

# EQUIVALENT INCOME AND FAIR EVALUATION OF HEALTH CARE

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## ABSTRACT

We argue that the economic evaluation of health care (cost–benefit analysis) should respect individual preferences and should incorporate distributional considerations. Relying on individual preferences does not imply subjective welfarism. We propose a particular non-welfarist approach, based on the concept of equivalent income, and show how it helps to define distributional weights. We illustrate the feasibility of our approach with empirical results from a pilot survey. Copyright © 2012 John Wiley & Sons, Ltd.

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## 1. INTRODUCTION

Traditional welfare economics usually takes it as axiomatic that individual preferences should be the ultimate guide in all matters of resource trade-offs. Yet, in the context of evaluation of health care, evaluation criteria that incorporate individual preferences, and more specifically individual willingness to pay, have been submitted to recurrent criticism. In this article, we reaffirm the traditional principle that it is desirable to rely on the population's preferences to set priorities in health care. Let us imagine a population with preferences that are extremely concerned with health and much less with other goods. Would it not be normal for such a population to spend more on health than another population with less extreme preferences? Now imagine a population that is supremely concerned with mental health. Would it not be normal for such a population to spend more on mental health, as compared with other branches of health care, than other populations? Who is in the position to legitimately overrule people's own ideas about what is important in life, for decisions with a direct impact on these people themselves?<sup>1</sup> At the same time, we also emphasize that fairness is an essential element in any evaluation study, and we will show how distributional considerations can enter the picture in a coherent way.

This article fits into the huge literature on the theoretical foundations of economic evaluation techniques in the healthcare sector (be it through cost-effectiveness or through cost–benefit analysis). It is not easy to position ourselves clearly with respect to the many articles in that literature, however, because very different perspectives have been taken, and there is a lot of confusion about definitions. Our position about preferences is one specific position

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<sup>1</sup>Of course, individual preferences are not always reliable and may be plagued with many flaws of irrationality, myopia, interdependence, antisocial drives, and so on. It is even possible that some of these shortcomings are especially frequent in matters of health and health care. We agree that in these cases revealed or stated preferences should be corrected before using them for economic evaluation. However, this is not the main point of this article.

in the debate on welfarism versus non-welfarism or extra-welfarism. All these terms have been defined in different ways by different authors (e.g. Birch and Donaldson, 2003; Brouwer and Koopmanschap, 2000; Brouwer *et al.*, 2008). Our position about distribution also relates to a long-standing debate. Some claim that the Kaldor–Hicks criterion is an essential component of traditional cost–benefit analysis (e.g. Brouwer *et al.*, 2008, who consider this to be a weakness, and Kenkel, 1997 and Pauly, 1995, who defend the approach). Others have argued that a coherent social welfare–based cost–benefit analysis requires introducing distributional weights (Drèze, 1998; Donaldson *et al.*, 2002). There is a similar debate about using weighted or unweighted sums of QALYs in the case of cost-effectiveness analysis (Bleichrodt, 1997; Nord, 1999; Sassi *et al.*, 2001; Wagstaff, 1991).

Rather than entering into definitional finesses, we prefer to describe our own perspective as clearly as possible:

- (a) The most common interpretation of welfarism defines it as an approach in which the only information that is used to evaluate social states is information about individual utilities. This is interchangeably seen as using individual subjective satisfaction measures as an indicator of individual well-being or as respecting individual preferences (Brouwer *et al.*, 2008). We emphasize that these two approaches are *not* equivalent. It simply is not true that relying on individual preferences implies welfarism, interpreted as measuring well-being in terms of subjective utility, happiness or satisfaction and performing interpersonal comparisons with such measures. Our main contribution in this article is the introduction of the concept of “equivalent income” as a measure of individual well-being that does respect preferences but does not coincide with subjective satisfaction.
- (b) We will also show that introducing equivalent incomes makes it possible to integrate fairness considerations into the analysis in a coherent way, with distributional weights related to the level of these equivalent incomes. We do not believe that the distributional weights should follow from individual preferences (a position taken e.g. by Dolan, 1998 and Johannesson, 1999, and ascribed to the traditional position by Brouwer *et al.*, 2008). Distributional considerations are embodied in a social welfare function capturing an ethical position—individual preferences are only used to derive an attractive measure of individual well-being.
- (c) Certainly within the medical community, “many decision makers might object to monetary values being placed on something as fundamental as health” (Oliver *et al.*, 2002, p. 1774). We argue that this widespread repugnance against using money metrics in health economic evaluations is based on a misunderstanding. The only thing that really drives cost–benefit analysis is the possibility to convert changes in all dimensions of well-being into changes in a single dimension (that of the numeraire). We therefore agree with Kenkel’s bold pronouncement that “when the economics profession eschews cost–benefit analysis of healthcare interventions we are not giving our clients our best service. Even at the risk of being rude, as experts we should make the case that much of the skepticism that greets cost–benefit analysis of health interventions is not well-founded” (Kenkel, 1997, p. 750) However, we strongly disagree with Kenkel (1997) in that we will show that this argument about the numeraire hinges crucially on the use of distributional weights.

The structure of our article is as follows. In Section 2, we integrate and summarize different arguments that have already been taken up in the literature. We argue that to construct sensible criteria for economic evaluation, one needs a sound set of ethical principles dealing with distributive justice. In Section 3, we introduce the concept of equivalent income as a measure of individual well-being respecting individual preferences. Finally, we show in Section 4 how our proposed methodology for dealing with distributive justice in healthcare evaluation, involving the concept of equivalent income, can be implemented in practice, and, as an illustration, we calculate a set of distributional weights on the basis of a pilot study. Section 5 concludes.

## 2. COST–BENEFIT ANALYSIS AND DISTRIBUTIONAL WEIGHTS

We take a simple model in which the situation of individual  $i$  ( $i = 1, \dots, n$ ) is depicted by  $(y_i, h_i, z_i)$ , where  $y_i$  denote  $i$ ’s income,  $h_i$  his health, and  $z_i$  other dimensions of well-being such as leisure, public goods, social

relations, and so on.<sup>2</sup> The quantities  $h_i$  and  $z_i$  can be multidimensional vectors, and each component  $h_{ik}$  takes values between 0 (the worst state) and 1 (good health in this dimension). Let  $h^* = (1, \dots, 1)$  denote the state of good health. This state of good health is the same for all individuals.

The exercise of economic evaluation boils down to a social ordering of the vectors  $((y_1, h_1, z_1), \dots, (y_n, h_n, z_n))$ . This statement is very general, as different social orderings may reflect different ethical considerations and, more specifically, different views on equity and efficiency. As proposed by Bergson (1938) and Samuelson (1947), it is then convenient to define the criterion for economic evaluation in terms of a real-valued social welfare function,

$$E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n)),$$

which simply is a numerical representation of the social ordering.

Let us now assume that individual  $i$  has her own preference ordering over  $(y_i, h_i, z_i)$ , which is defined as a transitive and complete binary relation  $R_i$ . The expression

$$(y_i, h_i, z_i) R_i (y'_i, h'_i, z'_i)$$

means that  $i$  considers  $(y_i, h_i, z_i)$  to be at least as good as  $(y'_i, h'_i, z'_i)$ . The terms  $I_i$  and  $P_i$  will denote the associated indifference and strict preference relations. Moreover, we assume that this preference ordering is monotonic in  $y_i$  and  $h_i$ , so that  $y_i \geq y'_i$  and  $h_i \geq h'_i$  imply  $(y_i, h_i, z_i) R_i (y'_i, h'_i, z'_i)$ , with strict preference if  $y_i \neq y'_i$  or  $h_i \neq h'_i$ . A utility function  $u_i$  represents this ordering when, for all pairs  $(y_i, h_i, z_i)$ ,  $(y'_i, h'_i, z'_i)$ ,

$$u_i(y_i, h_i, z_i) \geq u_i(y'_i, h'_i, z'_i) \Leftrightarrow (y_i, h_i, z_i) R_i (y'_i, h'_i, z'_i).$$

We can now use this preference information to give a more specific form to the general evaluation function  $E(\cdot)$ . If this function satisfies the Pareto principle according to which two situations yield the same social welfare if every individual is indifferent between them, and one situation yields a greater welfare if at least one individual prefers it while nobody prefers the other, then for every collection of utility functions  $u_i$  representing  $R_i$  for each  $i = 1, \dots, n$ , there exists an increasing function  $W$  such that

$$E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n)) = W(u_1(y_1, h_1, z_1), \dots, u_n(y_n, h_n, z_n)) \quad (1)$$

We consider that the Pareto principle is a good principle if one wants to respect individual preferences, and we assume throughout this article that the social welfare function should be decomposable as in Equation (1). However, the phrase “for every collection of utility functions  $u_i$  representing  $R_i$ ” is important. It is not assumed at this stage that utility is cardinally measurable nor that it is interpersonally comparable. Therefore, the use of the social welfare function  $W$  does not imply that one is welfarist. This insight will be crucial in Section 3.

