Health Prevention and Ambiguity

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In this paper, we study the preventive behaviors of individuals faced with uncertainty in their health status. We analyze individual choices of primary and secondary prevention when there is uncertainty in the probability of becoming ill. In order to distinguish between risk aversion and ambiguity aversion, we use the model of preferences over acts proposed by Klibanoff, Marinacci, and Mukerji (2005). We show that ambiguity motivates individuals to take more primary and secondary prevention under the assumption that their marginal utility of wealth increases with their health status.

PRÉVENTION EN SANTÉ ET AMBIGUÏTÉ

Dans cet article, nous étudions les comportements individuels de prévention face à une incertitude sur l’état de santé. Nous analysons les choix individuels de prévention primaire et de prévention secondaire lorsque la probabilité d’apparition de la maladie n’est pas parfaitement connue. Afin de distinguer l’aversion pour le risque et l’aversion à l’ambiguïté, nous utilisons le modèle de représentation des préférences proposé par Klibanoff, Marinacci et Mukerji [2005]. Nous montrons que l’aversion à l’ambiguïté incite les individus à faire plus de prévention primaire et secondaire sous l’hypothèse d’une utilité marginale de la richesse croissante avec l’état de santé.

Classification JEL: D91, I12, I18.

INTRODUCTION

Preventive measures enable individuals to control their exposure to health risks and to take action to improve their health. If the probability of becoming ill is uncertain, individuals can change their behaviors, taking more or less risk according as they over- or underestimate the effects of these behaviors on their health.

The elimination of health risks is set in an increasingly uncertain environment where technological innovation and climate change have health effects

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that are not yet fully known or understood. In general, it is difficult to accurately quantify and account for potential interactions between risk factors. Thus, it may be difficult to link a specific risk factor to its health effect with a view to adopting adequate prevention. Additionally, one finds conflicting information on the likelihood of environmental and technological risks. Medical publications report different probabilities for individuals in similar situations – see, for example, Namer (2010) on breast cancer.

The aim of this paper is to better understand the determinants of prevention when individuals have imperfect knowledge of the illness occurrence probability and of the effects of prevention. In this context, we consider two types of preventive health – (i) primary prevention which reduces the illness probability and (ii) secondary prevention which reduces the illness severity.

Based on the work of Ehrlich and Becker (1972), Dervaux and Eeckhoudt (2004) analyze two types of health prevention – the primary, comparable to self-protection, and the secondary which is more comparable to self-insurance. More generally, in models of behavior under risk to health, it is assumed that individuals are fully aware of the risk characteristics and the effectiveness of prevention – see, for example, Eeckhoudt et al. (1998) and Zweifel et al. (2009). This paper innovates by introducing the concept of an imperfect knowledge that modifies prevention behaviors. Two key concepts play an important role in understanding behavior under uncertainty – risk aversion and ambiguity aversion.

Since Ellsberg (1961), numerous experimental studies have confirmed that individuals are averse to ambiguity, so theoretical aversion models were proposed – among others, those of Gilboa and Schmeidler (1989), Epstein and Schneider (2003), and Klibanoff et al. (2005). To distinguish aversion to risk from aversion to ambiguity, we use the representation of preferences model proposed by Klibanoff, Marinacci, and Mukerji (2005). Recently, in a univariate utility function framework, Treich (2010) showed that ambiguity aversion increases the value of statistical life (VSL). Snow (2010) also emphasized the role of ambiguity aversion by showing that it increases the value of information.

Following, among others, Dardanoni and Wagstaff (1990), Courbage and Rey (2006), and Eeckhoudt, Rey, and Schlesinger (2007), we consider a bivariate utility function. We show that, in the presence of uncertainty, ambiguity aversion does not always motivate individuals to increase their level of primary and secondary prevention. The analysis of these behaviors requires assumptions about aversion to correlation as characterized by the sign of the cross-partial derivatives of the utility function – see Eeckhoudt et al. (2007). Specifically, correlation-averse individuals have marginal utilities of consumption which decrease with deterioration of their health status. So an ambiguity-averse individual will undertake less prevention than one who is ambiguity-neutral.

1. See Etner et al. (2012) for a review of the literature.
In Section 2, we present our basic model. In sections 3 and 4, we successively consider primary and secondary prevention. The final section is devoted to brief conclusions.

THE MODEL

Consider an individual facing a health risk. With probability $p$, she is ill and has health status $H_0$ while, with probability $1 - p$, she is healthy with health status $H_1 > H_0$. At the beginning of a period, the individual may invest in primary and secondary prevention. Nevertheless, the effectiveness of prevention, whether primary or secondary, is not fully known.

For primary prevention, the individual can influence the probability of the illness. It is assumed that this probability depends on a parameter $\alpha$, of which it is an increasing function, $p_{\alpha} \geq 0$. For a given parameter $\alpha$, let $p(h, \alpha)$, with $p_h(h, \alpha) < 0$ and $p_{hh}(h, \alpha) > 0$, represent the illness occurrence probability when the individual has $h$ prevention units.\footnote{Note that, for any function $f$, its partial derivative with respect to the argument $i$ is written as $f_i$.}

This parameter $\alpha$ can be used to represent different situations such as the effectiveness of prevention, or changes in the illness occurrence probability consequent to changes in exogenous variables such as the level of ambient pollution.

Similarly, the effectiveness of secondary prevention, which reduces the severity of an illness without changing its occurrence probability, may be unknown. The health status in the event of illness depends on the amount, $y$, invested in secondary prevention, with according to a technology represented by $m(y)$. We will have $m_y(y) \geq 0$ and $m_{yy}(y) \leq 0$ if prevention is effective. Otherwise, prevention has no effect and $m(y) = 0$. We assume that the ill, but treated, individual does not feel better than a healthy individual, $H_0 + m(y) < H_1$.

In this paper, the monetary cost of prevention efforts which is normalized to 1. However, the cost of prevention may also be expressed as a reduction in the quality of life.\footnote{We thank an anonymous referee for this remark.}

Let $W$ be wealth and $H$ health status. The preferences of the individual are represented by a bivariate utility function $u(W, H)$, with $u_W > 0$, $u_H > 0$, $u_{WW} \leq 0$ and $u_{HH} \leq 0$.

