Optimal Health Prevention and Savings: How to deal with Fatalism? ∗

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Abstract

In this paper, we analyze the determinants of primary prevention and the social optimum. First, we analyze optimal decisions on primary prevention and savings when individuals face a health risk involving expenses that can not be covered by any insurance (private or public). To manage health risks, individuals have two possibilities: invest in primary prevention, in order to reduce the probability of the disease and/or save, in order to face the costs of the disease that are not covered by insurance. We show that the impact of wealth and interest rates on prevention and savings decisions strongly depends on the perceived substitutability between health and wealth. Moreover, agents have their own risk perceptions which influence their decisions. In the second part of the paper, as prevention generates externalities, individuals’ optimal levels of prevention are lower than the socially optimal ones. In this context, we analyze the social optimum and its decentralization by tax-financed government subsidies on prevention expenses.

Key words: health risk, primary prevention, savings.

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1. Introduction

According to an estimate by the centers for Disease Control and Prevention, total spending on prevention in the US in the nineties (around 0.8% of GNP) is significantly lower than the levels recommended by major professional organizations such as the US Preventive Services Task Force and the American Cancer Society (Brown et al., 1991). In France, prevention expenses are evaluated at about 0.6% of GDP in 2002. In this same year, the French Codex of social security was modified in order to give more importance to prevention in public health policy.

The aim of this paper is to determine the determinant of individuals decisions on primary prevention and savings, and their consequences on the public policy, when individuals face a health risk involving expenses that cannot be covered by any insurance (private or public). Indeed, contrarily to treatment, the effects of prevention decisions often appear after a long period of time. Thus, prevention decisions have to be considered in a long term setting and naturally interact with savings decisions.

The theoretical literature on prevention has essentially developed in two main directions: one using human capital models, in which prevention is considered as a special type of investment in human capital (see Grossman, 1972, Ehrlich, Chuma, 1990, etc.); and the other focusing on individual decisions concerning prevention under risk. We are particularly interest in the second approach. The classic paper by Elhrich, Becker (1972) explores the moral hazard problems caused by insurance in an expected utility model where consumers have uncertainty about two possible states of the world. Consumers can protect themselves from risk by purchasing market insurance, self-insuring, or engaging in self-protection. They use the term self-protection to describe primary prevention which we analyze in this paper. Self-insurance includes those activities that reduced the size of the loss once the state occurs. This is a close analog to secondary prevention in the public health literature. One of their main results is that secondary prevention is a substitute for insurance as it leads to the same type of risk reduction as insurance does under complete information. Moreover, when preventive effort is not observable to the insurer, the presence of market insurance reduces self-protection. In health economics literature, the effects of insurance on prevention have come to be referred to as ex ante moral hazard. This differentiates it from the type of moral hazard that occurs ex post the realization of the health state (for a survey of the theoretical literature in this area, see Zweifel et al., 2009). Recently there has been great interest in secondary prevention (Barigozzi, 2004; Kenkel, 2000; Newhouse, 2006) which in our framework differs from primary prevention in two dimensions. First, the consumers who benefit from secondary prevention have already realized an unfavorable state of nature, and primary prevention may prevent whatever the state of nature. The other feature of secondary prevention is that often it combines elements of treatment and prevention and in our framework, treatment cost is given for individuals but it can be modified by a health prevention policy.

There is also a literature on the trade-offs between insurance and savings. As
observed by Dionne and Eeckhoudt (1984), for nonactuarial premia, it is not true that insurance is always more efficient than savings for the purpose of protection. Gollier (1994) show that when insurance is costly, under some conditions, partial insurance coverage is dominated by precautionary savings and self-insurance a long run setting. In a health context, simulations by Kotlikoff (1986) and Hubbard, Skinner and Zeldes (1995) have suggested that uncertain medical costs could have great effects on individual savings behavior. It has been empirically shown by Levin (1995) for elderly.

Some recent proposals, such as the Medicare Health Savings Accounts, permits to an individual and/or an employer to contribute pre-tax dollars to pay for most health care services (Nichols et al., 1996, Pauly and Herring, 2000). The concept of Medical Savings Accounts, existing in the United States, can illustrate the importance of savings for health risk coverage (see Moon et al., 1996 and Courbage, 2006). Cardon and Showalter (2007) model the interaction between insurance choice and the dollar amount to allocate to a tax-preferred health savings account. Their simulations show that the availability of HSAs will lead to large increases in savings specically for health expenditures. More recently, Gandjour (2009) shows that aging diseases in added years of life may prevent prevention from cost savings: the additional expenditures for aging diseases are not compensated by savings. Consequently, the prevention motive is clearly determinant.

Moreover, the way people perceive risks is often subjective and intuitive and they frequently view risks in a way that differs from scientific assessments. At the individual level, perceptions would determine whether or not appropriate actions will be taken, while at the societal level, these would drive the agenda of public health agencies. Many studies have demonstrated the importance of probability distortion in risky choice, both for monetary outcomes (Tversky and Kahneman, 1992; Camerer and Ho, 1994; Wu and Gonzalez, 1996; Gonzales and Wu, 1999; Abdellaoui, 2000) and for health outcomes (Bleichrodt and Pinto, 2000). As Brewer et al. (2007) showed the consistent relationships between risk perceptions and behavior suggest that risk perceptions are rightly placed as core concepts in theories of health behavior.

A formal theory of probability distortion is Rank Dependent Utility model (Quiggin, 1982, Yaari, 1987) that we use in this paper, which involves, in addition to standard utility function, a probability transformation function that can reflect pessimism or optimism. To focus on the trade-off between primary prevention and savings, we ignore the insurance choices. Our paper explores the relationship between health prevention and savings decisions at the individual and social level. We consider a two-period model. Individuals, whose utility functions depend both on consumption and health, face a health risk which probability of occurrence is perfectly known. To manage the health risk, individuals have two possibilities: invest in primary prevention, which reduces the probability of the disease, and/or save, in order to face the costs of the disease that are not covered by a public or private insurance.

