Regret and Regulation

Rachel J. Huang[1] Alexander Muermann[2] Larry Y. Tzeng[3]

NTUST WU Vienna NTU

January 2011

[1]National Taiwan University of Science and Technology, Graduate Institute of Finance, #43, Sec. 4, Keelung Rd., Taipei, 106, TAIWAN, rachel@mail.ntust.edu.tw

[2]Vienna University of Economics and Business, Department of Finance, Accounting and Statistics, Heiligenstaedter Str. 46-48, A - 1190 Wien, AUSTRIA, alexander.muermann@wu.ac.at, +43 1 31336 4948, +43 1 31336 90 4948 (fax)

[3]National Taiwan University, Department of Finance, #1, Sec. 4, Roosevelt Rd., Taipei, 106, TAIWAN, tzeng@ntu.edu.tw

Abstract

We analyze the welfare effect of governmental regulation for individuals who consider anticipated regret in their decision making process. While governmental policies by directing choice distort individual decisions in the private market they can alleviate individuals' pain associated with the feeling of regret. We specify a general model to highlight this trade-off and investigate two policies more closely: tax deduction for non-insured losses and mandated investment guarantees in private retirement accounts. We derive conditions under which these policies are welfare increasing.

Key Words regret; regulation; tax deduction; insurance demand; retirement saving; investment guarantee

JEL Classification D03, G18, H31

1 Introduction

Regulation of competitive markets is typically justified by inefficiencies arising from externalities or asymmetric information problems. A different line of reasoning argues that individuals make certain decisions that are not in their own best interests, e.g., caused by problems of self-control or incorrect beliefs. This gives rise to the role of the government as a paternalist. By correcting these decisions the government increases welfare for those individuals (see, e.g., Camerer et al. 2003; O'Donoghue and Rabin, 2003; Thaler and Sunstein, 2003; Beshears et al., 2008). The nature and degree of paternalism can take various forms from soft paternalism such as providing information, specifying default rules (Madrian and Shea, 2001; Choi et al., 2006), or taxation (Gruber and Köszegi, 2004; O'Donoghue and Rabin, 2006) up to hard paternalism such as limiting or even forcing choices.[1] Camerer et al. (2003) propose asymmetric paternalism with large benefits for boundedly rational consumers and little costs to fully rational consumers, e.g., default rules that can easily be overruled. Glaeser (2006), on the other hand, argues that consumers might face stronger incentives than governments do to correct those errors and that millions of consumers might be less prone to persuasion by private firms than a few government bureaucrats. Sandroni and Squintani (2007) also urge to be cautious about the paternalistic rationale for governmental intervention. They show that the asymmetric information rationale for compulsory insurance might be eroded by the existence of individuals who have overconfident beliefs.

In this paper, we examine a different reason for governments to direct individuals' choice - either directly by restricting the choice set or indirectly by providing incentives for specific choices. Our rationale is built on the assumption that individuals' welfare depends on foregone alternative choices, i.e., choices that individuals decided not to choose but could have chosen. This dependence on foregone alternative choices arises from the feeling of regret or self-blame if some foregone alternative choice would have yielded a superior outcome. Governmental intervention in markets by means of directing choice might either change the set of foregone alternative decisions the individual could have chosen from freely and/or the wealth levels implied by foregone alternative decisions. This effect can be beneficial for individuals if they associate a cost to the feeling of regret or self-blame. Since they are either directly or indirectly forced by the government to certain

[1] Glaeser (2006) defines soft paternalism as "governmental policies that change behavior without actually changing the choice sets of consumers."

decisions, individuals feel no regret or self-blame for those decisions because they were not available for choice to them. Directing individuals' choices in that way thus reduces the feeling of regret and thereby increases their welfare.[2] However, the partial imposition of or provision of incentives for certain decisions potentially implies a distortionary effect of individuals' decisions in the private market and thereby reduces individual welfare.

In this paper, we examine this trade-off of governmental intervention under individual preferences that take into account the feeling of regret and investigate two applications more closely: income tax deduction of privately non-insured losses and mandated investment guarantees for private retirement accounts. In both settings, the governmental policy creates an incentive problem which reduces individual welfare. While the tax deduction system serves as partial insurance and thereby provides incentives to underinsure (see Kaplow, 1992), mandated guarantees provide incentives to increase the exposure to investment risk (see Bodie and Merton, 1993; Smetters, 2002). On the other hand, these governmental policies reduce the wealth levels of foregone alternative decisions since individuals are forced to finance the policies through taxes. This effect reduces the feeling of regret and thereby increases welfare. We show that some degree of governmental intervention is beneficial to individuals if their marginal utility of realized wealth is increasing in the foregone level of wealth that would have resulted from the foregone best alternative. This condition is consistent with regret preferences explaining observed violations of expected utility theory (Braun and Muermann, 2004; Gollier and Salanié, 2006; Laciana and Weber, 2008) and is supported by empirical evidence (Bleichrodt et al., 2010).

There is much empirical evidence of both individuals experiencing regret and the anticipation of regret influencing individual decision making (see, e.g., Loomes, 1988; Loomes et al., 1992; Simonson, 1992; Larrick and Boles, 1995; Ritov, 1996). We refer to Zeelenberg (1999) who reviews the evidence from these and other studies in which regret is made salient to individuals at the time of choice and from studies in which the uncertainty resolution of alternative choices is manipulated. More recently, Zeelenberg and Pieters (2004) compare two lotteries in the Netherlands, a regular state lottery and a postcode lottery in which the postcode is the ticket number. In the latter

[2] We note that directing individuals' choice does not alleviate the feeling of disappointment. Regret arises from comparing the actual decision outcome with counterfactual outcomes in the same state of the world, but derived from foregone alternative decisions. Disappointment, instead, arises from comparing the actual outcome with counterfactual outcomes in different states of the world (Loomes, 1988, Zeelenberg et al., 2000b). Since directing individuals' choice does not change the state space, such governmental interventions do not effect the feeling of disappointment.

lottery, individuals who decide not to play the lottery thus receive feedback about whether they would have won had they played the lottery. They conduct different studies which all confirm that this feedback causes regret and changes the decision whether to play the lottery. Filiz-Ozbay and Ozbay (2007) conduct first price auction experiments and show that individuals experience loser regret - the regret a losing bidder experiences if the winning bid is revealed - which leads them to overbid. Finally, Camille et al. (2004) and Coricelli et al. (2005) find that the medial orbitofrontal cortex plays a central role in mediating the feeling of regret. In the experimental study of Camille et al. (2004) normal subjects reacted to the experience of regret and chose to minimize it in the future while patients with orbitofrontal cortex lesions did not report regret or anticipated negative consequences from their choices. Using functional magnetic resonance imaging (fMRI), Coricelli et al. (2005) found enhanced activity in the medial orbitofrontal cortex in response to an increase in regret.

There is also empirical evidence that responsibility for choices and the feeling of regret are positively related (Zeelenberg et al., 1998; Ordóñez and Connolly, 2000; Zeelenberg et al., 2000a). That is, if some foregone decision would have implied a superior outcome, individuals who personally make a decision experience more regret than individuals on whom that same decision is imposed. Botti and McGill (2006) also examine the effect of personal versus other-made choice on subjects' satisfaction and emphasize the importance of perceived personal responsibility of choice. They confirm the evidence that only subjects who feel personally responsible for their choice experienced both greater self-credit and self-blame than subjects on whom the choice was imposed. Iyengar and Lepper (2000) show that subjects facing a larger choice set reported that they are more dissatisfied and have more regret about the choices they have made than subjects facing a more limited choice set.[3] These empirical findings support our reasoning in this paper that governmental regulation by taking on responsibility for certain decisions partially relieves individuals of that choice responsibility and thereby of subsequent potential regret.

