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Risk selection and the specification of the conventional risk adjustment formula

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Abstract

We argue that a sharp distinction must be made between the empirical problem of finding the best equation for *explaining* medical expenditures and the *normative* question of deriving capitations which give health plans the appropriate incentives. We propose a procedure, taken from the social choice literature, to go from the estimated equations to the capitations. If the estimated equations are not additively separable in legitimate and illegitimate risk-adjusters, it is impossible to remove all incentives for risk selection while respecting at the same time a straightforward requirement of horizontal equity. This has immediate implications for the choice of the functional form. Moreover, in so far as the conventional risk adjustment literature only includes so-called "legitimate" risk-adjusters in the estimations, its results may suffer from omitted variables-bias. We illustrate our general methodological points with empirical results, obtained from a cross-section of 321,111 Belgian patients.

JEL classification: I11; I18

Keywords: Risk selection; Medical expenditure; Risk adjustment

1. Introduction

In many countries the move towards prospective financing of health plans has been accompanied by the gradual introduction of risk adjustment schemes. In a situation with competing health plans and premium regulation, the risk adjustment formula has to be designed so as to minimise the danger of cream-skimming.[1] Policy-makers are confronted

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[1] van de Ven and Ellis (2000) describe the concrete situation in 11 countries which have introduced risk adjustment within a scheme of prospective financing of competitive health plans. Rice and Smith (1999) include in their overview also many countries with a health care system of the NHS-type. In these latter countries the problem of risk selection is less relevant. In this paper we focus on the competitive case.

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with a difficult trade-off. While they introduce prospective payments to create incentives for efficiency, these prospective payments create a potential danger of risk selection. We will use the latter broad term to indicate all behaviour by health plans inducing an undesirable unequal treatment of individual patients (either through unequal access or through differences in quality of services).[2]

The choice of the risk adjustment formula has received much attention from the policy-makers in the different countries involved. In the first place they have to decide about the variables to include, the so-called risk-adjusters. Although in actual practice the choice has been most often determined by considerations of data availability, there is at the same time a consensus that ideally the risk-adjusters should reflect the health risks of the insured population. In the second place, the weights to be given to the different risk-adjusters have to be fixed. Current practice uses empirical information on actual expenditure patterns to estimate these weights. Average historical costs per group play a dominant role in these calculations. Some countries have based the capitation amounts for different groups on simple cell means, where the cells are defined on the basis of a discrete set of values for demographic variables such as age and gender. Where sufficient data are available one can improve upon this procedure through the econometric estimation of a medical expenditure function.

Policy-makers have been looking at the academic world for econometric advice about the risk adjustment scheme to be used. There is by now a huge literature comparing the statistical performance of various risk-adjusters and analysing their potential to curb risk selection. Large sets of individual data have been used to show the limited explanatory power of demographic variables and the importance of introducing more direct information on health status (see van de Ven and Ellis, 2000, for a survey including the most important references). While the large bulk of this literature has concentrated on statistical aspects and “typically uses explained variance to judge the goodness of risk-adjusters” (Newhouse, 1996), there also seems to be a growing awareness about the normative aspects of the question. Not all the factors which influence medical expenditures are considered to be legitimate risk-adjusters: think about differences in drinking or smoking behaviour, or about interregional differences in the practice style of the medical profession. What to do with statistically significant but “illegitimate” risk-adjusters? These worries are strengthened by some recent theoretical papers, which suggest that optimal risk adjustment does not generally require the capitations to equal average costs (Ellis, 1998; Frank et al., 2000; Glazer and McGuire, 2000, 2002; Sappington and Lewis, 1999). At the moment, there is a rather large gap between the theoretical literature and the empirical work on “estimating” risk adjustment schemes.

With this paper we try to bridge part of that gap. Our starting point is the conventional empirical risk adjustment literature and we will illustrate our ideas with empirical results from a sample of 321,111 Belgian patients. In Section 2, we summarise the point made by

[2] See van de Ven and Van Vliet (1992) for an overview of different risk selection strategies. As we focus on situations with a universal compulsory health insurance scheme, in which consumers do not have a choice between different insurance policies, we concentrate on the behaviour of the insurers. We therefore neglect the possibility that risk adjustment can also be used to reduce the problems following from consumer behaviour in the case of adverse selection (see, e.g. Keeler et al., 1998).

Schokkaert et al. (1998) that recent theories of responsibility-sensitive fair compensation offer a useful framework to analyse the tension between the econometric and statistical work on the one hand and the normative questions on the other hand. The notion of risk selection will be formalised taking explicitly into account the difference between legitimate and illegitimate risk-adjusters, between "compensation" and "responsibility" variables. In this paper we concentrate on the implications of this theoretical approach for the direction of further empirical work. We therefore put ourselves in the position of an econometrician who has to give concrete advice about the risk adjustment scheme to be implemented. Our real-world background is the Belgian situation, as sketched in Section 3. Section 4 shows some empirical results concerning the introduction of (il)legitimate risk-adjusters in a simple linear model, estimated with individual data. In Section 5, we comment on the implications for risk selection of working with a non-linear model. Section 6 concludes with some concrete lessons for empirical work. We will argue that it is advisable to include all explanatory variables in the estimation of medical expenditures, even if some of these are "illegitimate" risk-adjusters and have to be taken out for the calculation of the capitation payments. The choice of functional form is crucial. If the explanatory model is not additively separable in compensation and responsibility variables, it is impossible to remove all incentives for risk selection.

2. A simple model of responsibility-sensitive risk adjustment

Let us first take the position of an empirical economist who wants to explain and/or predict individual medical expenditures. She will estimate a function relating individual medical expenditures x_i to a set of individual and environmental characteristics a_i:

$$x_i = f(a_i), \quad i = 1, \ldots, n \tag{2.1}$$

In this section, the possible stochastic error term in (2.1) is simply included in the vector a_i. We suppose that the function $f(\cdot)$ is monotonous and we define the variables a in such a way that $\forall i$, $\partial f/\partial a_i \geq 0$. The functional form $f(\cdot)$ and the variables to be included in the model will be chosen on the basis of theoretical and empirical considerations. A whole range of potential variables can be considered. Demographic variables such as age and gender definitely are important but not sufficient. Additional information on morbidity considerably increases the explanatory power of the regressions. Economic, environmental and behavioural factors also play a role: think about the importance of income and social class or about the influence of smoking and drinking behaviour. Moreover, there is much evidence on interregional variation in medical expenditures, linked to differences in factor prices or in the practice style of the medical profession. As to the functional form, there is a large literature comparing different approaches to capture the empirical phenomena of: (a) a large fraction of zero medical expenditures in the individual data; (b) the non-existence of negative medical expenditures; and (c) the right skewed distribution of the positive observations on medical expenditures (see Jones, 2000, for an overview). Our empirical economist has to solve a whole series of difficult but interesting questions.

The purpose of the estimation exercise, however, is not to find the most complete explanation. Rather it is to give advice to a central fund, which has to decide about the allocation of a total amount ω over different health plans v ($v = 1, \dots, V$) through a set of prospective but risk adjusted capitation amounts. We assume that the amount ω is fixed a priori by the central fund. Therefore, there is in general no reason why ω would exactly cover total medical expenditures ex post. The difference $\sum x_i - \omega$ has to be paid by the health plans, i.e. they have to cover all costs. For simplicity, we assume that there are no co-payments to be paid by the patients. Moreover, health plans are not allowed to differentiate the premiums for different groups of patients. The purpose of the risk adjustment is then to reduce the incentives for risk selection. These incentives to treat patients differently are directly linked to the monetary loss or gain made on the patients, which can be written as:

$$\pi_i = \omega_i - x_i \tag{2.2}$$

where ω_i denotes the amount received for individual i by the health plan which includes i among its members (with $\sum_i \omega_i = \omega$).[3]

Eq. (2.2) immediately suggests that the capitation payments will have to be related in one way or another to the differences in medical expenditures. It is therefore not surprising that empirical information plays a crucial role everywhere capitations have been introduced. But, as noted before, not all significant explanatory variables are acceptable as risk-adjusters. Actual expenditures also reflect the existing inefficiencies in the system, which the prospective payment scheme is aiming to remedy. It is therefore better to assume that the capitation payments have to reflect an “acceptable” cost level (van de Ven and Ellis, 2000), i.e. the expenditures to deliver medically necessary care in a cost-effective way.

