Willingness to pay for reductions in morbidity risks under anticipated regret

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Abstract Prevention decisions that reduce individuals' morbidity risks are important, generally irreversible, and particularly difficult since they imply a trade-off between two important attributes: the safety and its cost. All those features make regret more likely to be anticipated. In this paper, we study the willingness to pay for reductions in morbidity risks within a framework of anticipated regret. As results, we find that with other things being equal, an individual who is disproportionately averse to large regrets has a higher willingness to pay than a standard expected utility individual. This notion of regret aversion has been shown to be relevant for regret theory to reconcile with many decision patterns which are not in line with standard expected utility theory. Moreover, the effect induced by this notion of regret aversion can be interpreted as if the regret averse individual overweighs risk reductions due to prevention, i.e., probability weighting effect. We further discuss how the resolution of uncertainty may affect the regret averse individual's willingness to pay, and how the attribution effect in belief formation may bias its estimates.

Keywords Regret · Willingness to Pay · Morbidity Risks · Health Policy · Benefit-Cost Analysis

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1 Introduction

Benefit and cost analyses of public programs with the objective of reducing morbidity risks require an estimate of the monetary value of health. These estimates are obtained from either market data or some stated-preference methods (e.g., Andersson and Treich 2011). Whatever methods are utilized for an estimate of the monetary value of health, most of this literature has made a crucial assumption that people are standard expected utility maximizers. Empirical evidence abounds, however, that people violate standard expected utility in systematic ways (e.g., Camerer 1995, Starmer 2000). Assuming expected utility in the face of such violations may lead to biased risk valuations and, consequently, to biased policy recommendations. There appears to be a need to derive valuation formulas for changes in risks that take into account the fact that people deviate from expected utility.

One important reason for why people deviate from standard expected utility is that they not only value the outcome obtained from their decisions, but are also sensitive to whether their decisions were correctly made ex-post.[1] People experience regret when realizing or imagining that their current situation would have been better, if they had decided differently. Regret is not only an affective reaction to bad decision outcomes or processes but also a powerful force in motivating and giving direction to behavior. In the 1980s, the economists Bell (1982, 1983), and Loomes and Sugden (1982) formulated decision theories that take regret into account.[2] In principle, regret theory can explain many of the deviations from expected utility theory (e.g., the common ratio effect, preference intransitivity).[3] Empirical tests have also produced results in line with the theory (e.g., Loomes et al. 1991, Bleichrodt et al. 2010).

Although regret theory has been widely accepted and been successful in explaining decision making (e.g., Braun and Muermann 2004, Michenaud and Solnik 2008, Gollier and Salanié 2006, Gollier 2018), to our best knowledge, it has not been formally introduced into the study of benefit and cost analysis.[4] In particular, when facing decisions about ones' health or lives such as whether working in a dangerous sector or not, people tend to be more likely to anticipate regret and act upon it. This is because these decisions are important, difficult and generally not easy to undo (Zeelenberg 1999). For instance, in a field study Wroe et al. (2004) compared different potential predictors of actual immunization decisions and found that anticipated regret was the strongest predictor of likelihood of immunizing children.[5] The objective of this paper is therefore to take the first step to examine the willingness to pay (WTP) under anticipated regret for reductions in morbidity risks.

In our prevention model, a regret-sensitive decision maker faces a binary choice situation: taking

[1] One plausible argument for why we behave like so is that the ability of feeling such emotions, both regret and rejoicing, may lead to learning and to behavioral adaptations and thereby to avoiding future regrets. As Shefrin and Statman (1985) stated, "both the unpleasant pain of regret and the pleasurable glow of pride can lead to learning. They help us to remember clearly both bad and good choices" (p. 57).

[2] Earlier, in the 1950s, researchers had already pursued a more formal approach to regret (e.g., Luce and Raiffa 1957, Savage 1951). The "minimax regret" decision criterion they proposed however ignored the importance of probability.

[3] See Bleichrodt and Wakker (2015) for more details.

[4] As surveyed by Zeelenberg and Pieters (2007), regret theory has recently attracted a lot attention from academic researchers in many disciplines (see its figure 1).

[5] See more in Boeri et al. (2013) and Brewer et al. (2016) about the impact of anticipated regret on health decisions.

(act T) or not taking (act N) a costly preventive measure to reduce morbidity risks. As our benchmark, to decide which act to choose, a standard expected utility individual makes a trade-off between his marginal expected consumption utility gain due to the increased safety and marginal expected consumption utility loss due to the cost of the preventive measure. For small reductions in morbidity risks, his WTP is simply the marginal rate of substitution between wealth and baseline risk in his consumption utility. But the regret sensitive decision maker has another goal which is to minimize ex-post regret. No matter whether the preventive measure is taken or not, regret could always occur. For instance, when the preventive measure was taken, the decision maker may regret for having wasted money because it was either not needed or not effective; when the preventive measure was not taken, he may regret for not having taken it because it was actually needed and effective.

Our main result is that with other things being equal, the decision maker who is disproportionately averse to large regrets has a higher WTP for small reductions in morbidity risks than a standard expected utility individual. This notion of disproportionate aversion to large regrets has been termed *convexity* of the anticipated net advantage function in regret theory by Loomes and sugden (1982), and plays a crucial role in explaining lottery-choice observations that are not in line with standard expected utility theory. Intuitively, it means that people prefer experiencing two small regrets separately than experiencing the sum of them at once. In our prevention model, we can show that with this notion of regret aversion, the ratio between the anticipated net utility gain from reducing one unit of risk and the anticipated net utility loss from paying one unit of wealth is larger than the marginal rate of substitution between wealth and baseline risk in consumption utility. This implies a higher WTP for the regret sensitive decision maker. Moreover, disproportionate aversion to large regrets induces an effect which can be interpreted as if the decision maker overweights the probability reduction. This interpretation reflects on the fact that people often spend too much effort in prevention, just in case.

The remainder of this paper is organized in the following way: Section 2 introduces regret-theoretic expected utility theory and its straightforward extension for our study; Section 3 sets up our theoretical framework and discusses the decision problem under anticipated regret; Section 4 examines the WTP and presents our main results; some extensions are further discussed in Section 5; and the last section concludes.