Zeelenberg and Pieters (2007) propose various strategies for individuals to self-regulate their feeling of regret including transferring decision responsibility to others, e.g., to financial advisors or to other experts. Even though delegating a decision might reduce the feeling of regret for that

[3] Sarver (2008) provides an axiomatic representation of preferences over menus of lotteries that account for the individual's preference to reduce the number of choices due to anticipated regret.

decision, the delegation decision itself might induce regret. While this is not an issue in our context of governmental enforcement, such regulation can create distortionary effects on individual decision making in the private market. This is the trade-off we are exploring in this paper.

Bell (1982) and Loomes and Sugden (1982) propose modified forms of the utility function which incorporate regret. They show that anticipated regret can help explain empirically observed violations of expected utility theory, e.g., the Allais paradox, the common ratio effect, or simultaneous gambling and insuring. Sugden (1993) and Quiggin (1994) provide an axiomatic foundation for representing regret preferences by the expected value of a utility function which depends only on the realized level of wealth and the level of wealth the individual could have achieved with the foregone best alternative, that is, with the foregone alternative that would have led to the highest level of wealth. This representation of regret preferences has then been applied in various settings. Braun and Muermann (2004) and Muermann et al. (2006) examine the demand for insurance and portfolio allocation. They show that regret leads individuals to *hedge their bets* by avoiding extreme decisions. Moreover, regret can help explain the disposition effect, the tendency of investors to sell winning assets too early and hold on to losing assets (Muermann and Volkman, 2006). Gollier and Salanié (2006) consider an Arrow-Debreu economy and show that regret implies a preference for skewed distributions as observed in horse race betting and national lotteries. We contribute to this literature by analyzing the benefit of governmental intervention with regard to reducing individuals' pain associated with regret while taking into account its distortionary effect on individuals' decisions in the private market.

We structure the paper as follows. In Section 2 we specify individuals' preferences taking into account the feeling of anticipatory regret and examine the trade-off of governmental intervention in a general model. In Sections 3 and 4 we apply the general model to income tax deduction of non-insured losses and to mandated guarantees for private retirement accounts, respectively, and determine the condition under which governmental intervention raises individual welfare. We conclude in Section 5.

2 Preferences and General Setup

We assume that preferences are represented by the maximization of expected utility with respect to a two-attribute utility function $U = U(W, W^{\max})$ which depends on the realized level of wealth, W, and the maximum level of wealth, $W^{\max}$, the individual could have achieved by the foregone best alternative in the realized state of nature. Ex post, the individual thus regrets that he did not make the decision that would have led to the wealth level $W^{\max}$. Ex ante, the individual anticipates his ex post feeling of regret which he takes into account in his decision making process.

Representing this anticipatory feeling of regret by the two-attribute utility function $U = U(W, W^{\max})$ is justified by the axiomatic foundation of Sugden (1993) and Quiggin (1994) and includes the functional form proposed by Bell (1982) and Loomes and Sugden (1982).[4] We impose the usual assumptions that the utility function is twice continuously differentiable in both attributes, increasing and concave in wealth, $U_1 > 0$ and $U_{11} < 0$, and satisfies Inada's conditions $\lim_{W \to 0+} U_1 = +\infty$ and $\lim_{W \to +\infty} U_1 = +0$.[5] If $U_2 = 0$, then individuals are not subject to the feeling of regret and make decisions by maximizing their expected utility of wealth. For regret sensitive individuals, we assume $U_2 < 0$. The feeling of regret is thus painful to the individual and the pain is increasing in the maximum level of wealth the individual could have obtained, $W^{\max}$.

Let wealth $W = W(q, t, \tilde{x})$ be a continuously differentiable function of the individual's choice $q \in \mathcal{Q}$, the governmental policy $t \in \mathcal{T}$, and the state variable $\tilde{x}$. We assume that the choice set $\mathcal{Q}$ and the policy set $\mathcal{T}$ are compact subsets of the real line and that the state variable is a real-valued random variable. We consider the following sequence of events.

Time 0 The government sets the policy t.

Time 1 The individual chooses q.

Time 2 The state variable realizes and the individual consumes his wealth.

We solve for the subgame perfect Nash equilibrium by backward induction which implies the following optimization problems.

[4] Sugden (1993) and Quiggin (1994) formulate axioms such that the representative value function depends only on the realized level of wealth and the maximum level of wealth the individual could have obtained in each realized state of the world. Bell (1982) suggests the following functional form $U(W, W^{\max}) = u(W) + g(u(W) - u(W^{\max}))$ for some Bernoulli utility function u and function g.

[5] We use the notation U_i for the partial derivative of U with repsect to the i-th variable.

Time 2 For a given policy t and realized state of nature $\tilde{x} = x$, the corresponding foregone best alternative, $q^{\max}(t, x)$, is given by

$$q^{\max}(t, x) \in \arg\max_{q \in \mathcal{Q}} W(q, t, x). \tag{1}$$

The implied maximum level of wealth the individual could have obtained is therefore $W^{\max} = W(q^{\max}(t, x), t, x)$.

Time 1 Given the policy t, the individual chooses q to maximize his expected utility according to the utility function $U = U(W, W^{\max})$. Since the individual has no influence on the choice of the governmental policy t, he only regrets towards his own decision q.[6] The optimal choice q is then given by the solution of the following maximization problem

$$\max_{q' \in \mathcal{Q}} E\left[U\left(W\left(q', t, \tilde{x}\right), W\left(q^{\max}(t, \tilde{x}), t, \tilde{x}\right)\right)\right].$$

Time 0 The government sets the policy t to maximize individual welfare taking into account its influence on the individual's choice q at time 1. The optimal individual welfare in this setting is thus given by the following maximization problem

$$\max_{(q,t) \in \mathcal{Q} \times \mathcal{T}} E\left[U\left(W(q, t, \tilde{x}), W\left(q^{\max}(t, \tilde{x}), t, \tilde{x}\right)\right)\right] \tag{2}$$

$$s.t. \quad q \in \arg\max_{q' \in \mathcal{Q}} E\left[U\left(W\left(q', t, \tilde{x}\right), W\left(q^{\max}(t, \tilde{x}), t, \tilde{x}\right)\right)\right] \text{ and} \tag{3}$$

$$s.t. \quad q^{\max}(t, x) \in \arg\max_{q' \in \mathcal{Q}} W\left(q', t, x\right) \text{ for all } x \text{ and } t. \tag{4}$$

We point out that governmental intervention under these preferences causes multiple effects on individual welfare.

First, it distorts the individual decision q which is resembled by the constraint (3). The distortionary effect of governmental intervention arises from an incentive problem. For individuals who

[6] We thus assume that the individual does not associate a cost to blaming the government in case the imposed policy t turns out to be suboptimal ex-post. This assumption is supported by empirical evidence showing that responsibility for choices is positively related to the subsequent feeling of regret (Zeelenberg et al., 1998; Ordóñez and Connolly, 2000; Zeelenberg et al., 2000a; Botti and McGill, 2006).

are not sensitive to the feeling of regret, i.e., for which $U_2 = 0$, this is the only effect and it implies a reduction in individual welfare.

