Smoking Behavior and Rank-Dependent Expected-Utility

Christophe Courbage*

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1. Introduction

Information on and perception about risk play a fundamental role in the context of smoking decisions. Individuals do make smoking decisions based on risk information, but they tend to estimate poorly smoking risks due to important information gaps (Viscusi, 1992). Various studies confirm this behaviour even if they provide contrary results. For instance, using data from the U.S.A., Schoenbaum (1997) shows that smokers are likely to underestimate the probability of survival at age 75. Along the same line, Sloan, Smith and Taylor (2001) point out that smokers are too optimistic about their own longevity risk. This may make one think that better information would help to deter people from smoking, a view confirmed by Hsieh, Yen, Liu and Lin (1996) who find that anti-smoking campaigns reduce the probability of smoking in Taiwan. Other studies, among which Viscusi, Carvalho, Antonanzas, Rovira, Brana and Portillo (2000), on the contrary, indicate that smokers in Spain overestimate the risk of smoking suggesting that improved information on smoking risk might lead to a greater consumption of cigarettes amongst smokers. Overestimation of smoking risk is also assumed in Zweifel (2001) who theoretically addressed, under the Expected Utility theory, the conditions in which better information increases the demand for cigarettes.

The aim of this note is to analyse, under a very general model of decision, namely the Rank-Dependent Expected-Utility model (Quiggin, 1982; Yaari,
how the effect of improved information on smoking risks impacts the consumption of cigarettes. Our choice of Rank-Dependent Expected-Utility (RDEU) rests upon two reasons. First, the Expected Utility theory, as a model of decision, appears to be unsatisfactory from a descriptive point of view (Stamer, 2000), and RDEU is now recognised as the prominent alternative model to Expected Utility theory. Second, RDEU enables one to incorporate and disentangle the effects of concavity of the utility function on the one hand (which corresponds to the notion of risk aversion in the Expected Utility theory) and of probability transformation on the other hand (which can be used to incorporate the effect of pessimism or optimism), and then allows the analysis to take into account the way individuals perceive smoking risks.

It turns out, under RDEU, that in addition to the sign of the marginal utility of wealth with respect to health, the properties of the probability transformation function are crucial to determine the effects of improved information on the consumption of cigarettes.

Our note is organised as follows. In section 2, the basic model is presented. In section 3, the results are provided and interpreted. Finally, we conclude in section 4.

2. The Model

Let us consider an individual with an initial wealth \( Y \). This individual smokes and consumes cigarettes, \( c \), which leads to an increase in the probability of being sick, \( \pi \) (with \( \partial \pi / \partial c > 0 \)). Let \( M \) be the level of medical care in the event of sickness, with its price normalized at 1 and \( p \) the price of cigarettes.

Let \( u'() \), \( i = s, h \), a VNM state dependent utility function, where \( u'(\cdot) \) represents utility in case of sickness and \( u'^h(\cdot) \) in case of good health, and with \( u'^h(\cdot) > u'(\cdot) \). Smokers enjoy smoking cigarettes and they also derive satisfaction from it. Let \( d(\cdot) \) be the satisfaction of smoking, which is an increasing and concave function. Smoking satisfaction is separated from the utility function as we assume that the marginal utility of cigarettes is the same in both states. Note that the marginal utility of cigarette consumption could be different depending on the state of health. However, this is excluded on the grounds that it is not at all clear whether the marginal utility increases or decreases.

We assume that the individual is a Rank-Dependent Expected-Utility maximiser (Quiggin, 1982; Yaari, 1987), such that probabilities are treated in a nonlinear way. RDEU allows for a distortion of probabilities and makes it possible to integrate individuals’ perception with regards to smoking risk.
The valuation function is:

\[ L = f(\pi(c)) \cdot u'(Y - M - pc) + (1 - f(\pi(c))) \cdot u'(Y - pc) + d(c) \]  

(1)

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

Individual perception with regard to risk is conveyed in the properties of the function \( f \) which transforms probabilities of the true probability function of possible outcomes into subjective probabilities. Indeed, if \( f \) is concave, the individual is said to be pessimistic as he increases subjectively the objective probability of bad events, and on the contrary reduces that of good events\(^1\). Conversely, if \( f \) is convex, the individual is said to be optimistic as he underweights bad results, to the advantage of good ones. Naturally, when \( f \) is linear \( (f(\pi) = \pi) \), RDEU reduces to Expected Utility theory.

