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Prevention of diseases and preventive co-payment rate

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Abstract

In this paper, we use the Rank-Dependent Expected-Utility (RDEU) model to analyse the preventive behaviour of an individual faced with the risk of being sick. The RDEU model makes it possible to take into account the way economic agents perceive the risk of being sick in the future. We first exhibit the condition under which the level of prevention chosen by the agent is higher or lower than the first best level. Then, we determine the optimal level of preventive co-payment rate which implements the first best level of prevention.

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1 Introduction

Prevention is considered as one of the main tool to protect against health risks. The importance of prevention in health can not be overstated. It is estimated that a large part of medical expenses could be avoided by the development of more prevention (Kenkel (2000)). Thus, the question of the determinants of optimal prevention for health risks is at the forefront.

Consider for instance the case of obesity. Over the past two decades, the rate of obesity has more than doubled in nearly all OECD countries (OECD health data (2003)).[1] This evolution raises major public health concerns as obesity is a known risk factor in a number of acute and chronic conditions such as diabetes, hypertension, cardiovascular diseases, respiratory problems and so on (see e.g. Allison *et al.* (1999), Pan *et al.* (2004)). Obesity is responsible both for large economic and non-economic consequences. For example, in Canada, the total direct costs of obesity were estimated to be over 2.4% of total health care expenditures in 1997 (Birmingham *et al.* (1999)). In 1995 in the U.S. they represented 5.7% of the total cost of illness (Wolf and Colditz (1998)). Furthermore, recent research in Australia has shown that people who fall outside the healthy weight boundary are more likely to use a range of medical services (Reidpath *et al.* (2002)). Obesity is also responsible for external effects such as a poorer quality of life (Katz *et al.* (2000)). The prevention of obesity, in the main, involves encouraging people to be more physically active and to alter their eating habits. It is estimated that mortality caused by a non-optimal level of exercise and food intake is second only to tobacco consumption with regards to the number of deaths that could be prevented by behavioral change (Chou *et al.* (2002)). The issue of reducing obesity through prevention is not only linked to information but also to incentives; even if we know how to lose weight and to prevent obesity, few of us are willing to pay the price, in effort or expense, of doing it.

Therefore, it may be that the behavior patterns of individuals to prevent future illnesses are not optimal in terms of public health. This may be the case because individuals incorrectly estimate the risks linked to being sick (Hill and Roberts (1998)), or because they have short-time horizons. It is well known that biases in risk perception have a potentially large effect on risk-related behavior (e.g. Viscusi (1995)). Concerning the risk of sickness it is recognized that public authority has a better information that the population. This relies on a paternalistic view of consumers' preferences. It presumes that the regulator has a better knowledge of consumers's preferences than the individual himself. These differences in preferences come from a difference in beliefs. From a policy viewpoint, the inability of individuals to accurately evaluate the consequences of their own decisions has often been a justification for extensive regulatory programme (Viscusi (1995)). Public authority, for example, could provide financial incentives to individuals to help them alter these perceptions and modify their behavior patterns accordingly. This is done essentially through participation to the cost of care, whether curative or preventive. Recent works have dealt with theses issues. For instance, under an Expected- Utility framework, Eeckhoudt *et al.* (2000) examine wether different co-payment rates should be applied to preventive and curative medicine.

The main goal of this research is to define the co-payment rate that an individual has to meet in order to adopt preventive behavior that would correspond to the one that is optimal in terms of public health. We use a recent model of decision, the Rank-Dependent

[1]Some obesity statistics in the US can be found in Finkelstein *et al.* (2003).

Expected-Utility (RDEU) model (Quiggin (1982), Yaari (1987)) that permits us to take into account the way individuals perceive probability, so that we can model individual behavior when faced with the risk of becoming ill. Indeed, numerous works have shown that individuals tend to underestimate the risk of becoming ill (see e.g. Hill and Roberts (1998)).

In the first section we present the outline of the model. In the second section, we first define the optimal agent behavior in terms of choice of prevention and then look at the impact of certain factors that may influence preventative behavior, such as the cost of prevention and the cost of treatment. In the third section, we introduce a regulator that is concerned with the utility of the representative agent and by the fact that the budget has to be balanced. We first exhibit the condition under which the level of prevention chosen by the agent is higher or lower than the first best level of prevention. Then, we determine the optimal level of preventive co-payment rate which implements the first best level of prevention.