The main results that concerning the impact of risk perception on optimal prevention, two types of pessimist have to be distinguished: the moderate pe-
simists and the fatalists. The moderate pessimists overestimate the probability of disease and can overreact by choosing a relatively high level of prevention. Fatalists, who can also be pessimists, do not believe in the efficiency of prevention and thus invest less in it. The understanding of individual behaviors allows us to better analyze the role of risk perception on public policy. As a result, the treatment cost can depend on the number of patients. For some pathologies, the cost admits some decreasing returns to scale (scanner, Magnetic Resonance Imaging (MRI)); for others, it can be an increasing function (for example, in the case of epidemics, some congestion can appear in hospitals). Individuals levels of prevention are thus lower than the socially optimal ones. This gives room for public intervention in order to restore optimality. We propose a public policy, financed by taxes, and combining subsidies for prevention with partial financing of health expenses.

The paper is organized as follows. In Section 2, we state the model and analyze the optimal savings and prevention decisions. In Section 3, we determine the social optimum and we propose to decentralize it by introducing a public health insurance system and a system of prevention subsidies. Section 4 is devoted to some simulations. Section 5 contains a brief conclusion.

2. Individual choice

Individuals live for two periods and derive utility from consumption and health quality in their two periods of life. They face a health risk. For simplicity, we assume that there are only two states of health at each period. With probability \( p \), an individual falls ill in the second period of life. There is a (imperfect) treatment for this disease and we assume that all agents adopt this treatment. After the treatment, the individual’s health status is \( H = H' \). With probability \( (1 - p) \), the individual remains in good health, \( H = H > H' \).

Agents’ preferences are assumed separable in time. Moreover, their preferences under risk are represented by the RDU model as follows:

\[
U(c, H) + \delta E\varphi U(\tilde{d}, H) = U(d, H) + \varphi (1 - p) [U(d, H) - U(d, H)]
\]

where \( c \) and \( d \) are respectively consumptions at period 1 and 2, \( \delta \) the discount factor and function \( E\varphi U(\tilde{d}, H) \) writes:

\[
E\varphi U(\tilde{d}, H) = U(d, H) + \varphi (1 - p) [U(d, H) - U(d, H)]
\]

\[
= [1 - \varphi (1 - p)] U(d, H) + \varphi (1 - p) U(d, H)
\]

with \( \varphi \) an increasing and differentiable function : \([0, 1] \rightarrow [0, 1]\), which transforms the probability distribution. Function \( U(,,) \) is assumed to be twice continuously differentiable, strictly increasing and strictly concave with respect to its two arguments. We assume that \( \lim_{c \rightarrow 0} U'_c(c, H) = +\infty \) so that consumption is always positive.
Remark 1. Attitude toward risk is characterized by the properties of functions \( U \) and \( \varphi \). An individual will be called pessimist if \( \varphi(q) < q, \forall q \in [0,1] \) and optimist in the opposite case. Pessimism is well emphasized in our case of two states of nature. Indeed, as \( (\tilde{d}, \tilde{H}) \) takes only two values \((\underline{d}, \underline{H}) \) and \((\overline{d}, \overline{H}) \), with \( \underline{d} < \overline{d} \) and \( \underline{H} < \overline{H} \), it appears that a pessimistic (optimistic) agent will underestimate (overestimate) the probability of the good state of nature: \( \varphi(1-p) < (>)1-p \) and overestimate (underestimate) the probability of the bad state of nature: \( 1-\varphi(1-p) < (>)p \). Let us notice also that pessimism increases when \( \varphi(1-p) \) decreases.

At the first period, agent \( i \), whose health status, \( H_0 \), is given, receives an income, \( w_i \), pays taxes \( \tau w_i \) and consumes \( c_i \). To warm against the health risk, two tools are available: prevention and savings. S/he has the possibility of investing a part of his/her net income in primary prevention, \( h_i \), which marginal individual cost is \((1-\theta)\) \(^3\), and in savings, \( s_i \), with return, \( R = 1 + r \), where \( r \) is the interest rate. Primary prevention reduces the probability of the disease according to the following prevention technology: an expense of \( h \) in prevention leads to a probability of illness of \( p(h) \) with \( p'(.) < 0 \) and \( p''(.) \geq 0 \), \( 0 < p(0) < 1 \).

Let us denote by \( T \) the given cost of the treatment paid by patients. Cost of treatment cannot be influenced by the individual. Through prevention, the individual is assumed to be able to influence the probability distribution of health care expenditure. But once the event “illness” is realized, the cost of treatment is exogenously fixed.

In her/his second period of life, agent \( i \) consumes all her/his net income that is savings return, \( R s_i \), minus the potential net treatment costs, \((1-\rho)\) \( \tilde{T} \), where \( \tilde{T} \) takes two values, \( T \) with probability \( p \) and 0 with probability \( 1-p : \tilde{d}_i = d_i - (1-\rho)\) \( \tilde{T} \) with \( d_i = R s_i \) and where \( (1-\rho) \) is the co-payment rate applied to the treatment.

