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*A target level of risk model  
of respiratory pathologies and smoking behaviour*

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*Abstract:*

Levels of morbidity and healthcare utilisation related to respiratory pathologies are correlated, firstly, with an indicator of the level of risk that individuals are prepared to take, namely their 'individual target level of risk', and then secondly with smoking behaviour. The results based on a French survey with a sample of 13,150 individuals show that higher target levels of risk are associated with a higher probability of being ill, with higher levels of tobacco consumption but with lower levels of consumption of preventive medicine. More generally, this article shows how a target level of risk model can be formalized in an economic optimizing approach.

## I. INTRODUCTION

Cigarette smoking has been associated with a wide range of health problems and is considered to be one of the most important preventable causes of morbidity and mortality for the 15-65 age group<sup>1</sup>. On the other hand, in many fields of human activity, the development of a desire for safety has influenced lifestyles and has modified consumer products and their use. In developed countries, in particular, knowledge of the potentially damaging effects of tobacco is becoming more and more widespread. Nevertheless, smoking behaviour has tended to persist in most categories of the population in such countries. In France, tobacco consumption is actually increasing in women under 35. How can we explain this apparent contradiction?

My initial aim is to emphasize the extent to which many safety developments have not had the desired effect, in that they have failed to modify an individual's acceptable level of risk and have not therefore led to a decrease in preventable morbidity or accidents.

Twenty years ago, Peltzman (1975), in his classic study on car safety regulations, found that road-users adjusted their behaviour in such a way that the potentially beneficial effects of new safety standards was negated. He showed, for instance, that the decrease in car-occupant deaths in highway fatality rates over a ten-year period was exactly matched by increases in nonoccupant deaths (pedestrians, cyclists and motorcyclists). More recently, data gathered by Evans and Graham (1991) showed that, although laws making the use of safety-belts compulsory have reduced deaths among car occupants, there is some evidence to suggest an increase

in mortality among nonoccupants. Such offsetting behaviour is not irrational: individuals tend to drive less carefully with safer cars (Pelzmann, 1975).

We may also extend the hypothesis to matters of health. For instance, we know that medical improvements in the treatment of cancer of the lungs, throat or larynx have decreased the risk of death or incapacity associated with smoking-related diseases. Publicising advances in medicine thus increases to some degree smokers' sense of security. To the extent that individuals are unwilling to change the degree of risk inherent in their behaviour, their increased ability to repair the damage caused by their behaviour tends to make them behave carelessly, for instance, by increasing tobacco consumption.

What are the theoretical tools that allow us to conceptualize the relationships between smoking behaviour, perception of risk and, for instance, respiratory diseases?

The framework of economic theory provides us with the expected-utility hypothesis and the possible assumption of « risk aversion » to be applied to « the welfare economics of medical care » . Arrow (1963) wrote the assumption of risk aversion follows « that if an individual is given a choice between a probability distribution of income, with a given mean  $m$ , and the certainty of the income  $m$ , he would prefer the latter ». For instance, to study problems of shareholders or of investments, this theory assumes that we should focus our attention mainly on the concavity of the individual utility function and, then, on the decrease risk aversion with increase wealth (for instance, see McKenna, 1986, ch. 2). Thus, economic theory invites us to assume that the shape of the individual's utility function in regard to risk is comparable in many areas of his or her behaviour. This implies that

we can propose *a first hypothesis: we can use as proxies for risk aversion in health matters the estimated degree of risk aversion in other fields, such as the propensity to avoid overdue payments or to protect oneself from serious domestic, work-related or traffic-related accidents.*

From another classical point of view, namely of psychologists studying traffic-related accidents, Wilde (1982) assumes a hypothetical framework, which expresses the same facts in slightly different terms. He assumes that individuals, while making decisions in any behavioural domain that may have health or safety implications, are acting in a way that may be considered a « homeostatically controlled self-regulation process ». He states that « at any moment of time, the instantaneously experienced level of risk is compared with the level of risk the individual wishes to take, and decisions to alter ongoing behaviour will be made whenever these two levels are discrepant ». Over a sufficiently long time span, for example one year, these adjustment actions will influence the frequency and severity of traffic accidents in a given area. This will lead to a new equilibrium, and then to a change in the accident rate. It is also assumed that the new accident rate will, in turn, affect the perceived level of risk, producing a feed-back response, which may not necessarily be immediate. Hence, according to Wilde's « Risk Homeostasis » theory (1982), the only factor that determines the number of accidents would seem to be the road user's desire for safety, i.e. the individual's target level of risk.

The main aim of this article is to examine how far this type of analysis can be applied to health-related behaviour. This theory explains how certain warning signs in relation to health status lead to a chain reaction in the individuals concerned,

resulting in consequences for the individuals' health according to their target level of risk. When individuals are confronted with warning signs implying specific health problems, such as early morning coughing or shortness of breath when climbing stairs, they have to make a decision. Either they can continue, with perhaps a reduction, for instance in their smoking, or they can decide to undergo a thorough medical examination. Should such an examination conclude that their health status is low, they may decide to modify their behaviour to try to avoid more unpleasant health problems.