2 Outline of the model

We consider a two-period model. The representative agent has an initial wealth W_o. In the first period, the agent is assumed to be healthy and can exert a prevention effort x (balanced diet or exercising), which increases his probability of not becoming sick $\pi(x)$ in the second period, with $\pi'(x) > 0$ and $\pi''(x) \leq 0$. The monetary cost of prevention is normalized to one. We assume that the agent pays a proportion p_x of the prevention cost while the remainder $(1 - p_x)$ is paid by the government. As an example, p_x may represent the proportion of the price paid by an agent for a swimming ticket. Indeed, in a public swimming pool the reminder $(1 - p_x)$ may be financed through taxation . To be insured, the agent pays a premium P. This context corresponds to a public health system such as the British National Health System or the French system where most care is provided or financed by the government, which is funded through taxation. Concerning the cost of curative medicine, we assume, without loss of generality, that the agent bears a co-payment equal to m when he is sick. We consider m as an exogenous variable. The remainder $(1 - m)$ is paid by the government through taxation. Thus the final wealth of the individual writes as $y_s = W_o - P - p_x x - m$ in case of sickness and $y_h = W_o - P - p_x x$ otherwise.

Let $u_i(.)$, $i = s, h$, an increasing and concave VNM state dependent utility function, where $u_s(.)$ represents utility in case of sickness and $u_h(.)$ in case of good health, and with $u_h(.) > u_s(.)$. We further assume that $u'_h(.) > u'_s(.)$. This assumption, which states that the marginal utility of wealth is higher when healthy than when sick, is commonly assumed in the literature in the sense that enjoyment of additional material goods would require good health (see Zweifel and Breyer (1997)).

3 The agent's behavior

We assume that the individual is a Rank-Dependant Expected-Utility maximizer (Quiggin (1982), Yaari (1987)) such that probabilities are treated in a non-linear way. This model allows individuals to distort the probabilities subjectively, in addition to the usual transformation of payments and health into utilities. The RDEU model makes it possible to consider the fact that individuals underestimate (or overestimate) the risk of becoming sick (see for instance Hill and Roberts (1998) in the context of obesity). In our model, the goal of the agent is to choose the optimal amount of preventive effort x^* to exert in the first period. Then, the program of the agent writes as follows

$$\underset{x}{Max} L = u_s(y_s) + \phi(\pi(x))[u_h(y_h) - u_s(y_s)], \tag{1}$$

such as $\phi : [0,1] \rightarrow [0,1], \phi(0) = 0, \phi(1) = 1$ and ϕ a non-decreasing function.

Rearranging equation (1), L rewrites as $L = \phi(\pi(x))u_h(y_h) + (1 - \phi(\pi(x))u_s(y_s)$. The shape of ϕ describes the way an individual perceives the occurrence of becoming sick. If ϕ is concave, the individual is optimistic as he reduces subjectively the objective probability of becoming sick and increases that of good health. On the contrary, a pessimistic individual overweighs or overestimates bad events and underweights good ones.[2]

The first order condition with respect to x is

$$\begin{aligned} L_x &= -p_x u_s'(y_s) - p_x \phi(\pi(x))[u_h'(y_h) - u_s'(y_s)] \\ &\quad +\phi'(\pi(x))\pi'(x^*)[u_h(y_h) - u_s(y_s)] = 0. \end{aligned} \tag{2}$$

This condition yields an implicit solution $x^*(p_x, P, W_o, m)$ for the choice of the optimal preventive effort level.

Using comparative statics, we can consider successively the effect of the cost of prevention, the effect of the initial wealth and the effect of the cost of curative treatments on the level of prevention chosen by the agent.

By differentiating (2) respectively with respect to x and p_x , we get

$$\frac{\partial L_x}{\partial x}dx + \frac{\partial L_x}{\partial p_x}dp_x = 0 \Leftrightarrow \frac{dx}{dp_x} = -\frac{\partial L_x}{\partial p_x}/\frac{\partial L_x}{\partial x}$$

As the second order condition implies that $\frac{\partial^2 L}{\partial x^2} < 0$, $sign\left(\frac{dx}{dp_x}\right) = sign\left(\frac{\partial L_x}{\partial p_x}\right)$. Then, we can compute

$$\begin{aligned} \frac{\partial L_x}{\partial p_x} &= -u_s'(y_s) + xp_x u_s''(y_s)[1 - \phi(\pi(x))] - \phi(\pi(x))[u_h'(y_h) - u_s'(y_s) - xp_x u_h''(y_h)] \\ &\quad -x\phi'(\pi(x))\pi'(x)[u_h'(y_h) - u_s'(y_s)]. \end{aligned}$$

