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**Abstract**

This paper extends the standard two-period prevention model by incorporating *anticipatory emotions*. We introduce an additional cost, referred as the *emotional load*, which is endogenously determined by future risk but can be mitigated by current preventive effort. We show that a more intense emotional load incentivizes the emotional agent to increase investment in either self-insurance or self-protection. By contrast, greater uncertainty sensitivity has an ambiguous effect: It depends on the curvature of the emotional load function and wealth. When savings are substitutes, the effect of these parameters may diverge, whereas they align when savings are complements to risk prevention. Finally contrasting our setting with a setting without uncertainty or emotions, we show that, under prudence, the introduction of a zero-mean risk leads to a higher optimal level of self-insurance. Anxiety amplifies the incentive to reduce risk by lowering present well-being.

*Keyword*: Self-insurance, Self-protection, Anticipatory emotions, Uncertainty.

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# 1 Introduction

Self-protection and self-insurance are two fundamental concepts in the economics of risk management, helping to explain how individuals mitigate risks in uncertain environments. Since the seminal work of Ehrlich and Becker [20], an extensive body of literature has emerged to examine the determinants of optimal prevention. However, no existing analysis has incorporated the impact of emotions on such decisions. Yet, a large literature has shown that emotions play a significant role in decision-making processes (e.g., Loewenstein and Lerner [36] and references included). The aim of this paper is precisely to investigate whether immediate emotions affect savings decisions when future wealth is exposed to uncertain losses.

The existing literature on prevention traditionally distinguishes between self-protection and self-insurance activities. Self-protection refers to efforts individuals undertake to reduce the probability of a negative event occurring, while self-insurance involves actions aimed at mitigating the consequences of such events once they occur. A central strand of the literature performs comparative statics to analyze how changes in risk attitudes affect optimal prevention. Early models focused on the role of risk aversion within a single-period framework. Dionne and Eeckhoudt [16] showed that more risk-averse individuals tend to invest more in self-insurance, but not necessarily in self-protection. Subsequent studies (e.g., Briys and Schlesinger [5], Jullien and al. [32], and Huber [29]) provided more nuanced results depending on a probability threshold. Later contributions have incorporated higher-order risk preferences, such as prudence. For instance, Eeckhoudt and Gollier [18] demonstrate that prudent individuals may invest less in self-protection — at intermediate probabilities of loss—than risk-neutral individuals.

Since Menegatti [41], the literature has been extended to two-period models, allowing for a richer set of considerations, such as time preferences, consumption–saving trade-offs, and the influence of additional risks on optimal prevention decisions. Menegatti and Rebessi [42], as well as Peter [43], find that the results from the single-period setting generally continue to hold, even when endogenous saving is introduced. However, the presence of other risks — along with the timing of their potential realization — may encourage individuals to increase precautionary saving and/or preventive effort (e.g., Courbage and Rey [10]; Eeckhoudt et al. [19]).

A further strand of the literature has applied the theoretical framework to health economics (e.g., Courbage and Rey [11], Crainich and Eeckhoudt [12], or Liu and Menegatti [34]). In this context, individual preferences depend on a second argument — health — which becomes the variable exposed to risk. This literature explores how the interaction between wealth and health considerations influences decisions related to risk management and prevention.

However, to the best of our knowledge, most of the literature abstracts from the role of emotions in shaping individual prevention decisions. Existing models typically assume fully rational behavior, despite advances in decision-making theory and behavioral economics have shown that individuals are subject to numerous cognitive and emotional biases. Kahneman and Tversky [33] emphasized that people often make decisions based on psychological reactions rather than objective probabilities. Only a limited number of studies have incorporated insights from behavioral economics into the analysis of self-protection and self-insurance. For instance, some of these works show that ambiguity aversion increases the optimal levels of both self-protection and self-insurance (e.g., Alary et al. [1], Berger [3], and Snow [44]). Conversely, Baillon et al. [2] find that probability distortion may lead to underinvestment in prevention. More recently, Fujii and Osaki [25] demonstrated that regret-sensitive individuals invest more in self-insurance when the probability of loss is low, and less when it is high. To the best of our knowledge, no economic study has explicitly examined how immediate emotions affect prevention decisions. Yet, many real-life situations involving future risk and uncertainty are likely to trigger emotional responses, which in turn may influence economic decision-making. This paper aims to fill this gap.

To carry out our analysis, we consider emotions that arise prior to the resolution of uncertainty, in line with the economic literature developed by Caplin and Leahy [6], and Loewenstein et al. [38]. These studies focus on the emotions experienced at the moment of decision-making, before outcomes materialize—commonly referred to as anticipatory emotions, commonly refer to as *anticipatory* emotions. Indeed, emotions can differ depending on *when* they arise relative to the time of the decision, and *how* they are linked to either the decision itself or its outcomes. In many real-life situations, a (sometimes long) period may elapse between the decision and the realization of uncertainty. During this interval, individuals may experience immediate emotional responses associated with possible future outcomes. For example, gambling players may feel excited anticipation about the possibility of winning the jackpot before the draw takes place. Conversely, someone who has undergone a medical examination may experience stress and anxiety while awaiting the results. These feelings directly influence instantaneous utility and can alter the intertemporal trade-off involved in decision-making. In this study, we specifically associate anxiety with the possibility of incurring a random economic loss resulting from the occurrence of a damaging event.

This paper develops a two-period model in which individuals allocate their initial wealth between saving and risk management. Future consumption is uncertain due to a potential harmful event, occurring with an exogenous probability. This uncertainty creates anticipatory anxiety, which we refer to as the individual's *emotional load*. While risk-reduction efforts typically precede the realization of benefits, in our framework they also influence emotional well-being by reducing the emotional load. We first examine a benchmark case without savings. We show that an anxious individuals tend to invest more in self-insurance activities than an emotional-free agent. Contrasting with a setting with no uncertainty, the introduction of random economic losses leads to a higher level of self-insurance, under prudence. We then extend this framework to include savings. We show that self-insurance and self-protection increase with a more intense emotional load, as well when the emotional agent is more sensitive to uncertainty under restrictions.

The paper proceeds as follows. Section 2 reviews the economic literature on emotions and decision-making under risk. Section 3 introduces the two-period model of optimal prevention, incorporating immediate anxiety and a potential random loss. In Section 4, we develop our benchmark model when the emotional agent can also invest in self-insurance. In Section 5, we analyze self-insurance and self-protection decisions when the agent jointly chooses savings and risk-mitigation investments. In Section 6, we develop intuition for our results by drawing on a recent decomposition of optimal self-protection in terms of stochastic changes. Section 7 concludes.

# 2 Emotions and economic decisions

Emotions are inextricably linked to economic decisions. Economic choices — and their outcomes — can trigger emotional responses, just as emotions can shape economic behavior. The earliest economic analyses of emotions can be traced back to Hirshleifer [27] and Frank [24], who both emphasized the role of emotions in cooperative interactions. Later, Elster [21] and Loewenstein [35] highlighted the more complex role emotions play in the evaluation and perception of costs and benefits. Since then, the literature on the interplay between emotions and decision-making has expanded along three main dimensions: (i) the role of emotions in social behavior, (ii) their impact on intertemporal choices, and (iii) how emotions influence decision-making under risk and uncertainty.

The first strand of the literature builds on the pioneering work of Hirshleifer [27] and Frank [24], focusing on commitment problems and, more specifically, on the role of anger in motivating punishment. For instance, Bosman and van Winden [4], using a power-to-take game experiment, show that negative emotions lead to high levels of resource destruction. Similarly, Dickinson and Masclet [15] find that venting emotions reduces excessive punishment. Hopfensitz and Reuben [28] report that anger can also provoke retaliatory behavior from punished individuals. Finally, Drouvelis and Grosskopf [17] compare the effects of happiness and anger on cooperation and sanctioning behavior in a public goods game: They find that angry individuals contribute less than happy ones and tend to impose harsher punishments. Taken together, these studies highlight that individuals may make different choices under identical scenarios once emotions are taken into account. More generally, Capra [7] demonstrates that mood influences strategic behavior, further emphasizing the emotional foundations of decision-making.

The second body of literature explores the relationship between emotions and time, and by extension, their influence on intertemporal choices. How individuals value time can be strongly affected by their emotional states and moods. This line of research intersects with the economic literature on time discounting, time preferences, and the psychological notion of self-control. Indeed, a number of studies examine how emotions shape temporal decision-making, particularly in the context of hyperbolic discounting (Loewenstein and Prelec [37]). For example, Geoffard and Luchini [26] explain distortions in time perception through the sequentiality of events, leading to the puzzling observation that individuals may sometimes prefer unpleasant events in the near future rather than in the distant future. Similarly, Ifcher and Zarghamee [30] find that a mild positive affect significantly reduces time preference, i.e., it decreases the preference for immediate utility over future utility.

