Direct versus indirect standardization in risk adjustment

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Abstract

Direct and indirect standardization procedures aim at comparing differences in health or differences in health care expenditures between subgroups of the population after controlling for observable morbidity differences. There is a close analogy between this problem and the issue of risk adjustment in health insurance. We analyse this analogy within the theoretical framework proposed in the recent social choice literature on responsibility and compensation. Traditional methods of risk adjustment are analogous to indirect standardization. They are equivalent to the so-called conditional egalitarian mechanism in social choice. In general, they do not remove incentives for risk selection, even if the effect of non-morbidity variables is correctly taken into account. A method of risk adjustment based on direct standardization (as proposed for Ireland) does remove the incentives for risk selection, but at the cost of violating a neutrality condition, stating that insurers should receive the same premium subsidy for all members of the same risk group. Direct standardization is equivalent to the egalitarian-equivalent (or proportional) mechanism in social choice. The conflict between removing incentives for risk selection and neutrality is unavoidable if the health expenditure function is not additively separable in the morbidity and efficiency variables.

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1 Introduction

As soon as the regulator imposes community-rating on a market of health insurance, he creates incentives for undesirable risk selection. This is the basic reason for introducing a so-called equalization fund or a system of risk adjusted premium-subsidies (Newhouse, 1996; van de Ven and Ellis, 2000). The aim of risk adjustment (RA) is to compensate the insurers for differences in the needs profiles of their members, while at the same time keeping incentives for cost control. In practice, the financial streams to and from the equalization fund or the risk adjusted premium subsidies are derived from observations on health care expenditures. Yet observed expenditures do not only reflect differences in needs, but also differences in the cost efficiency of the insurers. To get a good estimate of the former, one has to remove the effect of the latter. This immediately suggests that there is a close analogy between risk adjustment and the issue of direct and indirect standardization, which is analyzed mainly in the epidemiological literature. Indeed, direct and indirect standardization procedures aim at comparing differences in health or differences in average expenditures between different groups after controlling for observable morbidity differences, captured by variables such as age and gender. The analogy with risk adjustment is clear as soon as the memberships of the different insurers are seen as the groups for which the health care expenditures have to be standardized.

The relationship between different methods of standardization on the one hand and different RA-systems on the other hand has not been analyzed in the literature until now. As we will show, the main reason for this lack of interest may be that almost all the existing systems (implicitly) use the method of indirect standardization. This is true both for the so-called "internal" models of Germany and Switzerland and for the so-called "external models" of the Netherlands, Belgium, Israel and the US Medicare system. The choice for indirect standardization is not self-evident, however, and one can ask how risk adjustment based on direct standardization would look like and what are the relative advantages and disadvantages of both approaches. The question becomes more relevant because the risk equalization procedure, proposed in Ireland, is the proverbial exception on the general rule that risk adjustment is based on indirect standardization. In fact, in the Irish system, financial streams to and from the equalization fund are based on the actual costs of the insurers themselves and it has been claimed (Armstrong, 2006) that this improves the incentives for efficiency for the contributing insurers, i.e. the insurers with a favorable needs profile. We investigate (and reject) this claim.

We analyze the problem of risk adjustment in a system of (social) health insurance. Very similar issues arise in other systems with risk adjustment, e.g. when a given budget has to be allocated over different geographical entities (Rice and Smith, 2001). One can easily argue that the problem of individual risk selection is much less urgent in the latter systems, because it is more difficult (or nearly impossible) for local authorities to "select" individual citizens. More emphasis should therefore be put on the (easier) problem of equity at an aggregate level and less on incentives for individual risk selection. Yet, in so far as there remains a problem of differential treatment of different groups of citizens because of financial reasons, our results are also relevant in a context of geographical allocation of resources.

Our analysis remains purely theoretical. We focus on the basic principles underlying both methods and analyze the incentives for risk selection and efficiency in the hypothetical setting in which the regulator has perfect information on the needs profile of the members of the different insurers. It will turn out that even with perfect information the questions raised are not trivial. Of course, in the real world the most urgent problems of risk selection follow from the fact that the morbidity information used is far from perfect and most attention goes precisely to the improvement of the informational basis. Yet, while it is true that the problem we analyze is of second order for policy makers, we still feel that our analysis throws an interesting light on the structural features of different risk adjustment systems.

The problem of risk adjustment is related to the issue of measuring inequity in health and in health care delivery. There also, one of the challenges is to correct adequately for differences in needs, in this case between different socioeconomic groups. The choice between direct and indirect standardization has been discussed in that setting by Wagstaff and van Doorslaer (2000). Our paper is even more closely related to Gravelle (2003), who argues that direct standardization is the better approach to measuring income related inequality in health, because indirect standardization leads to inconsistent estimates. Some of our results are similar, but we focus less on the statistical aspects. Moreover, we explicitly introduce a formal framework to analyze incentives for risk selection and efficiency. This formal framework boils down to a reinterpretation of the recent social choice literature on redistribution, in which an explicit distinction is made between individual responsibility and compensation characteristics (Fleurbaey and Maniquet, forthcoming).

We believe that this framework should receive more attention in health economics.[1]

In section 2 we introduce a simple model with two insurers and two risk groups to explain the relationship between risk adjustment and indirect versus direct standardization. We show how traditional risk adjustment systems coincide with the former, while the proposed scheme in Ireland coincides with the latter. In section 3 we set up our theoretical framework for the evaluation of RA-systems. We formalize the incentives for risk selection and for efficiency and we analyze a number of popular solutions from the social choice literature. It will turn out that it is generally impossible to reconcile different desirable features of the RA-system, even in the hypothetical situation of perfect information. Sections 4 and 5 are the core of the paper, in which we discuss the characteristics of indirect and direct standardization methods respectively. We show that they represent different positions on the trade-off between solidarity and efficiency. Section 6 concludes.

2 A simple model of standardization and risk adjustment

Consider a situation with N individuals. Denote the health care expenditures of individual i by E_i. We distinguish two needs groups, the old and the young, indicated by the subscripts $g = O, Y$ respectively. There are N_O old and N_Y young individuals in society, with $N_O + N_Y = N$. There are two insurers A and B, indicated by the superscripts $s = A, B$ respectively. With a similar notation we have $N^A + N^B = N$. The numbers of the old and the young who are insured with insurers A and B respectively are given by N_O^A, N_O^B, N_Y^A, and N_Y^B.The share of subgroup g, insured by insurer s, as a fraction of the total population is given by $p_g^s = (N_g^s/N)$. Average expenditures in the two groups, for the two insurers and for the respective subgroups are written in an obvious notation as $E_g^s, s = A, B, g = O, Y$. We assume that $E_O > E_Y$.[2]

[1] See Fleurbaey (2006) for a general treatment of health-related issues and Fleurbaey and Schokkaert (2007) for an application to the measurement of inequity and inequality in health and health care delivery.

[2] A warning concerning our notation is in place here to avoid confusion. Each time we use the subscript i, we refer to variables at the level of the individual. In all other cases the same variable refers to averages. Hence, E_i denotes the expenditures of individual i, while E, E^A, E^B, E_O and E_Y refer to average expenditures for the population and for the

Using this notation, the average expenditures in the population are given by

$$E = p_O E_O + p_Y E_Y = p^A E^A + p^B E^B \tag{1}$$

while the average expenditures E^s for insurer s ($s = A, B$) can be written as

$$E^s = (p^s_O/p^s)E^s_O + (p^s_Y/p^s)E^s_Y \tag{2}$$

This expression immediately shows that there are two possible causes for differences between E^A and E^B. First, the two insurers may differ in their efficiency to control costs. This will be captured by differences in the expenditures per need group, i.e. differences in (E^s_O, E^s_Y). Secondly, the needs composition of their membership $(p^s_O/p^s, p^s_Y/p^s)$ may differ.

