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REINSURANCE, REPAYMENTS, AND RISK ADJUSTMENT IN INDIVIDUAL HEALTH INSURANCE: GERMANY, THE NETHERLANDS AND THE U.S. MARKETPLACES

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Reinsurance, Repayments, and Risk Adjustment in Individual Health Insurance: Germany, The Netherlands and the U.S. Marketplaces

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ABSTRACT

Reinsurance can complement risk adjustment of health plan payments to improve fit of payments to plan spending at the individual and group level. This paper proposes three improvements in health plan payment systems using reinsurance. First, we base reinsurance payments on spending not accounted for by the risk adjustment system, rather than just high spending. Second, we propose pairing reinsurance for individual-level losses with repayments for individual-level profits. Third, we optimize the weights on the risk adjustors taking account of the presence of reinsurance/repayment. We implement our methodology in data from Germany, The Netherlands and the U.S. Marketplaces, comparing our modified approach to plan payment with risk adjustment as currently practiced in the three settings. The combination of the three improvements yields very substantial improvements in the individual-level fit of payments to plan spending in all three countries.

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1. Introduction

Reinsurance -- extra payments a health plan receives once spending for an individual exceeds a pre-defined threshold[1] -- can complement risk adjustment of health plan payments to improve fit of payments to plan spending at the individual and group level. Reinsurance can reduce selection incentives not corrected by risk adjustment and mitigate a plan's business risk. Where used, however, reinsurance payments typically make up a small share of total plan payments.[2] The reason is two-fold. First, like other forms of risk sharing, reinsurance dilutes incentives for cost control. Second, reinsurance payments must be financed, either by reducing the funds available for risk adjustment or by external sources. Nonetheless, even when reinsurance is only a very small share of total payments, because it targets the highest-cost cases, a little reinsurance goes a long way to reducing the variation in health care costs not accounted for by risk adjustment (Swartz, 2006).

This paper proposes three improvements in health plan payment systems using reinsurance. First, we base reinsurance payments on spending *not accounted for by the risk adjustment system*, which we refer to as *residual spending*, rather than just *high spending*. Targeting reinsurance to residuals rather than spending is more effective at reducing variation in individual-level profits and losses.

Second, we *pair reinsurance with repayments*. It is well-known that risk adjustment payment models underpay for individuals with extremely high spending by amounts that can rise to millions of dollars or Euros. But there is another side to the mismatch of payments to spending. Sophisticated disease-based risk adjustment algorithms (as are in place in the three countries studied here) generate plan payments for individuals with (multiple) disease indicators that can run into the hundreds of thousands of dollars or Euros. And sometimes, recording of disease indicators in health claims notwithstanding, plans spend little to treat the individuals *predicted* to be expensive. For some individuals, plan spending is much less than plan revenue.[3] A repayment policy that limits plan gains along with a reinsurance policy that limits plan losses further improves fit of the payment

[1] This has also been referred to as 'excess loss compensation' (Van de Ven et al., 2000).

[2] An exception is reinsurance in the free-standing prescription drug plans in Medicare Part D where reinsurance payments make up more than half of total plan payments. The original design of the Part D reinsurance program was not intended to constitute such a large share of payments, and various reforms have been proposed to reduce the share of reinsurance payments. Medicare Payment Advisory Commission (March, 2014).

[3] Risk adjustor variables are imperfect signals of an individual's health status. For example, use of home care in the prior year (one of the risk adjustor variables used in the Netherlands) identifies people with very different risk types, e.g. young people recovering from an incidental hospital treatment and elderly people with progressive end-of-life health problems. A compensation based on the average predicted spending for these risk types likely generates substantial overpayments for the first group.

system. Furthermore, pairing repayments with reinsurance has the attractive feature that pay-ins from plans on highly profitable enrollees help finance the pay-outs to plans for the enrollees with very large losses.

Third, we *optimize the weights on the risk adjustors taking account of the presence of reinsurance/repayment*. Risk adjusted payments to plans are intended to cover spending which is the responsibility of the health plan. Risk adjusted payments need not cover spending that will be taken care of by reinsurance. We show that a simple iteration optimizes the regression weights predicting plan spending net of reinsurance/repayment and optimizes the upside and downside thresholds where reinsurance and repayment, respectively, should kick in. The benefits of this integrated approach to estimation can be illustrated with a simple example. Imagine a risk adjustment model that includes a morbidity indicator x which identifies a group of people with high spending on average but with considerable variation around the average. A payment weight for this indicator based on the average incremental spending in the group will underpay some people and overpay others. Our integrated estimation procedure accounts for the presence of reinsurance which directly improves fit for the group members with spending much above the group average. The consequent reduction in the estimated payment weight indirectly improves fit for those with lower than average costs. A similar argument could be made for the beneficial effects of the repayment component.

We implement our methodology in data from Germany, The Netherlands and the U.S. Marketplaces, comparing our modified approach to plan payment with risk adjustment as currently practiced in the three settings. The combination of 1) targeting reinsurance/repayment to residual spending rather than absolute spending, 2) supplementing reinsurance with repayments for highly overpaid enrollees, and 3) optimizing regression weights in the presence of reinsurance/repayment yields very substantial improvements in the individual-level fit of payments to plan spending in all three countries. Conducting empirical risk adjustment research in parallel in three countries is a novel contribution. Similar results in the three distinct individual health insurance markets supports the generality of our findings about the impacts of health plan payment alternatives considered.

Previous research in the three countries and elsewhere has investigated the properties of supplementing risk adjustment with reinsurance or other forms of risk sharing. Studies in the US, including a number focusing on the Marketplaces,[4] have found that conventional reinsurance,

[4] The following papers all use payment systems modelled on the Marketplaces. Geruso and McGuire (2016) use MarketScan data from 2008-09, and Zhu et al., (2013) and Layton, McGuire and Sinaiko (2016) use data from the Medical Expenditure Panel Survey (MEPS) with characteristics matching likely Marketplace

defined on spending rather than residuals, improves fit at the person level as well as at the level of groups defined by use of certain services. Consistent findings emerge in research in Israel (Brammli-Greenberg, Glazer and Waitzburg, 2018) the Netherlands (Van Barneveld et al., 1998, 2001), and Switzerland (Schmid and Beck, 2016). As far as we know, Schillo et al. (2016), in a paper on Germany, are the first to propose and check a reinsurance system based on residual spending – also highly effective at improving fit of the payment model.[5]

A limitation on gains at the individual level (as is done with a repayment feature) has been paired with a limitation on losses (the reinsurance function) in U.S. Medicare payment models for hospital and home health care. Medicare pays hospitals prospectively on the basis of Diagnosis-Related-Groups (DRGs), but if the cost of a stay exceeds a fixed loss threshold, Medicare covers 80% of the cost above the threshold. On the other side of the realized cost distribution, if a patient is transferred and their length of stay at the transferring hospital is lower than the DRG-specific geometric mean, Medicare pays a per diem rate – in effect, requiring a repayment from the DRG-based payment.[6] For long-term care (LTC) hospitals, 'short-stay outliers' receive less than full payment.[7] A short-stay outlier is a stay length that is less than or equal to $5/6^{th}$ of the LTC-DRG specific geometric mean length of stay. For these cases, Medicare pays roughly the LTC-DRG per

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participants. Using an updated version of the data used for calibration of the ACA risk adjustment models -- the same data are used in this paper -- Layton, Ellis, McGuire and Van Kleef (2017) show that reinsurance paired with prospective risk adjustment produces an individual-level fit of payments to costs much higher than concurrent risk adjustment with no reinsurance.

[5] In a related approach some research groups have studied including a variable representing "high cost" as a risk adjustor directly. Schillo et al. (2016) study including an indicator for high-cost groups, Layton and McGuire (2017) propose including costs above the reinsurance attachment point as a risk adjustor, and Van Kleef and Van Vliet (2012) include an indicator of persistent high cost in multiple previous years as an adjustor, an approach subsequently incorporated in the Dutch risk adjustment model.