Finally, a substantial body of literature examines the influence of emotions on risk attitudes and risk perception. As expected utility theory came under increasing scrutiny, several alternative models were developed to better capture observed behaviors under risk and uncertainty. These include weighted expected utility, prospect theory, and regret theory, all of which incorporate emotional components into decision-making frameworks. For example, Kahneman and Tversky [33] introduced key psychological principles such as loss aversion and probability weighting, while Loomes and Sugden [39] formalized the role of regret and disappointment/elation in shaping preferences. More recently, several studies have focused explicitly on the direct impact of emotions on risk attitudes. Conte et al. [8], for instance, show that specific emotions — joviality, sadness, fear, and anger — can reduce risk aversion. Meier [40], using a large German panel dataset, finds that fluctuations in emotional states over time significantly influence individuals' willingness to take risks. Fehr-Duda et al. [23] further show that women in a positive mood tend to weight probabilities more optimistically, an effect that is less pronounced among men.

Surprisingly, however, the role of emotions in risk management decisions — such as prevention and insurance — has received little to no attention. To the best of our knowledge, no existing studies investigate how emotions influence preventive behavior. Yet, it is reasonable to expect that individuals experiencing anxiety may engage in self-protective actions to reduce the probability of a loss, or invest in self-insurance to mitigate its potential consequences.

# 3 The model

We consider a two-period framework, where period 0 represents the "present" and period 1 the "future". The individual is endowed with a certain initial income, denoted $w_0 > 0$, which is allocated between current consumption, $c_0$, and savings, $s$. The level of future consumption is endogenously determined by the return on savings, taking into account the interest rate, $r$.

In period 1, the economic agent faces the risk of a hazardous event, which occurs with probability $p \in (0, 1)$. If the event occurs, it causes an uncertain economic loss, denoted $\tilde{L}$, which reduces both future wealth and future consumption, $\tilde{c}_1$. We refer to this situation as the loss state. Conversely, the agent enjoys her entire (certain) wealth, resulting in future consumption, $c_1$. This is referred to as the no-loss state.

Assuming utility is of the same form in both periods and introducing a parameter $\gamma \in (0, 1)$ to distinguish the weight of the present against the future, we so far get the standard two-period utility:

$$\mathbb{E}U = \gamma u(c_0) + (1 - \gamma) \left[ p\mathbb{E}u(\tilde{c}_1) + (1 - p)u(c_1) \right]. \tag{1}$$

with $w_0 = c_0$ and $w_1 = \tilde{c}_1 - \tilde{L}$ in the loss state or $c_1 = (1+r)s$ in the non-loss state. We moreover assume the standard properties: $u' > 0$ and $u'' \leqslant 0$.

In this setting, we introduce a new component by assuming that economic agents experience ex-ante, or *anticipatory* emotions, in the present regarding future uncertain outcomes. Such anticipatory emotions typically include fear, anxiety, or hope. In our model, we focus on a representative agent who experiences anxiety, denoted $a_0$, as she faces uncertain future economic losses occurring in period 1, which negatively affect future consumption, $\tilde{c}_1$. The intensity of this anxiety depends on both the level of uncertainty and the expected magnitude of the potential loss. Following Caplin and Leahy [6], and Wälde [46], we adopt the following specification:

$$a_0 = a\left(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1)\right) = var(\tilde{c}_1)^{\zeta}\mathbb{E}(\tilde{c}_1)^{-(1-\zeta)}, \tag{2}$$

with $\zeta \in (0.5, 1)$ an emotional-specific parameter.[1] This corresponds to the "personality parameter" introduced by Wälde [46] to balance the weight of the variance as opposed to the mean. We hereafter refers to as the uncertainty sensitivity. We further assume that:

$$\frac{\partial a}{\partial \zeta} > 0. \tag{3}$$

Anxiety rises with a higher weight of the variance.

In the first period, the agent's utility depends on two arguments: current consumption, $c_0$, and anxiety, $a$. Since anxiety is a function solely of future uncertainties, we assume an additively separable utility function of the form $u(c_0) - \phi v(a)$, with $\phi \geqslant 0$ a parameter capturing the agent's sensitivity to anxiety. The disutility generated by anxiety represents the *emotional load*, reflecting the emotional impact of facing uncertain future outcomes. We further assume that this emotional load is increasing in anxiety, i.e., $v'(a) > 0$.

All together, the total utility of the "emotional agent" is thus characterized as follows:

$$\mathbb{E}U = \gamma\left[u(c_0) - \phi v(a)\right] + (1-\gamma)\left[p\mathbb{E}u(\tilde{c}_1) + (1-p)u(c_1)\right]. \tag{4}$$

In what follows, we will consider that the emotional agent will exert effort in the present to either reduce the probability of damages, or mitigate the impacts of future losses.

# 4 Basic framework with anticipatory emotions

As a benchmark, we first consider an emotional agent who cannot save for future consumption, but instead receives an exogenous and deterministic endowment, respectively $w_0$ in period 0 and $w_1$ in period 1. We focus on the case where the emotional agent may

[1] We reduce the set of parameters values to ensure that the variance outweighs the mean.

invest in insurance coverage at a unit price $\pi$ to reduce the negative effect of uncertain losses by an amount $e\tilde{L}$.[2] The optimization program reads as:

$$\max_{e>0} \quad \{\mathbb{E}U(e) = \gamma\left[u(c_0) - \phi v(a)\right] + (1-\gamma)\left[p\mathbb{E}u(\tilde{c}_1) + (1-p)u(c_1)\right]\}, \tag{5}$$

$$\text{subject to} \quad c_0 = w_0 - \pi e > 0, \tag{6}$$

$$\text{and} \quad \tilde{c}_1 = w_1 - (1-e)\tilde{L} > 0. \tag{7}$$

with anxiety, $a$, defined following Eq. (2).

The optimal level of effort, $e^* > 0$, is determined by the following first-order condition for an interior solution:

$$\frac{\partial \mathbb{E}U}{\partial e} = \gamma\left(-\pi u_0^{'} - \phi v^{'}(a)\frac{da}{de}\right) + p(1-\gamma)\mathbb{E}\left(\tilde{L}\tilde{u}_1^{'}\right) = 0, \tag{8}$$

$$\text{with} \quad \frac{da}{de} = \frac{\partial a}{\partial var(\tilde{c}_1)}\frac{\partial var(\tilde{c}_1)}{\partial e} + \frac{\partial a}{\partial \mathbb{E}(\tilde{c}_1)}\frac{\partial \mathbb{E}(\tilde{c}_1)}{\partial e} < 0, \tag{9}$$

and adopting the notation $u_0$ for the initial period utility, $\tilde{u}_1$ for the future utility in the loss state, and $u_1$ for the future utility in the no-loss state, respectively.

The first term of Eq. (8), $-\pi u_0^{'} < 0$, is the standard marginal cost of insurance, i.e. the loss of the first-period utility due to investment in insurance activities. The second term, $-\phi v'(a)\frac{da}{de} > 0$, represents the marginal benefit of a decrease of the emotional load. More precisely, this represents the feedback impact of a decreased random loss on the current disutility because of a lower anxiety. The last term is then the marginal gain of insurance in the next period if damage occurs. Rearranging Eq. (8) as follows:

$$\frac{p(1-\gamma)\mathbb{E}\left(\tilde{L}\widetilde{u_1'}\right)}{\gamma u_0^{'}} - \phi\frac{da}{de}\frac{v^{'}(a)}{u_0^{'}} = \pi. \tag{10}$$

We can see how the introduction of anticipatory emotions modifies the standard intertemporal tradeoff. In particular, the first term in the left-hand side (LHS) of Eq. (10) corresponds to the marginal rate of intertemporal substitution. This reflects the rate at which the individual is willing to give up one unit of consumption in the present in order to invest in self-insurance in exchange for the expected benefits if a loss occurs. The second term represents another type of substitution marginal rate, but balanced the marginal utility of current consumption with the marginal reduction in emotional load due to anxiety relief. It captures the feedback effect on anxiety from the decision to invest in self-insurance: giving up one unit of consumption today secures an amount of consumption tomorrow, which then marginally alleviates the burden of this feeling. As the direct effect of self-insurance effort on anxiety, $\frac{da}{de}$, is negative, and the emotional load is increasing in anxiety, $v'(a) > 0$, the second term of the LHS is negative. In other words, self-insurance provides

[2] Optimal self-protection choices are independent on anxiety, and thus align with standard results in the literature.

emotional relief, adding value beyond its direct financial effect. The sum of these two marginal rates must equal the unit insurance cost. Accounting for anticipatory feeling fundamentally alters the trade-off between current consumption and self-insurance, as it introduce a psychological benefit to investing in protection.

Now let us examine how self-insurance changes with emotions. We first totally differentiate Eq. (8) with respect to the measure of the emotional load, $\phi$, and the sensitivity parameter, $\zeta$. This will respectively leads to observe the following:

$$\frac{de}{d\phi} = -\frac{\mathbb{E}U_{e\phi}}{\mathbb{E}U_{ee}}, \ \frac{de}{d\zeta} = -\frac{\mathbb{E}U_{e\zeta}}{\mathbb{E}U_{ee}},$$

with $\mathbb{E}U_{ee}$, $\mathbb{E}U_{e\phi}$ and $\mathbb{E}U_{e\zeta}$ the second derivatives of the marginal expected utility respectively with respect to $e$, $\phi$ and $\zeta$. Since the denominator corresponds to the second order condition, which is assumed to be negative, the sign of both expressions will be of the same sign of the numerator. As expected, an increase in the intensity of emotional load, $\phi$, leads to higher investment in self-insurance. This results from the fact that self-insurance reduces anxiety, which in turn lowers the emotional load. Thus, a more emotionally sensitive agent finds it more valuable to protect against future uncertainty.