The role of individual preferences in Equation (1) should be carefully defined. More specifically, the social welfare function  $E$  (or  $W$ ) should incorporate the efficiency and equity concerns of the evaluator, not necessarily those of any particular member of the population under scrutiny. It is sometimes claimed that “for distributional issues to matter individuals have to be concerned with the distribution” (Johannesson, 1999, p. 382), as if the evaluator was constrained by the ethical opinions of the population. However, even in a society of perfect egoists, there are equity issues and the social criterion should embody equity principles. The problem of economic evaluation is to adjudicate individual interests according to one particular political view or a sample of political views (with a different social welfare function  $E(\cdot)$  for each), not to synthesize the citizens’ political views into a “collective” doctrine. Note that we only introduced self-centered preferences  $R_i$  in Equation (1). In so doing, we do not assume that people are selfish. Simply, even if individuals may have ethical opinions about

<sup>2</sup>The vector  $z_i$  can also depict variables such as market prices. Then,  $y_i$  is simply nominal income. Another possible reading of the model is that  $y_i$  is a suitable notion of real income, in which case market prices are already taken into account in  $y_i$ .

the distribution, be altruistic or resentful toward their fellow citizens or have meddlesome preferences about their neighbors' lifestyle, the social criterion only asks them what they prefer for themselves.<sup>3</sup>

To keep the analysis simple, we will focus on the problem of evaluating an infinitesimal change to some initial situation. That is, we consider a situation in which each individual vector  $(y_i, h_i, z_i)$  is changed into  $(y_i + dy_i, h_i + dh_i, z_i + dz_i)$ . Social welfare, as a result, changes by the amount  $dE$  and the change is good or bad depending on  $dE >$  or  $< 0$ . Assuming that  $E$  is suitably differentiable, one can write

$$dE = \sum_i \frac{\partial E}{\partial y_i} \left[ dy_i + \frac{\partial E}{\partial h_i} .dh_i + \frac{\partial E}{\partial z_i} .dz_i \right].$$

The expression  $\frac{\partial E}{\partial h_i} / \frac{\partial E}{\partial y_i}$  denotes the vector of social marginal rates of substitution between  $y_i$  and each of the  $h_{ik}$ , so that  $\left( \frac{\partial E}{\partial h_i} / \frac{\partial E}{\partial y_i} \right) .dh_i$  is a scalar product, and similarly for  $\frac{\partial E}{\partial z_i} / \frac{\partial E}{\partial y_i}$ , whereas  $\frac{\partial E}{\partial y_i}$  is the social marginal value of  $i$ 's income.

Under the Pareto principle, one can equivalently write (assuming differentiability of  $W$  and of the  $u_i$  functions)

$$dE = \sum_i \frac{\partial W}{\partial u_i} \frac{\partial u_i}{\partial y_i} \left[ dy_i + \frac{\partial u_i}{\partial h_i} .dh_i + \frac{\partial u_i}{\partial z_i} .dz_i \right].$$

In particular, the social marginal rates of substitution are then equal to the individual marginal rates of substitution, which can be denoted as  $MRS_i^h$  and  $MRS_i^z$  (recall that these are vectors with as many dimensions as components in  $h$  and  $z$ , respectively). In other words, the social criterion espouses individual views on the trade-off between personal income and other personal goods such as health. Note again that these marginal rates of substitution only depend on preferences and that no assumptions of cardinality or interpersonal comparability are needed.

The expression  $[dy_i + MRS_i^h .dh_i + MRS_i^z .dz_i]$  can be read as a willingness to pay for the change  $[dy_i, dh_i, dz_i]$  because if one subtracted this amount from  $dy_i$ , one would then restore individual satisfaction to its initial value:

$$\frac{\partial u_i}{\partial y_i} (dy_i - [dy_i + MRS_i^h .dh_i + MRS_i^z .dz_i]) + \frac{\partial u_i}{\partial h_i} .dh_i + \frac{\partial u_i}{\partial z_i} .dz_i = 0.$$

We therefore let  $WTP_i$  denote  $[dy_i + MRS_i^h .dh_i + MRS_i^z .dz_i]$ . It is also customary to let  $\beta_i$  denote  $\frac{\partial E}{\partial y_i} = \frac{\partial W}{\partial u_i} \frac{\partial u_i}{\partial y_i}$ . With these notations, we obtain the classical formula

$$dE = \sum_i \beta_i WTP_i \tag{2}$$

An important feature of Equation (2) is that it distinguishes an empirical quantity,  $WTP_i$ , and an ethical parameter,  $\beta_i$ , which encapsulates distributional judgments. Some cost-benefit analyses simply disregard the  $\beta$ 's and compute the unweighted sum  $\sum_i WTP_i$ .<sup>4</sup> The previous analysis immediately shows that this attitude is no more distributionally neutral than any other choice of parameters. Despite the visual illusion that the term  $\beta_i$  seemingly disappears from the formula, this amounts to considering that every individual's income has the same social priority, no matter how well off or badly off she is.

<sup>3</sup>If individual preferences over one's situation depend on the others' situations, then  $R_i$  is not well defined because it changes from one allocation to the other. We assume away such difficulties and consider that the best way to tackle them in practice may be to ask people what they would want for themselves if the others were always in a similar situation as theirs.

<sup>4</sup>In addition, practitioners of cost-benefit analysis very often define willingness-to-pay only with respect to the nonincome part of the change:  $WTP_i = MRS_i^h .dh_i + MRS_i^z .dz_i$ , and consider the change to be good if the sum of  $WTP_i$  is greater than the total cost of the change—which equals the reduction in total income incurred by the population. This is equivalent to checking that the unweighted sum of  $WTP_i$ , as defined in this article, is positive.

Positive arguments in favor of adopting equal weights  $\beta_i$  can be found. First, there is the tradition of compensation tests initiated by Kaldor and Hicks. Checking that the unweighted sum of  $WTP_i$  is positive is equivalent to checking that the individuals who benefit from the change could compensate the losers. This approach has, however, been completely disqualified by welfare economists.<sup>5</sup> In particular, the fact that compensation could be made is not a sufficient justification when it is not really made.

Another somewhat more sophisticated argument for disregarding the  $\beta$ 's has been floating around in the literature. Pauly (1995) has been one of the main proponents of this position stating that "if we observe . . . that society . . . does not seem disposed to make further transfers from rich to poor, then we are not justified in asserting that the same society would value health benefits of a given money value more if they go to poor people than to rich people" (p. 118). This position does not seem to presuppose a specific form for  $E$ . However, it can be easily seen that it is only valid if we live in a first-best world. In such a first-best context, the government can redistribute income at will across people, so that if total income is  $Y$ , then any distribution  $(y_1, \dots, y_n)$  such that  $\sum_i y_i = Y$  is feasible. If the best distribution of the total amount  $Y$  is chosen, it maximizes  $E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n))$  under the constraint  $\sum_i y_i = Y$ . For an interior solution, the first-order condition of this problem implies that for all  $i, j$ ,

$$\frac{\partial E}{\partial y_i} = \frac{\partial E}{\partial y_j},$$

that is,  $\beta_i = \beta_j$ . In a first-best context, it is therefore correct to assume equal weights in Equation (2) when the current distribution of income is optimal.