[6] Centers for Medicare and Medicaid Services (CMS). "Medicare Claims Processing Manual. Chapter 3-Inpatient Hospital Billing. (2018) Section 20.1.2.4 https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/clm104c03.pdf. The Medicare Learning Network (MLN). Acute Care Hospital Inpatient Prospective Payment System. March 2018 https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/downloads/acutepaymtsysfctsht.pdf

[7] Centers for Medicare and Medicaid Services (CMS). "Medicare Claims Processing Manual. Chapter 3-Inpatient Hospital Billing. (2018) Section 150.9.1.1 https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/clm104c03.pdf. Long-term care hospitals specialize in providing care to patients with complex needs (often transferring from an intensive care unit) who usually stay more than 25 days. https://www.medicare.gov/Pubs/pdf/11347-Long-Term-Care-Hospitals.pdf

diem amount.[8] Finally, in the home health setting also, reinsurance supplements payments for cases for which spending during the 60-day episode greatly exceeded the 60-day case-mix adjusted payment. On the other hand, beneficiaries whose episode consisted of four or fewer visits are paid a standardized amount per visit rather than the full 60-day adjusted episode payment.[9] In this light, our paper imports the idea of reinsurance/repayment from these other areas, with the added features that we designate thresholds based on spending *residuals*, and we optimize the risk adjusted payment amount for the presence of the up and down-side risk sharing.

Section 2 contains a brief overview of risk adjustment and risk sharing in health plan payment in the three countries as well as a description of the data used for the empirical application. In the case of The Netherlands and the Marketplaces, the data are those actually used to calibrate the national risk adjustment system. The data from Germany are from a large sickness fund operating nationwide. In all countries, we split the data into equal-sized "training" and "test" samples to avoid overfitting problems. All estimation, including reinsurance thresholds, is done on the training samples. All outcome measures are calculated on the test samples.

Section 3 presents the results in step-wise fashion in order to isolate the contribution of each modification we propose. All simulations are balanced-budget, meaning any risk sharing is financed by reducing funds available for the risk-adjusted payment. Our baseline is current practice: a risk adjustment model estimated on total spending without regard for any reinsurance or other risk sharing features. We then add conventional reinsurance – i.e. based on spending – equal to 2% of total spending in each country.[10] By choosing the same percentage devoted to reinsurance we can more readily compare results across the three health insurance markets. We next target reinsurance to *residual* spending. Next, we add a repayment feature defined on negative residual spending (where risk adjustment payments exceed spending) and set the repayments equal to 2% of total spending. Finally, in the context of residual-based reinsurance and repayments, we reestimate the risk adjustment weights and simultaneously optimize the weights and the up and down-side thresholds

[8] The Medicare Learning Network (MLN). Fiscal Year (FY) 2018 Inpatient Prospective Payment System(IPPS) and Long Term Care Hospital (LTCH) PPS Changes. October 2017 https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/clm104c03.pdf

[9] CMS.gov website, Home Health PPS. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HomeHealthPPS/index.html

[10] In this paper we choose the shares of spending allocated by reinsurance (and repayments) for purposes of illustration. In practice, the regulator might set these parameters in the light of the tradeoffs involved in improving selection-related incentives at the expense of reducing incentives for cost control. We make some comments on this tradeoff in the context of reinsurance and repayment policy later in the paper.

for reinsurance and repayment. After this exercise for a fixed share devoted to reinsurance, we show results for various combinations of reinsurance and repayment, all with optimized regression weights. Specifically, we study the four combinations of reinsurance at 1% and 2% and repayment at 0% and 1%. All this is done in parallel in the three countries to compare the impacts of identical policies in different health insurance markets.

We find that in spite of major differences in patterns of health care spending and risk adjustment practices in the three countries, residual-based reinsurance and repayment has powerful and remarkably similar impacts on individual-level fit across settings. In the optimized systems, 2% residual-based reinsurance paired with 2% residual-based repayments leads to improvements in individual-level payment fit varying from about 30 percentage points in the Netherlands and the Marketplaces to about 40 percentage points in Germany. Section 4 comments on the practical application of our findings and discusses some potential next steps in research. Methodologically, the primary takeaway from our paper is that full optimization of payment system parameters requires teamwork between risk-adjustment weights and reinsurance/repayments. Empirically, the primary takeaway is that modifying payment systems using 2% reinsurance/2% repayment based on residual spending and optimized risk adjustment weights approximately doubles the individual-level fit of conventional risk adjustment models.

2. Health Plan Payment in Germany, The Netherlands and the U.S. Marketplaces

Individual health insurance markets in Germany, The Netherlands and Marketplaces in the U.S. are organized around principles of regulated (or managed) competition, as first proposed by Enthoven (1980). Belgium, Colombia, Israel, Switzerland, and Medicare Advantage (the private option for Medicare beneficiaries in the U.S.) among other countries and sectors, share some similar features.[11] Regulated competition puts health plans in competition with the goal of generating incentives for cost containment and efficient plan design.[12] In policies that differ country-by-country, regulators promote competition by allowing health plans some, but limited, discretion about plan design (e.g. in terms of provider network and cost sharing options). At the same time,

[11] McGuire and Van Kleef, eds. (2018) contains descriptions of the individual health plan markets structured as regulated competition in 14 countries and sectors.

[12] By 'health plan competition' we mean competition among health insurers who offer one or multiple health plans. A 'health plan' refers to a health insurance product. All consumers who have the same 'health plan' have an identical contract with the same insurer concerning benefits coverage, cost-sharing, quality, services, etc. Since objectives and strategies of insurers can differ across health plans (primarily in the U.S. and The Netherlands), this paper will speak of health plans instead of insurers as decision makers.

the regulators manage competition in order to guarantee public objectives such as affordability and accessibility. In all three countries, enrollee premiums do not differ according to the health status of individuals while some form of risk adjustment of plan payment is done centrally to transfer funds to plans enrolling more costly individuals. Risk adjustment is designed to ensure plan viability, but more importantly, to counter plan incentives to attract the healthy and deter the sick from joining the plan.

2.1 Germany

The public health insurance system in Germany is the largest individual health insurance market in the world, both in terms of the number of lives covered and in the total plan payments (Wasem et al., 2018). In 1996, free choice of sickness funds was introduced for all members of the social health insurance system. Two years prior, in 1994, risk adjustment was established to provide equal opportunities for sickness funds with diverging risk profiles of their insured. In 2009, the formerly mostly demographic risk adjustment system became morbidity-based. Since then the payments to the sickness funds are calculated by an individual-level least squares regression weighted by the fraction of the year the individual is insured in the social health insurance system. Risk adjustors (see Table 1) are included in the form of dummy-variables. The model is prospective: expenditures from one year are explained by demographic characteristics from the same year but the morbidity characteristics are taken from the previous year.[13] From 2002 until 2009, risk adjustment was complemented by reinsurance from a high expenditure pool through which sickness funds were reimbursed 60% of spending above a certain individual threshold. With the introduction of the morbidity-based risk adjustment the high expenditure pool was abolished. Debate continues about reintroduction of elements of reinsurance.[14]

Data from Germany used in this paper are from one large national insurer.[15] Table 2 summarizes some features of the German data as well as for the other countries.

2.2 The Netherlands

Since 2006, The Netherlands have had a national health insurance system based on principles of regulated competition, with a risk adjustment system that has been improved over time. In the early years, the risk adjustment system was supplemented with reinsurance to mitigate

[13] The German regression is run on cost per day which is equivalent to an annualization.

[14] See for example Drösler et al. (2017).

