for example, further breaking up the circulatory system category into claims associated with hypertension versus acute myocardial infarction—would necessarily reveal even further imbalance *within* each MDC.

[30] The mean used for calculating deviations in the table is the mean power among the MDCs listed, weighted by spending in the MDC.

How much reimbursement is affected depends on how predictive this particular condition was for total costs.

With reinsurance the power reduction from 1.0 for services in each clinical area is roughly proportional to the likelihood that the person with the medical event has annual spending over the cut-point (if not reinsurance is not activated) times the share of spending covered by reinsurance (here 80%). Results for reinsurance only are reported in Row (2). Clinical areas that tend to be more frequently experienced by more expensive enrollees, are the ones with greater power loss.[31] For example MDC 5, Circulatory System, is a category with low power under reinsurance because an expense in this MDC category is correlated with the probability of individual spending exceeding the reinsurance threshold. In contrast MDC 14, Pregnancy and Childbirth, has very high power under reinsurance (but not concurrent risk adjustment) because pregnancy, despite being a strong predictor of costs below the reinsurance threshold, isn't associated with high right-tail spending by individuals.

At the bottom right of the table, the summary measure of imbalance shows that the loss under concurrent risk adjustment alone is about 3 times as large as under reinsurance alone. For outpatient events, the loss from imbalance is 5 times as large under concurrent risk adjustment. Row (3) shows that combining concurrent risk adjustment and reinsurance, as is done in the Exchanges from 2014 to 2016, worsens imbalance compared to either mechanism separately.[32]

Prospective risk adjustment, a standard alternative that we consider in Rows (4) and (5), represents a middle case. Compared to reinsurance alone, balance under prospective risk adjustment alone (Column 4) is worse for outpatient events, but symmetrically better for inpatient events. Rows (4) and (5) calculate power for each

[31] This is an attractive feature of reinsurance, implying that illnesses a plan might want to stint on to avoid attracting high-cost enrollees are subject to lower-powered incentives. The measures in this paper do not credit this feature of reinsurance.

[32] For MDC 4, power actually becomes negative when concurrent risk adjustment is combined with reinsurance, indicating that insurers are reimbursed more than dollar-for-dollar for consumer utilization in this category.

clinical area assuming 100% retention. Power results for less than 100% retention could be figured in the way we did for power overall in Table 1 above.

4.3 Summary

To visually summarize the many results in Tables 1 and 2, Figure 2 plots the three "grades" for each payment system, with power along the horizontal axis and fit along the vertical axis. Balance is represented by the diameter of the circle around each marker, which is proportional to the weighted variance measure in (6). A wider circle indicates a larger loss from imbalance. The mixed system curve—which pays a lump sum plus a fixed fraction of each healthcare dollar spent by the insurer—is plotted as a solid line with the parameter r from Equation (2) ranging from zero to one. The mixed system has perfect balance.

Focusing first on inpatient events in the left panel of Figure 2, the most striking results are for concurrent risk adjustment only and concurrent risk adjustment with reinsurance. These represent, respectively, the Exchange payment policies planned for 2017 and beyond and in place for 2014-2016. Not only are these payment policies dominated in terms of fit, power and balance by other feasible policies, they are also dominated by a simple mixed system, as they fall inside the solid curve. For outpatient events in the right panel, the concurrent risk adjustment policies also fare poorly. They have the worst balance and power of any scheme, and only marginally better fit than reinsurance alone. In sum, the chosen payment scheme for the Exchanges is a dominated regulatory choice. This finding is significant and runs counter to the common intuition that risk adjustment is the best way to achieve fit without reimbursing actual realized costs on the margin.

Prospective risk adjustment alone sits on the envelope of the mixed system curve in the lower right of both panels, and unlike concurrent risk adjustment, is not dominated by reinsurance alone. It is characterized by high power, low fit, and good balance. Still, a mixed system with a low weight of about .1 on realized costs beats prospective risk adjustment in terms of fit, approximately matches it in power, and

dominates it in terms of balance. Adding reinsurance to prospective risk adjustment yields a payment system that grades similarly to reinsurance alone, which sits well outside the mixed system envelope, and sacrifices some power to achieve a better fit. Despite a small fit advantage, balance and power are better under reinsurance alone than under prospective risk adjustment combined with reinsurance.

In sum, the non-dominated options among the payment schemes assessed here are prospective risk adjustment alone and reinsurance alone. The choice between the two should hinge on whether cost control or information asymmetries are the problems the regulator considers most important. An additional consideration may be the relative regulatory simplicity of a reinsurance program.

Traditional treatments of risk adjustment in the literature have ignored balance, and have either implicitly or explicitly assumed away what we call the power incentive. However, Figure 2 shows that risk adjustment, and in particular concurrent adjustment, can be significantly imbalanced, and exhibit low power. To put the size of the power problem in context, consider that concurrent risk adjustment yields a fit of .4 and power of .62, but a mixed system that simply pays insurers a fixed fraction for each enrollee dollar of healthcare utilization would achieve a power of .77 with the fit "set" to .4. In other words, concurrent risk adjustment reimburses insurers more generously on the margin than a policy explicitly aimed at reimbursing insurers on the margin. This is the principle reason we argue that the *de facto* insurer incentives involved in risk adjustment have been misunderstood.

5. Discussion

Our most significant finding is that concurrent risk adjustment, the permanent feature of ACA Exchange plan payment, fares poorly in relation to reinsurance, or even a simple mixed system, on all three performance metrics. Years of empirical research have improved the statistical fit of risk adjustment formula

when these systems are used prospectively (predicting this year's costs based on last year's events). The fit is even higher when, as in Exchanges, the risk adjustment is implemented concurrently. Nonetheless, the current reinsurance feature of Exchanges alone has much higher fit than the concurrent risk adjustment alone. Furthermore, concurrent risk adjustment contributed little incrementally to fit in when added to Exchange reinsurance.

Turning to power, diagnostic risk adjustment systems are conditioned on health care events that generate costs for insurers, affecting incentives to supply services. This is true even of prospective risk adjustment, which creates no direct tie between current period utilization and an enrollee's risk score, as long as there is at least partial retention. Here we encounter another surprising result. Exchange reinsurance dilutes power on average less than concurrent risk adjustment. Exchange reinsurance also performs better than concurrent risk adjustment on our third measure of performance, the balance of incentives across clinical areas.