In the more realistic second-best context, however, things are different. Assume that incentive constraints make it impossible to redistribute income without losing some resources in the process. In our simple setting, this can be represented by a generalized feasibility constraint  $\sum_i y_i = F(y_1, \dots, y_n)$ , where  $F$  is an increasing convex function. Convexity of the function is meant to capture the fact that reducing income inequality reduces total income. We can still examine what happens if the distribution is optimal under this constraint. The first-order condition of this problem, with  $\lambda$  denoting the Lagrange multiplier of the feasibility constraint, now reads, for an interior solution:

$$\frac{\partial E}{\partial y_i} = \lambda \left( 1 - \frac{\partial F}{\partial y_i} \right),$$

implying that the parameter  $\beta_i$  should be proportional to  $1 - \frac{\partial F}{\partial y_i}$ . Convexity of the function  $F$  suggests that  $\beta_i$  is decreasing with  $i$ 's income, although it may also depend on  $i$ 's health  $h_i$  and on  $z_i$ . In conclusion, in the second-best context, even if we assume that the current distribution of income is optimal from the point of view of the social welfare function  $E$ , the distributional weights  $\beta_i$  are not equal, and should exhibit some priority for the worst-off. The incentive constraints prevailing in the second-best context prevent a fully satisfactory redistribution of income, so that those at the lower tail of the distribution are left with a greater degree of priority even if optimal use is made of the available redistributive tools. If applied to the real world, Pauly's position is simply wrong.<sup>6</sup>

Before addressing further the issue of distribution, let us first show how Equation (2) relates to the criticism that in cost-benefit analysis everything revolves around money. In fact, the previous analysis shows that it is possible to use another numeraire than income. Health itself, if it were one-dimensional,<sup>7</sup> could serve as an alternative metric. Under this alternative formulation,  $WTP_i$  would be redefined in terms of health, that is, it would measure the amount of health reduction that  $i$  would accept jointly with the change  $(dy_i, dh_i, dz_i)$  to be

<sup>5</sup>See in particular Arrow (1951), Boadway and Bruce (1984), and Blackorby and Donaldson (1990).

<sup>6</sup>In contrast, Drèze and Stern (1987) correctly note that "the optimal nonlinear income tax . . . does not imply the equality of the social marginal utilities of income. . . across households: the disincentive aspects of the non-lump sum tax provide a reason for not fully equating them" (p. 958).

<sup>7</sup>One-dimensional health is sufficient but not necessary. It would suffice if health were separable in everyone's preferences, so that one could define a subutility function of health, such as a "health-utility index" (Torrance *et al.*, 1995).

maintained at his initial satisfaction. The real ethical requirement to do cost–benefit analysis is the possibility to express all changes in many dimensions, for each individual, into his willingness to pay in some particular dimension. This implies that people do accept trade-offs between health and other consumptions (as we observe in people’s everyday choices regarding work, food, physical exercise, sex, and other dimensions of lifestyle). Money is a convenient numeraire simply because many statistics are already produced in this unit of measurement.

However, the presence of the distributional parameters  $\beta_i$  in Equation (2) plays a crucial role in this interpretation. As was made clear in the exchange of ideas between Brekke (1997), Drèze (1998) and Johansson (1998), the choice of numeraire may matter if one uses an unweighted sum of net benefits as the criterion for project evaluation. Suppose one has to choose between financing two equally costly treatments which have a similar effect on the health status (calculated in terms of the number of QALYs) of the individuals concerned. Illness A hits mainly the (few) rich in a country, whereas illness B hits mainly the (many) poor. If QALYs are taken as the numeraire, the unweighted benefits criterion will favor the treatment of illness B. If income is taken as the numeraire, it may well be possible that priority is given to the treatment of illness A because the willingness to pay of the rich will be larger than the willingness to pay of the poor. The problem in this case, however, does not reside in the choice of the numeraire, but in the use of an unweighted benefits criterion. When applying Equation (2), social valuations are captured by the distributional parameters  $\beta_i$  and an adequate application of Equation (2) makes the final evaluation independent of the choice of numeraire.

We have now established that unweighted cost–benefit analysis is based on unpalatable distributional judgments. Moreover, the choice of money as the numeraire is only acceptable in an approach with distributional weights. Therefore, the derivation of these distributional weights  $\beta_i$  is essential for economic evaluation. As mentioned earlier, these weights should correspond to relevant ethical views. As there are typically several relevant views in a democracy, there is a need for analytical work in the derivation of weights from basic ethical principles. In the next sections, we will show how distributional weights can be derived within a coherent non-welfarist approach respecting individual preferences.

### 3. EQUIVALENT INCOME FOR COST–BENEFIT ANALYSIS

Our advocacy of cost–benefit analysis hinges critically on the use of ethically attractive distributional weights  $\beta_i$ . Moreover, because we want to respect preferences, we adopt Equation (1) as our specification of the social welfare function and define  $\beta_i$  as

$$\beta_i = \frac{\partial W}{\partial u_i} \frac{\partial u_i}{\partial y_i}. \quad (3)$$

At first sight, it may seem that this approach is necessarily welfarist because  $\beta_i$  depends on the subjective utility  $u_i$ . However, in this section we will show that this conclusion is wrong. After a summary of the welfarist approach in the first subsection, we introduce in the second subsection a non-welfarist alternative, ethically more attractive and easier to implement.

#### 3.1. The welfarist approach

If one takes subjective utility as the correct metric for distributional judgments, one has to introduce in Equation (1) a utility function  $u_i$ , for each  $i$ , which does not only represent the preference ordering  $R_i$  (as before), but now also correctly measures subjective utility so as to permit interpersonal comparisons of utility. When  $\frac{\partial u_i}{\partial y_i}$  is empirically measurable, the only ethical judgment that remains to be made is to choose a social welfare function  $W$ . A salient family of functions of this sort is the constant elasticity of substitution (CES) family

$$W(u_1(y_1, h_1, z_1), \dots, u_n(y_n, h_n, z_n)) = \frac{1}{1-\varepsilon} \sum_i (u_i(y_i, h_i, z_i))^{1-\varepsilon},$$

where the parameter  $\varepsilon$  can be interpreted as measuring aversion to inequality. The Benthamite (utilitarian) sum of utilities corresponds to  $\varepsilon=0$  and  $\beta_i = \partial u_i / \partial y_i$ . For other (nonunit) value of  $\varepsilon$ , one gets

$$\beta_i = (u_i(y_i, h_i, z_i))^{-\varepsilon} \frac{\partial u_i}{\partial y_i} \quad (4)$$

so that, for a given individual marginal utility of income,  $\beta_i$  is inversely proportional to the level of utility (to the power  $\varepsilon$ ).

Welfarism has been challenged in many ways. The measurement of subjective utility is practically very hard to perform, and some authors have even questioned the idea that subjective utility can be meaningfully compared across individuals (Robbins, 1932). In the absence of a consensual measure of utility, it has become common to simply disregard the welfarist decomposition of  $\beta_i$  into the two terms and perform a sensitivity analysis with various possible vectors  $(\beta_1, \dots, \beta_n)$  (see e.g. Donaldson, 1999, Donaldson and Shackley, 2003). In this *ad hoc* approach,  $\beta_i$  is determined fully by  $y_i$ , and there is no longer a clear link with any ethical approach respecting preferences (be it welfarist or not). Moreover, unless one accepts a simple parametric specification, such a sensitivity analysis may be a rather daunting task.