However, for individuals who do regret foregone alternative decision, i.e., for which $U_2 < 0$, there are additional effects of governmental intervention on that feeling of regret. First, governmental intervention affects the reference level of wealth towards which the individual regrets. More specifically, we have

$$\frac{dW\left(q^{\max}\left(t,x\right),t,x\right)}{dt} = W_q\left(q^{\max}\left(t,x\right),t,x\right)\cdot q_t^{\max}\left(t,x\right) + W_t\left(q^{\max}\left(t,x\right),t,x\right) \tag{5}$$

for all t and x. This impact includes a direct effect, $W_t\left(q^{\max}\left(t,x\right),t,x\right)$, and an indirect effect through influencing the ex-post optimal choice, $q_t^{\max}\left(t,x\right)$. The former effect could, for example, result from taxation whereas the latter effect could result from limiting or forcing choice. By taking over part of the individual's decision the government liberates the individual from partly blaming himself. If governmental intervention overall reduces the maximum level of wealth the individual could have obtained, then it reduces the pain associated with regret and thereby increases individual welfare. Second, there is a potential effect through the interaction between the realized level of wealth, $W\left(q,t,x\right)$, and the level of wealth derived from the foregone best alternative, $W\left(q^{\max}\left(t,\tilde{x}\right),t,x\right)$. Governmental intervention might, for example, reallocate the differences between those two wealth levels across different states of nature. Depending on preferences this might increase or reduce individual welfare.

In the two sections below, we examine two specific governmental policies, tax deduction for uninsured losses and mandatory return guarantees in private retirement accounts, and focus on the trade-off between the two effects, distorting decisions and reducing regret. For both policies, we specify the condition under which governmental intervention can be justified.

3 Income Tax Deduction for Losses

The Department of Treasury of the United States allows individuals to deduct some of their uninsured losses from their taxable income, such as casualty losses due to natural catastrophes (e.g., after Hurricane Katrina), theft losses, or medical and dental expenses. Kaplow (1992) argues that this type of tax deduction for individuals' net losses serves as partial insurance and distorts insurance decisions in the private insurance market. Since tax deductions only apply to the uninsured portion of losses Kaplow (1992) shows that such tax deductions are welfare decreasing. It has been recently argued that a tax deduction system can improve welfare if the private insurance market is restricted to offer upper-limit policies (Huang and Tzeng, 2007a), or if insurance companies can become insolvent (Huang and Tzeng, 2007b). The aim of this section is to argue that tax deductions of net losses can improve welfare by reducing individual's pain associated with the feeling of regret. We show that this reduction in regret can outweigh the negative effect of tax deduction through distorting individuals' insurance decision.

We adopt the setup of Kaplow (1992) in which the individual is endowed with some initial wealth w_0 and with probability π faces a loss of size $l < w_0$, i.e., $\tilde{x} \in \{0, l\}$ with associated probabilities $1-\pi$ and π, respectively. The sequence of events is as follows.

Time 0 The government sets a tax deduction rate $0 \leq t < 1 - (1+\lambda)\pi$ at which the individual is allowed to deduct the non-insured portion of the loss.[7] The expected revenue loss is financed by a lump-sum tax τ.

Time 1 The individual chooses the amount of insurance coverage $q \in [0, l]$ in a private insurance market at a premium $P = (1+\lambda)\pi q$, where $\lambda \geq 0$ is the loading factor proportional to the expected insurance payment.

For comparison, we assume a proportional loading factor λ for the lump-sum tax that is identical to the one in the private insurance market.[8] The self-financing lump-sum tax is thus given by $\tau = (1+\lambda)\pi(l - q^*(t))t$ where $q^*(t)$ is optimal amount of insurance coverage purchased in the private market given a tax deduction rate t. The final levels of wealth in the two states are thus

$$W(q, t, \tilde{x}) = \begin{cases} w_0 - \tau - P - (l-q)(1-t) & \text{if } \tilde{x} = l \\ w_0 - \tau - P & \text{if } \tilde{x} = 0 \end{cases}.$$

First, we reestablish the result of Kaplow (1992) for individuals who are not sensitive to regret.

[7] For $t \geq 1 - (1+\lambda)\pi$, it is state-wise optimal to set $q = 0$. Since our focus is on the interplay between the private insurance market and tax deductions, we assume $t < 1 - (1+\lambda)\pi$.

[8] If the government were more or less efficient in financing the expenditure than the private insurance market, this would add an additional advantage or disadvantage in providing insurance coverage through the government.

Proposition 1 *A tax deduction scheme implemented by the government cannot improve individual's welfare if* $U_2 = 0$. *Moreover, under decreasing absolute risk aversion, individual welfare is strictly decreasing in the level of the tax deduction rate.*

Proof. See Appendix A.1. ■

The inefficiency results from the imposition of insurance coverage for non-insured losses through the tax deduction system which induces individuals to overall purchase less insurance than they would optimally do without the tax deduction.

We now consider the effect of an imposed tax deduction scheme on individuals who are sensitive to the feeling of regret. Since the government determines the tax deduction rate t and the lump-sum tax τ, the individual only regrets towards his choice q at time 1. After the state variable has realized, he regrets that he did not choose the foregone best alternative $q^{\max}(t, \tilde{x})$, as defined in equation (6), which is state-wise given by[9]

$$q^{\max}(t, \tilde{x}) = \begin{cases} \arg\max_q \{w_0 - \tau - (1+\lambda)\pi q - (l-q)(1-t)\} = l & \text{if } \tilde{x} = l \\ \arg\max_q \{w_0 - \tau - (1+\lambda)\pi q\} = 0 & \text{if } \tilde{x} = 0 \end{cases}. \tag{6}$$

The individual would have chosen full or no insurance coverage had he known that a loss realizes or not, respectively. Note that both choices, $q^{\max}(t, \tilde{x} = l)$ and $q^{\max}(t, \tilde{x} = 0)$, do not depend on the tax deduction rate t, i.e., $q^{\max}(t, \tilde{x}) = q^{\max}(\tilde{x})$. In reference to (5), there is no effect of governmental intervention on the ex-post optimal choice. However, there is a direct effect on the reference level of wealth towards which the individual regrets since

$$W(q^{\max}(\tilde{x}), t, \tilde{x}) = \begin{cases} w_0 - \tau - (1+\lambda)\pi l & \text{if } \tilde{x} = l \\ w_0 - \tau & \text{if } \tilde{x} = 0 \end{cases}.$$

Governmental intervention thus reduces the reference level of wealth towards which the individual regrets, in this case state-wise by the lump-sum tax τ, which benefits regret sensitive individuals. Intuitively, since individuals are forced to finance the implicit insurance provided by the governmental policy, they feel no regret for being mandated such insurance and having to pay for it. In addition, this reduction in the counterfactual level of wealth causes a "cross-effect" on the marginal

[9] Note that the individual has paid the lump-sum tax τ at time 0 before he made his choice q at time 1.

utility of realized wealth. Last, governmental intervention distorts insurance decisions in the private insurance market. In the following proposition, we provide a condition under which governmental intervention is overall beneficial.

Proposition 2 *It is optimal for the government to implement a tax deduction scheme, that is,* $t^* > 0$*, if* $U_2 < 0$ *and* $U_{12} > 0$*.*

Proof. See Appendix A.2. ■

This proposition shows that it is optimal for the government to partially impose an implicit insurance scheme through a tax deduction system if individuals are sensitive to the feeling of regret and if $U_{12} > 0$. The benefit in terms of the reduction in regret is derived from the fact that the lump-sum tax state-wise reduces the level of wealth towards which the individual regrets. If $U_{12} > 0$, then this state-wise reduction in the counterfactual level of wealth implies the additional benefit of, ceteris paribus, state-wise reducing the marginal utility of realized wealth. For small values of t, these benefits outweigh the cost of distorting insurance decisions in the private market implied by the incentive problem.