2 Regret-theoretic expected utility theory

Assume that there are in total n possible states of nature. We denote the set of states of nature as $\mathcal{S} = \{s_1, s_2, \cdots, s_n\}$ where s_k occurs with a probability p_k with $\sum_{k=1}^{n} p_k = 1$. An act $\mathcal{A}_i$ is defined as an n-tuple of state-contingent consequences with $\mathcal{A}_i = (a_{i1}, \cdots, a_{in})$. A decision maker faces a choice between actions $\mathcal{A}_i$ and $\mathcal{A}_j$. If $\mathcal{A}_i$ is chosen and s_k occurs then a_{ik} is received and a_{jk} foregone, which would have been received under s_k had $\mathcal{A}_j$ been chosen. In the original regret theory (Bell 1982, 1983, and Loomes and Sugden 1982), the decision maker receives (real-valued) modified utility $V(a_{ik}, a_{jk})$ which is increasing in the outcome which occurs under the chosen act

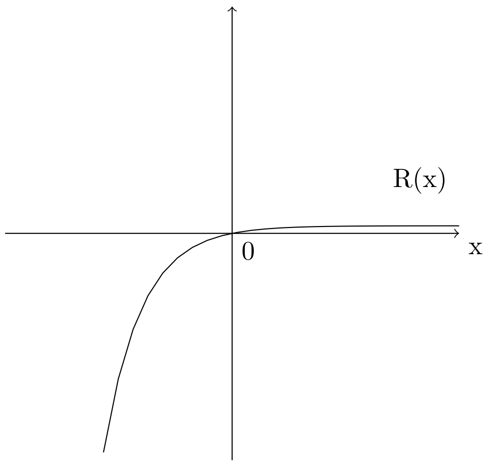

Figure 1 Regret-rejoicing function $R(\cdot)$, calibrated with $R(x) = 0.1 - 0.1exp(-2x)$

and decreasing in the outcome from the foregone act under the same state, namely, $V_1(\cdot,\cdot) > 0$ and $V_2(\cdot,\cdot) < 0$.[6] Before making a choice, the decision maker compares what is under a particular state having chosen a particular act with what might have been had he chosen differently under the same state. The decision is made according to the following expression:

$$\mathcal{A}_i \underset{\prec}{\overset{\succ}{\sim}} \mathcal{A}_j \Longleftrightarrow \sum_{k=1}^{n} p_k V(a_{ik}, a_{jk}) \underset{<}{\overset{>}{=}} \sum_{k=1}^{n} p_k V(a_{jk}, a_{ik}) \tag{2.1}$$

A slight different expression of regret theory is to assume that $V(a,b)$ has the following form:

$$V(a,b) = u(a) + R\big(u(a) - u(b)\big) \tag{2.2}$$

where $u(a)$ was referred by Loomes and Sugden (1982) as a choice-less utility function, which reflects the utility the decision maker would derive from an outcome a if he experienced it without having chosen it, and Bell (1982) referred to $u(\cdot)$ as a value function measuring strength of preference, or incremental value; $u(a) - u(b)$ reflects the level of decision rejoicing as $u(a) > u(b)$, or decision regret as $u(a) < u(b)$; $R(\cdot)$ is the regret-rejoicing function with $R'(\cdot) > 0$, and without any loss of generality, $R(0)$ is assumed to be zero. This two-attribute specification has the advantage of separating the decision maker's risk aversion into two components: the changing marginal value the decision maker attaches to different levels of wealth and the decision maker's intrinsic dislike of uncertainty which is regret. This separability therefore makes our analysis comparable to standard expected utility theory. So we will continue this tradition in the rest of this paper.[7]

Bell (1982, 1983) and Loomes and Sugden (1982) further demonstrated that the above specification of regret theory with $R(\cdot)$ being decreasingly concave (i.e., $R''(\cdot) < 0$ and $R'''(\cdot) > 0$) could explain many observations in lottery choices such as the common ratio effect, preference intransitivity and so on, which are, however, not consistent with standard expected utility theory. These properties have also been coined as disproportionate aversion to large regrets in Bleichrodt et al.

[6] The negative sign of $V_2(\cdot,\cdot)$ is in line with Sarver (2008)'s notion of regret or aversion to regret in Gollier (2018).

[7] For the same arguments we provide, this specification has been widely adopted in finance and insurance literature, see, for instance, Braun and Muermann (2004) and Michenaud and Solnik (2008).

Table 1 Payoff matrix

Acts	States of nature		
	s_1	s_2	s_3
$\mathcal{A}_1$	c	b	a
$\mathcal{A}_2$	a	c	b

Note: all the states of nature are equiprobable, i.e., $P(s_1) = P(s_2) = P(s_3) = \frac{1}{3}$.

(2010), which provided empirical support for it.[8] Figure 1 shows an example of regret-rejoicing function satisfying all these properties. Given its importance in our following study, we give below the definition of disproportionate aversion to large regrets:

Definition of disproportionate aversion to large regrets:

A decision maker with risk preferences shown in (2.2) is said to be disproportionately averse to large regrets as long as for all $a > b > c$, $R\big(u(a) - u(c)\big) - R\big(u(c) - u(a)\big) > R\big(u(a) - u(b)\big) - R\big(u(b) - u(a)\big) + R\big(u(b) - u(c)\big) - R\big(u(c) - u(b)\big)$. And this is true if $R(\cdot)$ is decreasingly concave, i.e., $R''(\cdot) < 0$ and $R'''(\cdot) > 0$..[9]

To illustrate this definition, let us consider the example shown in Table 1. It's obvious that acts $\mathcal{A}_1$ and $\mathcal{A}_2$ have the same marginal distribution. So an expected utility individual will be indifferent between the two. However, an individual who is disproportionately averse to large regrets will strictly prefer $\mathcal{A}_2$ to $\mathcal{A}_1$. Intuitively, he prefers experiencing two small (relative) regrets separately than experiencing the sum of them at once, i.e., $R\big(u(c) - u(a)\big) - R\big(u(a) - u(c)\big) < R\big(u(b) - u(a)\big) - R\big(u(a) - u(b)\big) + R\big(u(c) - u(b)\big) - R\big(u(b) - u(c)\big)$.[10]

In the context of prevention of morbidity, a decision maker's choice-less utility function will depend not only on his wealth (i.e., w) but also on his health status which, for simplicity, can be either good or bad (i.e., $h = g$ or b). We introduce below a rather straightforward modification of the formulation (2.2) allowing for a bivariate choice-less utility function $u(w, h)$:

$$V^{RT}\big(u(w_1, h_1), u(w_2, h_2)\big) = u(w_1, h_1) + \lambda R\big(u(w_1, h_1) - u(w_2, h_2)\big) \tag{2.3}$$

where $R(\cdot)$ is as previously defined with the same properties. We also introduce a non-negative parameter λ as a measure of *regret sensitivity*. Obviously, as $\lambda = 0$, the decision maker is just a standard expected utility maximizer.