2.1 Modelling the risk adjustment (RA) system

Expenditures are financed by insurers[3]. The regulator imposes that premiums are community-rated, because premium differentiation on the basis of health risks is considered unacceptable for equity reasons. As soon as community-rating is imposed, however, there is a danger of explicit risk selection by insurers: the better risks will in general be more profitable, since their actual expenditures will be lower than the average community-rated premium. The aim of introducing a system of risk adjustment is precisely to remove these incentives for risk selection through a system of premium subsidies. However, in order to keep incentives for cost efficiency, these premium subsidies should only reflect differences in needs and not differences in efficiency. Therefore, for each individual member i, the regulator defines a level of "acceptable costs" A_i, i.e. "the costs generated in delivering a specified basic benefits package containing only medically necessary and cost-effective care" (van de Ven and Ellis, 2000, p. 767). Premium subsidies should reflect only these acceptable costs.

Broadly speaking, there are two ways of setting up a system of risk adjustment.[4] The first is the "*internal model*", in use in Switzerland and Germany.

different subgroups respectively.

[3]We assume that out-of-pocket payments of the patients are zero. Alternatively, one may interpret the expenditures E_i as expenditures net of out-of-pocket payments.

[4]See van de Ven and Ellis (2000) for a detailed description of different models of risk adjustment on health insurance markets. Institutional details of the system in different European countries can be found in van de Ven et al. (2003).

In this model all the financial means are collected by the insurers through their community-rated premiums. In principle, insurers for which $A^s < E$ should pay into the central fund, while insurers for which $A^s > E$ should receive from the fund. However, there is a budget condition to be satisfied. Denoting financial streams to and from the fund by S, this budget condition implies $S^A + S^B = 0$. If $\sum_i A_i = \sum_i E_i$, the budget constraint will automatically be satisfied for $S_i = A_i - E$. If this is not the case, imposition of the budget constraint requires some adjustment to the acceptable costs level A_i. We will denote these "adjusted" acceptable costs by ω_i^{int}, implying that $\sum_i E_i = \sum_i \omega_i^{int}$.The financial streams to and from the fund are then written as

$$S^s = \omega^{int,s} - E \tag{3}$$

After paying to or receiving from the fund, the net average financial cost for the insurer (to be financed by the community rated premium) is given by

$$P^s = E^s - S^s = E + (E^s - \omega^{int,s}) \tag{4}$$

showing that premium differences between insurers will only reflect differences between actual cost and acceptable costs, i.e. differences in efficiency.

In the alternative "*external model*" of risk adjustment (implemented in the Netherlands, in Belgium, in Israel and in the U.S. Medicare system), a central fund collects the financial means (e.g. through social security contributions) and pays premium subsidies to the individual insurers. These premium subsidies then correspond to the acceptable costs. We denote the total budget of the fund by Ω. If $\Omega(\equiv \sum_i A_i) = \sum_i E_i$, all health care expenditures are covered through premium subsidies. In practice, however, Ω will be smaller than total expenditures and the difference $(\sum_i E_i - \Omega)$ has to be covered by the insurers through community-rated premiums. To simplify matters, we will neglect this feature and assume that $\Omega = \sum_i E_i$. Introducing this simplification boils down to adding or subtracting an irrelevant constant to all expressions below and does not change any of our conclusions. We will then denote the premium subsidy for individual i in the external model by ω_i^{ext}, with $\Omega = \sum_i \omega_i^{ext}$ and therefore $\sum_i E_i = \sum_i \omega_i^{ext}$. There is now a perfect analogy between the internal and the external model. We will therefore drop the superscripts "int" and "ext" and denote acceptable costs for individual i by A_i and adjusted acceptable costs (and premium subsidies) for individual i by ω_i. In the sequel we will also use

$$\pi_i = \omega_i - E_i \tag{5}$$

as a shorthand notation for the "profitability" of member i in a system of community rating.

Where do the acceptable costs come from? In principle they could be based on an external judgment of what is "medically necessary and cost-effective care". In practice, however, they are always based on observed expenditures. Yet it would make no sense to simply equate acceptable costs A_i with observed expenditures E_i. As was made clear in eq. (2), differences in observed expenditures reflect both differences in needs and differences in efficiency - and the whole idea of risk adjustment is that differences in acceptable costs should only reflect the former. Therefore the effect of the latter differences should be removed from E_i. This way of formulating the problem shows the clear analogy between "defining acceptable costs" on the one hand and the epidemiological literature on direct and indirect standardization on the other hand. When applied to medical care expenditures, these standardization procedures aim at comparing differences in average expenditures between different groups after controlling for differences in needs, or, alternatively, aim at checking whether individuals at the same needs level end up with an identical amount of care, irrespective of the group to which they belong. In our setting the relevant "groups" are the two insurers. Let us now introduce both methods of standardization in this setting.

2.2 Indirect standardization

The indirect standardization method transforms expenditures by applying an exogenously given standard level of expenditure to the actual population structure of the group. Analogous to (2), the indirectly standardized expenditures for group s ($s = A, B$) are given in general by

$$E^{s,ind} = (p^s_O/p^s)E^*_O + (p^s_Y/p^s)E^*_Y \tag{6}$$

where E^*_O and E^*_Y refer to the expenditure standards. A common choice for these standards is to take the average values in the population, in which case eq. (6) becomes

$$E^{s,inda} = (p^s_O/p^s)E_O + (p^s_Y/p^s)E_Y \tag{7}$$

Applying this idea to the risk adjustment problem, it is striking that equations (6) and (7) remove differences in "efficiency" by construction, while differences in needs profile are kept. One can therefore immediately equate the acceptable costs to the indirectly standardized expenditures, i.e. define

$A^{s,ind} = E^{s,ind}$. In general, as explained before, one will still have to adjust these acceptable costs in order to satisfy the budget constraint. However, this will automatically be taken care of if one opts for the special case (7). We therefore define

$$\omega^{s,ind} = E^{s,inda} \tag{8}$$

and, using (4), the premium contribution to be raised by insurer s becomes

$$P^{s,ind} = E + E^s - E^{s,inda} \tag{9}$$

While, as far as we know, the literature on risk adjustment does not refer to the issue of standardization, this indirect procedure boils down exactly to the traditional method of risk adjustment as implemented in practice. In fact, in the internal models of countries like Switzerland and Germany, the population is divided in groups which are homogeneous with respect to needs. Average expenditures are calculated for each of the corresponding cells and taken as the standard. In our model with two risk groups, this boils down to choosing

$$\begin{aligned} \omega_O &= E_O \\ \omega_Y &= E_Y \end{aligned} \tag{10}$$

The average premium subsidies at the level of the insurer are then given by the weighted average of the expressions in (10), which gives immediately eq. (7). The per capita transfers to and from the equalization fund (3) are computed as

$$S^{s,ind} = (p_O^s/p^s - p_O)E_O + (p_Y^s/p^s - p_Y)E_Y. \tag{11}$$

In the external models the usual starting point is a regression equation of expenditures on needs factors (and needs factors only). Acceptable costs are defined as the expenditures predicted by these equations. In a linear model with the sum of disturbances equal to zero, this of course also boils down to an application of (10).

2.3 Direct standardization

The alternative direct standardization method is less known in the risk adjustment literature. It transforms expenditures by applying a standard needs profile to the actual expenditure profile of the group. Directly standardized expenditures of group s $(s = A, B)$ are then given in general by

$$E^{s,dir} = p_O^* E_O^s + p_Y^* E_Y^s \tag{12}$$

and, in the special case where the average needs profile in the population is taken as the standard,

$$E^{s,dira} = p_O E_O^s + p_Y E_Y^s \tag{13}$$

We will further focus on case (13). Differences between insurers in these directly standardized expenditures can only be due to efficiency differences, since the needs profile is kept constant. Therefore, these differences should be reflected in the community rated premiums of the insurers. On the other hand, if for insurer s actual expenditures are larger (smaller) than directly standardized expenditures, this necessarily reflects a worse (better) needs profile. This suggests to define contributions to and from the fund as $(E^s - E^{s,dira})$.