At the beginning of the period, the individual receives an income, $w$, which may be invested in primary prevention, $h$, and secondary prevention, $y$. In this paper, we study primary and secondary prevention separately.
PRIMARY PREVENTION

In this section, we consider the primary prevention decision. For a given parameter \( \alpha \), the expected utility of the individual is written:

\[
U(h, \alpha) = p(h, \alpha)[u(w - h, H_0)] + (1 - p(h, \alpha))[u(w - h, H_1)]
\]  

The ambiguity here is on the illness occurrence probability, \( p(., \alpha) \), which is itself random. Let \( F_\alpha \) be the distribution function of the random variable \( \alpha \) supported on: \([\alpha, \bar{\alpha}]\).

According to Klibanoff, Marinacci, and Mukerji (2005), ambiguity aversion is characterized by a concave function \( \phi \) defined on \( U(., \alpha) \). Risk aversion is, in turn, represented by the concavity of the function \( u \) with respect to health status. The well-being of the individual is measured by the function \( V(h) \), defined by:

\[
V(h) = \phi^{-1}\{E_\alpha[\phi(U(h, \alpha))]\}
\]  

with \( \phi'(.) > 0 \) and \( \phi''(.) \leq 0 \) and \( E_\alpha \) is the expectation conditional on \( F_\alpha \).

The optimality condition for an interior solution, \( h^* \), is:

\[
E_\alpha[\phi'(U(h^*, \alpha))U_h(h^*, \alpha)] = 0
\]  

with:

\[
U_h(h, \alpha) = -p(h, \alpha)u_w(w - h, H_0) - (1 - p(h, \alpha))u_w(w - h, H_1).
\]

The second order condition is assumed verified:

\[
E_\alpha[\phi'(U(h^*, \alpha))U_h(h^*, \alpha)]^2 + \phi'(U(h^*, \alpha))U_{hh}(h^*, \alpha) < 0
\]  

with:

\[
U_{hh}(h, \alpha) = p(h, \alpha)u_{ww}(w - h, H_0) + (1 - p(h, \alpha))u_{ww}(w - h, H_1)
\]

\[
-2p_h(h, \alpha)[u(w - h, H_0) - u_w(w - h, H_1)] + p_{hh}(h, \alpha)[u(w - h, H_0)]
\]

\[
-2p_h(h, \alpha)[u(w - h, H_0) - u_w(w - h, H_1)] + p_{hh}(h, \alpha)[u(w - h, H_0)]
\]

assumed negative.

Using the covariance, the optimality condition (3) can be written as follows:

\[
E_\alpha[p(h^*, \alpha)u_w(w - h^*, H_0) + (1 - p(h^*, \alpha))u_w(w - h^*, H_1)] =
E_\alpha[p_h(h^*, \alpha)[u(w - h^*, H_0) - u(w - h^*, H_1)] + \frac{\text{cov}_\alpha[\phi'(U), U_h(h^*, \alpha)]}{E_\alpha[\phi'(U)]}\]

\[
E_\alpha[p_h(h^*, \alpha)[u(w - h^*, H_0) - u(w - h^*, H_1)]]
\]
The left-hand side represents the marginal cost expressed in terms of expected utility, given the investment in primary prevention. The expression on the right-hand side decomposes into two terms,

- the first representing the marginal benefit of prevention and
- the second corresponding to a marginal benefit related to the presence of ambiguity, its sign being the sign of the covariance between \( f(U) \) and \( U_h(\alpha) \).

The sign of \( \text{cov}_\alpha(\phi'(U(\alpha), U_h(\alpha))) \) is non-trivial and depends on the relationship between the illness occurrence probability and exogenous factors represented by \( \alpha \) and the individual’s trade-offs between wealth and health. Considering an ambiguity-averse individual, with decreasing \( \phi'(.) \), it is easily shown that the covariance is positive for an individual if:

- the effectiveness of prevention increases with \( \alpha \), \( p_{\alpha} \leq 0 \);
- the individual is correlation-liking, \( u_{WH} \geq 0 \).

The hypothesis \( p_{\alpha} \leq 0 \) means that the prevention effectiveness (\( |p_{\alpha}| \)) increases with the parameter \( \alpha \) at a given prevention level, since we already know that the illness occurrence probability increases with \( \alpha \) (\( p_{\alpha} \geq 0 \)).

The sign of the cross-derivative of the utility function, \( u_{WH} \), represents correlation-loving or correlation-aversion – see Epstein and Tanny (1980). \(^1\) According Eeckhoudt et al. 2007), correlation-loving \( u_{WH} > 0 \), is the more realistic assumption in terms of preferences, one which also implies that the marginal utility of consumption increases with health. The papers of both Viscusi and Evans (1990) and Sloan et al. (1998) point out that this assumption is reasonable in the case of severe illnesses.

Furthermore, Evans and Viscusi (1991) showed empirically that the sign of the cross-derivative of the utility could be strictly negative when the illness was not too serious. In this case, the individual is correlation-averse or multivariate-risk-averse according Richard (1975), and it is possible that prevention changes in the opposite direction to severity of the illness.

We will assume in the remainder of this paper that \( p_{\alpha} \leq 0 \) and \( u_{WH} \geq 0 \). Under these two assumptions, the marginal benefit of prevention becomes increasingly important as the individual displays ambiguity aversion.

### Neutrality and Ambiguity Aversion

Ambiguity aversion is characterized by a concave function \( f \). When \( f \) is linear, we have the standard expected utility model and the individual is ambiguity-neutral.

The well-being of an ambiguity-averse individual is written:

\[ V \]
\[ V_{A}(h) = \phi^{-1}E_{a}\left[ \phi[ p(h,\alpha)u(w-h,H_0) + (1 - p(h,\alpha))u(w-h,H_1)] \right] \]  

(6)

where \( E_{a}[.] \) is the expectation conditional on \( F_{\alpha} \).

The well-being of an ambiguity-neutral individual is:

\[ V_{N}(h) = E_{a}\left[ p(h,\alpha)u(w-h,H_0) + (1 - p(h,\alpha))u(w-h,H_1) \right] \]  

(7)

Moreover, in the absence of uncertainty, the illness occurrence probability is known exactly and an individual’s well-being simply becomes:

\[ V(h) = p(h)u(w-h,H_0) + (1 - p(h))u(w-h,H_1) \]  

(8)

The behavior of ambiguity-neutral individuals should not be affected by introducing uncertainty into their choices. One will then have equality between equations (7) and (8), leading to:

\[ E_{a}\left[ p(h,\alpha) \right] = p(h) \]  

(9)

According to Snow (2011), the introduction of ambiguity constitutes an increased risk which keeps the average individual beliefs regarding the probability \( p(h) \) unchanged, so that the equilibrium condition (9) continues to hold. Since the parameter \( \alpha \) is random, investigating it amounts to making a detailed analysis of the effect of this risk.\(^1\)

The effect of greater ambiguity aversion on the amount invested in prevention is given by the following proposition.