To make this more specific we can partition $a_i \equiv (m_i, \mathrm{dp}_i, \mathrm{dh}_{j(i)})$, where m_i represents a set of morbidity variables, typical for patient i and beyond her own responsibility, dp_i is a set of decision variables of patient i and $\mathrm{dh}_{j(i)}$ a set of decision variables for the health plan j, which has i as a member. While most people would agree that morbidity differences must be included in the risk adjustment system, things are less clear for the other variables. Examples of dh_j variables are the availability of preferred provider arrangements, the creation of a set of incentives for the patients to choose the less expensive providers or to keep loyal to one general practitioner, efforts to put pressure on providers to minimise supply-inducement. Each of these may have a significant effect on medical expenditures and if information is available should probably be included in an explanatory model of medical expenditures. However, if one wants to create the right incentives for health plans, it is not very sensible to incorporate these variables in the risk adjustment system, i.e. to compensate the health plans that did not take this kind of actions for their larger expenditures. An obvious example of a dp_i variable is the life-style of the individual, e.g. her drinking and smoking behaviour. If insurers are fully compensated for the larger expenditures following from differences in life-style, they will not be motivated to deter this kind of behaviour. Moreover, risk adjusting the subsidies for life-style differences implies that solidarity with drinkers and smokers is imposed on the non-drinkers and non-smokers and this may be inconsistent with the dominant ethical feelings in a given society. These examples are only meant to be

[3] This expression neglects the fact that the incentives for risk selection will be determined by *future* and not by actual expenditures and that these future expenditures are uncertain. A more adequate approach would be to define $E(\pi_i) = \omega_i - E(x_i)$. However, in this section no additional insights are gained by this complication. The treatment of the stochastic disturbance term in (2.1) is further discussed in Schokkaert et al. (1998).

examples. The decision on what variables to include in the risk adjustment scheme involves difficult ethical and/or political questions and the answers given may be different in different societies as they inter alia depend on the content given to the notion of solidarity. In this paper we do not want to elaborate upon these ethical aspects. We simply take as given the basic idea that some variables which have a significant effect in (2.1) should not be included in the risk adjustment formula and we want to explore the consequences of this starting point for the specification of the risk adjustment system.

As a matter of fact, if one takes into account this possibility of statistically significant but "ethically illegitimate" variables, it is no longer obvious how to use the information from the estimated expenditure function (2.1). As a necessary first step, the central fund will have to take an explicit decision about what risk-adjusters are considered as legitimate for the calculation of ω_i, in the sense that they contribute to the definition of the "acceptable" cost level. Let us denote these "compensation" variables as a^{C}. It seems reasonable to assume that $a^{\mathrm{C}} \subseteq a$, since it is not sensible to work with risk-adjusters that have no influence on medical expenditures. We denote by a^{R} the "responsibility" variables which have an influence on medical expenditures, but are not included in the set of risk-adjusters, i.e. $a^{\mathrm{R}} = a \setminus a^{\mathrm{C}}$. The health plans will remain responsible for differences in medical expenditures linked to these a^{R} variables. Using this notation we can adapt (2.1):

$$x_i = f(a_i^{\mathrm{C}}, a_i^{\mathrm{R}}) \tag{2.3}$$

As said before, prime candidates for *not* being included in the risk adjustment formula are variables which are directly linked to the behaviour of insurers and/or individual members, i.e. variables which are under their control. Using the notation introduced before, a possible choice would be to put $a_i^{\mathrm{C}} \equiv m_i$ and $a_i^{\mathrm{R}} \equiv (\mathrm{dp}_i, \mathrm{dh}_{j(i)})$. However, at this stage we want to remain general and we simply take as given the partitioning $(a^{\mathrm{C}}, a^{\mathrm{R}})$ decided upon by the central fund.

Against this background it is now possible to formulate two requirements on the risk adjustment scheme. The first is a neutrality assumption.

Axiom 1 (*neutrality* (*NEUT*)). For any two individuals i and j with $a_i^{\mathrm{C}} = a_j^{\mathrm{C}}$, $\omega_i = \omega_j$.

If two individuals have exactly the same value for all legitimate risk-adjusters (for all compensation variables) the health plans should get the same subsidy for these two individuals. All risk adjustment schemes in the world satisfy this requirement. Note, however, that this apparently innocuous horizontal neutrality assumption has strong consequences. It immediately follows from *NEUT* that:

$$\forall i, j: \quad a_i^{\mathrm{C}} = a_j^{\mathrm{C}}, \quad a_i^{\mathrm{R}} > a_j^{\mathrm{R}}, \quad \pi_i < \pi_j \tag{2.4}$$

The implications of (2.4) become clear if we combine *NEUT* with a second axiom, designed to capture the requirement that the risk adjustment scheme should create no incentives for risk selection.

Axiom 2 (*no incentives for risk selection* (*NIRS*)). For any two individuals i and j with $a_i^{\mathrm{R}} = a_j^{\mathrm{R}}$, $\pi_i = \pi_j$.

This axiom implies:

$$\forall i, j: \quad a_i^{\mathrm{R}} = a_j^{\mathrm{R}}, \quad a_i^{\mathrm{C}} > a_j^{\mathrm{C}}, \quad \omega_i > \omega_j \tag{2.5}$$

or health plans must receive a larger capitation for individuals with a larger value for the risk-adjusters.

To understand these axioms, consider a situation with $\pi_i < \pi_j$. This implies that health plans make larger profits on individual j than on individual i. If premium differentiation were possible, such differences in π_i would create incentives for premium differentiation. However, we have assumed that premium differentiation is forbidden by the regulator. This leaves the insurers with two options. Either, they can try to select the good risks (i.e. individuals with a larger π_i), or they can focus their efforts to curb medical expenditures on the individuals with a small π_i. In both cases there will be incentives for differential treatment of the individuals.

Now, suppose first that the differences between π_i and π_j follow only from differences in a^{C} variables, i.e. variables related to the morbidity of the individuals and for which we want to compensate. It is reasonable to suppose that a^{C} will not include many variables which can be directly influenced by the health plans and that $\pi_i < \pi_j$ would therefore lead to risk selection, i.e. to cream-skimming of individuals of type j. Such differential treatment is socially undesirable. As a matter of fact, the basic purpose of risk adjustment is to avoid this kind of incentives. This is precisely what is captured by *NIRS*. If two individuals have the same value for the responsibility variables, they differ only in the level of legitimate risk-adjusters (compensation variables). A risk adjustment scheme satisfying *NIRS* will imply the same value of π, whatever the value of these compensation variables and will therefore remove the incentives for such socially undesirable risk selection.