However, as before this specification does not necessarily satisfy the budget constraint. Two adjustment procedures readily suggest themselves. The first is an additive one and defines $\widetilde{E}^{s,dira}$, the adjusted directly standardized expenditures, as

$$\widetilde{E}^{s,dira,add} = E^{s,dira} + (E - p^A E^{A,dira} - p^B E^{B,dira}) \tag{14}$$

The second is a proportional adjustment, leading to

$$\widetilde{E}^{s,dira,prop} = \frac{E}{p^A E^{A,dira} + p^B E^{B,dira}} E^{s,dira} \tag{15}$$

In both cases we arrive at $p^A \widetilde{E}^{A,dira} + p^B \widetilde{E}^{B,dira} = E$. We will discuss both procedures in section 5. For the moment, we leave this choice open and we use the general notation $\widetilde{E}^{s,dira}$ to indicate budget-adjusted directly standardized expenditures. This then leads to the following definition for the contributions to and from the fund

$$S^{s,dira} = E^s - \widetilde{E}^{s,dira} \tag{16}$$

As before, acceptable costs are defined as the average expenditures plus the "acceptable" differences. Interpreting (16) as these acceptable differences yields

$$\omega^{s,dira} = E + E^s - \widetilde{E}^{s,dira} \tag{17}$$

which is to be compared with (8). Moreover, using (4) and (17) we obtain

$$P^{s,dir} = \widetilde{E}^{s,dira} \tag{18}$$

which can be compared with (9). Note that eq. (18) perfectly reflects the idea that differences between insurers in directly standardized expenditures are due to efficiency differences and should therefore be reflected in the community rated premiums.

As noted before, this direct standardization approach is less known in the risk adjustment literature. To the best of our knowledge, there is only one real-world example: the proposed (but hotly debated) scheme in Ireland. Under the Irish equalization scheme insurers either contribute to or receive payments from the solidarity fund based upon their own cost distribution, rather than that of the market (Armstrong, 2006). This is exactly the system described in eqs. (13) and (16). The budget constraint is satisfied in the Irish system through a proportional adjustment (15).

We can now formulate the basic questions of this paper. How to interpret the differences between the indirect and the direct standardization methods in the context of risk adjustment? Are there conditions under which they coincide? If they lead to different premium subsidies, what are their relative advantages and disadvantages? Is the empirical dominance of the indirect standardization method a reflection of its theoretical superiority?

3 A theoretical framework for evaluating risk adjustment systems

To evaluate the two approaches, we need a theoretical framework formalizing the basic principles underlying the system of community-rating with risk adjustment. In Schokkaert et al. (1998) and Schokkaert and Van de Voorde (2004), we argued that the problem of risk adjustment is formally similar to the treatment of redistribution in the social choice literature on responsibility and compensation (Fleurbaey and Maniquet, forthcoming). We first briefly repeat the main features of this approach in abstract terms and then apply it to a simple linear model along the lines described in the previous section.

3.1 Responsibility and compensation

Given the setting of the problem, it is obviously necessary to distinguish two sets of explanatory factors in the expenditure equation. We therefore write:

$$E_i = f(C_i, R_i) \tag{19}$$

where C_i refers to "compensation" variables (related to morbidity) and R_i refers to "responsibility" variables (related to the efficiency of the insurers). We assume that there is a monotonic positive relationship between expenditures and the level of C_i and R_i. The whole point now is to derive acceptable costs A_i (or ω_i) from the information about E_i in such a way that the incentives for risk selection are removed, while the incentives for efficiency are kept. Moreover, the regulator has to respect the budget constraint[5]

$$\sum_i \omega_i = \sum_i E_i \equiv \sum_i f(C_i, R_i) \tag{20}$$

The incentives of insurers can be represented using the "profitability" (5) of the different individuals in a system of community rating. These differences in relative profitability may reflect differences in efficiency: in that case they are not problematic from a social point of view. However, they may also reflect differences in morbidity. To focus on the latter, consider two individuals i and j with $R_i = R_j$, i.e. differing only in morbidity (or compensation) variables. If $\pi_i > \pi_j$, it is profitable for an insurer to attract individual i rather than individual j. This immediately creates the danger of unequal treatment of these two individuals in terms of open risk selection or differentiated supply of service quality. This is exactly what we try to avoid through the RA-system. This crucial condition to remove the incentives for risk selection, or more generally, the incentives for differential treatment, can be formalized as follows[6]:

Condition 1 *NO INCENTIVES FOR RISK SELECTION (NIRS). Take any two individuals with $R_i = R_j$. Then the RA-system should be such that $\pi_i = \pi_j$.*

[5] Remember that this implies an innocuous simplification in the case of the external model, where in reality $\sum_i \omega_i = \Omega < \sum_i E_i$. Because we introduced this simplification, the following expressions are simpler than the analogous expressions in Schokkaert et al. (1998) and Schokkaert and Van de Voorde (2004).

[6] As noted before, our analysis focuses on social health insurance systems. Its relevancy for the issue of risk-adjusted geographical allocation of resources depends on the relevancy of condition NIRS in the latter setting.

Of course, condition NIRS can be satisfied in many different ways. As an obvious example, consider a system in which $\forall i,\ \omega_i = E_i$ and, therefore, $\forall i,\ \pi_i = 0$. This clearly removes all incentives for risk selection, but it implies the simple reimbursement of all expenditures and would therefore destroy all incentives for efficiency. As mentioned before, differences in expenditures will also reflect differences in efficiency between different insurers, which should not lead to larger premium subsidies. A simple condition to formalize this requirement is that insurers should get the same premium subsidy for two individuals i and j with the same health care needs, irrespective of possible differences in expenditure following from efficiency differences:

Condition 2 *NEUTRALITY (NEUT). Take any two individuals with $C_i = C_j$. Then the RA-system should be such that $\omega_i = \omega_j$.*

The interpretation of condition NEUT is straightforward. It is instrumental in introducing incentives for efficiency. Indeed, applying (5) and the assumption of monotonicity of (19), it follows from NEUT that

$$\pi_i < \pi_j \qquad \forall i, j \text{ with } C_i = C_j \text{ and } R_i > R_j,$$

i.e. increases in efficiency (keeping morbidity constant) lead to increases in profitability. More efficient insurers can therefore enjoy their efficiency advantage. Of course, this simple conclusion only holds in a system of strict community rating by insurers. Moreover, even then it is only a minimal condition for efficiency, neglecting all considerations of quality differentials and costs of expenditure control for the insurers. This is the reason why we prefer to give the condition a less ambitious neutrality interpretation. Formulated as such, however, it seems a very intuitive and straightforward condition.

While it can be argued easily that respect of conditions NIRS and NEUT is not *sufficient* to have an adequate RA-system, we think that they both are *strongly desirable.* The following result from the social choice literature is therefore rather worrying:

Lemma 3 *(Fleurbaey, 1994,1995) If the medical expenditure function f(.) is not additively separable in C- and R-variables, then no risk adjustment scheme can satisfy both NIRS and NEUT (if $N \geqslant 4$).*

Note that this result holds under the condition that the regulator has perfect information about (19). It is therefore *not* a traditional second best-result. Its intuition can be grasped as follows. Consider four individuals I, J, K and L with individual characteristics $(\widetilde{c}, \widetilde{r})$, $(\widetilde{c}, \overline{r})$, $(\overline{c}, \widetilde{r})$ and $(\overline{c}, \overline{r})$ respectively. Condition NIRS then requires (see (5))

$$\begin{aligned} \omega_I - \omega_K &= f(\widetilde{c}, \widetilde{r}) - f(\overline{c}, \widetilde{r}) \\ \omega_J - \omega_L &= f(\widetilde{c}, \overline{r}) - f(\overline{c}, \overline{r}) \end{aligned} \tag{21}$$

On the other hand, NEUT requires that $\omega_I = \omega_J$ and $\omega_K = \omega_L$. This implies that the expressions at the RHS of (21) have to be equal. It is easily seen that this can only be true if the expenditure function $f(.)$ is additively separable in the compensation and responsibility variables, i.e. if it can be written as $f(C_i, R_i) = g(C_i) + h(R_i)$. In all other cases there is a basic conflict between NEUT and NIRS and compromise solutions will have to be sought.