**Proposition 1.** Under the assumptions \( p_{ha} \leq 0 \) and \( u_{WH} \geq 0 \), primary prevention increases with ambiguity aversion.

**Proof.** See Appendix.

It is interesting to note that our theoretical model allows us to show that primary prevention can increase under ambiguity aversion when the utility function is bivariate. In the case of a single variable utility function, Alary, Gollier, and Treich (2010) have shown that an ambiguity-averse individual is motivated to undertake less primary prevention (self-protection) than an ambiguity-neutral one. According to Proposition 1, an ambiguity-averse individual who is correlation-liking (and who takes both wealth and health into account), will undertake more primary prevention than one who is ambiguity-neutral.\(^2\)

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1. This paper does not consider the effects of risk changes in the sense of stochastic dominance of order 1 or 2. We do, however, compare the amount invested in primary prevention by two individuals who differ only in terms of their ambiguity aversions.
2. In a two-period model with a univariate utility function, Berger (2011) found a positive relationship between self-protection and ambiguity aversion.
Effect of Income and Health Status on Primary Prevention

The effects of wealth and levels of health depend heavily on ambiguity aversion. Similar to risk-aversion, we can define an ambiguity-aversion coefficient, \( \gamma(.) = -\frac{\phi''(.)}{\phi'(.)} \).

The effects of income, \( w \), and base level of health status, \( H_0 \), on primary prevention are given by the following proposition.

**Proposition 2.** Under the assumptions \( p_{\text{HA}} \leq 0 \) and \( u_{\text{WH}} \geq 0 \),

1. if \( \gamma \) is an increasing function of well-being, an increase in income motivates the individual to increase the level of primary prevention, while the effect of an improvement in health status, \( H_0 \), is ambiguous;
2. if \( \gamma \) is a decreasing function of well-being, improved health status, \( H_0 \), motivates the individual to reduce the primary prevention level, while an increase in income has an ambiguous effect;
3. if \( \gamma \) is a constant function of well-being, primary prevention increases with income and decreases with health status, \( H_0 \).

**Proof.** See Appendix.

Two effects are distinguished: an “income” effect and an “ambiguity-aversion” effect.

Regarding increased income, the “income” effect motivates individuals to increase their level of primary prevention because the relative cost of prevention decreases. In addition, following an income increase, the utility increases. If ambiguity aversion is an increasing function, the individual becomes more averse to ambiguity. An increase in ambiguity aversion thus motivates the individual to increase the level of prevention. If ambiguity aversion is a decreasing function of well-being, the second effect opposes the first.

Similarly, following an improvement in health status, \( H_0 \), the individual is motivated to reduce the level of primary prevention (“income” effect). If ambiguity aversion is a decreasing function of well-being, then *ceteris paribus*, as the latter increases, the individual becomes less ambiguity-averse and this second effect (“ambiguity-aversion” effect) works in the same direction as the first. Otherwise, the effects work in opposite directions.

**SECONDARY PREVENTION**

We assume that an individual can invest in secondary prevention activities to reduce the severity of the illness without affecting its occurrence probability.
Two types of uncertainty may be considered. We will first investigate the demand for secondary prevention in the same framework as that of the previous section, i.e., when people face uncertainty about the illness occurrence probability. Then, we will analyze the case where there is uncertainty about probability of the effectiveness of secondary prevention.

Uncertainty in the Illness Occurrence Probability

For a given \( \alpha \), the expected utility of an individual is defined by:

\[
U(y, \alpha) = p(\alpha)u(w - y, H_0 + m(y)) + (1 - p(\alpha))u(w - y, H_1) \tag{10}
\]

The individual’s prevention program is:

\[
\max V(y) = \phi^{-1}\left\{ E_\alpha\left[ \phi\left( (1 - p(\alpha))u(w - y, H_1) + p(\alpha)u(w - y, H_0 + m(y)) \right) \right] \right\}
\]

and the optimality condition is:

\[
E_\alpha\left[ \phi'(U(y, \alpha)) \right] U_y(y, \alpha) = 0 \tag{12}
\]

with:

\[
U_y(y, \alpha) = -p(\alpha)u_w(w - y, H_0 + m(y)) - (1 - p(\alpha))u_w(w - y, H_1) + p(\alpha)m_y(y)u_{\|}(w - y, H_0 + m(y)).
\]

Using the covariance, the optimality condition (12) becomes:

\[
E_\alpha\left[ p(\alpha)u_w(w - y, H_0 + m(y)) + (1 - p)u_w(w - y, H_1) \right]
= E_\alpha\left[ p(\alpha)m_y(y)u_{\|}(w - y, H_0 + m(y)) \right] + \frac{\text{cov}_\alpha\left( \phi'(U(y, \alpha)), U_y(y, \alpha) \right)}{E_\alpha\left[ \phi'(U(y, \alpha)) \right]} \tag{13}
\]

The left-hand side of the expression represents the expected marginal cost of secondary prevention. The expression on the right-hand side represents the marginal benefit and is composed of two terms:

- the first term is the benefit in terms of the utility relating to an improvement in health status;
- the second term is associated with the presence of ambiguity and is positive when both \( u_{WH} \) is non-negative and the individual is ambiguity-averse.

We find similarities with the primary prevention situation. An increase in ambiguity aversion has the same effect on secondary prevention as it has on primary prevention.

**Proposition 3.** Under the assumption that \( u_{WH} \geq 0 \), secondary prevention increases with ambiguity aversion.

**Proof.** Similar to the proof of Proposition 1.
The more ambiguity-averse individuals are, the more they are willing to pay (an increase in the amount of secondary prevention) as a hedge against the risk of ill health if the marginal utility of wealth increases with health status \( u_{WH} \geq 0 \).