Suppose on the contrary that the differences between π_i and π_j reflect differences in a^{R} variables, i.e. variables which are under the control of the individual health plans and for which they are held responsible. In that case *NIRS* does not impose anything. However, *NEUT* implies that such differences in a^{R} variables will have no effect on the capitations received, and hence that health plans have to bear themselves the higher expenditures, resulting from these differences. This is made explicit in (2.4). The "profit" health plans make on a member with a high value for a_i^{R} will be smaller than the profit they make on a member with a small value of a_i^{R} and may even be negative. This gives health plans the incentives to curb the expenditures related to a^{R} variables. This can be interpreted as creating incentives for efficiency.[4] Of course, in some circumstances differences in a^{R} variables may also induce incentives for selection of certain individuals (see the interpretation in Shmueli, 2000): if smoking and drinking habits are not included in the list of risk-adjusters, health plans will make predictable losses on smoking and drinking individuals. If differences in practice styles are regionally determined, health plans may be motivated to leave certain "expensive" regions and concentrate their activities in other regions. However, in our setting—and given that a decision has been taken on the partitioning of the explanatory variables into legitimate

[4] This explains why *NEUT* was called *NICI* ("no incentives for cost inflation") in Schokkaert et al. (1998). Efficiency is interpreted here only in the sense of cost containment. The possibility of quality distortions (Glazer and McGuire, 2000) is not modelled explicitly. In the empirical context of many European countries in general, and Belgium in particular, quality competition between insurers is very limited.

"compensation" and illegitimate "responsibility" variables—this kind of behaviour does not reflect "socially unacceptable risk selection".[5] Indeed, it will push towards socially desirable behavioural changes (in life-styles of patients or practice styles of providers).

Schokkaert et al. (1998) have argued that the formal setting of this problem is similar to the analysis of responsibility-sensitive fair compensation in the recent social choice literature (Bossert, 1995; Bossert and Fleurbaey, 1996; Fleurbaey, 1994, 1995).[6] It turns out that the rather straightforward axioms *NEUT* and *NIRS* have very strong consequences for the risk adjustment scheme. A first important result is the following.

Proposition 2.1 (Bossert, 1995; Bossert and Fleurbaey, 1996). *If the medical expenditure function* $f(\cdot)$ *is additively separable in the variables* a^{C} *and* a^{R}, *i.e. if* $\forall i$, $f(a_i^{\mathrm{C}}, a_i^{\mathrm{R}}) = g(a_i^{\mathrm{C}}) + h(a_i^{\mathrm{R}})$, *then the following natural mechanism satisfies both NIRS and NEUT*:

$$\omega_i = \frac{\omega}{n} + g(a_i^{\mathrm{C}}) - \frac{1}{n}\sum_k g(a_k^{\mathrm{C}}) \tag{2.6}$$

It is obvious that mechanism (2.6) indeed satisfies both requirements. Moreover, it can be derived from the more general results in Fleurbaey (1995) that adding a rather weak consistency assumption to *NIRS* and *NEUT* is sufficient to characterise the mechanism, i.e. that (2.6) is the *only* mechanism satisfying *NIRS* and *NEUT*. To interpret (2.6) it is useful to define so-called "normative expenditures" of individual *i* as:

$$N_i = g(a_i^{\mathrm{C}}) + \frac{1}{n}\sum_k h(a_k^{\mathrm{R}}) \tag{2.7}$$

Differences in expenditures following from differences in the a^{C} variables are fully taken into account in the definition of the normative expenditures. For the a^{R} variables, however, only the average value is used as a normative reference point.[7] Using (2.7) the natural mechanism can also be written as:

$$\omega_i = N_i + \frac{\omega}{n} - \frac{1}{n}\sum_k (g(a_k^{\mathrm{C}}) + h(a_k^{\mathrm{R}})) = N_i + \frac{\omega}{n} - \frac{1}{n}\sum_k x_k \tag{2.8}$$

Although the natural mechanism (2.6) may look rather convoluted, this only follows from the imposition of a budget constraint. As (2.8) shows, if $\omega = \sum_k x_k$, i.e. if the total subsidy is just sufficient to cover total medical expenditures of all health plans, then the natural mechanism boils down to the simple rule:

$$\forall i: \quad \omega_i = N_i \tag{2.9}$$

[5] Let us emphasise once again that this is a normative statement and that in this paper we do not want to discuss in detail the possible motivations leading to the partitioning of the set of explanatory variables. We take this partitioning as determined by the decision-makers and therefore as given for the analyst. We concentrate on the methodological implications of the fact that there is such a partitioning and our examples are only meant to be examples.

[6] See Fleurbaey (1998) for a general overview.

[7] The concept of "normative expenditures" gives a concrete content within our setting to the notion of "acceptable costs" in the terminology of van de Ven and Ellis (2000).

This is the approach which is often adopted in practice. To simplify the exposition, we will later on neglect the presence of a binding budget constraint in our empirical illustrations, i.e. we will work with (2.9). However, it is important to emphasise that Proposition 2.1 shows that there is only one attractive way of "adapting" (2.9) in the situation of a binding budget constraint and this is the method described in (2.6).

While Proposition 2.1 is an interesting result in the specific context of risk adjustment, the social choice literature has spent more attention on the following.

Proposition 2.2 (Bossert, 1995; Fleurbaey, 1994, 1995). *If the medical expenditure function* $f(\cdot)$ *is not additively separable in the variables* a^{C} *and* a^{R}, *then no risk adjustment scheme can satisfy both NIRS and NEUT* (*if* $n \geq 4$).[8]

The implications of this result are very strong. If the central fund does not want to depart from horizontal neutrality (as defined in *NEUT*) it will be impossible to satisfy *NIRS*. This conclusion is not dependent on the availability of information or on the imperfect knowledge about the medical expenditure function (2.1): it follows from the fact that *NEUT* imposes strong restrictions on the choice of the vector of instruments $(\omega_1, \ldots, \omega_n)$. However, we do not have the impression that a system in which health plans get different capitations for individuals within the same (acceptable) risk category will become politically feasible in the short run. If political reality makes it impossible to depart from *NEUT*, the central fund will have to content itself with a risk adjustment scheme which does not take away all incentives for risk selection. Bossert and Fleurbaey (1996) then propose to pick a mechanism out of the family of so-called conditionally egalitarian mechanisms: these satisfy *NEUT* and they satisfy *NIRS* as well as possible.[9] Formally, they can be described as:

$$\omega_i^{\mathrm{CE}} = \frac{\omega}{n} + \left[f(a_i^{\mathrm{C}}, \tilde{a}^{\mathrm{R}}) - \frac{1}{n} \sum_k f(a_k^{\mathrm{C}}, \tilde{a}^{\mathrm{R}}) \right] \tag{2.10}$$

where $\tilde{a}^{\mathrm{R}}$ is any freely chosen benchmark vector. To understand (2.10) it is useful to write it as:

$$\omega_i^{\mathrm{CE}} = \lambda + f(a_i^{\mathrm{C}}, \tilde{a}^{\mathrm{R}}) \tag{2.11}$$

where λ is a constant amount, the same for all individuals i and introduced to satisfy the budget constraint. If $\omega = \sum_k x_k$, it follows that $\lambda = (1/n)(\sum_k x_k - \sum_k f(a_k^{\mathrm{C}}, \tilde{a}^{\mathrm{R}}))$. Expressions (2.2) and (2.11) imply:

$$\pi_i^{\mathrm{CE}} = \lambda + f(a_i^{\mathrm{C}}, \tilde{a}^{\mathrm{R}}) - x_i \tag{2.12}$$

Expression (2.11) shows that the conditionally egalitarian mechanism (2.10) indeed satisfies horizontal neutrality. At the same time, (2.12) indicates that it does not satisfy *NIRS*, since

[8] The requirement that $n \geq 4$ is necessary for constructing the cases in the proof of the proposition showing the incompatibility between *NIRS* and *NEUT*. It is a very weak requirement, since in all relevant situations there will be more than four individuals involved.

[9] In the unlikely case that the central fund were willing to give up horizontal neutrality, it could opt for the so-called egalitarian-equivalent mechanisms, which do satisfy *NIRS* (Bossert and Fleurbaey, 1996; Schokkaert et al., 1998).

π_i will in general depend on a_i^{C}. However, (2.10) satisfies a weaker axiom,[10] which can be described as follows.

Axiom 3 (*no incentives for risk selection at a reference value for the responsibility variables* (*NIRSREF*)). For any two individuals i and j with $a_i^{\mathrm{R}} = a_j^{\mathrm{R}} = \tilde{a}^{\mathrm{R}}$, $\pi_i = \pi_j$.