But what are the determinants of such a decision? In accordance with Wilde, we assume that it depends on two different psychological levels: whether the warning signs are perceived as such depends on individuals' perceptual skills; whether or not they decide to take into account this « perceived level of risk » depends on the balance between this subjective perceived risk and the « target level of risk » they are ready to accept. Whatever they do, depending upon the consequences for their health status, changes in their behaviour and any healthcare they may have decided to seek, they will learn and update their decision, possibly improving the accuracy of their perceptual skills. Wilde interprets this as a feedback process.

More generally, we may assume that cautious behaviour is, to some extent, the consequence of such a perception and awareness of the danger, in that this subjective risk is not counterbalanced by a higher target level of risk. For example, people who are fully aware of the consequences of “passive smoking” are more likely to promote non-smoking behaviour in their relatives, unless their own individual target level of risk allows them to avoid this time-consuming task. As the feedback response shows, they will, however, have a higher level of perceived

risk and, hence, an amplified non-smoking behaviour if their relatives experience respiratory problems.

However, by adopting an economic approach, we may consider that these feedback and adaptative processes are merely steps along a path to a new economic behavioural equilibrium. The first aim of this article is therefore to show how these two different types of approaches are equivalent. In particular, we will try to show that target level of risk models can be formalized with a standard economic approach as an additional constraint in an optimizing model.

This implies that we can propose *a second form of our hypothesis*: in terms of health or of domestic-related, work-related or traffic-accident-related or other randomly determined matters, *individuals behave as if they wish to maintain the level of risk they are prepared to take, i.e. their « individual target level of risk »*.

If these two assumptions are equivalent and correct, individuals with a higher target level of risk will, on average, be more exposed to illness. On the other hand, they will be less concerned about adopting preventive behaviour, such as non-compulsory vaccinations, routine dental or medical checkups, or other cautious behaviour such as not smoking.

In Section 3, we present the data used for this analysis and establish a proxy for target level of risk. Section 4 reports on the empirical results, firstly of the multinomial logit model and, secondly, of the plot between standardized disease and consultation ratios and other determinants. In the closing section, we discuss some interpretations of these results, with reference to economic theory and, last but not least, consider the implications for health policy. Firstly, however, we need



to show, in section 2, why the psychological approach to target level of risk may be considered as equivalent to the optimizing approach of risk aversion.

## II. THEORETICAL APPROACH

Arrow (1963) assumes that « individuals are normally risk-aversers »<sup>2</sup>. He stated that « in utility terms, this means that they have a diminishing marginal utility of income,  $U'' < 0$  ». The meaning of the latter may be seen if we consider the choice between a certain prospect  $X_0$  and a 50 per cent chance of gaining  $h$  or losing  $h$ . If the individuals prefer a certain outcome, then we have

$$U(X_0) > \frac{1}{2} U(X_0 - h) + \frac{1}{2} U(X_0 + h)$$

Intuitively, the more concave the utility function, the more risk-averse the individuals become. This may be formalized with a slight modification of the standard economic programme to take into account a set of random situations when it can be assumed that the individual's utility function is strictly concave.

Let us consider the optimization problem of an individual with an income. Let the parameter  $z$  be defined as the individual's activity in an initial period  $T_0$ , that involves individual's choice of consumption  $X$  in the next period, knowing that he or she has an additive utility function which is thus strictly concave and that he or she is assumed to maximise expected utility within the constraints of his or her income.

$$(1) \quad U(z, X) = U_0(z) + U(X)$$

In addition to the standard programme, let us consider that this individual is facing a set of random and independent states  $S_k(z)$ , each of which is associated with a random consumption variable  $X_k(z)$  which follows a discrete distribution, implying

either a negative utility  $U[X_{k-}(z)]$  with a probability of  $R_k(z)$ , or a positive utility  $U[X_{k+}(z)]$  with a probability of  $1 - R_k(z)$ .

If  $U_0(z)$  is the individual's utility function stemming from the choice of the command variable  $z$  in the initial period,  $Y$  the income, and  $p$  the price, we have

$$(2) \quad \text{Max} \{U_0(z) + \sum_k [1 - R_k(z)] \cdot U[X_{k+}(z)] + \sum_k R_k(z) \cdot U[X_{k-}(z)]\}$$

$$(3) \quad p \cdot X_{k+}(z) \leq Y$$

$$(4) \quad p \cdot X_{k-}(z) \leq Y$$

Moreover, Arrow (1965) and Pratt (1964) have shown that the individual's risk aversion can be approximated by a measure of the concavity of his or her utility function at a point representative of his or her mean consumption. Intuitively, the more concave the utility function, the more risk-averse the individual. When  $U(X)$  is twice continuously differentiable, the so-called Arrow-Pratt absolute risk aversion ratio  $A(X)$  is estimated by

$$(5) \quad A(X) = - \frac{U''(X)}{U'(X)}$$

*Characteristics of the 'target level of risk' constraint:*

If we assume that individuals behave as if they have a given target level of risk,  $R_{\max}$ , that they do not want to exceed, then this assumption involves the addition of supplementary constraints for each of the states  $S_k$  for which the risk cannot be ignored:

$$(6) \quad R_k(z) \leq R_{\max}$$

We may also specify the characteristics of the function  $R_{\max}$ . It is assumed that individuals behave as if they have a target level of risk,  $R_{\max}$ , which they are