Agent \( i \)'s prevention and saving levels are solutions of the following program:

\[
\begin{align*}
\max_{s_i, h_i \geq 0} & \quad U (w_i (1-\tau) - s_i - (1-\theta) h_i, H_0) + \\
& \delta \left[ (1-\varphi(1-p(h_i))) U (R s_i - (1-\rho) T, H) + \varphi(1-p(h_i)) U (R s_i, \overline{H}) \right]
\end{align*}
\]

The following assumption guarantees that the second order conditions are verified:

**Assumption A1.**

\(^3(1-\theta)\) is the co-payment rate applied to the cost of prevention which is equal to 1.
For all \( c > 0, \ d > 0, \) and \( H, \) one has \(^4\)
\[
V_{ss} \equiv U_{11}(c, H_0) + \delta R^2 E U_{11}(d, H) < 0, \\
V_{hh} \equiv U_{11}(c, H_0) + \delta [\varphi' (1 - p(h)) p''(h) - \varphi'' (1 - p) (p'(h))^2] \\
[U (d - T, \underline{H}) - U (d, \underline{H})] < 0 \\
V_{ss} V_{hh} - (V_{sh})^2 > 0 \\
V_{sh} \equiv U_{11}(c, H_0) + \delta R p'(h) \varphi'(1 - p(h)) [U_1(d - T, \underline{H}) - U_1(d, \underline{H})].
\]

Let us remark that expression \( V_{sh} \) can be positive, negative or nil. Its sign depends on the sign of \([U_1(d - T, \underline{H}) - U_1(d, \underline{H})]\) and thus on the second cross derivative \( U_{12}(c, H) \) which can be positive or negative. A common assumption in the literature is that \( U_{12}(c, H) \geq 0. \) As it has been showed by Viscusi and Evans (1990) and Sloan et al. (1998), this assumption is reasonable in the case of severe injuries. For minor one, Evans and Viscusi (1991) find that \( U_{12}(c, H) \) could be negative.

For agent \( i, \) the optimal conditions are

\[
V_{s_i} \equiv -U_1(c_i, H_0) + \delta R [(1 - \varphi (1 - p(h_i))) U_1 (Rs_i - (1 - \rho) T, \underline{H}) \\
+ \varphi(1 - p(h_i)) U_1 (Rs_i, \underline{H})] = 0
\]

\[
V_{h_i} = - (1 - \theta) U_1 (c_i, H_0) + \delta \varphi' (1 - p(h_i)) p'(h_i) \times \\
[U (Rs_i - (1 - \rho) T, \underline{H}) - U (Rs_i, \underline{H})] = \begin{cases} 
0 & \text{if } h_i > 0 \\
\leq 0 & \text{if } h_i = 0 
\end{cases}
\]

(i) The first condition (2) is the trade-off condition between consumptions over the life cycle.

For a given level of prevention, we find that savings have the usual properties: an increasing function of first period income, \( w_i, \) increasing function of \( T, \) and the effect of an increase in interest rate is indeterminate.

(ii) Regarding the second condition (3), the level of prevention is strictly positive when

\[
-(1 - \theta) U'_1(w_i(1 - \tau) - s_i, H_0) + \delta \varphi'(1 - p(0)) p'(0)[U(d_i - (1 - \rho) T, \underline{H}) - U(d_i, \underline{H})] > 0
\]

for a given \( s_i. \)

\(^4\)index \( i \) denotes the first derivative with regards to the \( i^{th} \) argument and index \( ii \) the second derivative.
This condition is always verified under the assumption \( \lim_{h \to 0} p'(h) = -\infty \) which means that an increase in primary prevention is infinitely efficient around zero.

Let us consider the case where \( h_i > 0 \), (3) rewrites

\[
(1 - \theta) U_1 (c_i, H_0) = \delta \varphi' (1 - p (h_i)) p' (h_i) [U (d_i - (1 - \rho) T, H) - U (d_i, H)]
\]

The right-hand side of equation (4) represents the increase in utility due to a reduction in the perceived probability of illness due to an increase of one unit \( h_i \). The left-hand side shows the loss of utility due to the reduction of the disposable income for savings and consumption. This condition (close to the standard one in prevention literature) says that the individually optimal level of prevention equals the marginal cost with the marginal benefits of prevention.

For a given level of savings, the level of prevention increases with the income and with the part of the treatment cost paid for by the individual, \((1 - \rho) T\).

2.1. Analysis of savings and prevention choices

The consumer i optimal choice is the level of savings, \( s_i = \hat{s}_i (w_i, \tau, \theta, R, T, \rho) \) and prevention, \( h_i = \hat{h}_i (w_i, \tau, \theta, R, T, \rho) \), solutions of equations (2) and (3). The impact of different parameters on optimal savings and prevention strongly depends on the preference relation between wealth and health. Thus, we have to distinguish two cases according the sign of \( U_{12} (c, H) \).

If \( U_{12} (c, H) \leq 0 \), the effects of \( w_i, \tau, \theta, T \), and \( \rho \) on savings and prevention are ambiguous.

If \( U_{12} (c, H) > 0 \), the following table sums up the comparative statics results:

<table>
<thead>
<tr>
<th>Effects on ( s_i )</th>
<th>Effects on ( h_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( w_i )</td>
<td>+</td>
</tr>
<tr>
<td>( \tau )</td>
<td>-</td>
</tr>
<tr>
<td>( \theta )</td>
<td>+</td>
</tr>
<tr>
<td>( T )</td>
<td>+</td>
</tr>
<tr>
<td>( \rho )</td>
<td>-</td>
</tr>
</tbody>
</table>

The previous results can be interpreted in the following way.

(i) Effects of an increase in first-period net revenue.

When the first-period net revenue increases, first-period and second-period consumption increases, thus \((s_i + h_i)\) increases but there are two effects on each decision variable.

A positive direct effect. When income increases, as savings and health prevention are normal goods, the individual is incited to increase each variable.

5See appendix 1.
A positive or negative cross effect. If the marginal utility of consumption is an increasing function of health, the first effect is reinforced. Else, the increase in savings incites individual to decrease health prevention and conversely. This second effect is opposite to the first one and consequently, the total effect is ambiguous.

(ii) Effects of an increase in treatment cost paid by patients.

Our results imply that an increase in treatment cost is not always a good tool for increasing prevention. Its impact results from the respective magnitude of two effects.

A positive direct effect. When the treatment cost increases, as savings and health prevention are normal goods, the individuals tend to increase the two variables.

A positive or negative cross effect. If the marginal utility of consumption is an increasing function of health, the first effect is reinforced. Else, the substitution effect can overperform the first effect and lead to a decrease in one of the variables. The total effect can be negative for one of the variables if there is a large gap between the efficiency of the two tools in risk reduction.