One reason why reinsurance may receive a better grading along power, fit, and balance than risk adjustment is that a large fraction of healthcare spending is generated by a small fraction of enrollees. Reinsurance activates in the upper tail of spending by design, while risk adjustment tends to systematically underpredict for persons with high expected costs (Van de Ven and Ellis 2000), and it necessarily underpredicts for persons with high *realized* costs. Figure 3 demonstrates the extent to which healthcare spending is highly right-skewed. The figure bins the sample population into 3 groups defined by utilization percentiles: [0, 90), [90, 99), and [99, 100]. Each of these groups corresponds to roughly one third of total spending. Because of the squaring property of a variance measure, the contributions to the variance in spending are even more highly skewed than the contributions to the mean spending. Among the 2M enrollees included in the simulations, the top 1% of the distribution accounts for 27.7% of the spending but 85.4% of the variance. This remarkable property of health care spending distributions largely explains the

effectiveness of a seemingly modest reinsurance policy in achieving surprising improvements in measured fit. Reinsurance by design targets the upper tail of the patient distribution in cost. At the same time, reinsurance provides little or no reimbursement at the margin for the vast majority of plan enrollees, retaining high power for the majority of enrollees.

In 2017, when the payment system for Exchanges moves out of its transition phase, regulators plan to keep risk adjustment and drop reinsurance. Our results imply that from the perspective of power, fit, and balance it would be better to do the opposite: keep reinsurance and drop the risk adjustment.

We realize that this proposition strays from conventional wisdom about paying competing managed care plans, and more conceptual and empirical research is necessary to justify any radical change in policy direction. We identify a number of directions for future research to build on and confirm our initial findings. The first is to incorporate more features of Exchange payment systems and on updated data. Exchange payment systems include premiums, risk corridors (limiting gains and losses at plans) and plans with a higher or lower "actuarial value," referring to the share of total costs paid for by the plans. Adding consideration of these features will affect our fit and power measures, though we have no reason to expect the dominance of reinsurance will change. Updated data, including eventually data from the Exchanges themselves, will enable a more accurate quantification of our performance metrics.

A second direction is to consider optimizing over the parameters of the payment systems features considered. Our paper takes the risk adjustment specification and the form of reinsurance as given in our simulations, but these could be modified and the effects studied on fit, power and balance. The cut point and cost sharing of reinsurance could be changed, for example, and the tradeoffs evaluated. Increasing the reinsurance share above the cut point improves fit, lowers power but has ambiguous effects on balance. Lowering the cut point improves fit,

lowers power and improves balance. Variables included in the risk adjustment formula could also be modified. Both exercises would require new empirical analysis. New combinations of risk adjustment and other forms of payment can be explored. A risk adjustment system with only demographic adjustors improves fit at no power loss or introduction of imbalance. Such a system could be combined with reinsurance, for example, and improve fit relative to reinsurance alone with no cost in terms of the other two metrics.

Third, most of our analysis has implicitly assumed that there are no other margins of distortion aside from those directly embedded in the payment system itself. In the presence of additional distortions, second-best policy might not correspond with our notions of fit, power, and balance. For example, plans might seek to attract or deter enrollees by channeling resources towards or away from clinical areas. Such "service-level selection" might be countered with some imbalance in power.[33] Further, if consumers make systematic errors in assessing the value of a certain medical technology, an imbalanced incentive for utilization of that technology could correct the information problem. We expect future empirical work to explore such additional complexities, including the interaction between the incentives created by imbalance and insurers' differential ability across clinical areas to respond to those incentives.[34] Nonetheless, we note that this paper already advances the understanding of second-best policy in insurance markets by providing the first analysis of the simultaneous impacts of several key payment system mechanisms in the presence of multiple information and incentive problems, and in particular those problems that are most commonly targeted by regulators.

[33] One measure of plan incentives for engaging in service-level selection is the "predictive ratio" for enrollees with a condition (Pope et al., 2012). The predictive ratio is the sum of total payments to total costs for the group. Ideally, this should be near 1.0. If it is lower, revenue is less than costs, and the plan has incentives to discourage membership from users of the service used to define the group.
[34] For example, higher power for birth events might incentivize lower Cesarean section rates, while higher power for AMI may have little impact if insurers can't as easily influence providers' choice of treatments.

Finally, as a fourth direction, each criterion we propose here may merit further development. While the concept of power is well-established in contract theory, our work is the first to apply it empirically to health plan contracting. The objective of balance is new and raises additional questions about the application of power-type measures to particular service areas.[35] Our payment systems R^2 measure is the most standard of the three measures we propose, but the results with respect to fit were nonetheless the most striking and surprising. It was particularly notable to us how well reinsurance and mixed systems did in terms of fit, since fit has been the metric of choice for proponents of risk adjustment. The finding implies that either the use of risk adjustment is correct and the fit objective that the risk adjustment literature seeks to maximize is the wrong target, or the fit objective is correct, and risk adjustment is simply inferior. Reinsurance and risk adjustment "explain" different parts of the distribution of costs, and it would be worth considering whether the square of the deviation from the mean captures in a single dimension all of the relevant incentives for cream-skimming and adverse selection distortions. If a different metric for evaluating the cream-skimming and adverse selection incentives of risk adjustment is proposed, we hope our explicit accounting of the performance metrics can help illuminate such future research.

6. Conclusions

Delegation of responsibility for providing health care services to managed care plans which compete on price and quality is the foundation of health policy in many countries, making the design of the payment system for health plans the most important regulatory task in health care. In a nearly universal practice, regulators apply risk adjustment formula to transfer funds to plans enrolling individuals with higher expected costs. Other payment features such as enrollee-paid premiums and

[35] Importantly, the grouping of medical spending into categories will affect measured balance. We took what we thought was a natural approach here to capture the relative balance property of the payment systems studied, but no doubt improvements can be made.

reinsurance also generally contribute to plan payments. Our paper proposes and implements a method to grade alternative plan payment schemes based on one measure related to selection incentives—fit—and two measures related to incentives to supply services—power, and balance. To our knowledge these incentives have not been previously measured. Our paper develops a method for quantifying these incentives and thus comparing payment system alternatives. We assess the two major components of the ACA payment system, concurrent risk adjustment and reinsurance, separately and when combined on these three dimensions of performance, and compare them to prospective risk adjustment.

Our analysis illustrates one way in which the incentives implicit in diagnosis-based risk adjustment have been misunderstood. Rather than being influenced only by enrollee characteristics, risk adjustment is influenced by utilization, and therefore affects incentives to provide services. Concurrent risk adjustment, which ties diagnoses to payments in the same plan period, performs particularly poorly in this regard. Surprisingly, we find that a simple reinsurance scheme dominates the actual payment policy in the ACA exchanges in term of fit, power, and balance.

The grading we outline formalizes and builds upon existing insights into payment systems incentives, capturing the main regulatory concerns in health insurance markets. Nonetheless, other criteria could be considered when assessing the relative merits of alternative payment schemes. Risk adjustment and reinsurance, for example, will differ in their incentives to "upcode" claims (Geruso and Layton 2014), in how well they respond to changing medical technology and practice patterns generally, and in costs of administration. Importantly, our work could be linked to other research on efficiency in health plan payment that focuses on the two adverse selection related issues of efficient sorting of individuals between plans (Einav, Finkelstein and Cullen, 2010), and on the incentives to plans to distort benefits to attract or deter enrollees based on their profitability (McGuire et al., 2014). A more comprehensive evaluation of risk adjustment in comparison to

reinsurance and other payment options is necessary before making wholesale changes in the basis of payment to managed health care plans competing in markets for individual health insurance.