unwilling to exceed.  $R_{\max}$  is partially inherited by individuals from their childhood family environment<sup>3</sup> (see Menahem, 1994), and partially experienced from their playmates and relatives during their youth. This implies that an increase in their absolute risk aversion ratio will result in a proportionate decrease of their target level of risk. If we assume  $R_m$  as a continuously differentiable and monotonic function, we have

$$(7) \quad R_{\max} = R_m[ A(X) ]$$

$$(8) \quad R_m' [ A(X) ] \leq 0$$

Constraint (6) then becomes, for each k:

$$(9) \quad R_k(z) \leq R_m[ A(X_k) ] = R_m\{- U''(X_k)/U'(X_k)\}$$

with (10)  $R_m' \{- U''(X_k)/U'(X_k)\} \leq 0$

Let us calculate the lagrangian expression corresponding to the optimization problem within the constraints of the individual's programme. Let  $\lambda_{k+}$ ,  $\lambda_{k-}$  and  $\pi_k$  be the Lagrange multipliers associated respectively with the available income constraints (3) and (4) and the maximum target level of risk constraint (9). We then have

$$(11) \quad L(z) = U_0(z) + \sum_k [1 - R_k(z)].U[X_{k+}(z)] + \sum_k R_k(z).U[X_{k-}(z)] \\ - \sum_k \lambda_{k+} p.X_{k+}(z) - \sum_k \lambda_{k-} p.X_{k-}(z) - \sum_k \pi_k.[R_k(z) - R_m\{- U_0''(z)/U_0'(z)\}]$$

If  $U(z)$  is three times continuously differentiable, the first-order conditions relating to the lagrangian expression at the optimum can be written, for each k:

$$(12) \quad \pi_k \cdot [R'_k - R_m^1 \{-U''/U'\} \cdot \{-U''/U' + (U''/U')^2\}] + p \cdot (\lambda_{k+} \cdot X'_{k+} + \lambda_{k-} \cdot X'_{k-})$$

$$=$$

$$U'_0(z) + \{[1 - R_k] \cdot U'_{X_{k+}} \cdot X'_{k+} + R_k \cdot U'_{X_{k-}} \cdot X'_{k-}\} + R'_k \cdot [-U(X_{k+}) + U(X_{k-})]$$

The first term on the right-hand side,  $U'_0(z)$ , represents the marginal variation of the utility function in the initial period, the second term,  $[1 - R_k] \cdot U'_{X_{k+}} \cdot X'_{k+} + R_k \cdot U'_{X_{k-}} \cdot X'_{k-} = B'(z)$ , expresses the marginal benefit in the following period (where the risk is constant) of having taken a risk, and the third term represents the sum of the decrease in utility and the negative utility associated with the marginal variation of risk  $R'_k$ .

At the optimum, the marginal variation of utility combining the three terms on the right-hand side may also be expressed with the virtual values on the left-hand side, namely  $\pi_k \cdot R'_k$ , corresponding to risk-taking at its virtual price  $\pi_k$  increased by a « premium » for the target level of risk constraint (since  $R_m^1$  is negative), and  $p \cdot (\lambda_{k+} \cdot X'_{k+} + \lambda_{k-} \cdot X'_{k-})$  corresponding to the marginal variations in consumption associated with either the state  $S_{k+}$  or  $S_{k-}$  valued with the ratio  $\lambda_k$  of marginal desirability of income.

Where  $\lambda_{k+}$ ,  $\lambda_{k-}$  and  $\pi_k$  are zero, this means that constraints (3), (4) and (6) are weak and that the corresponding inequalities do not define the limits restricting the individual's field of action. In this case, the marginal utility for the individual is equal to the difference between the expectations of benefit or loss resulting from marginal variations of risk.

Finally, this formalization of the general choices in uncertainty shows that rational economic optimization may take into account both the target level of risk constraint and the results of the so-called « theory of risk homeostasis » with an optimizing model. This may be illustrated with a case of choice under uncertainty.

*An example of taking into account the 'target level of risk' constraint: the case of delay in care for disease*

In the aim of formalizing the attempts of the individuals to manage their time and their other resources to take care of their health capital, we shall use a simple form of the Grossman's model of health capital and healthcare (cf. Grossman, 1972). To keep the analysis simple, we use a two-period model with a reduced form of the health investment production as proposed by Dardanoni and Wagstaff (1987). We simplify also the formalization by considering only one random state  $S$ , in the set of  $S_k$ , which is associated with a random consumption variable  $X$  following a discrete distribution, either  $X_-$  with a probability of  $R$ , or  $X_+$  with a probability of  $1 - R$ .