As in the previous section, the effects of income and levels of health depend on aversion to ambiguity, as measured by the ambiguity-aversion coefficient, \( \gamma(.) = -\frac{\phi''(.)}{\phi'(.)} \).

**Proposition 4.** Under the assumption that \( u_{WH} \geq 0 \),

1. if \( \gamma \) is an increasing function of well-being, an increase in income motivates the individual to increase the secondary prevention level, while the effect of an improvement in health status, \( H_0 \), is ambiguous;
2. if \( \gamma \) is a decreasing function of well-being, an improvement in health status, \( H_0 \), motivates the individual to reduce the secondary prevention level, while an increase in income has an ambiguous effect;
3. if \( \gamma \) is a constant function of well-being, secondary prevention increases with income and decreases with health status, \( H_0 \).

**Proof.** See Appendix.

As in the case of primary prevention, there are two effects: an “income” effect and an “ambiguity-aversion” effect.

On the one hand, an increase in income motivates an individual to invest more in secondary prevention (“income” effect). On the other hand, the increase in income leads to an increase in aversion to ambiguity if the ambiguity-aversion coefficient is increasing (“ambiguity-aversion” effect). This results in a new motivation for increased prevention. If now the ambiguity-aversion coefficient is decreasing, the decline in aversion motivates the individual to undertake less prevention and the total effect is indeterminate.

A similar result arises with the initial health status.

Unlike the risk-aversion situation, the effect of ambiguity aversion is similar in both types of prevention.

**Effect of Introduction of Risk on the Effectiveness of the Secondary Prevention**

The uncertainty here relates to the effectiveness of secondary prevention which now contains a random element. Assume that, with probability \( q(\beta) \), secondary prevention is effective and reduces the severity of the illness by an amount \( m(.) \) while, with probability \( 1 - q(\beta) \), prevention is ineffective. Assume that \( q(\beta) \geq 0 \). Let \( F_\beta \) be the distribution function of the random variable \( \beta \) with support on \( [\bar{\beta}, \hat{\beta}] \). The effectiveness of primary prevention is fixed, \( p(\alpha) = p \).
For a given level of \( \beta \), the expected utility of an individual is defined by:

\[
U(y, \beta) = p[q(\beta)u(w - y, H_0 + m(y)) + (1 - q(\beta))u(w - y, H_1)] + (1 - p)u(w - y, H_i)
\]  

(14)

The individual’s prevention program is:

\[
\max_y V(y) = \frac{1}{\bar{x}} \left\{ E_\beta \left[ \frac{1}{\bar{x}} \left( \frac{p[q(\beta)u(w - y, H_0 + m(y)) + (1 - q(\beta))u(w - y, H_1)]}{(1 - p)u(w - y, H_i)} \right) \right] \right\}
\]

(15)

The optimality condition is:

\[
E_\beta \left[ \frac{1}{\bar{x}} (U(y, \beta)) \right] U_y(y, \beta) = 0
\]  

(16)

with:

\[
U_y(y, \beta) = -pq(\beta)u_w(w - y, H_0 + m(y)) + pq(\beta)m_y(y)u_{y1}(w - y, H_0 + m(y))
- p(1 - q(\beta))u_{y1}(w - y, H_0) - (1 - p)u_{y1}(w - y, H_i).
\]

The effect of an increase in ambiguity aversion on the effectiveness of secondary prevention is given by the following result.

**Proposition 5.** Secondary prevention decreases with ambiguity aversion.

**Proof.** See Appendix.

Unlike the previous case, an increase in ambiguity aversion motivates the individual to undertake less secondary prevention in the presence of uncertainty about the effectiveness of this prevention. When ambiguity aversion increases, individuals deciding to reduce their level of secondary prevention reduce the difference between the two states of nature (effectiveness/ineffectiveness) of prevention.

**Effect of Income and Health Status on Secondary Prevention**

As before, the effects of income and health depend on assumptions about the ambiguity-aversion coefficient.

**Proposition 6.** Under the assumption that \( u_{WH} \geq 0 \),

1. if \( \gamma \) is an increasing function of well-being, an improvement in health status, \( H_0 \), reduces the secondary prevention effort, while an increase in income has an ambiguous effect;
2. if \( \gamma \) is a sufficiently rapidly decreasing function of well-being, an increase in income motivates individuals to undertake more prevention, but the effect of improved health status, \( H_0 \), is ambiguous.

**Proof.** See Appendix.
When income increases, individuals are motivated to invest more in secondary prevention (“income” effect). If, on the one hand, the ambiguity aversion increases with income, the individual becomes more ambiguity-averse, and this second effect (“ambiguity aversion”), motivates a reduction of the amount invested in prevention. Overall, the effect is ambiguous. If, on the other hand, aversion decreases sufficiently rapidly with income, the two effects are in the same direction and, in total, the individual invests more in prevention.

Consider an increase in the initial health status, $H_0$. The individual is first motivated to invest less in secondary prevention (“income” effect). If, on the one hand, ambiguity aversion increases with health status, the individual becomes more ambiguity-averse, and this second effect (“ambiguity aversion”), motivates a reduction of the amount invested in prevention. If, on the other hand, ambiguity aversion decreases with health status, the two effects are in opposite directions and overall the effect is ambiguous.

CONCLUSION

In this paper, we considered two types of prevention for individuals facing a health risk. We introduced several types of uncertainty (illness occurrence probability, effectiveness of prevention probability) and studied the effects of these uncertainties on prevention behaviors. Attitudes to risk and ambiguity are defined using a bivariate utility function whose variables are wealth and health. In this context, we have shown that ambiguity aversion motivates people to undertake more prevention (primary and secondary) under reasonable assumptions (correlation-loving).

Our results can be extended to other settings. The effectiveness parameter may be reinterpreted as a variable affecting the illness occurrence probability. For example, one might include pollution in the model and assume that both the illness occurrence probability increases and prevention becomes more effective as the level of pollution increases. While the effect of the environment on the occurrence probabilities of certain illnesses such as cancer is not fully known, it is clear from our results that individuals averse to ambiguity are motivated to undertake primary prevention, but not always secondary prevention.

BIBLIOGRAPHY


APPENDIX

I. PROOF OF PROPOSITION 1

Consider two individuals who differ only in their ambiguity-aversion levels. Suppose that \( \phi_1 \) is less ambiguity-averse than \( \phi_2 \), then, as in the risk aversion analysis, there exists an increasing concave function, \( k \), such that \( \phi_2 = k(\phi_1) \). Let \( h_i \) be the optimum level of primary prevention of individual \( \phi_i \).

