GEORGES MENAHEM

Is a risk homeostasis model relevant to the analysis of morbidity and health care utilization ?

Abstract

This article provides evidence of a relationship between the level of morbidity and medical consumption and an indicator of the level of risk that individuals do not wish to exceed. These results support a homeostatic model of decision in uncertainty which may be applied equally for matters of health and safety. This evidence suggests that health and safety regulations may be somewhat ineffective. It also suggests what kind of measures may be more effective, especially those which decrease an individual's target level of risk.

It is first shown that we can break down a nationally representative sample of 13,150 French individuals according to the level of risk they are prepared to take, namely their "target level of risk". For this purpose, the number of serious accidents and money difficulties that individuals have experienced over a three-year period is used as a proxy of risk. Secondly, if we estimate the parameter values for the probability of being ill, using a reduced-form logit model, when an individual's socio-demographic and socio-economic characteristics are held constant, we find that higher target levels of risk are associated with a probability of being ill ranging from 1.8 to 2.5 times higher than that associated with the most cautious individuals. Furthermore, this article shows that higher levels of risk are also correlated with lower levels of consumption of medical or dental checkup.

Keywords: risk, health risk, risk homeostasis, behavioral response, homeostatic model, health, morbidity, preventive medecine.

I - INTRODUCTION

In this time of rapid growth in health expenditure, the multiplication of health and safety regulations has led to many economic questions being asked as to their effectiveness. Evidence has shown the relentless growth of diseases related to tobacco, alcohol, obesity or other lifestyle factors, despite numerous policies aimed at arresting it. Are they any links between such diseases? Is there any kind of offsetting behavior, which would imply an increase in one group of diseases when another group decreases? Or are they associated with some unknown factor unrelated to health policies?

A similar process concerning traffic accidents was studied in North America. In the U.S.A., in the 1970's, following the introduction of several federal automobile safety regulations (on use of highways, wearing of seat-belts, etc.), many studies of traffic-related accidents suggested that such safety regulations are ineffective. They showed that the aggregate level of risk of injury may be unchanged if the regulation simply redistributes risk from one activity to another, or from automobile users to groups of pedestrians, bicyclists and motorcyclists. For instance, Peltzman (1975), in his classic study on car safety regulations, found that offsetting behavior had negated the potentially beneficial effects of the new safety standards: the decrease in car-occupant deaths in highway fatality rates was exactly matched by increases in nonoccupant deaths. More recently, Crandall and Graham (1984) published new time series which also revealed offsetting behavior, though at a lower level than Peltzman's original empirical results.

Such offsetting behavior is not irrrational: individuals tend to drive more recklessly with safer cars (see Peltzman, 1975). It is only a substitution of the marginal benefits of driving intensity for the reduced marginal cost of risk. In many other areas, safety standards have provided better means for safety, but have not modified the public's desire to be safe and, hence, do not imply a decrease in accidents. For example, Viscusi (1985) found that consumers were less careful in storing bottled medicine after the introduction of safety caps, thus counteracting their potential for accident reduction. Alexander (1990) shows how lawn mower safety regulation led to an increase in the accident rates associated with the use of power lawn mowers.

The homeostatically controled decision: according to Peltzman, Viscusi and Alexander, it can be assumed that the behavioral response of individuals may first be explained by their willingness to maintain their chosen level of risk. In particular, in accordance with several studies of traffic-related accidents, Wilde (1982) assumes that individuals, while making decisions in any behavioral domain that may have implications for health or safety, are acting in a way that may be understood as 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 behavior 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 accident rate. It is also assumed that this accident rate will, in turn, have an influence upon the perceived level of risk, producing a feed-back response, which may be delayed in time. Hence, according to the Wilde's "Risk Homeostasis" theory, 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.

May we apply this type of analysis to health-related behavior? Figure 1 shows how certain warning signs in relation to health status lead to a process of reactions on the part of the individual concerned which finally resulting in consequences for the individual's health according the size of his target level of risk. An examination of Fig. 1 suggests two ways in which a similar kind of homeostatic process may occur when individuals are confronted with warning signs implying certain health problems. First, individuals who are aware of such signs as for instance, cough early in the morning, be coming out of breath when climbing the stairs, or seeing stars or flashing lights while working or reading a newspaper, individuals who have perceived these signs have to make a decision. Either they can continue, with perhaps a slight reduction in their pace of life, or they can decide to have 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 (which takes place in the decision box A in Fig. 1)? Along with Wilde, we assume that it depends on two different psychological instances and that, more precisely, at any moment in time the individual perceives a certain level of subjective risk which he compares with the level he is prepared to accept. On the left side, whether the warning signs are perceived as such depends of the individual's perceptual skills; on the right side, whether or not he decides to take into account this "perceived level of risk" depends of the balance between this subjective perceived risk and the "target level of risk" he is ready to accept. Whatever he does, depending upon the consequences for his health status, changes in his behavior and any health care he may have decided to seek, he will learn and update his decision, possibly improving the accuracy of his perceptual skills. This is the first feedback process.

We have observed that the individual, when taking his decision, has balanced his ability to change his health status with the facilities offered by the health system (decision box B in Fig. 1). If the individual is aware that he lacks the ability to face up to his health problems, he will try to adapt his ability by many means, such as gathering information, seeking advice, taking up gymnastics or even yoga, etc. This is the second feedback process.