Let us use the following shorthand notations: \( y_s = Y - M - pc \) and \( y_h = Y - pc \).

The first order condition for an optimum is:

\[
\frac{\partial L}{\partial c} = (u'(y') - u'(y_h)) \frac{\partial f}{\partial \pi} \frac{\partial \pi}{\partial c} + \left( \frac{\partial u'}{\partial y'} - \frac{\partial u'}{\partial y_h} \right) pf(\pi(c)) - p \frac{\partial u'}{\partial y'_s} + \frac{\partial d}{\partial c} = 0
\]

(2)

Let \( \hat{c} \) be the solution of equation (2).

We assume that the second order conditions for a maximum are satisfied, i.e. \( L \) concave in \( c \). It turns out that we cannot guarantee that \( L \) is concave without placing additional restrictions on the utility function. As commonly done in the literature, we assume that \( L \) is concave without examining these restrictions explicitly.

3. Improved Information on Smoking Risks

In the present model, information is very closely related to subjective probability, and improved information on smoking risk is described by a less concave or less convex transformation function depending on whether one considers that the individual overestimates or underestimates smoking risks. Thus, the less the

\(^1\) As concavity of \( f \) implies \( f(\pi) \geq \pi \), CHATEAUNEUF and COHEN (1994) dissociate strong pessimism \( (f \text{ concave}) \) from weak pessimism \( (f(\pi) \geq \pi) \); the same distinction applying to optimism. The present article deals with optimism and pessimism in the strong sense.
function transforms probability, the better the information is. At the extreme, perfect information is presented by a linear transformation function. In that case, the valuation function is given by:

$$H = \pi(c) u'(y') + (1 - \pi(c)) u^k(y^k) + d(c)$$  \hspace{1cm} (3)

The first order condition with respect to $c$ is:

$$\frac{\partial H}{\partial c} = (u'(y') - u^k(y^k)) \frac{\partial \pi}{\partial y} - \left( \frac{\partial u^k}{\partial y} \frac{\partial \pi}{\partial c} - \frac{\partial u'}{\partial y} \right) + \frac{\partial d}{\partial c} = 0$$  \hspace{1cm} (4)

Let $c^*$ be the solution of equation (4).

The passage from $L$ to $H$ represents improved information on the risk of smoking.

In order to study the effect of improved information on cigarette consumption, let’s compare $\hat{c}$ to $c^*$.

We evaluate $\frac{\partial L}{\partial c}$ at $c^*$:

$$\frac{\partial L}{\partial c} = (u'(y') - u^k(y^k)) \left( \frac{\partial f}{\partial \pi} - 1 \right) \frac{\partial \pi}{\partial c} + \left( \frac{\partial u^k}{\partial y} \frac{\partial \pi}{\partial c} - \frac{\partial u'}{\partial y} \right) \left( f(\pi(c)) - \pi(c) \right) p$$  \hspace{1cm} (5)

Because we assume that $L$ is concave in $c$, $\hat{c}$ will be larger than $c^*$ if equation (5) is negative. The opposite arises if equation (5) is positive.

Three terms of equation (5) are not signed, these are

$$A = f(\pi(c)) - \pi(c), \quad B = \left( \frac{\partial f}{\partial \pi} - 1 \right), \quad \text{and} \quad C = \left( \frac{\partial u^k}{\partial y} - \frac{\partial u'}{\partial y} \right)$$

With regard to the first term, $A$, its sign depends on whether one considers that the individual overestimates or underestimates smoking risk. Indeed, it is not totally clear in which direction the information gap goes. As said earlier, if some empirical studies (e.g. Viscusi, 1992; Viscusi, Carvalho, Antonanzas, Rovira, Brana, and Portillo, 2000) suggest that individuals overestimate smoking risks, others suggest that individuals may also underestimate those risks (Schoenbaum, 1997; Sloan, Smith and Taylor, 2001). Hence, if $f$ is concave,
the individual is pessimistic and overestimates smoking risk leading to $A \geq 0$.

The result is opposite for $f$ convex.

Regarding the second term, $B$, $\partial f / \partial \pi$ corresponds to the slope of the function $f$. Therefore, as $f$ is increasing, if $f$ is concave (convex), then $\partial f / \partial \pi < (>) 1$ for small $\pi$ and $\partial f / \partial \pi > (<) 1$ for high $\pi$ i.e. close to one.