A higher sensibility toward uncertainty, $\zeta$, has however an ambiguous impact. The overall effect depends on the relative strengh of two opposing forces: The feedback effect of increased anxiety sensitivity on the marginal emotional load, $v''(a)\frac{da}{de}\frac{da}{d\zeta}$, and the interaction effect between self-insurance effort and worries about uncertainty, $\frac{d^2a}{ded\zeta}$. Proposition 1 summarizes the previous discussion.

**Proposition 1** *An emotional agent invests a higher level of effort in self-insurance activities than a non-emotional agent. Moreover, she adjusts her optimal self-insurance effort as follows:*

**i** *The greater the intensity of the emotional load ($\phi$), the more she invests in self-insurance activities, $\frac{de}{d\phi} > 0$.*

**ii** *An increase in uncertainty sensitivity ($\zeta$) has an ambiguous impact, and depends on the agent's wealth in the next period and the curvature of the emotional load function:*

- *When wealth satisfies $w_1 \geq \frac{3}{2}(1-e)\mathbb{E}(\tilde{L})$, and the marginal emotional load is increasing ($v''(a) \geq 0$), then effort in self-insurance increases with uncertainty sensitivity, $\frac{de}{d\zeta} \geq 0$.*

- *Whenf wealth satisfies $w_1 < \frac{3}{2}(1-e)\mathbb{E}(\tilde{L})$, and the elasticity of marginal emotional-induced disutility, $-a \cdot \frac{v''(a)}{v'(a)}$, is higher than 1, with $v''(a) < 0$, then effort in self-insurance decreases with uncertainty sensitivity, $\frac{de}{d\zeta} < 0$.*

Proposition 1 highlights how the emotional load influences the decisions related to risk reduction. The ambiguity of the impact of the parameter $\zeta$ arises from two main sources:

the curvature of the anxiety disutility ($v''(a) > 0$ vs $v''(a) < 0$ vs $v''(a) = 0$), and the interaction between risk reduction effort and worries about uncertainty, $\frac{d^2a}{ded\zeta} \lesseqgtr 0$. Specifically, we may observe a decrease in self-insurance effort even as anxiety increases. This may occur when the marginal emotional load increases only slightly at high levels of anxiety (when $v(a)$ is a concave function), in combination with low future wealth level, or low average economic losses. In such cases, the psychological benefit of additional self-insurance may not be sufficient to outweigh its cost, leading to reduced investment in protection despite higher emotional tension.

# 5 Anticipatory emotions & saving

We now turn toward a situation where the emotional agent may save money in the present to consume in the future. On the contrary with the previous case, emotions may also affect optimal choices of self-protection. In the first period, consumption level, $c_0$, is derived from an (exogenous) wealth, $w_0$, net of saving, $s$, and effort in protective activities (self-protection or self-insurance).

$$c_0 \quad = \quad w_0 - \pi e - s. \tag{11}$$

Consumption in the next period, $\tilde{c}_1$, is now determined by saving plus the interest rate , $r$, net of a random loss, $\tilde{L}$. In the remaining part of the section, we will have:

$$\tilde{c}_1 = (1+r)s - \tilde{L} \text{ under self-protection activities,} \tag{12a}$$

$$\text{or } \tilde{c}_1 = (1+r)s - (1-e)\tilde{L} \text{ under self-insurance activities.} \tag{12b}$$

Let analyze successively those two scenarios to examine how emotions affect risk reduction decisions with endogenous savings.

## 5.1 Optimal self-protection with saving

The representative emotional agent maximizes her expected utility by choosing self-protection $e > 0$ and saving $s > 0$.

$$\mathbb{E}U(s,e) \quad = \quad \gamma\left(u(c_0) - \phi v(a)\right) + (1-\gamma)\left[p(e)\left(\mathbb{E}u_1(\widetilde{c}_1)\right) + (1-p(e))u_1\right].$$

with respect to budget constraints (11) and (12a).

We obtain the first-order conditions:

$$\frac{\partial \mathbb{E}U}{\partial s} \quad = \quad \gamma\left(-u_0' + \phi v'(a)\frac{da}{ds}\right) + (1-\gamma)(1+r)\left[p(e)\mathbb{E}\tilde{u}_1' + (1-p(e))u_1'\right] = 0, \tag{13}$$

$$\frac{\partial \mathbb{E}U}{\partial e} \quad = \quad -\gamma\pi u_0' + (1-\gamma)p'(e)\left(\mathbb{E}\tilde{u}_1 - u_1\right) = 0. \tag{14}$$

Eqs. (13) and (14) respectively capture the familiar trade-off between benefit and cost of self-protection and saving. Indeed, an investment in self-protection reduces first-period consumption, but increases expected second-period consumption by lowering the probability of damage. Similarly, saving involves forgoing current consumption in exchange for higher future wealth. However, we observe here that the marginal cost of saving in term of foregone marginal utility is mitigated by the feedback effect of savings on the emotional load, $\phi v^{'}(a)\frac{da}{ds}$. Since saving contributes to secure a higher amount of future consumption, it decreases anxiety, $\frac{da}{ds} < 0$, thereby lowering the emotional burden. This emotional benefit may incentivize the emotional individual to save more than an emotion-free agent. however, because she must allocate part of her wealth between self-protection activities and saving, the increase in savings may crowd out self-protection, depending on the relative strength of the emotional feedback and trade-off between both types of investment .

Taking the total differentiation of Eq. (13), assessed at the equilibrium, we obtain:

$$\frac{de}{ds} = -\frac{\mathbb{E}U_{es}}{\mathbb{E}U_{ee}} = -\frac{\gamma u_0'' + (1-\gamma)(1+r)p'(e)\left[\mathbb{E}\widetilde{u}_1' - u_1'\right]}{U_{ee}}.$$

Since $\mathbb{E}U_{ee}$ must be be negative, the sign depends on the sign of the numerator. Given that both $u_0''$ and $p'(e)$ are negative, the overall signs determined by the balance between the expected marginal utility in the loss state and the marginal utility in the no-loss state. Lemma 1 provides a sufficient condition. In other words, under a fixed budget constraint, if the emotional agent increases savings, this implies a reduction in self-protection effort compared to an emotional-free agent. This reflects a reallocation of resources derived by the emotional feedback on anxiety, which alters the standard trade-off between precautionary saving and risk-reduction activities.

**Lemma 1** *It is sufficient that the representative agent is prudent to have self-protection and saving substitutes.*

Now, we examine the effects of a change in one of the parameter $\theta = \{\phi; \zeta\}$ on the optimal choices of self-protection and saving. We totally differentiate Eqs. (13) and (14) with respect to the parameters of interest. Examining Eq. (14), we observe that the emotional load does not directly affect the optimal condition for self-protection. Such investment is consequently influenced by anxiety only indirectly.

Similar to the benchmark model, the effect of the intensity of the emotional load is straightforward and is entirely captured by the feedback effect of savings on anxiety. However, the effect of the sensitivity parameter, $\zeta$, once again depends on the balance between variations in anxiety caused by changes in the marginal emotional load due to variations in savings, $v''(a)\frac{da}{ds}\frac{da}{d\zeta}$, and the interaction effect arising from a simultaneous change in risk protection efforts and uncertainty sensitivity, $v'(a)\frac{d^2s}{ded\zeta}$.

Proposition 2 summarizes the different results

**Proposition 2** *An anxious individual will adjust her investment in prevention as follows:*

**i** *A more intense emotional load ($\phi$) decreases savings, $\frac{ds}{d\phi} < 0$, but increases investment in self-protection, $\frac{de}{d\phi} > 0$.*

**ii** *An increase in risk uncertainty sensitivity ($\zeta$) may either increase or decrease savings and investment in self-protection according to the following situations:*

- *If $\frac{1}{1-\zeta} > \ln(var(\tilde{c}_1)) + \ln(\mathbb{E}(\tilde{c}_1))$ and $v''(a) \leq 0$, then investment in self-protection increases, $\frac{de}{d\zeta} > 0$, while savings decrease, $\frac{ds}{d\zeta} < 0$.*
- *If $\frac{1}{1-\zeta} \leq \ln(var(\tilde{c}_1)) + \ln(\mathbb{E}(\tilde{c}_1))$, and $v''(a) \geq 0$, savings increase, $\frac{ds}{d\zeta} \geq 0$, while decrease self-protection investemnt decreases, $\frac{de}{d\zeta} \leq 0$.*

Proposition 2 outlines that the curvature of the function $v(a)$ determines the impact on optimal choices. Consistent with earlier findings, we observe that risk reduction efforts increase with greater uncertainty worries when the anxiety-induced disutility grows at an increasing rate.