In the same way, we may also assume that cautious behavior is, to some extent, the consequence of such perception and awareness of the danger, in that this subjective risk is not counterbalanced by a higher target level of risk. For instance, people who are more fully aware of the consequences of insufficient dental care are more likely to brush their teeth regularly since they have learnt of the associated danger, but only to the extent that their individual target level of risk does or does not allow them to avoid this unpleasant task, for instance when they are tired or busy. If dental problems occur, they will modify their perceived ability and, hence, their teeth brushing behavior, as the feedback response shows. This would be the case for the two categories of preventive medical care which were distinguished by Ehrlich and Becker (1972): 1) purchasing of services of primary prevention or for adopting time-consuming behaviours which reduce the probability of illness, such as vaccinations, teeth-brushing or regular physical exercise, and 2) services of secondary prevention which reduce the consequences of illness, such as breast examinations and the Pap test which allows earlier prognosis of breast or cervical cancer, limiting the health loss.

If these assumptions are correct, individuals with a higher target level of risk will, on average, be less concerned about adopting preventive behavior, such as spontaneous dental or medical checkups, or other cautious behavior. On the other hand, taking into account age and socioeconomic variables, they will be more exposed to illness.

In section II we describe the theoretical model. Section III presents the data used for this analysis and establishes a proxy for target level of risk. Section IV reports on the empirical results of the logit multinomial econometric model. Lastly section V, we discuss some interpretations of these results, with reference to economic theory and, last but not least, consider the implications for health policy.

II - FORMALISING THE TARGET LEVEL OF RISK MODEL WITHIN AN OPTIMIZING FRAMEWORK

Can individuals be categorised according to their propensity to adopt different target levels of risk? We may take advantage of the reliable framework of economic theory, by using the classical concept of "expected utility theory" and, more especially, "risk aversion"[1]. For instance, to separate risk-lovers from risk-avoiders, these theories suggest, firstly, that we should focus our attention mainly on the concavity of their utility function and, secondly, that risk-aversion decreases with increased wealth[2].

This may be formalized in the following way when it is assumed that the individual's utility function is strictly concave: if the individual is faced with a set of random states S_k, where X_k is a random variable for a part of the individual's consumption in state S_k, if p is the price and Y the income, the maximisation of the expected utility function U(X) can be expressed as:

$$\text{Max } E\,[U(X_k)] \qquad (1)$$

$$p.X_k \leq Y \qquad (2)$$

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

$$A(X) = -\frac{U''(X)}{U'(X)} \qquad (3)$$

Numerous studies and experiments have been carried out within the theoretical framework of expected utility. At the end of a survey of such theoretical approaches, B. Munier concluded that a risky attitude is not an income-related characteristic of an individual. It is rather a function of the relationship between the individual and the risk structure of which he is faced. We shall now try to elucidate this relationship.

---

[1] For measurement of risk aversion, see Pratt (1964) and Arrow (1965), given that individuals are far from the conditions of the so-called "Allais paradox", cf. Allais (1953) and Munier (1989).

[2] For example, see McKenna (1986), ch. 2.

The characteristics of 'target level of risk': If an individual behaves as if he had chosen a target level of risk, R_{max}, that he is unwilling to exceed, this implies that, as his absolute risk aversion ratio increases, so his chosen level of risk will decrease proportionately. With a continuously differentiable and monotonic function, we have

$$R_{max} = R_m[\, A(X)\,] \tag{4}$$

$$R_m{}'_A[\, A(X)\,] \leq 0 \tag{5}$$

If we assume that the shape of the individual's utility function regarding risk is comparable in several areas of his behavior, we can use as proxies of risk-aversion in health matters the risk-aversion estimates in other fields, such as the propensity to experience overdue payments or have serious domestic, work-related or traffic-related accidents.

An example of target level of risk analysis: the case of traffic-related accidents

In the area of automobile transportation, let us define the command variable as the maximum speed, v, at which the vehicle is driven in the present period, and the random variable, X, as the consumption in the next period. X may take two values, according to the occurrence or absence of an accident: either X_+, the consumption which would occur at the end of the journey if there is no accident, or X_-, the same consumption plus cost of repairs minus the activities planned but no longer possible if an accident occurs.

We also need to specify the two advantages resulting from the high level of speed v: the direct pleasure originating from v, $U_0{}'_V$, and the time saved in corering the distance d, $\Delta(d/v) = - d..\Delta v/ v^2$. When taking into account the time saved, we also need to consider the available time constraint. Let T be the total available time, L the available time for leisure and rest, and D the total distance covered at the average speed $v_0 < v$. This implies :

$$D/v + L \geq T \tag{5}$$

Taking the likely example of a utility function U, where U(z) = c.Log (z), and a risk cost function R, where R(z) is proportionate to the kinetic energy of the vehicle, hence to the squared speed v^2, we have

$$R(z) = h.v^2 \tag{6}$$

Let τ be the Lagrange multiplier associated to the constraint (5), λ_+ and λ_- the Lagrange multipliers associated to the available income constraint (2) for the two values X_+ and X_- of X. The first-order conditions of the optimum can then be expressed as:

$$\pi.[2h.v - Rm'_A(1/v).(-2/v + 1/v^2)] + p.(\lambda_+.X'_+ + \lambda_-.X'_-) + \tau\ D/v^2 = 0 \qquad (7)$$

We thus observe that the virtual price of risk π is proportionate to the speed of the vehicle. Furthermore, for the chosen logarithmic utility function, the fact that the target level of risk constraint is taken into account considerably decreases the risk premium π .2h.v for slow speeds; but this effect declines as the speed increases.