We will further assume that the bivariate choice-less utility function $u(w, h)$ has the following properties: $u_1(w, h) > 0$, $u_{11}(w, h) < 0$, $u(w, g) > u(w, b)$ and $u_1(w, g) > u_1(w, b)$. The first two

[8] A more recent work by Somadundaram and Diecidue (2017) further replicated their results. These properties of $R(\cdot)$ can be shown to be equivalent to the convexity of function $Q(\cdot)$ in their papers with $Q\big(u(a) - u(b)\big)$ being $u(a) - u(b) + R\big(u(a) - u(b)\big) - R\big(u(b) - u(a)\big)$.

[9] Note that this is not a biconditional relationship and that a positive third derivative is rather mild assumption. If the third derivative of regret-rejoicing function has a constant sign, it must be positive given that regret-rejoicing function is increasing and concave (see Clark 2011).

[10] This notion of regret aversion is fairly close to the notion of aversion to risk of regret introduced by Gollier (2018) which defines regret as the difference between the obtained outcome and the best forgone outcome. It's worth noting that both notions of regret aversion can be interpreted as a preference for positive correlation.

inequalities indicate that the decision maker prefers more wealth to less, and is averse to risk in his wealth; the last two indicate that both the decision maker's utility of wealth and her marginal utility of wealth are higher at good condition than at bad condition. Note that these assumptions are common in the literature (e.g., Jones-Lee 1974, Weinstein et al. 1980). Also, Viscusi and Evans (1990), Sloan et al. (1998), and more recently Finkelstein et al. (2013) provided empirical support for the assumption that a person enjoys the benefits of an extra dollar at least as much when healthy as when ill.

3 Prevention model

Our model has two dates. At date 1, a decision maker who is initially at good condition faces some uncertainty in his future health status which can be either good or bad, i.e., $h = g$ or b. At date 2, the uncertainty resolves. Whether the decision maker ends up being at good condition or not depends on some *latent* variable x with $x \in \mathcal{X} = \{0, 1\}$. With a probability $p \in (0, 1)$, x tends out to be 1, and the decision maker is eventually at bad condition. One can think of morbidity risks here as an infectious disease which only affects these people with some genetic disorders. Although the defect cannot be diagnosed, we know that each person has it with a probability p.

At date 1, the decision maker can decide either to take (i.e., act T) or not to take (i.e., act N) a preventive measure, which costs an amount of money C and can reduce the morbidity risk on the population level from p to $p - \epsilon$. The *effectiveness* of the preventive measure is denoted by y with $y \in \mathcal{Y} = \{0, 1\}$; as $y = 0$, the preventive measure is effective, and not otherwise. It's easy to derive that the probability of the preventive measure being effective is equal to ϵ/p. Whether the decision maker is eventually at good or bad condition depends on the realization of *latent* variable x and the *effectiveness* of the preventive measure y. So the set of all possible states of nature, denoted as $\mathcal{S}$, can be represented by a Cartesian product of $\mathcal{X}$ and $\mathcal{Y}$, namely, $\mathcal{S} = \{(x, y) \mid x \in \mathcal{X}, y \in \mathcal{Y}\}$. The choice problem can be further characterized by a menu $\mathcal{M} = \big\{N, T \mid \mathcal{S} \to R \times \{g, b\}\big\}$ (see Table 2).[11,12]

The decision maker feels either rejoicing or regret, depending on the difference between his actual choice-less utility from the obtained outcome and the utility that could been obtained if he had chosen differently. When the preventive measure is taken, the decision maker feels regret for having wasted money in prevention which was either not used at states of nature s_1 and s_2 or not useful at state of nature s_4, and feels rejoicing at state of nature s_3 for having made a good choice given the cost is not too high (i.e., $u(w - C, g) > u(w, b)$). It's a completely opposite story when the decision maker does not take the preventive measure: the decision maker feels rejoicing at states of nature s_1, s_2 and s_4 for not having wasted money in prevention, and feels regret at state of nature s_3 for not having invested in prevention which could have been used and useful.

[11] One can also think of the decision problem here as a binary decision in some stated preference methods such as contingent valuation used to estimate the value of a statistical life in traffic and other areas (e.g., Mitchell and Carson 1989, Bateman et al. 2002).

[12] Adding side effects decreases the WTP. Let g^- and b^- denote the decision maker's health status if the preventive measure was taken and he is eventually not sick and sick, respectively. Suppose that $g \succ g^- \succ b \succ b^-$. So there is a first-order risk increase on the health dimension in act T. The preventive measure becomes less valuable. To study properly the impact of regret on the WTP, we isolate regret from side effects.

Table 2 Payoff matrix

Acts	States of nature (x, y)			
	s_1	s_2	s_3	s_4
	$(0, 0)$	$(0, 1)$	$(1, 0)$	$(1, 1)$
N	(w, g)	(w, g)	(w, b)	(w, b)
T	$(w - C, g)$	$(w - C, g)$	$(w - C, g)$	$(w - C, b)$

Note: each element inside of the matrix consists of the decision maker's final wealth and health status; moreover, $P(s_1) + P(s_2) = 1 - p$, $P(s_3) = \epsilon$, and $P(s_4) = p - \epsilon$.

Notice that acts N and T are mutually exclusive: once one act is chosen, the other will never be resolved. So at date 2, the decision maker may only observe the outcome of his chosen act, i.e., his final wealth and health status. This specific feature of our prevention model deviates from other applications of regret theory where people finally observe the realized state of nature and hence know ex-post what could have been obtained had they chosen differently. In our previous example, suppose the decision maker took the preventive measure and he's eventually at good condition, he may not know whether it's because the preventive measure was effective (i.e., $y = 0$) or because he does not have the genetic disorders (i.e., $x = 0$).