References

Akerlof, George (1970), "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84: 488–500.

Breyer, F., K. Bundorf, ; Pauly, M. (2012), "Health Care Spending Risk, Health Insurance, and Payment to Health Plans," in *Handbook of Health Economics, Volume II*, M. Pauly, T. McGuire; Barros, P., eds, Elsevier. p. 691-762.

Chetty, R. and A. Finkelstein (2013) "Social Insurance: Connecting Theory to Data" in *Handbook of Public Economics* Volume 5, edited by A. Auerbach, R. Chetty, M. Feldstein, and E. Saez, Elsevier, 111-193.

Cutler, D. and R. Zeckhauser (2000) "The Anatomy of Health Insurance," *Handbook of Health Economics. Volume IA.* A. J. Culyer and J. P. Newhouse, eds. Amsterdam, Elsevier: 563-644.

Glazer, J. and T.G. McGuire (2000) "Optimal Risk Adjustment of Health Insurance Premiums: An Application to Managed Care," *American Economic Review*, 90(4): 1055-71.

Geruso, M. and T. Layton (2014). "Risk Selection, Risk Adjustment, and Manipulable Medical Coding: Evidence from Medicare," working paper, Harvard University.

Ellis, R.P and T.G. McGuire (1986), "Provider Behavior Under Prospective Payment: Cost Sharing and Supply," *Journal of Health Economics* 5(2): 129-151.

Ellis, R.P. and T.G. McGuire (1988), "Insurance Principles and the Design of Prospective Payment Systems," *Journal of Health Economics* 7(3): 215-237.

Ellis, R.P. and T.G. McGuire (2007), "Predictability and Predictiveness in Health Care Spending," *Journal of Health Economics*, 26(1): 25-48.

Einav, L, Finkelstein A, and M.R. Cullen (2010), "Estimating Welfare in Insurance Markets Using Variation in Prices," *Quarterly Journal of Economics*, 125(3): 877-921.

Frank, Richard G., Jacob Glazer, and Thomas G. McGuire (2000), "Measuring adverse selection in managed health care." *Journal of Health Economics* 19(6): 829-854.

Keeler, E.B., G.M. Carter and S. Trude (1988), "Insurance Aspects of DRG Outlier Payments," *Journal of Health Economics* 7(3): 193-214.

Kifmann, M. and N. Lorenz (2011), "Optimal Cost Reimbursement of Health Insurers to Reduce Risk Selection," *Health Economics* 20: 532-552.

Laffont, J.-J., and J. Tirole (1993) *A Theory of Incentives in Procurement and Regulation*, MIT Press.

McClellan, M. (1997). Hospital reimbursement incentives: An empirical analysis. *Journal of Economics and Management Strategy,* 6(1), 91-128.

McGuire, T., J. Newhouse, S-L. Normand, J. Shi and S. Zuvekas, (2014) "Assessing Incentives for Service-Level Selection in Health Insurance Exchanges," *Journal of Health Economics,* 35(1): 47-63.

McGuire, T. G., J. P. Newhouse and A.D. Sinaiko (2011), "An Economic History of Medicare Part C," *Milbank Quarterly* 89(2): 289-332.

Newhouse, J.P. (1996) "Reimbursing Health Plans and Health Providers: Efficiency in Production Versus Selection," *Journal of Economic Literature* (34) 1236-1263.

Newhouse, J.P. and T.G. McGuire (2014) "How Successful is Medicare Advantage?" *Milbank Quarterly* 92(2): 351-194.

Pope, G.C., Kautter, J., Ingber, M.J., Freeman, S., Sekar, R., Newhart, C., (2011) "Evaluation of the CMS-HCC Risk Adjustment Model," Final Report, RTI Project Number 0209853.006. RTI International, March.

Rothschild, M. and J. Stiglitz (1976) "Equilibrium in Competitive Insurance Markets: An Essay in the Economics of Imperfect Information," *Quarterly Journal of Economics* 90(4): 629-649.

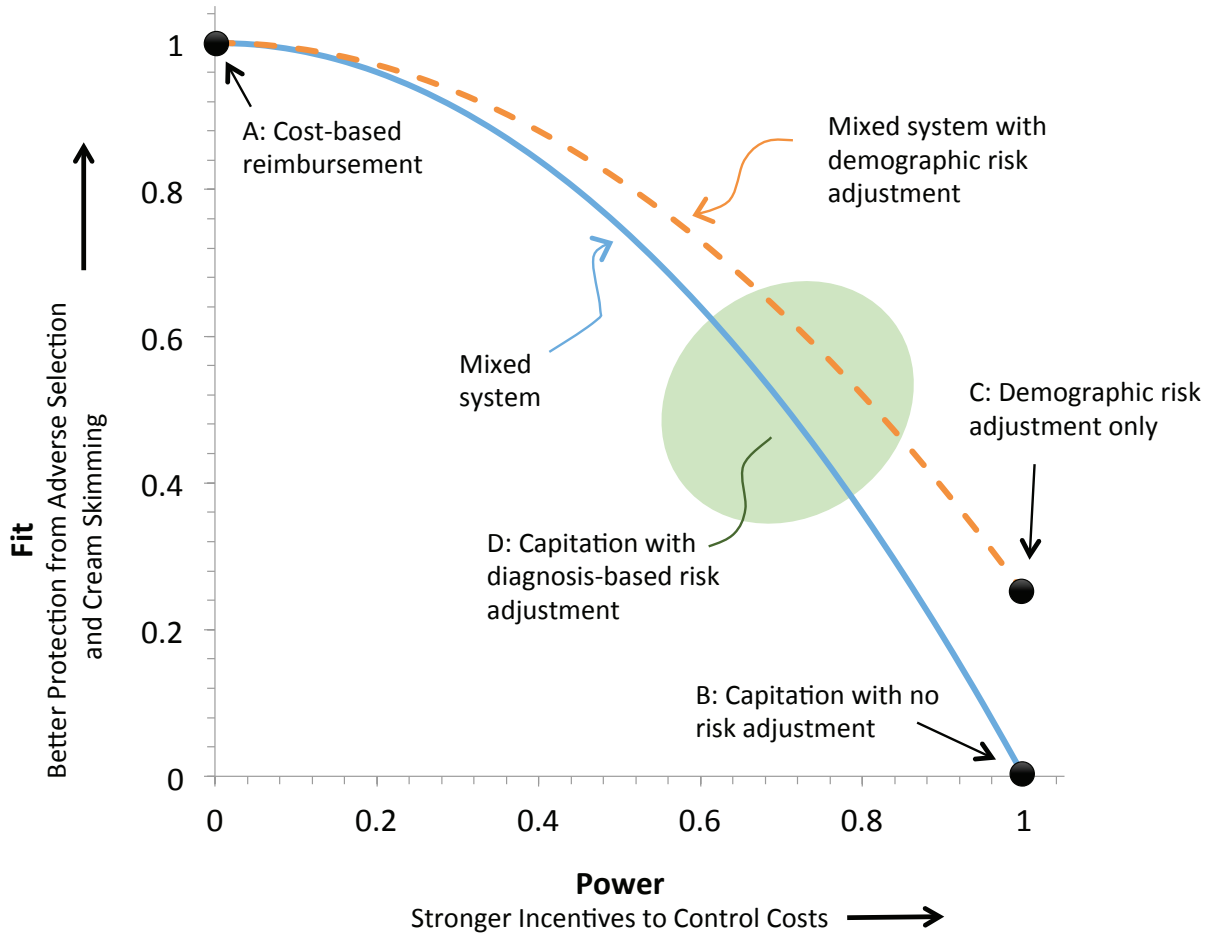
Sommers, B. P. (2014), "Insurance Cancellations in Context: Stability of Coverage in the Nongroup Market Prior to Health Reform," *Health Affairs* 33(5): 887-894.