## 5.2 Optimal self-insurance level with saving

Now turn to a situation where the emotional agent may invest in self-insurance in the first period. The maximization programm now reads as follows:

$$\max_{e>0,s>0} \quad \mathbb{E}U = \gamma\left(u_0(w_0) - \phi v(a_0)\right) + (1-\gamma)\left[p\left(\mathbb{E}u_1(\tilde{c}_1)\right) + (1-p)u_1\left(c_1\right)\right] \tag{15}$$

with respect to the two budget constraints (11) and (12b).

The first-order conditions (for an interior solutions) are:

$$\frac{\partial \mathbb{E}U}{\partial s} = -\gamma\left(u_0' + \phi v'(a)\frac{da}{ds}\right) + (1-\gamma)(1+r)\left[p\mathbb{E}\tilde{u}_1' + (1-p)u_1'\right] = 0, \tag{16}$$

$$\frac{\partial \mathbb{E}U}{\partial e} = -\gamma\left(\pi u_0' + \phi v'(a)\frac{da}{de}\right) + (1-\gamma)p\mathbb{E}(\tilde{L}\tilde{u}_1') = 0. \tag{17}$$

Once again, the system of equations characterizes the optimal choices for saving and self-insurance by equalizing the reduction in current utility to the expected gains of utility in the next period for each monetary unit invested or saved today. However, we easily observe that both decisions are influenced by the feedback effects of saving and self-insurance on the emotional load. In both optimality conditions, saving, like self-insurance, alleviates anxiety by securing a higher future wealth, thereby reducing the emotional load in the present. In other words, these investments reduce the cost of postponing consumption as reflected the negative relationships $\frac{da}{ds} < 0$ and $\frac{da}{de} < 0$.

The relationship between saving and self-insurance is not straightforward. Indeed, from Eq. (17), we get the following condition:

$$\frac{de}{ds} = -\frac{\mathbb{E}U_{es}}{\mathbb{E}U_{ee}} = -\frac{\gamma\pi u_0'' - \gamma\phi\left(v''(a)\frac{da}{ds}\frac{da}{de} + v'(a)\frac{d^2a}{deds}\right) + p(1-\gamma)(1+r)\mathbb{E}\tilde{u}_1''}{U_{ee}}.$$

The sign of $\frac{de}{ds}$ now depends on the curvature of the emotional load, $v''(a)$. If $v''(a) \geq 0$, it is evident that $\frac{de}{ds} < 0$, given the denominator is negative and utility is concave. In this case, saving and self-insurance are substitutes: Increasing one reduces the marginal benefit of the other. However, when $v''(a) < 0$, saving and self-insurance might become complementary. This specially arises when the condition below is verified:

$$v'(a)\frac{d^2a}{deds}\left(\frac{v''(a)}{v'(a)}\frac{\frac{da}{ds}\frac{da}{de}}{\frac{d^2a}{deds}}+1\right) < \frac{\gamma\pi u_0''+p(1-\gamma)(1+r)\mathbb{E}\tilde{u}_1''}{\gamma\phi} < 0. \tag{18}$$

This scenario can only arise for $v''(a) < 0$. More specifically, it might occur when the emotional load is quite elastic, $-\frac{v''(a)}{v'(a)}\frac{\frac{da}{ds}\frac{da}{de}}{\frac{d^2a}{deds}} > 1$.

The comparative statics analysis is more complex in this situation. We however may identify specific cases under which clear qualitative results can be derived.

**Proposition 3** *For the linear quadratic class of utility function, and if $\pi(1+r) \leq \mathbb{E}(\tilde{L})$, we can say that:*

**i** *An increase in the anxiety coefficient, $\phi$, leads to higher self-insurance expenditures and lower savings:*

$$\frac{de}{d\phi} > 0 \text{ and } \frac{ds}{d\phi} < 0.$$

**ii** *An increase in the sensitivity coefficient, $\zeta$, leads to lower self-insurance expenditures and higher savings, provided that $v''(a) \geq 0$ and $2(1+r)s \geq 3(1-e)\mathbb{E}(\tilde{L})$:*

$$\frac{de}{d\zeta} > 0 \text{ and } \frac{ds}{d\zeta} < 0.$$

Although more restrictive, Proposition 3 further outlines the central role of the functional form of the emotional load (in the second point). Moreover, this proposition emphasizes new conditions that hinge on the intertemporal tradeoff between costs and benefits in the future. First, all results hold when the potential return from saving an amount equivalent to the unit cost of self-insurance, $\pi(1+r)$, is lower than expected economic losses, $\mathbb{E}(\tilde{L})$. In other words, the emotional agent is more strongly incentivized to invest in self-insurance rather to save. Conversely, for higher values of the sensitivity parameter, the emotional agent is more inclined to save when the future return from saving is at least one and half times the expected net economic losses (after accounting for insurance effort).

Contrasting this proposition with Proposition 1, we find consistency: Risk reduction through self-insurance increases with the sensitivity parameter when wealth is sufficiently high and when the emotional load is convex ($v''(a) > 0$). In contrast, Proposition 2 outlines that self-protection increases only when the emotional load is concave. This highlights a key distinction between the two types of prevention mechanism under emotional influence.

## 6 A discussion on changes in risk

So far we have examined the impact of the intensity of emotions on preventive strategies. We now would like to investigate the broader implications of introducing emotions. Here the source of anxiety is the random economic losses, $\tilde{L}$. In the absence of uncertainty, that is, when losses are perfectly known and deterministic, no anticipatory emotion arises: Anxiety disappears ($a = 0$), and accordingly the emotional load vanishes as well, $v(0) = 0$. Let us first briefly recall the standard two-period model without uncertainty, and therefore without anxiety. For clarity, we limit our discussion to the benchmark case.

$$U(e) = \gamma u(w_0 - \pi e) + (1-\gamma)\left[pu(w_1 - (1-e)L) + (1-p)u(w_1)\right]. \tag{19}$$

The optimal level of effort, $\bar{e} > 0$, is determined by the following first-order condition:

$$U'(\bar{e}) = -\pi\gamma u'(w_0 - \pi\bar{e}) + (1-\gamma)pLu'(w_1 - (1-\bar{e})L) = 0. \tag{20}$$

We first study the effect of introducing a random loss, $\tilde{L}$ with $\mathbb{E}(L) = L$.[3] The optimal level of effort, $\hat{e} > 0$, is determined by the following first order condition, in the presence of a random loss but still without anticipatory emotion, is given by:

$$\mathbb{E}\left[U'(\hat{e})\right] = -\pi\gamma u'(w_0 - \pi\hat{e}) + (1-\gamma)p\mathbb{E}\left[Lu'(w_1 - (1-\hat{e})L)\right] = 0. \tag{21}$$

Following Crainich and Menegatti [13] or Yin and Meng [45], and by comparing Eq. (20) with Eq. (21), we know that the optimal level of self-insurance, $\hat{e}$, is lower (resp. higher) than the level $\bar{e}$ if the optimality condition (20) evaluated at $\hat{e}$ is positive, $U'(\hat{e}) > 0$ (resp. negative, $U'(\hat{e}) < 0$). Let us denote $h(L)$ the right-hand side of Eq. (20) for $e = \hat{e}$. By the Jensen's inequality, $U'(\hat{e}) > 0$ (resp., $U'(\hat{e}) < 0$) if $h(L)$ is concave (resp., convex) in $L$. Let us now compute the second derivative of $h(L)$:

$$h''(L) = p(1-\gamma)(1-\hat{e})\left[-u_1'' + (1-\hat{e})Lu_1'''\right]. \tag{22}$$

The sign of $h''(L)$ thus depends on the sign of the third derivative, $u_1'''$. We can derive the following Lemma.

**Lemma 2** *Prudence is a sufficient condition for the introduction of a zero-mean risk on economic losses to generate an increase in self-insurance, $\hat{e} > \bar{e}$.*

Now, let us address the question of how the presence of an emotional load affects investment in self-insurance. In our setting with anticipatory emotion, the optimality condition Eq. (8) looks like Eq. (21) augmented by an additional term, $-\gamma\phi v'(a)\frac{da}{de}$, arising in the first period. In this context, the random variable is ubiquitous: It affects both anxiety in the first period, and the utility associated with the loss-state in the second-period. Comparing now Eq. (8) with Eq. (20), self-insurance effort should be higher when the individual experiences negative anticipatory emotions. Indeed, assess

[3] This assumption allows us to capture an increase in risk.