However, without receiving a direct feedback over the forgone act, people could still feel regret and rejoicing. Due to interdependency between acts, the outcome of the chosen act reveals either partial or full information about which state of nature materialized.[13] In case of only partial revelation, people could mentally construe feedback and compare the obtained outcome to this construed alternative as research on counter-factual thinking (e.g., Roese 1997, Zeelenberg et al. 1998) shows. The results of Bar-Hillel and Neter (1996) suggest that in some cases regret stemming from counter-factual thinking can be of equal strength. However, some other studies (e.g., Larrick and Boles 1995, Zeelenberg 1999) suggest that it may be less relevant. Since regret and rejoicing are supposed to be quite salient in the context of prevention of morbidity, we hereafter assume that people feel regret and rejoicing of equal strength with or without full information about the realized state of the nature. A more detailed discussion on this issue will be given in Section 5.

4 Willingness to pay under anticipated regret

Under anticipated regret, the willingness to pay (WTP) and the willingness to accept (WTA) share a lot of similarities and are equal for small changes in morbidity risks.[14] So in our study, we choose to focus on the WTP which is also the basic principle underlying benefit-cost analyses. Suppose the decision maker is indifferent between taking (i.e., act N) and not taking (i.e., act T) a preventive measure which costs C and helps to reduce the baseline probability p by $\Delta p = \epsilon$. By

[13] Smith (1996) studied treatment decisions for chronic diseases within a similar framework but considered them as independent acts in his study.

[14] Note that this is also true under standard expected utility theory (e.g., Hammitt 2000).

definition, the cost C is the WTP for a risk reduction of ϵ if $N \sim T$. Under our regret-theoretic expected utility theory, it means:

$$V^{RT}(N) = V^{RT}(T) \tag{4.1}$$

where

$$\begin{aligned} V^{RT}(T) \equiv {} & [P(s_1) + P(s_2)]\big[u(w-C,g) + \lambda R\big(u(w-C,g) - u(w,g)\big)\big] \\ & + P(s_3)\big[u(w-C,g) + \lambda R\big(u(w-C,g) - u(w,b)\big)\big] \\ & + P(s_4)\big[u(w-C,b) + \lambda R\big(u(w-C,b) - u(w,b)\big)\big] \end{aligned} \tag{4.2}$$

$$\begin{aligned} V^{RT}(N) \equiv {} & [P(s_1) + P(s_2)]\big[u(w,g) + \lambda R\big(u(w,g) - u(w-C,g)\big)\big] \\ & + P(s_3)\big[u(w,b) + \lambda R\big(u(w,b) - u(w-C,g)\big)\big] \\ & + P(s_4)\big[u(w,b) + \lambda R\big(u(w,b) - u(w-C,b)\big)\big] \end{aligned} \tag{4.3}$$

with $P(s_1) + P(s_2) = 1 - p$, $P(s_3) = \epsilon$, and $P(s_4) = p - \epsilon$ (see Table 2).

Note that as ϵ tends to zero, C also needs to converge to zero so that $V^{RT}(T)$ and $V^{RT}(N)$ remain equal, i.e., $\lim_{\epsilon\to 0} C(\epsilon) = 0$. Fully differentiating Equation (4.1) with respect to ϵ and taking a limit as ϵ gets close to zero, we have:

$$\begin{aligned} & \underbrace{u(w,g) - u(w,b)}_{(1)} - \underbrace{\big[(1-p)u_1(w,g) + pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}}_{(2)} \\ & - \underbrace{\lambda R'(0)\big[(1-p)u_1(w,g) + pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}}_{(3)} + \underbrace{\lambda R\big(u(w,g) - u(w,b)\big)}_{(4)} = \\ & \underbrace{\lambda R'(0)\big[(1-p)u_1(w,g) + pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}}_{(5)} + \underbrace{\lambda R\big(u(w,b) - u(w,g)\big)}_{(6)} \end{aligned} \tag{4.4}$$

On the left hand side of Equation (4.4), the term (1) is the expected marginal choice-less utility increase from reducing one unit of morbidity risks; the term (2) is the expected marginal choice-less utility decrease from spending one unit of wealth in prevention; the term (3) is the expected marginal utility loss due to regret for spending one unit of wealth in prevention; and the term (4) is the expected marginal utility gain due to rejoicing for reducing one unit of morbidity risks. On the right side of of Equation (4.4), the term (5) is the expected marginal utility gain due to rejoicing for not spending one unit of wealth in prevention, and the term (6) is the expected marginal utility loss due to regret for not reducing one unit of morbidity risks. So under regret-theoretic expected utility theory, the decision maker not only trades off between the expected marginal choice-less utility cost and benefit but also between the expected marginal utility loss due to regret and the expected marginal utility gain due to rejoicing from taking and not taking the preventive measure. Rearranging Equation (4.4) gives:

$$\begin{aligned} WTP^{RT}|_{\epsilon\to 0} &= \frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0} \\ &= \frac{u(w,g) - u(w,b) + \lambda\big[R\big(u(w,g) - u(w,b)\big) - R\big(u(w,b) - u(w,g)\big)\big]}{(1-p)u_1(w,g) + pu_1(w,b) + 2\lambda R'(0)[(1-p)u_1(w,g) + pu_1(w,b)]} \end{aligned} \tag{4.5}$$

In the above expression, as $\lambda = 0$, we obtain the WTP of a standard expected utility decision maker for small reductions in morbidity risks, i.e., $WTP^{EU}|_{\epsilon \to 0}$.

Proposition 1. *For $\lambda > 0$, $WTP^{RT}|_{\epsilon \to 0} > WTP^{EU}|_{\epsilon \to 0}$ if and only if $R(\cdot)$ is decreasingly concave.*

Proof. see Appendix A. □

The driving force of this result is that when the decision maker is disproportionately averse to large regrets, the ratio between the anticipated net utility gain at state of nature s_3 from reducing one unit of risk, i.e., $R(u(w,g) - u(w,b)) - R(u(w,b) - u(w,g))$, and the anticipated net utility loss at states of nature s_1, s_2 and s_4 from spending one unit of wealth in prevention, i.e., $2R'(0)[(1-p)u_1(w,g) + pu_1(w,b)]$, will be larger than the marginal rate of substitution between wealth and baseline risk in choice-less utility, i.e., $WTP^{EU}|_{\epsilon \to 0}$. Intuitively, the decision maker who is disproportionately averse to large regrets is more concerned about regret at state of nature s_3 where he can be eventually at good condition only if the prevention measure is effective than regret at the other states of nature where he waste money for nothing. With other things being equal, this asymmetry in regret between taking and not taking a preventive measure pushes him to value it more than an expected utility decision maker does. It's worth noticing that assuming alone concavity of $R(\cdot)$ is not sufficient for delivering this result. Particularly, as $R'(\cdot)$ is linear, $WTP^{RT}|_{\epsilon \to 0}$ and $WTP^{EU}|_{\epsilon \to 0}$ are equal.