More importantly, even if the empirical measurement of utility were not a problem, it might not be the ethically appropriate metric for interpersonal comparisons. For instance, Rawls (1982) observed that comparing subjective satisfaction across people with different utility functions is tantamount to assuming that there is a goal in life which is “to be satisfied,” and that there is a shared higher-order ordering that enables us to rank individuals with different goals according to how well they succeed with respect to this higher goal. However, people’s goal in life is typically not to be satisfied with any goal but to satisfy their own specific goals. Because there is no consensual higher-order ordering, Rawls concluded against taking subjective utility as the metric of comparison and proposed to rely on a resource metric instead. In a similar vein, Dworkin (2000) argued that people with high ambitions (“expensive tastes”) do not deserve to receive more resources for that sole reason. Sen (1992) also opposed welfarism by raising the problem of adaptive preferences. Because people adapt their preferences and ambitions to their current situation, a naive measurement of utility is likely to conclude that inequalities are not so great because the utility gap between the rich and the poor (or the healthy and the sick) is not that large.

Many of these arguments have been taken up in the health economics literature, in which the so-called *extra-welfarist* views have gained considerable popularity. However, it is often believed that there is no room between disregarding individual preferences and full-fledged welfarism. In the next section, we correct received wisdom on this topic. We introduce a particular non-welfarist approach that does respect individual preferences in the sense of satisfying the Pareto principle, without falling back into full-fledged welfarism and, notably, without relying on any other information about subjective utility than ordinal noncomparable preferences described by the ordering  $R_i$ .

### 3.2. A non-welfarist alternative

From Equation (2), it is easy to see that the Pareto principle does not require using subjective utility as the metric of comparison. In this formula, the satisfaction of the Pareto principle is guaranteed by the presence of  $WTP_i$ , provided that the weights  $\beta_i$  are all positive. Recall that  $WTP_i$  can be computed on the sole knowledge of  $R_i$  because it involves only marginal rates of substitution. Moreover, one is obviously not forced to compute the weights  $\beta_i$  on the basis of subjective utility, so that clearly, it is possible to apply Equation (2) without measuring subjective utility. One might object that the Pareto principle implies that  $E$  can be written as in Equation (1), where utility functions seem to matter. However, recall that Equation (1) was introduced by saying that for every collection of utility functions  $u_i$  representing  $R_i$  for each  $i = 1, \dots, n$ , there exists an increasing function  $W$

satisfying Equation (1). This allows one to use utility functions that do not measure subjective utility but nevertheless represent preferences. We now show that such functions exist and that they can be ethically relevant.

Let us first consider the hypothetical situation in which all individuals are perfectly healthy, that is,  $h_i = h^*$  for all  $i$ , and all benefit from a certain reference value of  $z$ , that is,  $z_i = z^*$  for all  $i$ . In such situations, individuals only differ in their income, and they do not suffer from health problems. Theories of justice such as Rawls' and Dworkin's could, presumably, accept the idea that when income is the only unequal variable in the population,<sup>8</sup> one can rank the distributions of income without looking at people's utility functions and, more specifically, that a simple ranking of income distributions could do the job. For instance, in this hypothetical situation, a CES function would again be a natural candidate<sup>9</sup>:

$$E((y_1, h^*, z^*), \dots, (y_n, h^*, z^*)) = \frac{1}{1-\varepsilon} \sum_i (y_i)^{1-\varepsilon}. \quad (5)$$

The Pareto principle (respect for individual preferences) can now be mobilized to also rank situations in which individuals have different levels of  $h$  and  $z$ . Assume that for every  $i$  there is a level of income  $y_i^*$  such that

$$(y_i, h_i, z_i) I_i (y_i^*, h^*, z^*).$$

We propose to call  $y_i^*$  the "equivalent income" of  $i$ . It gives  $i$  the same satisfaction as with  $(y_i, h_i, z_i)$  but with good health and the reference  $z^*$ . One then has, by the Pareto principle,

$$E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n)) = E((y_1^*, h^*, z^*), \dots, (y_n^*, h^*, z^*)).$$

Substituting Equation (5) into this equality, one obtains<sup>10</sup>:

$$E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n)) = \frac{1}{1-\varepsilon} \sum_i (y_i^*)^{1-\varepsilon}. \quad (6)$$

Equation (6) is in fact a special case of Equation (1) with  $W$  being a CES function. Indeed, the equivalent income  $y_i^*$ , when it is well defined, actually yields one utility function that represents  $R_i$ .<sup>11</sup> To see this, consider  $(y_i, h_i, z_i)$  and  $(y'_i, h'_i, z'_i)$  such that  $(y_i, h_i, z_i) R_i (y'_i, h'_i, z'_i)$ , and let  $y_i^*, y'^*_i$  denote the corresponding equivalent incomes. By transitivity of preferences, one necessarily has

$$(y_i^*, h^*, z^*) R_i (y'^*_i, h^*, z^*),$$

which, by monotonicity of preferences, is equivalent to  $y_i^* \geq y'^*_i$ . We will hereafter denote this particular utility function simply as  $y_i^*(y_i, h_i, z_i)$ .

This approach is not welfarist, although it satisfies the Pareto principle. The welfarist approach satisfies the Pareto principle by defining social welfare as a function of individual subjective utilities  $u_i(y_i, h_i, z_i)$ . The equivalent income  $y_i^*(y_i, h_i, z_i)$  is not a welfarist notion because it is not a measure of subjective utility. Truly enough, the function  $y_i^*(y_i, h_i, z_i)$  is a utility function representing  $R_i$ , just like  $u_i(y_i, h_i, z_i)$ . However, the two functions, although ordinally equivalent, are different. One way of illustrating the difference is to look at what happens when two individuals  $i$  and  $j$  have the same preferences  $R_i = R_j$  but different utility functions  $u_i \neq u_j$ . For the welfarist approach, the difference in utilities justifies a different treatment in general. For instance, if  $u_i = \alpha u_j$  for some number  $\alpha > 1$ , this may justify giving more resources to  $j$  if the function  $W$  displays enough aversion

<sup>8</sup>Recall that because leisure would feature in  $z$ , income inequalities in such a situation would not come from different choices of labor.

<sup>9</sup>Rawls and Dworkin would advocate a strong degree of inequality aversion  $\varepsilon$ , but this is a side issue here, which, at any rate, does not challenge Equation (5) as such because  $\varepsilon$  can be arbitrarily high. Moreover, although the CES function is a natural candidate and in line with the existing literature, it is clear that other specifications are possible.

<sup>10</sup>A different, axiomatic derivation of a social criterion involving equivalent incomes can be found in the study of Fleurbaey (2005).

<sup>11</sup>To avoid any confusion about the interpretation of this "utility function," let us repeat that it is only a representation of the preference ordering  $R_i$  and does not refer to a notion of subjective happiness.

to inequalities, or less resources if  $W$  is, for instance, the utilitarian sum. For the equivalent-income approach, in contrast, this difference in subjective utility does not matter because  $i$  and  $j$  have the same equivalent income functions  $y_i^* = y_j^*$ , just as they have the same preferences  $R_i = R_j$ . The equivalent income approach therefore is not subject to Dworkin's and Sen's criticism with respect to expensive tastes and adaptation.<sup>12</sup>

Of course, the ethical attractiveness of the equivalent income depends on the choice of reference values for  $h_i$  and  $z_i$ . We consider that good health  $h^*$  is a natural choice of a reference for the following reason. In Equation (5), it is apparent that one considers an individual to be better off than another whenever he has a greater income, provided both are healthy (let us disregard  $z$  for the moment). This makes sense, whereas the same kind of judgment would appear questionable if both individuals were not healthy. Imagine that they have the same mediocre health and slightly unequal incomes. In this case, it is not obvious that the individual with a greater income is better off. Maybe he cares more about health and therefore suffers more from his health condition than the other one. This problem cannot occur with healthy individuals, and it seems reasonable to consider that preferences about health do not matter to evaluate how well-off a healthy individual is. We do not claim that some healthy individuals do not enjoy their good health more than others. We simply say that it would be strange to seek to tax the healthy individuals who care about health to subsidize other healthy individuals who care less about health. If one accepts the idea that equality of incomes would be a sound ideal for a uniformly healthy population, then the reference to  $h^*$  in Equation (5) should appear acceptable.