[15] More description of the data source is contained in Schillo et al. (2016).

selection incentives remaining after risk adjustment and to mitigate plans' business risk due to financial uncertainties surrounding specific healthcare system reforms. As risk adjustment was improved and the health insurance market stabilized, reinsurance thresholds were increased; in 2014, reinsurance was abolished altogether. In 2018, the Dutch risk adjustment system consists of three different models, one for each of the following categories: somatic care, mental health care, and out-of-pocket payments due to the mandatory deductible of 385 Euros per adult per year (Van Kleef et al., 2018a). For simplicity, our analyses will be based on the model for somatic care only. This model accounts for about 85% of total spending and includes 193 risk classes, which are described in Table 1. Risk classes take the form of dummy variables indicating whether an individual is a member of a class or not. Currently, risk adjustor coefficients are derived by an individual-level weighted least squares regression of annualized expenditures in 2015 on demographic variables from year 2015 and the disease indicators listed in Table 1 from 2014 or before. Data on expenditures and characteristics cover the entire Dutch population with a health plan in 2015. Prior to estimation, some modifications are applied to make the available data representative for 2018 (e.g. including modifications for changes in the benefits package).[16]

Data from The Netherlands are those actually used for calibration of plan payment models, and have been used in a number of research papers.[17]

2.3 U.S. Marketplaces

The U.S. Marketplaces, created as part of the Affordable Care Act (2010) and popularly known as "Obamacare," began enrolling individuals and families in 2014 (Layton, Montz and Shepard, 2018). These markets, organized at the state level, are intended to provide affordable health insurance for those who do not receive insurance through their employers or through public programs providing coverage for the elderly (Medicare) or for low-income families (Medicaid). The law included a number of reforms which shifted the individual health insurance market toward a version of regulated competition, including income-related subsidies, (partial) community rating of premiums, mandated coverage of a basket of "essential health benefits," and guaranteed issue and renewal provisions prohibiting plans from rejecting applicants based on their health status. As of

[16] In the regression model expenditures are annualized and the observations weighted by the fraction of the year an individual was enrolled in 2015 (which can be smaller than 1.0 due to birth, death, migration and other factors). For example, a person with a half-year enrollment and 2,000 Euro expenditures is given a weight of 0.5 and annualized expenditures of 4,000 Euro (2,000/0.5).

[17] For some recent papers see Layton, McGuire and Van Kleef (2016), Van Kleef et al., (2017), Van Veen et al., (2017).

the first quarter of 2018, about 10.6 million Americans were enrolled in a Marketplace plan, 87% of whom receive premium subsidies, representing over 70% of the individual health insurance market. The extent of coverage in Marketplace plans ranges from approximately 60% on average for "bronze" plans to 90% for "platinum" plans. The Marketplace risk adjustment model assigns risk scores to enrollees based on their demographics and observed diagnoses during the concurrent plan year (i.e. calendar year). Risk scores are calculated using a model developed by the Department of Health and Human Services (HHS), the HHS Hierarchical Condition Categories (HHS-HCC) model. The HHS-HCC model predicts an enrollee's medical spending in the current year by mapping diagnoses coded on insurance claims into one of currently 127 HHS-selected HCCs, which were drawn selected from the larger set of HCCs available in the diagnostic classification system).[18] A "temporary" reinsurance component was part of the Marketplace payment system in the first three years, and due to a continuing concern about high-cost cases, a modest reinsurance function was restored through changes in the formula transferring funds among health plans (Jost, 2016; Layton and McGuire, 2017). As of August, 2018, seven states in the U.S. have received waivers from the federal government to reintroduce reinsurance in their Marketplaces.[19]

The U.S. data are an updated version of the MarketScan data used to calibrate plan payment models in the Marketplaces. The 8.2 million sample from the larger MarketScan files is drawn using the same exclusion/inclusion criteria used by HHS in estimating risk adjustment models, as has been done in previous research on Marketplace payment models.[20]

3. Residual-Based Reinsurance and Repayment, and Optimized Risk Adjustment Weights

This section defines parameters of the plan payment systems and summarizes the payment systems studied in the simulations.

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[18] Kautter et al. (2014) describe the choice of the original 100 HCCs. In 2016, there were 127 HCCs. In 2018 some modifications were added using drug use indicators and enrollment duration factors. https://www.cms.gov/CCIIO/Programs-and-Initiatives/Premium-Stabilization-Programs/Downloads/2018-Benefit-Year-Final-HHS-Risk-Adjustment-Model-Coefficients.pdf.

[19] https://www.commonwealthfund.org/blog/2018/affordable-care-act-under-trump-administration?omnicid=EALERT1465357&mid=mcguire@hcp.med.harvard.edu.

[20] See Layton et al. (2017), Layton and McGuire (2017). Following practice for estimating risk adjustment models in the Marketplaces, our sample is restricted to those individuals who had both prescription drug and mental health coverage and who had no negative or capitated claims. In addition, we further restricted our sample population to those continuously enrolled for twelve months who were in a non-HMO plan in the first and last month. The U.S. data are for full-year enrollees only, following current practice used for estimation of risk adjustment models for the Marketplaces.

3.1 Plan Payment Models

A risk adjustment payment consists of the summed product of the scores on a set of risk adjustor variables and the payment weights on these variables which we call the β weights. The risk adjustor variables differ by country as set out in Table 1. We treat the choice of risk adjustors as given. That is, for the plan payment models studied for Germany, for example, the risk adjustor variables are the same as those actually used and described in Table 1. Model 1 in the first row in Table 3 refers to this risk-adjustment-only payment model where the β weights are estimated in a least-squares procedure following the estimation practices used in each country.

Model 2 adds conventional reinsurance. A plan receives a reinsurance payment equal to spending less a preset threshold of spending, referred to as an attachment point.[21] Figure 1 depicts typical reinsurance defined on plan spending per person. Some individuals within an insurance pool will have spending at zero. For those with positive values of spending, the distribution is highly skewed to the right. In a typical large population, there will be individuals with spending in the millions of dollars or Euros. We set the threshold in our first set of models such that 2% of total plan payments consist of reinsurance and finance the reinsurance by a flat reduction of the risk adjustment payment from all individuals (equal to 2% of mean spending).

Model 3 begins incorporating the ideas in this paper. Keeping the same risk adjustment weights estimated in Model 1, reinsurance now applies to spending residuals after risk adjustment rather than total spending. A typical distribution of residuals, i.e., spending less risk adjustment payment, is depicted in Figure 2. Residuals could be positive or negative (and must average zero in the population used for estimating the risk adjustment payment weights). A positive residual indicates the plan is spending more than it is paid. A large right tail persists after risk adjustment because risk adjustment payments do not fully capture extreme spending. Reinsurance based on residuals reimburses a plan for residual spending above a positive residual threshold. Residual-based reinsurance in our first set of analyses redirects the 2% in reinsurance payments.

Model 4 also keeps the β weights from Model 1 but adds a repayment feature to the plan payment system, requiring a plan to repay residual spending below a negative threshold. For example, the negative threshold might be -$100k, in which case a plan would have to return any individual-level overpayment exceeding $100k. Figure 2 shows what a reinsurance/repayment

[21] Reinsurance can pay less than 100% of costs above a threshold. For simplicity, we assume a reinsurance share of 100%, though our methods would work for other shares.

system looks like, with upper and lower thresholds based on residuals defining the regions for reinsurance and repayment.

Finally, Model 5 optimizes the β weights to take account of the presence of reinsurance and repayments. Specifically, the β weights are reestimated on plan obligations net of reinsurance and repayment. New β weights, however, imply new thresholds for reinsurance and repayment. With these new β weights the distribution of residuals changes and we refigure the thresholds that would set aside 2% of funds for reinsurance and for repayment. With new thresholds, we reestimate β weights again and repeat the iterative procedure until β weights and reinsurance/repayment thresholds no longer change materially.[22]

3.2 Combinations of Residual-based Reinsurance and Repayment

A second set of analyses studies various combinations of residual-based reinsurance and repayment all with optimized β's. Specifically, we consider the following alternatives, with the first number indicating the percent of funds set aside for residual reinsurance and the second number the percent designated for residual repayment: (1,0), (1,1), (2,0).