The well-being functions of the two individuals are:

\[
V_i(h) = \phi_i^{-1} \{E_\alpha[\phi_i \left[ p(h, \alpha)u(w - h, H_0) + (1 - p(h, \alpha))u(w - h, H_1) \right]] \} \quad \text{(A1)}
\]

\[
V_2(h_2) = \phi_2^{-1} \{E_\alpha[\phi_2 \left[ p(h_2, \alpha)u(w - h_2, H_0) + (1 - p(h_2, \alpha))u(w - h_2, H_1) \right]] \} \quad \text{(A2)}
\]

Under the assumptions \( p_{h0} \leq 0 \) and \( p_{h1} \geq 0 \) the function \( v \) with \( v(\alpha) = U_h(h, \alpha) \) is increasing and there exists a value \( \hat{\alpha} \), such that: \( \forall \alpha \leq \hat{\alpha}, v(\alpha) \leq 0 \), and \( \forall \alpha \geq \hat{\alpha}, v(\alpha) \geq 0 \).

Furthermore, \( k'(\cdot) \) is a decreasing and positive function of \( \phi_i \). However, \( \phi_i(\cdot) \) is increasing for each individual and since the utility function \( U(h, \alpha) \) is a decreasing function of \( \alpha \), \( \phi_i(\cdot) \) is a decreasing function of \( \alpha \). Thus, \( k'(\cdot) \) increases with \( \alpha \).

We then obtain the following result:

- \( \forall \alpha \leq \hat{\alpha}, k'(\phi_i(U(h, \alpha))U_h(h, \alpha)) \geq k'(\phi_i(U(h, \hat{\alpha}))U_h(h, \alpha)) \);
- \( \forall \alpha \geq \hat{\alpha}, k'(\phi_i(U(h, \alpha))U_h(h, \alpha)) \geq k'(\phi_i(U(h, \hat{\alpha}))U_h(h, \alpha)) \).

This implies that:

\[
E_\alpha \phi_i'[U(h, \alpha)]U_j(h, \alpha) = E_\alpha k'(\phi_i(U(h, \alpha))U_h(h, \alpha)) \geq k'(\phi_i[U(h, \hat{\alpha})]U_h(h, \alpha)) = 0
\]

II. PROOF OF PROPOSITION 2

1. The effect of income on the demand for primary prevention is given by the sign of:

\[
\frac{\partial V_h}{\partial w} = E_\alpha \left[ \phi'(U(h, \alpha))U_h(h, \alpha) \times \frac{\partial U(h, \alpha)}{\partial w} + \phi'(U(h, \alpha)) \times \frac{\partial U_h(h, \alpha)}{\partial w} \right]
\]

Using the ambiguity-aversion coefficient \( \gamma(h, \alpha) = \frac{\partial^2 U(h, \alpha)}{\partial \alpha^2} \phi'(U(h, \alpha)) \) we obtain:

\[
\frac{\partial V_h}{\partial w} = -E_\alpha \left[ \gamma \phi'(U(h, \alpha))U_h(h, \alpha) \times \frac{\partial U(h, \alpha)}{\partial w} \right] + E_\alpha \left[ \phi'(U(h, \alpha)) \times \frac{\partial U_h(h, \alpha)}{\partial w} \right]
\]

Under our assumptions, the second term has a positive sign.
To study the sign of the first term, we must consider the monotonicity of the function \( \frac{\partial U(h,\alpha)}{\partial w} \) with respect to \( \alpha \).

\[
\frac{\partial U(h,\alpha)}{\partial w} = p'(h,\alpha)u'_w(w-h,H_0) + (1-p(h,\alpha))u'_w(w-h,H_1) > 0
\]

and

\[
\frac{\partial U(h,\alpha)}{\partial \alpha} = p'_\alpha(h,\alpha)[u_w(w-h,H_0) - u_w(w-h,H_1)] \leq 0.
\]

So, the expression \( \frac{\partial U(h,\alpha)}{\partial w} \) is positive and increasing with respect to \( \alpha \).

(a) Let us suppose that \( \gamma(.) \) is a non-decreasing function of the well-being (hence, a non-increasing one of \( \alpha \)), then the function \( \gamma(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \) is decreasing with respect to \( \alpha \). One thus obtains the following result:

- \( \forall \alpha \leq \hat{\alpha}, \gamma(h,\alpha)U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \geq \gamma(h,\hat{\alpha})U_{h}(h,\alpha)\times\frac{\partial U(h,\hat{\alpha})}{\partial w} \);
- \( \forall \alpha \geq \hat{\alpha}, \gamma(h,\alpha)U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} = \).

Consequently,

\[
E_\alpha \left[ \gamma(h,\alpha)\phi'(U(h,\alpha))U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \right] \leq
E_\alpha \left[ \gamma(h,\alpha)\phi'(U(h,\alpha))U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \right] =
E_\alpha \left[ \gamma(h,\alpha)\phi'(U(h,\alpha))U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \right]
\]

The sign of the first term is positive.

(b) If we suppose that \( \gamma \) is strictly decreasing, then the monotonicity of the function \( \gamma(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial w} \) is not established, and the result is ambiguous.

2. The effect of the health status \( H_0 \) on the demand for primary prevention is given by the sign of:

\[
\frac{\partial V}{\partial w} = E_\alpha \left[ \phi'(U(h,\alpha))U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial H_0} + \phi'(U(h,\alpha))\times\frac{\partial U(h,\alpha)}{\partial H_0} \right]
\]

Using the ambiguity-aversion coefficient \( \gamma(h,\alpha) \), we obtain:

\[
\frac{\partial V}{\partial H_0} = -E_\alpha \left[ \gamma \phi'(U(h,\alpha))U_{h}(h,\alpha)\times\frac{\partial U(h,\alpha)}{\partial H_0} \right] + E_\alpha \left[ \phi'(U(h,\alpha))\times\frac{\partial U(h,\alpha)}{\partial H_0} \right]
\]

Under our assumptions, the second term has a positive sign.