Thus the utility function can be approximated by

$$(13) \quad U(z) = q \cdot \text{Log}(z) \quad \text{for a variation interval } z \in [s, t] \subset \mathbb{R}^+$$

For an individual who experiences pathological symptoms, PS, for instance early morning coughing, let us define the command variable,  $t$ , the time the individual waits before taking action and consulting a general practitioner, and the random variable  $X$  in the next period, which contains  $(H, M, C)$ , i.e. health stock variable,  $H$ , healthcare variable,  $M$ , and consumption variable,  $C$ . With the reduced form of the health production function, this implies only one additional constraint to our model, which thus becomes:

$$(14) \quad \text{Max} \{U_0(t) + [1 - R(t)].U[X_+(t)] + R(t).U[X_-(t)]\}$$

$$(15) \quad H = H_0 + b.M$$

$$(16) \quad p.X_+(t) \leq Y$$

$$(17) \quad p.X_-(t) \leq Y$$

where  $H_0$  is the stock of health which the individual is assumed to inherit at the beginning of the period, and  $b$  is a random variable measuring in the second period the efficacy of healthcare consumption  $M$ . In the second period, according to the absence or presence of a disease  $D$  following the symptom  $PS$ , the function  $b.M$  may take two values: either  $b_+M$ , the increase in health involved by healthcare investment which would occur at the end of the period if there were no disease, or  $b_-M = b_+M - (c.t + d).M$ , the same increase minus cost of healthcare consumption, cost which would increase proportionally to the delay  $t$ . Let  $\beta$  be the Lagrange multiplier associated to the constraint (15).

Let us specify the main inconvenient and the two advantages resulting from the delay  $t$ . Firstly, if the individual waits too long before taking care of his or her symptom, he or she may increase the risk of becoming hardly sick and, thus, will later on decrease its consumption. On the other hand, waiting for a longer period of time,  $t$ , before taking care involves a direct pleasure originating from the increasing of the utility function,  $U_0'$ , and an indirect advantage resulting from the release of the available time constraint. Let  $T$  be the total time available,  $L$  the time available for leisure and rest, and  $W = \theta.T$ , the total time devoted to work at the average wage  $w_0$  (where, for the sake of simplicity, we suppose than the proportion  $\theta = W/T$  is fixed). This implies, first, an additional constraint:

$$(18) \quad W + L \leq T + t \quad (\text{let } \tau \text{ be the associated Lagrange multiplier})$$

and, second, a modification of the income constraint (3) and (4) for  $X_+$  and  $X_-$ .

$$(19) \quad p.X \leq Y + \theta.w_o.t \quad (\text{let } \lambda_+ \text{ and } \lambda_- \text{ be the Lagrange multipliers})$$

Lastly, we have to define the target level of risk constraint, which formalizes the fact that the perceived level of risk,  $R(t)$ , which is related to the symptoms  $S$ , here, does not exceed the individual's target level of risk,  $R_{\max}$ . Let us assume that the seriousness of the risk that the symptom  $PS$  involves a disease  $D$  increases cumulatively with  $t$ , from (0) when  $t = 0$  as to reach the probability (1) when  $t$  is sufficiently big. We may for example formalize  $R(t)$  as

$$(20) \quad R(t) = t / (t + a)$$

The target level of risk constraint (9) thus becomes

$$(21) \quad t/(t + a) \leq R_m \{-U''(X)/U'(X)\} \quad (\text{let } \pi \text{ be the associated Lagrange multiplier})$$

If, as previously noted,  $\beta$ ,  $\tau$ ,  $\lambda_+$  and  $\lambda_-$ , and  $\pi$  are the Lagrange multipliers associated with the constraints (15), (18), (19) and (21) respectively, then the lagrangian expression (11) becomes

$$(22) \quad L(t) = U_0(t) + [1 - R(t)].U[X_+(t)] + R(t).U[X_-(t)] - \tau.(W+L - t- T) \\ - \beta.[H - H_0 - (b_+ - c.t - d).M] - \lambda_+[p.X_+(t) - \theta.w_o.t] - \lambda_-[p.X_-(t) - \theta.w_o.t] \\ - \pi.[R(t) - R_m \{-U_0''(t)/U_0'(t)\}]$$

If we take the likely example of a utility function  $U$ , where  $U(t) = c.Log(t)$ , then the first-order conditions (12) of the optimum can be expressed as

$$(23) \quad \pi.[a/(t + a)^2 - 1/t^2.R_m'(1/t)] + \lambda_+[p.X_+' - \theta.w_o] + \lambda_-[p.X_-' - \theta.w_o] \\ + \tau + \beta.c.M = 0$$

We thus observe that, for the weak value of the delay  $t$  before the individual consults a general practitioner, the effect of the virtual price of risk  $\pi$  is independent of  $t$ . However, when  $t$  increases, this effect becomes less and less influential<sup>4</sup>. So, for the chosen logarithmic utility function, the fact that the target level of risk constraint is taken into account decreases the risk premium for brief delays; but this effect declines as the delay increases.

For many examples of random situations, such as the set of random and independent states  $S_k(z)$  quoted above, it is possible to formalize the general relationship between marginal risk, marginal benefit of risk-taking, loss and negative utility associated with marginal risk, and the initial satisfaction derived from risk-taking. If we assume that the shape of the individual's utility function regarding risk is comparable in several areas of his or her behaviour, or in several situations  $S_k(z)$ , we can use as proxies of risk aversion in health matters, the risk aversion estimates in other fields, for instance the propensity to experience overdue payments or have serious domestic, work-related or traffic-related accidents.

We may therefore assume that, in the case of delay in health care as in those other risks assumed by individuals, to take into account a target level of risk constraint implies a similar kind of modification of the optimum choice. A clear conclusion founded on the general formalization of the target level of risk approach thus appears: whatever the approach we use -rational economic optimization or psychological risk homeostasis theory-, we formalize the same kind of behavioural pattern. Individuals' attempts to maintain their own target level of risk lead to the same offsetting behaviour when they make their choice by optimizing the expected utility and when there is homeostasis feedback. However, rational optimization



would appear to be preferable when we want to parametrize the different factors of individual choice and collective risks.