3.3 Metrics of Plan Payment Performance

We report several metrics for plan payment system performance beginning with fit at the individual level. When plan payments are the predicted values from a risk adjustment regression, fit at the individual level is simply the R^2 from the risk adjustment model. Any net contribution of risk sharing to fit is captured by a generalization of the R^2 referred to as 'Payment System Fit' (PSF).[23] PSF is an R^2-type statistic (analogous to a pseudo-R^2) measuring the degree to which plan payments for individual i, R_i, track spending for that individual, Y_i. PSF recognizes that the payment a plan receives for an individual, R_i, can include other components in addition to the predicted spending from a risk adjustment model.

$$PSF = 1 - \frac{\sum(Y_i - R_i)^2}{\sum(Y_i - \bar{Y})^2} \qquad (1)$$

We also measure individual fit by Cumming's Prediction Measure (CPM), a linear version of (1).[24]

Payment system alternatives are also commonly evaluated on how funds are redistributed among different population groups, defined, for example by a specific illness. Policy evaluations in

[22] We found there is little gained from iterating after the second time.

[23] For other applications of payment system fit see Geruso and McGuire (2016) and Layton et al. (2017).

[24] Although R-squared is by far the most commonly reported statistic, CPM is also frequently used. For a discussion of the many measures used in risk adjustment research, see Van Veen et al. (2015).

each country define groups of interest based on illness, previous levels of spending, past health care use, and other information available in the country.[25] In order to define a group of potential interest in parallel across the three countries, we study over/undercompensation for those in the top decile of spending in the previous year. Persistence of spending means that the high spenders from last year are likely to be underpaid in the current year. Our group-level payment fit measure, the predictive ratio (PR), is, as a ratio, comparable across the three health insurance markets. Letting the index g designate those in the top decile last year

$$PR_g = \frac{\sum_g R_g}{\sum_g Y_g} \qquad (2)$$

PR_g will take a value like 80% if plan payments for this group underpay on average by 20%. PR_g closer to 100% indicates better plan payment performance for this group.

Finally, we track the redistributions accomplished by the payment system in relation to the baseline risk-adjustment payment model with no reinsurance/repayment. Funds redistributed between models 2-5 and model 1 are measured by the absolute value of changes in payment at the individual level between the two systems. For example:

$$\text{Funds redistributed for model 2} = \sum_i |(R_i^2 - R_i^1)| \qquad (3)$$

where R_i^2 is the payment for individual i in model 2 and R_i^1 is the payment in model 1. Funds redistributed measures the potential of a payment system to affect group-level allocations for as-yet unspecified groups. To make measure (3) comparable across the three settings, we present the funds redistributed as a percentage of total spending. We do not regard funds distributed as a measure of plan performance; it simply tells us how much money is moved around with the various payment models.

4. Results

In each country, data were randomly divided into equal-sized training and test samples. All estimation, including selection of reinsurance and repayment thresholds, is conducted on the training sample; all outcome measures are calculated on the test sample. For example, when we estimate risk adjustment models, the β weights are estimated on the training sample, but fit statistics are reported from the test sample. Similarly, when we choose an upper threshold in order for reinsurance to pay for the top 2% of spenders, the choice is made based on the distribution of

[25] For a review of some of these evaluations from Europe and the U.S., see Layton et al. (2017).

spending in the training sample. Results reported on the test sample will therefore not yield exactly 2% set aside for reinsurance.

4.1 Base Risk Adjustment Model and Residuals

We estimate risk adjustment models on total spending with the current specification used in each country. Table 4 reports summary statistics from the test samples for the risk adjustment models and information on the distribution of residuals (i.e. spending less risk adjustment predictions). The values of the R-squared are similar to those in other reports, 24.6% for Germany (Drösler et al., 2017), 31.6% for the Netherlands (Cattel et al., 2017), and 35.8% for the U.S. Marketplaces (Layton, Montz and Shepard, 2018). Better fit for the Marketplace model compared to that for Germany or The Netherlands is because Marketplaces use a concurrent risk adjustment model rather than the prospective models used in the other two countries.

Positive residuals result when spending is higher than predicted; negative residuals result when spending is lower than predicted. The mean absolute deviation ranges from over five thousand dollars in the Marketplaces to less than two thousand Euros in The Netherlands. Even after risk adjustment, the maximum residuals are in the millions of dollars or Euros, and the minimum residuals in the hundreds of thousands of dollars or Euros. Properties of the left side of the distribution of residuals depend heavily on the risk adjustment model. The minimum possible value for residual spending is the maximum value for predicted spending from the risk adjustment model (if that person spends nothing). In all three countries risk adjustment generates substantial overpayments for a meaningful share of the population. In Germany and The Netherlands one percent of the population is overpaid by about 10k Euros or more, and in the Marketplaces, overpayment exceeds $25k for one percent of the population. The median residual in each country is negative. In all three countries, residuals do not turn positive until about the 75th percentile of the distribution. This means that the large majority of the population is profitable for plans; losses are concentrated in the much smaller share of the population on the right side of the residual distribution.

4.2 Residual-Based Reinsurance and Repayment

Table 5 reports results for Models 1-5 listed in Table 3. In Models 2-3, reinsurance payments sum to 2% of total spending. In Models 4-5, reinsurance payments and repayments each sum to 2% of total spending. Risk adjustment alone leaves the top decile of spenders from the previous year undercompensated in each country, with the U.S. Marketplaces showing the lowest PR; the Dutch model is most successful by this metric. The Dutch model contains risk adjustors

based on prior high spending (see Table 1) which partially address underpayment for the last-year high-spending group.

The second set of rows for Model 2 shows the impact of conventional reinsurance. Setting aside 2% of funds for reinsurance corresponds to reinsurance thresholds of €140k in Germany, €122k in the Netherlands, and $350k in the U.S. Marketplaces. Notably, these thresholds touch a very small fraction of the population, less than .1 % in all markets – another indicator of the concentration of spending on the far-right tail of the spending distribution. Conventional reinsurance at 2% has a powerful effect on individual fit of payments to spending. Compared to the risk-adjustment-only model, PSF more than doubles for Germany, and moves to the range of around 60% in all three countries. PR for the top-decile of spenders in the prior year increases everywhere.[26] Conventional reinsurance moves about 4 % of the funds in comparison to risk-adjustment only in all three countries.

Model 3 targets the 2% set aside for reinsurance to residuals from the base risk adjustment model rather than spending. Thresholds defined in terms of residuals are lower than with conventional reinsurance since the risk adjustment amount is subtracted from spending to define residuals. Still, less than .1 % of the population is affected by residual-based reinsurance at 2%. Targeting the same reinsurance funds to residuals rather than spending buys an increase of about 3 percentage points in PSF in all countries. The 3 percentage point gain in individual fit compared to Model 2 is 'free' in incentive terms since the funds set aside for risk sharing are the same. Moreover, the 3 percentage point increase is substantial compared to potential improvements from adding risk-adjustor variables to already rich models.[27] Targeting residuals does not improve the PR for the top-decile of spenders in the prior year; in fact, it decreases slightly in all three markets. A potential explanation for this finding is that – in contrast to conventional reinsurance (Model 2) – residual-based reinsurance avoids 'double' payments for people with both high predicted spending and high

[26] Note that the PR for the top decile of spenders in t-1 is likely to be sensitive to how reinsurance is financed and whether or not risk adjustment weights are optimized for the presence of reinsurance. More specifically, the combination of a flat contribution and no optimization (as is true for model 2) is likely to result in double payments for people with both high predicted spending and high actual spending. Since these people are likely to be overrepresented in the group of high spenders in t-1, this group as a whole is likely to benefit from these overpayments.