Eq. (8) for $e = \hat{e}$, the condition reduces to $-\gamma\phi v'(a)\frac{da(\hat{e})}{de} > 0$. Given the second order conditions, we know that Eq. (8) is decreasing in $e$. Hence, to hold the equilibrium condition, effort level must be increased. Consequently, an anxious individual invests more in self-insurance than a non-anxious agent, $e^* > \hat{e}$. We can then conclude the following Proposition:

**Proposition 4** *Under Lemma 2, the introduction of an emotional load leads to an increase in self-insurance, $e^* > \bar{e}$, where $e^*$ denotes the optimal self-insurance level derived from Eq. (8).*

Proposition 4 shows that a prudent agent exerts less effort than an emotional agent experiencing anticipatory anxiety in first period, in order to reduce the size of potential economic losses in the future. In this context, the random variable is indeed ubiquitous: The introduction of random economic losses implies a new risk in the second period, and induces anxiety in the first period. The emergence of an emotional load reduces well-being in the first period, and investing in a risk mitigation strategy serves the dual purpose of reducing both future economic risk and current anxiety. Moreover, random economic losses lead to uncertain future wealth if the loss-state occurs. These combined effects incentivize the emotional agent to invest more in risk mitigation than a purely prudent agent. This result is consistent with Proposition 1, which shows that the greater the weight assigned to the emotional load, $\phi$, the higher the effort level.

An interesting point would have been to examine the effect for higher levels of risk. Assuming an exogenous mean-preserving change in loss, $L_1$, but an increase in the variance $var(\tilde{L}) < var(\tilde{L}_1)$, this consequently means that anxiety rises, as so the fear load, $v(a)$. This also implies a larger spread in future wealth in the loss-state. Following intuitions provided by Proposition 4, we might expect an increase in effort levels.

# 7 Conclusion

This study extends the standard two-period model by explicitly incorporating anticipatory emotions as part of the agent's decision-making process. In addition to facing a future risk of economic loss, the agent now experiences a present emotional load arising from the anticipation of uncertainty. This emotional component, modeled through an emotional load in the first period, modifies the agent's preferences and alters the standard cost-benefit trade-off of preventive effort. This anxiety is moreover endogenous: It can be mitigated by increasing either future wealth and/or preventive effort.

Our main result shows that investment in prevention increases with emotions. We specifically demonstrate that self-insurance and self-protection increase with a more intense emotional load. Moreover, an emotional agent tends to invests more when she faces random of economic losses than an emotional-free agent. One explanation stems from the fact that anxiety is endogenous and can be mitigated by increasing preventive effort, which amplifies the incentive to reduce risk exposure. Second, uncertainty sensitivity has an ambiguous effect, depending on the wealth level and the curvature of the emotional load. Overall, the model reveals that emotional anticipations significantly influence decision-making under risk. By integrating emotions into economic behavior, we obtain richer comparative statics and a better understanding of the psychological underpinnings of risk mitigation.

While the model provides valuable insights into the interaction between emotions and risk prevention, there are several limitations. Indeed, a simple emotion structure is introduced. We might extend this approach by incorporating temporal dynamics to capture how emotions adapt over time. Second, a dynamic structure also allow to consider how past experiences could trigger or modify anxiety for future. Third, we here assume that the emotional agent know the distribution of the distribution of economic losses, while she may have a biased risk perception. Specifically, we may assume that anxiety is a source of risk distortion.

Despite these limitations, the model contributes to a deeper understanding of how emotions shape risk-related behavior. This insight may have practical implications for designing policies that account for emotional responses to uncertainty — especially in domains such as health, safety, and climate risk.

# References


[1] Alary D., Gollier C., Treich N., (2013), The effect of ambiguity aversion on insurance and self-protection. Economic Journal, 123, p.1188–1202.

[2] Baillon, A., H. Bleichrodt, A. Emirmahmutoglu, J. Jaspersen, and R. Peter. 2022, When risk perception gets in the way: Probability weighting and underprevention. Operations Research 70 (3): 1371–1392.

[3] Berger, L., (2016), The impact of ambiguity and prudence on prevention decisions, Theory and Decision 80 (3): 389–409.

[4] Bosman, R., and van Winden, F., (2002), Emotional Hazard in a Power-to-Take Experiment, The Economic Journal, 112(476), p.147–169.

[5] Briys, E., and Schlesinger, H., (1990), Risk aversion and the propensities for self-insurance and self-protection. Southern Economic Journal 57 (2), p.458–467.

[6] Caplin, A., and Leahy, J., (2011), Psychological expected utility theory and anticipatory feelings, The Quaterly Journal f Economics, 116(1), p.55-79.

[7] Capra, C. M., (2004), Mood-driven behavior in strategic interactions, American Economic Review, 94(2), p. 367-372.

[8] Conte, A., Levati, M. V., and Nardi, C., (2018), Risk Preferences and the Role of Emotions. Economica, 85(338), p. 305-328.

[9] Courbage, C., (2001), Self-insurance, self-protection and market insurance within the dual theory of choice. The Geneva Papers on Risk and Insurance Theory 26 (1), p.43-56.

[10] Courbage, C., Rey, B., (2012), Optimal prevention and other risks in a two-period model, Mathematical Social Sciences 63(3), p. 213–217.

[11] Courbage C., Rey B., (2006), Prudence and optimal prevention for health risks. Health Economics, 15, p.1323-1327.

[12] Crainich, D., and Eeckhoudt, L., (2017), Average willingness to pay for disease prevention with personalized health information, Journal of Risk and Uncertainty, 55(1), p.29–39.

[13] Crainich, D., and Menegatti, M., (2021), Self-protection with random costs. Insurance: Mathematics and Economics, 98, pp.63-67.

[14] Dachraoui, K., Dionne, G., Eeckhoudt, L., and Godfroid, P., (2004), Comparative mixed risk aversion: Definition and application to self-protection and willingness to pay. Journal of Risk and Uncertainty 29 (3), p.261-276.

[15] Dickinson, D. L., and Masclet, D., (2015), Emotion venting and punishment in public good experiments, Journal of Public Economics, 122, p.55-67.

[16] Dionne G., and Eeckhoudt L., (1985), Self-insurance, self-protection and increased risk aversion, Economics Letters, 17, p.39–42.

[17] Drouvelis, M., and Grosskopf B., (2016), The effects of induced emotions on pro-social behaviour, Journal of Public Economics, 134, p.1–8.

[18] Eeckhoudt L., and Gollier C., (2005), The impact of prudence on optimal prevention, Economic Theory, 26, p.989–994.

[19] Eeckhoudt, L., Huang, R.J., Tzeng, L.Y., (2012), Precautionary effort: A new look, Journal of Risk and Insurance 79(2), p. 585–590.

[20] Ehrlich I., and Becker, G.S., (1972), Market insurance, self-insurance, and self-protection, Journal of Political Economy, 80, p.623–648.

[21] Elster, J. (1996), Rationality and the Emotions, The Economic Journal, 106(438), p. 1386–1397.

[22] Elster, J. (1998), Emotions and Economic Theory, Journal of Economic Literature, 36(1), p. 47–74.

[23] Fehr-Duda, H., Epper, T., Bruhin, A., and Schubert, R., (2011), Risk and rationality: The effects of mood and decision rules on probability weighting, Journal of Economic behavior & Organization, 78, p.14-24.

[24] Frank, R. H., (1988), Passions within reason, New York: Norton.

[25] Fujii Y., and Osaki, Y., (2023), Effect of regret sensitivity on self-insurance and self-protection, Applied Economics, 55(44), p.5202-5212.

[26] Geoffard, P.Y., and Luchini, S., (2010), Changing time and emotions, Philos Trans R Soc Lond B Biol Science, 365(1538), p.271-80.

[27] Hirshleifer, J., (1987), On emotions as guarantors of threats and promises. In J. Dupré (Ed.), The latest on the best: Essays on evolution and optimality (pp. 307–326). The MIT Press.

[28] Hopfensitz, A., and Reuben, E., (2009), The importance of emotions for the effectiveness of social punishment, The Economic Journal, 119(540), p.1534-1559.

[29] Huber, T., (2022), Comparative risk aversion in two periods: An application to self-insurance and self-protection, Journal of Risk & Insurance, 89(1), p. 97-130.

[30] Ifcher, J., and Zarghamee, H., (2011), Happiness and time preference: The effect of positive affect in a random-assignment experiment, American Economic Review, 101(7), p.3109-3129.

[31] Johnson, E.J., and Tversky, A., (1983), Affect, generalization, and the perception of risk, Journal of Personality and Social Psychology, 45, p.20-31.

[32] Jullien B., Salanié B., and Salanié, F., (1999), Should more risk-averse agents exert more effort? Geneva Papers on Risk and Insurance Theory, 24, p.19–28.

[33] Kahneman, D., and Tversky, A., (1979), Prospect Theory: An Analysis of Decision under Risk, Econometrica, 47(2), p.263–291.

[34] Liu, D., and Menegatti, M., (2019), Optimal saving and health prevention, Journal of Economics, Springer, vol. 128(2), p. 177-191

[35] Loewenstein, G., (2000), Emotions in economic theory and economic behavior, The American Economic Review, 90(2), p.426-432.

[36] Loewenstein, G., and Lerner, (2002), The role of affect in decision making. In Handbook of affective science, J.S., Davidson, R., Scherer, K., Goldsmith, H. (eds), Oxford University Press, New York.

[37] Loewenstein, G., and Prelec, D., (1992), Anomalies in Intertemporal Choice: Evidence and an Interpretation. The Quarterly Journal of Economics, 107(2), p. 573–597.