The condition $U_{12} > 0$ requires that increasing wealth has a smaller positive effect on utility if the maximum wealth towards which the individual regrets is small than if it is large.[10] Under this condition, individuals are *correlation-loving* (see Eeckhoudt et al., 2007) in the two attributes of the utility function, W and $W^{\max}$. This is intuitive in our context since utility is increasing in wealth, W, but decreasing in the maximum wealth the individual could have obtained, $W^{\max}$. Individuals thus prefer higher levels of wealth realizations being "matched" with higher levels of wealth that they could have obtained from the foregone best alternative. Put differently, individuals favor differences between the realized levels of wealth and the maximum levels of wealth towards which the individual regrets being evenly distributed between different states of nature. That is, they prefer experiencing a similar degree of regret across all states of nature to experiencing little or no regret in some states while a strong degree of regret in other states.

The condition $U_{12} > 0$ also proves to be crucial for determining the impact of regret on decision making under uncertainty. It induces individuals to "hedge their bets" by avoiding extreme decisions such as the choice of full or no insurance coverage (Braun and Muermann, 2004). Moreover,

[10] In the specification of Bell (1982), $U(W, W^{\max}) = u(W) + g(u(W) - u(W^{\max}))$, the condition $U_{12} > 0$ is equivalent to the concavity of the function g.

this condition is necessary for explaining preferences for skewed distributions as observed in horse race betting and national lotteries (Gollier and Salanié, 2006) and the Allais paradox (Laciana and Weber, 2008) under regret preferences. Last, Bleichrodt et al. (2010) provide empirical support for this condition.

4 Return Guarantees in Private Retirement Accounts

In this section, we examine the effect of governmental intervention on investment decisions in private retirement accounts. In many countries governments react to demographic changes by introducing a funded defined contribution (DC) plan. This private account system is either a supplement, substitute, or replacement of the unfunded pay-as-you-go defined benefit (DB) system. Under DC plans participants face their own investment choice and bear investment risk. With the reasoning of partially protecting DC participants from market downturns, some governments have mandated investment guarantees of various forms. Germany and Japan, for example, mandated a principal guarantee such that all contributions are guaranteed in nominal terms. In Chile and Mexico a minimum pension payment of about 25% and 40%, respectively, of average wages is guaranteed. In the US there is a huge debate about reforming the Social Security system including the introduction of private retirement accounts (Cogan and Mitchell, 2003). One controversial issue in this debate is the provision of investment guarantees including proposals that suggest guaranteeing a real rate of return. Whereas investment guarantees would protect DC participants from investment risk they are costly. Moreover, guarantees induce an incentive problem since they provide DC participants with the incentive to increase their investment risk and thereby the cost of the guarantee (Bodie and Merton, 1993; Smetters, 2002). Some governments, e.g., Chile and Mexico, have recognized this distortionary effect and responded by restricting the investment choice of DC participants.

For regret-sensitive individuals, a governmentally imposed guarantee, or for that matter a governmentally mandated portfolio restriction, reduces the feeling of blaming oneself for his own investment choice and is therefore beneficial. We trade this benefit off against the distortionary effect on investment choice mentioned above and determine the conditions under which a governmentally imposed guarantee increases individual welfare.

For this purpose, we specify the following simple model. The individual has initial wealth w_0 and can invest in two assets, a risk-free asset and a risky asset. We assume that the return of the risk-free asset is normalized to 0 and the return of the risky asset is $\tilde{x} \in \{x^-, x^+\}$ with $-1 \leq x^- < 0 < x^+$ and probabilities π for $\tilde{x} = x^+$ and $(1-\pi)$ for $\tilde{x} = x^-$. Furthermore, we assume that the expected return of the risky assets is strictly positive, that is, $\pi x^+ + (1-\pi)\, x^- > 0$.

Since the financial market is complete, each payoff profile and therefore each return guarantee can be replicated by the individual. In the following, we first show that a return guarantee which is self-constructed by the individual or which he individually chooses has no impact on individual's welfare.

We consider the following sequence of events.

Time 0 The government mandates a return guarantee $x^- \leq t < 0$ in case the realized return of the risky asset is $\tilde{x} = x^-$. The return guarantee is financed by the no-arbitrage price $\tau = \frac{(t-x^-)x^+}{(x^+-x^-)} \cdot q$.

Time 1 The individual decides the dollar amount $q \in [0, w_0 - \tau]$ he invests in the risky asset.

The final levels of wealth in the two states are

$$W(q,t,\tilde{x}) = \begin{cases} w_0 - \tau + qx^+ & \text{if } \tilde{x} = x^+ \\ w_0 - \tau + qt & \text{if } \tilde{x} = x^- \end{cases}.$$

For regret insensitive individuals, we derive the following result.

Proposition 3 *A governmentally imposed return guarantee cannot improve individual's welfare if $U_2 = 0$. Moreover, under decreasing absolute risk aversion, individual welfare is strictly decreasing in the level of the return guarantee.*

Proof. See Appendix A.3. ■

A return guarantee which is imposed by the government distorts the individual investment decision and thereby reduces individual welfare. The government essentially creates an incentive problem since the imposed return guarantee induces individuals to choose a riskier portfolio (Bodie and Merton, 1993; Smetters, 2002). This result resembles the insight of Kaplow (1992) that tax deduction of non-insured losses distorts the decision in the private insurance market.

We now consider regret sensitive individuals. Ex post, after the state variable has realized, the foregone best alternative $q^{\max}(t,\tilde{x})$, as defined in equation (1), is state-wise given by

$$q^{\max}(t,\tilde{x}) = \begin{cases} w_0 - \tau & \text{if } \tilde{x} = x^+ \\ 0 & \text{if } \tilde{x} = x^- \end{cases}.$$

It would have been optimal to either invest all remaining wealth, $w_0 - \tau$, or nothing into the risky asset had the individual known that the return of the asset was positive or negative, respectively. Note that $q^{\max}(t,\tilde{x})$ does not depend on t and thus $q^{\max}(t,\tilde{x}) = q^{\max}(\tilde{x})$. The levels of wealth towards which the individual regrets are then

$$W(q^{\max}(\tilde{x}), t, \tilde{x}) = \begin{cases} (w_0 - \tau)(1 + x^+) & \text{if } \tilde{x} = x^+ \\ w_0 - \tau & \text{if } \tilde{x} = x^- \end{cases}.$$

We observe again that governmental intervention state-wise reduces the reference level towards which the investor regrets. We now derive the following result.

Proposition 4 *It is optimal for the government to impose a return guarantee, that is, $t^* > x^-$, if $U_2 < 0$ and $U_{12} > 0$.*

Proof. See Appendix A.4. ■

Analogously to a tax deduction system for non-insured losses, the governmental imposition of a return guarantee reduces the pain derived from regret and thereby improves individual welfare. Under the equivalent condition $U_{12} > 0$, this effect together with the associated state-wise reduction in marginal utility of realized wealth outweigh the distortionary effect on individual welfare for some return guarantee level. For this welfare improvement it is important that the government imposes the return guarantee. Otherwise the individual would regret having chosen a return guarantee and welfare could not be improved.

5 Conclusion

Governmental intervention in markets shifts individual choices in private markets. We emphasize that such a shift can be beneficial if individuals regret about foregone alternative choices. By directing choice the government not only distorts individual decisions in the private market but also reduces the feeling of regretting those decisions. We explore this trade-off for two types of governmental intervention: tax deduction for non-insured losses and mandated investment guarantees in private retirement accounts. We show that both types of interventions can be justified if individuals' marginal utility of wealth is increasing in the maximum level of wealth the individual could have achieved with the foregone best alternative decision. This condition on preferences is supported by empirical evidence and is necessary for regret explaining observed violations of expected utility theory.