Reformulating Equation (4.5) to Equation (4.6), we can also say that the decision maker who is disproportionately averse to large regrets behaves as if he overweights the probability of state of nature s_3. That is, this notion of regret aversion induces an effect equivalent to a probability weighting effect. This interpretation sheds light on the fact that people often exert too much effort, just in case. It's, however, worth noting that this "probability weighting" effect depends also on the decision maker's initial wealth, choice-less utility function and his sensitivity to regret.[15]

$$WTP^{RT}|_{\epsilon \to 0} = WTP^{EU}|_{\epsilon \to 0} \left[\frac{1 + \lambda \frac{R(u(w,g)-u(w,b)) + R(u(w,b)-u(w,g))}{u(w,g)-u(w,b)}}{\frac{1}{1+2\lambda R'(0)}} \right] \tag{4.6}$$

Proposition 2. *For $\lambda > 0$,*

1. $\frac{\partial WTP^{RT}|_{\epsilon \to 0}}{\partial \lambda} > 0$ *if and only if $R(\cdot)$ is decreasingly concave;*
2. $\frac{\partial WTP^{RT}|_{\epsilon \to 0}}{\partial p} > 0$;
3. $\frac{\partial WTP^{RT}|_{\epsilon \to 0}}{\partial w} > 0$.

Proof. see Appendix A. □

As the decision maker puts a higher weight on utility from regret and rejoicing (i.e., a higher λ), he becomes more concerned about the trade-off between regret and rejoicing from taking and not taking a preventive measure. From proposition 1, we know that if the decision maker is

[15] Gollier (2018) found that adopting a multiplicative form of regret theory with both regret and rejoicing could explain the binary rank-dependent utility.

disproportionately averse to large regrets, he will be willing to pay more compared to the situation where he is insensitive to regret. This leads to our proposition 2.1 that the higher the regret sensitivity is, the more the decision maker will be ready to pay for small reductions in morbidity risks. We also find this prediction is readily amenable to empirical tests with the regret sensitivity λ elicited through some psychometric test questionnaire (e.g., Schwartz et al. 2002).

Proposition 2.2 tells us that the WTP for small risk reductions is increasing in the baseline risk under regret theory. In Equation (4.5), the baseline risk only shows up in the denominator. Intuitively, a person facing a large probability of being sick has little incentive to limit his spending on risk reduction since he is unlikely to be healthy, as the first two terms in the denominator mean, i.e., $u_1(w, g) > u_1(w, b)$. At the same time, the anticipated net utility gain from not taking the prevention measure also decreases, i.e., $2\lambda R'(0)[(1-p)u_1(w, g) + pu_1(w, b)]$, because it's less likely to be healthy. These two effects work in the same direction and further increase the decision maker's incentive to spend on prevention.

By proposition 2.3, the WTP for small risk reductions is increasing in wealth under regret-theoretic expected utility theory. The intuition for the wealth effect is four-fold. First, wealthier people have more to lose in their choice-less utilities if they get sick. This is because the first two terms of the numerator in Equation (4.5), i.e., $u(w, g) - u(w, b)$, increase with w. Second, the cost of spending in choice-less utility is smaller due to weakly diminishing marginal choice-less utility with respect to wealth, i.e., $u_{11}(\cdot, \cdot) < 0$, that is, the first two terms of the denominator in Equation (4.5) do not increase in w. Third, at state of nature s_3 wealthier paper would obtain higher anticipated net utility gains from taking a preventive measure since the third term of the numerator in Equation (4.5), i.e., $\lambda[R\big(u(w, g) - u(w, b)\big) - R\big(u(w, b) - u(w, g)\big)]$, is increasing in w. Last, at states of nature s_1, s_2 and s_4 wealthier people would suffer a lower anticipated net utility loss from taking a preventive measure since the third term of the denominator in Equation (4.5), i.e., $2\lambda R'(0)[(1-p)u_1(w, g) + pu_1(w, b)]$, is decreasing in w. Note that both propositions 2.2 and 2.3 also hold under standard expected utility theory, i.e., $\partial WTP^{EU}|_{\epsilon\to 0}/\partial p > 0$ and $\partial WTP^{EU}|_{\epsilon\to 0}/\partial w > 0$.

5 Discussion

Regret with partial resolution of uncertainty

Although the decision maker in our prevention model does not directly observe the realized state of nature, his eventual health state can reveal either partial or full information about it. Assume that the decision maker updates correctly his beliefs. Suppose that he took the preventive measure and is eventually at bad condition, he feels certainly regret because the preventive measure was useless and he could have been better off if he had not wasted money on it; but suppose that he did not take the preventive measure and is eventually at good condition, he feels certainly rejoicing because he saved the cost of the preventive measure. In these two situations, it's equivalent to say that the decision maker receives a direct feedback about the forgone acts. While in the other situations the decision maker can only infer partially the realized state of nature, and the forgone acts may be never resolved to him. Since there is no uncertainty in the wealth aspect, with some abuse of notation, we denote health outcomes from choosing act N and T as $N(h)$ and $T(h)$, respectively. In case that the decision maker took the preventive measure and is eventually at good condition, he knows he could have been either at good or bad condition with the following probabilities:

$$P\big(N(h) = g \mid T(h) = g\big) = \frac{P(s_1) + P(s_2)}{P(s_1) + P(s_2) + P(s_3)} = \frac{1-p}{1-p+\epsilon} \tag{5.1}$$

$$P\big(N(h) = b \mid T(h) = g\big) = \frac{P(s_3)}{P(s_1) + P(s_2) + P(s_3)} = \frac{\epsilon}{1-p+\epsilon} \tag{5.2}$$

if he had chosen act N instead. Alternatively, in case that the decision maker chose to not take the preventive measure and is eventually at bad condition, he knows that he could have been either at good or bad condition with the following probabilities:

$$P\big(T(h) = g \mid N(h) = b\big) = \frac{P(s_3)}{P(s_3) + P(s_4)} = \frac{\epsilon}{p} \tag{5.3}$$

$$P\big(T(h) = B \mid N(h) = b\big) = \frac{P(s_4)}{P(s_3) + P(s_4)} = \frac{p-\epsilon}{p} \tag{5.4}$$

if he had chosen act T instead.