[38] Loewenstein, G., and Weber, E.U., Hsee, C.K., and Welch, N., (2001), Risk as feelings, Psychological Bulletin, 127(2), p.287-286.

[39] Loomes, G., and Sugden, R., (1986), Disappointment and dynamic consistency in choice under uncertainty, Review of Economic Studies, 53, p. 271-282.

[40] Meier, A. N., (2022), Emotions and Risk Attitudes, American Economic Journal: Applied Economics, 14(3), p.527–58.

[41] Menegatti M., (2009), Optimal prevention and prudence in a two-period model, Mathematical Social Sciences, 58, p.393–397.

[42] Menegatti M., and Rebessi, F., (2001), On the substitution between saving and prevention, Mathematical Social Sciences, 62(3), p.176-182.

[43] Peter R., (2017), Optimal self-protection in two periods: On the role of endogenous saving, Journal of Economic Behavior & Organization, 137, p.19–36.

[44] Snow A., (2011), Ambiguity aversion and the propensities for self-insurance and self-protection, Journal of Risk and Uncertainty, 42, p.27–43.

[45] Yin, Y., and Meng, S., (2025), Self-protection and Nth-degree risk increase of random unit cost, Insurance: Mathematics and Economics, 122, p.137-142.

[46] Wälde, K., (2016), Emotion Research in Economics), CESifo Working Paper 5982.

# Appendix

## General computations for Section 4

We have $\tilde{c}_1 = w_1 - (1-e)\tilde{L}$ and $a\,(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1)) = var(\tilde{c}_1)^{\zeta}\mathbb{E}(\tilde{c}_1)^{-(1-\zeta)} > 0$. We first observe that:

$$var(\tilde{c}_1) = (1-e)^2 var(\tilde{L}), \qquad \mathbb{E}(\tilde{c}_1) = w_1 - (1-e)\mathbb{E}(\tilde{L}), \tag{23}$$

$$\tfrac{\partial(var(\tilde{c}_1))}{\partial e} = -2(1-e)var(\tilde{L}) < 0, \qquad \tfrac{\partial \mathbb{E}(\tilde{c}_1)}{\partial e} = \mathbb{E}(\tilde{L}) > 0. \tag{24}$$

We then deduce that:

$$\frac{da}{de} = \frac{\partial a}{\partial var(\tilde{c}_1)}\frac{\partial var(\tilde{c}_1)}{\partial e} + \frac{\partial a}{\partial \mathbb{E}(\tilde{c}_1)}\frac{\partial \mathbb{E}(\tilde{c}_1)}{\partial e} = -a\,(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1))\left(\tfrac{2\zeta}{(1-e)} + \tfrac{(1-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right) < 0, \tag{25}$$

$$\frac{d^2a}{de^2} = a\,(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1))\left[\left(\tfrac{2\zeta}{(1-e)} + \tfrac{(1-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)^2 - \tfrac{2\zeta}{(1-e)^2} + \tfrac{(1-\zeta)(\mathbb{E}(\tilde{L}))^2}{(\mathbb{E}(\tilde{c}_1))^2}\right] > 0. \tag{26}$$

Examining the term in brackets of Eq. (26), we get that it is positive since $2\zeta - 1 > 0$ with $\zeta \in (0.5, 1)$.

## Proof of Proposition 1

First, computing the second derivative of Eq. (8), we get:

$$\begin{aligned}
\frac{\partial^2 \mathbb{E}U}{\partial e^2} &= \gamma\left[\pi^2 u_0^{''} - \phi\left(v'(a)\frac{d^2a}{de^2} + v''(a)\left(\frac{da}{de}\right)^2\right)\right] + (1-\gamma)p\mathbb{E}\left(\tilde{L}^2\tilde{u}_1^{''}\right) < 0 \ (SOC), \\
\frac{\partial^2 \mathbb{E}U}{\partial e \partial \phi} &= -\gamma v'(a)\frac{da}{de} > 0 \text{ with } v'(a) > 0 \text{ and } \frac{da}{de} < 0, \\
\frac{\partial^2 \mathbb{E}U}{\partial e \partial \zeta} &= -\gamma\phi\left(v'(a)\frac{d^2a}{ded\zeta} + v''(a)\frac{da}{de}\frac{da}{d\zeta}\right) \gtreqless 0.
\end{aligned}$$

Remark that:

$$\frac{d^2a}{ded\zeta} = -\frac{da}{d\zeta}\left(\frac{2\zeta}{(1-e)} + \frac{(1-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right) - a\left(\frac{2}{(1-e)} - \frac{\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right) = \frac{1}{a}\frac{da}{de}\frac{da}{d\zeta} - a\left(\frac{2}{(1-e)} - \frac{\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right).$$

and let us rewrite the partial derivative as follows:

$$\frac{\partial^2 \mathbb{E}U}{\partial e \partial \zeta} = -\gamma\phi\left[-av'(a)\left(\frac{2}{(1-e)} - \frac{\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right) + \tfrac{da}{de}\tfrac{da}{d\zeta}\left(\tfrac{v'(a)}{a} + v''(a)\right)\right].$$

Using Assumption $\frac{da}{d\zeta} > 0$ and Eq. (25), and $v'(a) > 0$, we observe that:

- If $w_1 \geq \frac{3}{2}(1-e)\mathbb{E}(\tilde{L})$ and $v''(a) \geq 0$, then $\frac{\partial^2 \mathbb{E}U}{\partial e \partial \zeta} \geq 0$.
- If $w_1 < \frac{3}{2}(1-e)\mathbb{E}(\tilde{L})$ and $-a\,(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1))\,\frac{v''(a)}{v'(a)} \geq 1$ with $v''(a) < 0$, then then $\frac{\partial^2 \mathbb{E}U}{\partial e \partial \zeta} < 0$.

This concludes Proposition 1.

# General computations for Section 5

### Computations with self-protection

When the emotional agent may invest in self-protection, we know $\tilde{c}_1 = (1+r)s - \tilde{L}$. In this case we deduce that:

$$var(\tilde{c}_1) = var(\tilde{L}),\ \ \mathbb{E}(\tilde{c}_1) = (1+r)s - \mathbb{E}(\tilde{L}), \tag{27}$$

$$\frac{\partial(var(\tilde{c}_1))}{\partial e} = \frac{\partial(\mathbb{E}(\tilde{c}_1))}{\partial e} = 0,\ \ \frac{da}{de} = 0, \tag{28}$$

$$\frac{\partial(var(\tilde{c}_1))}{\partial s} = 0,\ \ \frac{\partial(\mathbb{E}(\tilde{c}_1))}{\partial s} = 1+r, \tag{29}$$

$$\frac{da}{ds} = \frac{\partial a}{\partial \mathbb{E}(\tilde{c}_1)}\frac{\partial(\mathbb{E}(\tilde{c}_1))}{\partial s} = -(1-\zeta)(1+r)var(\tilde{c}_1)^{\zeta}(\mathbb{E}(\tilde{c}_1))^{-(1-\zeta)-1} < 0, \tag{30}$$

$$\frac{d^2a}{ds^2} = (1-\zeta)(2-\zeta)(1+r)^2 var(\tilde{c}_1)^{\zeta}(\mathbb{E}(\tilde{c}_1))^{-(1-\zeta)-2} > 0 \text{ with } \zeta \in (0,1), \tag{31}$$

$$\frac{d^2a}{dsd\zeta} = (1+r)var(\tilde{c}_1)^{\zeta}(\mathbb{E}(\tilde{c}_1))^{-(1-\zeta)-1}\left[1-(1-\zeta)\left[\ln\left(var(\tilde{c}_1)\right) + \ln\left(\mathbb{E}(\tilde{c}_1)\right)\right]\right] \lesseqgtr 0. \tag{32}$$

# Proof of Lemma 1

Take the total differentiation of Eq. (13), assessed at the equilibrium, we obtain:

$$\frac{de}{ds} = -\frac{\mathbb{E}U_{es}}{\mathbb{E}U_{ee}} = -\frac{\gamma\pi u_0'' + (1-\gamma)(1+r)p'(e)\left[\mathbb{E}\widetilde{u}_1' - u_1'\right]}{\mathbb{E}U_{ee}} < 0.$$

with $\mathbb{E}\widetilde{u}_1' > u_1'$ if $u''' > 0$. This concludes the proof.

# Proof of Proposition 2

Taking the total differentiation of the system composed by Eqs. (13)-(14), we get the following system:

$$\underbrace{\begin{pmatrix} \mathbb{E}U_{ss} & \mathbb{E}U_{se} \\ \mathbb{E}U_{es} & \mathbb{E}U_{ee} \end{pmatrix}}_{A} \begin{pmatrix} \frac{ds}{d\theta} \\ \frac{de}{d\theta} \end{pmatrix} + \begin{pmatrix} \mathbb{E}U_{s\theta} \\ 0 \end{pmatrix} = 0 \text{ with } \theta = \{\phi;\zeta\}$$

This consequently provides:

$$\frac{de}{d\phi} = -\frac{\mathbb{E}U_{es}\mathbb{E}U_{s\phi}}{det(A)},\quad \frac{ds}{d\phi} = \frac{\mathbb{E}U_{ee}\mathbb{E}U_{s\phi}}{det(A)},\quad \frac{de}{d\zeta} = -\frac{\mathbb{E}U_{es}\mathbb{E}U_{s\zeta}}{det(A)},\quad \frac{ds}{d\zeta} = \frac{\mathbb{E}U_{ee}\mathbb{E}U_{s\zeta}}{det(A)}.$$

with $det(A)$ the determinant of matrix A, which should be negative to insure an interior solution.