Acknowledgments

We wish to thank Christian Laux, Gyöngyi Lóránth, and seminar participants of the EGRIE meeting for valuable comments.

A Appendix: Proofs

A.1 Proof of Proposition 1

If $U_2 = 0$, we can write $U(W, W^{\max}) = U(W)$ and individual welfare under a tax deduction scheme is given by the following optimization problem

$$\max_{(q,t)} E\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right] \tag{A.1}$$

$$s.t. \quad q \in \arg\max_{q'} E\left[U\left(W\left(q',t,\tilde{x}\right)\right)\right]. \tag{A.2}$$

Since this optimization problem includes the incentive compatibility constraint, the implied individual welfare can never be strictly higher compared to a system without a tax deduction scheme. The first order condition for the constraint $(A.2)$ at time 1 is given by

$$\begin{aligned} \frac{dE\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right]}{dq} &= \left(1-t-\left(1+\lambda\right)\pi\right)U'\left(w_0-\tau-P-\left(l-q\right)\left(1-t\right)\right) \\ &\quad -\left(1-\pi\right)\left(1+\lambda\right)\cdot U'\left(w_0-\tau-P\right) \\ &= 0. \end{aligned} \tag{A.3}$$

We note that

$$\frac{dE\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right]}{dq}|_{q=l} = -\left(t+\lambda\right)U'\left(w_0-\tau-P\right) < 0$$

and thus $q^*(t) < l$ for all $t > 0$. The first derivative of expected utility at time 0 is

$$\begin{aligned} &\frac{dE\left[U\left(W\left(q^*\left(t\right),t,\tilde{x}\right)\right)\right]}{dt} \\ = \;&\pi\left(1-\left(1+\lambda\right)\pi\right)\left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)U'\left(W\left(q^*\left(t\right),t,l\right)\right) \\ &-\left(1-\pi\right)\left(1+\lambda\right)\pi\left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)U'\left(W\left(q^*\left(t\right),t,0\right)\right) \end{aligned}$$

Substitution of the first order condition $(A.3)$ at time 1 yields

$$\frac{dE\left[U\left(W\left(q^*\left(t\right),t,\tilde{x}\right)\right)\right]}{dt} = \left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)\pi t U'\left(W\left(q^*\left(t\right),t,l\right)\right). \tag{A.4}$$

We show that $l-q^*(t)+q^{*\prime}(t)(1-t) < 0$ for all $0 \leq t < 1-(1+\lambda)\pi$. Implicitly differentiating the first order condition $(A.3)$ with respect to t yields

$$q^{*\prime}\left(t\right) = \frac{U'\left(W\left(q^*\left(t\right),t,l\right)\right)-\left(1-t-\left(1+\lambda\right)\pi\right)\left(l-q^*\left(t\right)\right)U''\left(W\left(q^*\left(t\right),t,l\right)\right)}{\left(1-\pi\right)\left(1+\lambda\right)^2\pi U''\left(W\left(q^*\left(t\right),t,0\right)\right)+\left(1-t-\left(1+\lambda\right)\pi\right)^2U''\left(W\left(q^*\left(t\right),t,l\right)\right)}$$

and thus

$$\begin{aligned} &l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right) \\ = \;&\frac{\left[\begin{array}{c}\left(1-t\right)U'\left(W\left(q^*\left(t\right),t,l\right)\right) \\ +\left(1+\lambda\right)\pi\left(l-q^*\left(t\right)\right)\left(\left(1-\pi\right)\left(1+\lambda\right)U''\left(W\left(q^*\left(t\right),t,0\right)\right)-\left(1-t-\left(1+\lambda\right)\pi\right)U''\left(W\left(q^*\left(t\right),t,l\right)\right)\right)\end{array}\right]}{\left(1-\pi\right)\pi\left(1+\lambda\right)^2U''\left(W\left(q^*\left(t\right),t,0\right)\right)+\left(1-t-\left(1+\lambda\right)\pi\right)^2U''\left(W\left(q^*\left(t\right),t,l\right)\right)} \end{aligned}$$

Decreasing absolute risk aversion implies

$$(1-\pi)(1+\lambda)U''(W(q^*(t),t,0))-(1-t-(1+\lambda)\pi)U''(W(q^*(t),t,l))>0$$

for all $0\leq t<1-(1+\lambda)\pi$[11] and thus $l-q^*(t)+q^{*\prime}(t)(1-t)<0$ for all $0\leq t<1-(1+\lambda)\pi$. Equation $(A.4)$ thus implies that $\frac{dE[U(W(q^*(t),t,\tilde{x}))]}{dt}=0$ for $t=0$ and $\frac{dE[U(W(q^*(t),t,\tilde{x}))]}{dt}<0$ for $0<t<1-(1+\lambda)\pi$.

A.2 Proof of Proposition 2

For convenience, let us introduce the following notation.

$$EU(q,t)=E[U(W(q,t,\tilde{x}),W(q^{\max}(\tilde{x}),t,\tilde{x}))]$$

with

$$\begin{aligned} W(q,t,\tilde{x}) &= \begin{cases} w_0-\tau-P-(l-q)(1-t) & \text{if } \tilde{x}=l \\ w_0-\tau-P & \text{if } \tilde{x}=0 \end{cases} \\ W(q^{\max}(\tilde{x}),t,\tilde{x}) &= \begin{cases} w_0-\tau-(1+\lambda)\pi l & \text{if } \tilde{x}=l \\ w_0-\tau & \text{if } \tilde{x}=0 \end{cases} \end{aligned}$$

and lump-sum tax $\tau=(1+\lambda)\pi(l-q)t$ paid at time 0 and premium $P=(1+\lambda)\pi q$ paid at time 1.

At time 1, for a fixed tax rate t, the derivative of expected utility with respect to q is given by

$$\begin{aligned} \frac{dEU(q,t)}{dq} &= \pi(1-t-(1+\lambda)\pi)\cdot U_1(W(q,t,l),W(q^{\max}(l),t,l)) \\ &\quad -(1-\pi)(1+\lambda)\pi\cdot U_1(W(q,t,0),W(q^{\max}(0),t,0)). \end{aligned}$$

Evaluating this derivative at $q=l$ yields

$$\begin{aligned} &\frac{dEU(q,t)}{dq}|_{q=l} \\ =\ & \pi(1-t-(1+\lambda)\pi)\cdot U_1(W(l,t,l),W(q^{\max}(l),t,l)) \\ & -(1-\pi)(1+\lambda)\pi\cdot U_1(W(l,t,0),W(q^{\max}(0),t,0)) \\ =\ & -(t+\lambda)\pi\cdot U_1(W(l,t,l),W(q^{\max}(l),t,l)) \\ & +(1-\pi)(1+\lambda)\pi\cdot(U_1(W(l,t,l),W(q^{\max}(l),t,l))-U_1(W(l,t,0),W(q^{\max}(0),t,0))). \end{aligned}$$

Since $W(l,t,l)=W(l,t,0)$, $W(q^{\max}(l),t,l)<W(q^{\max}(0),t,0)$, and $U_{12}>0$, we derive $\frac{dEU(q,t)}{dq}|_{q=l}<0$ and thus $q^*(t)<l$ for all $t\geq 0$. The inner solution $q^*(t)$ to the constraint (3) thus satisfies the first order condition

$$\begin{aligned} \frac{dEU(q,t)}{dq}|_{q=q^*(t)} &= \pi(1-t-(1+\lambda)\pi)\cdot U_1(W(q^*(t),t,l),W(q^{\max}(l),t,l)) \\ &\quad -(1-\pi)(1+\lambda)\pi\cdot U_1(W(q^*(t),t,0),W(q^{\max}(0),t,0)) \\ &= 0. \end{aligned} \tag{A.5}$$

[11] This follows from $-\frac{U''(W(q^*(t),t,0))}{U'(W(q^*(t),t,0))}<-\frac{U''(W(q^*(t),t,l))}{U'(W(q^*(t),t,l))}$ and the first order condition $(A.3)$.