We will analyse in Section 5 some of the empirical implications of Proposition 2.2 in the context of risk adjustment.

3. Our real-world background: Belgium

To analyse the empirical implications of the approach sketched in Section 2, we will make use of Belgian data.[11] Health insurance in Belgium is compulsory and centralised. The insurance cover in the compulsory system is very broad. All insured pay an income-related premium to a central fund. The sum of all these contributions is supplemented by a subsidy from the central government, financed out of general tax revenue. The management and administration of health insurance is left to about 100 local non-profit sickness funds. The insured can choose their own sickness fund and can change sickness fund every 3 months. These sickness funds can be seen as the "health plans" referred to in Section 2. The market for compulsory health insurance is closed for new entrants. Moreover, since the local funds are grouped into five national associations of private sickness funds and one (residual) public fund, there are in each region at most six competing health plans. The central fund distributes the financial resources over the sickness funds. The insured pay a small flat rate premium to the sickness fund of their choice. This premium can be different for different sickness funds but must be community rated within a sickness fund. In the compulsory scheme, selective contracting with providers is not allowed. The sickness funds negotiate as a cartel with the providers to fix the official fee schedule. They have more individual freedom in the supplementary insurance market. It is well known that this offers ample scope for risk selection, even when there is forced enrolment and some official quality control (van de Ven and Van Vliet, 1992; and for a theoretical analysis see Kifmann, 1999). Until now, however, there is no strong evidence of explicit cream-skimming in Belgium. Citizens can freely choose their doctors, which are remunerated through a fee-for-service system. About 25% of the expenditures are covered through the own payments of the patients, the remainder is reimbursed by the insurers.

Before 1995 the sickness funds got basically all their expenditures reimbursed by the central fund. Since 1995 there is a gradual shift towards a system of prospective risk-adjusted capitations. Each year the government fixes ex ante an overall budget: this is the Belgian equivalent of ω in Section 2. Normative expenditures are derived from a regression analysis with aggregate (per capita) data at the level of the local sickness funds. Since the regression

[10] See Bossert and Fleurbaey (1996) for a complete characterisation of both the egalitarian-equivalent and the conditional-egalitarian mechanisms.

[11] A more detailed description of the Belgian system of health insurance and risk adjustment is given in Schokkaert and Van de Voorde (2000, in press).

equation is a simple linear specification, the additive separability-assumption is satisfied and the rule from Proposition 2.1 can be applied. Because there is no a priori reason why one would have $\omega = \sum_i x_i$, the risk-adjusted capitations are computed with (2.6) or (2.8). While medical supply (provider density) is a significant variable in the estimated regressions, it was decided by the policy-makers and by the central fund to treat it as an a^{R} variable. The effect of medical supply is therefore averaged out to calculate N_i as in (2.7). We will return to this choice in Section 4.

It is well known that the use of aggregate data does not give sufficient information to remove all the incentives for individual risk selection in a competitive environment. To remedy this problem a large database with individual information has been set up by the sickness funds under the supervision of the central fund. This database contains for a representative sample of individuals from all the sickness funds: (a) the medical expenditures in 1995, as reimbursed by the sickness funds and therefore *not* including the own payments of the patients;[12] (b) all individual information on social and economic characteristics which is available from the sickness funds and the central fund; and (c) additional information on regional variables (such as population density and the number of medical providers). At this stage diagnostic information is not yet available. For this paper we use the data from four national associations. Since it is impossible to follow the identity of the individuals when they move from one sickness fund to another, we only use the data for all individuals who have remained with the same sickness fund for the whole year 1995. Those who are born in 1995 or died in that same year were also included. Since the number of moves is rather limited and—in the present situation—not related to the morbidity or the expenditures of the insured,[13] this does not bias our sample. The estimates in the following sections are based on a resulting sample of 321,111 individuals, which is representative for the whole Belgian population (including all age groups in both the active population and the pensioners, and also the disabled).[14] Per capita (reimbursed) health expenditures (without medicines) amount to 38,299 Belgian Francs, i.e. 949 Euros.

4. Conventional risk adjustment with a linear model: what variables to include?

In this section, we will first describe what can be called the "standard procedure" in the conventional risk adjustment literature.[15] This procedure has the following characteristics:

[12] Expenditures for medicines cannot be allocated by the sickness funds to their individual members, since they are paid within a third-payer arrangement. They are therefore *not* included in our concept of medical expenditures.

[13] We already noted that even now there is hardly any evidence of cream-skimming in Belgium. This was the more true in 1995 because the degree of financial responsibility of the sickness funds was very low at that initial stage and they had no experience at all with a system of risk-adjusted capitations. More information can be found in Schokkaert and Van de Voorde (in press).

[14] The self-employed are not included in the sample, since they have in Belgium a separate and different health insurance system, in which the compulsory scheme does not cover the so-called minor risks (such as ambulatory care, medicines, dental care).

[15] We are fully aware that this is an extremely dangerous statement. There are very probably examples in the literature which do not follow the sketched procedure. However, our judgement follows van de Ven and Ellis (2000), although they are more in sympathy with the traditional approach than we are.

(a) One works with a simple linear model. There are good reasons for this choice. In the first place, with very large samples the robustness of OLS regression is an attractive property. More complicated functional forms—such as two-part models with a logarithmic specification for the second part—often raise difficult statistical problems of retransformation, certainly when the error term is heteroskedastic (Mullahy, 1998). In the second place, the final purpose of the estimation exercise is to derive an understandable and flexible risk adjustment formula, which can be interpreted correctly and used by policy-makers. The simple linear model stays close to the cell-based approach, which is used so often in practice. As a matter of fact when all the explanatory variables can take only a limited number of discrete values, the cell means corresponding to these variables can be immediately recovered from the coefficients of a set of dummy variables in a simple linear OLS-equation. We will return to the choice of functional form in Section 5.
(b) The analyst takes an explicit decision about what risk-adjusters are acceptable and includes these variables in the equation to be estimated. Other variables, including the disturbance terms, are omitted. This is not always due to data considerations. To give but one example: in the pathbreaking work on diagnostic cost groups (Ellis et al., 1996; Lamers, 1998) it is quite explicitly stated that some diagnostic groups are excluded from the estimations because of the concern for discretionary admission and for creating inappropriate incentives. This implies that normative considerations influence the specification of the functional form to be estimated. We will analyse the implications of this procedure in this section.

Opting for a linear specification, (2.3) can be written as follows:

$$x_i = \alpha_0 + \alpha' a_i^{\mathrm{C}} + \beta' a_i^{\mathrm{R}} + u_i \qquad (4.1)$$

where we make an explicit distinction between the vectors of "legitimate" and "illegitimate" risk-adjusters a_i^{C} and a_i^{R}, respectively, and where we now introduce a stochastic error term u_i. In (4.1), the parameters to be estimated are given by $[\alpha_0, \alpha', \beta']$. The standard procedure, however, consists of estimating (4.1), but with the a^{R} variables omitted. If (4.1) is the true model, this may lead to an omitted variables-bias. Are there any good reasons for this omission?

An explicit discussion of the problem can be found in the work of the York-group on the English capitation scheme for regional authorities (Carr-Hill et al., 1994). They estimate the expenditure equation with aggregate data at a regional level. The relevant a^{R} variable is "medical supply" and is deliberately omitted from the final estimated equation. The argumentation to do so rests on the problem of simultaneity bias. Medical supply is partly endogenous, i.e. dependent on the regional differentiation in morbidity and, hence, medical expenditures. Including medical supply in the estimated equation would then lead to an underestimation of the total effects of the morbidity variables, because the indirect link via medical supply is neglected. The procedure of estimating (4.1) with medical supply excluded can be interpreted as a direct estimation of the reduced form, which is what really matters for the correct calculation of the capitations. An alternative approach with aggregate data at a regional level is followed in Belgium (Schokkaert and Van de Voorde, 2000, in press). In this approach, (4.1) is estimated with medical supply included and the capitations are then computed with formula (2.6). This Belgian procedure underplays the simultaneity problem and rather focuses on the omitted variables-bias which results if one leaves out medical supply from the "true" model (4.1). With aggregate data, a way out of this dilemma can probably only be found in the estimation of a complete multi-equation structural model, in which one then will have to indicate explicitly what are "legitimate" and "illegitimate" components of the medical supply effect.