2.2. Prevention and risk perception

A key question of interest in this paper concerns the impact of risk perception (probability transformation function $\varphi$) on the individually optimal prevention level $h$. More precisely, we compare the level of prevention of a realistic individual, that is, $\varphi(p) = p$ with the level of a pessimistic or optimistic one.

2.2.1. Case of a given level of savings

We first consider the case where savings level $s$ is given. The impact of risk perception only depends on the perception of a modification of probabilities.

Lemma 1. Consider 2 individuals differing only in their probability transformation functions, denoted by $\varphi_1$ and $\varphi_2$. Then, for a fixed level of savings, $h_2 > h_1$ $\iff$ $\varphi_2'(1-p(h_2)) > \varphi_1'(1-p(h_2))$.

Proof. Let us denote by $V^i_h_i(h_i), i = 1, 2$ the first order condition (4) for individual $i$. $h_2 > h_1$ $\iff$ $V^i_{h_i}(h_2) < 0$ $\iff$ $V^1_{h_1}(h_2) < V^2_{h_2}(h_2)$ which for fixed $s$ is true for $\varphi_2'(1-p(h_2)) > \varphi_1'(1-p(h_2))$ because $p'(h_i) [U(d_i - T, H) - U(d_i, H)] > 0$ for any $h_i$ and $d_i$. 

For a deeper interpretation of the properties of probability transformation function, we have to distinguish two types of non-realist: the moderate and the fatalist.

Definition 1. An individual with a probability transformation function $\varphi$ is called fatalist if, for any $p \in ]0, 1[$, $\varphi'(p) < 1$. 

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Note that for this property \( (\varphi'(p) < 1) \) to be satisfied for a function \( \varphi \) with \( \varphi(0) = 0 \) and \( \varphi(1) = 1 \), it is necessary that the probability transformation function presents discontinuities in 0 and/or in 1. These discontinuities are plausible and justified by the well known potential and certainty effects.

Fatalists perceive the probability of the disease as being relatively stable and do not trust in its possible reduction by preventive measures. More generally, these individuals underestimate the modification of probabilities and in the same way, underestimate prevention efficiency. The difference between optimistic and pessimistic fatalists is that optimists overestimate the probability of the good state of nature (no disease) while pessimists underestimate it.

**Definition 2.** An individual with a convex probability transformation function \( \varphi \) is called **moderate pessimist** if there exists \( \overline{p} \in [0,1] \) such that, for any \( p < \overline{p}, \varphi'(p) < 1 \) and for any \( p \geq \overline{p}, \varphi'(p) \geq 1 \).

An individual with a concave probability transformation function \( \varphi \) is called **moderate optimist** if there exists \( \overline{p} \in [0,1] \) such that, for any \( p < \overline{p}, \varphi'(p) > 1 \) and for any \( p \geq \overline{p}, \varphi'(p) \leq 1 \).

An individual with \( \varphi(p) = p \) (and thus \( \varphi'(p) = 1 \)) for any \( p \in [0,1] \) is called **realist**.

Following those definitions, we obtain that:

**Proposition 1.** The prevention level only depends on the individual level of fatalism.

**Proof.** Direct consequence of Lemma 1. ■

Contrary to the intuition, the demand for health prevention depends on the level of fatalism and not on pessimism or optimism. It implies that a pessimist (\( \varphi(p) < p \)) and an optimist (\( \varphi(p) < p \)), if they are fatalists, can choose the same level of prevention. For a more intuitive interpretation, let us now compare optimal prevention levels of fatalists, moderate pessimists and optimists, and realists.

First, consider the case of pessimists and denote by \( h^r, h^{mp} \) and \( h^f \) the realist, moderate pessimist and fatalist optimal prevention levels for a given level of saving. From Proposition 1 and Lemma 1, we obtain that \( h^r > h^f \). The case of moderate pessimist is more complex since moderate pessimist can make more or less prevention than realists. It depends on the maximal probability of disease, \( p(0) \), and the minimal probability of disease, \( p(w) \).

Remember that \( \overline{p} \) denotes the benchmark value for a pessimistic individual, we obtain that (i) if \( p(0) < \overline{p} \), then \( h^{mp} > h^r \), (ii) if \( p(w) > \overline{p} \), then \( h^{mp} < h^r \) and (iii) if \( p(w) \leq \overline{p} \leq p(0) \), both \( h^r < h^{mp} \) and \( h^r > h^{mp} \) are possible. This is illustrated in Figure 1.
Second, consider the case of optimists and denote by $h^{r}$, $h^{mo}$ and $h^{f}$ the realist, moderate optimist and fatalist optimal prevention levels for a given level of saving. As for the pessimists, we obtain that $h^{r} > h^{f}$. The comparison between moderate optimist prevention and realist one depends on the maximal probability of disease, $p(0)$, and the minimal probability of disease, $p(w)$. Remember that $\overline{p}$ denote the benchmark value for a optimistic individual, we obtain that (i) if $p(0) < \overline{p}$, then $h^{mo} > h^{r},$(ii) if $p(w) > \overline{p}$, then $h^{mo} > h^{r}$ and (iii) if $p(w) \leq \overline{p} \leq p(0)$, both cases are possible. This is illustrated in Figure 2.

\begin{center}
INSERT FIGURE 2
\end{center}

2.2.2. Optimal levels of savings and prevention

The analyzing of the impact of risk perception on both $s$ and $h$, needs some more assumptions on the link between consumption and health.

**Proposition 2.** Consider 2 individuals differing only in their probability transformation functions, denoted by $\varphi_1$ and $\varphi_2$.

(i) If $U_{12} \leq 0$, then $s_1 > s_2$ and $h_2 > h_1$ if $\varphi_1(p) > \varphi_2(p)$ for any $p \in [0, 1]$ and $\varphi'_2(1 - p(h_2^2)) > \varphi'_1(1 - p(h_2^2))$.