[27] For example, Van Kleef et al. (2018b) find that inclusion of chronic conditions reported by general practitioners would improve the R-squared of the Dutch risk adjustment model by <.01. The latest published evaluation of the CMS-HCC risk adjustment system (Pope et al., 2011) reports an increase in R-squared of .014 between V12 and V21. V21 was, however, viewed as too gameable and some variables were dropped in the V22 put in place. The R-squared of V22 will thus be less than for V21.

actual spending (see also footnote 26). Assuming these people are overrepresented in the top decile of spending in the prior year, this group as a whole might receive less payment under residual-based reinsurance than under conventional reinsurance, thereby lowering the PR. This finding indicates that switching from spending-based reinsurance to residual-based reinsurance may not improve group-level fit for some groups of interest. Finally, funds redistributed increase only slightly in relation to conventional reinsurance.

Residual-based repayments at 2% are added to the payment models in the results for Model 4 in the next set of rows. The repayment threshold is much lower in absolute value than the reinsurance threshold because, as we have seen, the residual distribution is much less skewed on the left. While less than .1% of the population remain touched by reinsurance, the repayment threshold is crossed by less than 1% of the population in the three countries. Repayments augment payment system fit further in the .02 - .04 range. PR for the top-decile of spenders in the prior year decreases slightly. Some of those with high spending last year would generate high risk scores this year, and may fall in the highly overcompensated group if spending for whatever reason falls a lot this year. Taking funds from these people increases undercompensation from past high spenders. A repayment feature has little effect on the share of funds redistributed.[28]

The last set of results optimizes β weights in each country, derived from the iterative procedure described earlier. Thresholds from the previous set of rows (e.g., $209,826 for the reinsurance threshold for the Marketplaces) are used to truncate the left and right-hand side of the spending distribution for estimation of the β weights. Iteration is required since the thresholds from the "old" model are not exactly right for the "new" model. Reestimation of β weights has some interesting effects. The thresholds for reinsurance fall, which leads to slightly more people crossing the reinsurance threshold. Both in absolute and in relative terms, the effects of reestimation on the thresholds for repayment are bigger. Consequently, the share of population crossing the repayment threshold falls substantially, to, for example in the Marketplaces, only .28%. Reestimation of β weights must improve payment system fit, but the gains in fit at the individual level are small, in the third decimal place in all countries. PR for the previous high spenders is improved in relation to Model 4, but remains below the PR with Models 2 and 3. Optimization of β weights adds to the redistribution of funds in comparison to the base risk adjustment model. Whereas Model 4 only

[28] One possibility: (in modalities without optimization/changes of RA weights) 2% reinsurance will always result in about 4% redistribution (2% due to the reinsurance payments themselves and 2% due to the necessary reinsurance contributions). It doesn't really matter who makes the reinsurance contributions.

affects payments for people in the reinsurance and repayment ranges, Model 5 affects payments for other people too (due to changes in risk adjustment payment weights).

Results for PSF from Table 5 are summarized in Figure 3. The improvements in individual fit are very large, and remarkably similar in the three markets. Adding 2% conventional (i.e. spending-based) reinsurance to risk adjustment comes with a substantial gain in PSF. Changing from conventional to residual-based reinsurance gives non-trivial improvement. Adding 2% residual-based repayments also improves fit, though not as much as 2% (residual-based) reinsurance. The latter is because the residual distribution is more skewed on the right than on the left. Optimization of risk adjustment for the presence of 2% reinsurance/2% repayments does not substantially affect PSF. Note however that the importance of basing reinsurance on residuals and optimizing β weights is likely to increase as the share of funds devoted to reinsurance increases. The intuitive explanation is that with larger shares of reinsurance, overlap with risk adjustment payments is greater. Paying on residuals and optimizing the β's both contribute to avoiding overlap.

4.3 Reinsurance and Repayment with Alternative Thresholds

Table 6 presents the results for four new combinations of residual-based reinsurance and repayment. All payment models in Table 6 are similar to Model 5 from Table 5 except the share of funds devoted to reinsurance or repayment is the same or less. For each of the repayment/reinsurance modalities in the table β weights are optimized. Generally, the payment alternatives do little to increase the PR for last year's high spenders relative to conventional reinsurance. With residual-based reinsurance at 1%, with or without repayment, PSF is 50% or higher, increasing the individual-level fit of the Dutch model by 20 percentage points and the models in Germany and the US Marketplaces by 30 percentage points. When residual-based reinsurance is 2% of funds, with and without repayments, PSF is in the 60% range or higher, ultimately doubling the PSF in comparison to the current risk adjustment model in each market. For all the options shown, the number of people touched by reinsurance or repayment is very small, less than .05% (5 in 10,000) in all simulations.

Figure 4 summarizes the increments to PSF by residual-based reinsurance and repayment with optimized β weights. Patterns are very similar in all three countries.

Results in Table 6 and Figure 4 bear on the tradeoff of loss of cost containment incentives from risk sharing and fit of the payment system at the individual level. Incentives are diluted as

more funds are devoted to reinsurance or repayment.[29] The loss of cost control incentives depends on plan expectations about patterns of cost, but is approximated by the share of funds devoted to reinsurance and repayment.[30]

5. Discussion

Where reinsurance and risk adjustment are applied simultaneously, individual-level fit is maximized by basing reinsurance on the residuals that remain after risk-adjustment payments, and calibrating risk-adjustment weights on the spending net of the risk-sharing features of the payment system. Reinsurance can be flanked by repayments to further improve the fit in the tails of the residual distribution. Full optimization of payment system parameters to improve fit requires teamwork between risk-adjustment weights and reinsurance/repayments. Our paper shows that it is straightforward to mesh choice of risk adjustment weights with choice of risk sharing parameters. We do this for a series of models with the data actually used to build the payment systems in The Netherlands and the U.S. Marketplaces, and with a large insurer's data from Germany.

It will come as no surprise to researchers that conventional reinsurance can markedly improve the individual-level fit of a payment system. We add to this by showing that with a fixed share of funds going to reinsurance, teamwork – paying on residuals/optimizing risk-adjustment weights – gives fit another boost. The empirical results in terms of introduction of residual-based reinsurance, repayment, and optimized risk adjustment weights work in remarkable parallel in the three health insurance markets, with their different risk-adjustment models, health care systems, and

[29] Reinsurance based on residuals after risk adjustment is likely to improve incentives for cost control over conventional reinsurance with the same budget for reinsurance. The argument is parallel to that made by Van Kleef, Van de Ven and Van Vliet (2009) in the case of "shifted deductibles" where the authors moved the deductible range to be more likely to hit where the marginal decisions were being made about consumption. The deductible range was moved higher for those with higher predicted costs. In our case of "shifted reinsurance," moving the range where reinsurance kicks in higher for individuals likely to be higher costs makes it less likely a plan could anticipate being in the reinsurance range for any individual. Thus, reinsurance based on residuals maintains plans' incentives to control costs even for those with very high predicted costs. Our constraint on incentives is best interpreted as a simple operational way for a regulator to limit the degree incentives are diluted with reinsurance/repayment, not as a precise measure of "power" of a plan payment contract.

[30] With "static" expectations, the loss of incentive is just equal to the share of plan spending devoted to reinsurance and repayments. With perfect foresight, a plan knows that for persons destined to fall above the reinsurance or below the repayment threshold, the marginal spending is not plan responsibility, and the incentive effects are equal to the share of spending associated with the individuals over or below the thresholds.

simple magnitudes of spending. We come out of our analysis with a high degree of confidence that our findings generalize to other health care systems and payment models.