$u_h'(y_h) > u_s'(y_s)$ is then a sufficient condition to insure that $\frac{\partial L_x}{\partial p_x} < 0$ (and so $\frac{dx}{dp_x} < 0$). The more the agent has to support the cost of prevention, the less he will pursue prevention activities. Hence by acting based on the cost of prevention, through taxation or subsidization, stakeholders can influence the level of prevention undertaken by individuals.

Let us now considering the effect of W_o on the demand for prevention. Differentiating (2) respectively with respect to x and W_o yields

$$\frac{dx}{dW_o} = -\frac{\partial L_x}{\partial W_o}/\frac{\partial L_x}{\partial x}$$

We can compute

$$\begin{aligned} \frac{\partial L_x}{\partial W_o} &= -p_x u_s''(y_s)[1 - \phi(\pi(x))] + \phi'(\pi(x))\pi'(x)[u_h'(y_h) - u_s'(y_s)] \\ &\quad -p_x \phi(\pi(x))u_h''(y_h). \end{aligned} \tag{3}$$

[2]We assume strong optimism and strong pessimism as in Chateauneuf and Cohen (1995).

Since $u_h'(y_h) > u_s'(y_s)$, we have $\frac{\partial L_x}{\partial W_o} > 0$ and then $\frac{dx}{dW_o} > 0$. Thus, the higher the initial wealth of the agent, the more he will pursue prevention activities. We can give an intuition of this result. An increase in W_o may have two opposite effects. The direct effect of a rise in W_o makes prevention more worthwhile. However, since the marginal utility of wealth is decreasing, a rise in W_o reduces the marginal utility of wealth. This income effect tends to reduce the demand for prevention. However, the assumption $u_h'(y_h) > u_s'(y_s)$ implies here that there is no income effect.

We can now investigate how the level of prevention is affected by the cost of curative care. Indeed, we can show that the effect of m on the demand for prevention is less clear-cut. Indeed, By differentiating (2) respectively with respect to x and m, we have

$$\frac{dx}{dm} = -\frac{\partial L_x}{\partial m} / \frac{\partial L_x}{\partial x}$$

Then we have

$$\frac{\partial L_x}{\partial m} = p_x u_s''(y_s)\left[1 - \phi(\pi(x))\right] + \phi'(\pi(x))\,\pi'(x)\,u_s'(y_s). \tag{4}$$

Since the sign of this last expression is not clear-cut, the effect of the cost of curative care on the demand for prevention remains ambiguous. We can give an intuition of this result. In our model, when m increases, it is as if the initial wealth decreased but only in the case of sickness. Indeed, it is easy to see that the comparative statics effect in (4) corresponds to (3) except that it ignores the effects on marginal utility in the case of good health (the wealth is not modified in this case). Thus, the income effect does not vanish since it now takes the perception of the marginal utility $u_s'(y_s)$ into account, and this is not compensated by the perception of the marginal utility $u_h'(y_h)$.

Thus, using the cost of treatment to influence individual prevention activities may not be that efficient as we do not know its impact on prevention.[3] So, in the following we restrict attention to the impact of the preventive co-payment rate.[4]

4 The optimal preventive co-payment rate

Once the optimal individual behavior in terms of prevention has been determined, we can now pass on the point of view of the regulator. What is the optimal level of prevention he would choose? This optimal level is the first best (FB) level. We assume that the regulator is concerned by the utility of the representative agent and by the fact that the budget has to be balanced. As commonly assumed, we also consider that the regulator benefits from better information than the individual on the probability of being sick. Thus from the point of view of the regulator, the valuation function of the agent can be written as L given that $\phi(\pi) = \pi$ (Expected utility model).

Thus, if the regulator could choose the first best level of prevention, he would choose x^{FB} which solves the following program

$$\begin{cases} \underset{x}{Max}\, W = \pi(x)\, u_h(y_h) + [1 - \pi(x)]\, u_s(y_s) \\ \text{s.t.} \;\; [1 - \pi(x)](1 - m) + (1 - p_x)\, x = P \end{cases}$$

[3]Intuitively, we could expect the income effect to be empirically unimportant.