(ii) If $U_{12} > 0$, then $s_1 > s_2$ and $h_2 > h_1$ if $\varphi_2(p) > \varphi_1(p)$ for any $p \in [0, 1]$ and $\varphi'_2(1 - p(h_2^2)) > \varphi'_1(1 - p(h_2^2))$.

**Proof.** From optimal condition (3), we obtain an implicit function $s(h)$ and thus, from optimal condition (4), we obtain an implicit function of $h$ denoted by $V^\varphi_h(s(h), h) = 0$ when the transformation function is $\varphi$. Notice that $V^\varphi_h$ is a decreasing function of $h$.

Thus, we obtain that $h_2 > h_1$ iff $V^\varphi_h(s_2(h_2), h_2) > V^\varphi_h(s_1(h_2), h_2)$.

(i) Suppose $U_{12} \leq 0$ then $s_1(h) > s_2(h)$ if $\varphi_1(p) > \varphi_2(p)$ for any $p \in [0, 1]$. Consequently, the above inequality is verified under the condition $\varphi'_2(1 - p(h_2^2)) > \varphi'_1(1 - p(h_2^2))$.

(ii) Suppose $U_{12} > 0$, then $s_1(h) > s_2(h)$ if $\varphi_1(p) < \varphi_2(p)$ for any $p \in [0, 1]$ and the above inequality is verified under the condition $\varphi'_2(1 - p(h_2^2)) > \varphi'_1(1 - p(h_2^2))$.  

Let us first compare pessimists and realists behaviors.

The comparison between realists and moderate pessimist is trivial in the case where $U_{12} \leq 0$. Indeed, on one hand, due to $\varphi'^{mp}(p) > 1$, for a given level of savings, $h_r < h_{mp}$ and on the other hand, due to $\varphi'^{mp}(p) < 1$, for a given level of prevention, $s_r > s_{mp}$. These two effects are not opposite in the case of $U_{12} \leq 0$. We now compare the optimal decisions of a pessimistic fatalist and a realist. Due to $\varphi^{f}(p) < p$ and $\varphi'^{f}(p) < 1$, we obtain two direct effects: $s_f > s_r$ and $h_f < h_r$ and these direct effects are not opposite if $U_{12} > 0$. 

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The case where $U_{12} \leq 0$ is no trivial and it is impossible to obtain an unambiguous result without specifying the utility function. Indeed, two opposite effects can be distinguished: firstly, pessimism incites individuals to decrease their level of savings and thus to increase their level of prevention; secondly, fatalism incites individuals to decrease their level of prevention. Finally, the total effect of risk perception is not clear.

Let us turn to the optimists. Contrary to the case of pessimism, we obtain unambiguous effect when $U_{12} \leq 0$. In this case, $s_f > s_r$ and $h_f < h_r$. Indeed, optimism incites individuals to decrease their level of prevention and this effect is reinforced by fatalism.

The case of moderate optimists is more complex. If $U_{12} > 0$ and $\varphi^{mo}(p) > 1$, then $s_{mo} > s_r$ and $h_{mo} < h_r$.

3. Social optimum

We consider that the population is divided into $n$ groups with respect to risk perception. We assume that there is a given proportion $\pi_i$ of agents of type $i$, $i = 1$ to $n$. $\sum_{i=1}^{n} N \pi_i p(h_i)$ represents the number of agents who become sick at the second period.

The marginal cost of treatment, $T$, depends on the number of patients. For some pathologies, the cost admits some decreasing returns to scale. For others, it can be an increasing function of the number of patients. In this model, we do not specify the sense of the relation between cost and number of patients. Nevertheless, we assume that such a relation exists, $T = T(\sum_{i=1}^{n} N \pi_i p(h_i))$.

3.1. First-best solution

Here, we determine the levels of consumption and health prevention chosen by a central planner when the treatment cost is offered free of charge and the health prevention investment is also free. This program is financed by a tax, $\tau$, in order to cover entirely the treatment cost ($\rho = 1$) and the prevention investment cost ($\theta = 1$). We consider a standard welfare objective in which the authorities take into account individuals’ preferences, that is, the possible probability transformations. The central planner’s problem then writes:

$$
\max_{s_i, h_i} \sum_{i=1}^{n} N \pi_i (U(w_i (1 - \tau) - s_i - (1 - \theta) h_i, H_0)
+ \delta(1 - \varphi_i(1 - p(h_i)))U(Rs_i - (1 - \rho) T(\sum_{i=1}^{n} N \pi_i p(h_i)), H)
+ \delta\varphi_i(1 - p(h_i))U(Rs_i, \overline{H}))
$$

subject to government budget constraint

$$\sum_{i=1}^{n} N \pi_i \tau w_i = \sum_{i=1}^{n} N \pi_i h_i + T\left(\sum_{i=1}^{n} N \pi_i p(h_i)\right) \times \sum_{i=1}^{n} N \pi_i p(h_i)$$

11
The interior solution, \(\{s_i^*, h_i^*\}_{i=1}^n\) verifies:

- For savings:

\[
-U_1(w_i(1 - \tau) - s_i^*, H_0) + (\delta R \left[ (1 - \varphi_i (1 - p(h_i^*))) U_1(Rs_i^*, H) \right. \\
+ \left. \varphi_i (1 - p(h_i^*)) U_1(Rs_i^*, H) \right]) = 0
\]

- For health prevention:

\[
-U_1(w_i(1 - \tau) - s_i^*, H_0) + \delta \varphi_i' (1 - p(h_i^*)) p'(h_i^*) \times \left[ U_1(Rs_i^*, H) - U_1(Rs_{-i}^*, H) \right] \\
+ \sum_{j \neq i} \pi_j w_j \left( U_1(w_j(1 - \tau) - s_j^*, H_0) - U_1(w_j(1 - \tau) - s_j^*, H_0) \right) \\
- \sum_{i} \pi_i w_i U_1(w_i(1 - \tau) - s_i^*, H_0) = 0
\]

