Risk aversion and savings behavior

Antoine Bommier   François Le Grand   Lionel Wilner*

September 13, 2023

Abstract

This paper investigates the relationship between lifetime savings and risk aversion. First, we take a theoretical approach in a two-period framework with a very general non-parametric model. We show that risk aversion reduces savings in the presence of mortality risk. We then verify the negative impact of risk aversion on savings in a numerical exercise, with a multi-period setting where mortality risk is calibrated on actual demographic life-tables. Finally, we check that this prediction holds based on an econometric analysis, resorting on the US Health and Retirement Study (HRS) longitudinal survey. The result is robust to different specifications for risk aversion and savings, and to the introduction of a number of controls – including income risk.

Keywords: risk aversion, savings, lifecycle models.
JEL codes: D15, G51, J14.

1   Introduction

There are statements which look so intuitive that they do not need to be debated or tested. One of them is that risk aversion increases savings. Savings indeed help to cope with adverse outcomes, such as unemployment spells or unexpected health expenditures, and it sounds most natural to think that the more risk averse an individual, the more she should save to get prepared for such adverse events. The fact that risk aversion must have a positive effect on savings seems so indisputable that it is sometimes seen as providing an external validity criterion for the evaluation of experimental of risk aversion measurements (see e.g., Galizzi et al., 2016 or Charness et al., 2020): A good measure of risk aversion should be positively correlated with savings, since it is plain common-sense that risk aversion increases savings.

---

*Bommier: ETH Zurich; `abommier@ethz.ch`. LeGrand: Rennes School of Business; `francois.le-grand@rennes-sb.com`. Wilner: CREST; `lionel.wilner@ensae.fr`.

A rigorous scientific approach would nevertheless argue that such "indisputable truth" needs to be challenged. In fact, if we go back to the empirical literature, the most striking aspect is the absence of convincing evidence supporting a positive relation between risk aversion and savings. A major difficulty for the empirical investigation is that risk aversion is only an aspect of individual preferences, and hence difficult to measure as such. It is only in the last 20 or 30 years that standard household surveys started to include questions aiming at having a direct measurement of aversion. Only few studies, including Bartzsch (2008), Schunk (2009), Limosani and Millemaci (2014), Noussair et al. (2014) and Charness et al. (2020) tried to use these variables to investigate how risk aversion impacts saving behavior. Among these papers, the first three report that risk aversion has a negative (and not positive) effect on savings behavior, no significant result being found in the two others. Such a finding, on the negative relation between risk aversion and savings, actually looks so embarrassing that it is either hardly commented or embedded in a set of convoluted explanations aiming at reducing the tension between the readers' likely a priories and the reported empirical results.[1] But, why not considering that risk aversion could truly have a negative impact on savings? The theoretical literature actually provides specific examples where risk aversion is shown to negatively impact saving (see for example Kihlstrom and Mirman, 1974 or Bommier et al., 2012). Could it be that such a negative relation is actually the one that prevails? This is the question that we investigate in the current paper.

Our contribution gathers a theoretical part, a numerical one and an empirical one. In the theoretical part, which assumes a two-period setting, we adopt a very general non-parametric approach and show that risk aversion has a negative impact on saving when individuals face a risk of dying. Intuitively, more risk averse individuals tend to save less, since mortality creates a risk that accumulated savings will not be used. We also derive results on the joint impact of mortality and risk aversion, which is expected to be negative until advanced ages. The numerical part complements our theoretical analysis by considering a more realistic multiperiod setting. We assume that individuals hold risk-sensitive preferences and face an age-dependent mortality risk similar to the one reported in demographic life-tables.[2] Our simulations, in line with our theoretical results, indicate that risk

---

[1]For example, Bartzsch (2008) writes "The coefficient of risk aversion is highly significant and negative. This result might seem to be somewhat counterintuitive and is in contrast to the positive effect usually found by simulations. But, as shown by Carroll (1997), this outcome is possible in a buffer-stock model and arises when the effect of a lower intertemporal elasticity of substitution is stronger than the precautionary saving motive. Notwithstanding, an omitted variable bias might be responsible for the negative coefficient of risk aversion. But it is at least not evident what variable could have been omitted."

[2]Such preferences were shown to be the only ones to disentangle risk aversion from intertemporal substitutability, while assuming preference monotonicity, stationarity and the structure of Kreps and Porteus (1978)'s dynamic choice theory. See Bommier et al. (2017).

aversion has a negative impact on savings. Moreover, we find that this negative impact is larger (in absolute) when mortality is higher, again in line with our theoretical predictions. The last part of the paper provides an econometric analysis investigating whether our theoretical and numerical results have some empirical support. We use U.S. data from the Health and Retirement Study (HRS) longitudinal survey which includes variables about risk aversion, mortality risk and saving behavior. We find that both risk aversion and mortality decrease savings, as predicted. Moreover, we find that the interaction term between mortality and risk aversion is negative and statistically significant, as theory suggests. Introducing income risk as an explanatory variable, our analysis also confirms the existence of a precautionary saving motive. However, while such motive is expected to be exacerbated by risk aversion (see Bommier and Le Grand, 2019) the interaction term between risk aversion and income risk is found to be non-significant. In other words, while risk aversion should be an amplifying factor for both the (negative) impact of mortality and the (positive) impact of income risk on savings, the econometric analysis tends to indicate that it is the first channel that is dominant. Overall, risk aversion is then found to have a negative impact on savings. This is in contrast with the conventional wisdom, which is based on intuitive arguments related to precautionary motives but ignore mortality effects.

The rest of the article is organized as follows. Section 2 presents our theoretical framework and derives our predictions on the effect of mortality risk, risk aversion, as well as their joint effect on savings behavior in a 2-period setting. Section 3 is devoted to numerical simulations in a multi-period setting. Our empirical analysis is exposed in section 4.

2 Formal results in a 2-period framework

We derive our theoretical insights on how mortality and risk aversion may impact savings in a two-period framework.

2.1 Setting and preferences

We assume that agents live for one or two periods, and denote by p the probability to survive in the second period. Agents have to choose among pairs $(c_1, c_2) \in X$ where X is a subset of $\mathbb{R}_+^2$.[3] The quantity c_1 is the first-period consumption, while c_2 interprets either as second period consumption when the agent survives or as the bequest if she dies at the end of the first period.

---

[3] By allowing X to be smaller than $\mathbb{R}_+^2$ we keep the possibility to introduce a minimum consumption level - which may be useful to rule out cases where agents would be so poor that they would prefer to die than to survive.

We assume that agents have preferences over consumption levels and survival preferences, which are triplets of the form (c_1, c_2, p) belonging to $X \times [0, 1]$. We denote by $\succeq$ such a preference relationship and we assume that this preference relationship can be represented by a continuous differentiable utility function ϕ : $(c_1, c_2, p) \in X \times [0, 1] \rightarrow \phi(c_1, c_2, p) \in \mathbb{R}$.