III - DATA AND ESTIMATION OF AN INDIVIDUAL'S TARGET LEVEL OF RISK

1-The data set

An INSEE survey combining these two kinds of data gave us the opportunity to test more accurately for any such relationship between risky behavior and health matters. A representative sample of 13,150 individuals responded on their health status and consumption of preventive and curative medicine, and information was gathered on their involvment in any serious accidents or any experience of overdue payments they may have had (see Borkowski, 1989).

A survey conducted by INSEE in 1986 and 1987 on a nationally representative sample of 13,150 French individuals provides data about their socio-demographic characteristics, the level of their assets and their income and, more especially, the incidence of illness during the previous year and some aspects of their social and economic behavior concerning health. Such a survey allows us to evaluate the relationships between health variables and some of an individual's characteristics in terms of risky behaviour (see Borkowski, 1986 and Menahem, 1994).

2. How the target level of risk variable has been built

Two groups of questions in the INSEE survey deal directly with the consequences of risky behavior: the number of expenditure types for which individuals have experienced any overdue payment over a three-years period, and the number of serious accidents they have had during their life. To take into account the concentration of specific populations more exposed to these risks, we used an income, gender and age standardised ratio.

- After being asked about the size and composition of his assets and liabilities (including any property, loans, etc.), the representative of each household was asked whether or not he had experienced any overdue payments over the last three years, either in paying the rent, electricity, gas or phone bills, in his hire purchase repayments, in paying medical practitioners or, lastly, in holiday bookings. A total of 3,700 of the households (29% of the sample) admitted they had encountered such problems on at least two occasions.

- Later, the individual had to answer a question on the number of serious accidents he had had during his life. A total of 2,806 individuals (21%) had at less one serious accident, including traffic-related, occupational and domestic accidents, etc.

- Economic variables such as poverty, unemployment or difficult working conditions are important factors in accidents and overdue payments. However these troubles are also, on average, the consequences of risky attitudes. The use of income, age and gender standardised 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 behavior, we obtain a combined index of an individual's target level of risk.

Table 2 gives details of the mean characteristics of the following four classes of target level of risk: accidents, overdue payments (both measured by index constant for income, age and gender), average age, and gender distribution. We can therefore verify that they do not imply specific groups according to these characteristics. The last two colums show a first proxy of 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-weeks period (measured by index constant for age and gender).

IV - THE ECONOMETRIC MODEL

Our analysis is designed to test three questions: whether or not the target level of risk is related, firstly with the level of six types of pathology, secondly with medical consultations associated with these six types of diseases 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 disease or the decision to utilise either curative health care or preventive health care, such as resource variables and exogeneous sociodemographic factors. It is also necessary to take into account the fact that the observation of illness or of health care utilisation is dichotomous, not continuous. To meet these needs, we estimated the parameters of the logistic function

Our analysis is designed to test two questions: whether or not the target level of risk is related, firstly with the level of six types of pathology and, secondly, with the level of "investment" in health. The model must take into account the other main influences affecting vulnerability to disease or the decision to utilize preventive health care, such as resource variables and exogeneous sociodemographic factors. It is also necessary to take into account the fact that the observation of illness or of health care utilization is dichotomous, not continuous. To meet these needs, we estimate the parameters of the logistic function

$$Prob(ILL_i) = f(X) = 1 / (1 + e^{-\beta_i X}) \qquad (1)$$

where $Prob(ILL_i)$ is the probability of experiencing at least one disease or symptom of group i during the year preceding the survey, X is the vector of explanatory variables, and β_i is the vector of estimated parameters for group i.

To control for the influence of different levels of health status in the decision to utilize preventive health care (PREV), the logistic function to be estimated becomes

$$Prob(PREV) = f(Y) = 1 / (1 + e^{-\pi Y}) \qquad (2)$$

where Y comprises vector X plus synthetic variables of the number of diseases affecting the individuals, and π is the vector of estimated parameters for prevention.

<u>1. Dependent variables</u>

ILL: The INSEE survey provides us with the incidence of illness during the past year for 28 diseases and 30 symptoms. We have aggregated them into six different groups of diseases:

- 2 diseases and 4 symptoms relating to the digestive system (for 2,811 individuals);
- 2 disease and 3 symptoms relating to the cardiovascular system (for 3,881 individuals);
- 1 disease and 3 symptoms relating to the respiratory system (for 2,167 individuals);
- 5 diseases and 3 symptoms relating to the locomotor system (for 6,669 individuals);

- 1 disease and 2 symptoms relating to allergies and related conditions (for 1,925 individuals);
- 1 disease and 3 symptoms for psychiatric and nervous disorders (for 4262 individuals).

PREV: The INSEE survey also covers some aspects of "investment" behavior concerning health. Individuals provide information on whether or not they have consulted a general practitioner for a reason related purely to prevention during the previous six months. A total of 4,417 individuals (34% of the sample) answered in the affirmative.

Secondly*,* we have considered two cases of investment behaviour in secondary prevention: 6,106 individuals responded that they had consulted a dental practitioner for a routine checkup during the previous year; otherwise, 1,133 individuals responded that they had had a medical checkup during the previous two years.

Thirdly*,* we have also considered two other cases of investment behaviour in primary prevention: voluntary vaccinations against influenza and hepatitis B, involving 2,621 and 375 individuals, respectively.