In fact, for the additively separable case, Bossert (1995) and Bossert and Fleurbaey (1996) introduce what they call a "natural mechanism":

$$\omega_i^{NAT} = g(C_i) + \frac{1}{N} \sum_k h(R_k) \tag{22}$$

It is easy to check that this mechanism satisfies NEUT and the budget condition (20). It also satisfies NIRS. This immediately follows from the fact that the individual profitability π_i, given by

$$\pi_i^{NAT} = \frac{1}{N} \sum_k h(R_k) - h(R_i) \tag{23}$$

is independent of the level of C_i.

Compromise solutions for the non-additively separable case have been proposed by (among others) Bossert and Fleurbaey (1996) and were already reinterpreted for the problem of risk adjustment in Schokkaert et al. (1998). A first possibility is to pick a member from the family of so-called conditional egalitarian solutions, defined for a freely chosen benchmark value $\widetilde{R}$ as:

$$\omega_i^{CE} = f(C_i, \widetilde{R}) + (1/N) \sum_k (f(C_k, R_k) - f(C_k, \widetilde{R})) \tag{24}$$

Note that the second term is a constant, introduced so as to satisfy (20). Differences in the premium subsidies between different individuals can only follow from the first term in (24). It is therefore obvious that (24) satisfies NEUT. Applying (5) yields

$$\pi_i^{CE} = f(C_i, \widetilde{R}) - f(C_i, R_i) + (1/N) \sum_k (f(C_k, R_k) - f(C_k, \widetilde{R})) \qquad (25)$$

This expression shows that π_i^{CE} in general will depend on the level of C_i. Therefore, NIRS is not satisfied and there may be incentives for risk selection.

If one wants to satisfy NIRS, but not necessarily NEUT, one can choose a member from the family of so-called egalitarian equivalent solutions, defined for a freely chosen benchmark value $\widetilde{C}$ as:

$$\omega_i^{EE} = (1/N) \sum_k f(\widetilde{C}, R_k) + f(C_i, R_i) - f(\widetilde{C}, R_i) \qquad (26)$$

The first term in (26) is identical for all individuals and gives average expenditures in the hypothetical situation in which everybody would be characterized by the same level of health risk $\widetilde{C}$. Differences in individual expenditures following from differences between C_i and $\widetilde{C}$ are then taken care of by the remaining terms in (26). This difference will in the general case depend on the level of R_i: therefore the egalitarian-equivalent mechanism does not satisfy NEUT. However, it satisfies NIRS, since the relative profitability of individuals, given by

$$\pi_i^{EE} = (1/N) \sum_k f(\widetilde{C}, R_k) - f(\widetilde{C}, R_i) \qquad (27)$$

does not depend on the level of C_i.

The social choice literature (Fleurbaey and Maniquet, forthcoming) gives a full axiomatic characterization of these (and other) solutions. We do not discuss these theoretical results here. For our purposes it is sufficient to mention that the conditional-egalitarian mechanism (24) goes as far as possible in removing the incentives for risk selection while satisfying NEUT. The egalitarian-equivalent mechanism (26) goes as far as possible in the direction of NEUT without conflicting with NIRS. It is easy to see that in the additively separable case, both mechanisms always coincide with the natural solution (22), satisfying both NIRS and NEUT.

The solutions described until now are by far the most popular in the social choice literature. Note that both the egalitarian-equivalent and the conditional-egalitarian mechanism implement an additive correction so as to satisfy the budget constraint. This is obvious in (24) for the latter. It is also clear for the former if we rewrite (26) as

$$\begin{aligned} \omega_i^{EE} &= (1/N)\sum_k f(C_k,R_k) + f(C_i,R_i) - f(\widetilde{C},R_i) \\ &\quad +(1/N)(\sum_k f(\widetilde{C},R_k) - \sum_k f(C_k,R_k)) \end{aligned} \tag{28}$$

An alternative mechanism (analyzed by Iturbe-Ormaetxe, 1997) replaces this additive correction by a proportional adjustment so as to satisfy the budget constraint. He calls this the "proportional solution with exogenous reference point $\widetilde{C}$" and defines it as

$$\omega_i^{PROP} = (1/N)\sum_k f(C_k,R_k) + f(C_i,R_i) - f(\widetilde{C},R_i)\frac{\sum_k f(C_k,R_k)}{\sum_k f(\widetilde{C},R_k)} \tag{29}$$

which is directly comparable to (28). It follows that

$$\pi_i^{PROP} = (1/N)\sum_k f(C_k,R_k) - f(\widetilde{C},R_i)\frac{\sum_k f(C_k,R_k)}{\sum_k f(\widetilde{C},R_k)} \tag{30}$$

Inspection of (29) and (30) shows that the proportional solution does not satisfy NEUT, but does satisfy NIRS. It shares these properties with the egalitarian-equivalent mechanism.[7] However, contrary to the egalitarian-equivalent (and the conditional-egalitarian) mechanism it does not become independent of the choice of the reference value $\widetilde{C}$ (respectively $\widetilde{R}$) in the case of additive separability.[8] It therefore does not in general reduce to the natural solution in the case of additive separability. In fact, it is easily seen that this will only occur for a specific choice of $\widetilde{C}$. For later reference, we summarize this result as a lemma:

[7] Both mechanisms are characterized (see Bossert and Fleurbaey, 1996 and Iturbe-Ormaetxe, 1997) through axioms which are stronger than NIRS, and therefore imply NIRS. Not surprisingly, they are called "additive solidarity" and "multiplicative solidarity" respectively in Fleurbaey and Maniquet (forthcoming). We do not go into the interpretation of these axioms, as they are not very intuitive in the context of risk adjustment.

[8] The result of the proportional model with exogenous reference point is independent of the choice of the reference value in the case of multiplicative separability, i.e. if the expenditure function can be written as $f(C_i,R_i) = g(C_i)h(R_i)$. This condition is less interesting in our context, however.

Lemma 4 *(Iturbe-Ormaetxe, 1997; Fleurbaey and Maniquet, forthcoming). If the expenditure function is additively separable in the C- and the R-variables, i.e. if it can be written as $f(C_i, R_i) = g(C_i) + h(R_i)$, the proportional solution with exogenous reference point coincides with the natural solution for a reference point $\widetilde{C}$ satisfying the condition $g(\widetilde{C}) = (1/N)\sum_k g(C_k)$.*

3.2 Application to a simple model of medical expenditures

Let us now return to our simple model with two insurers A and B and two risk groups O and Y. Real-world risk adjustment schemes are based on cell-means or on simple linear regression models to explain medical expenditures. To keep the mathematics as simple as possible (without losing any essential insights) we will therefore adopt in the sequel the following linear specification:[9]

$$E_i = E_0 + \alpha C_i + \beta R_i + \gamma C_i R_i \tag{31}$$

The variable C_i is a binary variable with $C_i = 1$ for the old and $C_i = 0$ for the young. In the same way, R_i is a binary variable with $R_i = 1$ for insurer A and $R_i = 0$ for insurer B. Starting from (31), we get

$$E = E_0 + \alpha p_O + \beta p^A + \gamma p_O^A \tag{32}$$

The interpretation of the parameters is obvious. The parameter α (> 0) captures the difference in costs directly related to morbidity differences between the old and the young, β (> 0) is a general efficiency factor capturing the lower overall cost efficiency of insurer A. The parameter γ (> 0) is different from zero if there is in addition a differentiated efficiency effect, i.e. if insurer A is relatively less efficient for the old as compared to the young.[10] If $\gamma = 0$, eq. (31) becomes additively separable and the natural solution (22) is applicable. If $\gamma \neq 0$, the compromise solutions introduced in the previous

[9] We do not include a disturbance term in eq. (31). Therefore, it is best to interpret this specification as an expected expenditures equation. Another possibility is to see the disturbance term as included in either the C_i or the R_i-variable. Some theoretical results about the treatment of the disturbance term have been discussed in Schokkaert et al. (1998).

[10] The following analysis does not all depend on the sign of γ.

subsection have to be implemented. Introducing eq. (31) in equations (24), (25), (26), (27), (22) and (23), the following definitions follow immediately.