As far as the choice of  $z^*$  is concerned, we will be less precise because the content of the vector  $z_i$  can vary from one application of this model to the other. In the same fashion as for health, the choice of  $z^*$  can be guided by the observation that when an individual is at  $z^*$ , his preferences about  $z_i$  should no longer matter to evaluate his situation. For instance, if  $z_i$  is leisure, one can think that it is only when an individual does not work that his preferences about labor do not matter. As a consequence, one would then take full leisure as the reference  $z^*$ . This is just an example and a detailed discussion would go beyond the scope of this article.<sup>13</sup>

Using Equation (6) for economic evaluation has the essential advantage that it allows for an easy calculation of the distributional weights. These are given by

$$\beta_i = (y_i^*(y_i, h_i, z_i))^{-\varepsilon} \frac{\partial y_i^*}{\partial y_i}. \quad (7)$$

Although Equation (7) is formally identical to the welfarist Equation (4), it is much easier to implement. The equivalent income is measured in monetary units and depends only on ordinal and noncomparable preferences  $R_i$ . In terms of observability, it is therefore comparable with  $WTP_i$ . It can also be measured with similar techniques. The only "unobservable" parameter in Equation (7) is  $\varepsilon$ , which corresponds to the degree of inequality aversion. This is a pure value judgment, about which there is no consensus in society. It is therefore advisable to perform a sensitivity analysis with respect to it.<sup>14</sup> Note, however, that such a sensitivity analysis with respect to  $\varepsilon$  keeps us firmly in the ethical setting of Equation (7) and is therefore very different from a general sensitivity analysis over the whole space of vectors  $(\beta_1, \dots, \beta_n)$ .

The following proposition summarizes the argument:

**Proposition 1:** *If, for a population with uniformly good health  $h^*$  and uniform  $z^*$ , one ranks distributions of incomes by a CES function, then respecting individual preferences implies that the evaluation of any social*

<sup>12</sup>Adaptation can affect not only the level of subjective utility but also the direction of preferences. The equivalent income approach is immune only to the former form of adaptation, not the latter. We consider this to be a minor issue. First, while the level of subjective satisfaction generally comes back to its initial level after serious health problems, people still strongly want to improve their health, which suggests that the main form of adaptation is the one affecting the utility level (Frederick and Loewenstein, 1999). Second, insofar as preferences change, this may involve a sort of learning, so that it is not clear that the final preferences are less respectable than the initial preferences.

<sup>13</sup>A more complete and more formal treatment can be found in the study of Fleurbaey and Maniquet (2011).

<sup>14</sup>For an analysis of the division of labor between observation and value judgment in various approaches to the definition of social welfare, see Fleurbaey and Hammond (2004).

situation is made by the same CES function applied to equivalent incomes  $y_i^*(y_i, h_i, z_i)$ . In a cost–benefit analysis, the weights are then equal to  $\beta_i = (y_i^*(y_i, h_i, z_i))^{-\varepsilon} \partial y_i^* / \partial y_i$  and therefore only depend on individual ordinal noncomparable preferences and on the parameter of inequality aversion in the CES function.

This conclusion shows in particular that despite Arrow's (1951) theorem, it is possible to construct a reasonable social criterion  $E((y_1, h_1, z_1), \dots, (y_n, h_n, z_n))$  on the sole basis of ordinal and noncomparable preferences.<sup>15</sup>

#### 4. ESTIMATING EQUIVALENT INCOMES AND DISTRIBUTIONAL WEIGHTS

In the preceding sections, we have argued that distributional weights must be introduced in any economic evaluation of healthcare policies. We have suggested that the concept of equivalent income offers an ethically attractive non-welfarist method for calculating these weights. In this section, we will show how our theoretical concepts can be implemented for policy making. We first argue that it is not necessary to recompute the equivalent incomes (and hence the distributional weights) for each evaluation exercise. We then present a set of distributional weights derived from a pilot survey.

##### 4.1. Distributional weights in practice

Implementing Equation (2) requires estimating (a) the individual willingness-to-pay  $WTP_i$  for the change to be evaluated and (b) the distributional weights  $\beta_i$ . The former task is a traditional one, for which various methods have been developed in the literature. Therefore, we will not dwell on it here, and we will focus on the latter. As is clear from Equation (7), the weights  $\beta_i$  do not depend on the particular policy to be evaluated. Therefore, we can evaluate once and for all the equivalent incomes of all individuals in society and apply the corresponding weights to the willingness-to-pay figures relative to whatever health program or intervention under consideration.<sup>16</sup> Of course, gathering information on equivalent incomes or willingness to pay for each individual in society is not feasible. A realistic approach is then to calculate the equivalent income of a representative sample of the population and to compute average or median weights for different income and health categories, provided that the same categories are also identified in the willingness-to-pay study.<sup>17</sup>

More specifically,  $\beta_i$  depends on (i) the equivalent income  $y_i^*(y_i, h_i, z_i)$ ; (ii) the derivative of  $y_i^*(y_i, h_i, z_i)$  with respect to  $y_i$ ; and (iii) the parameter of inequality aversion  $\varepsilon$ . We mentioned already that for the latter a sensitivity analysis is advisable. Equivalent incomes are based on a comparison of individuals' current situation in terms of health ( $h_i$ ) and income ( $y_i$ ) with a situation of perfect health  $h^*$ .<sup>18</sup> It follows from the implicit definition  $(y_i, h_i)I_i(y_i^*, h^*)$  that

$$y_i^* = y_i - w_i^*, \quad (8)$$

where  $w_i^*$  is the willingness to pay of individual  $i$  to be in perfect health.<sup>19</sup> The whole range of methods that can be used to estimate a willingness to pay for specific projects  $WTP_i$  can also be used to estimate  $w_i^*$ . In this article, we present the results of a pilot study in the tradition of contingent valuation (see e.g., Klose, 1999, and Donaldson *et al.*, 2006, for a presentation of the method in health care), but the usefulness of other methods

<sup>15</sup>For more details on this issue, see, for example, Fleurbaey and Mongin (2005).

<sup>16</sup>We obviously refer to a static context in which the policy maker needs to evaluate a given set of health care interventions based on people's given preferences. In the long-run, the equivalent income would need to be recomputed and updated.

<sup>17</sup>In that respect, the estimation of distributional weights based on equivalent income follows the same logic as the evaluation of health utilities (Drummond *et al.*, 1997). Health utilities are evaluated once in a representative sample of the general population from which weights are derived that account for the QALYs gained, which can then be applied to different health care interventions.

<sup>18</sup>In the general model, the equivalent income will also depend on  $z_i$  and  $z^*$ . For this illustrative exercise, we assume that  $z$  is identical for all individuals.

<sup>19</sup>We use the notation  $w_i^*$  for this notion of willingness to pay to be in perfect health to avoid confusion with the willingness-to-pay  $WTP_i$  for specific projects.

(such as discrete choice experiments) in this context should be explored in future work.<sup>20</sup> Our pilot study is not aimed at providing a definitive estimation of distributional weights, but to show that the concept of healthy equivalent income can be implemented and that doing so is not more difficult than a standard stated preferences survey. We first explain the design of the questionnaire, we then show how preferences can be estimated (which is necessary to calculate the derivative of  $y_i^*(y_i, h_i, z_i)$  with respect to  $y_i$ ), and we finally derive a set of distributional weights for different income and health categories.

#### 4.2. Design of the pilot study

The pilot survey was carried out in 2007 with a total number of 542 respondents. Respondents were selected randomly in the different areas of the city of Marseilles, France, and subjected to face-to-face interviews. This sample is obviously not representative for the French population at large.<sup>21</sup> However, this is not an important issue for this exploratory study. What is important for our estimations is that there is sufficient income and health variation within the sample and there does not seem to be a problem in this respect (see Appendix A for sample characteristics).