Now let us compute the derivatives.

$$\begin{aligned}
\mathbb{E}U_{ee} &= \gamma\pi^2 u_0'' + (1-\gamma)p''(e)\left[\mathbb{E}\widetilde{u}_1 - u_1\right] < 0 \text{ with } p''(e) > 0 \text{ and } \mathbb{E}\widetilde{u}_1 < u_1 \text{ as u is concave,} \\
\mathbb{E}U_{ss} &= \gamma\left[u_0'' - \phi\left(v''(a)\left(\frac{da}{ds}\right)^2 + v'(a)\frac{d^2a}{ds^2}\right)\right] + (1-\gamma)(1+r)^2\left[p(e)\mathbb{E}\widetilde{u}_1'' + (1-p(e))u_1''\right] < 0, \\
\mathbb{E}U_{es} &= \gamma\pi u_0'' + (1-\gamma)(1+r)p'(e)\left[\mathbb{E}\widetilde{u}_1' - u_1'\right] < 0 \text{ with } \mathbb{E}\widetilde{u}_1' > u_1' \text{ if } u''' > 0, \\
\mathbb{E}U_{e\phi} &= U_{e\zeta} = 0, \\
\mathbb{E}U_{s\phi} &= -\gamma v'(a)\frac{da}{ds} > 0, \\
\mathbb{E}U_{s\zeta} &= -\gamma\phi\left(v'(a)\frac{d^2a}{dsd\zeta} + v''(a)\frac{da}{d\zeta}\frac{da}{ds}\right).
\end{aligned}$$

We straightforwardly conclude that $\frac{de}{d\phi} < 0$ and $\frac{ds}{d\phi} > 0$. However, we observe that $\frac{de}{d\zeta} = -sign\{\mathbb{E}U_{s\zeta}\} \lesseqgtr 0$ and $\frac{ds}{d\zeta} = sign\{U_{s\zeta}\} \gtreqless 0$. Let analyze the sign of $\mathbb{E}U_{s\zeta}$. We know that $\frac{da}{ds} < 0$ and by assumption (3) $\frac{da}{d\zeta} > 0$. Moreover,

- If $\frac{1}{1-\zeta} > \ln(var(\tilde{c}_1)) + \ln(\mathbb{E}(\tilde{c}_1)) \geq 0$, we get that $\frac{d^2a}{dsd\zeta} > 0$. It is sufficient that $v''(a) \leq 0$ to get $\mathbb{E}U_{s\zeta} < 0$. Therefore $\frac{de}{d\zeta} > 0$ and $\frac{ds}{d\zeta} < 0$.
- If $\frac{1}{1-\zeta} \leq \ln(var(\tilde{c}_1)) + \ln(\mathbb{E}(\tilde{c}_1))$, we get that $\frac{d^2a}{dsd\zeta} \leq 0$. It is sufficient that $v''(a) \geq 0$ to get $\mathbb{E}U_{s\zeta} \geq 0$. Therefore $\frac{de}{d\zeta} \leq 0$ and $\frac{ds}{d\zeta} \geq 0$.

This concludes the proof of Proposition 2.

# Computations with self-insurance

When the emotional agent may invest in self-insurance, we know that $w_0 = c_0 + \pi e + s$ and $\tilde{c}_1 = (1+r)s - (1-e)\tilde{L}$. In this case we deduce that:

$$var(\tilde{c}_1) = (1-e)^2 var(\tilde{L}), \qquad \mathbb{E}(\tilde{c}_1) = (1+r)s - (1-e)\mathbb{E}(\tilde{L}).$$

The derivative of $a = var(\tilde{c}_1)^{\zeta}\mathbb{E}(\tilde{c}_1)^{-(1-\zeta)}$ with respect to $e$ is similar to those we get in the basic framework. We deduce the derivative with respect to saving, $s$.

$$\frac{da}{ds} = -(1-\zeta)(1+r)var(\tilde{c}_1)^{\zeta}\mathbb{E}(\tilde{c}_1)^{-(1-\zeta)-1} < 0, \tag{33}$$

$$\frac{d^2a}{ds^2} = (1-\zeta)(2-\zeta)(1+r)^2 var(\tilde{c}_1)^{\zeta}\mathbb{E}(\tilde{c}_1)^{-(1-\zeta)-2} > 0, \tag{34}$$

$$\frac{d^2a}{dsde} = a\left(var(\tilde{c}_1), \mathbb{E}(\tilde{c}_1)\right)\frac{(1-\zeta)(1+r)}{\mathbb{E}(\tilde{c}_1)}\left(\frac{2\zeta}{(1-e)} + \frac{(2-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right) > 0. \tag{35}$$

## 7.1 Proof of Proposition 3

Applying the theorem of the implicit function on the system composed by Eq. (13)-(14), we get that:

$$\frac{de}{d\phi} = \frac{\mathbb{E}U_{ss}\mathbb{E}U_{e\phi} - \mathbb{E}U_{es}\mathbb{E}U_{s\phi}}{det}, \quad \frac{de}{d\zeta} = \frac{\mathbb{E}U_{ss}\mathbb{E}U_{e\zeta} - \mathbb{E}U_{es}\mathbb{E}U_{s\zeta}}{det},$$
$$\frac{ds}{d\phi} = \frac{\mathbb{E}U_{ee}\mathbb{E}U_{s\phi} - \mathbb{E}U_{se}\mathbb{E}U_{e\phi}}{det}, \quad \frac{ds}{d\zeta} = \frac{\mathbb{E}U_{ee}\mathbb{E}U_{s\zeta} - \mathbb{E}U_{se}\mathbb{E}U_{e\zeta}}{det}.$$

with $Det = \mathbb{E}U_{ss}\mathbb{E}U_{ee} - \mathbb{E}U_{se}\mathbb{E}U_{es}$, the determinant of the system which we assume to be negative to ensure the existence of an equilibrium.

We compute the derivative of Eqs. (13)-(14):

$$\begin{aligned}
\mathbb{E}U_{ss} &= \gamma\left[u_0'' - \phi\left(v'(a)\frac{d^2a}{ds^2} + v''(a)\left(\frac{da}{ds}\right)^2\right)\right] + (1-\gamma)(1+r)^2\left[p\mathbb{E}\tilde{u}_1'' + (1-p)u_1''\right],\\
\mathbb{E}U_{ee} &= \gamma\pi^2 u_0'' - \gamma\phi\left(v'(a)\frac{d^2a}{de^2} + v''(a)\left(\frac{da}{de}\right)^2\right) + p(1-\gamma)\mathbb{E}(\tilde{L}^2\tilde{u}_1''),\\
\mathbb{E}U_{es} &= \mathbb{E}U_{se} = \gamma\pi u_0'' - \gamma\phi\left(v'(a)\frac{d^2a}{dsde} + v''(a)\frac{da}{ds}\frac{da}{de}\right) + p(1-\gamma)(1+r)\mathbb{E}(\tilde{L}\tilde{u}_1''),\\
\mathbb{E}U_{s\phi} &= -\gamma v'(a)\frac{da}{ds} > 0,\\
\mathbb{E}U_{s\zeta} &= -\gamma\phi\left(v''(a)\frac{da}{d\zeta}\frac{da}{ds} + v'(a)\frac{d^2a}{dsd\zeta}\right),\\
\mathbb{E}U_{e\phi} &= -\gamma v'(a)\frac{da}{de} > 0,\\
\mathbb{E}U_{e\zeta} &= -\gamma\phi\left(v''(a)\frac{da}{d\zeta}\frac{da}{de} + v'(a)\frac{d^2a}{ded\zeta}\right).
\end{aligned}$$

We now compute the numerator of the derivative $\frac{de}{d\phi}$, $\frac{de}{d\zeta}$, $\frac{ds}{d\phi}$ and $\frac{ds}{d\zeta}$.