Definition 5 *(CE). If expenditures are given by (31), the conditional egalitarian RA-subsidies are given by*

$$\omega_i^{CE} = E_0 + \alpha C_i + \beta p^A + \gamma \left[p_O^A + \widetilde{R}(C_i - p_O) \right] \tag{33}$$

yielding the relative profits

$$\pi_i^{CE} = \beta(p^A - R_i) + \gamma \left[p_O^A + \widetilde{R}(C_i - p_O) - C_i R_i \right] \tag{34}$$

Conditional-egalitarian RA-subsidies satisfy NEUT, but they do not satisfy NIRS.

Definition 6 *(EE). If expenditures are given by (31), the egalitarian equivalent RA-subsidies are given by*

$$\omega_i^{EE} = E_0 + \alpha C_i + \beta p^A + \gamma \left[C_i R_i + \widetilde{C}(p^A - R_i) \right] \tag{35}$$

yielding the relative profits

$$\pi_i^{EE} = \beta(p^A - R_i) + \gamma \widetilde{C}(p^A - R_i) \tag{36}$$

Egalitarian-equivalent RA-subsidies satisfy NIRS, but they do not satisfy NEUT.

Definition 7 *(NATURAL SOLUTION). If expenditures are given by (31) with $\gamma = 0$, the natural solution to defining RA-subsidies yields*

$$\omega_i^{NAT} = E_0 + \alpha C_i + \beta p^A \tag{37}$$

with the relative profits

$$\pi_i^{NAT} = \beta(p^A - R_i) \tag{38}$$

The natural solution satisfies both NIRS and NEUT.

We can also define the proportional solution with exogenous reference point by introducing (31) in (29) and (30) to arrive at

Definition 8 *(PROP). If expenditures are given by (31) the proportional solution with exogenous reference point $\widetilde{C}$ yields*

$$\begin{aligned}\omega_i^{PROP} &= 2E_0 + \alpha(p_O + C_i) + \beta(p^A + R_i) + \gamma(p_O^A + C_i R_i) \\ &\quad - \frac{E_0 + \alpha p_O + \beta p^A + \gamma p_O^A}{E_0 + \alpha\widetilde{C} + \beta p^A + \gamma\widetilde{C} p^A}(E_0 + \alpha\widetilde{C} + \beta R_i + \gamma\widetilde{C} R_i)\end{aligned} \tag{39}$$

with the relative profits

$$\pi_i^{PROP} = E_0 + \alpha p_O + \beta p^A + \gamma p_O^A - \frac{E_0 + \alpha p_O + \beta p^A + \gamma p_O^A}{E_0 + \alpha\widetilde{C} + \beta p^A + \gamma\widetilde{C} p^A}(E_0 + \alpha\widetilde{C} + \beta R_i + \gamma\widetilde{C} R_i) \tag{40}$$

The proportional solution satisfies NIRS, but does not satisfy NEUT. In the case of additive separability, it reduces to the natural solution for the specific choice of $\widetilde{C} = p_O$.

To understand the last sentence, note that a comparison of (39) with 37) immediately shows, as expected, that the proportional solution with exogenous reference point does not automatically reduce to the natural solution in the case of additive separability ($\gamma = 0$). It does so, however, for $\widetilde{C} = p_O$. This is a simple application of lemma 4, since with eq. (31), $g(C_i) = E_0 + \alpha C_i$.[11]

4 Indirect standardization and conventional risk adjustment

The stage is now set for a closer investigation and comparison of the direct and indirect standardization methods, as applied to risk adjustment. Let us first consider the conventional approach, which is equivalent to indirect standardization. In the first subsection, we show that this is a particularly inadequate model if one does not explicitly control for the correlation between the R- and C-variables. In the second subsection, we argue that keeping the philosophy of indirect standardization while controlling for differences in the R-variable leads us to the conditional egalitarian model.

[11] The constant E_0 is irrelevant and could also have been included in $h(R_i)$.

4.1 Inconsistent estimates. The explicit versus the conventional model

As was described before, the conventional method of risk adjustment defines acceptable costs as cell means for homogeneous needs groups or as the predicted expenditures from an equation containing only needs factors. This procedure is equivalent to the traditional method of indirect standardization. Using (31) to compute (10) yields

$$\begin{aligned} \omega_O &= E_0 + \alpha + (N_O^A/N_O)(\beta + \gamma) \\ \omega_Y &= E_0 + (N_Y^A/N_Y)\beta \end{aligned} \tag{41}$$

It is obvious that the acceptable costs in (41) satisfy NEUT. A first insight into further features of this solution can be gained by focusing on the additively separable case. Comparing (41) for $\gamma = 0$ with (37) makes clear that the conventional model does not coincide with the natural solution. If we want to avoid incentives for risk selection, the difference $\omega_O - \omega_Y$ should reflect the difference in expected costs between the old and the young, which in this simple case is given by α. The expressions (41) show that this condition is not satisfied in the conventional RA-method, unless $(N_O^A/N_O) = (N_Y^A/N_Y)$, which would imply that the C- and R-variables are distributed independently in the population. An intuitively attractive way of interpreting this result is to see it as a problem of omitted variables in an estimation exercise. In fact, the conventional model uses observations of expenditures to estimate the effect of C_i. This estimate will be biased if we do not adequately control for the variation in R_i. The β-terms in eqs. (41) exactly represent this omitted variables-bias. This interpretation was already discussed and empirically illustrated for the case of risk adjustment by Schokkaert and Van de Voorde (2004, 2006). An analogous result is described by Gravelle (2003) in the context of measuring income related inequality in health.

Since the difference between ω_O and ω_Y does not adequately capture the morbidity-related differences in expected costs, it is not surprising that the conventional method of risk adjustment runs into problems with the incentives for risk selection. This finding is summarized in the following proposition, the proof of which is given in the appendix.

Proposition 9 *The traditional risk adjustment model is equivalent to conventional indirect standardization. It does satisfy NEUT. However, if needs and efficiency variables are not independently distributed in the population, it*

does not satisfy NIRS, i.e. it does not remove the incentives for risk selection, even if the expenditure function is additively separable in C- and R-variables.
Proof. *See appendix.* ■

It is striking that the conventional approach to risk adjustment does not remove the incentives for risk selection, even in the case of an additively separable expenditure function, in which there should be no problem in principle. Since the problem is due to the failure to take into account explicitly the effects of the R-variables, it is inherent to the conventional model of indirect standardization (7), in which the "standard" levels of expenditures are taken to be the simple averages E_O and E_Y. However, one can still work within the basic philosophy of indirect standardization, while taking another approach to defining the "standard" level of expenditures E_O^* and E_Y^* in (6). An obvious alternative consists in first estimating (31) with all variables included, so as to get unbiased estimates of the effects of morbidity and efficiency. In the next step one then defines acceptable costs as the predicted expenditures from this equation with neutralization of the effects of the efficiency variables by fixing them at a benchmark level. A similar procedure has been proposed by Gravelle (2003) in the context of measuring income related inequality in health.[12] It is called the "explicit model" of risk adjustment in Schokkaert and Van de Voorde (2006) and they show that the resulting premium subsidies satisfy NIRS in the additively separable case.[13] Let us now look at the characteristics of this explicit approach to indirect standardization.

4.2 Indirect standardization and the conditional egalitarian mechanism

The most obvious choice of a benchmark level for calculating the acceptable costs in the explicit approach is to take the average of R, which is given by p^A in our simple model. For this choice, (unadjusted) acceptable costs can

[12] Gravelle (2003)'s notion of "essential non-linearity" coincides with what we call the lack of additive separability. While he also proposes to fix the standardizing variables across individuals (as we do), he does not discuss the normative consequences of this choice.