As soon as one starts working with individual data, however, the argument of simultaneity bias loses much of its force because it is not realistic to assume that *individual* medical expenditures would influence medical supply at the *regional* level. In that case only the potential omitted variables-problem remains and we do not see any good theoretical reason for the standard procedure of omitting the a^{R} variables from the estimated equation. As we have shown in Section 2, the legitimate concern not to create inappropriate incentives can be perfectly met by using (2.7) to compute the capitation payments. Of course, it is possible that the omitted variables-bias is not a serious problem, because the correlation between the a^{C} variables and the excluded a^{R} variables is negligible. But this will depend on the dataset analysed and can hardly be a general argument for use of the standard procedure.

The problem is illustrated for our empirical data in the first two columns of Table 1. The first column shows the estimation results of what could be seen as an example of the standard procedure. The "legitimate" risk-adjusters included are a series of age–gender dummies,[16] additional dummies for death, for the disabled (distinguished according to the period of disablement being less or more than 1 year) and for the individuals with a preferential treatment,[17] and a number of environmental variables: housing quality (an indicator of unfavourable socio-economic circumstances) and housing density (an indicator of urbanisation). The non-dummy variables are calculated as deviations from the mean. A detailed description of the variables is given in Table 2. All the variables get the expected signs and are significant. The R^2 is relatively high, which can be explained by the fact that we work with a sample of the whole population, including children and pensioners. The variance in medical expenditures is large but at the same time a large part of this variance can be explained by demographic variables (see also van de Ven and Ellis, 2000). This reasonably estimated equation leads to the normative expenditures for some "typical" individuals in the first column of Table 3. For the computations in Table 3 all the continuous variables which do not appear explicitly in the description of the types are put at the value of their sample mean.

However, our dataset also contains some information on variables which influence medical expenditures but could be interpreted as "illegitimate" risk-adjusters. A first example is the variable "medical supply", which was already introduced in the discussion about the York-procedure and plays an important role in the Belgian political debate. A second example is the variable "loyalty to a general practitioner", which we calculate as the (individual-specific) ratio of the number of consultations with a preferred general

[16] The reference category is a man between 25 and 30 years old.

[17] Our sample contains a group of individuals (low-income pensioners, disabled, widowers, widows and orphans) with a so-called "preferential treatment". Their co-payments are lower. Since our dependent variable represents reimbursements, it will be larger for this group even if their medical consumption were the same. If there is in addition a moral hazard effect, this will further increase the effect of "preferential treatment" in our estimations.

Table 1
Estimation results

	Linear model with only compensation variables included (1)	Model (1) with responsibility variables included (2)	Model (2) with multiplicative effects included (3)	Semilogarithmic model with responsibility variables included (4)
Intercept	8802 (595)	8542 (595)	8675 (594)	7.44 (0.0261)
(D) Man aged 0–5 years	11808 (1158)	11539 (1159)	11630 (1158)	0.57 (0.0375)
(D) Man aged 5–10 years	4904 (1041)	5048 (1041)	4942 (1041)	0.49 (0.0355)
(D) Man aged 10–15 years	2454 (924)	2677 (924)	2538 (923)	0.41 (0.0364)
(D) Man aged 15–20 years	−585 (774)	−418 (774)	−539 (773)	0.18 (0.0380)
(D) Man aged 20–25 years	−117 (936)	−136 (936)	−111 (934)	−0.14 (0.0392)
(D) Man aged 30–35 years	2421 (986)	2503 (986)	2468 (984)	0.11 (0.0356)
(D) Man aged 35–40 years	1549 (881)	1765 (881)	1612 (880)	0.13 (0.0360)
(D) Man aged 40–45 years	6824 (1524)	7139 (1522)	6940 (1520)	0.17 (0.0369)
(D) Man aged 45–50 years	10687 (1427)	11069 (1427)	10940 (1426)	0.30 (0.0374)
(D) Man aged 50–55 years	9824 (1410)	10369 (1412)	10193 (1410)	0.45 (0.0401)
(D) Man aged 55–60 years	15260 (1550)	15870 (1550)	15744 (1547)	0.71 (0.0406)
(D) Man aged 60–65 years	28881 (1858)	29629 (1860)	29375 (1859)	1.01 (0.0413)
(D) Man aged 65–70 years	44862 (2208)	45661 (2209)	45327 (2209)	1.49 (0.0415)
(D) Man aged 70–75 years	61621 (2578)	62517 (2580)	65871 (2860)	1.85 (0.0420)
(D) Man aged 75–80 years	70451 (3917)	71326 (3917)	73580 (4260)	1.94 (0.0545)
(D) Man aged 80–85 years	84980 (4344)	85864 (4344)	91888 (4895)	2.22 (0.0620)
(D) Man aged 85–90 years	110527 (7775)	111499 (7771)	124668 (9070)	2.52 (0.0832)
(D) Man aged 90–95 years	122656 (13619)	123464 (13621)	122691 (14967)	2.35 (0.1870)
(D) Man aged >95 years	120856 (41096)	122075 (41101)	100095 (42434)	2.53 (0.4159)
(D) Woman aged 1–5 years	7419 (980)	7250 (980)	7269 (980)	0.32 (0.0384)
(D) Woman aged 5–10 years	1138 (877)	1351 (878)	1205 (877)	0.34 (0.0358)
(D) Woman aged 10–15 years	507 (836)	847 (837)	686 (835)	0.46 (0.0362)
(D) Woman aged 15–20 years	1960 (796)	1870 (796)	1887 (795)	0.64 (0.0354)
(D) Woman aged 20–25 years	6966 (1547)	6433 (1545)	6652 (1544)	0.95 (0.0336)
(D) Woman aged 25–30 years	14186 (1058)	13834 (1059)	13978 (1058)	1.37 (0.0323)
(D) Woman aged 30–35 years	10582 (847)	10426 (847)	10462 (845)	1.26 (0.0317)
(D) Woman aged 35–40 years	9849 (1121)	9886 (1121)	9866 (1120)	1.03 (0.0328)
(D) Woman aged 40–45 years	10235 (1148)	10412 (1147)	10294 (1146)	0.96 (0.0341)
(D) Woman aged 45–50 years	12036 (1210)	12277 (1209)	12023 (1208)	1.03 (0.0351)
(D) Woman aged 50–55 years	11621 (1182)	11951 (1182)	11672 (1180)	1.15 (0.0375)
(D) Woman aged 55–60 years	18981 (1543)	19457 (1543)	19223 (1542)	1.27 (0.0375)
(D) Woman aged 60–65 years	25984 (1534)	26554 (1535)	26313 (1533)	1.47 (0.0377)
(D) Woman aged 65–70 years	37904 (1932)	38648 (1934)	38322 (1933)	1.63 (0.0383)

Table 1 (*Continued*)