So far, we have assumed that the regret-sensitive decision maker feels regret and rejoicing with equal strength no matter whether there is any direct feedback about the forgone acts or not. To our best knowledge, Bell (1983) first studied this problem and defined what is called resolution premium, i.e., an amount of money that an individual is ready to pay to cancel his forgone acts.[16] In Bell (1983), a regret-sensitive decision maker was assumed to feel regret or rejoicing through comparing his obtained choice-less utility with the expected choice-less utility he could have obtained had he chosen differently. Expectation is a convenient reference point since it takes into account properly the likelihoods of possible forgone outcomes. The concavity of regret-rejoicing function $R(\cdot)$ further implies that the decision maker would prefer to not have any feedback over his forgone acts.[17] This is in line with the fact that people tend to avoid feedback about their forgone acts if possible or react more aggressively to regret when they anticipate future feedback (e.g., Larrick and Boles 1995, Zeelenberg 1999 and more recently Gigerenzer and Rocio 2017).

Following the same idea of Bell (1983), we redo our previous analysis to allow for different levels of regret intensity in case of having and not having feedback over the forgone acts (see more details in Appendix B). We find that with all other things being equal, the regret-sensitive decision maker has the same WTP for small reductions in morbidity risks as a standard expected utility individual. So it's lower than what we obtained previously (see proposition 1). Intuitively, as there is no direct feedback over the forgone acts, both regret and rejoicing matter to a less extent, so the regret-sensitive decision maker will behave similarly as a standard expected utility individual does. This therefore suggests that the WTP in Equation (4.5) is the upper limit the regret-sensitive

[16] Humphrey (2004) also studied this feedback issue and provided what he called feedback-conditional regret theory. However, the behavioral foundations of this theory were not very clear.
[17] It is easy to show that $E[u(x) + kR(u(x) - E(u(y) \mid x))] > E[u(x) + kR(u(x) - u(y))]$ by Jensen's inequality.

decision maker is willing to pay for small reductions in morbidity risks. If information available in hindsight, which has no value for standard expected utility individuals, matters for regret sensitive individuals, we will expect the way of resolving uncertainty will influence their WTP. In some cases, after prevention decisions are made, uncertainty is fully resolved; but in the other cases, uncertainty is partially resolved. Then according to our previous discussion, the estimated WTP in the later cases would be lower.

Belief formation and attribution effect

In our above discussion, the decision maker has been assumed to revise his beliefs correctly.[18] However, this assumption may be not always valid in reality. In particular, people often have a tendency to neglect correlation when aggregating information (e.g., Enke and Zimmermann 2017). In our study, the decision maker may perceive acts N and T as independently distributed. This misperception of interdependence could distort the WTP estimates. However, we believe that this type of bias could be corrected through necessary clarification of decision situations and training.

What remains worrying is that individuals may not appreciate precisely to what extent their decisions have contributed to their actual situations—the *attribution effect*. This form of bias in belief formation is probably more related to regret emotion and difficult to be corrected.[19] In the context of prevention of morbidity, the decision maker may take either a pessimistic or optimistic view towards the effectiveness of a preventive measure. To incorporate this attribution effect, conditional probabilities in Equations (5.1)-(5.4) can be written as follows:

$$P\big(N(h) = g \mid T(h) = g\big) = \frac{1-p}{1-p+\alpha\epsilon} \tag{5.5}$$

$$P\big(N(h) = b \mid T(h) = g\big) = \frac{\alpha\epsilon}{1-p+\alpha\epsilon} \tag{5.6}$$

$$P\big(T(h) = g \mid N(h) = b\big) = \frac{\beta\epsilon}{p} \tag{5.7}$$

$$P\big(T(h) = b \mid N(h) = b\big) = \frac{p-\beta\epsilon}{p} \tag{5.8}$$

where both α and β are non-negative and not necessarily equal to one, i.e., the decision maker may put unequal weights on the base rates and the change of the baseline risk. In particular, as $\alpha > 1$ and $\beta < 1$, we can show that the decision maker is ready to pay more for small reductions in morbidity risks. Intuitively, the decision maker feels less regret when the preventive measure was not taken and he is eventually sick, since he attributes his sickness more to bad luck (i.e., $\beta < 1$); and he feels more rejoicing for having made a good decision when he is eventually alive after taking the preventive measure, since he attributes his health more to the preventive measure (i.e., $\alpha > 1$). Overall, this makes the preventive measure more valuable (see more details in Appendix

[18] The decision maker may also misperceive probabilities, as is commonly observed in empirical studies of decision under risk. See, for instance, Bleichrodt and Eeckhoudt (2006) which studied the willingness to pay for reductions in health risks when probabilities are distorted and showed that for the levels of baseline risk typically considered, probability weighting strongly affects willingness to pay estimates and may lead to unstable monetary valuations of health.

[19] Individuals may form subjective beliefs which are different from the objective ones to regulate ex-post regret and rejoicing. Anticipating this, individuals may react differently when considering their decisions. This strategy of regulation entails cognitive dissonance and could be mentally costly.

C). However, in other cases, the WTP could be either higher or lower compared to the situation without the attribution effect.

Regret theory with more than two acts

Throughout this paper, we have considered the original regret theory introduced in Bell (1982, 1983) and Loomes and Sugden (1982) because this version of regret theory helps to reconcile with many observed behaviors which are not in line with standard expected utility theory. However, some criticism may arise because this version of regret theory is restricted to pairwise choice situations and induces intransitive preferences. Loomes and Sugden (1982) have argued that the decision maker would take all available acts into consideration. If that is so, the criticism of intransitivity will be rejected. Sugden (1993) further presented an axiomatization for this idea. Later on, Quiggin (1994) suggested that if adding or removing a state-wise dominated act does not affect the optimal choice, i.e. the irrelevance of statewise dominated acts principle, only regret will matter. Then the regret sensitive decision maker's utility of obtaining a consumption utility $u(w_1, h_1)$ but forgoing a consumption utility $u(w_2, h_2)$ becomes as follows

$$V^{RT}\big(u(w_1,h_1), \max\{u(w_1,h_1), u(w_2,h_2)\}\big) = u(w_1,h_1)+\lambda R\big(u(w_1,h_1)-\max\{u(w_1,h_1), u(w_2,h_2)\}\big) \tag{5.9}$$

With the above preference, the regret sensitive decision maker has a higher WTP than a standard expected utility individual if and only if function $R(\cdot)$ is concave (see Appendix D). This concavity captures the notion of aversion to risk of regret defined in Gollier (2018), which is close to our notion of disproportionate aversion to large regrets. We can show that all the results in proposition 2 also hold under the preference (5.9) with $R''(\cdot) < 0$. However, from a theoretical point of view, Gollier has demonstrated that rejoicing is important for explaining certain behaviors such as "certainty effect", which is typically observed in experimental studies. Moreover, many pieces of evidence show that people do sometimes violate transitivity of preferences (e.g., Tversky 1969, Loomes et al 1991). Since we're interested in how people really behave, we have adopted the original regret theory for our study.