At time 0, the derivative of expected utility with respect to t is then given by

$$\begin{aligned}
&\frac{dEU\left(q^*\left(t\right),t\right)}{dt} \\
=\ & \pi\left(1-\left(1+\lambda\right)\pi\right)\left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)U_1\left(W\left(q^*\left(t\right),t,l\right),W\left(q^{\max}\left(l\right),t,l\right)\right) \\
& -\left(1-\pi\right)\left(1+\lambda\right)\pi\left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)U_1\left(W\left(q^*\left(t\right),t,0\right),W\left(q^{\max}\left(0\right),t,0\right)\right) \\
& -\pi\left(1+\lambda\right)\pi\left(\left(l-q^*\left(t\right)\right)-q^{*\prime}\left(t\right)t\right)U_2\left(W\left(q^*\left(t\right),t,l\right),W\left(q^{\max}\left(l\right),t,l\right)\right) \\
& -\left(1-\pi\right)\left(1+\lambda\right)\pi\left(\left(l-q^*\left(t\right)\right)-q^{*\prime}\left(t\right)t\right)U_2\left(W\left(q^*\left(t\right),t,0\right),W\left(q^{\max}\left(0\right),t,0\right)\right)
\end{aligned}$$

Substitution of the first order condition $(A.5)$ yields

$$\begin{aligned}
&\frac{dEU\left(q^*\left(t\right),t\right)}{dt} \\
=\ & \left(l-q^*\left(t\right)+q^{*\prime}\left(t\right)\left(1-t\right)\right)\pi t U_1\left(W\left(q^*\left(t\right),t,l\right),W\left(q^{\max}\left(l\right),t,l\right)\right) \\
& -\left(1+\lambda\right)\pi\left(\left(l-q^*\left(t\right)\right)-q^{*\prime}\left(t\right)t\right)\cdot\left[\begin{array}{c}\pi U_2\left(W\left(q^*\left(t\right),t,l\right),W\left(q^{\max}\left(l\right),t,l\right)\right) \\ +\left(1-\pi\right)U_2\left(W\left(q^*\left(t\right),t,0\right),W\left(q^{\max}\left(0\right),t,0\right)\right)\end{array}\right]
\end{aligned}$$

Evaluating this derivative at $t=0$ implies

$$\frac{dEU\left(q^*\left(t\right),t\right)}{dt}|_{t=0}=-\left(1+\lambda\right)\pi\left(l-q^*\left(0\right)\right)\cdot\left[\begin{array}{c}\pi U_2\left(W\left(q^*\left(0\right),0,l\right),W\left(q^{\max}\left(l\right),0,l\right)\right) \\ +\left(1-\pi\right)U_2\left(W\left(q^*\left(0\right),0,0\right),W\left(q^{\max}\left(0\right),0,0\right)\right)\end{array}\right]$$

Since $U_2<0$ and $q^*\left(0\right)<l$, we have $\frac{dEU(q^*(t),t)}{dt}|_{t=0}>0$ and thus $t^*>0$.

A.3 Proof of Proposition 3

The proof is analogous to the proof of Proposition 1. Individual welfare under a governmentally imposed return guarantee is given by

$$\max_{(q,t)} E\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right] \tag{A.6}$$

$$s.t. \quad q\in\arg\max_{q'} E\left[U\left(W\left(q',t,\tilde{x}\right)\right)\right]. \tag{A.7}$$

The first order condition for the constraint $(A.7)$ at time 1 is given by

$$\frac{dE\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right]}{dq}=\pi x^+U'\left(w_0-\tau+qx^+\right)+\left(1-\pi\right)tU'\left(w_0-\tau+qt\right)=0. \tag{A.8}$$

We note that

$$\frac{dE\left[U\left(W\left(q,t,\tilde{x}\right)\right)\right]}{dq}|_{q=0}=\left(\pi x^++\left(1-\pi\right)t\right)U'\left(w_0-\tau\right)>0$$

and thus $q^*\left(t\right)>0$ for all $x^-\leq t<0$. The first order condition at time 0 is

$$\begin{aligned}
&\frac{dE\left[U\left(W\left(q^*\left(t\right),t,\tilde{x}\right)\right)\right]}{dt} \\
&=\pi\left(x^+q^{*\prime}\left(t\right)-\frac{\left(t-x^-\right)x^+}{x^+-x^-}q^{*\prime}\left(t\right)-\frac{x^+}{x^+-x^-}q^*\left(t\right)\right)U'\left(w_0-\tau+qx^+\right) \\
&+\left(1-\pi\right)\left(tq^{*\prime}\left(t\right)+q^*\left(t\right)-\frac{\left(t-x^-\right)x^+}{x^+-x^-}q^{*\prime}\left(t\right)-\frac{x^+}{x^+-x^-}q^*\left(t\right)\right)U'\left(w_0-\tau+qt\right)
\end{aligned}$$

Substitution of the first order condition $(A.8)$ at time 1 yields

$$\frac{dE\left[U\left(W\left(q^*\left(t\right),t,\tilde{x}\right)\right)\right]}{dt}=\left(1-\pi\right)\frac{t-x^-}{x^+-x^-}\left(q^*\left(t\right)-\left(x^+-t\right)q^{*\prime}\left(t\right)\right)U'\left(w_0-\tau+qt\right). \tag{A.9}$$

We show that $q^*\left(t\right)-\left(x^+-t\right)q^{*\prime}\left(t\right)<0$ for all $x^-\leq t<0$. Implicitly differentiating the first order condition $(A.8)$ with respect to t yields

$$q^{*\prime}\left(t\right)=-\frac{\left(1-\pi\right)\left(U'\left(w_0-\tau+q^*\left(t\right)t\right)+tq^*\left(t\right)U''\left(w_0-\tau+q^*\left(t\right)t\right)\right)}{\pi\left(x^+\right)^2U''\left(w_0-\tau+q^*\left(t\right)x^+\right)+\left(1-\pi\right)t^2U''\left(w_0-\tau+q^*\left(t\right)t\right)}$$

and thus

$$q^*\left(t\right)-\left(x^+-t\right)q^{*\prime}\left(t\right)=\frac{\left[\begin{array}{c}q^*\left(t\right)x^+\left(\pi x^+U''\left(w_0-\tau+q^*\left(t\right)x^+\right)+\left(1-\pi\right)tU''\left(w_0-\tau+q^*\left(t\right)t\right)\right)\\+\left(x^+-t\right)\left(1-\pi\right)U'\left(w_0-\tau+q^*\left(t\right)t\right)\end{array}\right]}{\pi\left(x^+\right)^2U''\left(w_0-\tau+q^*\left(t\right)x^+\right)+\left(1-\pi\right)t^2U''\left(w_0-\tau+q^*\left(t\right)t\right)}$$

Decreasing absolute risk aversion implies

$$\pi x^+U''\left(w_0-\tau+q^*\left(t\right)x^+\right)+\left(1-\pi\right)tU''\left(w_0-\tau+q^*\left(t\right)t\right)>0$$

for all $x^-\leq t<0$[12] and thus $q^*\left(t\right)-\left(x^+-t\right)q^{*\prime}\left(t\right)<0$ for all $x^-\leq t<0$. Equation $(A.9)$ thus implies that $\frac{dE[U(W(q^*(t),t,\tilde{x}))]}{dt}=0$ for $t=x^-$ and $\frac{dE[U(W(q^*(t),t,\tilde{x}))]}{dt}<0$ for $x^-<t<0$.