[13] The explicit approach is followed in Belgium where "medical supply" is included in the regression equations to explain medical expenditures but removed for the calculation of the acceptable costs (Schokkaert and Van de Voorde, 2003). It is also followed in the regional allocation formula proposed by Gravelle et al. (2003).

be written as

$$\begin{aligned} A_O &= E_0 + \alpha + p^A(\beta + \gamma) \\ A_Y &= E_0 + p^A \beta \end{aligned} \tag{42}$$

It is obvious that the expressions in (42) satisfy NEUT. It is worthwhile comparing (42) with the conventional model (41). The two are only equivalent if $N_O^A/N_O = N_Y^A/N_Y = p^A$, i.e. if the young and the old are distributed proportionally over the two insurers. In the additively separable case $\gamma = 0$, eq. (42) now yields $A_O - A_Y = \alpha$, i.e. the direct morbidity effect is estimated in an unbiased way.

Less obvious are the characteristics of (42) if the expenditure function is not additively separable. However, the procedure of choosing a reference value for the R-variable suggests a direct analogy with the conditional egalitarian solution. Going through some straightforward algebra shows that the analogy is perfect. We summarize this result in the following proposition.

Proposition 10 *(a) The (explicit) method of indirect standardization is equivalent to implementing the conditional egalitarian model for $\widetilde{R} = p^A$. If the expenditure function is not additively separable in C- and R-variables, it satisfies NEUT but it does not satisfy NIRS (and hence creates incentives for risk selection). (b) If the expenditure function is additively separable in C- and R-variables, the (explicit) method of indirect standardization yields the natural solution, which satisfies both NEUT and NIRS.*
Proof. *See appendix.* ■

In general, the acceptable costs defined in (42) do not satisfy the budget constraint. In fact, as shown in the proof of the proposition, the difference between total expenditures and total acceptable costs (42) is equal to $\gamma(N_O^A - N_O p^A)$. Therefore, an adjustment will be needed unless the expenditure function is additively separable ($\gamma = 0$) or $N_O^A = N_O p^A$, i.e. both insurers have the same needs profile.[14] To arrive at the conditional egalitarian solution, we have to adjust the acceptable costs in (42) through an additive correction, i.e.

$$\omega_i = A_i + \gamma(p_O^A - p_O p^A) \tag{43}$$

[14] Of course, this specific result depends on the choice of the reference value p^A for the efficiency variable.

We can now summarize the basic result of this section as follows. As soon as the expenditure function is not additively separable in C- and R-variables, the indirect method of standardization, underlying almost all the existing RA-systems in the world, does not satisfy NIRS. This means that, even with perfect information, it cannot remove the incentives for risk selection, neither in its conventional nor in its explicit form. The policy relevancy of this result depends on the empirical importance of the interaction effects between C- and R-variables. It has been shown in Schokkaert and Van de Voorde (2004) that these interaction effects may be not only statistically but also economically significant. The result in proposition 10 can therefore not be discarded as a mere theoretical curiosity. Moreover, lemma 3 shows that we face here a very basic contradiction: if one wants to respect NEUT, one cannot respect NIRS. Yet, NEUT is a straightforward requirement and in most countries political reality excludes the possibility of introducing a system in which different premium subsidies would be given to individuals in the same (acceptable) risk category.

5 Direct standardization as an alternative?

For those who give a high priority to the avoidance of risk selection, the results in the previous section are rather worrying. Apparently the traditional methods of risk adjustment based on the indirect method of standardization cannot remove the incentives for risk selection. The question now arises whether direct standardization offers an attractive alternative. As discussed in section 2, one will in general have to adjust directly standardized expenditures in order to satisfy the budget constraint. The Irish system uses the proportional adjustment rule (15). We will postpone the discussion of that rule until the second subsection. We first focus on the theoretically more straightforward procedure in which -as before with indirect standardization- the additive adjustment (14) is implemented.

5.1 Imposing the budget constraint: the additive approach

Implementing the method of direct standardization amounts to introducing the information from eq. (31) in the equations for directly standardized expenditures (13), in the additive adjustment rule (14), in the streams to and from the equalization fund (16) and in the definition of acceptable costs (17). This requires some tedious algebra. At the end, it turns out that the method of direct standardization with an additive adjustment to satisfy the budget constraint leads to the egalitarian-equivalent model:

Proposition 11 *(a) The (additively adjusted) method of direct standardization is equivalent to implementing the egalitarian equivalent model for* $\widetilde{C} = p_O$*. If the expenditure function is not additively separable in C- and R-variables, it satisfies NIRS (and hence removes the incentives for risk selection) but it does not satisfy NEUT. (b) If the expenditure function is additively separable in C- and R-variables, the (additively adjusted) method of direct standardization yields the natural solution, which satisfies both NEUT and NIRS.*

Proof. *See appendix.* ■

Although this result is not trivial, it is not really surprising when we look at the formal structure of the direct standardization approach and compare it with the egalitarian-equivalent mechanism. In both cases, we take a benchmark value for the needs: the overall average needs profile in (13), the reference value $\widetilde{C}$ in (35). These benchmark values are consistent with the finding that the method of direct standardization is equivalent to the egalitarian equivalent mechanism for $\widetilde{C} = p_O$.

On the other hand, the result in proposition 11 goes against the intuition that basing the financial streams to and from the equalization fund on the actual costs of the insurers themselves improves the incentives for efficiency for the contributing insurers (Armstrong, 2006). However, it is clear that this intuition is indeed one-sided: one could as well claim that the incentives for efficiency for the receiving insurers are diluted if the financial stream coming from the equalization fund is based on their own actual costs. Proposition 11 shows that the latter effect dominates if the expenditure function is not additively separable in the morbidity and the efficiency variables.[15]

The potential of the direct standardization method to remove the incentives for risk selection comes at a cost. As is clear from (35) the egalitarian-equivalent mechanism does not satisfy NEUT. In our specific setting this means that the insurers get *different* premium subsidies (have a different

[15]Remember that all these statements are derived for the situation of perfect information.

level of acceptable costs) for the same risk groups. In fact, it follows from the proof of proposition 11 (see eq. (57) in the appendix) that

$$\begin{aligned} \omega_O^A - \omega_O^B &= \gamma(1 - p_O) \\ \omega_Y^A - \omega_Y^B &= -\gamma p_O \end{aligned} \quad (44)$$

Insurer A gets more than insurer B for its old members and less for its young members, so as to compensate for the fact that it is relatively less efficient for its old[16] - and given that we aim at removing fully the incentives for a differential treatment between the old and the young. Formulated as such, it is pretty obvious that the chances are minimal that the egalitarian-equivalent mechanism would be accepted in the political process, *provided* that its consequences are well understood. The procedure with direct standardization and financial streams to and from an equalization fund is not very transparent, however. For those who like the egalitarian-equivalent mechanism, it is like a "clever" way to hide its consequences with respect to NEUT.

All this is only relevant if the expenditure function is not additively separable. Indeed, combining propositions 10 and 11, we can immediately derive the following corollary:

Corollary 12 *If the expenditure function is additively separable in C- and R-variables, the (additively adjusted) method of direct standardization and the (explicit) method of indirect standardization are equivalent. They both reduce to the natural solution.*

Note that the equivalence in the corollary is *not* between direct standardization and the conventional method of indirect standardization but between direct standardization and what we called the explicit method of indirect standardization. As is clear from the discussion of proposition 9, the conventional method does not adequately take into account the effects of the efficiency-related variables, even in the case of additive separability.

As noted before, the mechanism described in this section is not the mechanism that is proposed in Ireland. To arrive at the egalitarian-equivalent mechanism we implemented the additive correction (14). The proof of the proposition shows that the additive correction needed is equal to $\gamma(p_O^A - p_O p^A)$. This is identical to the correction we had to introduce in the (explicit) model of

[16]Note that, obviously, the differences in (44) become zero if the specific efficiency effect disappears, i.e. if $\gamma = 0$.

indirect standardization. As before, no adjustment will be needed if the expenditure function is additively separable ($\gamma = 0$) or if $N_O^A = N_O p^A$, i.e. both insurers have the same needs profile.[17] Although the theoretical framework rather suggests to apply an additive correction, proportional adjustments are quite popular in practice. This is also what is proposed in Ireland. Let us now turn to that system.