Let us now compare the socially optimal levels of prevention and savings and the levels obtained in the \textit{laissez-faire} economy. In this last case, the choice of individual \(i\) is determined as in equations (2) and (3) with \(\tau = 0\) and \(\rho = \theta = 0\). We obtain that the health prevention level is sub-optimal in the \textit{laissez-faire} economy. This is due to the presence of externality and to the suboptimality of Nash non-cooperative games equilibria. When agents invest in prevention, it reduces the number of agents who will become sick and thus it reduces the overall cost of treatment for a fixed marginal cost. Consequently, the government budget is balanced for a lower amount of taxes that increase agents’ welfare. Moreover, the presence of externality has to be taken into account: reducing the number of agents who become sick leads to a change in the marginal cost of treatment. According to the sense of variation which we did not specify, we can obtain a positive or negative effect on the overall cost of treatment.

### 3.2. Second-best approach

Internalizing the externality implies an optimal level of health prevention that is larger than obtained in the \textit{laissez-faire} setting. To reconcile the decentralized choices and the efficient allocation, one can subsidize the agents’ level of health prevention and finance part of treatment costs. To finance these subsidies, the government increases taxes on wages such that the government’s budget is balanced:

\[
\tau \sum_{i=1}^n N\pi_i w_i = \theta \sum_{i=1}^n N\pi_i h_i + \rho T \left( \sum_{i=1}^n N\pi_i p(h_i) \right) \times \sum_{i=1}^n N\pi_i p(h_i).
\]
In the same way as in the previous section, we define the social welfare function as $W(\theta, \rho)$ with

$$W(\theta, \rho) \equiv \sum_{i=1}^{n} N \pi_i \left[ U(w_i (1 - \tau) - s_i(\theta, \rho) - (1 - \theta) h_i(\theta, \rho), H_0) \right] + \delta(1 - \varphi_i (1 - p(h_i(\theta, \rho)))) U(Rs_i(\theta, \rho) - (1 - \rho) T(\sum_{i=1}^{n} N \pi_i p(h_i(\theta, \rho))), \Pi) + \delta \varphi_i(1 - p(h_i(\theta, \rho))) U(Rs_i(\theta, \rho), \Pi)$$

Then, the government’s program is:

$$\max_{\theta, \rho} W(\theta, \rho) \quad (8)$$

subject to the government budget constraint:

$$\tau \sum_{i=1}^{n} N \pi_i w_i = \theta \sum_{i=1}^{n} N \pi_i h_i(\theta, \rho) + \rho T(\sum_{i=1}^{n} N \pi_i p(h_i(\theta, \rho))) \times \sum_{i=1}^{n} N \pi_i p(h_i(\theta, \rho))$$

where $h_i(\theta, \rho)$ and $s_i(\theta, \rho)$ are the best responses of agent of type $i$ to a subsidy $\theta$ and a co-payment $\rho$:

$$-U_1(w_i (1 - \tau) - s_i - (1 - \theta) h_i, H_0) + \delta R \left[ [1 - \varphi_i(1 - p(h_i))] U_1(Rs_i - (1 - \rho) T, H) + \varphi_i(1 - p(h_i)) U_1(Rs_i, H) \right] = 0$$

$$-(1 - \theta)U_1(w_i (1 - \tau) - s_i - (1 - \theta) h_i, H_0) + \delta \varphi_i(1 - p(h_i)) p(h_i) [U(Rs_i - (1 - \rho) T, H) - U(Rs_i, H)] = 0$$

Program (8) does not yield a tractable solution for the optimal subsidy and co-payment rate (see appendix). Therefore, we proceed by developing a computer simulation model in the next section.

4. Some simulations

We present a tractable two-period simulation model to explore more in detail some of the implications of the theory. Our focus being on the trade-off between savings and prevention, we propose to analyze the case of a given government budget and thus maintain fixed the amount of taxes. We assume

$^6$The numerical results are obtained with Mathematica 7.
that the population is composed of two types of individual who may differ in their wealth and in their risk perception. The proportion of type \( i \) is \( \pi_i, i = 1, 2 \).

The individual bi-variate utility function we consider is linear in health and CRRA in wealth, more precisely, \( u(c, H) = H^{1-\alpha}c^{\alpha} \) which is a special case of the utility function considered in Finkelstein et ali (2008). This function verifies \( U_{12} > 0 \) and thus, as established in sections 2.1 and 2.2, leads to clearcut results concerning the impact of wealth and risk perception on individual prevention and savings decisions. More precisely, both prevention and savings increase with wealth and prevention increases with pessimism and decreases with fatalism. Following Prelec (1998), we adopt, for the individuals of type \( i \) a probability transformation function given by: \( \varphi_i(p) = b_ip^{\beta_i} \) with \( b_i > 0, \beta_i \geq 1 \) where the value of the parameter \( b_i \) measures the degree of fatalism, and the value of \( \beta_i \), the degree of pessimism. Realism is characterized by \( b_i = 1 \) and \( \beta_i = 1 \). The impact of prevention expenses on illness probability is given by the following function: \( p(h) = \frac{p_0}{1+p_0h} \) that verifies the standard properties, \( p'(.) < 0 \) and \( p''(.) > 0 \).

Moreover, we consider the case where the cost of treatment, \( T \), is an increasing function of the number of sick individuals. More precisely, the cost is linear: \( T = t_0 + t_1 \times \sum_{i=1}^{n} N\pi_i p_i(h_i(\theta, \rho)) \) with \( t_0 \geq 0 \) and \( t_1 \geq 0 \).