The objective of this section is to derive the impact of risk aversion and survival probability on savings choices while relying on a very minimal set of assumptions. To express such assumptions, it is convenient to define the functions U_1 and U_2 that map X into $\mathbb{R}$ as follows:

$$
\begin{cases}
U_1(c_1, c_2) = \phi(c_1, c_2, 0), \\
U_2(c_1, c_2) = \phi(c_1, c_2, 1).
\end{cases}
$$

These functions provide the utilities obtained from the pair (c_1, c_2) if living only one period for sure (case $p = 0$, which defines U_1) or if living two periods for sure (case $p = 1$, which defines U_2). We will call them lifetime utilities.

To simplify the analysis, we will assume along the paper that for all $(c_1, c_2) \in X$:

$$
U_1(c_1, c_2) < U_2(c_1, c_2),
$$

meaning that agents have a strict preference for living two periods rather than only one.

A first assumption is that of preference monotonicity. Formally:

Assumption 1. *For all* $(c_1, c_2), (c_1', c_2') \in X$:

$$
\begin{cases}
U_1(c_1', c_2') \geq U_1(c_1, c_2) \\
and \\
U_2(c_1', c_2') \geq U_2(c_1, c_2)
\end{cases}
\Rightarrow \phi(c_1', c_2', p) \geq \phi(c_1, c_2, p) \ for\ all\ p \in (0, 1),
$$

with moreover $\phi(c_1', c_2', p) > \phi(c_1, c_2, p)$ *when* $U_1(c_1', c_2') > U_1(c_1, c_2)$ *or* $U_2(c_1', c_2') > U_2(c_1, c_2)$.

Monotonicity says that a pair (c_1, c_2) should not be chosen when another pair (c_1', c_2') is available providing better utilities independently of whether the agent survives or dies. In other words, Monotonicity involves ruling out the choice of dominated strategies. As such this property as long be seen as an "extremely reasonable" assumption (see Arrow, 1951, p. 426).

A noteworthy implication of Monotonicity is that the utility function $\phi(c_1, c_2, p)$ can be obtained through the "aggregation" of the lifetime utilities, associated to living one or two periods for sure. Indeed, as shown in Lemma 2 of Appendix

C.1, if preferences are monotone in the sense of Definition 1, then there exists a (unique) increasing real-valued function ψ defined on the domain $D \times [0,1]$, with:

$$D = \{(U_1, U_2) \in \mathbb{R}^2_+ : U_1 = U_1(c_1, c_2) \text{ and } U_2 = U_2(c_1, c_2) \text{ for some } (c_1, c_2) \in X\},$$

such that for all $(c_1, c_2, p) \in X \times [0,1]$:

$$\phi(c_1, c_2, p) = \psi(U_1(c_1, c_2), U_2(c_1, c_2), p). \tag{1}$$

The ex-ante utility $\phi(c_1, c_2, p)$ can therefore be computed from the combination of three elements: (i) the lifetime utility when living one period (U_1), (ii) the lifetime utility when living two periods (U_2), and (iii) the survival probability p. The formulation of equation (1) makes it explicit that choices under uncertainty (i.e., when $p \in (0,1)$) involve making trade-offs between the two possible lifetime utilities (i.e., death at the end of the first period, or survival for two periods).

For the sake of analytical simplicity, we will assume in the rest of the section that the function ψ is continuously differentiable and has strictly positive derivatives.[4] We also introduce an assumption of consequentialism (see Definition 2 in Appendix) which, for differentiable utility representations, imply that:

$$\text{for all } p' \geq p, \quad \frac{\frac{\partial \psi}{\partial U_1}(U_1, U_2, p')}{\frac{\partial \psi}{\partial U_2}(U_1, U_2, p')} \leq \frac{\frac{\partial \psi}{\partial U_1}(U_1, U_2, p)}{\frac{\partial \psi}{\partial U_2}(U_1, U_2, p)}, \tag{2}$$

which is formally stated in Lemma 6 in Appendix. This property states that the more likely is the two-period survival (thus the larger p), the larger the weight given to the lifetime utility U_2 (obtained when living two periods) compared the the weight given to U_1 (obtained when living only one period). Such an assumption is obviously fulfilled in the case of expected utility (where $\psi(U_1, U_2, p) = (1-p)U_1 + pU_2$)), but also for all kinds of bi-separable preferences (Ghirardato and Marinacci, 2001), which are a very general class of models nesting almost all non-expected utility models of the literature.

The formulation (1), where ex-ante utility appears to be an aggregation of lifetime utilities obtained when living only one period and when living two periods, offers a very simple interpretation of risk aversion. Intuitively, risk aversion should magnify the marginal rate of substitution $\frac{\frac{\partial \psi}{\partial U_1}}{\frac{\partial \psi}{\partial U_2}}$ which quantifies the relative importance given to the bad state of of nature (i.e., living for one period only) compared to that given to the good state of nature (i.e., living for two periods).

Formally, consider two agents A and B endowed with monotone preferences

---

[4]This assumption can actually be weakened – see Assumption 4 in Appendix C.2. All results are proved in the context of this weaker assumption.

that would make the same choices when there is no uncertainty.[5] It is proved in Lemma 4 of Appendix C.2 that their preferences can be represented by:

$$\phi^A(c_1, c_2, p) = \psi^A(U_1(c_1, c_2), U_2(c_1, c_2), p), \tag{3}$$

$$\phi^B(c_1, c_2, p) = \psi^B(U_1(c_1, c_2), U_2(c_1, c_2), p), \tag{4}$$

for the same functions U_1 and U_2. Comparison about their risk aversion can be made as follows:

Definition 1. Consider two agents A and B with preferences represented as in (3) and (4). We will say that agent A is more risk averse than agent B if and only if for all $(U_1, U_2), (U_1', U_2') \in D$ such that $U_1' \leq U_1 \leq U_2 \leq U_2'$ and $p \in [0, 1]$ we have:

$$\left(\psi_A(U_1', U_2', p) \geq \psi_A(U_1, U_2, p)\right) \Rightarrow \left(\psi_B(U_1', U_2', p) \geq \psi_B(U_1, U_2, p)\right). \tag{5}$$

In the statement of the above definition, we assume $U_1' \leq U_1 \leq U_2 \leq U_2'$ implying that the pair of utilities (U_1', U_2') brackets the pair of utilities (U_1, U_2). Thus (U_1', U_2') looks riskier than (U_1, U_2), providing a lower utility in the (bad) state where the agent lives only one period ($U_1' \leq U_1$) and a higher utility in the (good) state where the agent lives two periods ($U_2' \geq U_2$). Definition 1 states that an agent is more risk averse than another one if any risk increase preferred by the more risk averse agent is also preferred by the less risk averse agent. This definition of comparative risk aversion is similar to the one of Yaari (1969) with one difference. Our notion of risk increase is a notion of utility spread, as in Bommier et al. (2012), while Yaari considered that a lottery was riskier than another one if the latter was riskless.