5.2 Imposing the budget constraint: the proportional approach

We can follow the same procedure as in the previous subsection, but with substitution of the proportional adjustment rule (15) for the additive rule in the model of direct standardization. The analogy between the two methods is so close, however, that it will come as no surprise that the proportionally adjusted method of direct standardization is equivalent to the proportional solution with exogenous reference point:

Proposition 13 *(a) The (proportionally adjusted) method of direct standardization is equivalent to implementing the proportional solution with exogenous reference point* $\widetilde{C} = p_O$*. It satisfies NIRS, but it does not satisfy NEUT. (b) Even if the expenditure function is additively separable in C- and R-variables, the result of the (proportionally adjusted) method of direct standardization in general does depend on the choice of* $\widetilde{C}$*. For the linear model (31), however, the choice of* $\widetilde{C} = p_O$ *yields the natural solution.*
Proof. *See appendix.* ■

The Irish model of risk adjustment (equivalent to the proportional solution with exogenous reference point) has therefore similar features as the egalitarian-equivalent solution. It removes the incentives for risk selection at the cost of violating NEUT. The choice between the proportional and the additive adjustment rule may therefore not be very crucial in the real-world policy debate. There are some (perhaps minor) arguments in favor of the additive adjustment. First, the idea of egalitarian-equivalence has by now already a long tradition[18] and plays an important role as a reference point

[17] This specific result again depends on the choice of the reference value p_O for the morbidity variable.

[18] It basically originated with Pazner and Schmeidler (1978).

in the theoretical analysis of other distribution problems with a more complicated structure than the quasi-linear specification used here (Fleurbaey and Maniquet, forthcoming).[19] Second, the link with the attractive natural solution in the case of additive separability is much closer with the additive correction than with the proportional one. As noted before, the egalitarian equivalent solution is independent of the value chosen for $\widetilde{C}$ and reduces to the natural solution as soon as the expenditure function is additively separable and whatever the functional form of $g(C_i)$ and $h(R_i)$. On the contrary, the last statement in proposition 13 is crucially dependent on the extremely simple specification of the expenditure function (31), as is made clear by lemma 4. In the everyday practice of risk adjustment (with cell means or linear regressions) the notion of additive separability is more relevant than the one of multiplicative separability.

6 Conclusion

There is a close analogy between on the one hand the methods of direct and indirect standardization, used in the epidemiological literature and in the literature on equity in health (care), and on the other hand the issue of risk adjustment in health insurance. Indeed, the notion of "acceptable costs" in risk adjustment basically refers to standardized expenditures. We have argued that traditional methods of risk adjustment are analogous to indirect standardization. In its conventional interpretation they do not adequately control for the effects of efficiency variables and therefore lead to biased estimates of the morbidity effects. However, even in an explicit model in which these non-morbidity effects are controlled for, they do not remove incentives for risk selection. A method of risk adjustment based on direct standardization (as proposed for Ireland) does remove the incentives for risk selection, but at the cost of violating a neutrality condition, stating that insurers should receive the same premium subsidy for all members of the same risk group. This latter finding is hidden because of the rather intransparent nature of the financial streams to and from the equalization fund in this model.

To analyze these issues, we exploited another analogy: that between risk adjustment and responsibility-sensitive redistribution, as analyzed in the re-

[19] The model used here can be seen as quasi-linear, because the result of interest (π_i in eq. (5)) can be written as $\omega_i - f(C_i, R_i)$.

cent social choice literature on fair allocations. Direct standardization is equivalent to the egalitarian-equivalent mechanism which was already proposed by Pazner and Schmeidler (1978). Indirect standardization with the explicit model is equivalent to the conditional egalitarian mechanism. The proportional (instead of additive) adjustment proposed for Ireland leads to the so-called proportional solution with exogenous reference point. All these solutions have been axiomatically characterized (Fleurbaey and Maniquet, forthcoming). We believe that the application of this literature to health economics issues is a fruitful area of future research. More specifically, in this paper we worked with a very simple model where efficiency differences are immediately linked to insurers. A broader approach should integrate the relations with (and the responsibility of) providers and patients in the C- and R-variables. Moreover, a full analysis should go beyond the static first best-setting of this paper and integrate in a coherent way behavioral reactions.

We have shown that the conflict between removing incentives for risk selection and neutrality is unavoidable if the health expenditure function is not additively separable in the morbidity and efficiency variables. This suggests that the prospects for solidarity are bleak, since a solution where different insurers receive different premium subsidies for individuals within the same risk group, does not look politically realistic. In fact, as stated, the problem is hidden in the equalization process in the Irish system. While there is in principle no problem to implement the egalitarian-equivalent mechanism in the external model (through an explicit regression analysis), this necessarily will lead to a broader discussion about the trade-off between solidarity (or equity) and efficiency. If the choice is restricted to the conditional egalitarian mechanism because of the sacrosanct character of NEUT, an interesting research question is the choice of the best value for $\widetilde{R}$, minimizing the incentives for risk selection[20].

The analysis in this paper is set in a context in which the regulator has perfect information about the different variables influencing health care expenditures and can therefore distinguish the effects of morbidity and efficiency. On the one hand, this is the main strength of our approach. It is very striking indeed that the basic conflict between removing incentives for risk selection and neutrality appears even in a setting with perfect infor-

[20] Some results on this question with respect to the problem of income redistribution are presented in Luttens and Van de gaer (2007).

mation. This finding suggests that there is a deep incompatibility between the different notions. On the other hand, it is also a basic limitation of this paper. It would be interesting to investigate the characteristics of the different solutions in a model in which the regulator has imperfect information and is confronted with information asymmetries. This requires a full formal treatment of the effects of missing variables and an explicit interpretation of the disturbance term in the health expenditure equation in terms of responsibility and compensation. Moreover, it remains true that the most important challenge for the regulators in the real world is the improvement of the informational basis for deriving the RA-scheme. An advantage of the approach followed in this paper is that it allows to build a bridge between this econometric work of estimating expenditure models and the theoretical and normative issues concerning the best specification of the RA-formula.

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PROOFS

Proof of proposition 9.

Applying the method of indirect standardization (7) and (10) to the expenditures as specified in (31) yields

$$\begin{aligned} A_O &= (N_O^A/N_O)(E_0+\alpha+\beta+\gamma)+(N_O^B/N_O)(E_0+\alpha) \\ &= E_0+\alpha+(N_O^A/N_O)(\beta+\gamma) \end{aligned} \tag{45}$$

$$A_Y = E_0 + (N_Y^A/N_Y)\beta$$

It is easy to check that with these definitions the budget constraint is satisfied, i.e. the sum of acceptable costs equals total expenditures. No correction is needed and we can define

$$\begin{aligned} \omega_O &= A_O \\ \omega_Y &= A_Y \end{aligned}$$

This immediately shows that the method satisfies NEUT.

Let us now check NIRS. Introducing (45) and (31) in the expression for the individual profitability (5) gives

$$\pi_O^A = \left[(N_O^A/N_O)-1\right](\beta+\gamma)$$

$$\pi_Y^A = \left[(N_Y^A/N_Y)-1\right]\beta$$

$$\pi_O^B = (N_O^A/N_O)(\beta+\gamma)$$

$$\pi_Y^B = (N_Y^A/N_Y)\beta$$

and therefore

$$\pi_O^A - \pi_Y^A = \beta\left[(N_O^A/N_O)-(N_Y^A/N_Y)\right]+\gamma\left[(N_O^A/N_O)-1\right]$$

$$\pi_O^B - \pi_Y^B = \beta\left[(N_O^A/N_O)-(N_Y^A/N_Y)\right]+\gamma(N_O^A/N_O)$$

Both insurers will have incentives for risk selection unless (a) $\gamma = 0$; AND (b) $N_O^A/N_O = N_Y^A/N_Y$. Additive separability is not sufficient to remove the incentives for risk selection. It is moreover necessary that the young and the old are distributed proportionally over both insurers, i.e. that there are no differences in the needs profiles of both insurers. ■

Proof of proposition 10.