To calculate equivalent incomes, we need information about the current levels of income and health of the respondents and about their willingness to pay for perfect health. While eliciting income is a common feature of questionnaires in economics, health needs more attention. For our purposes, it seems preferable to interpret  $h$  as a vector of objective health characteristics. We measured it by presenting respondents with a detailed list of diseases grouped by categories (e.g. cardio-vascular diseases, respiratory diseases, etc.). Respondents were asked which of the diseases he or she experienced in the last 12 months (they could eventually add diseases which are not in the list through open-ended questions for each of the disease categories).<sup>22</sup> Respondents were also asked about their use of healthcare services in the last 12 months (number of visits to a general practitioner, number of visits to a specialist, if they have a private health insurance, etc.) as well as about the usual sociodemographic characteristics.

Once respondents completed the income and health questionnaires, they were presented with the equivalent income questions. The introduction ran as follows:

*During the first part of the questionnaire, you provided us information on your health in the past 12 months and on your current health. You also provided us information on your financial resources. We now would like to evaluate with you the burden of your health problems in the past 12 months and the way you compare health gains and income.*

After this introduction, respondents were given a summary of their responses to the health and financial resources questions. They were then shown the following hypothetical scenario<sup>23</sup>:

<sup>20</sup>We are well aware of the criticism that can be formulated with respect to contingent valuation (see, e.g. Olsen and Smith, 2001, Smith, 2003). However, we still think that its application yields useful results in our setting. Note that our application does not concern public goods that have a low impact on people (remote issues) but rather relates to individual preferences on important personal matters such as income and health. Respondents may be therefore less prone to error (List and Gallet, 2001). This also means that free riding is not an issue in our application.

<sup>21</sup>In particular, respondents are poorer than the French population (mean equivalized income in France was 1807 euros in 2007 and mean income is 1073 euros in our sample). This is not surprising as the Bouches du Rhône district, to which Marseille belongs, is a relatively poor district with 16.6% of people living under the poverty rate (source: Institut National de la Statistique et des Etudes Economiques, [www.insee.fr](http://www.insee.fr)). Respondents are also relatively older: mean age is 48 years in our sample and 40 years for the French population.

<sup>22</sup>This part of the questionnaire is derived from the Institut de Recherche et Documentation en Économie de la Santé health questionnaire, which is meant to study health inequalities (see, e.g. Jusot *et al.*, 2008). A complete description of the data is presented by Fleurbaey *et al.* (2008).

<sup>23</sup>We think that the formulation in the first sentence (“...and you would *therefore* have been in perfect health”) is justified, because the list of diseases given in the first part of the questionnaire was very extensive, including both minor and serious diseases.

*If no health problems had occurred in the past 12 months and you would therefore have been in perfect health, you would have saved the health expenditures that you stated earlier. Moreover, you would have benefited from a better quality of life. Without accounting for health expenditures, would you have preferred a lower income in the last 12 months without any of the health problems that you had? (yes/no/do not know)*

Respondents answering “yes” were asked the valuation question:

*Indicate the monthly decrease in your personal consumption in the last 12 months that you would have accepted, to be in perfect health (during the same period), on top of the health expenditures that you would have saved.*

When answering this question, respondents were helped by a payment card presenting monetary values in intervals starting from “0 euros” to “more than 1500 euros” per month. We will interpret the answers to this question as a measure of the individual’s “willingness to pay” for perfect health ( $w_i^*$ ). Equivalent incomes can then be computed as in Equation (8). It is not obvious whether the theoretical concept  $y_i$  should best be measured by the personal income of the respondent or by her household income per consumption unit. We will work with personal income for this illustrative exercise.

The answers given by the 435 respondents (80.3%) that answered “yes” to the hypothetical scenario question seem overall quite reasonable without extreme outliers. One hundred one respondents (18.6%) answered “no” to the hypothetical scenario question, and only 6 respondents (1.1%) did not know. The latter two groups were asked a series of questions to distinguish the individuals who expressed no concern for health from those who protested at the evaluation exercise or found it too difficult. A detailed analysis of these debriefing questions for the respondents that answered “no” identified four classes of motivations. Only 2 respondents found the evaluation exercise difficult, 52 respondents declared that other aspects of their life were more important, 36 respondents declared that their level of income was already too low, and, interestingly, only 11 respondents refused to participate. This protest rate of 2% over the whole sample is particularly low, which might be because our scenario does not involve state intervention and new taxes. Protest responses, “do not know” responses and answers for the individuals that found the evaluation exercise too difficult were excluded from the analysis.<sup>24</sup> Respondents who declared that other aspects of their life were more important and that their level of income is already too low are included in the following analysis. For these respondents, we put  $w_i^* = 0$  (and, therefore,  $y_i^* = y_i$ ).

Descriptive statistics on WTP values show that mean WTP increases with personal income. Mean WTP is 33 in the first quartile of the income distribution, 48.1 in the second, 66.1 in the third and 150.2 in the fourth. Table I shows that the mean ratio of WTP over personal income decreases along personal income quartiles.<sup>25</sup> WTP values thus increase less than proportionally with personal income. In Table II, we report the relationship between the mean ratio of WTP over personal income and access to health care, measured as the number of visits to a general practitioner (GP). Finally, Table III presents the relationship between the mean ratio and the current self-reported health (the different categories are the modalities of a standard verbal scale question as, for instance, in the Short Form 12). As expected, the ratio decreases with health.<sup>26</sup>

### 4.3. Estimation of preferences

The next step is the estimation of preferences, needed to evaluate the derivative of  $y_i^*(y_i, h_i, z_i)$  with respect to  $y_i$ . As described earlier, information about health status  $h_i$  is captured in the questionnaire by information about

<sup>24</sup>Only a few respondents are therefore dropped from the sample, making a selection effect unlikely.

<sup>25</sup>Midpoints of the intervals are used to compute Tables I–III. We use interval regressions to estimate the econometric model.

<sup>26</sup>Respondents reporting excellent current health may have had health problems in the last 12 months.

Table I. WTP and personal income

Income Quantile	Mean ratio WTP/personal income
0–25%	10.1%
25–50%	7.7%
50.75%	6.7%
75–100%	6.7%

Table II. WTP and access to health care

Annual number of visits to the GP	Mean ratio WTP/personal income
<2	6.0
2 to 3	8.9
3 to 6	7.7
More than 6	11.0

Table III. WTP and self-reported health

Self-reported health (verbal scale)	Mean ratio WTP/personal income
Very bad	10.9%
Bad	8.1%
Good	8.4%
Very good	5.9%
Excellent	3.0%

specific diseases. For tractability, we proxy health by two variables  $d_{1i}$  and  $d_{2i}$ , which indicate, respectively, the number of mild and severe diseases that the respondent experienced in the last 12 months.<sup>27</sup> Neglecting differences in  $z_i$ , we consider the following random utility model as an approximation of  $y_i^*(y_i, h_i, z_i)$ :

$$y_i^* = y_i - w_i^* = U(y_i, d_{1i}, d_{2i}) + \varepsilon_i \quad (9)$$

where  $y_i^*$  is respondent's healthy equivalent income per month,  $y_i$  is respondent's monthly personal income,  $w_i^*$  is the (latent) amount of personal consumption that the respondent would have been willing to forgo to avoid his health problems,  $U(\cdot)$  is her utility function and  $d_{1i}$  and  $d_{2i}$  are the number of mild and severe diseases, respectively.<sup>28</sup>

The utility function  $U(\cdot)$  is specified in a flexible way as a polynomial in its arguments  $y_i$ ,  $d_{1i}$  and  $d_{2i}$  (see Van Soest *et al.*, 2002):

$$U(y_i, d_{1i}, d_{2i}) = \sum_{p=0}^K \sum_{q=0}^{K-p} \sum_{r=0}^{K-p-q} \alpha(p, q, r) d_{1i}^p d_{2i}^q y_i^r \quad (10)$$

where  $K$  is the order of the polynomial and determines the flexibility of the utility function. When  $K$  is arbitrarily large, the parameters  $\alpha(p, q, r)$  can be seen as a nonparametric family of utility functions (with

<sup>27</sup>We classified the number of diseases according to a scale proposed by Institut de Recherche et Documentation en Économie de la Santé: severe diseases are those diseases that lead to a decrease of professional or domestic activity, reduced mobility, or worse (Khlal *et al.*, 2000, 2004).