Using the assumption of a continuously differentiable representation, we obtain the following result:

Lemma 1. *Consider two agents A and B with preferences represented as in (3) and (4). Agent A is more risk averse than agent B, if and only if for all $(U_1, U_2) \in D$ and all $p \in (0, 1)$:*

$$\frac{\frac{\partial \psi^A}{\partial U_1}(U_1, U_2, p)}{\frac{\partial \psi^A}{\partial U_2}(U_1, U_2, p)} \geq \frac{\frac{\partial \psi^B}{\partial U_1}(U_1, U_2, p)}{\frac{\partial \psi^B}{\partial U_2}(U_1, U_2, p)}. \tag{6}$$

Lemma 1 states using marginal rates of substitution that the more risk averse agent is more willing than the less risk averse one to transfer resources from the good state of the world (i.e., two-period life) to bad state (i.e., one-period life).

---

[5]As explained in the seminal papers of Kihlstrom and Mirman (1974) and Epstein and Zin (1989), comparing agents in terms of risk aversion requires them to rank deterministic outcomes (i.e., in the absence of risk) in the same way. See Definition 3 of Appendix C.2 for a formal definition.

The inequalities (2) and (6) are quite general, since they do not rely on a specific decision model (like expected utility). However, as discussed in the next section, they are sufficient to derive clear-cut results on how mortality risk and risk aversion impact savings behaviors.

2.2 Savings behavior

We now analyze agents' savings behavior. We consider two agents A and B endowed with the same initial wealth W and assume that they can save (without borrowing restriction) through a riskless asset paying off the gross interest rate $R > 0$. The consumer problem consists in finding the first- and second-period consumption pair (c_1, c_2) that maximizes her utility subject to a given mortality risk and a budget constraint.

Formally, we consider a survival probability $p \in [0, 1]$. Consumer i's problem can be written as follows:

$$\max_{(c_1, c_2) \in \mathbb{R}_+^2} \phi^i(c_1, c_2, p) \text{ s.t. } c_1 + \frac{c_2}{R} \leq W. \tag{7}$$

We assume that the consumer problem (7) admits a unique solution.[6]

This consumption-saving problem can be reformulated using the notation of the previous section. We denote by $U_1(c_1, c_2) = \phi^A(c_1, c_2, 0) = \phi^B(c_1, c_2, 0)$ the common lifetime utility function when agents live for one period and $U_2(c_1, c_2) = \phi^A(c_1, c_2, 1) = \phi^B(c_1, c_2, 1)$ the lifetime utility function when agents live for two periods. The consumer problem (7) can be written as follows:

$$\max_{s \in [0, W]} \psi^i(U_1(W - s, Rs), U_2(W - s, Rs), p). \tag{8}$$

The solution of the consumer problem (8) depends on model parameters, such as for instance the interest rate R, the wealth W and the survival probability p. In the remainder, we are mostly interested in the relationship with the mortality risk. For the sake on conciseness, we will thus denote the optimal saving solving the consumer problem (8) by $s_*^i(p)$, or even s_*^i to avoid overloading the notation by dependencies that we do not focus on.

To study the impact of mortality risk and risk aversion, we make the following assumption.

Assumption 2. *We assume that lifetime utility functions U_1 and U_2 verify the following two points.*

1. The functions $s \mapsto U_1(W - s, Rs)$ and $s \mapsto U_2(W - s, Rs)$ are strictly concave.

---

[6]This can be guaranteed by assuming that $(c_1, c_2) \mapsto \phi_i(c_1, c_2, p)$ is strictly quasi-concave.

2. $\underline{s} = \arg\max_{s \in [0,W]} U_1(W-s, Rs) \leq \overline{s} = \arg\max_{s \in [0,W]} U_2(W-s, Rs)$.

The first point of Assumption 2 guarantees that the consumption-saving problem in the absence of mortality risk admits a unique solution. The second point means that agents saves more when living for two periods, than when living for only one period.

2.2.1 Impact of mortality risk

Since agents would save more if living for two periods than if living for one period ($\underline{s} \leq \overline{s}$), we expect that savings level increases with the survival probability. This is formalized in the following result.

Proposition 1. *Under Assumption 2, we can show that for all $p \in (0,1)$:*

$$\frac{\partial s_*^i}{\partial p}(p) \geq 0.$$

The proof can be found in Appendix C.3.3. A higher mortality risk thus contributes to reduce savings, a result that is well-known in the case of additively separable preferences, and which is shown here to extend to a much wider class of models.

2.2.2 Impact of risk aversion

Regarding the impact of risk aversion on savings behavior, we state the following result.

Proposition 2. *Under Assumption 2, and further assuming $p \in (0,1)$, we have the following results:*

1. $\underline{s} \leq s_*^A, s_*^B \leq \overline{s}$;

2. *if A is more risk averse than B, then: $s_*^A \leq s_*^B$.*

The proof can be found in Appendix C.3.1. Proposition 2 first states that optimal savings level under uncertainty lies in between the state-specific optimal saving levels. As a consequence of preference monotonicity, agents do not save more than what they would do if expecting to live two periods for sure, and not less that what they would save if being sure of dying at the end of the first period. The second point states that more risk averse agents save less. Indeed, in the presence of mortality risk, saving is risky since there is a possibility to die in the bad state of the world (i.e., short lives) when the utility of savings is reduced (optimal saving when living one period is lower than when living two periods). More risk averse agents engage to a fewer extent into risk-taking activities and hence, save less.

8

2.2.3 Cross effect mortality × risk aversion

We finally focus on the cross effects of mortality risk and risk aversion on savings. In other words, we investigate the impact on savings of a given increase in mortality risk for agents differing along their risk aversion. We know that for both agents, savings increase with survival probabilities (the functions $p \mapsto s_*^i(p)$ are increasing). However, we also know that agents choose the same amount of savings in the absence of risk (that is when $p = 0$ or $p = 1$). Indeed, agents have the same preferences in the absence of risk, and thus form the same choices. Thus, we cannot derive any general result about the cross effect of mortality risk and risk aversion. In fact, whenever p is different from 0 and 1, we have $s_*^A(p) \neq s_*^B(p)$ implying that consumption levels also differ. In the absence of further assumptions on the utility functions, it turns impossible to derive statements on how $\frac{\partial s_*^A}{\partial p}$ and $\frac{\partial s_*^B}{\partial p}$ compare, since "income effects" and "substitution effects" are simultaneously at play. We can however derive results in the neighborhoods of $p = 0$ and $p = 1$, by taking advantage of the fact that $s_*^A(0) = s_*^B(0)$ and $s_*^A(1) = s_*^B(1)$.