Van de Ven, W.P.M.M., and R. P. Ellis, (2000) "Risk Adjustment in Competitive Health Plan Markets," in A. Culyer and J. Newhouse (eds.), *Handbook of Health Economics*, *Volume 1,* Elsevier, pp. 755-846.

Zeckhauser, R. (1970) "Medical Insurance: A Case Study of the Tradeoff Between Risk Spreading and Appropriate Incentives," *Journal of Economic Theory* 2(1): 10-26.

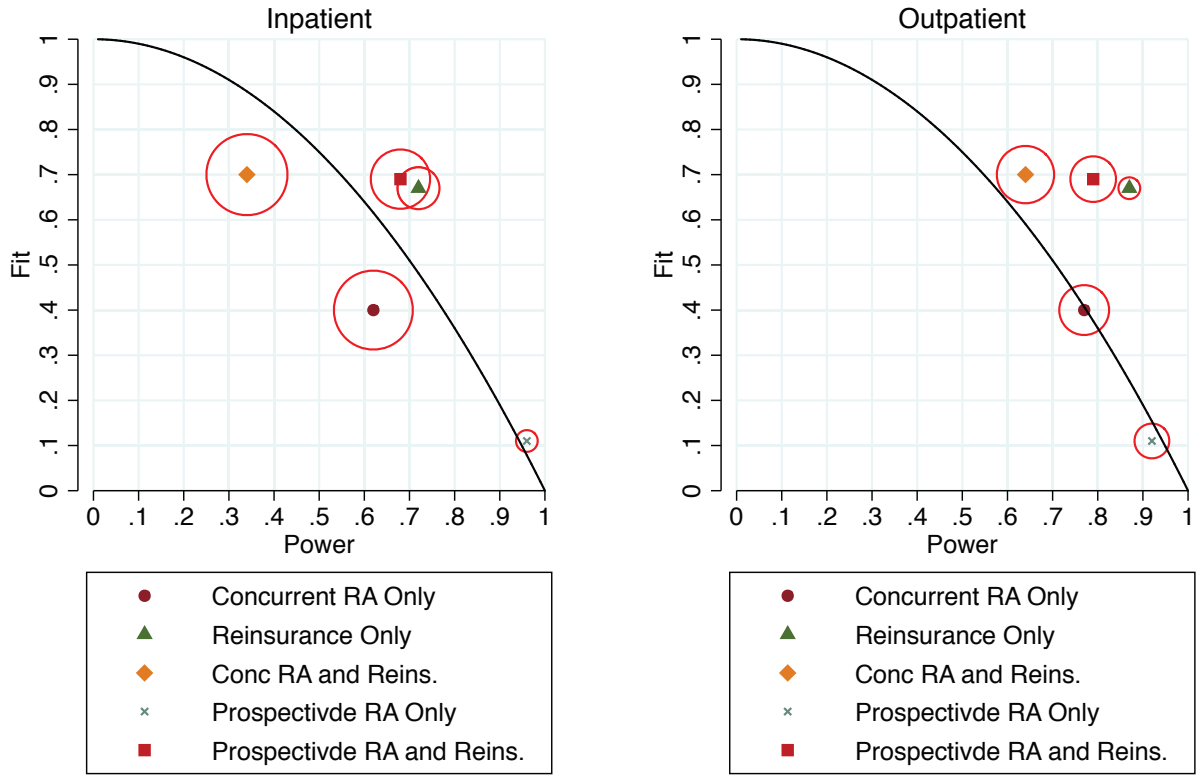
Zhu, J., T. Layton, A. Sinaiko and T. McGuire "The Power of Reinsurance in Health Insurance Exchanges to Improve the Fit of the Payment System and Reduce Incentives for Adverse Selection," forthcoming, *Inquiry*.