### III. EMPIRICAL ANALYSIS

A survey conducted on a large nationally representative sample gave us the opportunity to test any relationship between healthcare, smoking behaviour, and risky behaviour both in relation to overdue payment and traffic-related accident. Such a survey allows us, firstly, to approximate risky behaviour by a target level of risk variable and, secondly, to evaluate the relationships between respiratory disease variables, smoking behaviour and this individual's characteristics in terms of target level of risk.

To schematize the effects of smoking and of healthcare behaviour on health, we use, as shown before, the model of the main determinants of health status and health care, as defined by the theoretical framework of the demand for health by Grossman (1972). To analyse the effects of risky behaviour, we add, as discussed above, a target level of risk constraint to the Grossman model.

#### *The INSEE “ Survey on living conditions 1986-1987 ” survey:*

This survey was conducted in 1986 and 1987 by INSEE, the French National Institute for Studies in Statistics and Economics, on a nationally representative sample of 13,154 French individuals. Individuals responded on their health status and consumption of preventive and curative medicine. Information was also gathered on their involvement in any serious accidents or any experience of overdue payments they may have had experienced (see Borkowski, 1986). Data on 28 diseases and 30 symptoms were collected for each of the 13,154 individuals

questioned. Four items in particular were related to respiratory pathologies. In total, these four items covered 2,167 individuals suffering from at least one respiratory disease or symptom. Of these, 1,048 individuals had consulted at least a general practitioner physician about their respiratory condition.

*How the target level of risk variable was built*

Two groups of questions in the INSEE survey deal directly with the consequences of risky behaviour: the number of expenditure types for which individuals have experienced any overdue payment over a three-year period, and the number of serious accidents they have had during their lifetime.

After being asked about the size and composition of his or her assets and liabilities, (including any property, loans, etc.), a representative of each household was asked whether he or she had experienced any overdue payments over the last three years, either in paying the rent, electricity, gas or phone bills, in credit repayments, in paying medical practitioners or, lastly, in holiday expenditure. A total of 3,700 of the individuals questioned (29% of the sample) reported that their households had encountered such problems on at least two occasions.

Later, the individual had to answer a question on the number of serious accidents he or she had had during his or her life. A total of 2,806 individuals (21%) had at least one serious accident.

We assume that those 5,644 individuals (43% of the sample) who reported of having had at least one serious accident or that their household had encountered some overdue payment, have a probability larger than zero to adopt a risky behaviour during their usual life time and, thus, have a risk aversion ratio lower

than the average. We know that this assumption is very approximate because a lot of people who had accidents or overdue payments were mainly victims of some unforeseeable events such as meteorological trouble, carelessness of some other people, customers' business failure, etc. Economic variables such as poverty, unemployment or difficult working conditions are thus important factors in accidents and overdue payments. However, these events are also statistically linked with the consequences of risky attitudes. Our experience with standardized income, age and gender ratios leads us to believe that we can use these two types of events as a suitable proxy for the propensity to adopt a high level of risk. Thus, when we combine these two kinds of consequences of risky behaviour, we obtain a combined index of an individual's target level of risk.

Table 1 gives details of the mean characteristics of the following four classes of target level of risk: accidents, overdue payments (both measured by ratio constant for income, age and gender), mean age, and gender. We can, therefore, verify that they do not imply specific groups according these characteristics. The last two columns show a first proxy for the degree to which the four classes of target level of risk are associated with the higher number of chronic illnesses declared, and of related symptoms over a three-week period (measured by index constant for age and gender).

### *Empirical model*

According to the framework of the Grossman model, gross investment in health can be obtained according to a household production function, and thus both the health status and the demand for health input are derived from the demand for health capital. We have distinguished between consulting a physician for diagnosis

or treatment, and consultations for purely preventive reasons. It should be noted that, unlike palliative or curative care, preventive care is normally purchased before the individual's health status is known.

Our analysis is designed to answer three questions: whether or not the target level of risk is related, firstly, with the level of respiratory pathologies, secondly, with medical consultations associated with respiratory pathologies or with hospital care service utilisation and, thirdly, with several dimensions of 'investment' in health, such as preventive medical care. The model must take into account the other main influences affecting vulnerability to pathology or the decision to utilise either palliative, curative healthcare or preventive healthcare, such as resource variables and exogenous sociodemographic factors. It is also necessary to take into account the fact that the observation of illness or healthcare utilisation is dichotomous, not continuous. To meet these needs, we estimated the parameters of the logistic function

$$(24) \quad \text{Prob}(\text{ILL}) = f(\mathbf{X}) = 1 / (1 + e^{-\beta\mathbf{X}})$$

where  $\text{Prob}(\text{ILL})$  is the probability of experiencing at least one pathology from the respiratory group during the year preceding the survey,  $\mathbf{X}$  is the vector of explanatory variables, and  $\beta$  is the vector of estimated parameters for the respiratory group.

We used the same model to estimate a proxy for the investment in health, the decision to utilize a form of preventive healthcare ( $\text{PREV}_k$ ) when the individual's health status was not seriously affected.

$$(25) \quad \text{Prob}(\text{PREV}_k) = f(\mathbf{X}) = 1 / (1 + e^{-\pi_k \cdot \mathbf{X}})$$

where  $\pi_k$  is the vector of estimated parameters for  $k$ , the kind of prevention.