Proposition 3. *If the functions $p \to s_*^i(p)$ are (left)-differentiable in $p = 1$, then:*

$$\left. \frac{\partial s_*^A}{\partial p}(p) \right|_{p=1} \geq \left. \frac{\partial s_*^B}{\partial p}(p) \right|_{p=1} \geq 0. \tag{9}$$

If the functions $p \to s_*^i(p)$ are (right)-differentiable in $p = 0$, then:

$$0 \leq \left. \frac{\partial s_*^A}{\partial p}(p) \right|_{p=0} \leq \left. \frac{\partial s_*^B}{\partial p}(p) \right|_{p=0}. \tag{10}$$

The proof can be found in Appendix C.3.4. Proposition 3 shows that the cross effect of survival probability and risk aversion is expected to be positive around $p = 1$ and negative around $p = 0$. If, as in our empirical analysis, one prefers to look at the effect of mortality (rather than survival probability) the effects are simply reversed, with a negative cross effect around $p = 1$ (i.e, for low mortality levels) and a positive cross effect around $p = 0$ (i.e., when death is almost certain). In practice, until very advanced ages, death is a very unlikely outcome (in the Human Mortality Database for 2020, the survival probability in the US general population does not fall below 80% before age 93), and one would rather expect to observe a negative cross effect of mortality and risk aversion on savings. The numerical simulations provided in the following section seem indeed to confirm that when one uses mortality rates taken from actual life tables, savings decrease with mortality risk and risk aversion, and that these two effects tend to magnify each other (the cross effect being negative).

3   Numerical simulations

In this section, we verify that the results derived in the two-period model of the theory section can be extended to a multi-period model, in which the decision-maker faces a mortality risk that is realistically calibrated. More precisely, we check that: (i) an increase in risk aversion diminishes savings; (ii) a higher mortality risk decreases savings; and (iii) the decrease in savings due to a larger mortality risk is higher for more risk-averse decision makers.

Set-up.   We consider a decision-maker that lives for a finite but unknown number of periods in an economy with a unique good. She is endowed with risk-sensitive preferences, that are the only monotone preferences in the Kreps and Porteus (1978) setting that allow one to disentangle risk aversion and elasticity of substitution. Absent of other risk than the mortality risk and of bequest motive, the utility function U_t representing her preferences can be defined through the following recursion:

$$U_t = u(c_t) - \frac{\beta}{k} \ln \left(p_t e^{-kU_{t+1}} + 1 - p_t \right), \qquad (11)$$

where c_t is date-t consumption, u the instantaneous utility, $\beta \in (0, 1)$ the discount factor, $k > 0$ the risk aversion parameter and p_t the probability that she will be alive at date $t + 1$. Recursion (11) assumes that the agent's utility when dead (with probability $1 - p_t$ at $t + 1$) is set to zero. Since risk-sensitive preferences are translation-invariant, this choice is a harmless normalization – as long as no other constraint is imposed on u. We further assume that u features constant IES, denoted $\sigma^{-1} > 0$:

$$u(c) = \begin{cases} u_0 + \frac{c^{1-\sigma}-1}{1-\sigma}, & \text{if } \sigma \neq 1, \\ u_0 + \ln(c), & \text{otherwise,} \end{cases}$$

where u_0 is the utility gap between being alive and consuming one unit of goods and being dead. We further assume that the agent can trade a one-period riskless asset paying the gross interest rate still denoted by $R > 0$. Denoting agents' saving choices by a_t and her income by y_t, the agent's budget constraint is:

$$c_t + a_t \leq y_t + Ra_{t-1}. \qquad (12)$$

The agent's consumption-saving program thus consists in finding the allocation $(c_t, a_t)_{t \geq 0}$ that maximizes her utility (11) subject to budget constraints (12) and borrowing constraints $a_t \geq 0$ for all t.

Calibration. We use the mortality data of the US general population in 2018 as reported in the Human Mortality Database. Beyond date T (corresponding to age 110), the agent's survival probability is null: $p_t = 0$ for $t \geq T$. The risk free rate is set to $R = 1.02$, following Campbell and Viceira (2002). For the income process, we assume that before retirement at date T_R (set to age 65), the income is fixed and equal to \$50000, which is the average net compensation in 2018 as reported by the US Social Security.[7] After retirement, the income is assumed to be 40% of the working-age wage. The replacement rate of 40% is approximately the average value offered by the Social Security in the US (Biggs and Springstead, 2008). Regarding preference parameters, we set $\sigma = 2$, $k = 1$, $\beta = 0.9983$, and $u_0 = 6.2407$. The value for σ is standard and the value of k is adapted from Bommier et al. (2020). The values of u_0 and β are calibrated so as to match a value of mortality risk reduction of 10 million USD (see Viscusi, 2018) and a wealth at age 65 of \$540000, which corresponds the mean net worth of singles above 55 years with no child in 2019, as reported in the Survey of Consumer Finances.[8]

Results. In Figure 1, we report the savings paths for the benchmark calibration. This corresponds to the blue plain line in the two panels.
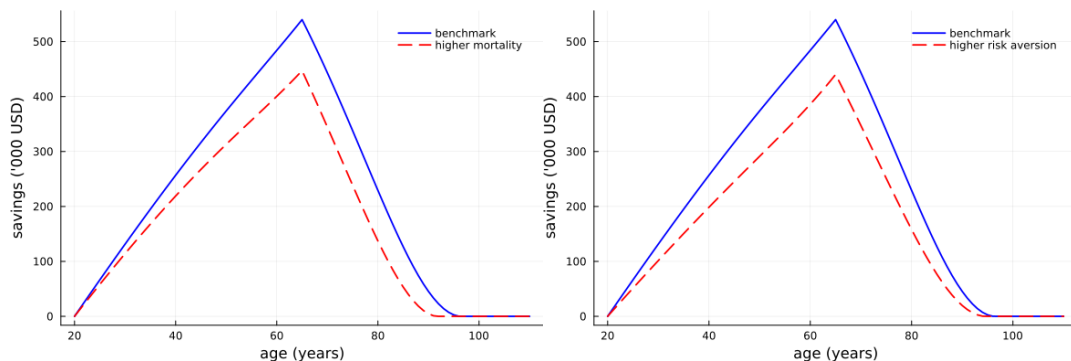
(a) Impact of a 50% increase in the mortality risk at all ages.
(b) Impact of an increase in the risk aversion parameter.