[4]Eeckhoudt *et al.* (2000) consider two instruments, namely the preventive and curative co-payment rates and wonder if both co-payment rates are substitutable or complementary.

To obtain the first best prevention effort x^{FB}, we first substitute the value of P given by the budget constraint in the objective function W. Then the first order condition with respect to x is

$$\pi' \left(x^{FB}\right) \left[u_h \left(y_h\right) - u_s \left(y_s\right)\right] + \left[(1-m) \pi' \left(x^{FB}\right) - 1\right] Eu' \left(y\right) = 0, \tag{5}$$

with $Eu'(y) = \left(1 - \pi \left(x^{FB}\right)\right) u'_s \left(y_s\right) + \pi \left(x^{FB}\right) u'_h \left(y_h\right)$. In particular, (5) yields an implicit solution $x^{FB} \left(p_x, P, W_o, m\right)$.

As mentioned earlier, because of biases in risk perception, the level of prevention chosen by the individual may be too high or too low in comparison with the first best level. Tackling this issue, the following proposition can be stated:

Proposition 1 *The level of prevention chosen by the individual is lower (resp. higher) than the first best if and only if*

$$\phi' \left(\pi \left(x^*\right)\right) < (resp >) \frac{p_x \left[u'_s \left(y_s\right) + \phi \left(\pi \left(x^*\right)\right) \left[u'_h \left(y_h\right) - u'_s \left(y_s\right)\right]\right]}{\left[1 - (1-m) \pi' \left(x^*\right)\right] \ Eu' \left(y\right)}.$$

Proof of proposition 1.

Recall that from (2), which describes the preventive effort of the agent, we have

$$\pi' \left(x^*\right) \left[u_h \left(y_h\right) - u_s \left(y_s\right)\right] = p_x \frac{u'_s \left(y_s\right) + \phi \left(\pi \left(x^*\right)\right) \left[u'_h \left(y_h\right) - u'_s \left(y_s\right)\right]}{\phi' \left(\pi \left(x^*\right)\right)}. \tag{6}$$

By evaluating the LHS of (5) in x^*, and using (6) we find that

$$\pi' \left(x^{FB}\right) \left[u_h \left(y_h\right) - u_s \left(y_s\right)\right] + \left[(1-m) \pi' \left(x^{FB}\right) - 1\right] Eu' \left(y\right) > 0,$$

which implies $x^* < x^{FB}$, if

$$\phi' \left(\pi \left(x^*\right)\right) < \frac{p_x \left[u'_s \left(y_s\right) + \phi \left(\pi \left(x^*\right)\right) \left[u'_h \left(y_h\right) - u'_s \left(y_s\right)\right]\right]}{\left[1 - (1-m) \pi' \left(x^*\right)\right] \ Eu' \left(y\right)}. \tag{7}$$

Q.E.D.

When this condition is satisfied, the level of prevention chosen by the individuals is inferior to the first best. This condition is closely related to the slope of the function ϕ. Its interpretation is quite simple and follows the analysis of Konrad and Skaperdas (1993). Indeed, since ϕ is increasing and concave in π, the slope is decreasing with the probability. As the individual transforms the probability, the perception of the variation of the occurrence of the event depends on the level of the probability. As a matter of fact, as ϕ is concave, the higher the probability π, the smaller the impact of the variation of π on ϕ. In this case, prevention is not perceived to strongly reduce the occurrence of the loss. On the contrary, for a low value of the probability π, prevention is perceived as strongly reducing the occurrence of the loss. Thus it explains why a "relatively low slope" is a necessary condition for the individual to pursue less prevention than the regulator's choice, because, contrary to the regulator, he perceives prevention to be relatively inefficient (see Figure 1).

As pointed-out in section 3, the co-payment rate of prevention is a more efficient tool to induce prevention than the co-payment rate of care. Thus, considering the co-payment rate in terms of prevention as an instrument of the regulator, we have the following corollary:

Corollary 1 *The regulator can determine the preventive co-payment rate which implements the first best level of prevention.*

Proof of corollary 1.