	Linear model with only compensation variables included (1)	Model (1) with responsibility variables included (2)	Model (2) with multiplicative effects included (3)	Semilogarithmic model with responsibility variables included (4)
(D) Woman aged 70–75 years	50521 (2194)	51288 (2195)	52682 (2313)	1.89 (0.0387)
(D) Woman aged 75–80 years	73741 (2939)	74564 (2941)	78365 (3200)	2.34 (0.0425)
(D) Woman aged 80–85 years	99587 (3509)	100467 (3510)	108285 (3979)	2.69 (0.0430)
(D) Woman aged 85–90 years	135069 (4580)	135832 (4581)	142409 (5006)	3.06 (0.0492)
(D) Woman aged 90–95 years	169161 (7809)	169910 (7805)	179262 (9056)	3.12 (0.0806)
(D) Woman aged >95 years	181251 (17057)	181777 (17035)	190174 (17502)	3.38 (0.1528)
Housing quality	762 (255)	973 (258)	943 (257)	0.02 (0.0055)
Housing density	1275 (209)	842 (221)	799 (221)	−0.04 (0.0047)
(D) Disability <1 year	63295 (1671)	63055 (1671)	64172 (1699)	2.23 (0.0151)
(D) Mortality	209463 (6981)	209389 (6980)	208165 (6982)	1.92 (0.0426)
(D) Preferential treatment	32696 (1482)	32818 (1482)	32798 (1480)	0.40 (0.0190)
(D) Disabled (>1 year) or handicapped	71149 (3028)	71035 (3027)	70783 (3025)	1.13 (0.0310)
Medical supply		1234 (264)	614 (249)	0.03 (0.0053)
GP-loyalty		−17575 (1219)	−9941 (1079)	−0.96 (0.0165)
(ME) gp × man of age 70–75 years			−96612 (24287)	
(ME) gp × man of age 75–80 years			−65887 (32822)	
(ME) gp × man of age 80–85 years			−147867 (44887)	
(ME) gp × man of age 85–90 years			−301998 (74894)	
(ME) gp × man of age 90–95 years			19260 (153477)	
(ME) gp × man of age >95 years			358537 (651501)	
(ME) gp × woman of age 70–75 years			−46889 (16426)	
(ME) gp × woman of age 75–80 years			−104635 (25029)	
(ME) gp × woman of age 80–85 years			−185909 (31626)	
(ME) gp × woman of age 85–90 years			−172569 (39227)	
(ME) gp × woman of age 90–95 years			−237728 (78528)	
(ME) gp × woman of age >95 years			−298583 (127909)	
(ME) ms × disability <1 year			8094 (2067)	
(ME) ms × disability >1 year or handicapped			9575 (3094)	
R^2	0.1193	0.1198	0.1216	0.1170

Additional information: see Table 2 for a complete description of the variables. Dummy variables are indicated with (D), multiplicative effects with (ME). The reference category for the age–gender dummies is a man of age 25–30 years. The non-dummy variables are written as deviations from the mean. In the definition of the multiplicative effects, “gp” is an abbreviation of GP-loyalty, and “ms” an abbreviation of medical supply. The dependent variable is expressed in Belgian Francs (1 Euro = 40.3399 BEF). White (heteroskedasticity-consistent) standard errors are given in parentheses.

Table 2
Description of the variables

Definition of the variable	Sample mean	Sample proportion
Continuous variables		
Medical expenditures: yearly medical expenditures excluding co-payments and expenditures for pharmaceuticals (expressed in Belgian Francs; 1 Euro = 40.3399 BEF)	38 299	134 006
Housing quality: indicator based on principal component analysis of the proportion of private houses built before 1919 and the proportion of private houses with little comfort	−0.265	0.843
Housing density: indicator based on principal component analysis of population density and the percentage of urbanised area	0.460	1.189
Medical supply: indicator based on principal components of the number of general practitioners, specialists, pharmacists, dentists and physical therapists per 10,000 inhabitants	0.155	0.975
GP-loyalty: ratio of the number of consultations with a preferred general practitioner over the total number of consultations with any general practitioner	0.896	0.158
Dummy variables		
Man aged 0–5 years		3.21
Man aged 5–10 years		3.22
Man aged 10–15 years		3.18
Man aged 15–20 years		3.08
Man aged 20–25 years		3.05
Man aged 25–30 years		3.50
Man aged 30–35 years		3.80
Man aged 35–40 years		3.72
Man aged 40–45 years		3.48
Man aged 45–50 years		3.37
Man aged 50–55 years		2.60
Man aged 55–60 years		2.54
Man aged 60–65 years		2.66
Man aged 65–70 years		2.42
Man aged 70–75 years		2.13
Man aged 75–80 years		1.11
Man aged 80–85 years		0.81
Man aged 85–90 years		0.37
Man aged 90–95 years		0.12
Man aged >95 years		0.02
Woman aged 0–5 years		3.01
Woman aged 5–10 years		3.03
Woman aged 10–15 years		2.97
Woman aged 15–20 years		3.04
Woman aged 20–25 years		3.00
Woman aged 25–30 years		3.60
Woman aged 30–35 years		3.86
Woman aged 35–40 years		3.74
Woman aged 40–45 years		3.55
Woman aged 45–50 years		3.30
Woman aged 50–55 years		2.61
Woman aged 55–60 years		2.69

Table 2 (*Continued*)

Definition of the variable	Sample proportion
Woman aged 60–65 years	2.84
Woman aged 65–70 years	2.92
Woman aged 70–75 years	2.74
Woman aged 75–80 years	1.69
Woman aged 80–85 years	1.56
Woman aged 85–90 years	0.98
Woman aged 90–95 years	0.40
Woman aged >95 years	0.08
Disability (<1 year): dummy taking the value 1 for individuals who have been disabled (and accepted as disabled by the sickness fund) for a period less than 1 year	4.16
Disabled (>1 year): dummy taking the value 1 for individuals who have been disabled (and accepted as disabled by the sickness fund) for a period longer than 1 year	3.30
Mortality: dummy taking the value 1 for individuals who died during the observation period	1.05
Preferential treatment: dummy taking the value 1 for individuals with "preferential treatment" in the health insurance system, i.e. low-income pensioners, disabled, widowers, widows and orphans. These individuals have to pay lower co-payments	11.96

Table 3
Normative expenditures (in BEF) with a conventional and a complete model for some specific types of individuals

	Normative expenditures as derived from model (1) in Table 1	Normative expenditures as derived from model (2) in Table 1
Man of age 75–80 years		
Housing quality minimum, housing density maximum	87394	84211
Housing quality minimum, housing density minimum	76557	77054
Housing quality maximum, housing density maximum	91052	88881
Housing quality maximum, housing density minimum	80214	81724
Man of age 0–5 years		
Housing quality minimum, housing density maximum	28751	24424
Housing quality minimum, housing density minimum	17914	17267
Housing quality maximum, housing density maximum	32409	29094
Housing quality maximum, housing density minimum	21571	21937

For the calculation of these normative expenditures all continuous variables not included in the description of the type are put at their sample means. All dummy variables not included in the definition of the types are put equal to zero.

practitioner over the total number of consultations with a general practitioner.[18] In the Belgian context patients can switch easily from one general practitioner to another. They

[18] For those individuals who did not have any consultation with a general practitioner in 1995, the effect of this variable was neutralised by giving them the average value in the sample.

are even free to consult directly a (more expensive) specialist. Many argue that a strengthening of the gatekeeper-role of the general practitioner could reduce medical expenditures per capita. *If* this is indeed the case, we would expect to find smaller expenditures for patients who are more loyal to their GP. Since it seems reasonable that the central fund would like to stimulate this behaviour (and would like to give the insurers the appropriate incentives to stimulate this behaviour) the insurers should be allowed to reap the fruits of the larger loyalty, i.e. the variable should *not* be included in the normative capitation formula. This does not mean, however, that it may not play a crucial role in the explanatory model. Estimation results for a broader regression model, including medical supply and GP-loyalty, are shown in the second column of Table 1.[19] Both variables have a significant effect.