We choose baseline parameters (See Table 1) that seem plausible and are likely to give some insights into the workings of the market: income is set between 50 and 500, representing the possibility of high inequality; the marginal tax rate is 0.10; the discount rate is set at 1; the interest rate on savings is nil in order to eliminate time preferences.

| \( r \) | 0 | interest rate |
| \( \delta \) | 1 | discount factor |
| \( \tau \) | 0.1 | tax rate |
| \( t_0 \) | 25 | fixed treatment cost |
| \( t_1 \) | 10 | variable treatment cost |
| \( \alpha \) | 2 | relative risk aversion coefficient |
| \( p_0 \) | 0.83 | illness probability without prevention |

Our main objective here is to study the impact of wealth and risk perception on the second best optimal solution. We first consider the impact of these characteristics separately, then jointly.

We start with the impact of risk perception, and consider that wealth is the same for all individuals. Both pessimism and fatalism are considered. For each of them, we first consider an homogeneous population, and then an heterogeneous one.
4.1. Impact of risk perception on second best prevention and savings

The values of the basic parameters in this subsection are the following:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_1$</td>
<td>100</td>
<td>wealth type 1 individuals</td>
</tr>
<tr>
<td>$w_2$</td>
<td>100</td>
<td>wealth type 2 individuals</td>
</tr>
<tr>
<td>$\pi_1$</td>
<td>0.5</td>
<td>proportion of type 1 individuals</td>
</tr>
</tbody>
</table>

- **Homogenous population**

Individuals are identical and thus their perception of the risk of illness is represented by the same probability transformation function. We then study the impact of (i) an increase in pessimism and (ii) an increase in fatalism considering only pessimists.

(i) Pessimism degree, measured by $\beta$, varies from 1 to 5 ($b_1 = b_2 = 1$).

Variation of the number of sick individuals for a population of size 1000, corresponding to $p(h) \times 1000$, and of subsidy $\theta$ appear in Figure 3.

![Insert Figure 3](image3)

The obtained treatment co-payment rate is $\rho = 0$ and savings are constant $s = 25.8$. Population being homogenous in terms of wealth, there is no redistribution via the co-payment rate $\rho$. As it appears in the individual decisions analysis, pessimism increases prevention and thus the number of sick individuals decreases. Consequently, the level of optimal subsidy diminishes with pessimism.

(ii) Fatalism, measured by $b$, varies from 1 to 0.25 ($\beta_1 = \beta_2 = 2$).

Variation of the number of sick individuals for a population of size 1000, corresponding to $p(h) \times 1000$, and of subsidy level $\theta$ appear in the Figure 4.

![Insert Figure 4](image4)

Such as previously, the treatment co-payment rate is $\rho = 0$ and savings increase from 25.79 to 31.96. Fatalism decreases the prevention investment, incentives increase (that is subsidy), as well as the number of sick individuals.

- **Heterogeneous population**

We now study the effect of an increase in pessimism (or fatalism) of one type of individuals, the other keeps the same risk perception that is realism. Such as the case of identical individuals, the optimal level of co-payment rate, $\rho$, is nil. This is due to the fact that the difference between agents only concerns
their risk perception and not their level of income. Thus, only one economic instrument is required.

(i) Only pessimism of group 2 increases, $\beta_2$ varies from 1 to 5 ($b_1 = b_2 = 1$).

Variation of the number of sick individuals in each group for a population of size 1000, corresponding to $p(h_1) \times 500$, and of subsidy level $\theta$ appear in Figure 5.

**Insert Figure 5**

(ii) Only fatalism of group 2 increases, $b_2$ varies from 1 to 0.25 ($\beta_1 = \beta_2 = 2$).

Variation of the number of sick individuals in each group for a population of size 1000, corresponding to $p(h_1) \times 500$, and of subsidy $\theta$ appear in Figures 6a and 6b.

**Insert Figures 6a and 6b**

The main results are summarized hereafter. First of all, when the income is the same for all individuals, there is no room for redistribution via the co-payment rate, so $\rho = 0$. Second, when pessimism increases (but no one is fatalist), the gap between the individual and the socially optimal prevention levels decrease and so the optimal level of subsidy decreases too. Third, when fatalism increases and individuals are pessimist, the gap between the individual and the socially optimal prevention levels increases, the individuals need financial incentives to increase their level of prevention, and so the optimal level of subsidy increases.

4.2. Impact of wealth on second best prevention and savings

In the following, we consider the impact of inequality in wealth on the optimal levels of prevention and savings. All the individuals are assumed to be realists. The difference between individuals concerns the level of initial wealth. We examine the effect of an increase in the income of individuals of type 1.

The parameters take then the following values:

<table>
<thead>
<tr>
<th>$\beta_1 = b_1$</th>
<th>= 1</th>
<th>type 1 individuals are realists</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_2 = b_2$</td>
<td>= 1</td>
<td>type 2 individuals are realists</td>
</tr>
<tr>
<td>$w_2$</td>
<td>= 50</td>
<td>wealth of type 2 individuals</td>
</tr>
</tbody>
</table>

The next figures give the impact of an increase in wealth of type 1 from 100 to 500 on the optimal levels of co-payment rate and of subsidy, on the level of prevention and on illness probabilities.
We obtain two main results. First, when individuals in the population differ in wealth, there is a place for redistribution via the co-payment rate $\rho$ that becomes strictly positive even when all the individuals in the population are realists. Second, the inequality in wealth generates inequality in health: when the wealth of one part of the population increases, $\theta$ decreases and thus the "poor" do less prevention because it becomes more expensive for them. Consequently, the illness probability becomes higher for them.

4.3. Impact of pessimism on second best prevention and savings in an heterogeneous population in terms of wealth

After examining the role of risk perception and of wealth inequality, we propose to study the impact of both differences in risk perception and in wealth distribution in the population. Two cases are presented: an increase in pessimism of the rich people and an increase in pessimism of the poor.

The case of an increase in pessimism of the rich is illustrated in figures 8a and 8b. And, the one of an increase in pessimism of the poor is done in figures 9a and 9b.