Figure 1: Power-Fit Tradeoff in Insurance Payment Systems



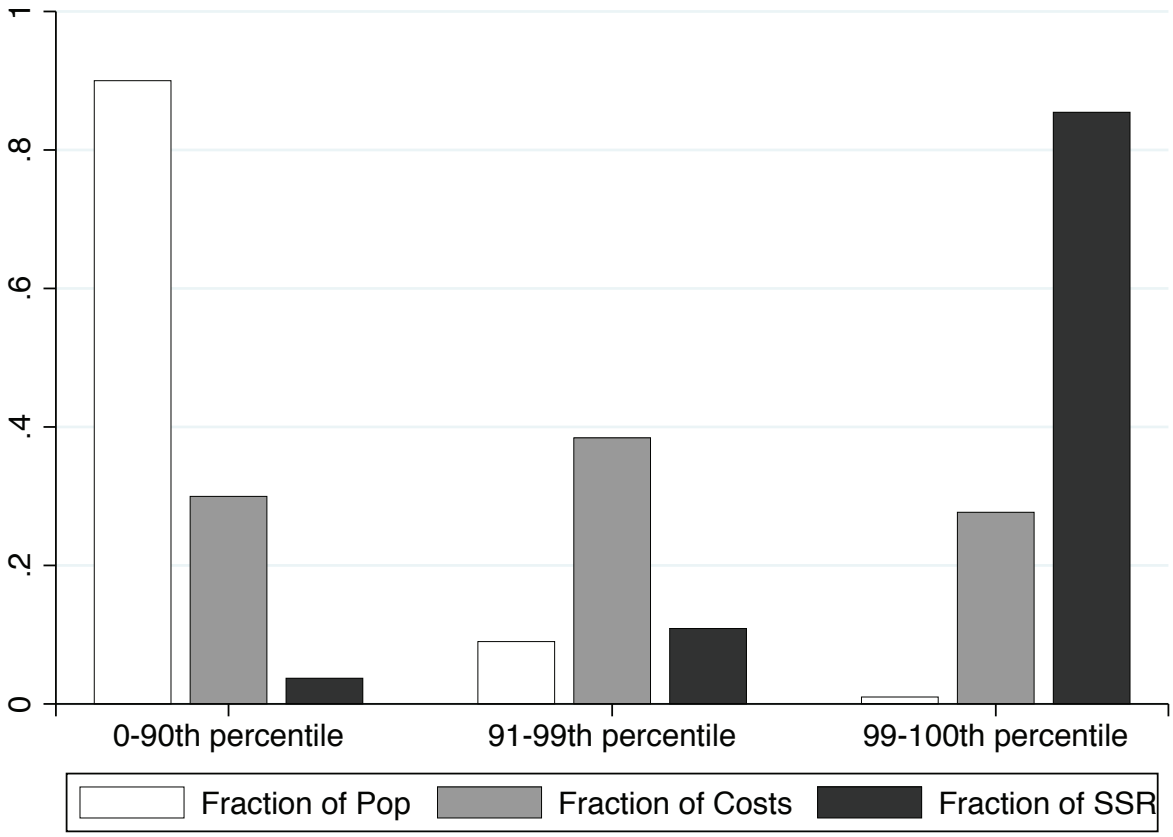
Notes: Figure illustrates the tradeoff between power and fit in insurance market payment systems. Fit, defined as the fraction of the variance of costs explained by payments as in Equation (1), is plotted along the vertical axis. Power, defined as the share of costs at the margin born by the health plan as in Equation (4), is plotted along the vertical axis. Points in black illustrate the exact fit-power combination for several payment system types. The solid and dashed curves trace the fit-power tradeoff in mixed systems over a range of parameter values for the weight put on the prospective portion of payment, as in Equation (2). The cloud at D illustrates the theoretically ambiguous cloud of potential points representing the incentives under capitation with diagnostic based risk adjustment.

Figure 2: Fit, Power, and Balance under Risk Adjustment and Reinsurance in the Exchanges



Notes: Figure illustrates fit, power, and balance for several actual and counterfactual payment systems. Vertical and horizontal positions indicate fit and power. The size of the circle around each marker indicates imbalance, with the diameter proportional to the weighted average of squared deviations. The solid curves trace, for reference, the theoretical fit-power tradeoff in a mixed system, as in Equation (2).

Figure 3: Skewness in Healthcare Spending



Notes: Figure shows distributions of costs and squared deviations of costs in the population, across groups defined by percentiles of individual costs: [0, 90), [90, 99), and [99, 100]. Vertical bars represent the fraction of the population within the percentile group, the fraction of total spending accounted for by the group, and the fraction of squared deviations (SSR) accounted for by the group.

Table 1: Fit and Power Simulation Results

		(1)	(2)	(3)
		Fit	Power, at F=0.10	
	Simulated Payment Scheme		Inpatient Events	Outpatient Events
1	Concurrent RA (ACA Policy, 2016+)	0.40	0.62	0.77
2	Concurrent RA + Reinsurance (ACA Policy, 2014, 2015)	0.70	0.34	0.64
3	Reinsurance	0.67	0.72	0.87
4	Prospective RA (100% Retention)	0.11	0.91	0.85
5	Prospective RA + Reinsurance (100% Retention)	0.69	0.64	0.72
6	Prospective RA (50% Retention)	0.11	0.96	0.92
7	Prospective RA + Reinsurance (50% Retention)	0.69	0.68	0.79

Notes: Table lists fit and power under several payment schemes. Rows 1 and 2 correspond to the actual payment policy in the ACA Exchanges, based on concurrent risk adjustment (RA) and reinsurance. Rows 3 through 7 consider several counterfactual policies. Fit in column (1) is measured as 1 - RSS/TSS in a regression of insurer payments on insurer costs. Power is calculated via a simulation in which healthcare events are randomly removed to determine the effect on insurer costs and payments at the individual level. Power for inpatient and outpatient events simulated separately. Consult the text for full details.

Table 2: Balance of Power Across 11 Major Diagnostic Categories (MDCs)

	Power by MDC													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Simulated Payment Scheme	Musculoskeletal System and Connective Tissue		Circulatory System		Digestive System		Factors Influencing Health Status		Skin, Subcutaneous Tissue and Breast		Nervous System		Respiratory System	
	IP	OP	IP	OP	IP	OP	IP	OP	IP	OP	IP	OP	IP	OP
Share of Total Costs	5.64%	13.74%	5.10%	6.87%	2.75%	6.92%	0.57%	6.76%	0.62%	5.80%	1.83%	3.63%	1.78%	2.21%
Concurrent RA	0.91	0.90	0.61	0.57	0.54	0.81	0.66	0.89	0.68	0.82	0.60	0.63	0.33	0.12
ACA Reinsurance	0.80	0.94	0.68	0.90	0.73	0.88	0.44	0.94	0.72	0.82	0.59	0.84	0.63	0.83
Concurrent RA + Reinsurance	0.71	0.85	0.28	0.47	0.26	0.69	0.12	0.83	0.38	0.64	0.18	0.46	-0.03	-0.04
Prospective RA	0.97	0.94	0.90	0.78	0.84	0.88	0.92	0.95	0.84	0.89	0.90	0.78	0.85	0.36
Prospective RA + Reinsurance	0.76	0.88	0.58	0.68	0.57	0.76	0.36	0.89	0.56	0.70	0.49	0.61	0.47	0.18

	Power by MDC													
	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)		(23)	(24)		(25)	(26)
	Pregnancy, Childbirth, and Puerperium		Kidney and Urinary Tract		Ear, Nose, Mouth, and Throat		Mental Diseases and Disorders			Range			Weigthed Average of Squared Deviations	
	IP	OP	IP	OP	IP	OP	IP	OP		IP	OP		IP	OP
Share of Total Costs	3.31%	0.83%	0.89%	3.91%	0.21%	4.22%	0.40%	1.53%						
Concurrent RA	0.20	0.63	0.69	0.85	0.65	0.91	0.79	0.64		0.20 - 0.91	0.12 - 0.91		0.053	0.037
ACA Reinsurance	0.95	0.98	0.61	0.64	0.77	0.95	0.86	0.97		0.44 - 0.95	0.64 - 0.98		0.015	0.007
Concurrent RA + Reinsurance	0.16	0.61	0.31	0.49	0.38	0.86	0.64	0.61		-0.03 - 0.71	-0.04 - 0.86		0.056	0.049
Prospective RA	1.01	0.80	0.88	0.87	0.88	0.94	0.89	0.69		0.84 - 1.01	0.36 - 0.97		0.004	0.018
Prospective RA + Reinsurance	0.96	0.78	0.48	0.50	0.65	0.88	0.75	0.66		0.36 - 0.96	0.18 - 0.89		0.030	0.031

Notes: Table lists power by major diagnostic category (MDC) for each of the five payment systems considered. Each cell in columns (1) through (22) is the average power from five replications of a simulations in which 10% of the admissions associated with the indicated MDC are removed at random. IP in odd columns indicates inpatient events and OP in even columns indicates outpatient events. Columns (23) and (24) in the bottom panel list the range of power across MDC. Columns (25) and (26) display the weighted average of squared deviations of power across the 11 MDC categories shown. This weighted average is equal to the expression in equation (6) normalized by the number of MDC categories.