6 Conclusion

Regret theory has been introduced into economics several decades ago since the seminal works by Bell (1982, 1983), and Loomes and Sugden (1982). Despite the fact that regret theory has been widely applied for explaining decision making, it has not been formally studied in benefit and cost analysis. In this paper, we took the first step to study the WTP for morbidity risks under anticipated regret. This measure plays a role much broader than its impact on benefit-cost analysis, as they have ramifications for policies dealing with health care. We showed that with other things being equal, an individual who is disproportionately averse to large regrets has a higher WTP for small reductions in morbidity risks than an expected utility individual. These results reveal the fact that the WTP estimates may reflect individuals' concern over regret and rejoicing.

Our finding raises up the question about whether our standard approaches used to measure the WTP and WTA should be adjusted to incorporate regret. Some specific methodologies in experimental economics such as trade-off method (Wakker and Deneffe 1996) already exist and could probably cope with this issue. So practitioners doing benefit and cost analysis may learn from other closely related disciplines. However, some other challenges and criticisms still remain. For instance, it may be difficult to compute welfare effects and to identify a robust health policy to include regret, which is very context-dependent (Croson and Treich 2014). The questions like whether the measured WTP and WTA of regret-sensitive individuals should be taken at face value for policy evaluations are also to be debated. It questions on whether social welfare should include emotional turmoil such as regret. If not, should governments correct individual decisions based on regret and be paternalistic?

Furthermore, regret can be crucial for evaluating different policy interventions. Different from other emotions, regret can only arise from making decisions and is more likely to be felt when people feel responsible for their situations (Zeelenberg et al. 2007). From that point of view, paternalism may be supported because enforcing prevention can help reduce self-blaming. Alternatively, financing prevention through taxation may also reduce regret but would induce certain distortions in private markets (Huang et al. 2014). Moreover, some information campaigns emphasizing the importance of prevention may encourage counterfactual thinking and make regret more overwhelming.

In the end, our study also provides some plausible explanations for why the estimated WTP often has a large variation (Viscusi 1993).[20] According to our results, this wide range may be not only due to the heterogeneity in individuals' wealth and other social characteristics but also due to different levels of regret sensitivity and intensity. Some other psychological effects such as the attribution effect and correlation neglect may lead to this large variation, too.

[20] Most surveyed studies fall within a $3.8-$9.0 million range, when converted into year 2000 dollars.

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Appendix A: Proofs

Proposition 1

Suppose that $WTP^{RT}|_{\epsilon\to 0} > WTP^{EU}|_{\epsilon\to 0}$, then

$$\frac{\lambda\big[R\big(u(w,g)-u(w,b)\big)-R\big(u(w,b)-u(w,g)\big)\big]}{2\lambda R'(0)[(1-p)u_1(w,g)+pu_1(w,b)]} > \frac{u(w,g)-u(w,b)}{(1-p)u_1(w,g)+pu_1(w,b)}$$
$$\Leftrightarrow R\big(u(w,g)-u(w,b)\big)-R\big(u(w,b)-u(w,g)\big) > 2R'(0)[u(w,g)-u(w,b)]$$

Denote $x = u(w,g)-u(w,b) > 0$. The above inequality can be rewritten as follows,

$$R(x)-R(-x) > 2R'(0)x$$

If $R(\cdot)$ is linear, the above inequality is binding. Define $F(x) = R(x)-R(-x)-2R'(0)x$ with $F(0)=0$. Then $F'(x)>0$ for $x>0$ if and only if

$$F'(x) = R'(x)+R'(-x)-2R'(0) > 0$$
$$\Leftrightarrow R'(-x)-R'(0) > R'(0)-R'(x)$$

Since $R''(\cdot)<0$, both terms on the left and right hand sides are positive. The above inequality is true if and only if $R'''(\cdot)>0$, that is, $R(\cdot)$ is decreasingly concave. This further implies that $R(x)-R(-x) \geq 2R'(0)x$ for $x>0$. So we have $WTP^{RT}|_{\epsilon\to 0} > WTP^{EU}|_{\epsilon\to 0}$ when $R(\cdot)$ is decreasingly concave.

Proposition 2

To prove proposition 2.1, let us denote $A = u(w,g)-u(w,b)$ and $B = (1-p)u_1(w,g)+pu_1(w,b)$ for simplifications. $WTP^{RT}|_{\epsilon\to 0}$ can be rewritten as follows

$$WTP^{RT}|_{\epsilon\to 0} = \frac{A+\lambda[R(A)-R(-A)]}{[1+2\lambda R'(0)]B}$$

Taking the first order derivative with respect to λ gives:

$$\frac{\partial WTP^{RT}|_{\epsilon\to 0}}{\partial\lambda} = \frac{[R(A)-R(-A)]B-2R'(0)BA}{[1+2\lambda R'(0)]^2B^2}$$

Note that the denominator is positive (see proof of proposition 1). Therefore, $\partial WTP^{RT}|_{\epsilon\to 0}/\partial\lambda > 0$. The proof for propositions 2.2 and 2.3 are straightforward, since $u_1(w,g) > u_1(w,b)$ for all w, and $u_{11}(\cdot,\cdot) < 0$.

