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Priority setting in health care and higher order degree change in risk

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ABSTRACT

This paper examines how priority setting in health care expenditures is influenced by the presence of uncertainty about the severity of the illness and the effectiveness of medical treatment. We provide necessary and sufficient conditions on social preferences under which a social planner will allocate more health care resources to populations at higher risk. Changes in risk are defined by the concept of stochastic dominance up to order *n*. The shape of the social utility function and an equity weighting function are used to model the inequality aversion of the social planner. We show that for higher order risk changes, the usual conditions on preferences such as prudence or relative risk aversion are not necessarily required to prioritise health care when there are different levels of uncertainty associated with otherwise similar patient groups.

1. Introduction

Uncertainty is one of the main features that distinguishes the demand for health care from the demand for other goods and services (Culyer, 1971). As stated by Arrow (1963) in his seminal work, uncertainty in health care relates mainly to two sources, the uncertainty surrounding the severity of illness and the uncertainty surrounding the effectiveness of medical treatment. Another feature of health care is that faced with high demands and a limited budget, most countries need to prioritise health care expenditures among their population. Surprisingly no theoretical works, except those of Hoel (2003) and Bui et al. (2005) to the best of our knowledge, have addressed the issue of priority setting in health care when there are different levels of uncertainty associated with otherwise similar patient groups. This paper tries to fill this gap.

As an example, consider a population having the same disease for which a medical treatment is available. The population comprises two types of individual identical in all respects except for the fact that the severity of the disease is more uncertain for the first type of patient than for the second. This might arise if the first type had co-morbidities or other health risks which increased the uncertainty of their health. Consider the socially optimal allocation of a fixed health care budget that has to be made at the societal level. Should the social planner allocate more resources to the patient who is more at risk? The aim of this paper is to provide necessary and sufficient conditions on social preferences under which the social planner will allocate more health care resources to the higher risk population. Following Arrow's (1963) classification, this paper considers two sources of risk, one concerning the severity of the disease, the other concerning the effectiveness of treatment. To define changes in risk, we use the idea of *n*th-order stochastic-dominance. Stochastic-dominance encompasses general forms of risk changes and provides a useful tool to model them (see e.g. Gollier, 2001). In particular, stochastic-dominance includes the concepts of mean-preserving increase in risk introduced by Rothschild and Stiglitz (1970) as well as of increase in downside risk as defined by Menezes et al. (1980).

Our work relies on the utility approach to model the aggregation of health benefit by the social planner as introduced by Wagstaff (1991) and Dolan (1998). Under this approach, aversion to health inequalities is modelled through a concave social utility function over health outcomes, i.e. extra health is considered to be as more desirable when one is in poor health than when in near perfect health. This approach has been criticised on the grounds that it does not allow one to dissociate attitudes towards outcome from attitudes towards inequality. Recently, an alternative approach has been proposed that assigns weights to individuals with respect to

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their health, reflecting the inequality aversion of the social planner through the shape of the equity weighting function. This approach is referred to as the Rank-Dependent QALY model (Bleichrodt et al., 2004).

In the case of uncertainty about the severity of the disease, we show how the most commonly used social utility functions, i.e. those whose successive derivatives to any order n alternate in signs such as the logarithmic function and the power function (Bleichrodt et al., 2005), lead to prioritisation of the patients more at risk for any nth-order increase in risk. In the case of uncertainty about the effectiveness of medical treatment, conditions on preferences needed to prioritise the patients whose benefits are more uncertain are more limiting and necessitate conditions on nth-order relative risk aversion. While the signs of higher derivatives to order n as well as conditions on nth-order relative aversion have been recently shown to influence various economic behaviours (see Eeckhoudt and Schlesinger, 2008; Chiu et al., 2011), it is the first time, to the best of our knowledge that these concepts are applied in health economics.

Our work differs from that of Hoel (2003) and Bui et al. (2005) in various respects. First they limit themselves to changes in risk in terms of second order increase in risk as they compare the certain case to the uncertain case. We consider higher order increase in risk up to order n, which makes it possible to generalise results to higher orders and to compare two risky situations. Second, Hoel (2003) and Bui et al. (2005) do not differentiate between the forms of uncertainty as introduced by Arrow (1963) which provide them only with conditions on the sign of the third derivative of the social planner's utility function to prioritise the patients at risk. We consider two types of uncertainty, one concerning the severity of the disease, the other concerning the effectiveness of medical treatment. In the latter case, we show that new conditions, i.e. on nth-order relative risk aversion, drive the results. Finally, Hoel (2003) and Bui et al. (2005) only consider the utility approach, whereas we consider inequality aversion in terms of both the concavity of the social utility function and the equity weighting function.