For our discussion, it is interesting to look at the effects of introducing the a^{R} variables on the estimates of the other coefficients. In general, these are relatively minor, indicating that the omitted variables bias in the first column remains limited. There are some serious shifts in the point estimates of older men and of housing density, however. Therefore, the normative expenditures shown in the second column of Table 3 also show some non-negligible differences.[20] For a male child (younger than 5 years) living in a densely populated area of low housing quality the overestimation with the conventional approach amounts to 4327 BEF (107 Euros) or 18% of the estimate with the complete model. For an old man (aged between 75 and 80 years) living in a similar area the conventional model yields an overestimate of 3183 BEF (79 Euros, or 4% of the “correct” amount). Similar differences could be shown for some other groups, as suggested by the coefficients in Table 1. Moreover, as emphasised before, the finding of relatively minor differences is contingent on the data used and could change with the inclusion of other a^{R} variables. One can only be sure by checking the correlation between the legitimate and the illegitimate risk-adjusters.

Let us conclude. Given the ease with which it is possible to go from a full estimated equation to a capitation formula including only legitimate risk-adjusters, it is advisable to include all available and potentially relevant explanatory variables in the equations to be estimated. So doing, one can be sure to minimise the problem of omitted variables-bias. Moreover, from a broader scientific point of view it seems eminently sound to distinguish explicitly between the *explanatory* exercise on the one hand and the *normative* decisions with respect to the determination of legitimate risk-adjusters on the other hand. In the first step one thinks as a social scientist trying to get a better insight into observed behaviour and including all theoretically relevant explanatory variables. In the second step one takes the position of a policy-maker who wants to create appropriate incentives—where “appropriate” can only be defined in a meaningful way on the basis of a well-defined ethical framework.

[19] Again, both variables are defined as deviations from the mean.

[20] Note that Table 3 does not contain information on the statistical precision of the estimated normative expenditures. In fact, we think that testing the *statistical* significance of the differences in Table 3 could be a misleading exercise. In the real world, point estimates of the normative expenditures are used to calculate the capitations and what matters for the sickness funds is the *economic* significance of the differences. Our use of the term “non-negligible” refers to this economic significance. Even if the difference between the capitations for two demographic groups were statistically insignificant, this would not be socially relevant if the regulator kept using the point estimates—which is what happens in practice. As a matter of fact, the question of how to exploit the information about the statistical precision of the estimates for refining the calculation of the normative expenditures is an important one, which has remained largely unexplored in the literature.

In the standard procedure of conventional risk adjustment, these two sets of considerations get mixed.

This statement also has immediate consequences for a simple cell-based approach: if the cells (as usual) are defined only on the basis of the legitimate risk-adjusters, the results are equivalent to the ones obtained by a linear estimation of (4.1) with only a^{C} dummy variables included. In so far as the cell means reflect the correlation between legitimate and illegitimate risk-adjusters, they are imperfect building blocks for a capitation system.

5. A non-additively separable specification

Until now we have remained within a linear setting. Although there are good reasons to adopt such a linearity-assumption if a large dataset is available (as in our case), there are also arguments to introduce non-linearities in the specification. At the very least, one could keep the estimated equation linear in the coefficients but introduce multiplicative relationships between variables. Many econometricians would go much further and advocate a sophisticated treatment of the null-expenditures and the choice of a logarithmic transformation of the dependent variable to take account of the skewed distribution of medical expenditures.

Going from a linear to a non-linear specification does not affect the applicability of the theoretical framework sketched in Section 2, because (2.1) and (2.3) represent general functions. However, it turns out that most practical applications soon lead us into trouble, because the estimated equations do no longer satisfy the requirement of additive separability between the responsibility and the compensation variables. We will illustrate the resulting problems, first for multiplicative effects and then for a semilogarithmic specification.

5.1. Multiplicative effects

We keep to our previous example and treat medical supply and GP-loyalty as responsibility variables. The third column of Table 1 gives the estimates for a model including some significant cross-effects between these a^{R} and a^{C} variables. GP-loyalty has a much stronger negative effect on the expenditures of the elderly, and the cost of invalidity and handicaps is larger in regions with a high density of medical providers. Both effects are theoretically meaningful.[21] By themselves they are already sufficient to make the specification no longer additively separable between legitimate and illegitimate risk-adjusters.[22] Therefore, the natural mechanism (2.6) or (2.8) cannot be applied and we have to resort to the conditional-egalitarian capitations in (2.10). This means that we have to choose a reference value $\tilde{a}^{\mathrm{R}}$ for provider density and GP-loyalty. The optimal choice of these reference

[21] It is reasonable to assume that the expenditure pattern of older and handicapped persons is more sensitive to the influence of providers than that of younger and active persons. Moreover, in our linear model the *absolute* effect of GP-loyalty and higher provider density on expenditures may simply be larger for groups with larger expenditures (such as older or handicapped persons). This relates to the choice of functional form, to which we will return in Section 5.2.

[22] Of course, cross-effects between two (or more) compensation variables or two (or more) responsibility variables do not lead to any difficulties for applying the natural mechanism of Section 2.

Table 4
Incentives for risk selection following from applying the conditional egalitarian solution in the model with multiplicative effects

	$f(a_i^{\mathrm{C}}, a_i^{\mathrm{R}})$	$f(a_i^{\mathrm{C}}, \bar{a}^{\mathrm{R}})$	$\pi_i - \lambda$
Minimal medical supply and maximal GP-loyalty			
Disabled man of age 75–80 years	115639	153038	37399
Disabled man of reference group	48924	79458	30534
Non-disabled man of age 75–80 years	72576	82255	9679
Non-disabled man of reference group	5862	8675	2813
Maximal medical supply and minimal GP-loyalty			
Disabled man of age 75–80 years	270435	153038	−117397
Disabled man of reference group	137834	79458	−58376
Non-disabled man of age 75–80 years	153163	82255	−70908
Non-disabled man of reference group	20561	8675	−11886
Maximal medical supply and maximal GP-loyalty			
Disabled man of age 75–80 years	194607	153038	−41569
Disabled man of reference group	127893	79458	−48435
Non-disabled man of age 75–80 years	77335	82255	4920
Non-disabled man of reference group	10620	8675	−1945
Minimal medical supply and minimal GP-loyalty			
Disabled man of age 75–80 years	191467	153038	−38429
Disabled man of reference group	58865	79458	20593
Non-disabled man of age 75–80 years	148404	82255	−66149
Non-disabled man of reference group	15803	8675	−7128

The variable "disabled" indicates that the type is disabled for a period longer than 1 year or handicapped (see Table 2). The reference group for the age–gender dummies is a male between 25 and 30 years old.

values is an interesting theoretical problem, but for our illustrative purposes it is sufficient to take as a reasonable first approximation the mean values in our sample (as an estimate of the population means). This choice of $\tilde{a}^{\mathrm{R}}$ is suggested by a naive extension of (2.7) to the non-separable case. We know of course that the resulting capitations will not satisfy the *NIRS* axiom, i.e. that there will remain incentives for risk selection. This problem is illustrated in Table 4.