Turning to the third term, $C$, it is commonly assumed in the literature that it is positive in that the marginal utility of wealth increases with health. Enjoyment of additional material goods would require good health (see Zweifel and Breyer, 1997). Evans and Visconti (1991) find support for this assumption in the case of severe injuries. For minor injuries, however, it can be negative (Evans and Visconti, 1991).

As a first comment, and contrary to Zweifel (2001), from equation (5) it is easy to show that, in case of overestimation, an increasing marginal utility of wealth with respect to health is not a sufficient condition for improved information leading to an increase in the consumption of cigarettes. The level of probability needs also to be considered. From equation (5), depending on the signs of $A$, $B$ and $C$, we derive the following conclusions:

If one supposes that individuals overestimate (underestimate) smoking risks, the passage from incomplete to full information leads to:

(i) A decrease (increase) in the consumption of cigarettes for a high level of illness probability and if the marginal utility of wealth increases with respect to health;

(ii) An increase (decrease) in the consumption of cigarettes for a low level of probability and if the marginal utility of wealth decreases with respect to health.

These results have an intuitive interpretation. Because individuals transform the probability of illness, their perception of the variation of the occurrence of the illness depends on the level of the probability. Indeed, when $f$ is concave, the higher the probability of illness, the smaller the impact of the variation of $\pi$ on $f$. Thus, for a high level of probability, consumption of cigarettes is perceived as weakly increasing the occurrence of the illness relative to a situation where the probability is not transformed. Better information makes the individual perceive cigarette consumption as more harmful for health. If, in addition, marginal utility of wealth is higher in the state of good health, it explains why the individual decreases his consumption of cigarettes, i.e. item (i). For a low level of

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2 Such interpretation partially follows Courbage (2001) where a similar modelisation was used to look at the interaction between prevention decision and insurance.
probability, the opposite effect arises. Consumption of cigarettes is perceived as strongly increasing the occurrence of the illness relative to the situation where the probability is not transformed. Better information makes the individual perceive cigarette consumption as less harmful for health. Coupled with marginal utility of wealth being higher in case of illness, this explains why in this situation better information leads to an increase in the consumption of cigarettes, i.e. item (ii).

Conversely, the results are opposite when individuals underestimate smoking risks ($f_{\text{convex}}$).

4. Conclusion

Our analysis can be helpful in terms of public health in the sense that providing smokers with better information on smoking risks, through health scare or anti-smoking campaign for instance, does not necessarily make cigarette consumption decrease. It may even increase it. Other points need also to be taken into account such as the prevalence of illness amongst smokers, pessimism or optimism behaviours, and the sensibility of the marginal utility of wealth with respect to health. However, there is still controversy regarding these last points. At present no consensus exists either on the extent and direction of biases in risk perception, or on the interaction between health and wealth in individual utility functions that best fits observed behaviours (see Rey and Rochet, 2004).

The present work assumes that biases in risk perception could be corrected through better information provided to individuals by public authorities or other stakeholders. Yet it seems to be that, very often, change in risk perception is the consequence of a personal health shock such as heart attack, stroke or lung cancer. These shocks are recognized as a source of information that can lead people to change their behavior (Sloan, Smith and Taylor, 2003). Making information on smoking risks endogenous would thus be a challenging topic for future research.
References


In this note we use the Rank-Dependent Expected-Utility (RDEU) model to theoretically analyse how the effect of improved information on smoking risks impacts the consumption of cigarettes. The RDEU model makes it possible to incorporate the ways individuals perceive smoking risks. We provide conditions on the utility function and on the probability of illness by which individuals modify their cigarette consumption in the face of improved information.

ZUSAMMENFASSUNG


RÉSUMÉ

Dans cette note nous utilisons le modèle d’utilité dépendante du rang pour analyser théoriquement comment les effets d’une meilleure information sur le risque de fumer modifient la consommation de cigarettes. Le modèle d’utilité dépendante du rang permet d’incorporer la façon dont les individus perçoivent le risque de fumer. Nous donnons des conditions sur la fonction d’utilité et sur la probabilité de maladie pour lesquelles les individus modifient leur consommation de cigarettes suite à une meilleure information sur ce risque.