To study the sign of the first term, we must consider the monotonicity of the function \( \frac{\partial U(h,\alpha)}{\partial H_0} \) with respect to \( \alpha \).
and
\[
\frac{\partial U(h,\alpha)}{\partial H_0} = p(h,\alpha)u_H(w-h,H_0) > 0
\]
and
\[
\frac{\partial U(h,\alpha)}{\partial \alpha} = p'(h,\alpha)u_H(w-h,H_0) \geq 0
\]

Hence, the expression \(\frac{\partial U(h,\alpha)}{\partial H_0}\) is positive and decreasing with respect to \(\alpha\).

(a) Let us suppose that \(\gamma(.)\) is non-increasing, then the function \(\gamma(h,\alpha) \times \frac{\partial U(h,\alpha)}{\partial H_0}\)
is increasing with respect to \(\alpha\). One thus obtains the following result:

- \(\forall \alpha \leq \hat{\alpha}, \gamma(h,\alpha)U_h(h,\alpha) \times \frac{\partial U(h,\alpha)}{\partial H_0} \geq \gamma(h,\hat{\alpha})U_h(h,\hat{\alpha}) \times \frac{\partial U(h,\hat{\alpha})}{\partial H_0}\);
- \(\forall \alpha \geq \hat{\alpha}, v(\alpha) \geq \gamma(h,\hat{\alpha})U_h(h,\alpha) \times \frac{\partial U(h,\alpha)}{\partial H_0}\).

Consequently,
\[
E_a[\gamma(h,\alpha)v'(U(h,\alpha))U_h(h,\alpha) \times \frac{\partial U(h,\alpha)}{\partial H_0}] \geq E_a[\gamma(h,\hat{\alpha})v'(U(h,\alpha))U_h(h,\hat{\alpha}) \times \frac{\partial U(h,\hat{\alpha})}{\partial H_0}] = 0.
\]
The sign of the first term is positive.

(b) If we suppose that \(\gamma\) is strictly increasing, then the monotonicity of the function \(\gamma(h,\alpha) \times \frac{\partial U(h,\alpha)}{\partial H_0}\) is not established, and the result is ambiguous.

**III. PROOF OF PROPOSITION 4**

1. Let us begin by studying the function \(U_y(y^*,\alpha)\).

From the first order condition (16), for an ambiguity-averse individual, there is an interior solution if the function \(U_y(y^*,\alpha)\) is negative for some values of \(\alpha\) and is positive for others.

However, by defining a function \(v\) with \(v(\alpha) = U_y(y^*,\alpha)\) it is easy to verify that \(v\) is an increasing function under the assumption \(\mu_{WH} \geq 0\). Therefore, there exists a value \(\hat{\alpha}\) such that: \(\forall \alpha \leq \hat{\alpha}, v(\alpha) \leq 0\) and \(\forall \alpha \geq \hat{\alpha}, v(\alpha) \geq 0\).

2. The effect of income on the demand for secondary prevention is given by the sign of:
\[
\frac{\partial V_h}{\partial w} = E_p\left[\phi'(U(y,\alpha))U_y(y,\alpha) \times \frac{\partial U(y,\alpha)}{\partial w} + \phi'(U(y,\alpha)) \times \frac{\partial U(y,\alpha)}{\partial w}\right]
\]

Using the ambiguity-aversion coefficient \(\gamma(y,\alpha) = -\frac{\phi'(U(y,\alpha))}{\phi'(U(y,\alpha))}\), we obtain:
Under our assumptions, the second term has a positive sign.

To study the sign of the first term, we must consider the monotonicity of the function \( \frac{\partial U(y, \alpha)}{\partial \alpha} \) with respect to \( \alpha \).

\[
\frac{\partial U(y, \alpha)}{\partial \alpha} = p(\alpha)u_w(w - y, H_0 + m(y)) + (1 - p(\alpha))u(w - y, H_1) > 0
\]

and

\[
\frac{\partial U(y, \alpha)}{\partial \alpha} = p(\alpha)\left[ u_w(w - y, H_0 + m(y)) - u_w(w - y, H_1) \right] \leq 0.
\]

So, the expression \( \frac{\partial U(y, \alpha)}{\partial w} \) is positive and decreasing with respect to \( \alpha \).

(a) Let us suppose that \( \gamma \) is a non-decreasing function of the well-being (hence, a non-increasing one of \( \alpha \)), then the function \( \gamma(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial w} \) is decreasing with respect to \( \alpha \). One thus obtains the following result:

- \( \forall \alpha \leq \hat{\alpha}, \gamma(y, \alpha)U_j(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial w} \leq \gamma(y, \hat{\alpha})U_j(y, \alpha) \times \frac{\partial U(y, \hat{\alpha})}{\partial w} \);
- \( \forall \alpha \geq \hat{\alpha}, \gamma(y, \alpha)U_j(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial w} \leq \gamma(y, \hat{\alpha})U_j(y, \alpha) \times \frac{\partial U(y, \hat{\alpha})}{\partial w} \).

Consequently,

\[
E_\alpha \left[ \gamma(y, \alpha)\psi(U(y, \alpha))U_j(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial w} \right] \leq E_\alpha \left[ \gamma(y, \hat{\alpha})\psi(U(y, \alpha))U_j(y, \alpha) \times \frac{\partial U(y, \hat{\alpha})}{\partial w} \right] = 0.
\]

The sign of the first term is positive.

(b) If we suppose that \( \gamma \) is strictly decreasing, then the monotonicity of the function \( \gamma(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial w} \) is not established, and the result is ambiguous.

3. The effect of the health status \( H_0 \), on the demand for secondary prevention is given by the sign of:

\[
\frac{\partial \gamma}{\partial H_0} = E_\alpha \left[ \phi'(U(y, \alpha))U_j(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial H_0} + \phi'(U(y, \alpha)) \times \frac{\partial U(y, \alpha)}{\partial H_0} \right]
\]

Using the ambiguity-aversion coefficient \( \gamma(y, \alpha) \), we obtain:

\[
\frac{\partial \gamma}{\partial H_0} = -E_\alpha \left[ \gamma\psi(U(y, \alpha))U_j(y, \alpha) \times \frac{\partial U(y, \alpha)}{\partial H_0} \right] \\
+ E_\alpha \left[ \phi'(U(y, \alpha)) \times \frac{\partial U_j(y, \alpha)}{\partial H_0} \right]
\]

Under our assumptions, the second term has a negative sign.
To study the sign of the first term, we must consider the monotonicity of the function $\frac{\partial U(y, \alpha)}{\partial H_0}$ with respect to $\alpha$.

$$\frac{\partial U(y, \alpha)}{\partial H_0} = p(\alpha)u_{H_1}(w - y, H_0 + m(y)) > 0$$

and

$$\frac{\partial U(y, \alpha)}{\partial \alpha} = p'(\alpha)u_{H_1}(w - y, H_0 + m(y)) \geq 0.$$ 

Hence, the expression $\frac{\partial U(y, \alpha)}{\partial H_0}$ is positive and increasing with respect to $\alpha$.