Teamwork adds to fit "for free" in the sense of creating no extra incentive cost associated with risk sharing. For any given share of funds devoted to risk sharing, joint optimization of payment and risk-adjustment parameters is worthwhile to improve fit. By analysis of a series of risk-sharing options, we quantify the tradeoff for a regulator, showing what can be had in terms of better fit at what cost in terms of the incentive effect of risk sharing. We regard the tradeoff to be very favorable. Massive gains in individual-level fit can be had touching only a very small portion of the individuals in the insurance pool.

Consideration of incentive effects of a payment system are important but complex. Even putting aside incentives related to risk selection, the cost control incentives of risk-adjusted payments are not always straightforward. The incentive effects of reinsurance and other risk-sharing features are evident, and can be measured in terms of the share of people or the share of funds affected. Risk-adjusted payments, depending on the adjustors used and their weights, also dilute cost-control incentives but the magnitude of the effects are less clear. Use of a concurrent risk adjustment model as in the US Marketplaces or use of past spending as a risk adjustor as in The Netherlands each also dilute incentives for cost control. More generally, any risk adjustor variable based on health care activity increases incentives for that activity to be undertaken.[31]

An alternative way to frame a policy discussion about incentives would be to ask, for example, what is the way to achieve a given fit with the least sacrifice in terms of incentives? A series of interesting questions emerges from this perspective. Suppose we were to ask, for The Netherlands, what would be needed in terms of residual-based reinsurance to achieve the same level of fit (in terms of the measure used in the Netherlands) as now but dropping past-spending groups from the risk adjustor variables? Or, for the Marketplaces, what level of residual-based reinsurance would be needed to achieve a target level of fit if only diagnoses from inpatient episodes counted toward morbidity indicators? Ideally, a regulator would have available comparative information about the incentive effects of risk adjustment as well as of any risk sharing. This is an open and important area for future research.

[31] This incentive is distinct from the incentive to "upcode" (or "right code") which refers to coding practices not incentives to do more. Use of risk adjustor variables based on activities reported in claims generally include both types of incentives.

We showed in our simulations that a little bit of residual-based reinsurance improves fit markedly keeping the current risk adjustment in place. A corollary is that a little bit of residual-based reinsurance could instead compensate for a simplification of the risk adjustment formula, going in the opposite direction to decades of research in all three countries seeking new risk adjustor variables to add to the formula. Simplification by dropping potentially problematic risk adjustors can improve incentives. Future work can study the simplifications that could be achieved by judicious use of targeted risk sharing.

The focus on residual spending calls attention to residuals on the other side of the spending distribution: individuals for whom risk adjustment payments greatly exceed what they spend. Our simulations explored this new territory in payment system design. Repayments, the mirror-image of reinsurance -- are an intriguing policy option. Repayments improve fit at the individual level. Repayments obviously also "give money back". If funds repaid, for example, were set equal to the funds devoted to reinsurance, the same level of funding could be devoted to risk adjustment before and after introduction of risk sharing. Very large left-hand side residuals also raise the simple question of whether it is necessary and appropriate to confer profits on the order of hundreds of thousands of dollars or Euros to a plan for a single individual. Should we limit profits such that, for example, a plan can make no more than $50k on any one person?

Before deciding what, if anything, should be done to modify payment systems in light of the high overpayments, research is needed to learn more about the people who fall on the far left of the distribution of residuals. To note just two relevant questions: What combination of flags and services is associated with such gross overpayments? Are people on the left persistently on the left?

In this paper our performance metrics were chosen so as to be comparable across the three countries. It is well-recognized, however, that health plan payment systems need to be evaluated on other criteria than simply fit at the individual level. Ideally, these criteria follow the specific objectives of the regulator in each country or sector. For example, when a regulator is concerned about selection incentives regarding groups with chronic illnesses evaluation, metrics should adequately capture these incentives. We believe consideration of other criteria, such as under payment for persons with chronic conditions and the practical feasibility of our ideas in a specific institutional setting, is best pursued on a country-by-country basis.

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Table 1
Health Plan Payment in Germany, the Netherlands and the U.S. Marketplaces

	Germany (2018)	Netherlands (2018)	Marketplaces (2018)
Number of individuals covered	72.2 m	17.1 m	10.6 m
Average plan spending per person per year	3,034 €	2,504 €	$5,772 (silver plan benchmark average premium 2018)
Geographic market	National	National	State with sub-state rating areas
Number of plans	110	About 60 (varying by premium and contracted care; each plan can come with deductible options and group arrangements)	1-15, mean 4.2 varies by rating area
Premiums	Single premium per health plan	Single premium per plan; rebates for voluntary deductibles and group arrangements	Limited age bands
Risk adjustment data	Morbidity data from 2017; spending data from 2018. Interim payments are made prior to final reconciliation	Spending from 2015 (made representative for 2018, e.g. in terms of benefits package and projected spending)	2016 MarketScan data on large employers/insurers
Risk adjustment demographics	Age, sex, reduced earning capacity, reimbursement status	Age, sex, regional factors, socio-economic status, source of income, household composition, yes/no institutionalized, level of education	Age, sex, geography
Risk adjustment disease indicators	201 hierarchical morbidity groups (HMG) based on: • prescribed drugs • in- and outpatient diagnoses	124 morbidity indicators based on: • prescribed drugs (PCGs) • hospital diagnoses (DCGs) • physiotherapy diagnoses • mental care diagnoses • durable medical equipment • multiple-year high or low spending • one-year spending on home care	Based on 127 HCCs (2016)

Table 1 continued

	Germany (2018)	Netherlands (2018)	Marketplaces (2018)
Timing of risk adjustment disease indicators	Prospective (i.e. disease indicators are based on information from the prior year)	Prospective (i.e. disease indicators are based on information from one or multiple prior years)	Concurrent (i.e., disease indicators are based on data from the same year as spending predictions)
Risk adjustment estimation procedure	Weighted least squares	Weighted least squares	Weighted least squares
Risk adjustment comments	Separate model for sick leave payments	Separate models for somatic care, mental health care and out-of-pocket spending below the mandatory deductible	Separate models for age groups and tiers of coverage
Risk sharing	Reinsurance 2002 - 2008	Reinsurance until 2014; risk corridors until 2016	Reinsurance 2014-2016; functional reinsurance restored in 2017 through transfer formula.
R-squared from the risk adjustment regression	26%	32% for somatic care 23% for mental healthcare 33% for OOP spending	35%

Note: Due to the volume of information presented here notes for each element are not provided. There are some additional features of the payment systems in each country not contained in the table, for example, Germany has special rules for those living abroad and for a small number of individuals paid by cost reimbursement. For detailed descriptions of each of these payment models with much of the information covered here, see Wasem et al. (2018), Van Kleef et al. (2018) and Layton, Montz and Shepard (2018).

Table 2
Data from Three Countries (Full Samples)

	Germany	The Netherlands (somatic care only)	U.S. Marketplaces
Source	Nationwide operating sickness fund	Insurers and government agencies	Large employers/insurers
Number of individuals	2.9 million	17.0 million	9.8 million
Year	2015	2015	2016
1st percentile spending	€ 0	€ 50	$0
10th percentile spending	€ 98	€ 92	$0
90th percentile spending	€ 7,062	€ 4,573	$14,085
99th percentile spending	€ 35,591	€ 33,003	$80,974
Maximum Spending	€ 2,267,508	€ 7,819,446	$8,541,629
Age range	Entire population	Entire population	21-64
Percent with disease indicator	49.1%	26.7%	21.4%

Note: U.S. data only covers people with full-year enrollment. Data from Germany and the Netherlands also covers people who were enrolled only part of the year. In the Dutch data spending is annualized here; in the German data it is not. The € 50 spending at the 1st percentile in The Netherlands is a mandatory fee everyone pays to register with a practitioner.