Figure 1: Lifetime savings paths

We also report in Panel 1a the savings path following an increase of 50% in the mortality risk at all ages (dashed red line). More precisely, we use the same calibration as in the benchmark, but instead of the survival probability $(p_t)_t$, we consider the updated survival rates $(\tilde{p}_{t,g})_t$ as:

$$1 - \tilde{p}_{t,g} = \begin{cases} \min((1+g)(1-p_t), 1), & \text{for } t < T, \\ 1 & \text{for } t \geq T, \end{cases}$$

---

[7]See https://www.ssa.gov/oact/cola/central.html.
[8]See https://www.federalreserve.gov/econres/scf/dataviz/scf/table/.

where g is set to 50%. The 50% increase is chosen so as to approximately replicate the gap in the life-expectancy at birth between males and females in the US in 2018 – which amounts to 5.01 years. For our general population data, the life-expectancy at birth decreases from 78.88 years to 73.85 years after the 50% increase in mortality. Panel 1a makes it clear that a higher mortality risk yields lower savings. This is consistent with the statement of Proposition 1.

We also report in Panel 1b the savings path following an increase in the risk aversion parameter, while the rest of the calibration, including mortality, is identical to the benchmark. The risk aversion parameter k is set to 3.689 instead of 1. This value is chosen such that the drop in savings at 65 due to the 50% higher mortality risk and the one due to the higher risk aversion are of similar magnitudes. It can be seen in Panel 1b that a higher risk aversion implies lower savings. This is consistent with the result of Proposition 2. By construction, the magnitude of the effects on the two panels of Figure 1 are of similar magnitude at age 65 and differ at other ages (which will be helpful for identification purposes in our empirical analysis).

Finally, we analyze the joint effect of a higher mortality risk and a higher risk aversion, where we control for the wealth level. To do so, we compare two cases. The first one corresponds to the benchmark calibration, which implies a savings path given by the blue plain line of Figure 1. In the second case, we compute at each age the end-of-period savings of an agent endowed with the same beginning-of-period wealth as in the benchmark case, but with both a higher mortality and a higher risk aversion. This combines together the two effects of Figure 1: the mortality risk is 50% higher and the risk aversion parameter is set to 3.689 instead of 1. We report the difference between the savings of the two cases in Figure 2 (blue plain line). Consistently with each individual effect, the higher mortality and the higher risk aversion imply smaller savings, and hence a negative variation in savings. To isolate the cross effect of mortality and risk aversion, we decompose the decrease in savings into three elements. First, we report the decrease in savings solely due to the higher mortality (dashed red line). Second, we add the decrease in savings to the sole increase in risk aversion. The cumulative decrease due to the two effects is plotted as the green dotted dashed line of Figure 2.[9] The cross effect of mortality and risk aversion is then measured as the gap between the total effect (blue line) and the sum of the two individual effects (green line). The effect is negative up to old ages (around age 80 approximately), where survival probabilities remain high and above 95%. At very old ages, when survival probabilities become small, the effect diminishes and vanishes. This is consistent with Proposition 3,

---

[9]These two individual effects an additional confirmation of the result of Propositions 1 and 2, where we furthermore control for the wealth effect.

even though we do not actually observe sizably negative cross effects. This is due to the fact that, at oldest ages, agents are credit-constrained in our simulation and survival probabilities remain fairly large. They only fall below 90% at age 88 and below 70% at age 99. Furthermore, it can also be observed from Figure 2 that the cross-effect is much smaller than each effect (related either to mortality risk or to risk aversion). It can be measured to be on average more than ten times smaller than each of the two effects.
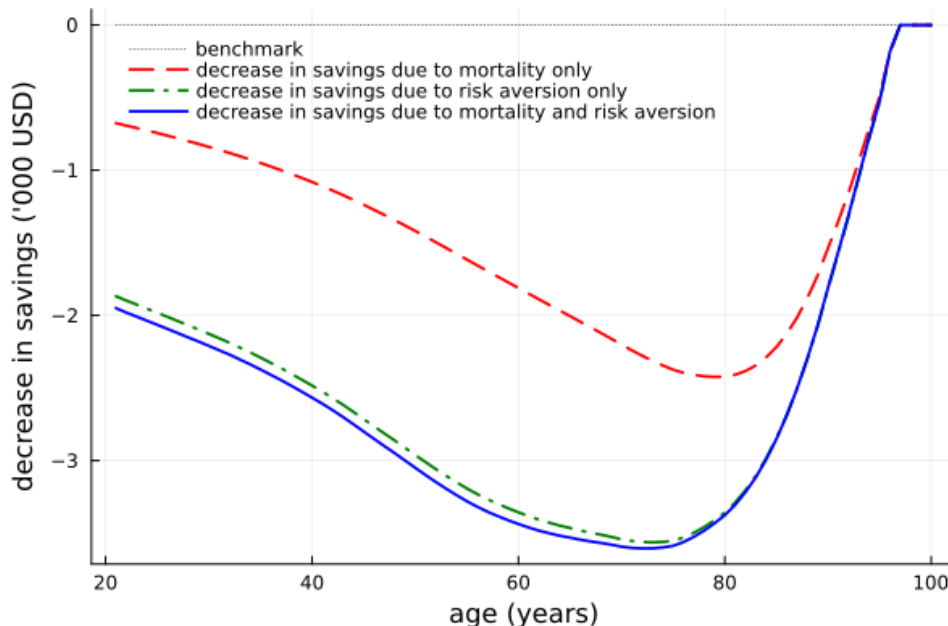

Figure 2: Saving variation implied by mortality increase.

4   Empirical analysis

We now bring the theory to the data, by testing previous predictions. We first verify that a higher mortality risk depresses savings as stated by Proposition 1. Then we determine whether risk aversion truly has a negative impact on wealth *ceteris paribus*, hereby confirming Proposition 2. Third, we look at cross effects between risk aversion and income risk, on the one hand, and between risk aversion and mortality risk, on the other hand: in the first case, we find no impact while we obtain a negative sign in the latter case, which supports Proposition 3. Overall, we find compelling evidence that theoretical mechanisms above have empirical relevance for modelling agents' behavior in the presence of both income and mortality risks.

4.1 Data

We resort to US data, namely the Health and Retirement Survey (HRS), a biennial panel of individuals aged at least 50 surveyed from 1992 to 2018. Our empirical analysis is mostly based on the panel version available to researchers, the RAND HRS longitudinal file (version 2 released in July 2022). The next paragraphs are devoted to measurement issues for both outcome (wealth) and other variables of interest (income and mortality risks, on the one hand, and risk aversion, on the other hand).

4.1.1 Wealth

We measure wealth at the household level, and truncate its distribution from below by selecting out observations that are smaller than the 30th percentile; we do so to abstract from possibly binding liquidity constraints.