We know that, by assuming a Weibull distribution of the random part of utility  $U(X)$ , the model is multinomial logit with  $\text{Prob}(\text{ILL})$  or  $\text{Prob}(\text{PREV}_k)$  given respectively by (23) and (24).

Finally, using a similar model, we can estimate a proxy for those who never smoked. Such healthy behaviour is very close to preventive healthcare because it also reduces exposure to smoking-related diseases. However, there are some important differences that must be emphasized. Firstly, it involves no expenditure and, hence, can hardly be considered as an investment. On the contrary, it allows money to be saved. Secondly, it is difficult to imagine how this healthy behaviour can be related to medical resources such as mutual or national healthcare. It therefore requires a specific model without the healthcare medical aid resource variables.

#### *Dependent variables*

Table 2 provides information obtained from The INSEE survey on three types of dependent variables: the incidence of illness during the previous year for one disease and three symptoms relating to the respiratory system; the number of persons who had one or more medical consultations relating to asthma or three respiratory symptoms during the previous year; some aspects of preventive behaviour concerning health.

#### *Explanatory variables*

From the classic « Demand For Health Model », we selected four socio-economic resource variables (cultural assets, professional skills capital, employment status,

income), three healthcare resource variables (nature of health insurance cover; marital status, which is associated with nonmedical healthcare resources; and level of urbanization, which is correlated with the density of general practitioners) and two exogenous socio-demographic factors (age and gender). These nine variables are among the principal factors which need to be taken into account in the analysis of demand for health. (See table 3 for the 34 dummy explanatory variables).

The French health insurance variables are considered as resource variables for the individuals because they contribute to reduce the cost of healthcare. In the French social care system, the biggest part of these variables are the result of administrative decisions. So, we may assume that these variables are not linked with target level of risk variables. Some sick individuals have special rights to get free health care. These kind of special health insurance is thus not considered in the health insurance variable, because it is administratively related with the disease and healthcare variables. Moreover, in the aim to be assured that there is no problem of collinearity between the risk target variable and the health insurance variable, we verified that Pearson's  $R^2$  coefficients are not significantly different from zero, nor for these two variables (equal to 0.2), neither for the associated dummy variables quoted in table 3 (respectively equal to values between -0.07 and 0.08).

We tested each modality of the ten variables versus the standard situation, i.e. a married male graduate, 26 to 45 years old, employed as a cadre with a family income per unit of more than twice the minimum guaranteed wage, living in a town with a population of 1,000-100,000, and who is covered by national health insurance and a mutual fund and has the least risky behaviour.

#### IV. RESULTS

Two main results appear. Firstly, the individual's propensity to adopt risky behaviour is a strong determinant of the probability of his or her suffering from a respiratory disease and, hence, of having a related medical consultation. Secondly, and more surprisingly, the data clearly show that the highest target level of risk class have a higher frequency of respiratory pathologies than a specific risky behaviour, namely cigarette smoking.

If we want to provide a clearer demonstration of relationships, we need a model which takes into account the main determinants of health. Table 6 shows the results of maximum-likelihood logit regressions in which the probability of suffering from a respiratory pathology, consulting a physician or consuming preventive medicine is a function of the two variables relating to risky and smoking behaviour and of the nine resource and socio-economic variables.

The logit coefficients and their t-ratios provide information on the sign, magnitude and statistical significance of each influence. For the results, the degree of significance is indicated as follows: \*=0.05 level, \*\*=0.01, \*\*\*=0.001. When the significance of a multinomial logit coefficient is equal to or greater than 0.05, i.e. when the probability of its being different from zero is greater than 99%, we calculate a third figure, namely the estimation of the probability supplement associated with this modality, SUPProba(Mod).

Since the explanatory variables (X) are discontinuous, we cannot estimate the marginal effects of a variation in X. We can, however, approximate it by estimating the probability  $\text{Proba}(\text{ill})=f(X)$  involved by only one specified modality of the vector X, 'Mod', all other explanatory variables being held constant, in comparison

with the estimation of the probability of the reference situation,  $\text{Proba}(\text{ill})=f(0)$ .

The marginal effect is approximated by

$$(23) \quad \text{SUPProba}(\text{Mod}) = [f(\text{Mod})-f(0)] / f(0)$$

Table 4 summarizes the main significant relationships between six dependent variables, i.e. respiratory disease, symptom or related medical consultation variables, and six explanatory variables concerning risky behaviour, i.e. smoking behaviour and target level of risk class, as evaluated by the model with 11 explanatory variables.

Five results thus appear:

1. The most striking result is the high significance of the target level of risk coefficients, whatever the disease, symptom or consultation. The relationship between target level of risk classes 3 and 4 and vulnerability in respiratory pathologies is highly significant for each of the six dependent variables; it is highly significant with target level of risk class 2 for four of the six dependent variables. Hence, higher target levels of risk are closely linked with higher beta, i.e. with a higher increase in the probability of being ill, as shown in Table 4.
2. An other important result is the significance of the smoking behaviour coefficients, in particular for the 'shortness of breath during activity' symptom. It can be seen that, except for asthma, each respiratory symptom and related consultation is closely linked to individuals who have smoked but have since given up. Nevertheless, these relationships with smoking behaviour are less significant than those with target level of risk classes 3 and 4. These two categories of smoking behaviour, past or present, are closely linked with a higher increase in the probability of suffering from the two main respiratory symptoms: 'feeling of



suffocation' and 'shortness of breath during activity'. However, only regular smoking behaviour in the past is linked with higher probability of the third symptom, 'shortness of breath at rest', and with the higher probability of consulting a physician for respiratory pathologies.