A.4 Proof of Proposition 4

The proof follows analogously the proof of Proposition 2. In this setting we have

$$EU\left(q,t\right)=E\left[U\left(W\left(q,t,\tilde{x}\right),W\left(q^{\max}\left(\tilde{x}\right),t,\tilde{x}\right)\right)\right]$$

with

$$\begin{aligned}W\left(q,t,\tilde{x}\right)&=\begin{cases}w_0-\tau+qx^+&\text{if }\tilde{x}=x^+\\w_0-\tau+qt&\text{if }\tilde{x}=x^-\end{cases}\\W\left(q^{\max}\left(\tilde{x}\right),t,\tilde{x}\right)&=\begin{cases}\left(w_0-\tau\right)\left(1+x^+\right)&\text{if }\tilde{x}=x^+\\w_0-\tau&\text{if }\tilde{x}=x^-\end{cases}\end{aligned}$$

and no-arbitrage price $\tau=\frac{\left(t-x^-\right)x^+}{x^+-x^-}q$ paid at time 0.

At time 1, for a fixed return guarantee t, the derivative of expected utility with respect to q is given by

$$\begin{aligned}\frac{dEU\left(q,t\right)}{dq}&=\pi x^+U_1\left(W\left(q,t,x^+\right),W\left(q^{\max}\left(x^+\right),t,x^+\right)\right)\\&\quad+\left(1-\pi\right)tU_1\left(W\left(q,t,x^-\right),W\left(q^{\max}\left(x^-\right),t,x^-\right)\right).\end{aligned}$$

[12] This follows from $-\frac{U''\left(w_0-\tau+q^*(t)x^+\right)}{U'\left(w_0-\tau+q^*(t)x^+\right)}<-\frac{U''(w_0-\tau)}{U'(w_0-\tau)}<-\frac{U''\left(w_0-\tau+q^*(t)t\right)}{U'(w_0-\tau+q^*(t)t)}$ and the first order condition $(A.8)$.

Evaluating this derivative at $q = 0$ yields

$$\begin{aligned}\frac{dEU(q,t)}{dq}\Big|_{q=0} &= \pi x^+ U_1\left(W\left(0,t,x^+\right), W\left(q^{\max}\left(x^+\right),t,x^+\right)\right) \\ &\quad + (1-\pi)\, t U_1\left(W\left(0,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right).\end{aligned}$$

Since $U_{12} > 0$, $W(0,t,x^+) = W(0,t,x^-)$, and $W(q^{\max}(x^+),t,x^+) > W(q^{\max}(x^-),t,x^-)$, we have $U_1(W(0,t,x^+), W(q^{\max}(x^+),t,x^+)) > U_1(W(0,t,x^-), W(q^{\max}(x^-),t,x^-))$ and thus

$$\frac{dEU(q,t)}{dq}\Big|_{q=0} > \left(\pi x^+ + (1-\pi)\, t\right)\cdot U_1\left(W\left(0,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right) > 0$$

for all $t \geq x^-$. Therefore $q^*(t) > 0$ for all $t \geq x^-$. The inner solution $q^*(t)$ to the constraint (3) thus satisfies the first order condition

$$\begin{aligned}\frac{dEU(q,t)}{dq}\Big|_{q=q^*(t)} &= \pi x^+ U_1\left(W\left(q^*(t),t,x^+\right), W\left(q^{\max}\left(x^+\right),t,x^+\right)\right) \\ &\quad + (1-\pi)\, t U_1\left(W\left(q^*(t)\, t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right) \\ &= 0.\end{aligned} \tag{A.10}$$

At time 0, the derivative of expected utility with respect to t is then given by

$$\begin{aligned}&\frac{dEU(q^*(t),t)}{dt} \\ =\ & \pi\frac{x^+}{x^+-x^-}\left(-q^*(t) + \left(x^+-t\right)q^{*\prime}(t)\right)U_1\left(W\left(q^*(t),t,x^+\right), W\left(q^{\max}\left(x^+\right),t,x^+\right)\right) \\ & + (1-\pi)\frac{x^-}{x^+-x^-}\left(-q^*(t) + \left(x^+-t\right)q^{*\prime}(t)\right)U_1\left(W\left(q^*(t)\,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right) \\ & + \pi\frac{x^+\left(1+x^+\right)}{x^+-x^-}\left(-q^*(t) - \left(t-x^-\right)q^{*\prime}(t)\right)U_2\left(W\left(q^*(t),t,x^+\right), W\left(q^{\max}\left(x^+\right),t,x^+\right)\right) \\ & + (1-\pi)\frac{x^+}{x^+-x^-}\left(-q^*(t) - \left(t-x^-\right)q^{*\prime}(t)\right)U_2\left(W\left(q^*(t)\,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right)\end{aligned}$$

Substitution of the first order condition $(A.10)$ yields

$$\begin{aligned}&\frac{dEU(q^*(t),t)}{dt} \\ =\ & -(1-\pi)\frac{t-x^-}{x^+-x^-}\left(-q^*(t) + \left(x^+-t\right)q^{*\prime}(t)\right)U_1\left(W\left(q^*(t)\,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right) \\ & + \frac{x^+}{x^+-x^-}\left(-q^*(t) - \left(t-x^-\right)q^{*\prime}(t)\right)\cdot\left[\begin{array}{c}\pi\left(1+x^+\right)U_2\left(W\left(q^*(t),t,x^+\right), W\left(q^{\max}\left(x^+\right),t,x^+\right)\right) \\ +(1-\pi)\,U_2\left(W\left(q^*(t)\,t,x^-\right), W\left(q^{\max}\left(x^-\right),t,x^-\right)\right)\end{array}\right]\end{aligned}$$

Evaluating this derivative at $t = x^-$ implies

$$\begin{aligned}&\frac{dEU(q^*(t),t)}{dt}\Big|_{t=x^-} \\ =\ & -\frac{x^+}{x^+-x^-}q^*\left(x^-\right)\cdot\left[\begin{array}{c}\pi\left(1+x^+\right)U_2\left(W\left(q^*\left(x^-\right),x^-,x^+\right), W\left(q^{\max}\left(x^+\right),x^-,x^+\right)\right) \\ +(1-\pi)\,U_2\left(W\left(q^*\left(x^-\right)x^-,x^-\right), W\left(q^{\max}\left(x^-\right),x^-,x^-\right)\right)\end{array}\right]\end{aligned}$$

Since $U_2 < 0$ and $q^*\left(x^-\right) > 0$, we have $\frac{dEU(q^*(t),t)}{dt}\left.\right|_{t=x^-} > 0$ and thus $t^* > 0$.

References

[1] Bell, D.E., 1982. Regret in decision making under uncertainty. *Operations Research* 30(5), 961-981.

[2] Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2008. How are preferences revealed? *Journal of Public Economics* 92(8-9), 1787-1794.

[3] Bleichrodt, H., Cillo, A., Diecidue, E., 2010. A quantitative measurement of regret theory. *Management Science* 56(1), 161-175.

[4] Bodie, Z., Merton, R., 1993. Pension benefit guarantees in the United States: a functional analysis, in: Schmitt, R. (Ed.), *The future of pensions in the United States*, Philadelphia: University of Pennsylvania Press, pp. 194-234.