In more details, we consider a notion of *net* wealth, which we define as the difference between gross wealth and debt (the sum of all mortgages/land contracts related to both primary and secondary residences, other home loans, as well as other debt). In the remainder, wealth should be understood as net wealth unless specified otherwise. Gross wealth is the aggregation of 18 distinct items available in the survey.[10] This aggregation is consistent with the literature (see, e.g., Lusardi et al. (2017), Poterba et al. (2018), Angrisani et al. (2019), Been et al. (2020)). All asset balances are converted to 2018 dollars using the CPI-U provided by the BLS. To alleviate concerns with measurement error, Hurd et al. (2016) explain that each biennial table, called "section U" in the RAND HRS longitudinal file, has been corrected for inconsistencies in surveyed individuals' answers related to assets.

One of the difficulties in the definition of wealth is the question of what share of wealth should be attributed to the different members of the household. To alleviate this concern, we focus on the definition of wealth at the household level and not at the individual level. This means that each member of the household has access to the wealth detained by that household. This is a standard approach in the literature: see, e.g., Poterba et al. (2018).[11] Consistently with this definition

---

[10]Namely: real estate (at the exclusion of residences), businesses and farms, IRA and Keogh accounts, stocks (including mutual funds and investment trusts), bonds (and bond funds), checkings and savings (or money market accounts), CDs (including government savings bonds and T-bills), vehicles, trusts, other assets, primary residence, mortgage 1 (primary residence), mortgage 2 (primary residence), equity line of credit, mobile home, secondary residence, mortgage/loan second home, and other debt.

[11]p80: "Our unit of observation is the individual [e.g. for risk aversion], but for those who are married, we associate household wealth with each member of the couple. It can be difficult to assign ownership of assets, such as housing or jointly held financial assets, to specific household members."

of wealth, our empirical analysis will include covariates of both members of the household when available. This is consistent with a recent strand of empirical literature devoted to the intra-household decisions: see, e.g., Ke (2021) and Frémeaux and Leturcq (2022). In particular, we will closely follow the methodology of Ke (2021) whose empirical analysis is partly based on the HRS panel.
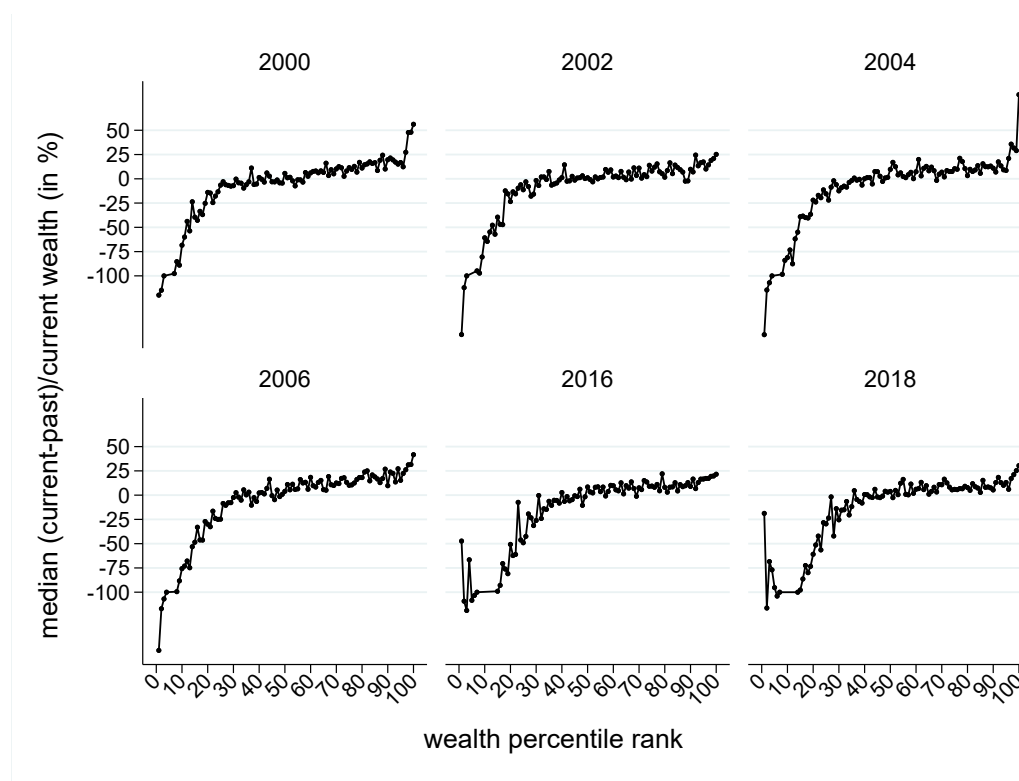

Figure 3: Median saving rate.

One possible difficulty in our analysis in the presence of households liquidating their assets to address unexpected personal shocks (such as unemployment, health problem, etc.). The presence of liquidity constraints may prevent these households from borrowing to smooth out the impact of these shocks. All households will hence behave in the same way and there is no role for risk aversion. Liquidity constraints can thus be viewed as a confounding factor. To understand the possibility of sudden wealth liquidation, we compute for each household the net saving rate, defined as the ratio of the change in net wealth between past and current waves over past net wealth. We then compute the median saving rate for each percentile of the wealth distribution. We then plot in Figure 3 the within-percentile median saving rate against the percentile value indicating the location in the distribution of current wealth. The pattern of saving rates is increasing along the distribution; it is rather concave at the bottom, then linear, and finally convex at the very top. This empirical evidence concurs with the one found by Fagereng et al. (2019) or Bach et al. (2020). Putting what happens at the right end of the distribution

aside, the regularity of the curve seems to change from, say, the 30th percentile of the wealth distribution. Lower percentiles exhibit negative saving rates, which likely reflects decumulation behavior. Since we want our empirical analysis to be immune to liquidity constraints, we remove household-year observations that lie below the 30th percentile of each annual wealth distribution. We check that the age distributions remain quite identical either above or below that threshold, which ensures that this selection does not disregard very old individuals who would decumulate savings, for instance. Reassuringly, observations that are selected out of our sample only tend to be slightly younger. We provide a sensitivity analysis with respect to that threshold in Section 4.4.

4.1.2 Income risk

As a proxy for income risk, we rely on the standard deviation of the difference between current and permanent income, both of them being measured at the household level. For scaling issues, we further consider the logarithm of that standard deviation. Permanent income is calculated as in Fuchs-Schündeln and Schündeln (2005). This involves two steps. First, a detrended income is obtained every year as the ratio of the household income over the average income for all households in corresponding survey year. Second, the permanent income is then equal to the average detrended household, computed for every household over all survey years, multiplied by the average income of all households within each survey year.

4.1.3 Mortality risk

We measure subjective mortality risk based on survival probabilities at distinct target ages, which are self-assessed by survey respondents. Doing so requires to restrict our attention to the post-2000 era since the information about survival probability is missing before that period. We rely on two proxies of subjective mortality risk: (i) a survival probability at a target age that is comprised between 11 and 15 years after current age, adjusted for the location within each 5-year age interval, and (ii) the "surmortality risk" computed as the difference between subjective and objective mortality risks, the latter being issued from life-tables.