Appendix A: Balance and Efficiency

This appendix shows that the efficiency loss from imbalance in power can be approximated by expression (6) in the text.

Let ρ' be the optimal power for all services. As we note in the text, the optimal power of a payment system might not be 1, and we show here that (6) measures loss due to imbalance for any ρ'. A ρ is optimal because it leads the plan to provide the optimal level of services, which we call x_1' and x_2' for services 1 and 2. Let ρ_1 and ρ_2 be the actual power for services 1 and 2, leading to service levels $x_1(\rho_1)$ and $x_2(\rho 2)$. We are interested in evaluating alternative payment systems in which the average power is held constant, i.e., where:

$$\bar{\rho} = \frac{\rho_1\overline{x_1}+\rho_2\overline{x_2}}{\overline{x_1}+\overline{x_2}}.$$

The inefficiency loss as a function of ρ_1 and ρ_2 we call $L(\rho_1, \rho_2)$. This loss can be approximated for one person (omitting i subscripts) by the quadratic form:[36]

$$L(\rho_1, \rho_2) = \frac{1}{2}\frac{\partial x_1}{\partial p_1}(\rho_1 - \rho')^2 + \frac{1}{2}\frac{\partial x_2}{\partial \rho_2}(\rho_2 - \rho')^2. \qquad \text{(a.1)}$$

Assume proportional responses to power so that $\frac{dx_1/d\rho_1}{x_1} = \frac{dx_2/d\rho_2}{x_2} = \alpha$. Then, even though α is unknown, we can say:

$$L(\rho_1, \rho_2) \sim x_1(\rho_1 - \rho')^2 + x_2(\rho_2 - \rho')^2$$

If we sum this for the entire population, we replace x_1 by $\bar{x}_1$ and x_2 by $\bar{x}_2$, and write the equivalent expression:

$$L(\rho_1, \rho_2) \sim \bar{x}_1((\rho_1 - \bar{\rho}) - (\rho' - \bar{\rho}))^2 + \bar{x}_2((\rho_2 - \bar{\rho}) - (\rho' - \bar{\rho}))^2$$

Expanding, we have three groups of terms:

$$L(\rho_1, \rho_2) \sim \bar{x}_1(\rho_1 - \bar{\rho})^2 + \bar{x}_2(\rho_2 - \bar{\rho})^2$$

$$+ \bar{x}_1(\rho' - \bar{\rho})^2 + \bar{x}_2(\rho' - \bar{\rho})^2 \quad \text{(loss from how } \bar{\rho} \text{ deviates from } \rho')$$

$$-2(\rho' - \bar{\rho})[\bar{x}_1(\rho_1 - \bar{\rho}) + \bar{x}_2(\rho_2 - \bar{\rho})] \qquad \text{(zero by definition of } \bar{\rho})$$

The last term is always zero. The middle term is the loss because the average power is wrong, and does not depend on ρ_1 and ρ_2. It is a constant when we compare payment systems with the same power. Thus, only the first term varies as we change ρ_1 and ρ_2 keeping average power fixed. This first part, expression (6) in the text, is the contribution to inefficiency due to imbalance.

[36] This assumes no "cross terms," i.e., the power of one service does not affect the supply of another.

Appendix B: Risk Adjustment Payments and Coefficient Estimates

Risk Adjusted Payments: In the simulations of the payment systems including risk adjustment, the plan payment for individual i is assumed to be equal to the average cost in the sample (prior to randomly eliminating claims) multiplied by the individual's relative risk score:

$$\text{Pay}_i = \frac{r_i}{\bar{r}}\bar{c}.$$

This is motivated by the following risk adjustment transfer formula used in the Exchanges:[37]

$$t_i = \left(\frac{r_i}{\bar{r}} - 1\right)\bar{P}$$

where $\bar{P}$ is the average premium in the market. If we assume that the market is perfectly competitive and that plan premiums equal average costs, then $\bar{P} = \bar{c}$. If we assume that all plans are identical, then the plan payment net of risk adjustment is equal to

$$\begin{aligned}\text{Pay}_i &= \bar{P} + \left(\frac{r_i}{\bar{r}} - 1\right)\bar{P} \\ &= \frac{r_i}{\bar{r}}\bar{c}\end{aligned}$$

In other words, plan payment for individual i is the average cost in the market, multiplied by i's relative risk score.

Coefficient Estimates: HHS provides a statutory set of risk adjustment coefficients—aka weights—for the concurrent model to be used in the Exchanges. We estimate our own vector of prospective weights, β^P, and in order to ensure that the prospective and concurrent models we evaluate are comparable, we estimate our own vectors of concurrent weights β^C as well.

In all models, risk scores are calculated using the same vector of risk adjusters, Y_i, used in the HHS-HCC model, so that only the coefficients attached to the risk adjusters may differ.. These risk adjusters consist of a set of age/sex cells, around 100 Hierarchical Condition Categories (HCCs), and a few interactions terms.[38] We use a program provided by HHS to generate these variables. The HCCs are generated using diagnoses from either the prior (prospective) or current (concurrent) year's claims. For each model, risk scores are assigned by multiplying the vector of risk adjusters by a vector of risk adjustment weights:

$$\begin{aligned}r^C{}_{it} &= Y_{it}\beta^C. \\ r^P_{it} &= Y_{i,t-1}\beta^P\end{aligned}$$

We estimate β^C and β^P using the portion of initial sample that was not selected as part of the random sample of 2,000,000 people we use in our simulations in order to avoid over-fitting. This estimation sample consists of around 15 million individuals. We estimate β^C and β^P via the following linear regressions of *total* costs on Y_i:

$$\begin{aligned}c_{it} &= Y_{it}\beta^C + e_{it} \\ c_{it} &= Y_{i,t-1}\beta^P + e_{it}\end{aligned}$$

[37] This is a simplified version of the actual Exchange transfer formula. The actual formula includes adjustments for age, actuarial value, geography, and induced demand. We abstract from these adjustments here.