In the explicit model of indirect standardization, the adjusted cell means are calculated as in (42), repeated here for the sake of convenience:

$$\begin{aligned} A_O &= E_0 + \alpha + (\beta + \gamma) p^A \\ A_Y &= E_0 + \beta p^A \end{aligned} \tag{46}$$

In order to satisfy the budget constraint the sum of acceptable costs has to be equal to total expenditures. This will not necessarily be the case with the definitions (46). In fact, it is easily seen that the difference between total expenditures and total acceptable costs is given by

$$\begin{aligned} & NE - N_O A_O - N_Y A_Y \\ = \; & NE_0 + N_O \alpha + N^A \beta + N_O^A \gamma - N_O \left[E_0 + \alpha + (\beta + \gamma) p^A \right] - N_Y (E_0 + \beta p^A) \\ = \; & \gamma (N_O^A - N_O p^A) \end{aligned} \tag{47}$$

where we used eqs. (32) and (46).

Therefore an adjustment will be needed, unless the expenditure function is additively separable ($\gamma = 0$) or $N_O^A = N_O p^A$. Implementing an additive correction to transform the expressions (46), the necessary correction will be equal to

$$(1/N) \gamma (N_O^A - N_O p^A) = \gamma (p_O^A - p_O p^A) \tag{48}$$

and we therefore get

$$\begin{aligned} \omega_O &= E_0 + \alpha + (\beta + \gamma) p^A + \gamma (p_O^A - p_O p^A) \\ \omega_Y &= E_0 + \beta p^A + \gamma (p_O^A - p_O p^A) \end{aligned} \tag{49}$$

Comparing these expressions with equations (33) in the main text shows immediately that the explicit model of indirect standardization coincides with the conditional egalitarian model for $\widetilde{R} = \overline{R} = p^A$. All the other statements in the proposition immediately follow. ■

Proof of proposition 11.

Introducing the information from eq. (31) in the definition (13), we get

$$\begin{aligned} E^{A,dira} &= (E_0 + \alpha + \beta + \gamma) p_O + (E_0 + \beta) p_Y \\ &= E_0 + \beta + (\alpha + \gamma) p_O \end{aligned} \tag{50}$$

and, analogously,

$$E^{B,dira} = E_0 + \alpha p_O \tag{51}$$

To check the budget constraint, we calculate the difference between total expenditures and total directly standardized expenditures. Using eqs. (32), (50) and (51), this gives

$$\begin{aligned}
& NE - N^A E^{A,dira} - N^B E^{B,dira} \\
= \; & NE_0 + N_O\alpha + N^A\beta + N_O^A\gamma - N^A\left[E_0 + \beta + (\alpha+\gamma)p_O\right] - N^B(E_0 + \alpha p_O) \\
= \; & \gamma(N_O^A - N^A p_O)
\end{aligned}$$

This expression is equal to (47). Again, an adjustment will be needed, unless the expenditure function is additively separable ($\gamma = 0$) or $N_O^A = N_O p^A$. As in the case of (explicit) indirect standardization the necessary additive correction will be equal to (48), and we therefore get

$$\begin{aligned}
\widetilde{E}^{A,dira,add} &= E_0 + \beta + (\alpha+\gamma)p_O + \gamma(p_O^A - p_O p^A) \\
\widetilde{E}^{B,dira,add} &= E_0 + \alpha p_O + \gamma(p_O^A - p_O p^A)
\end{aligned} \tag{52}$$

where the superscript "add" refers to the additive adjustment. It is easy to see that average expenditures of both insurers are given by

$$\begin{aligned}
E^A &= E_O + \alpha(N_O^A/N^A) + \beta + \gamma(N_O^A/N^A) \\
E^B &= E_O + \alpha(N_O^B/N^B)
\end{aligned} \tag{53}$$

Contributions to and from the equalization fund are given by (16). Subtracting (52) from (53) gives

$$\begin{aligned}
S^{a,dira,add} &= (\alpha+\gamma)(N_O^A/N^A - p_O) - \gamma(p_O^A - p_O p^A) \\
S^{B,dira,add} &= \alpha(N_O^B/N^B - p_O) - \gamma(p_O^A - p_O p^A)
\end{aligned} \tag{54}$$

Note that these expressions become zero, i.e. that there are no streams to and from the fund, if $N_O^A/N^A = N_O^B/N^B = p_O$. This is as it should be, since in that case the needs profile of the membership of both insurers is identical.

We can now calculate the acceptable costs for both insurers by adding (54) to (32) (see definition (17)). This yields

$$\begin{aligned}
\omega^A &= E_0 + \beta p^A + \alpha(N_O^A/N^A) + \gamma(N_O^A/N^A - p_O + p^A p_O) \\
\omega^B &= E_0 + \beta p^A + \alpha(N_O^B/N^B) + \gamma p^A p_O
\end{aligned} \tag{55}$$

These are acceptable costs formulated at the insurer level. In order to link them to acceptable costs at the level of the individuals, we have to take into account that in general (for $s = A, B$)

$$\omega^s = (N_O^s/N^s)\omega_O^s + (N_Y^s/N^s)\omega_Y^s \tag{56}$$

Eq. (56) is consistent with the acceptable costs (55) for the following definitions of acceptable costs at the level of the individuals:

$$\begin{aligned} \omega_O^A &= E_0 + \alpha + \gamma + \beta p^A + \gamma p_O(p^A - 1) \\ \omega_Y^A &= E_0 + \beta p^A + \gamma p_O(p^A - 1) \\ \omega_O^B &= E_0 + \alpha + \beta p^A + \gamma p_O p^A \\ \omega_Y^B &= E_0 + \beta p^A + \gamma p_O p^A \end{aligned} \tag{57}$$

Comparing these expressions with the definition of the egalitarian-equivalent mechanism in (35) shows that the method of direct standardization with additive adjustment coincides with the egalitarian-equivalent mechanism for $\widetilde{C} = \overline{C} = p_O$. All the other statements in the proposition then follow immediately. ■

Proof of proposition 13.

We exploit the relationship between the method of direct standardization and the egalitarian-equivalent mechanism as described in the proof of proposition 11. Start from definition (28), repeated here for the sake of convenience:

$$\begin{aligned} \omega_i^{EE} &= (1/N)\sum_k f(C_k, R_k) + f(C_i, R_i) - f(\widetilde{C}, R_i) \\ &\quad +(1/N)(\sum_k f(\widetilde{C}, R_k) - \sum_k f(C_k, R_k)) \end{aligned} \tag{58}$$

Within our model of health care expenditures, the first term in this expression is E, the second term is E_i. The last term is the additive correction to satisfy the budget constraint and it is identical for all individuals. Call it COR to simplify the notation. Computing the average value for insurer s we then get

$$\omega^{s,EE} = E + E^s - (1/N^s)\sum_{i\ in\ s} f(\widetilde{C}, R_i) + COR \tag{59}$$

where the summation is over individual members of insurer s. Since R_i is identical for all individual members of the same insurer, we can substitute $f(\widetilde{C}, R^s)$ for $f(\widetilde{C}, R^s)$ for all members of insurer s. Comparing (59) to (17), we see that

$$\widetilde{E}^{s,dira,add} = f(\widetilde{C}, R^s) - COR$$

or

$$E^{s,dira} = f(\widetilde{C}, R^s)$$

Using (50) and (51) gives

$$f(\widetilde{C}, R^s) = E^{s,dira} = E_0 + \alpha p_O + \beta R^s + \gamma p_O R^s$$

showing immediately that $\widetilde{C} = p_O$.

Applying the proportional adjustment rule (15) yields

$$\widetilde{E}^{s,dira,prop} = \frac{E_0 + \alpha + \beta p^A + \gamma p_O^A}{E_0 + \alpha p_O + \beta p^A + \gamma p_O p^A}(E_0 + \alpha p_O + \beta R^s + \gamma p_O R^s) \tag{60}$$

Using (53), (31) and (60) in (17) the resulting definition of acceptable costs under direct standardization with proportional adjustment coincides with (39) for $\widetilde{C} = \overline{C} = p_O$. The other statements in the proposition immediately follow. ■