(a) Let us suppose that $\gamma$ is non-increasing, then the function $\gamma(y, \alpha) \cdot \frac{\partial U(y, \alpha)}{\partial H_0}$ is increasing with respect to $\alpha$. One thus obtains the following result:

- $\forall \alpha \leq \hat{\alpha}$, $\gamma(y, \alpha)U_y(y, \alpha) \cdot \frac{\partial U(y, \alpha)}{\partial H_0} \geq \gamma(y, \hat{\alpha})U_y(y, \alpha) \cdot \frac{\partial U(y, \hat{\alpha})}{\partial H_0}$;
- $\forall \alpha \geq \hat{\alpha}$, $\gamma(y, \alpha)U_y(y, \alpha) \cdot \frac{\partial U(y, \alpha)}{\partial H_0} \leq \gamma(y, \hat{\alpha})U_y(y, \alpha) \cdot \frac{\partial U(y, \hat{\alpha})}{\partial H_0}$.

Consequently,

$$E_\alpha \left[ \gamma(y, \alpha)\phi'(U(y, \alpha))U_y(y, \alpha) \cdot \frac{\partial U(y, \alpha)}{\partial H_0} \right] \geq E_\alpha \left[ \gamma(y, \hat{\alpha})\phi'(U(y, \alpha))U_y(y, \alpha) \cdot \frac{\partial U(y, \hat{\alpha})}{\partial H_0} \right] = 0.$$ 

The sign of the first term is negative.

(b) If we suppose that $\gamma$ is strictly increasing, then the monotonicity of the function $\gamma(y, \alpha) \cdot \frac{\partial U(y, \alpha)}{\partial H_0}$ is not established, and the result is ambiguous.

**IV. PROOF OF PROPOSITION 5**

Consider two individuals, with individual 2 ($f_2$) being more ambiguity-averse than individual 1 ($f_1$). There exists an increasing, concave function, $k$, such that $f_2 = k(f_1)$. Let $\gamma_i$ be the optimum level of secondary prevention of individual $f_i$.

The well-being functions of the two individuals are:

$$V_1(y_1) = \phi^{-1}_{y_1} \left[ E_\beta \left[ p(q(\hat{\beta})u(w - y_1, H_0 + m(y)) + (1 - q(\hat{\beta}))u(w - y_1, H_0 - y_1, H_1)) \right] + (1 - p)u(w - y_1, H_1) \right]$$

(A3)

$$V_1(y_2) = \phi^{-1}_{y_2} \left[ E_\beta \left[ p(q(\hat{\beta})u(w - y_2, H_0 + m(y_2)) + (1 - q(\hat{\beta}))u(w - y_2, H_0)) \right] + (1 - p)u(w - y_2, H_1) \right]$$

(A4)
The optimality condition for individual 1 is:

$$E_\beta [\phi'(U(y_1, \beta)) U(y_1, \beta)] = 0 \quad (A5)$$

An interior solution exists if the function $U_y(y_1, \beta)$ is negative for some values of $\beta$ and is positive for others. We define the function $\nu$ with $\nu(\beta) \leq U_y(y_1, \beta)$.

$\nu(\beta)$ is an increasing function when $q_0(\beta) \geq 0$. Likewise, there exists a value $\hat{\beta}$ such that: $\forall \beta \leq \hat{\beta}, \nu(\beta) < 0$, and $\forall \beta \geq \hat{\beta}, \nu(\beta) \geq 0$.

Furthermore, the function $k'(.)$ is decreasing and positive. However, $\phi(.)$ is increasing for each individual and since the utility function $U(y, \beta)$ is an increasing function of $\beta$, $\phi(.)$ is an increasing function of $\beta$. Thus, $k'(.)$ decreases with $\beta$.

We then obtain the following result:

- $\forall \beta < \hat{\beta}$, $k'(\phi(U(y_1, \beta)) U_y(y_1, \beta)) U_y(y_1, \beta) \leq k'(\phi(U(y_1, \hat{\beta})) U_y(y_1, \beta))$.
- $\forall \beta \geq \hat{\beta}$, $k'(\phi(U(y_1, \beta)) U_y(y_1, \beta)) \leq k'(\phi(U(y_1, \beta))) U_y(y_1, \beta)$.

This implies that:

$$E_\beta \phi'_2 [U(y_1, \beta)] U_y(y_1, \beta) = E_\beta k'(\phi(U(y_1, \beta))) U_y(y_1, \beta) \leq k'(\phi(U(y_1, \hat{\beta}))) U_y(y_1, \beta)$$

Consequently, $y_2 < y_1$.

**V. PROOF OF PROPOSITION 6**

1. The effect of income on secondary prevention is given by the sign of:

$$\frac{\partial V_y}{\partial w} = E_\beta \left[ \phi'(U(y, \beta)) U_y(y, \beta) \frac{\partial U(y, \beta)}{\partial w} + \phi'(U(y, \beta)) \frac{\partial U(y, \beta)}{\partial w} \right]$$

Using the ambiguity-aversion coefficient $\gamma(y, \beta) = -\frac{\phi'(U(y, \beta))}{\phi(U(y, \beta))}$, we obtain:

$$\frac{\partial V_y}{\partial w} = -E_\beta \left[ \gamma \phi'(U(y, \beta)) U_y(y, \beta) \frac{\partial U(y, \beta)}{\partial w} + E_\beta \phi'(U(y, \beta)) \frac{\partial U_y(y, \beta)}{\partial w} \right]$$

with $\frac{\partial U(y, \beta)}{\partial w} = -pq(\beta) u_{ww}(w - y - H_0 + m(y)) + pq(\beta)m_{y}(y) u_{yfW}(w - y - H_0 + m(y))$.

$$-p(1 - q(\beta)) u_{ww}(w - y, H_0) - (1 - p) u_{ww}(w - y, H_1) \geq 0$$

under the assumption $u_{yfW} \geq 0$. The sign of the second term is negative under our assumptions.