2. Explanatory variables

So as to compare the findings of this research with wider economic theory, we used a model very similar to the classic "Demand For Health Model" (see Grossman, 1972). We therefore retained five resource variables (cultural assets, professional skill capital, employment status, income, and urbanistic degree -which is correlated with the density of general practitioners-) and two exogeneous sociodemographic factors (age, marital status). According to the economic theory, these seven variables are among the principal factors which have to be take into account in the analysis of demand for health. Thus, if we have a dummy variable for each modality taken into account, these variables, and the variable of target level of risk, will be transformed into 25 explanatory variables (the size of the sample and percent of the sample are given in brackets). So as to evaluate the probability of the dependent variable when we modify one character of the reference situation, we test each modality versus the standard situation (i.e. married, 26-45 years, a graduate, employed as a cadre, with an income upper than 2 legal minimum wage/personn, living in town with a population of 1,000-100,000, and having the lowest target level of risk).

Two exogeneous sociodemographic factors

Three classes of age were compared to the 26 to 45 years class (38%):

- 18-25 years old (1,809; 14%);
- 46-65 years old (2,735; 21%);
- 66-97 years old (3,539; 27%).

Two classes indicate whether the respondent cohabits or not and whether he or she is married. We compared this factor with the situation of individuals who live in married couples (55%).

- Unmarried and cohabiting (813; 6%);
- Unmarried and living alone (5168; 39%).

Four resources variables

"Professional skill capital" and earning ability are approximately represented by two variables: individual professional status, and employed or unemployed status of the respondent. We compared the following 8 categories with the status of cadre (12%) and those in employement (51%):

- Farmer (1,007; 8%);
- self-employed (1,151; 9%);
- cadre, technician (2,252; 17%) ;
- office worker (2,310; 18%);
- skilled worker (3,242; 25%);
- unskilled worker (1,586; 12%);
- registered unemployed (785; 6%);
- inactive, retired (5636; 43%).

The kind of the town, village, etc. in which the respondent lives was used as a proxy of another resource variable: the density of medical equipment and general practitioners available in the locality. We compared this to a town with a population between 1,000 and 100,000 (48%):

- Rural area (2,339; 18%);
- Town with a population of over 100,000 (4,505; 34%).

The previous years' income of the household per capita is more closely linked with the household's resources than with the interviewed individual's human capital. We compared this with the highest category of income, i.e. more than twice the legal minimum wage/person (10%):

- Less than 60% of the legal minimum wage/person (1,408; 11%);
- from 60 to 120% of the legal minimum wage/person (5,560; 42%);
- from 120 to 200% of the legal minimum wage/person (4,822; 37%).

Lastly, an approximate measure of "cultural assets" is obtained from the level of general education variable. Four levels are distinguished here and are compared with the highest status, that of higher education (7%):

- No academic qualifications (4,714; 36%);
- primary level (4,177; 32%);
- school certificate (2,119; 16%);
- Baccalaureat (1,259; 9%).

V - FINDINGS

Table 3 shows the results of maximum-likelihood logit regressions in which the probability of being ill or of consumpting preventive medecine is a function of the target level of risk, and resource and sociodemographic variables. The logit coefficients and their t-ratios provide information on the sign, magnitude and statistical significance of each influence. We have indicated with * results significant at the 0.05 level, with ** the 0.01 level, and with *** the 0.001 level.

When the significance of a multinomial logit coefficient is at least equal to 0.01, i.e. when the probability of its being different to zero is greater than 99%, we give a third figure, the calculation of the probability supplement associated with this modality, SUPProba(Mod).

Since the explanatory variables are discontinuous, we cannot estimate the marginal effects of a variation of X. We can, however, approximate it by estimating the probability Proba(ill)=f(X) involved by only one specified modality of the vector X, Mod, every other explanatory variables being held constant, in comparison with the estimation of the probability of the reference situation, Proba(ill)=f(0). The marginal effect is approximated by

$$\text{SUPProba(Mod)} = [f(\text{Mod})-f(0)] / f(0) \qquad (3)$$

Four results thus appear:

1 - The most striking result is the high significance of the target level of risk coefficients whatever the group of diseases. The relationship between target level of risk and vulnerability is strongly positive for each of the six groups of diseases and symptoms.

Higher target levels of risk are closely linked with higher beta, i.e. with a higher increase in the probability of being ill: +75% for the group of digestive diseases and symptoms; +58% for the cardiovascular group; +78% for the locomotor system; +83% for the psychological diseases group; +60% for the allergic disease group; and +150% for the respiratory diseases group.

2 - The second important result is the high significance of the negative relationship between target level of risk and preventive health-related behavior: twice at a 0.01% level, and the last at a 0.05% level. This negative relationship, though at a lower level of significance than the probability of being ill, means that individuals who take less care of safety also care less about their health. The higher target level of risk class is associated with a reduced probability (-19%) of consulting a physician for purely a preventive reason.

3 - We also carried several logit regressions to test whether general practitioner and specialist consultations which are associated with individual groups of diseases declared by the respondents are also related to the target level of risk. The main result is that we found a similar result for consultations related to each of the six groups of diseases. The increased probability of consulting associated with the highest target level of risk is similar in size to the increased probability of suffering from a disease: respectivly, for instance, +75% for consultations associated with digestive diseases and symptoms; only + 33% for those associated with cardiovascular group; but +118% for those associated with the locomotor group; +109% for the psychological diseases group; +100% for the allergic group; and +149% for the respiratory diseases group.

4 - It can be observed that the relationship of morbidity with resource variables is much less significant and much less clear than that with target level of risk. The lowest categories of income per capita involve a similar order of decrease in the probability of preventive consultations (-26% and -14%, respectivly) than the decrease associated with the highest target level of risk. Yet, on the other hand, low income resources are associated only with a significant decrease in the probability of suffering from digestive disorders (-19%). On the other hand, lower social status are positively and strongly correlated with cardiovascular, locomotor and respiratory diseases, but very weakly correlated with the digestive or psychological groups of diseases, not at all correlated with preventive consultations, and negatively correlated with the group of allergic diseases. As for low cultural resources, indicated by the lower groups of academic

qualifications, only two groups of diseases are related: positively for diseases of the locomotor system, and negatively for allergic diseases.