We can highlight four main results. First, in both cases, the level of optimal co-payment, $\rho$, increases and the level of subsidy, $\theta$, decreases, but $\rho$ increases more when the pessimism of the poor increases. An increase in pessimism leads to an increase in health prevention and thus the *laissez-faire* solution becomes nearer to the social optimum solution and subsidies decrease. But, such as the increase in pessimism concerns the poorest, the inequality increases and this causes an increase in co-payment rate. Second, the poor makes more prevention in a population with rich realists than in a population with rich pessimists. Indeed, rich pessimists much more invest in prevention than rich realist (risk perception effect). It contributes to decrease the number of sick individuals and thus the cost of treatment which the poor profit. Third, when pessimism of the rich increases, prevention increases for the rich and decreases for the poors. Indeed, when the rich become more pessimism, they increase their level of health prevention. Thus, the level of treatment cost diminishes. The poor are then incites to decrease their level of prevention for consuming more. Fourth, when pessimism of the poor increases, prevention of the rich first increases and then decreases, the opposite being true for the poor.
5. Concluding remarks

In this paper, we better understood the determinants of the trade-off between savings and primary prevention. In the first part, we showed that the determinants of these two decision variables strongly depend on the interaction between them and on the individuals degree of pessimism. We focused our discussion on the existence of a type of individuals that we call fatalists. These individuals, pessimistic or even optimistic, consider that prevention is inefficient and they decide to not invest much in it. In the second part of the paper, considering the existence of a public health insurance, the laissez-faire equilibrium leads to an insufficiently low level of prevention for any interaction between prevention and savings. We propose a decentralization of the social optimum by tax financed subsidies for prevention and treatment cost at uniform rates. From numerical simulations, it appears that the subsidies level and the proportion of sick individuals in the population strongly depends not only on risk perception, but also on the wealth distribution in the population. In designing the decentralization scheme, we assume that the government is not able to identify the different groups of individuals and uses unique co-payment rates, as well for the prevention, as for the treatment cost. The problem of the presence of fatalists is crucial when government cannot distinguish them. The subsidy system can then be very expensive when the proportion of fatalists is high. In this case, an important question is to know if prevention is cheaper than treatment. We could answer this question by extending our model. We have to specify medical care costs and compare the benefits of a decrease in medical care costs with the benefits of an increase in prevention for welfare.

There are some caveats and limitations to our work. First, there is no private insurance in our economy. A more realistic model would incorporate that consumers wants to purchase insurance contract which can be substitute to savings. This will certainly reduce the savings demand but the effect on primary prevention is not clear. Second, the role of information is crucial in analyzing prevention behaviors. An interesting extension should be introducing some incomplete information about the health risk. It would arise the problem of the way individuals use new information. Finally, prevention of epidemics is another extension of our work which implies to take into account the correlation between individual risks at the social optimum.

References


6. Appendix

6.1. Second-best optimum

We obtain that the optimal solution, \((\theta^*, \rho^*)\) verifies:

For \(\theta^*\):

\[
\sum_i N\pi_i U_1 (c_i^*, H_0) \times \left[ -w_i \frac{\partial \tau}{\partial \theta} + h_i (\theta^*, \rho^*) \right]
\]

\[-\delta \sum_i N\pi_i U_1 (d_i^* - (1 - \rho^*) T, H) \times (1 - \rho^*) \times \frac{\partial T}{\partial \theta} \times (1 - \phi_i (1 - p (h_i (\theta^*, \rho^*)))) = 0 \tag{9}\]

For \(\rho^*\):

\[
\sum_i N\pi_i U_1 (c_i^*, H_0) \times \left[ -w_i \frac{\partial \tau}{\partial \rho} \right] + \delta \sum_i N\pi_i U_1 (d_i^* - (1 - \rho^*) T, H) \times \left[ T - (1 - \rho^*) \frac{\partial T}{\partial \rho} \right] \times (1 - \phi_i (1 - p (h_i (\theta^*, \rho^*)))) = 0 \tag{10}\]

where

\[
\frac{\partial \tau}{\partial \theta} = \frac{1}{\sum_i N\pi_i w_i} \times \left[ \sum_{i=1}^{n} N\pi_i h_i (\theta^*, \rho^*) + \theta^* \times \sum_{i=1}^{n} N\pi_i \frac{\partial h_i (\theta^*, \rho^*)}{\partial \theta} \right]
\]

\[
+ \rho \sum_{i=1}^{n} N\pi_i p' (h_i (\theta^*, \rho^*)) \times \frac{\partial h_i (\theta^*, \rho^*)}{\partial \theta} \times \left( T' \times \sum_{i=1}^{n} N\pi_i p (h_i (\theta, \rho)) + T \right)
\]

\[
\frac{\partial \tau}{\partial \rho} = \frac{1}{\sum_i N\pi_i w_i} \times (\theta^* \times \sum_{i=1}^{n} N\pi_i \frac{\partial h_i (\theta^*, \rho^*)}{\partial \rho} + T \times \sum_{i=1}^{n} N\pi_i p (h_i (\theta, \rho))
\]

\[
+ \rho \sum_{i=1}^{n} N\pi_i p' (h_i (\theta^*, \rho^*)) \times \frac{\partial h_i (\theta^*, \rho^*)}{\partial \rho} \times \left( T' \times \sum_{i=1}^{n} N\pi_i p (h_i (\theta, \rho)) + T \right)
\]

6.2. Figures
Figure 1: Pessimism and fatalism

Figure 2: Optimism and fatalism
Figure 3: The impact of pessimism on prevention

Figure 4: The impact of fatalism on prevention
Figure 5: The impact of Group 2 pessimism on prevention

Figure 6: Heterogeneity in fatalism
Figure 7: Heterogeneity in wealth

Figure 8: Impact of pessimism of the rich
Figure 9: Impact of pessimism of the poor