Table 3
Plan Payment Models Studied

Payment Model	Risk-Adjustment	Reinsurance	Repayment
Model 1: Risk adjustment only	β weights from least squares regression on total plan spending	None	None
Model 2: Risk adjustment plus conventional (i.e. spending-based) reinsurance	β weights from least squares regression on total plan spending	Full reinsurance after threshold of spending; financed by flat reduction in risk adjustment payment	None
Model 3: Risk adjustment plus residual-based reinsurance	β weights from least squares regression on total plan spending	Full reinsurance after threshold of spending less risk adjustment payment; financed by flat reduction in risk adjustment payment	None
Model 4: Risk adjustment plus residual-based reinsurance and repayment	β weights from least squares regression on total plan spending	Full reinsurance after threshold of spending less risk adjustment payment; financed by repayments (and – when total reinsurance is larger than total repayments – a flat reduction in risk adjustment payment)	Full repayment after threshold of risk adjusted payment less spending; contributes to financing reinsurance
Model 5: Risk adjustment plus residual-based reinsurance and repayment and with optimized β weights	β weights from least squares regression on plan obligations net of reinsurance and repayment	Full reinsurance after threshold of spending less risk adjustment payment; financed by repayments (and – when total reinsurance is larger than total repayments – a reduction in risk adjustment payment via the optimized β weights)	Full repayment after threshold of risk adjusted payment less spending; contributes to financing reinsurance

Table 4

Residuals from the Base Risk Adjustment Model

	Germany	The Netherlands (somatic care only)	U.S. Marketplaces
Fit of the risk adjustment model			
R-squared	23.7%	31.6%	35.8%
CPM	24.0%	31.8%	28.3%
Residuals		(Euros or Dollars)	
Mean absolute deviation	3,566	1,985	5,559
Min	-334,029	-382,283	-529,274
1st percentile	-10,905	-8,988	-26,511
10th percentile	-3,283	-2,240	-5,037
25th percentile	-1,651	-1,098	-2,832
Median	-827	-444	-1,530
75th percentile	-110	-59	55
90th percentile	2,870	1,375	5,472
99th percentile	32,097	20,380	49,035
Max	1,892,219	7,812,633	3,578,792

Note: Statistics are reported from the test sample based on estimates from the training sample. Data from Germany and the Netherlands are annualized here. The maximum residual for Germany is the largest value for an individual enrolled for the full year. U.S. data are full-year enrollees.

Table 5
Risk Adjustment, Reinsurance, and Repayment

	Germany	The Netherlands	Marketplaces
Model 1: Base Risk Adjustment			
Payment System Fit	24.0%	31.6%	35.8%
PR_g	76.7%	94.5%	69.0%
Funds redistributed	NA	NA	NA
Model 2: Conventional (i.e. spending-based) Reinsurance 2%			
Attachment points			
Upper Threshold	€139,810	€122,044	$350,301
Lower Threshold	NA	NA	NA
Population affected			
Above Upper Threshold	.04%	.04%	.06%
Below Lower Threshold	NA	NA	NA
Payment System Fit	56.4%	55.6%	60.5%
PR_g	80.3%	96.9%	73.1%
Funds redistributed	3.9%	4.0%	4.3%
Model 3: Residual-based Reinsurance 2%			
Attachment points			
Upper Threshold	€102,789	€90,975	$209,959
Lower Threshold	NA	NA	NA
Population affected			
Above Upper Threshold	.07%	.07%	.07%
Below Lower Threshold	NA	NA	NA
Payment System Fit	59.9%	58.8%	62.6%
PR_g	79.9%	96.4%	73.2%
Funds redistributed	4.0%	4.1%	4.4%
Model 4: Residual-based Reinsurance and Repayment (2%, 2%)			
Attachment points			
Upper Threshold	€102,724	€90,929	$209,826
Lower Threshold	-€11,044	-€12,009	-$48,832
Population affected			
Above Upper Threshold	.07%	.07%	.07%
Below Lower Threshold	.96%	.59%	.34%
Payment System Fit	62.6%	61.7%	66.6%
PR_g	76.8%	92.6%	71.0%
Funds redistributed	4.0%	4.1%	4.1%
Model 5: Residual-based Reinsurance and Repayment (2%, 2%) with Optimized β weights			
Attachment points			
Upper Threshold	€101,179	€88,908	$206,502
Lower Threshold	-€13,830	-€15,198	-$54,801
Population affected			
Above Upper Threshold	.07%	.07%	0.08%
Below Lower Threshold	.61%	.41%	0.28%
Payment System Fit	63.0%	62.0%	6.8%
PR_g	78.4%	95.1%	.71.5%
Funds redistributed	6.2%	6.2%	5.9%

Table 6

Residual-Based Reinsurance and Repayment with Optimized β's

	Germany	The Netherlands	Marketplaces
Base Risk Adjustment			
Payment System Fit	24.0%	31.6%	35.8%
PR_g	76.7%	94.5%	69.0%
Funds redistributed	NA	NA	NA
Reinsurance 1%; Repayment 0%			
Attachment points			
Upper Threshold	€169,932	€150,650	$370,588
Lower Threshold	NA	NA	NA
Population affected			
Above Upper Threshold	.03%	.02%	.03%
Below Lower Threshold	NA	NA	NA
Payment System Fit	53.3%	51.6%	55.8%
PR_g	77.3%	94.7%	70.3%
Funds redistributed	2.6%	2.2%	2.8%
Reinsurance 1%; Repayment 1%			
Attachment points			
Upper Threshold	€166,474	€146,457	$353,552
Lower Threshold	€-19,700	€-22,159	$-80,484
Population affected			
Above Upper Threshold	.03%	.02%	.03%
Below Lower Threshold	.25%	.15%	0.14%
Payment System Fit	55.4%	53.8%	58.4%
PR_g	77.6%	94.9%	70.6%
Funds redistributed	3.5%	3.3%	3.3%
Reinsurance 2%; Repayment 0%			
Attachment points			
Upper Threshold	€105,068	€92,827	$223,529
Lower Threshold	NA	NA	NA
Population affected			
Above Upper Threshold	.07%	.07%	.07%
Below Lower Threshold	NA	NA	NA
Payment System Fit	60.2%	59.0%	63.0%
PR_g	77.6%	94.9%	70.9%
Funds redistributed	4.7%	4.1%	4.8%
Reinsurance 2%; Repayment 1%			
Attachment points			
Upper Threshold	€102,253	€89,860	$212,733
Lower Threshold	€-18,156	€-20,552	$-71,782
Population affected			
Above Upper Threshold	.07%	.07%	.07%
Below Lower Threshold	.28%	.18%	.16%
Payment System Fit	62.1%	60.9%	65.3%
PR_g	78.0%	95.0%	71.2%
Funds redistributed	5.5%	5.1%	5.1%