VI - CONCLUDING REMARKS

In conclusion, we can assume that the individual's target level of risk is an important determinant, first, of health status and, second, of health behavior. The high degree of significance of the relationships between health-related variables and an individual's target level of risk implies that it would be difficult to imagine an unknown and hidden variable which would explain such links. Nevertheless, this evidence is not sufficient to demonstrate that the homeostatic model presented above does indeed explain the individual's behavior in health or safety-related matters. However, it is important to note that this model is not refuted by the evidence reported here.

What are the implications of such a result for health and safety policy? If 35% of a nationally representative sample of the French population have a health status that is lower than the remainder party because of their higher target level of risk, it implies that they are responsible for higher costs of therapeutic health care (hospitalisation, expensive examinations, etc.). This also implies higher costs for the national economy (higher frequency of incapacity, fewer working hours, more frequent absences from work, etc.). It is clear that a considerable saving could be achieved by an improvement in the level of health of this population.

How could this be achieved? Fig. 1 shows that the best way of improving the health status of this specific population is neither to increase the availability of medical equipment, nor to decrease the cost of medical consumption, nor to increase the desire to avoid the unpleasant consequences of social pressure. The best way seems to be rather to reduce this population's target level of risk, i.e. increasing its desire to be safe. For instance, good motivational measures would be those which increase the expected benefits of cautious behavior, such as administrative incentives for physical exercise, preventive examination of diet or rewards for a cautious style of life. Equally, measures which decrease the expected costs of cautious behavior (for instance providing preventive medecine free of charge) would also contribute to a reduction in the target level of risk. Lastly, in order to avoid offsetting practices which occur when only one form of risky behavior is rendered more expensive, it would be necessary to define a global policy. Decreasing the expected benefits of risky behavior and increasing their expected costs must therefore cover the entire range of unsafe forms of behavior.

This implies an entirely new approach, in order to avoid unwanted results such as those due to offsetting behavior. Otherwise, we can imagine that the reduction in smoking which reduces the likelihood of certain illnesses may well be offset by an increase in other causes of death (e.g. cirrhosis of the liver or AIDS and other sexually transmitted diseases). Worse still, non-motivational measures, merely increasing the availability of costly heart-surgery equipment will facilitate 'reparative' heart surgery, which will lead to decreases in both the expected cost of an unsafe diet and the expected benefits of cautious behavior (e.g. regular testing of cholestérol levels and blood pressure), that will eventually increase the incidence of heart diseases and hence the global expenditure on heartsurgery.

To carry this research a stage further it would be necessary to test the reality of the feedback process which links together the consequences of health-related behavior and the ability to perceive warning signs in matters of health. It may also be potentially interesting to distinguish between different motivational states of target level of risk (i.e. long term compared to short-term, as for instance, when a depressive mood reduces individual's watchfulness). It would also be very useful to evaluate better the signs of health-related problems which are used by individuals as a warning system. Such a semiotic analysis of the different populations' perception skills might well permit more accuratly targeted health and safety policies.

APPENDIX

Theoretical consideration of target level of risk constraints: the example of traffic-related accidents

Let us consider the optimisation problem of the program of an individual who earns an income Y and has to define the parameter z of his activity in an initial period t_0, that involves his choice of consumption X in the next period t, knowing he has an additive utility function $U(z, X) = U_0(z) + U(X)$ that he wishes to maximise within the constraints of his income.

In addition to the standard program, 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 independent of z (n.b. this is not the case for random work-related accidents), and p the price, we have

$$\text{Max}\{U_0(z) + \Sigma\, [1 - R_k(z)].U[X_{k+}(z)] + \Sigma\, R_k(z).U[X_{k-}(z)]\} \qquad \text{(A2)}$$

$$p.X_{k+}(z) \leq Y \qquad \text{(A3)}$$

$$p.X_{k-}(z) \leq Y \qquad \text{(A4)}$$

If we assume that the individual behaves as if he has chosen a given target level of risk, R_{max}, that he does 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:

$$R_k(z) \leq Rmax \qquad \text{(A5)}$$

Furthermore, let us assume that a function associates the target level of risk with the absolute risk-aversion A(z), given that the higher the level of risk which an individual prefers not to exceed, the weaker the absolute risk-aversion level. The constraint A5 then becomes, with a continuous, derivable and monotonic function R_m (cf. equation 4) :

$R_k(z) \leq Rm\{- U''(z)/U'(z)\}$ (A6)

avec $Rm'_A\{- U''(z)/U'(z)\} \leq 0$ (A7)

Let us calculate the lagrangian expression corresponding to the optimisation problem within the constraints of the individual's program. Let λ_{k+}, λ_{k-} and π_k be the Lagrange multipliers associated respectively with the available income constraints A3 and A4 and the maximum target level of risk constraint A6; we then have

$$L(z) = U_0(z) + \Sigma_k [1 - R_k(z)].U[X_{k+}(z)] + \Sigma_k R_k(z).U[X_{k-}(z)]$$

$$- \Sigma \lambda_{k+} p.X_{k+}(z) - \Sigma \lambda_{k-} p.X_{k-}(z) - \Sigma \pi_k.[R_k(z) - P\{- U_0''(z)/U_0'(z)\}] \quad (A8)$$