[38] A detailed description of the HHS risk adjustment formula and downloadable algorithm are available at: http://www.cms.gov/CCIIO/Resources/Regulations-and-Guidance/

The coefficient estimates, normalized by dividing by $\bar{c}$, are found in Table B1. With the normalization, the coefficients indicate the contribution of each risk adjuster to the relative risk score. We use these weights combined with the risk adjusters, Y_i, to assign risk scores to individuals in our simulation sample.

Table B1: Estimated Coefficients from Risk Adjustment Regressions

Variables	Concurrent Coefficient	Prospective Coefficient
Male, age 21-24	0.18	0.25
Male, age 25-29	0.22	0.28
Male, age 30-24	0.25	0.32
Male, age 35-39	0.28	0.37
Male, age 40-44	0.32	0.44
Male, age 45-49	0.38	0.57
Male, age 50-54	0.45	0.72
Male, age 55-59	0.52	0.91
Male, age > 60	0.59	1.11
Female, age 21-24	0.31	0.57
Female, age 25-29	0.38	0.78
Female, age 30-24	0.45	0.79
Female, age 35-39	0.49	0.70
Female, age 40-44	0.53	0.69
Female, age 45-49	0.56	0.76
Female, age 50-54	0.60	0.84
Female, age 55-59	0.62	0.93
Female, age > 60	0.66	1.06
HIV/AIDS	0.42	0.63
Septicemia, Sepsis, Systemic Inflammatory Response Syndrome/Shock	11.68	2.51
Central Nervous System Infections, Except Viral Meningitis	5.11	1.16
Viral or Unspecified Meningitis	2.45	0.68
Opportunistic Infections	3.61	1.74
Metastatic Cancer	14.95	11.35
Lung, Brain, and Other Severe Cancers, Including Pediatric Acute Lymphoid Leukemia	6.25	5.28
Non-Hodgkin's Lymphomas and Other Cancers and Tumors	4.07	3.43
Colorectal, Breast (Age < 50), Kidney, and Other Cancers	3.91	2.70
Breast (Age 50+) and Prostate Cancer, Benign/Uncertain Brain Tumors, and Other Cancers and Tumors	2.28	1.31
Thyroid Cancer, Melanoma, Neurofibromatosis, and Other Cancers and Tumors	1.11	0.71
Pancreas Transplant Status/Complications	4.99	3.81
Protein-Calorie Malnutrition	8.59	2.23
Liver Transplant Status/Complications	10.55	3.40
End-Stage Liver Disease	3.52	5.49
Cirrhosis of Liver	1.28	2.37
Chronic Hepatitis	0.69	0.67
Acute Liver Failure/Disease, Including Neonatal Hepatitis	2.04	1.03
Intestine Transplant Status/Complications	28.22	20.70
Peritonitis/Gastrointestinal Perforation/Necrotizing Enterocolitis	13.36	2.26
Intestinal Obstruction	5.03	1.63
Chronic Pancreatitis	4.23	3.09
Acute Pancreatitis/Other Pancreatic Disorders and Intestinal Malabsorption	2.41	1.27
Inflammatory Bowel Disease	1.39	1.44
Rheumatoid Arthritis and Specified Autoimmune Disorders	1.34	1.48
Systemic Lupus Erythematosus and Other Autoimmune Disorders	0.68	0.88
Cleft Lip/Cleft Palate	1.44	1.11
Hemophilia	28.28	30.83
Coagulation Defects and Other Specified Hematological Disorders	2.00	1.04
Schizophrenia	1.36	1.03
Major Depressive and Bipolar Disorders	0.90	0.86
Reactive and Unspecified Psychosis, Delusional Disorders	1.94	1.06
Personality Disorders	0.67	0.67
Anorexia/Bulimia Nervosa	1.40	1.17
Prader-Willi, Patau, Edwards, and Autosomal Deletion Syndromes	2.86	1.14
Down Syndrome, Fragile X, Other Chromosomal Anomalies, and Congenital Malformation Syndromes	1.16	0.74
Autistic Disorder	0.28	0.45
Pervasive Developmental Disorders, Except Autistic Disorder	0.44	0.10
Spinal Cord Disorders/Injuries	4.28	1.65
Amyotrophic Lateral Sclerosis and Other Anterior Horn Cell Disease	2.08	3.42
Quadriplegic Cerebral Palsy	1.07	2.97
Cerebral Palsy, Except Quadriplegic	0.23	0.84
Spina Bifida and Other Brain/Spinal/Nervous System Congenital Anomalies	0.96	1.03
Myasthenia Gravis/Myoneural Disorders and Guillain-Barre Syndrome/Inflammatory and Toxic Neuropathy	2.97	2.47
Multiple Sclerosis	1.39	1.55
Seizure Disorders and Convulsions	6.63	1.13
Hydrocephalus	5.69	1.58

Non-Traumatic Coma, Brain Compression/Anoxic Damage	9.16	1.26
Respirator Dependence/Tracheostomy Status	25.91	4.06
Congestive Heart Failure	2.42	2.02
Acute Myocardial Infarction	8.29	1.06
Unstable Angina and Other Acute Ischemic Heart Disease	4.38	1.17
Heart Infection/Inflammation, Except Rheumatic	4.03	1.21
Specified Heart Arrhythmias	2.23	1.15
Intracranial Hemorrhage	6.50	1.15
Ischemic or Unspecified Stroke	2.98	1.06
Cerebral Aneurysm and Arteriovenous Malformation	3.67	1.27
Hemiplegia/Hemiparesis	4.17	1.75
Monoplegia, Other Paralytic Syndromes	2.55	1.29
Atherosclerosis of the Extremities with Ulceration or Gangrene	6.91	4.05
Vascular Disease with Complications	4.85	1.61
Pulmonary Embolism and Deep Vein Thrombosis	8.29	1.44
Lung Transplant Status/Complications	18.13	13.17
Cystic Fibrosis	2.59	4.27
Fibrosis of Lung and Other Lung Disorders	1.72	1.15
Aspiration and Specified Bacterial Pneumonias and Other Severe Lung Infections	3.39	1.06
Kidney Transplant Status	6.38	4.85
End Stage Renal Disease	24.95	29.00
Chronic Ulcer of Skin, Except Pressure	1.56	1.79
Hip Fractures and Pathological Vertebral or Humerus Fractures	6.08	2.49
Pathological Fractures, Except of Vertebrae, Hip, or Humerus	1.12	0.67
Stem Cell, Including Bone Marrow, Transplant Status/Complications	17.78	3.71
Artificial Openings for Feeding or Elimination	7.04	2.27
Amputation Status, Lower Limb/Amputation Complications	4.13	2.81
Group 01	0.58	0.72
Group 02A	1.55	1.13
Group 03	4.39	1.82
Group 04	2.67	1.55
Group 06	7.70	5.40
Group 07	5.08	3.83
Group 08	3.45	3.24
Group 09	2.49	1.78
Group 10	8.45	4.95
Group 11	6.77	4.43
Group 12	1.09	1.23
Group 13	12.02	1.72
Group 14	21.79	9.27
Group 15	0.68	0.66
Group 16	1.39	4.75
Group 17	0.95	1.20
Group 18	2.57	-0.14
Interaction Group M	-4.98	1.00
Interaction Group H	-3.00	1.31
Severe Illness Indicator	-6.05	-0.36
Severe X Opportunistic Infections	14.00	1.31
Severe X Metastatic Cancer	7.40	0.73
Severe X Lung, Brain, and Other Severe Cancers, Including Pediatric Acute Lymphoid Leukemia	6.44	0.33
Severe X Non-Hodgkin's Lymphomas and Other Cancers and Tumors	7.55	1.16
Severe X Myasthenia Gravis/Myoneural Disorders and Guillain-Barre Syndrome/Inflammatory and Toxic Neuropathy	7.13	0.42
Severe X Heart Infection/Inflammation, Except Rheumatic	7.94	0.53
Severe X Intracranial Hemorrhage	8.38	-1.78
Severe X Group 06	7.10	2.95
Severe X Group 08	5.28	1.16
Severe X End-Stage Liver Disease	3.33	0.03
Severe X Acute Liver Failure/Disease, Including Neonatal Hepatitis	6.47	-2.28
Severe X Atherosclerosis of the Extremities with Ulceration or Gangrene	7.51	2.78
Severe X Vascular Disease with Complications	7.56	-2.01
Severe X Aspiration and Specified Bacterial Pneumonias and Other Severe Lung Infections	8.44	-1.47
Severe X Artificial Openings for Feeding or Elimination	9.21	-0.59
Severe X Group 03	8.72	0.89