[5] Botti, S., McGill, A.L., 2006. When choosing is not deciding: the effect of perceived responsibility on satisfaction. *Journal of Consumer Research* 33(2), 211-219.

[6] Braun, M., Muermann, A., 2004. The impact of regret on the demand for insurance. *Journal of Risk and Insurance* 71(4), 737-767.

[7] Camerer, C.F., Issacharoff, S., Loewenstein, G., O'Donoghue, T., Rabin, M., 2003. Regulation for conservatives: behavioral economics and the case for 'asymmetric paternalism'. *University of Pennsylvania Law Review* 151, 1211-1254.

[8] Camille, N., Coricelli, G., Sallet, J., Pradat-Diehl, P., Duhamel, J.-R., Sirigu, A., 2004. The involvement of the orbitofrontal cortex in the experience of regret. *Science* May 21, 304(5674),1167-70.

[9] Choi, J.J., Laibson, D., Madrian, B.C., Metrick, A., 2006. Saving for retirement on the path of least resistance, in: McCaffrey, E., Slemrod, J. (Eds.), *Behavioral public finance: toward a new agenda,* New York: Russell Sage Foundation, pp. 304-351.

[10] Cogan, J.F., Mitchell, O.S., 2003. Perspectives from the President's Commission on Social Security Reform. *Journal of Economic Perspectives* 17(2), 149-172.

[11] Coricelli, G., Critchley, H.D., Joffily, M., O'Doherty, J.P., Sirigu, A., Dolan, R.J., 2005. Regret and its avoidance: a neuroimaging study of choice behavior. *Nature Neuroscience* 8(9), 1255-1262.

[12] Eeckhoudt, L., Rey, B., Schlesinger, H., 2007. A good sign for multivariate risk taking. *Management Science,* 53(1), 117-124.

[13] Filiz-Ozbay, E., Ozbay, E.Y., 2007. Auctions with anticipated regret: theory and experiment. *American Economic Review* 97(4) 1407-1418.

[14] Glaeser, E.L., 2006. Paternalism and psychology. *University of Chicago Law Review* 73(1), 133-156.

[15] Gollier, C., Salanié, B., 2006. Individual decisions under risk, risk sharing, and asset prices with regret. Working paper.

[16] Gruber, J., Köszegi, B., 2004. Tax incidence when individuals are time-inconsistent: the case of cigarette excise taxes. *Journal of Public Economics* 88(9-10), 1959-1987.

[17] Huang, R.J., Tzeng, L.Y., 2007a. Optimal tax deductions for net losses under private insurance with an upper limit. *Journal of Risk and Insurance,* 74(4), 883-893.

[18] Huang, R.J., Tzeng, L.Y., 2007b. Insurer's insolvency risk and tax deductions for the individual's net losses. *Geneva Risk and Insurance Review,* 32(2), 129-145.

[19] Iyengar, S.S., Lepper, M.R., 2000. When choice is demotivating: can one desire too much of a good thing? *Journal of Personality and Social Psychology* 79(6), 995-1006.

[20] Kaplow, L., 1992. Income tax deductions for losses as insurance. *American Economic Review*, 82(4), 1013-1017.

[21] Laciana, C.E., Weber, E.U., 2008. Correcting expected utility for comparisons between alternative outcomes: a unified parameterization of regret and disappointment. *Journal of Risk and Uncertainty*, 36(1), 1-17.

[22] Larrick, R.P., Boles, T.L., 1995. Avoiding regret in decisions with feedback: a negotiation example. *Organizational Behavior and Human Decision Processes* 63(1), 87-97.

[23] Loomes, G., 1988. Further evidence of the impact of regret and disappointment in choice under uncertainty. *Economica* 55(217), 47-62.

[24] Loomes, G., Starmer, C., Sugden, R., 1992. Are preferences monotonic - testing some predictions of regret theory. *Economica* 59(233), 17-33.

[25] Loomes, G., Sugden, R., 1982. Regret theory: an alternative theory of rational choice under uncertainty. *Economic Journal* 92(368), 805-824.

[26] Madrian, B.C., Shea, D.F. 2001. The power of suggestion: inertia in 401(k) participation and savings behavior. *Quarterly Journal of Economics* 116(4), 1149-1187.

[27] Muermann, A., Mitchell, O.S., Volkman, J., 2006. Regret, portfolio choice, and guarantees in defined contribution schemes. *Insurance: Mathematics and Economics* 39(2), 219-229.

[28] Muermann, A., Volkman, J., 2006. Regret, pride, and the disposition effect. Working paper 06-08 in PARC working paper series.

[29] O'Donoghue, T., Rabin, M., 2003. Studying optimal paternalism, illustrated by a model of sin taxes. *American Economic Review Papers and Proceedings* 93(2), 186-191.

[30] O'Donoghue, T., Rabin, M., 2006. Optimal sin taxes. *Journal of Public Economics* 90(10-11), 1825-1849.

[31] Ordóñez, L.D., Connolly, T., 2000. Regret and responsibility: a reply to Zeelenberg et al. (1998). *Organizational Behavior and Human Decision Processes* 81(1), 132-142.

[32] Quiggin, J., 1994. Regret theory with general choice sets. *Journal of Risk and Uncertainty* 8(2), 153-165.

[33] Ritov, I., 1996. Probability of regret: anticipation of uncertainty resolution in choice. *Organizational Behavior and Human Decision Processes* 66(2), 228-236.

[34] Sandroni, A., Squintani, F., 2007. Overconfidence, insurance, and paternalism. *American Economic Review* 97(5), 1994-2004.

[35] Sarver, T., 2008. Anticipating regret: why fewer options may be better. *Econometrica* 76(2), 263-305.

[36] Simonson, I., 1992. The influence of anticipating regret and responsibility on purchase decisions. *Journal of Consumer Research* 19(1), 105-118.

[37] Smetters, K., 2002. Controlling the costs of minimum benefit guarantees in public pension conversions. *Journal of Pension Economics and Finance* 1(1), 9-34.

[38] Sugden, R., 1993. An axiomatic foundation of regret. *Journal of Economic Theory* 60(1), 159-180.

[39] Thaler, R.H., Sunstein, C.R., 2003. Libertarian paternalism. *American Economic Review Papers and Proceedings* 93(2), 175-179.

[40] Zeelenberg, M., 1999. Anticipated regret, expected feedback and behavioral decision making. *Journal of Behavioral Decision-Making* 12(2), 93-106.

[41] Zeelenberg, M., Pieters, R., 2004. Consequences of regret aversion in real life: the case of the Dutch postcode lottery. *Organizational Behavior and Human Decision Processes* 93(2), 155-168.

[42] Zeelenberg, M., Pieters, P., 2007. A theory of regret regulation 1.0. *Journal of Consumer Psychology* 17(1), 3-18.

[43] Zeelenberg, M., van Dijk, W.W., Manstead, A.S.R., 1998. Reconsidering the relation between regret and responsibility. *Organizational Behavior and Human Decision Processes* 74(3), 244-272.

[44] Zeelenberg, M., van Dijk, W.W., Manstead, A.S.R., 2000a. Regret and responsibility resolved? Evaluating Ordóñez and Connolly's (2000) conclusions. *Organizational Behavior and Human Decision Processes* 81(1), 143-154.

[45] Zeelenberg, M., van Djik, W.W., Manstead, A.S.R., van der Pligt, J., 2000b. On bad decisions and disconfirmed expectancies: the psychology of regret and disappointment. *Cognition and Emotion* 14(4), 521-541.