**XVIII**
To study the sign of the first term, we must consider the monotonicity of the function \( \frac{\partial U(y, \beta)}{\partial w} \) with respect to \( \beta \).

\[
\frac{\partial U(y, \beta)}{\partial w} = pq(y)u_w(w - y, H_0 + m(y)) + p(1 - q(\beta))u_w(w - y, H_1) + (1 - p)u_w(w - y, H_1) \geq 0
\]

and

\[
\frac{\partial U(y, \beta)}{\partial \beta} = pq(\beta)[u_y(w - y, H_0 + m(y)) - u_y(w - y, H_0)] \geq 0.
\]

Thus, the expression \( \frac{\partial U(y, \beta)}{\partial w} \) is positive and increasing with respect to \( \beta \).

(a) Let us suppose that \( \gamma \) is an increasing function of the well-being (hence, an increasing one of \( \beta \)), then the function \( \gamma(y, \beta) \times \frac{\partial U(y, \beta)}{\partial w} \) is increasing with respect to \( \beta \). One thus obtains the following result:

\[
\forall \beta \leq \hat{\beta}, \quad \gamma(y, \beta)U_y(y, \beta) \times \frac{\partial U(y, \beta)}{\partial w} \geq \gamma(y, \hat{\beta})U_y(y, \beta) \times \frac{\partial U(y, \hat{\beta})}{\partial w};
\]

\[
\forall \beta \geq \hat{\beta}, \quad \gamma(y, \beta)U_y(y, \beta) \times \frac{\partial U(y, \beta)}{\partial w} \geq \gamma(y, \hat{\beta})U_y(y, \beta) \times \frac{\partial U(y, \hat{\beta})}{\partial w}.
\]

Consequently,

\[
E_\beta \left[ \gamma(y, \beta)\phi'(U(y, \beta))U_y(y, \beta) \times \frac{\partial U(y, \beta)}{\partial w} \right] \geq E_\beta \left[ \gamma(y, \hat{\beta})\phi'(U(y, \beta))U_y(y, \beta) \times \frac{\partial U(y, \hat{\beta})}{\partial w} \right] = 0.
\]

The sign of the first term is negative. Consequently, the sign \( \frac{\partial V_y}{\partial w} \) is ambiguous.

(b) Suppose that \( \gamma \) is sufficiently rapidly decreasing for the function \( \gamma(y, \beta) \times \frac{\partial U(y, \beta)}{\partial w} \) to be decreasing. Then, the first term is positive and the sign of \( \frac{\partial V_y}{\partial w} \) is also positive.

2. The effect of the health status \( H_0 \) on the demand for secondary prevention is given by the sign of:

\[
\frac{\partial V_y}{\partial H_0} = E_\beta \left[ \phi''(U(y, \beta))U_y(y, \beta) + \phi'(U(y, \beta)) \times \frac{\partial U(y, \beta)}{\partial H_0} \right]
\]

Using the ambiguity-aversion coefficient \( \gamma(y, \beta) \), we obtain:

\[
\frac{\partial V_y}{\partial H_0} = -E_\beta \left[ \phi'(U(y, \beta))U_y(y, \beta) \times \frac{\partial U(y, \beta)}{\partial H_0} \right] + E_\beta \left[ \phi'(U(y, \beta)) \times \frac{\partial U(y, \beta)}{\partial H_0} \right]
\]
with \( \frac{\partial U(y, \beta)}{\partial H_0} = -pq(\beta)u_{wH}(w - y, H_0 + m(y)) + pq(\beta)m_{\gamma}(y)u_{tH}(w - y, H_0 + m(y)) - p(1 - q(\beta))u_{wH}(w - y, H_0) \leq 0 \) assuming \( u_{wH} \geq 0 \).

Under our assumptions, the second term has a negative sign.

To study the sign of the first term, we must consider the monotonicity of the function \( \frac{\partial U(y, \beta)}{\partial H_0} \) with respect to \( \beta \).

\[
\frac{\partial U(y, \beta)}{\partial H_0} = p\left[q(\beta)u(w - y, H_0 + m(y)) + (1 - q(\beta))u_{tH}(w - y, H_0)\right] > 0
\]

and

\[
\frac{\partial U(y, \alpha)}{\partial H_0} = pq(\beta)\left[u_{tH}(w - y, H_0 + m(y))u_{tH}(w - y, H_0)\right] \geq 0.
\]

Hence, the expression \( \frac{\partial U(y, \beta)}{\partial H_0} \) is positive and increasing with respect to \( \beta \).

(a) Let us suppose that \( \gamma \) is a non-decreasing function of the well-being, then the function \( \gamma(y, \beta) \times \frac{\partial U(y, \beta)}{\partial H_0} \) is increasing with respect to \( \beta \). One thus obtains the following result:

\[
\forall \beta \leq \hat{\beta}, \gamma(y, \beta)U_{\gamma, \beta}(y, \beta) \times \frac{\partial U(y, \beta)}{\partial H_0} \geq \gamma(y, \hat{\beta})U_{\gamma, \hat{\beta}}(y, \beta) \times \frac{\partial U(y, \hat{\beta})}{\partial H_0};
\]

\[
\forall \beta \geq \hat{\beta}, \nu(\beta) \geq \gamma(y, \hat{\beta})U_{\gamma, \hat{\beta}}(y, \beta) \times \frac{\partial U(y, \hat{\beta})}{\partial H_0}.
\]

Consequently,

\[
E_{\bullet} \left[ \gamma(y, \beta)\phi(U(y, \beta))U_{\gamma, \beta}(y, \beta) \times \frac{\partial U(y, \beta)}{\partial H_0} \right] \geq E_{\bullet} \left[ \gamma(y, \bar{\beta})\phi(U(y, \bar{\beta}))U_{\gamma, \bar{\beta}}(y, \bar{\beta}) \times \frac{\partial U(y, \bar{\beta})}{\partial H_0} \right] = 0.
\]

The first term is negative.

(b) If we suppose that \( \gamma \) is a strictly decreasing function of the well-being, then the monotonicity of the function \( \gamma(y, \beta) \times \frac{\partial U(y, \beta)}{\partial H_0} \) is not established, and the result is ambiguous.