Figure 1

Conventional Reinsurance Defined in Terms of Spending

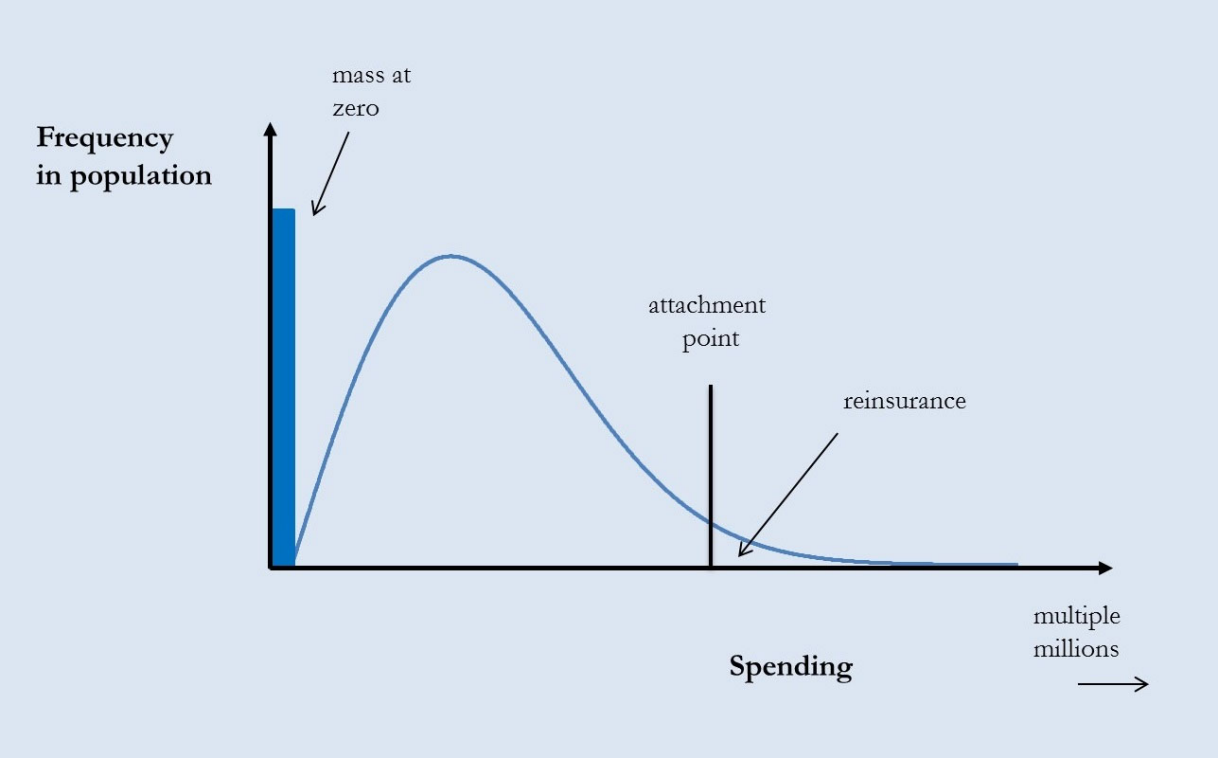

Figure 2

Reinsurance and Repayment Based on Residuals from Risk Adjustment

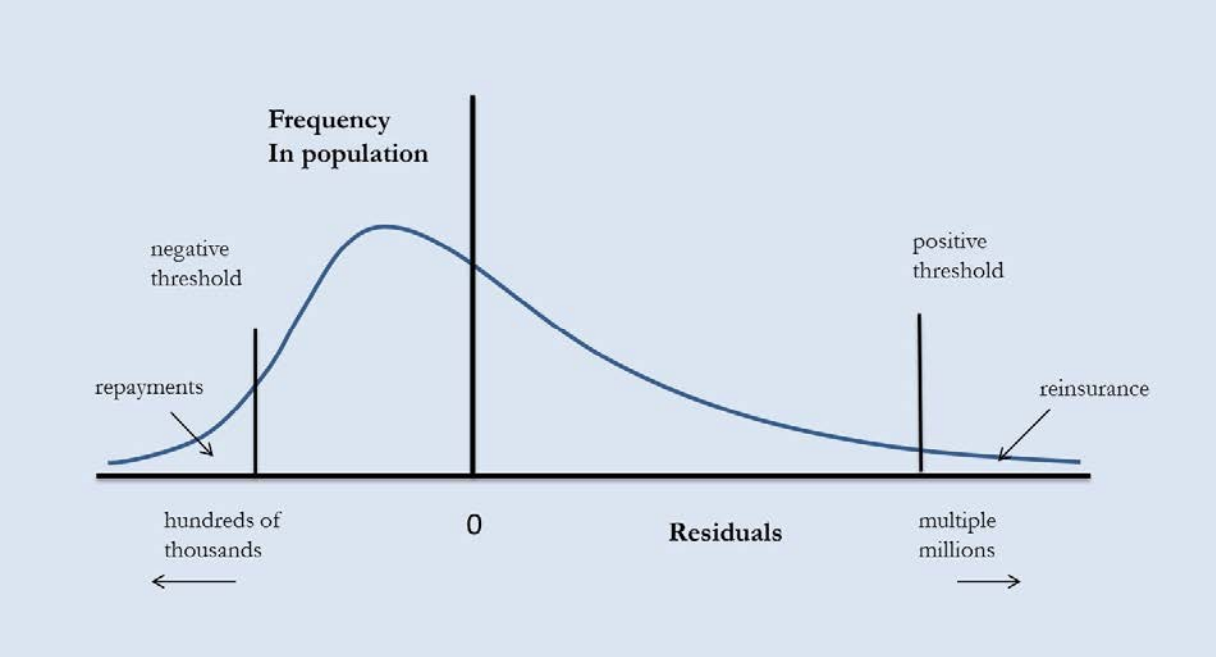

Figure 3

Payment System Fit of Five Models in Three Different Settings

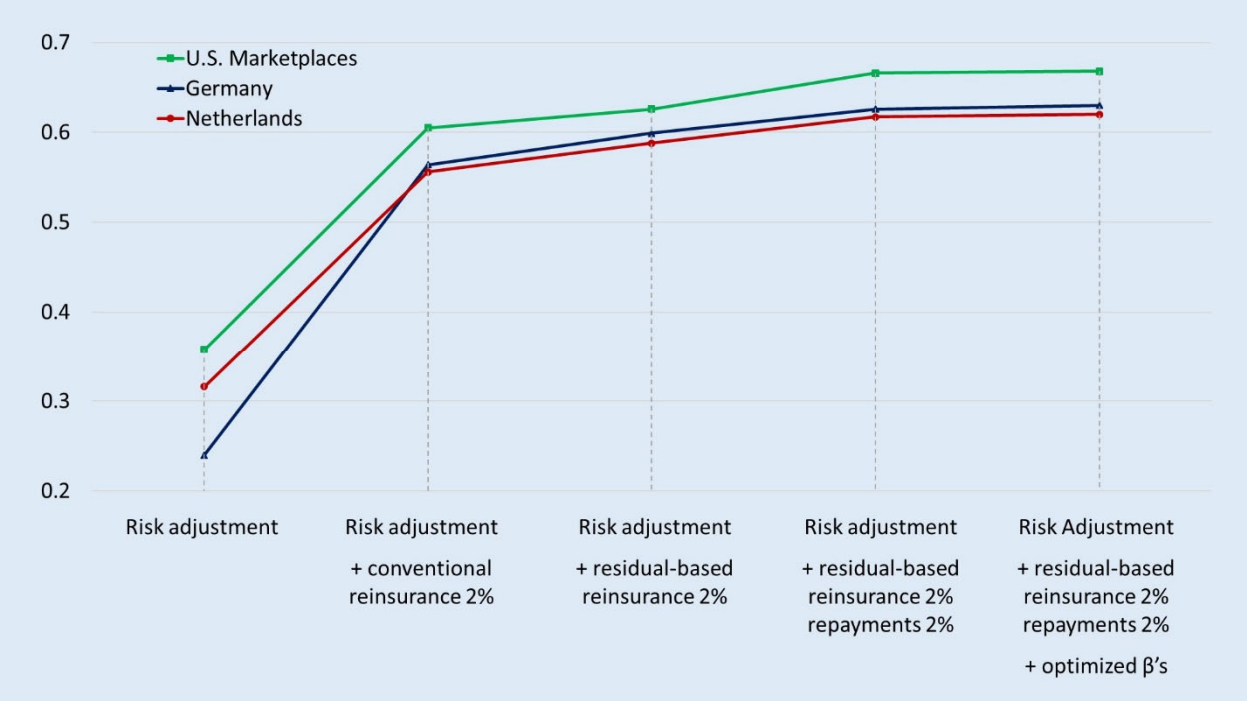

Figure 4

Payment System Fit of Six Combinations of Reinsurance/Repayment, all with Optimized Risk Adjustment Weights