If U(z) is three times continuously differentiable, the first-order conditions of the partial dérivées partielles du lagrangien at the optimum condition par rapport au vecteur paramètre z s'écrit alors, pour tous les k considérés :

Si U(z) est trois fois continument différentiable, la condition de nullité à l'optimum des dérivées partielles du lagrangien par rapport au vecteur paramètre z s'écrit alors, pour tous les k considérés :

$$\pi_k.[R'_k - Rm'_A\{-U''/U'\}.\{- U'''/U' + (U''/U')^2\}] + p.(\lambda_{k+}.X'_{k+} + \lambda_{k-}.X'_{k-}) =$$

$$U'_0(z) + \{[1 - R_k].U'_{X_{k+}}.X'_{k+} + R_k.U'_{X_{k-}}.X'_{k-}\} + R'_k.[- U(X_{k+}) + U(X_{k-}) \quad (A9)$$

Le premier terme du second membre, $U'_0(z)$, représente la variation marginale d'utilité dans la période initiale, le second terme, $B'(z) = [1 - R_k].U'_{X_{k+}}.X'_{k+} + R_k.U'_{X_{k-}}.X'_{k-}$, exprime le bénéfice marginal (estimé à risque constant) de la prise de risque initiale dans la période ultérieure, le troisième terme représentant la somme de la perte d'utilité et de la désutilité associées à la variation marginale du risque R'_k.

A l'optimum, la variation marginale d'utilité globalisant les trois termes du second membre peut aussi être exprimée avec les valeurs virtuelles du premier membre, soit $\pi_k.R'_k$ correspondant à la prise de risque à son prix virtuel π_k augmentée d'une "prime" de confrontation à la contrainte de niveau de risque programmé maximum (puisque P'_A est négatif), et $p.(\lambda_{k+}.X'_{k+} + \lambda_{k-}.X'_{k-})$ correspondant aux variations marginales des consommations associées à l'un ou l'autre des résultats de la situation aléatoire S_k valorisées avec l'indicateur λ_k de désirabilité marginale du revenu associé à cet état.

Dans le cas où π_k, λ_{k+} et λ_{k-} sont nuls, ceci signifie que les contraintes A6, A3 et A4 sont laches et que les inégalités correspondantes ne délimitent pas des frontières restreignant le champ des possibles de l'individu. Dans ce cas, la somme actualisée de l'utilité marginale pour l'individu est égale à la différence entre les espérances actualisées de gains et celles de perte d'utilité découlant des variations marginales du risque.

The example of traffic-related accidents

It is possible to formalise this relationship between marginal risk, in many examples of random situations.

Il est possible de formaliser dans plusieurs exemples de situations aléatoires cette relation générale entre le risque marginal, les avantages marginaux de la prise de risque, la perte et la désutilité du risque marginal, et la satisfaction initiale tirée de la prise de risque.

Afin de mieux préciser les conditions d'application de cette approche, on analysera ces exemples avec une fonction d'utilité approchée par U(z) = c.Log (z) pour un intervalle $z \in [s, t] \subset R^{+}$.

Le cas de la circulation automobile et des accidents de la route

Dans le cas du transport automobile, la variable de commande est la vitesse maximale adoptée pour le véhicule, v, et la variable aléatoire X est toujours le vecteur consommation dans la période suivante. Il peut prendre deux valeurs, soit X_{k+}, le vecteur des consommations réalisées à l'issue du voyage, dans le cas où le trajet s'est passé sans incident, soit X_{k-}, ce même vecteur consommation dans le cas ou un accident matériel est survenu, donc diminué des activités rendues impossibles du fait du retard à l'arrivée et augmenté des divers frais occasionnés par la perte de contrôle du véhicule (coûts de la réparation, de l'indemnisation et des soins aux blessés éventuels, voire de l'amende entrainée par une possible infraction).

D'autre part, on précise deux avantages initiaux découlant de la vitesse, à savoir le plaisir direct que l'on en tire, $U_{o}'_{V}$, et la diminution du temps dépensé pour parcourir la distance d du trajet, **Erreur ! Source du renvoi introuvable.**(d/ v) = - d.**Erreur ! Source du renvoi introuvable.**v/ v^2. La prise en compte de cette économie de temps implique que l'on considère la contrainte de temps disponible. Dans une expression ne prenant en compte que le temps total disponible hors travail, T, le temps disponible pour le repos et les loisirs, L, et la distance totale D parcourue en automobile personnelle avec la vitesse moyenne v, on a :

$D/v + L = T$ (A10)

Si τ est le multiplicateur de Lagrange associé à la contrainte A8, la condition A7 de nullité à l'optimum des dérivées partielles du Lagrangien devient :

$$\pi.[R' - Rm'_A\{-U''/U'\}.\{-U'''/U' + (U''/U')^2\}] + p.(\lambda_+.X'_+ + \lambda_-.X'_-) + \tau D/v^2 =$$
$$U'_0(z) + \{[1 - R].U'_{X+}.X'_+ + R.U'_{X-}.X'_-\} + R'.[- U(X_+) + U(X_-)] \quad (A11)$$

Si l'on prend l'exemple vraisemblable de U(z) = c.Log (z) et d'une fonction de risque R(z) proportionnelle à l'énergie cinétique du véhicule, et donc au carré de sa vitesse, soit

$R(z) = h.v^2$ (A12)

le premier membre de A9 devient :

$$\pi.[2h.v - Rm'_A(1/v).(-2/v + 1/v^2)] + p.(\lambda_+.X'_+ + \lambda_-.X'_-) + \tau D/v^2 \quad (A13)$$

On constate ainsi que la valorisation du risque au prix virtuel π est proportionnelle à la vitesse du véhicule. De plus, pour la courbe d'utilité logarithmique choisie, on montre aisément que la confrontation avec la contrainte de risque programmé maximum atténue fortement la prime de risque $\pi.2h.v$ pour les faibles vitesses, mais d'autant moins fortement au fur et à mesure que la vitesse augmente[3].