Appendix B: WTP under anticipated regret with partial resolution of uncertainty

Here assume that without full information about the realized state of nature, the decision maker feels regret or rejoicing through comparing the choice-less utility he obtained with the expected choice-less utility that could have been obtained if he had chosen differently. Therefore,

$$V^{RT}(T) \equiv P\big(T(h)=g\big)\Big[u(w-C,g)+\lambda R\Big(u(w-C,g)-P\big(N(h)=g \mid T(h)=g\big)u(w,g)-$$
$$P\big(N(h)=b \mid T(h)=g\big)u(w,b)\Big)\Big]+P\big(T(h)=b\big)\Big[u(w-C,b)+\lambda R\Big(u(w-C,b)-$$
$$P\big(N(h)=b \mid T(h)=b\big)u(w,b)-P\big(N(h)=g \mid T(h)=b\big)u(w,g)\Big)\Big]$$
$$V^{RT}(N) \equiv P\big(N(h)=g\big)\Big[u(w,g)+\lambda R\Big(u(w,g)-P\big(T(h)=g \mid N(h)=g\big)u(w-C,g)-$$
$$P\big(T(h)=b \mid N(h)=g\big)u(w-C,b)\Big)\Big]+P\big(N(h)=b\big)\Big[u(w,b)+\lambda R\Big(u(w,b)-$$
$$P\big(T(h)=b \mid N(h)=b\big)u(w-C,b)-P\big(T(h)=g \mid N(h)=b\big)u(w-C,g)\Big)\Big]$$

where $P\big(N(h)=b \mid T(h)=b\big)=0$, $P\big(T(h)=g \mid N(h)=g\big)=1$, and the other conditional probabilities are given by Equations (5.1)-(5.4). By definition, C is the WTP for a reduction of ϵ in morbidity risks if and only if $V^{RT}(T)=V^{RT}(N)$. In particular, we have $\lim_{\epsilon\to 0} C(\epsilon)=0$. Fully differentiating $V^{RT}(T)=V^{RT}(N)$ with respect to ϵ and taking a limit as ϵ gets close to zero, we obtain:

$$u(w,g)-u(w,b)-(1-p)u_1(w,g)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}-pu_1(w,b)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}-\lambda R'(0)(1-p)u_1(w,g)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}$$
$$-\lambda R'(0)pu_1(w,b)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}+\lambda R'(0)[u(w,g)-u(w,b)]=$$
$$\lambda R'(0)(1-p)u_1(w,g)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}+\lambda R'(0)pu_1(w,b)\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}-\lambda R'(0)[u(w,g)-u(w,b)]$$

Rearranging the above equation, we obtain:

$$WTP^{RT}|_{\epsilon\to 0}=\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}=\frac{u(w,g)-U(w,b)}{(1-p)u_1(w,g)+pu_1(w,b)}\frac{1+2\lambda R'(0)}{1+2\lambda R'(0)}=WTP^{EU}|_{\epsilon\to 0}$$

Appendix C: Attribution effect

Under the attribution effect, $V^{RT}(T)=V^{RT}(N)$ is rewritten as below:

$$(1-p+\epsilon)\big[u(w-C,g)+\lambda R\big(u(w-C,g)-u(w,g)\big)\frac{1-p}{1-p+\alpha\epsilon}+\lambda R\big(u(w-C,g)-u(w,b)\big)\frac{\alpha\epsilon}{1-p+\alpha\epsilon}\big]$$
$$+(p-\epsilon)\big[u(w-C,b)+\lambda R\big(u(w-C,b)-v(w)\big)\big]=(1-p)\big[u(w,g)+\lambda R\big(u(w,g)-u(w-C,g)\big)\big]$$
$$+p\big[u(w,b)+\lambda R\big(u(w,b)-u(w-C,g)\big)\frac{\beta\epsilon}{p}+\lambda R\big(u(w,b)-u(w-C,b)\big)\frac{p-\beta\epsilon}{p}\big]$$

Note that as ϵ tends to zero, C also needs to converge to zero so that the above equation is satisfied (i.e., $\lim_{\epsilon\to 0} C(\epsilon)=0$). Fully differentiating the above equation with respect to ϵ and taking a limit as ϵ gets close to zero, we have:

$$u(w,g)-u(w,b)-\big[(1-p)u_1(w,G)+pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}-\lambda R'(0)\big[(1-p)u_1(w,g)+pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}$$
$$+\lambda\alpha R\big(u(w,g)-u(w,b)\big)=\lambda R'(0)\big[(1-p)u_1(w,g)+pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}+\lambda\beta R\big(u(w,b)-u(w,g)\big)$$

Therefore,

$$WTP^{RT}|_{\epsilon\to 0} = \frac{u(w,g) - u(w,b) + \lambda\big[\alpha R\big(u(w,g) - u(w,b)\big) - \beta R\big(u(w,b) - u(w,g)\big)\big]}{[(1-p)u_1(w,g) + pu_1(w,b)][1 + 2\lambda R'(0)]}$$

Hence, for $\alpha > 1$ and $\beta < 1$, we have a higher WTP for small reductions in morbidity risks, compared to Equation (4.5).

Appendix D: Regret theory with more than two acts

Under the preference (5.9), $V^{RT}(T) = V^{RT}(N)$ is rewritten as below:

$$\begin{aligned}(1-p)\big[u(w-C,g) + \lambda R\big(u(w-C,g) - u(w,g)\big)\big] + \epsilon u(w-C,g) \\ + (p-\epsilon)\big[u(w-C,b) + \lambda R\big(u(w-C,b) - u(w,b)\big)\big] = \\ (1-p)u(w,g) + \epsilon\big[u(w,b) + \lambda R\big(u(w,b) - u(w-C,g)\big)\big] + (p-\epsilon)u(w,b)\end{aligned}$$

Note that as ϵ tends to zero, C also needs to converge to zero so that the above equation is satisfied, i.e., $\lim_{\epsilon\to 0} C(\epsilon) = 0$. Fully differentiating the above equation with respect to ϵ and taking a limit as ϵ gets close to zero, we have:

$$u(w,g) - u(w,b) - \big[(1-p)u_1(w,g) + pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0} - \lambda R'(0)\big[(1-p)u_1(w,g) + pu_1(w,b)\big]\frac{\partial C}{\partial \epsilon}|_{\epsilon\to 0}$$

$$= \lambda R\big(u(w,b) - u(w,g)\big)$$

Therefore,

$$WTP^{RT}|_{\epsilon\to 0} = \frac{u(w,g) - u(w,b) - \lambda R\big(u(w,b) - u(w,g)\big)}{[(1-p)u_1(w,g) + pu_1(w,b)][1 + \lambda R'(0)]}$$

So $WTP^{RT}|_{\epsilon\to 0} > WTP^{EU}|_{\epsilon\to 0}$ if and only if $-R\big(u(w,b) - u(w,g)\big) > R'(0)[u(w,g) - u(w,b)]$. The latter inequality is true if and only if $R''(\cdot) < 0$.