Obviously, given (7), the level of prevention chosen by the agent matches the first best if

$$\phi^{'}\left(\pi\left(x^{*}\right)\right)=\frac{p_{x}\left[u_{s}^{\prime}\left(y_{s}\right)+\phi\left(\pi\left(x^{*}\right)\right)\left[u_{h}^{\prime}\left(y_{h}\right)-u_{s}^{\prime}\left(y_{s}\right)\right]\right]}{\left[1-\left(1-m\right)\pi^{\prime}\left(x^{*}\right)\right]\ Eu^{\prime}\left(y\right)}. \tag{8}$$

Substituting the value of $x^{*}\left(p_{x}\right)$ into (8) yields the optimal value of p_x the agent has to bear [5] to match the first best. *Q.E.D.*

5 Conclusion

The aim of this article was to model the preventive behavior of individuals facing the risk of becoming sick, so as to define the co-payment rate that would be optimal for the point of view of the regulator. This optimal co-payment rate allows to take into account two agent's perception biases. On the one hand, the bias concerning the probability of being sick and on the other hand, the fact that the agent does not care about the global budget of health care. To do so, we have used the Rank-Dependent Expected Utility model that permits us to take into account the way individuals perceive probability. Our result has to be linked with Sandmo's paper (1983) which shows that levying a tax on a good can help correct the effect of the incorrect perception of individuals with regards to the probability of events which may decrease their well-being as a result of consuming that good. Our model has also pointed out that the level of the cost of prevention may be a more efficient tool in inducing prevention behavior to change than the cost of care. Setting-up a co-payment rate as the one defined in our model would then be a way to correct the perception bias many individuals have on the risk of becoming sick, and so can be viewed as an incentive mechanism to prevent the risk of becoming sick.

[5] Our result is related to the analysis of Pauly (1968) on optimal co-payment rate when there is moral hazard in insurance settings.

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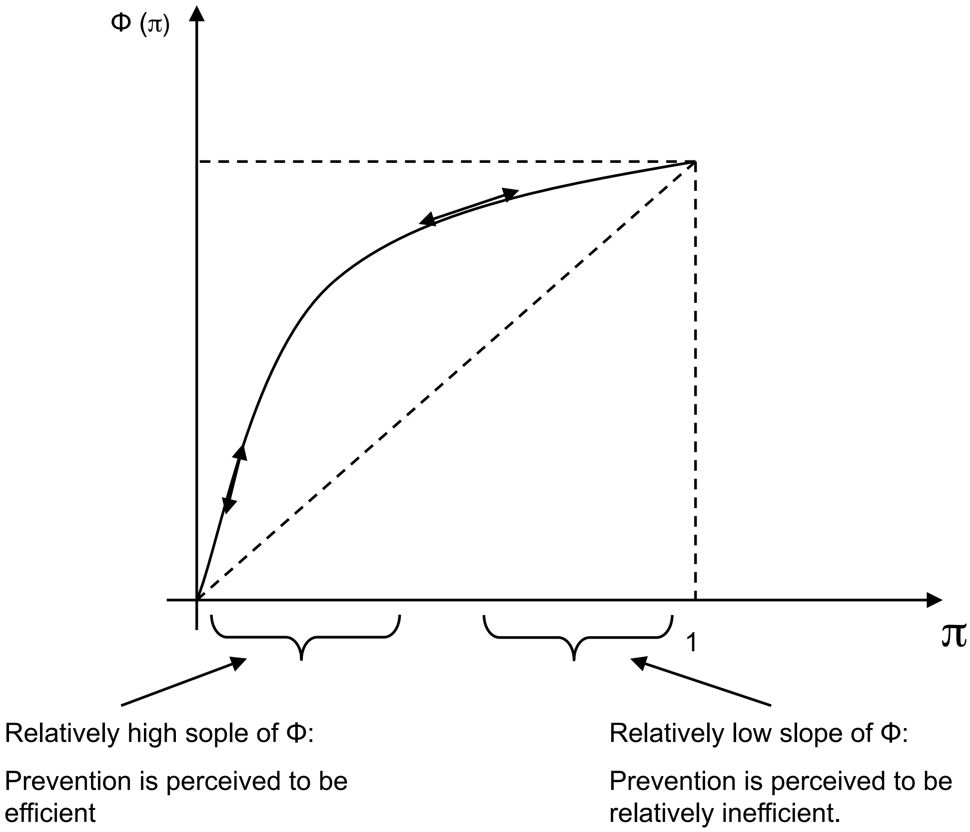

Figure 1: The relative efficiency of prevention