The HRS has provided since 2000 with subjective survival probabilities at 85 (in 1992) or at 80, 85, 90, 95, or 100 (after 1994), depending on both the year of survey and the age of respondents. From 2000 to 2004, individuals aged less than 70 were asked about their survival probability at 80; those aged 70 to 74 (resp. 75 to 79, etc.) answered about their survival probability at 85 (resp. 90, etc.). From 2006 onwards, individuals aged less than 65 have been asked about their survival

probability at 85. For each individual we define subjective mortality risk as one minus that subjective survival probability, and multiply this number by 100. We borrow here from a substantial empirical literature devoted to mortality risk and corresponding measurement issues.[12]

In a first approach, we consider 6 subjective mortality risks that are specific to each 5-year age interval and to the corresponding target, an age that has varied over time due to survey design. Individual i surveyed on year t aged $a_{it} = a$ answers a question related to her survival probability at target age $T_t(a) = T$, which we denote by p_surv_{it}^T. To correct for the fact that this probability increases within each 5-year interval, we adjust it as follows. We expurge this probability from the 1-year age effects issued from the simple equation:

$$\text{p\_surv}_{it}^T = \sum_{k=0}^{4} \delta_k \mathbb{1}\{\text{age}_{it} \equiv k[5]\} + u_{it}.$$

Adjusted survival probabilities correspond to the residuals $\hat{u}_{it}$, namely $\text{p\_surv}_{it}^T - \hat{\delta}_{a-5\lfloor a/5 \rfloor}$. The mortality risks mort_{it}^T are then equal to one minus those adjusted survival probabilities, and we multiply the number obtained by 100 accordingly. We include the latter as covariates in wealth equations, see section 4.2. By construction, those proxies are undefined outside an individual's 5-year age interval, hence the necessity to further control for 5-year age dummies in those equations.[13]

In a second approach, we seek to aggregate previous mortality risks into a single measure. In order to assess how pessimistic an individual is about her survival probability, we define her surmortality risk as the difference between subjective and objective mortality risk. For each age, gender and year, the objective mortality risk is obtained from the Human Mortality Database (HMD). We include this surmortality risk on top of the life-table, objective mortality risk as covariates, in place of the 6 mortality risks above. On average, respondents are slightly pessimistic about their remaining life expectancy: this surmortality risk has a positive mean and its median is +3pp. It mostly varies between −35pp (P10) and +46pp (P90).

---

[12]This literature includes at least Hurd and McGarry (1995), Hurd et al. (1998), Hurd and McGarry (2002), Hurd et al. (2004), Gan et al. (2005), Bloom et al. (2006), Hurd (2009), Delavande and Rohwedder (2011a), Manski and Molinari (2010), Salm (2010), Delavande and Rohwedder (2011b), Angrisani et al. (2012), Gan et al. (2015), Delprat et al. (2016), Bissonnette et al. (2017), Boyer et al. (2019).

[13]This requirement holds regardless of the fact that our dependent variable is conditional on age, see below.

4.1.4   Risk aversion

Individual preferences as regards aversion to risk are revealed by survey respondents themselves, and available as a 6-valued ordinal variable. In a conservative approach, we mostly focus on the 2000-2006 period, which ensures the stability of measurement over time. Due to survey design, we restrict our attention to individuals aged from 50 to 84.

To measure risk aversion, we indeed rely on questions related to risk behavior in financial matters when available in the HRS. From 1998 to 2006, some surveyed individuals are praised to answer a question related to income gambling, and have to indicate which lottery they would favor.[14]

Following Barsky et al. (1997), Kimball et al. (2008), Sahm (2012), Harrati (2014), we consider 6 ordinal values for risk aversion. In 1992, only 4 values are available in the survey. From 2014 to 2018, respondents indicate how much they are willing to take financial risks on a 0-10 scale.[15] The survey also includes several other questions related to risk aversion; for the sake of comparison with previous waves, we focus on aversion to risk in financial matters. Importantly, empirical studies (Dohmen et al., 2011, Vieider et al., 2015, Falk et al., 2022) have documented that the measurement of risk aversion did not depend much on that choice, those options being much correlated (see also section 4.4 for more details on that topic).

Exploiting information on risk aversion in the HRS raises nevertheless a bunch of empirical issues.

First, the question was absent from the survey in 1996 as well as from 2008 to 2012; it had been asked to some respondents in 1994 but with a different wording.[16] As a result, our empirical analysis is mostly based on the 2000-2006 subperiod for the sake of conceptual homogeneity. On top of that, we provide robustness checks with respect to that empirical choice.[17]

---

[14]The exact question is: *Suppose that you are the only income earner in the family. Your doctor recommends that you move because of allergies, and you have to choose between two possible jobs. The first would guarantee your current total family income for life. The second is possibly better paying, but the income is also less certain. There is a 50-50 chance the second job would double your total lifetime income and a 50-50 chance that it would cut it by [X]. Which job would you take -- the first job or the second job?* N.B. $X \in \{3/4, 1/2, 1/3, 1/5, 1/10\}$.

[15]The exact wording is: *People behave differently in different situations. We'd like to know how willing you are to take risks in the following areas. Using a 0 to 10 scale where 0 means "unwilling to take any risks" and 10 means "fully prepared to take risks" please mark one box (X) in each row. How willing are you to take risks (i) While driving (ii) In financial matters (iii) During leisure and sport (iv) In your occupation (v) With your health.*

[16]Though available in the corresponding HRS cross-sectional file, this information is missing from the RAND HRS longitudinal file.

[17]It is for instance possible to group answers from 2014 to 2018 surveys into 4 ordinal values and to compare the distributions obtained with the ones that prevailed from 1992 to 2006. One may group answers 0 to 4 into value 4, answer 5 into value 3, answers 6 and 7 into value 2 and

Second, due to survey design, the composition of the subsample of respondents to that question has changed over time. From 1998 onwards, this question has been asked to individuals based on a combination of cohort, age, and random selection. For instance, the question might be skipped for individuals older than 65, or for some cohorts, depending on the wave considered (see Figure 5 in Appendix). Since our dependent variable is conditional on age, our estimates should yet be immune to that problem. We finally restrict our attention to individuals aged from 50 to 84, almost like Ke (2021), except that we remove people aged 85.[18]

Third, a few hundreds individuals only have reported their (possibly time-varying) risk aversion over all waves from 1998 to 2006. Whether time-varying risk aversion is an empirical issue or not is unclear: see, e.g., Table 5.6 in Harrati (2014). We choose here not to restrict our attention to those peculiar individuals, which would further require to drastically lower sample size.