<sup>28</sup>Remember that the utility function in our interpretation is only a representation of preferences.

$\alpha(0, 0, 0)$  normalized to 0). The order of the polynomial  $K$  that can be used in a finite sample is usually small. To ensure computational tractability, we set  $K=3$  in the following (all parameters  $\alpha(p, q, r)$ , linear and nonlinear coefficients as well as interactions terms are estimated jointly). Note that we do not impose any monotonicity or concavity restrictions on the utility function. We will rather check if these properties are satisfied by the unrestricted estimates.

The maximal amount of personal consumption  $w_i^*$  that the respondent would have been willing to forgo to avoid his health problems during the last 12 months is not observed directly. Because a payment card was used to elicit preferences, we rather observe an interval. We therefore estimate Equation (9) by using an interval regression where  $y_i - w_i^*$  is the dependent variable that belongs to the interval  $[y_i - W_i^l; y_i - W_i^h]$ .  $W_i^l$  and  $W_i^h$  are the bounds of the interval that respondent  $i$  chose in stating her preferences for health and income. Note that when respondents stated a zero value (but were not protesting to the valuation question), the observation is considered as an uncensored observation.

Econometric results are presented in Table IV. For computational tractability, monthly personal income is divided by 100 in the estimation. The interval regression is estimated on a restricted sample of respondents who declared a strictly positive personal income (however small it is) and/or did not protest to the valuation question if they stated a zero value. This leads to exclude 30 respondents, that is, 5.53% of the original sample (30 other respondents were also excluded due to missing data). From the remaining, 400 respondents stated a positive amount (and are therefore considered as censored observations) and 82 respondents stated a zero value (and are therefore considered as uncensored observations).

Coefficients of the utility function associated with mild diseases  $d_1$  only are not significant (linear, square and cubic coefficients with  $p=0.138$ ,  $p=0.494$  and  $p=0.800$ , respectively), whereas those associated with

Table IV. Interval regression ( $n=482$ )

Variable	Parameter estimates	$p$
$d_1$ specific linear coefficient $\alpha(1, 0, 0)$	-54.449	0.138
$d_2$ specific linear coefficient $\alpha(0, 1, 0)$	-114.701	0.053*
$y$ specific linear coefficient $\alpha(0, 0, 1)$	113.786	0.000***
$d_1$ specific nonlinear coefficient $\alpha(2, 0, 0)$	5.091	0.494
$\alpha(3, 0, 0)$	0.115	0.800
$d_2$ specific nonlinear coefficient $\alpha(0, 2, 0)$	46.623	0.005***
$\alpha(0, 3, 0)$	-4.713	0.018**
$y$ specific nonlinear coefficient $\alpha(0, 0, 2)$	-1.271	0.051*
$\alpha(0, 0, 3)$	0.012	0.044*
Interaction coefficient between $d_1$ and $d_2$ only $\alpha(1, 1, 0)$	-4.819	0.708
$\alpha(1, 2, 0)$	5.726	0.111
$\alpha(2, 1, 0)$	-2.903	0.087*
Interaction coefficient between $y$ and $d_1$ only $\alpha(1, 0, 1)$	2.001	0.580
$\alpha(2, 0, 1)$	-0.268	0.461
$\alpha(1, 0, 2)$	0.039	0.529
Interaction coefficient between $y$ and $d_2$ only $\alpha(0, 1, 1)$	8.615	0.220
$\alpha(0, 2, 1)$	-3.488	0.022**
$\alpha(0, 1, 2)$	-0.133	0.418
Interaction coefficient between $y$ , $d_1$ and $d_2$ $\alpha(1, 1, 1)$	1.497	0.244
SE	165.28	0.000

severe diseases  $d_2$  are significant ( $p=0.053$ ,  $p=0.005$  and  $p=0.018$ ). Second, one of the interaction coefficients between mild diseases  $d_1$  and severe diseases  $d_2$  is significant too:  $\alpha(2, 1, 0)$  is negative with  $p=0.087$ . This means in particular that a mild disease  $d_1$  induces a utility loss when the respondent has also experienced a more severe disease  $d_2$ . Third, coefficients associated with income only are all significant:  $\alpha(0, 0, 1)$  with  $p < 0.001$ ,  $\alpha(0, 0, 2)$  with  $p=0.051$  and  $\alpha(0, 0, 3)$  with  $p=0.044$ . Finally, only one interaction coefficient that includes personal income  $y$  is significant and negative:  $\alpha(0, 2, 1)$  with  $p=0.022$ . This indicates that the loss of utility induced by having experienced a severe disease increases with personal income.

On the basis of the estimated parameters, it is possible to draw maps of indifference curves between personal income and the number of diseases  $d_1$  and  $d_2$  that occurred in the last 12 months. To facilitate the reading of these curves, we construct two health indices  $h_1$  and  $h_2$  on the basis of the numbers of mild and severe diseases  $d_1$  and  $d_2$ . Having suffered of no diseases during the last 12 months corresponds to maximal health,  $h_1=1$  and  $h_2=1$ . The lower bound depends on the type of disease considered. We draw the indifference curves on a range from 0 to 8 for diseases  $d_1$  (99.2% of the sample), so that  $h_1=(8-d_1)/8$ , and on a range from 0 to 4 for diseases  $d_2$  (99.6% of the sample), so that  $h_2=(4-d_2)/4$ . This is because it would be hazardous to draw indifference curves where no data points (or only a few) are available. In addition, we focus on significant parameter estimates only to simplify the analysis. Because one interaction term between  $d_1$  and  $d_2$  is significant, we have to set different levels of  $d_2$  (respectively  $d_1$ ) when considering the indifference curves between personal income  $y$  and  $d_1$  (respectively  $d_2$ ). We consider the case where  $d_2$  equals zero, one and three (and proceed identically for the indifference curves between personal income and  $d_2$ ). Indifference curves are presented in Figures 1(a)–1(f).<sup>29</sup> The results are reassuring. In the relevant range of the variables, the figures exhibit well-behaved indifference curves and satisfy monotonicity and convexity properties, although none of these properties were imposed *a priori*.

#### 4.4. Evaluating distributional weights on the basis of equivalent incomes

Finally, we can now compute the distributional weights [Equation (7)] from the estimated parameters. The results are presented in Table V. We focus on the number of severe diseases only because its effect on equivalent income is the largest and was estimated significantly. Weights are computed for three cases with respect to health: a respondent who has not experienced any severe disease, one severe disease and two severe diseases (for each of these examples, we assume that the respondent has not experienced any mild disease so that a respondent with  $d_2=0$  is assumed to have been in good health in the last 12 months). For each case, we compute different weights according to different levels of personal income. Estimated weights are normalized by attributing a weight of one to the poorer and sicker individual in Table V, that is, to an individual who has experienced two severe diseases and has a personal income of 500 euros.

When interpreting Table V, it is important to keep in mind that (i) the social marginal value of  $y_i^*$  increases when  $y_i$  is lower and  $i$  suffers from more diseases; and (ii) the derivative of  $y_i^*$  with respect to  $y_i$  decreases when  $i$  suffers from more severe diseases (due to the strongly negative parameter  $\alpha(0, 2, 1)$ ). Table V shows that the former effect always dominates for our data: distributional weights decrease monotonically with respect to personal income and health. Note also that for  $\varepsilon=5$ , the social welfare function gets close to maximin, with all weights close to zero except that of the individual with the lowest equivalent income.