This result was confirmed with logit regression involving both simple and joint variables: high target level of risk classes without present or past smoking behaviour are strongly linked with a higher probability of each of the four respiratory pathologies; in contrast, present smoking behaviour with lowest target level of risk classes are linked only with 'shortness of breath during activity', as the two other symptoms and related consultations are linked with past smoking behaviour.

3. The third result shown in Table 5 is less clear. It concerns the significance of the negative relationship between target level of risk and preventive health-related behaviour or non-smoking behaviour. This negative relationship is highly significant for non-smoking behaviour, and significant, though at a lower level of significance, for only one tested example of secondary prevention, i.e. action which reduce the consequences of illness by allowing earlier diagnosis. This case seems to suggest that individuals who pay less regard to safety also pay less attention to their health. However, although it is clearly significant for those individuals who had consulted a dental practitioner for a routine check-up, it is not so clear for the other preventive behaviour indicators such as medical check-up vaccination against influenza or hepatitis B.

Relationships between the various explanatory variables and the two indicators of preventive health-related behaviour are presented in Table 6. The main results

concerning the relationships between these five dependent variables and target level of risk classes are summarized in Table 5.

- The reduced probability of never having smoked is significantly linked to the three highest target level of risk classes, at a 0.0001% level;
- The reduced probability of having consulted a dentist for a routine check-up during the previous year is significantly linked to the highest target level of risk class, at a 0.002% level;
- The reduced probability of having had a is significantly linked to the highest target level of risk class, at a 0.05% level;
- On the other hand, there is no clear variation in the indicators of medical check-up during the two years prior to the survey, or in the indicators of primary prevention, either for influenza vaccination or for hepatitis B vaccination.

4. Socio-economic and socio-cultural variables seem to be an important factor only for preventive behaviour - which may be considered as an investment in health capital.

The two lowest levels of education are correlated with a lower demand for routine dental check-ups. These results are similar to those reported by Kenkel (1993) who showed that the level of schooling is an important determinant of demand for preventive health care, namely breast examination and Pap tests.

The two lowest categories of income involve a reduction (-25%) in the probability of preventive behaviour similar to that associated with the highest target level of risk, respectively -8% for routine dental check-up.

Health insurance variables, on the other hand, are frequently associated with the various means of investment in preventive behaviour: negatively for national health insurance and private complementary insurance.

5. Lastly, as we can see from Table 6, socio-economic resource variables are also important. Lower social status is positively and strongly correlated with three of the four respiratory pathologies. As for limited cultural resources, indicated by the lower groups of academic qualifications, only two of the four respiratory pathologies are correlated, and to a lesser degree.

## V. DISCUSSION AND CONCLUSIONS

Many of the weaknesses in the evidence presented here stem from the data that we used. The rest is related more to the economic model. Nevertheless, they allow us to derive some far-reaching conclusions.

The first weakness in the evidence arises from the very nature of the survey. Questions about accidents and payment difficulties were retrospective. People may well tend to rationalize their responses to some degree to try to make them more 'presentable', or exaggerate past events as a way of justifying more easily their present failures. In order to test these hypotheses and compare quantitative results with more reliable respondents' reports, a qualitative survey was conducted, in collaboration with a psychiatrist, P. Bantman, and an anthropologist, S. Martin (see Menahem, Bantman, Martin, 1994). The conclusion was clear: none of the individuals we studied appeared to have fabricated events in their youth, even if some of them clearly presented a revised version of their experiences. Also, when family problems encountered in youth were reported in the survey, they were always an indicator of a major event, even if this was often very different from that

described in the questionnaire.

Due to the limitations imposed by the questionnaire used in the survey, the multidimensional nature of risk situations was approximated by only two variables. These limits imply a considerable simplification of the risk attitudes which were to be described. On the other hand, it is likely that some risky situations taken into account were rather the consequence of randomly determined economic difficulties or accidents than the consequences of risky behaviour. Due to these two limitations, statistical tests are less accurate than would have been the case with more precise indicators of risk.

The third weakness arises when we consider the results shown by Calderon and Golby<sup>5</sup> (1993). According to them, individuals experiencing a debt crisis seem to be, in one case upon three, risk lovers in order to have an absolute risk preference which increases with income. Nevertheless, we may notice that only 10% of our sample (one third of the 29% who experienced an overdue payment) is concerned by this hypothetical limitation. Thus we may assume that, on the average, rational individuals should form unbiased expectations of such unforeseen shocks.

The economic model used here is also limited because it takes into account neither personal wealth nor indicators of an individual's economic attitude to the future, such as life assurance, financial investments shareholding, etc. This omission may well have reduced the significance of the approximated 'target level of risk' variable.