In this table we consider four "risk types", differing with respect to legitimate risk-adjusters: age and the presence of disability. Their medical expenditures are also influenced by the provider density in their region of residence and by their own loyalty to a general practitioner. Hence we distinguish between four "responsibility" levels, ranging from the lowest expenditures (minimal provider density and maximal GP-loyalty) to the highest expenditures (maximal provider density and minimal GP-loyalty). The first column gives the expected expenditures for these different possibilities, as computed with the coefficients in Table 1. This can be interpreted as $E(x_i) = f(a_i^{\mathrm{C}}, a_i^{\mathrm{R}})$ were the expectations-operator refers to the fact that we have neglected the disturbance term. As could be expected, there are large divergences in these expected expenditures. In so far as these differences are due to the responsibility variables, there is no problem from a social point of view. However, differences *within* a responsibility level should be compensated for by the risk adjustment mechanism. Implementing the conditional-egalitarian capitations under the assumption $\tilde{a}^{\mathrm{R}} = \bar{a}^{\mathrm{R}}$ and using the notation of (2.11), the second column of Table 4 shows the values of $f(a_i^{\mathrm{C}}, \bar{a}_i^{\mathrm{R}})$, i.e. $\omega_i^{\mathrm{CE}} - \lambda$. The last column gives $f(a_i^{\mathrm{C}}, \bar{a}_i^{\mathrm{R}}) - f(a_i^{\mathrm{C}}, a_i^{\mathrm{R}})$, i.e. $\pi_i^{\mathrm{CE}} - \lambda$ (see (2.12)). In so far as there are differences within the four "responsibility" blocks of this last column, *NIRS* is not satisfied and there are incentives for risk selection. It is obvious that these incentives are considerable—although of course dependent on the level of provider density and GP-loyalty.[23]

There seems to be a real problem here. Note that this problem is *not* due to lack of adequate data. The conventional risk adjustment literature tries to minimise the dangers of risk selection by looking for better risk-adjusters, i.e. less imperfect signals of risk type. This is an important task. However, even with perfect information the problem sketched in this section would remain.[24] The magnitude of the differences in the last column of Table 4 indicates that it is not negligible.

5.2. A semilogarithmic specification

Suppose now that one adopts a semilogarithmic specification to account for the skewed distribution of medical expenditures:

$$\ln x_i = \alpha_0 + \alpha' a_i^{\mathrm{C}} + \beta' a_i^{\mathrm{R}} + u_i \tag{5.1}$$

Estimation results for this specification are shown in the last column of Table 1.[25] It is well known that predicting expenditures on the basis of (5.1) entails a potentially difficult retransformation problem, but for our purposes it is sufficient to look at the consequences of applying the following naive translation of the "natural" normative expenditures (2.8) in this context:

$$\ln N_i = \alpha_0 + \alpha' a_i^{\mathrm{C}} + \beta' \bar{a}^{\mathrm{R}} \tag{5.2}$$

Applying (5.2) and (5.1) one sees immediately that:

$$\pi_i = \exp(\alpha_0 + \alpha' a_i^{\mathrm{C}})[\exp(\beta' \bar{a}^{\mathrm{R}}) - \exp(\beta' a_i^{\mathrm{R}} + u_i)] \tag{5.3}$$

which is clearly dependent on the a^{C} variables. Therefore, again, there will remain incentives for risk selection. This is not surprising, since specification (5.1) implies that $f(\cdot)$ in (2.3) is not additively separable in legitimate and illegitimate risk-adjusters. In fact, apart from the constant λ, the naive approach based on (5.2) boils down to the conditional egalitarian mechanism (2.11) for reference values of the a^{R} variables equal to their mean values. Note that in this case the problem of risk selection would remain even if one did not include explicit a^{R} variables in the specification: the presence of the disturbance term in (5.3) is sufficient to generate the problem.

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[23] It is obvious (and made explicit in the axiom *NIRSREF*) that the incentives for risk selection are nil for the individuals with $a_i^{\mathrm{R}} = \tilde{a}_i^{\mathrm{R}}$, or in our specific illustration with $a_i^{\mathrm{R}} = \bar{a}_i^{\mathrm{R}}$.

[24] This point might be somewhat surprising for economists who tend to think that in a perfect information setting the first best can be reached. However, in this case the *NEUT* axiom imposes additional restrictions on the choice of instruments.

[25] For observations with zero expenditures, we put $\ln x_i = 0$ (i.e. $x_i = 1$).

To get an idea about the magnitude of the risk selection incentives, it is not necessary to actually calculate anything. Indeed, it is easily seen that (5.1) and (5.3) imply:

$$\frac{\pi_i}{x_i} = \exp[\beta'(\bar{a}^{\mathrm{R}} - a_i^{\mathrm{R}}) - u_i] - 1 \tag{5.4}$$

The expression at the right-hand side is independent of a_i^{C} and can be denoted as $\zeta(a_i^{\mathrm{R}})$. Therefore, the naive mechanism (5.2) makes the incentives for risk selection proportional to the actual expenditures, i.e. it satisfies the following axiom.

Axiom 4 (*proportional incentives for risk selection* (*PROPIRS*)). For any two individuals i and j with $a_i^{\mathrm{R}} = a_j^{\mathrm{R}} = a^{\mathrm{R}}$, $(\pi_i/x_i) = (\pi_j/x_j) = \zeta(a^{\mathrm{R}})$.

The results in this section are worrying. As emphasised before, it is crucial to distinguish carefully between the "explanatory" power of estimated expenditure equations and the use of the resulting estimates in a capitation formula. At the same time, there may be very sound econometric reasons to introduce cross-effects in a linear equation or to move to (semi)logarithmic specifications—not to mention the use of two-part models which would still further complicate matters. If one were unaware of Proposition 2.2, it would be tempting to try to derive from such more sophisticated specifications a capitation formula satisfying *NIRS* (and the neutrality assumption *NEUT*). However, Proposition 2.2 shows that all such attempts are futile: if the "true" model is not additively separable, then no risk adjustment scheme can remove all the incentives for risk selection. This basic problem cannot be solved by collecting better data or by using more sophisticated statistical techniques. The only possibility to remove the incentives for risk selection when the expenditure equations are not additively separable in the variables a^{C} and a^{R} would be to give up horizontal neutrality *NEUT* (a restriction on the set of possible instruments). A more realistic approach in most real-world policy contexts is probably to keep *NEUT*, to work with what is the best possible estimation of the "true" model and to try to minimise the incentives for risk selection in the concrete setting, i.e. to choose the "best" possible rule within the family of conditional-egalitarian mechanisms (2.10). This "best" possible rule will be dependent on the concrete empirical setting and on an "ethical weighting scheme" to be applied to the various risk groups involved. This seems to be a useful topic for further research.

6. Conclusion

The conventional risk adjustment literature tends to underemphasize the basic difference between *explaining* medical expenditures and formulating *normative* capitations. We sketch a framework, derived from social choice theory, which makes it possible to handle this distinction explicitly. More specifically, we show how to derive in a rigorous way normatively acceptable capitations from estimated equations, even if these estimated equations contain "illegitimate" risk-adjusters, i.e. if real-world expenditures are codetermined by variables for which one does not want to compensate. This will always be true in the real world.

Our starting point is the empirical literature. However, further thinking along the lines sketched in this paper could contribute to bridging at least part of the gap between this empirical work and the theoretical literature on risk adjustment. At the very least an acceptable estimation of a full model, incorporating health plan behaviour, seems to be a necessary building-block in both approaches.

The lessons we can derive from our approach for future empirical work on risk adjustment are unambiguous. Let us briefly summarise:

(a) The theoretical setting suggests that it is possible to neutralise the effect of responsibility variables for the computation of the capitations. There is therefore no good argument for the standard procedure of omitting these variables during the estimations, because this may lead to biased estimates of the effects of the legitimate risk-adjusters. A better procedure consists in explicitly distinguishing between two phases. First, one tries to do the econometric work as carefully as possible, i.e. one tries to find the best *explanatory* model. Second, one argues explicitly about the *normative* distinction between legitimate and illegitimate risk-adjusters and one uses Eqs. (2.6)–(2.8) to calculate the capitations.

(b) In practice the cost of collecting the information is used as an additional argument for leaving certain variables out of the risk adjustment formula. Collection costs are an important issue but our results suggest that omitting such information may bias the estimates of the remaining coefficients and create additional incentives for risk selection.

(c) There may be good econometric reasons to drop the assumption of linearity in the variables. Introducing a (semi)logarithmic specification will lead to a model, which is no longer additively separable in the compensation and the responsibility variables. The same is true if one finds significant cross-effects between a compensation and a responsibility variable. If the true model is not additively separable, it becomes impossible to remove all incentives for risk selection while at the same time respecting a requirement of horizontal neutrality. In general our model shows that the choice of functional form has crucial implications which go beyond the merely statistical or econometric considerations.

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