This paper is organised as follows. Section 2 introduces the general model of health care allocation under uncertainty. Section 3 presents the concepts of nth-order stochastic dominance and of increase in nth-degree risk (Ekern, 1980) as a special case of nth-order stochastic dominance. Section 4 deals with uncertainty about the severity of the disease. Section 5 addresses the case of uncertainty about the effectiveness of health care. Section 6 considers the equity weighting function to define the inequality aversion of the social planner. Finally, a short conclusion is provided in the last section.

2. The model

The model is based on the Dardanoni and Wagstaff (1990) model in the way uncertainty in health care is defined and on the Hoel (2003) and Bui et al. (2005) models in terms of the health care allocation problem. Consider a population composed of two types of individual with α_i representing the share of individual of type-i (with $i=1, 2$) and such that $\alpha_1+\alpha_2=1$. We assume that health can be quantified, for instance through quality-adjusted life-years (QALY). Health is a function $H(c)$ of the form:[1]

$$H(c) = a + m(c), \tag{1}$$

where a is interpreted as the basic level of health (health condition) reflecting the severity of the disease, and $m(c)$ reflects the effectiveness or productivity of medical care c. We assume that higher investments in medical care improve the health of the patient, but that the marginal benefits from additional medical care decrease ($m'(c) > 0\ \forall c,\ m''(c) \leq 0\ \forall c$).

Uncertainty about the health level $H(c)$ can take two forms, either $\tilde{H}(c) = \tilde{a} + m(c)$, or $\tilde{H}(c) = a + \tilde{m}(c)$. In the first situation, the effectiveness of health care is known with certainty but there is uncertainty about the severity of the disease, i.e. a is random. Uncertainty on the health level has an additive form. In the second situation, the health condition is a deterministic variable, whereas there is uncertainty about the effectiveness of health care or the marginal product of medical care. This could also reflect uncertainty about the quality of health care as stated by Arrow (1963). In that case, uncertainty can appear either in an additive or multiplicative form, as further explained in Section 5.

Consider the socially optimal allocation of a fixed health care budget r. The risk-averse social planner has a social utility function u such as $u'(H) > 0$ and $u''(H) < 0\ \forall H$. The social planner must choose the level of health care expenditures, c_1 and c_2, respectively allocated to type-1 and type-2 patients, with the goal to maximise his expected welfare. The optimisation problem is then represented by the Lagrangian expression L:

$$L(c_1, c_2, \lambda) = \alpha_1 E[u(\widetilde{H}_1(c_1))] + \alpha_2 E[u(\widetilde{H}_2(c_2))] + \lambda(r - \alpha_1 c_1 - \alpha_2 c_2). \tag{2}$$

where the symbol E stands for the expectation. In the case of uncertainty about the severity of the disease, the patient i ($i=1, 2$) health is $\widetilde{H}_i(c_i) = \widetilde{a}_i + m(c_i)$, and patients differ in the uncertainty about the severity of the disease, $\tilde{a}_i$. In the case of uncertainty about the effectiveness of health care, the patient i ($i=1, 2$) health is $\widetilde{H}_i(c_i) = a + \widetilde{m}_i(c_i)$, and the two types of patient differ in the uncertainty about the effectiveness of health care.

3. Higher order degree change in risk

The changes in risk we consider in this paper are based on the concept of stochastic dominance. Stochastic dominance establishes a partial ordering of probability distributions. It is well documented that health and health care distributions are typically skewed, kurtotic (thick tailed) and heteroscedastic (see Blough et al., 1999; Hill and Miller, 2010) and the health econometrics literature is paying greater attention to higher order conditional moments (Manning et al., 2005; Cantoni and Ronchetti, 2006). The concept of stochastic dominance allows us to compare distributions that differ in their conditional moments of higher orders. A special case of stochastic dominance is the notion of increase in risk as developed by Ekern (1980). This includes the cases of mean preserving increase in risk of Rothschild and Stiglitz (1970) as well as of increase in downside risk defined by Menezes et al. (1980) as respectively a 2nd-degree and a 3rd-degree increase in risk.

To illustrate higher order increase in risk, we rely on Eeckhoudt and Schlesinger's (2006) framework which provides a unified approach based on preferences over specific class of lotteries to explain the meaning of the signs of the successive derivatives.

Let us consider an individual with an initial health status a facing the binary lottery $\tilde{H}_1 = [a-\delta_1, a; 1/2, 1/2]$, meaning that the individual has a fifty percent chance of contracting a disease that decreases a by δ_1 units. Now, let us assume that this individual is forced to undergo a second disease that decreases his health by δ_2 units. This second disease could occur either in the state of good health or in the state of bad health, where the first disease had already occurred, with equiprobable probability.

[1] While Dardanoni and Wagstaff (1990) limited themselves to a linear health function, we consider a more general function to reflect decreasing marginal productivity of health care.