- **Let us begin with the numerator of $\frac{de}{d\phi}$:**

$$\mathbb{E}U_{ss}\mathbb{E}U_{e\phi} - \mathbb{E}U_{es}\mathbb{E}U_{s\phi} = \gamma v'(a)\left[\frac{da}{ds}\mathbb{E}U_{es} - \frac{da}{de}\mathbb{E}U_{ss}\right].$$

Let us develop the term in the brackets:

$$\gamma u_0''\underbrace{\left(\pi\tfrac{da}{ds} - \tfrac{da}{de}\right)}_{a_1} - \gamma\phi v'(a)\underbrace{\left(\tfrac{d^2a}{dsde}\tfrac{da}{ds} - \tfrac{d^2a}{ds^2}\tfrac{da}{de}\right)}_{a_2} + (1-\gamma)(1+r)\underbrace{\left[p\mathbb{E}(\tilde{L}\tilde{u}_1'')\tfrac{da}{ds} - \tfrac{da}{de}(1+r)\left[p\mathbb{E}\tilde{u}_1'' + (1-p)u_1''\right]\right]}_{a_3}.$$

with

$$\begin{aligned}
a_1 &= \frac{da}{ds}\left(\pi - \frac{\mathbb{E}(\tilde{L})}{1+r}\right) + a\frac{2\zeta}{1-e} > 0 \quad \text{if} \quad \pi(1+r) \le \mathbb{E}(\tilde{L}),\\
a_2 &= a^2\frac{2\zeta(1-\zeta)(1+r)^2}{(1-e)\left(\mathbb{E}(\tilde{c}_1)\right)^2} > 0,\\
a_3 &= \frac{a2\zeta}{1-e}(1+r)\left[p\mathbb{E}\tilde{u}_1'' + (1-p)u_1''\right] + p\frac{da}{ds}\left(\mathbb{E}(\tilde{L}\tilde{u}_1'') - \mathbb{E}\tilde{u}_1''\mathbb{E}(\tilde{L})\right) - \frac{da}{ds}\mathbb{E}(\tilde{L})(1-p)u_1'' < 0 \quad \text{if utility is linear}\\
&\quad \text{quadratic since} \quad \mathbb{E}(\tilde{L}\tilde{u}_1'') - \mathbb{E}\tilde{u}_1''\mathbb{E}(\tilde{L}) = 0.
\end{aligned}$$

All together, the term in bracket is thus negative under $u'' < 0$ and $v' > 0$, and if $\pi(1+r) \le \mathbb{E}(\tilde{L})$ and the utility is linear quadratic. Consequently, we can conclude the numerator is negative. As such $\frac{de}{d\phi} > 0$.

- **We now compute the numerator of the derivative $\frac{ds}{d\phi}$:**

$$\mathbb{E}U_{ee}\mathbb{E}U_{s\phi} - \mathbb{E}U_{se}\mathbb{E}U_{e\phi} = \gamma v'(a)\left[\frac{da}{de}\mathbb{E}U_{se} - \frac{da}{ds}\mathbb{E}U_{ee}\right].$$

Analyze the term in brackets:

$$\gamma\pi u_0''\underbrace{\left(\frac{da}{de}-\pi\frac{da}{ds}\right)}_{b_1}-\gamma\phi v'(a)\underbrace{\left(\frac{d^2a}{dsde}\frac{da}{de}-\frac{d^2a}{de^2}\frac{da}{ds}\right)}_{b_2}+p(1-\gamma)\underbrace{\left[-(1+r)\mathbb{E}(\tilde{L}\tilde{u}_1'')\frac{a2\zeta}{1-e}+\frac{da}{ds}\left(\mathbb{E}(\tilde{L})\mathbb{E}(\tilde{L}\tilde{u}_1'')-\mathbb{E}(\tilde{L}^2\tilde{u}_1'')\right)\right]}_{b_3}.$$

with

$$\begin{aligned}
b_1 &= -a_1<0 \quad \text{if} \quad \pi(1+r)\leq\mathbb{E}(\tilde{L}),\\
b_2 &= a^2\tfrac{(1-\zeta)(1+r)}{\mathbb{E}(\tilde{c}_1)}\left[-\left(\tfrac{2\zeta}{(1-e)}+\tfrac{(2-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)\left(\tfrac{2\zeta}{(1-e)}+\tfrac{(1-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)+\left(\tfrac{2\zeta}{(1-e)}+\tfrac{(1-\zeta)\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)^2-\left(\tfrac{2\zeta}{(1-e)^2}-\tfrac{(1-\zeta)(\mathbb{E}(\tilde{L}))^2}{(\mathbb{E}(\tilde{c}_1))^2}\right)\right],\\
&= -a^2\tfrac{(1-\zeta)(1+r)}{\mathbb{E}(\tilde{c}_1)}\left(\tfrac{2\zeta\mathbb{E}(\tilde{L})}{(1-e)\mathbb{E}(\tilde{c}_1)}+\tfrac{2\zeta}{(1-e)^2}\right)<0,\\
b_3 &= -(1+r)\mathbb{E}(\tilde{L}\tilde{u}_1'')\frac{a2\zeta}{1-e}+\frac{da}{ds}\left(\mathbb{E}(\tilde{L})\mathbb{E}(\tilde{L}\tilde{u}_1'')-\mathbb{E}(\tilde{L}^2\tilde{u}_1'')\right)>0 \quad \text{if utility is linear}\\
&\quad\ \text{quadratic since} \quad \mathbb{E}(\tilde{L})\mathbb{E}(\tilde{L}\tilde{u}_1'')-\mathbb{E}(\tilde{L}^2\tilde{u}_1'')=0.
\end{aligned}$$

All together, the term in bracket is positive with $u''<0$ and if $\pi(1+r)\leq\mathbb{E}(\tilde{L})$ and the utility is linear quadratic. Consequently we can conclude that the numerator is positive. As such $\frac{ds}{d\phi}<0$.

- **Compute now the numerator of the derivative $\frac{de}{d\zeta}$:**

$$\mathbb{E}U_{ss}\mathbb{E}U_{e\zeta}-\mathbb{E}U_{es}\mathbb{E}U_{s\zeta} = \gamma\phi\left[v''(a)\tfrac{da}{d\zeta}\left(\tfrac{da}{ds}\mathbb{E}U_{es}-\tfrac{da}{de}\mathbb{E}U_{ss}\right)+v'(a)\left(\tfrac{da}{dsd\zeta}\mathbb{E}U_{es}-\tfrac{da}{ded\zeta}\mathbb{E}U_{ss}\right)\right].$$

Remark that the term $\frac{da}{ds}\mathbb{E}U_{es}-\frac{da}{de}\mathbb{E}U_{ss}$ is negative from the first bullet point. Let us focus on the second term:

$$\tfrac{da}{dsd\zeta}\mathbb{E}U_{es}-\tfrac{da}{ded\zeta}\mathbb{E}U_{ss}=\tfrac{a(1+r)}{\mathbb{E}(\tilde{c}_1)}\mathbb{E}U_{es}+\tfrac{1}{a}\tfrac{da}{d\zeta}\left(\tfrac{da}{ds}\mathbb{E}U_{es}-\tfrac{da}{de}\mathbb{E}U_{ss}\right)+a\left(\tfrac{2}{1-e}-\tfrac{\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)\mathbb{E}U_{ss}$$

This term is negative since $\mathbb{E}U_{es}<0$, $\mathbb{E}U_{ss}<0$ and $\frac{da}{d\zeta}>0$, and under the following additional assumptions: $(1+r)s\geq\frac{3(1-e)\mathbb{E}(\tilde{L})}{2}$ . Given $v'>0$ the second term is negative.
If $v''\geq 0$, the first term is also negative. The numerator is therefore negative and $\frac{de}{d\zeta}>0$.

- **Finally let us compute the numerator of the derivative $\frac{ds}{d\zeta}$:**

$$\mathbb{E}U_{ee}\mathbb{E}U_{s\zeta}-\mathbb{E}U_{es}\mathbb{E}U_{e\zeta} = \gamma\phi\left[v''(a)\tfrac{da}{d\zeta}\left(\tfrac{da}{de}\mathbb{E}U_{es}-\tfrac{da}{ds}\mathbb{E}U_{ee}\right)+v'(a)\left(\tfrac{da}{ded\zeta}\mathbb{E}U_{es}-\tfrac{da}{dsd\zeta}\mathbb{E}U_{ee}\right)\right].$$

We know that the first term in brackets is positive under similar restrictions explained in the second bullet point. Let us focus on the second term:

$$\tfrac{da}{ded\zeta}\mathbb{E}U_{es}-\tfrac{da}{dsd\zeta}\mathbb{E}U_{ee}=\tfrac{1}{a}\tfrac{da}{d\zeta}\left(\tfrac{da}{de}\mathbb{E}U_{es}-\tfrac{da}{ds}\mathbb{E}U_{ee}\right)-a\left(\tfrac{2}{1-e}-\tfrac{\mathbb{E}(\tilde{L})}{\mathbb{E}(\tilde{c}_1)}\right)\mathbb{E}U_{es}-\tfrac{a(1+r)}{\mathbb{E}(\tilde{c}_1)}\mathbb{E}U_{ee} \tag{36}$$

This term is positive since $\mathbb{E}U_{es}<0$, $\mathbb{E}U_{ss}<0$ and $\frac{da}{d\zeta}>0$ and under the following additional assumptions: $(1+r)s\geq\frac{3(1-e)\mathbb{E}(\tilde{L})}{2}$. Given $v'>0$ then the second term is positive.
If $v''\geq 0$, the first term is also positive. The numerator is therefore positive. Consequently $\frac{ds}{d\zeta}<0$.