<sup>29</sup>To get a better understanding, estimated utility levels are indicated in the figures. However, they have no particular meaning in absolute terms because they depend on the usual normalization to zero of the constant term in random utility models that use a polynomial form (see Van Soest *et al.*, 2002).

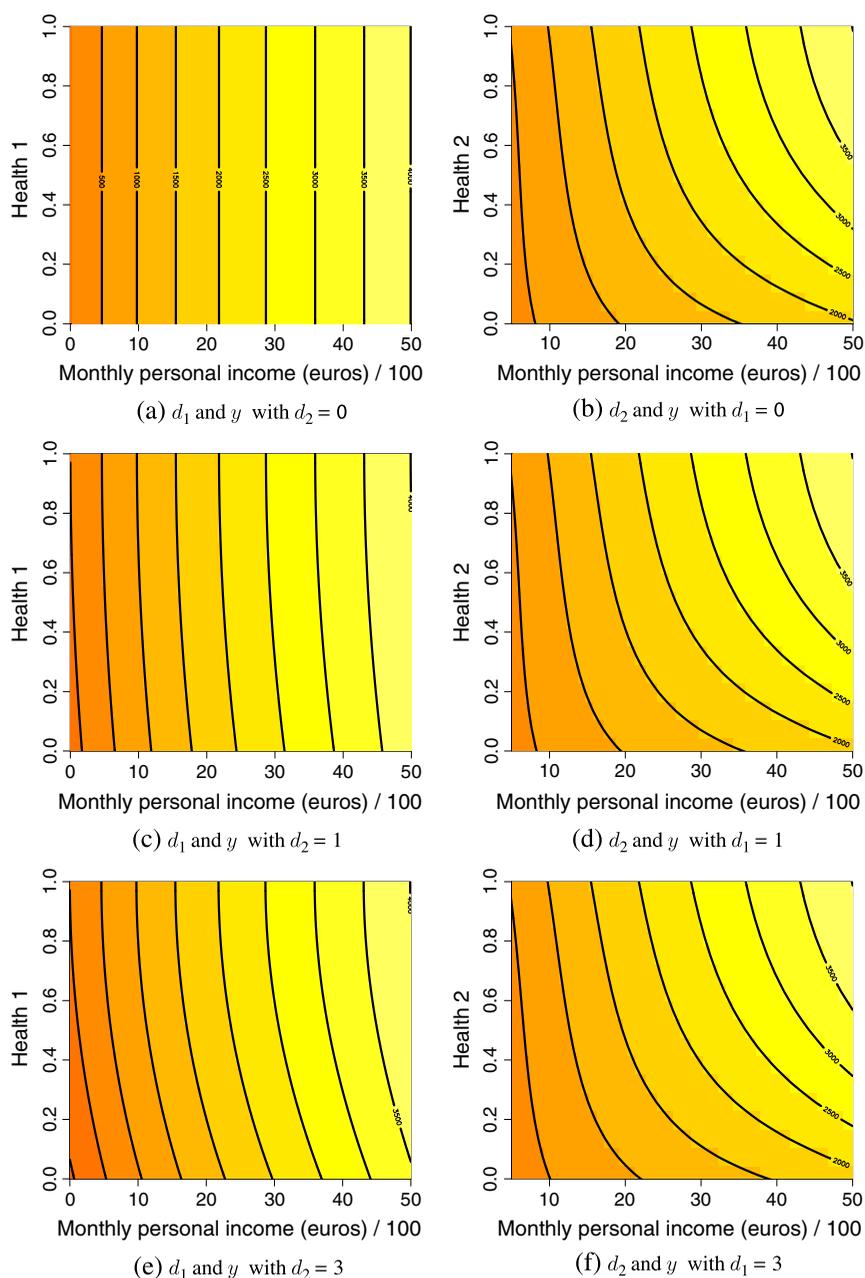


Figure 1. Indifference curves

## 5. CONCLUSION

We have argued that cost–benefit analysis is a theoretically coherent method of economic evaluation, under the (strict) condition that distributional weights are introduced. It can respect individual preferences, without being necessarily subjectively welfarist. Indeed, with the notion of equivalent income, we have shown a particular

Table V. Estimated distributional weights for severe diseases (with  $d_1 = 0$ )

	Personal income (euros)				
	500	1000	1500	2500	3500
$\varepsilon = 1$					
$d_2 = 0$	0.708	0.354	0.236	0.142	0.101
$d_2 = 1$	0.895	0.416	0.271	0.159	0.113
$d_2 = 2$	1.000	0.459	0.298	0.175	0.124
$\varepsilon = 3$					
$d_2 = 0$	0.448	0.056	0.017	0.004	0.001
$d_2 = 1$	0.802	0.080	0.022	0.005	0.002
$d_2 = 2$	1.000	0.097	0.026	0.005	0.002
$\varepsilon = 5$					
$d_2 = 0$	0.284	0.009	0.001	0.000	0.000
$d_2 = 1$	0.719	0.016	0.002	0.000	0.000
$d_2 = 2$	1.000	0.020	0.002	0.000	0.000

way to calculate distributional weights without resorting to welfarist comparisons of subjective utilities, and more in line with recent egalitarian theories of justice. The extra-welfarist intuitions of many health economists can thus be accommodated within cost–benefit analysis.

We do not claim that the equivalent income approach developed in this article provides the only reasonable criterion. First, it is actually a family of criteria because it can be applied with a variety of degrees of inequality aversion and even with different forms of the social evaluation function, thereby espousing many different views about social equity. A sensitivity analysis will therefore generally be useful. Second, it is associated with the particular, non-welfarist, view according to which equity would be a simple matter of equality of resources if no one experienced any health problem. It is therefore different from welfarist theories which are defined in terms of subjective utilities, and it also differs from non-welfarist theories which are defined in terms of opportunities or capabilities.<sup>30</sup> These other theories, insofar as they command approval from respectable parties in public deliberations, also deserve to be applied in suitable variants of cost–benefit analysis.

The pilot study we have used to illustrate our theoretical concepts has obvious limitations. We worked with a specific sample, and we are aware of the limitations of the contingent valuation approach. The use of other techniques—each with its own limitations—to calculate equivalent incomes should be explored in future work. Because of the small sample size, we could not provide accurate estimations of preferences for various sociodemographic groups. This limitation has to be remedied in future work with larger samples. We also focused in the pilot study on morbidity but we let aside the question of mortality risks. The theory as well as the questionnaire can however be adapted so as to include the case of life-threatening diseases. Again, dealing with survival issues would not be much different to what is currently carried out in stated preferences surveys aimed at estimating willingness to pay for a decrease of mortality risk. Yet, the pilot study is sufficiently reassuring to support the main constructive message of this article that the thorny issue of determining weights for the summation of willingness to pay is more tractable than usually thought.

<sup>30</sup>A broader discussion of the introduction of equity (in particular, responsibility) principles in health policies is made by Fleurbaey (2007).

## APPENDIX A SAMPLE CHARACTERISTICS (N = 542)

	Variable	Percentage or mean
Age groups	<30 years old	19
	Between 31 and 40 years old	15
	Between 41 and 50 years old	19
	Between 51 and 60 years old	16
	Between 61 and 70 years old	12
	More than 70 years old	19
Gender	Female	59
	Male	41
Household size	Single	33
	Two	25
	Three	15
	Four	14
	More than four	12
	Mean household size	2.58
Personal income	Mean income	1073.7 (SD = 896.7)
Level of education	No degree	24.0
	Primary education	30.8
	Secondary school certif.	18.8
	University degree	26.7
Health	Average no. of visits to a GP	4.2 (SD = 3.91)
	Average no. of visits to a specialist	2.3 (SD = 9.3)
	Average no. of minor disease $d_1$	2.4 (SD = 1.6)
	Average no. of major disease $d_2$	0.68 (SD = 1.0)

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