References

- Allais, M.: 1953, 'Le comportement de l'homme rationnel devant le risque. Critique des postulats et axiomes de l'école américaine', Econometrica, **21**(4), 503-546.

- Arrow, K. J.: 1965, Essays in the Theory of Risk Bearing, Amsterdam, North-Holland.

- Borkowski, J. L.: 1986, 'Etude des conditions de vie, une enquête sur le cumul des inégalités', Courrier des statistiques, **40**(10), INSEE.

- Borkowski, J. L.: 1989, 'L'obstacle de la langue', INSEE Première, **27**, INSEE.

[3] D'une part la dérivée de R_m est toujours négative et, d'autre part, pour les valeurs positives de la fonction d'utilité, donc pour z>1, le terme en (-2/v + 1/v²) est de plus en plus faiblement négatif quand z augmente et minore donc de plus en plus faiblement la prime de risque p.2h.v .

- Crandall, R. W. and Graham, J. D.: 1984, 'Automobile Safety Regulation and Offsetting Behavior: Some New Empirical Estimates', American Economic Review, **74**, 328-331.

- Fuchs, V. R.:1984, The Health Economy, Harvard University Press, Cambridge, Massachusetts, USA.

- Grossmann, M.: 1972, 'On the Concept of Health Capital and the Demand for Health', Journal of Political Economy, **80**, 1275-1294.

- McKenna, C. J.: 1986, The Economics of Uncertainty, Wheatsheaf Books Ltd., Brighton, Sussex.

- Menahem, G.: 1994, Problèmes de l'enfance, statut social et santé des adultes, CREDES, Paris, France.

- Munier, B.: 1989, ' Calcul économique et révision de la théorie de la décision en avenir risqué', Revue d'économie politique, **99**(2), 276-306.

- Peltzman, S.: 1975, 'The Effects of Automobile Safety Regulation', Journal of Political Economy, **83**, 677-725.

- Pratt, J. W.: 1964, 'Risk Aversion in the Small and in the Large', Econometrica, **32**(1-2), 122-136.

- Viscusi, W. K.: 1984, 'The Lulling Effect: The Impact of Child-Resistant Packaging on Aspirin and Analgesic Ingestions', American Economic Review, **74**, 324-327.

- Wilde, R. J.: 1982, 'The Theory of Risk Homeostasis: Implications for Safety and Health', Risk Analysis, **2**(4), 209-225.

Georges MENAHEM
Researcher in the CNRS - CREDES
(Center of Research, Study and Documentation in Health Economics)
1 rue Paul Cezanne, 75008 PARIS, FRANCE

Figure 1:

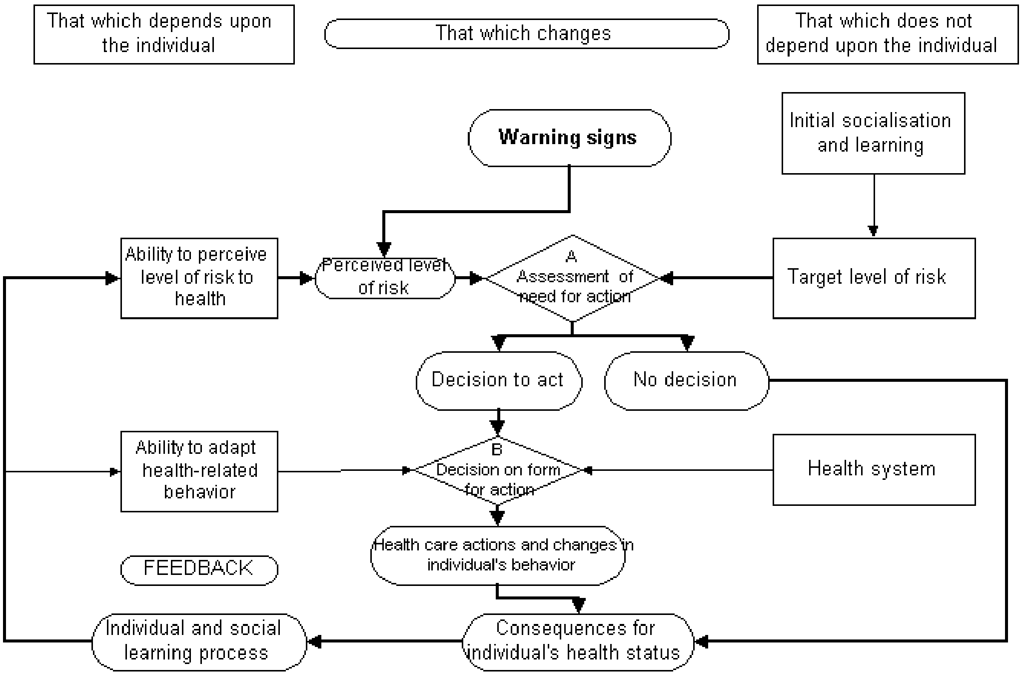

Fig. 1: Homeostatic model relating health status to perceived level of risk

Table 2:

Characteristics of the four classes of target level of risk

Target level of risk	Number	Average age	Women	Average index (constant for income, age and gender)		Average index (constant for age and gender)	
Class		years	%	No. of accidents	Overdue payments	No. of diseases	No. of symptoms
1	7,510	47	59	0	18	84	85
2	3,725	45	49	149	131	108	110
3	1,292	47	51	301	353	134	129
4	627	46	54	591	377	174	162
Sample	13,154	47	55	100	100	100	100

Source: INSEE "Survey on living conditions", 1986-1987

Table 3: <u>Maximum-likehood logit regression results for probability of adopting preventive health care or of being ill</u>

(coefficients and significance at: * 5%, ** 1%, *** 0.1% level for all variables, t-ratios and increasing probability for classes of target level of risk)

VARIABLES		Preventive health care	Digestive diseases	Cardiovascular diseases	Locomotor diseases	Psychiatric diseases	Allergic diseases	Respiratory diseases
n		4,417	2,811	3,881	6,669	4,262	1,925	2,167
INTERCEPT		-1.0938***	-1.9400***	-2.2985***	-0.8297***	-1.3152***	-1.6371***	-3.1733***
<u>"Target level of risk" variable</u>								
Class 1	(vs 0 level of risk)	-0.1163**	0.2513***	0.1395**	0.3481***	0.3144***	0.2102***	0.3790***
		(2.5) -8%	(5.0) +24%	(2.9) +13%	(8.3) +26%	(7.1) +27%	(5.7) +19%	(6.7) +43%
Class 2	(vs 0 level of risk)	-0.1574*	0.3784***	0.2571***	0.5255***	0.4923***	0.2683***	0.5719***
		(2.3) -11%	(5.3) +38%	(3.7) +26%	(8.2) +40%	(7.7) +44%	(3.2) +25%	(7.3) +72%
Class 3	(vs 0 level of risk)	-0.2693**	0.6729***	0.5208***	0.9935***	0.8575***	0.5904***	0.9818***
		(2.8) -19%	(7.2) +75%	(5.5) +58%	(10.8)+78%	(9.9) +83%	(5.6) +60%	(9.9)+150%
<u>Health status variables</u>								
1-2 symptoms	(vs 0 symptom)	0.0212						
3-5 symptoms	(" " ")	0.1278*						
6 symptoms and over	(" " ")	0.2640***						
1 disease	(vs 0 disease)	0.3423***						
2 diseases and over	(" " ")	0.5484***						
<u>Resource variables</u>								
Farmer	(vs cadre, manager)	0.0301	-0.0781	0.4553***	0.2743**	-0.1712	-0.2713	0.3939**
Self-employed	(" " ")	-0.0748	0.0234	0.3253**	-0.0440	0.0385	-0.4040***	0.0905
Cadre, technician	(" " ")	-0.0159	0.0158	0.4743***	0.1075	-0.0268	0.0045	0.2697**
Office worker	(" " ")	0.0994	0.1789	0.5202***	0.2530**	0.2879***	-0.0584	0.4129***
Skilled worker	(" " ")	-0.1319	0.1400	0.3949***	0.1961**	0.0292	-0.1386	0.3393**
Unskilled worker	(" " ")	-0.1237	0.0040	0.3651***	0.0759	-0.1349	-0.4564***	0.1786
Registered unemployed	(vs employed)	0.1348	0.1887*	0.0894	-0.2032**	0.4423***	0.1677	0.4137***
Inactive, retired	(" ")	0.3477***	0.3591***	0.4504***	0.1298**	0.4772***	0.1777**	0.4395***
No academic qualifications	(vs higher education)	-0.1019	0.2265*	0.2506*	0.3534***	-0.0382	-0.3553**	0.3339*
Primary level	(" " ")	-0.0910	0.1018	0.1992	0.3573***	0.0373	-0.3042**	0.1266
School certificate	(" " ")	-0.0123	0.1695	0.0600	0.3711***	0.0980	-0.0626	0.1903
Baccalaureat	(" " ")	-0.0250	0.0072	-0.1695	0.1681	-0.0068	-0.0789	0.2286
Less than 60% legal min. wage/person	(vs > 2 legal min. wage /pers.)	-0.3951***	-0.2067	0.1638	-0.1419	-0.0119	-0.2020	0.1315
60 to 100% legal min. wage/person	(" " " " ")	-0.1972**	-0.0534	0.1518	-0.0213	0.0915	-0.0270	0.1878
120 to 200% legal min. wage/person	(" " " " ")	-0.0782	0.0191	0.0831	-0.0132	0.0914	-0.0173	0.1404
<u>Sociodemographic variables</u>								
18-25 years	(vs 26-45 years)	-0.3540***	-0.2975***	-0.7477***	-0.2654***	-0.4845***	0.2673***	-0.3929***
46-65 years	(" " ")	0.2386***	0.1639**	0.7665***	0.5182***	0.0858	-0.0101	0.6279***
Over 65 years	(" " ")	0.8283***	0.3611***	1.2603***	0.8639***	0.0837	-0.1943*	0.9376***
Unmarried and cohabitinged	(vs married)	-0.1160	0.1303	-0.1129	-0.0223	-0.0230	0.1164	0.2170*
Single and living alone	(" ")	-0.0618	0.0175	-0.0377	-0.1619***	0.1618***	-0.0184	0.1184*
Rural area	(vs town with a pop. of 1,000 - 100,000)	-0.0244	-0.1170	-0.1150*	-0.1158*	-0.2319***	0.1477*	-0.2137**
Town with a population of over 100,000	(" " " ")	-0.0493	0.0992*	-0.0053	-0.0610	0.0945*	0.1690**	-0.0227

Source: INSEE "Survey on Living Conditions", 1986-1987.