Table B2: Group and Interaction Definitions

Group 01
Diabetes with Acute Complications
Diabetes with Chronic Complications
Diabetes without Complication
Group 02A
Mucopolysaccharidosis
Lipidoses and Glycogenosis
Amyloidosis, Porphyria, and Other Metabolic Disorders
Adrenal, Pituitary, and Other Significant Endocrine Disorders
Group 03
Necrotizing Fasciitis
Bone/Joint/Muscle Infections/Necrosis
Group 04
Osteogenesis Imperfecta and Other Osteodystrophies
Congenital/Developmental Skeletal and Connective Tissue Disorders
Group 06
Myelodysplastic Syndromes and Myelofibrosis
Aplastic Anemia
Group 07
Acquired Hemolytic Anemia, Including Hemolytic Disease of Newborn
Sickle Cell Anemia (Hb-SS)
Thalassemia Major
Group 08
Combined and Other Severe Immunodeficiencies
Disorders of the Immune Mechanism
Group 09
Drug Psychosis
Drug Dependence
Group 10
Traumatic Complete Lesion Cervical Spinal Cord
Quadriplegia
Group 11
Traumatic Complete Lesion Dorsal Spinal Cord
Paraplegia
Group 12
Quadriplegic Cerebral Palsy
Parkinson's, Huntington's, and Spinocerebellar Disease, and Other Neurodegenerative Disorders
Group 13
Respiratory Arrest
Cardio-Respiratory Failure and Shock, Including Respiratory Distress Syndromes
Group 14
Heart Assistive Device/Artificial Heart
Heart Transplant

Group 15
Chronic Obstructive Pulmonary Disease, Including Bronchiectasis
Asthma
Group 16
Chronic Kidney Disease, Stage 5
Chronic Kidney Disease, Severe (Stage 4)
Group 17
Ectopic and Molar Pregnancy, Except with Renal Failure, Shock, or Embolism
Miscarriage with Complications
Miscarriage with No or Minor Complications
Group 18
Completed Pregnancy With Major Complications
Completed Pregnancy With Complications
Completed Pregnancy with No or Minor Complications
Severe
Septicemia, Sepsis, Systemic Inflammatory Response Syndrome/Shock
Peritonitis/Gastrointestinal Perforation/Necrotizing Enterocolitis
Seizure Disorders and Convulsions
Respirator Dependence/Tracheostomy Status
Respiratory Arrest
Cardio-Respiratory Failure and Shock, Including Respiratory Distress Syndromes
Pulmonary Embolism and Deep Vein Thrombosis
Interaction Group H
Opportunistic Infections
Metastatic Cancer
Lung, Brain, and Other Severe Cancers, Including Pediatric Acute Lymphoid Leukemia
Non-Hodgkin's Lymphomas and Other Cancers and Tumors
Myasthenia Gravis/Myoneural Disorders and Guillain-Barre
Syndrome/Inflammatory and Toxic Neuropathy
Heart Infection/Inflammation, Except Rheumatic
Intracranial Hemorrhage
Group 06
Group 08
Interaction Group M
End-Stage Liver Disease
Acute Liver Failure/Disease, Including Neonatal Hepatitis
Atherosclerosis of the Extremities with Ulceration or Gangrene
Vascular Disease with Complications
Aspiration and Specified Bacterial Pneumonias and Other Severe Lung Infections
Artificial Openings for Feeding or Elimination
Group 03

Appendix C: Simulation Results Using HHS Concurrent Weights

Here we show comparability of results between the concurrent weights we estimate and those estimated by HHS. In table C.1, we replicate our main results using the statutory HHS weights. To do so, we use the same software that will be used by Exchange insurers to generate the risk scores that determine *ex-post* transfer payments across plans. For these simulations, the set of risk adjusters is the same as the set used in our prospective and concurrent models discussed above. Only the risk adjustment weights, β^C, differ.

Table C1. Fit and Power Simulation Results using HHS-HCC Statutory Coefficients

	Simulated Payment Scheme	(1) Fit	(2) Power, at F=0.10 Inpatient Events	(3) Power, at F=0.10 Outpatient Events
1	Concurrent RA (ACA Policy, 2016+)	0.35	0.60	0.70
2	Concurrent RA + Reinsurance (ACA Policy, 2014, 2015)	0.67	0.32	0.58
3	Reinsurance	0.64	0.72	0.88

Notes: This table replicates results from Table 1 using the statutory risk adjustment coefficients (aka "weights") developed by the Department of Health and Humans Services, in place of the risk adjustment model estimated for this paper. Rows 1 and 2 correspond to the actual payment policy in the ACA Exchanges, based on concurrent risk adjustment (RA) and reinsurance. Rows 3 considers reinsurance alone. Fit in column (1) is measured as 1 - RSS/TSS in a regression of insurer payments on insurer costs. Power is calculated via a simulation in which healthcare events are randomly removed to determine the effect on insurer costs and payments at the individual level. Power for inpatient and outpatient events simulated separately. Consult the text for full details.