Nevertheless, we may conclude that **the individual's target level of risk is the most important determining factor**, firstly, of health behaviour concerning respiratory pathologies; secondly, in consequence, **of health status and**

**associated healthcare consumption.** In view of the high degree of significance of the relationships between health-related variables and an individual's target level of risk, it would be hard to imagine some unknown and hidden variable that could explain such links.

Otherwise, compared to target level of risk class, **smoking appears to be a weaker determinant of respiratory pathologies.** In particular, heavy smoking is significantly related to only two of the four respiratory pathologies; while the 10-19 cigarettes a day category is significantly related to only one pathology.

How might this be explained?

Firstly, for pathologies of a specific type, this result described a more general relationship of diseases to the level of risk which people are prepared to accept in their everyday life. We have already established this fact for each of the six groups of pathologies, for the probability of being ill, for the probability of consulting a physician and the probability of being hospitalised (Menahem, 1995). Moreover, we may assume that part of the effects of present smoking upon respiratory diseases is due to the high correlation of this activity with target level of risk variables, even if there is clearly a strong medical relationship between respiratory pathologies and long-term cigarette smoking. Part of the evidence for such an assumption is that respiratory pathologies are much less significantly related to smoking behaviour alone than to target level of risk and smoking behaviour combined.

Secondly, the consideration of target level of risk implies an entirely new approach to the origin of vulnerability to diseases. In particular, this approach allows us to conceptualize the many consequences of offsetting behaviour (e.g. those

emphasized by Viscusi and Wilde). If individuals usually set themselves a global target level of risk, we might expect, for instance, that a reduction in their tobacco consumption, which reduces the likelihood of suffering from respiratory pathologies, would be offset by an increase in other unhealthy behaviour (e.g. alcohol consumption, unsafe sexual practices, etc.), which would imply other detrimental effects on their health status.

Worse still, we can assume other consequences of medical improvements: for instance, nonmotivational measures merely increasing the availability of costly lung surgery equipment aiming to facilitate 'reparative' lung surgery, which will lead to a decrease in the expected benefits of cautious behaviour (e.g. reduction in tobacco consumption), and which will eventually increase the incidence of smoking-related diseases and hence the global expenditure on lung surgery.

Some theoretical problems are raised by these results. It will be observed that our findings on preventive healthcare consumption are partially compatible with the theoretical considerations of Eeckhoudt (1995) about risk aversion. Eeckhoudt considers that a stronger demand for prevention does not necessarily result from a higher risk aversion. In view of our results (see Table 5) the question is rather: why is this theoretical result concerning higher risk aversion demonstrated for primary prevention and not for secondary preventive consultation, as such dental checkups?

In order to carry this research a stage further it would be necessary to test the reality of the feedback process linking together the consequences of health-related behaviour and the ability to perceive health-related warning signs. It may also be of potential interest, if we wish to improve the effectiveness of public health policy, to distinguish between different motivational states of target level of risk, since the

advertising and publicity techniques employed depend on whether the objectives are long- or short-term. It would also be very useful to evaluate more precisely those signs which individuals use as a warning system to try to detect the existence of health problems. Such a semiotic analysis of perception skills of the different populations might well allow health and safety policies to be more accurately targeted.

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<sup>1</sup> On the basis of National Safety Council (1990) data, Viscusi (1993) estimated that cigarette smoking involves an annual fatality rate of 1/150 for smokers, representing a much greater risk than that of being involved in a motor vehicle accident, 1/5,000, which is only 3% of the former.

<sup>2</sup> For measurement of risk aversion, see Pratt (1964) and Arrow (1965), given that individuals are a long way from meeting the conditions of the so-called "Allais paradox", see Munier (1988).

<sup>3</sup> Social problems during childhood are a key determinant of target level of risk. If we accept the proxy of target level of risk which is presented below, statistical data shows that, while less than half (46.4%) of individuals in the lowest target level of risk class declared having experienced some such event during childhood, the figure for the highest target level of risk class was over two-thirds (68.3%). The difference is even more marked when we consider long-term relational problems before the age of 18 years (parental discord, lack of affection, serious illness of either parent or their absence for more than one year). Individuals in the lowest target level of risk class are 1.6 times less likely to have experienced such events than individuals in the highest target level of risk class (28.6% compared to 46.6%).

<sup>4</sup> We may suppose, for weak values of  $t$ , firstly, that the ratio  $a/(t + a)^2$  is very close to  $1/a$  and, secondly, that the expression  $1/t^2 \cdot R_m A(1/t)$  is very close of zero, because  $R_m A$ , which is always negative, tends faster than  $t^n$  to zero when the absolute risk aversion ratio  $A(X)$  is too great. When  $t$  increases, the total effect of  $\pi$  decreases, as the derived coefficient is mainly proportionate to  $-t^4$ , and thus negative.

<sup>5</sup> The Cameron and Golby's study was realised from a non random sample of 240 individuals experiencing a debt crisis which leads them to come for advice and assistance to a citizens Advice Bureau in Staffordshire, England, during 1987-1990. Their results show a strong positive relationship between earnings and the probability of over-commitment, that could be taken to indicate the prevalence of risk loving behaviour. The authors indicate that it could be interpreted in other ways. « For example, they write, the thesis of 'animal spirits' applied by Joan Robinson to firms could be extended to households. It may be that 'good times' promote reckless behaviour. » (Cameron and Golby, 1993, p. 844).