Figure 6 in Appendix depicts cross-sectional distributions of risk aversion depending on the number of values considered (4, 6, or 11). About 60% (resp. 40%, 20%) of individuals reveal being most averse to risk when the question takes 4 (resp. 6, 11) possible values.

4.1.5 Working sample

Due to the above requirements, our main estimation sample is composed of 10,358 individual-year observations from 2000 to 2006, with non-missing wealth above the 30th percentile of the distribution, non-missing self-declared risk aversion, and non-missing survival probability at the corresponding targetage, as well as with non-missing covariates. Section 4.4 contains a sensitivity analysis to both the threshold of the distribution of wealth considered for truncation, and to restrictions defining that working sample.

4.2 Determinants of savings behavior

We now present our econometric specification. Our dependent variable is the location in each cross-sectional distribution of wealth, conditional on age, which we proxy by the percentile rank. Explanatory variables include usual determinants of savings behavior, namely sociodemographics and economical covariates, life-cycle effects. Our main object of interest is the role played by income and mortality risks, risk aversion, as well as their cross effects in explaining wealth.

---

answers 8-10 into value 1. It is yet possible to abstract from any grouping assumption when considering: i) 4 values from 1992 to 2006; ii) 6 values from 1998 to 2006, or iii) 11 values from 2014 to 2018.

[18]Due to subjective mortality risks being provided for each 5-year age interval, as explained in the previous paragraph.

Net wealth is distributed over a large support: it can be negative, null or very high. To alleviate concerns related to dispersion, we consider the percentile rank R^w in the cross-sectional distribution of net wealth, conditional on age, as the dependent variable. We follow here an empirical literature devoted to intergenerational mobility (Chetty et al., 2014, Epper et al., 2020, Fagereng et al., 2020, 2021). By definition, and up to a normalization, this rank belongs to $[0,1]$ and follows the standard uniform distribution. Such an approach does not rely on any functional form like, e.g., the logarithm or the inverse hyperbolic sine (IHS) transform, often used to deal with wealth as an outcome. We rely on cross-sectional surveys to compute those percentile ranks of the wealth distribution, conditional on each 1-year age dummy. Doing so requires to select 2,957 out of 42,233 individuals for whom no information on wealth is ever available.

We then consider the following econometric specification:

$$R_{it}^w = \alpha_i \text{ income risk}_{h(i)} + \alpha_m \text{ mortality risk}_{it} + \sum_{k=1}^{K} \beta_k \mathbb{1}(\text{risk aversion}_{it} = k)$$
$$+ X_{it}'\gamma + \delta_t + \epsilon_{it}, \quad (13)$$

where $h(i)$ designates the household of individual i, t is the year of survey, and K accounts for the number of values taken by risk aversion (6 in our main specification, 4 or 11 in robustness checks). Risk aversion is here ordinal as in the survey, hence different coefficients are estimated, one for each value of risk aversion. This unrestricted specification allows for a flexible dependence of wealth with risk aversion.

For the sake of readability, one may prefer a cardinal measure of risk aversion from 1 to 6, assigning numbers to ordinal values. This approach leads us to consider the linear specification in risk aversion:

$$R_{it}^w = \alpha_i \text{ income risk}_{h(i)} + \alpha_m \text{ mortality risk}_{it} + \beta \text{ risk aversion}_{it} + X_{it}'\gamma + \delta_t + \epsilon_{it},$$
$$(14)$$

From 2014 to 2018, we may either group responses from 0 to 10 into 4 values, or define risk aversion as 10 minus its ordinal value. Those methodological considerations are yet unimportant to our empirical results.
To investigate how β varies with both income and mortality risks, we may allow this marginal effect of risk aversion to depend on such risks in (14):

$$\beta = \beta_0 + \beta_i \times \text{income risk}_{h(i)} + \beta_m \times \text{mortality risk}_{it} \quad (15)$$

In all estimating equations, we control for sociodemographics X_{it} as in Ke (2021): our set of covariates includes the rank in the distribution of income, income

risk, marital status, number of children, gender, region-year FE, as well a whole set of interactions between the respondent and her spouse's characteristics (5-year age dummies, education, ethnicity, and religion). Standard errors are clustered at the household level.

4.3 Results

It is worthwile to emphasize that the usual determinants of wealth -namely, the control variables afore mentioned- play the expected role when predicting the rank in the conditional distribution of net wealth. For instance, the rank-rank correlation between income and wealth empirically amounts to 0.13-0.19, depending on the sample considered (i.e. either all respondents, or the sole respondents to risk aversion questions). Income risk has a highly significant impact on wealth accumulation: facing an income risk twice as high as her current one, an individual will save more, so that her rank in the conditional wealth distribution will increase by $5.8 \ln(2) \approx 4$. All other covariates, including life-cycle effects, have expected signs, see Table 4 in Appendix. From the viewpoint of wealth, restricting our attention to the subsample of individuals answering to risk aversion questions is rather innocuous. We now turn to our main objects of interest: income and mortality risks, risk aversion, as well as their cross effects.

Table 1: Effect of risk aversion

Dependent variable	rank in wealth distribution			
	(1)	(2)	(3)	(4)
Time period	2000-2006			
6-valued risk aversion	-1.238***	-1.194***	-0.437***	-0.428***
	(-8.60)	(-8.42)	(-3.50)	(-3.49)
Controls	No	No	Yes	Yes
Region-year FE	No	Yes	No	Yes
Observations	10688	10678	10367	10358
R^2	0.008	0.035	0.303	0.319

Lecture. A higher risk aversion (on a 1-6 scale) is associated with a -0.428 percentile rank in the wealth distribution (conditional on age).
Controls: income (rank), income risk, gender, marital status, number of children, spouse's age (5-year dummies), (education, ethnicity, religion) interacted with spouse's.
Note. Estimation period: 2000-2006.
Clustered standard errors at the household level.
t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3.1 Impact of income and mortality risks

Column 1 of Table 2 indicates that the income risk is strongly and positively correlated with wealth ($\widehat{\alpha_i} > 0$). By contrast, elicited mortality risk has a depressing impact on wealth accumulation ($\widehat{\alpha_m} < 0$), which is in line with Prediction 1.

4.3.2 Impact of risk aversion

First, we provide descriptive evidence issued from raw data. Relating median net wealth to risk aversion, Figure 4 strongly suggests the existence of some decreasing relationship between wealth and risk aversion. It is noticeable that most respondents confess being more risk averse, and that the rare, observed deviations from such a monotonocity may be found at low levels of risk aversion, hence concerning few individuals only. It is also useful to remember that risk aversion is measured at the individual level while wealth is measured at the household level: for this reason, such an eyeball evidence must be confirmed by a *ceteris paribus* econometric analysis.
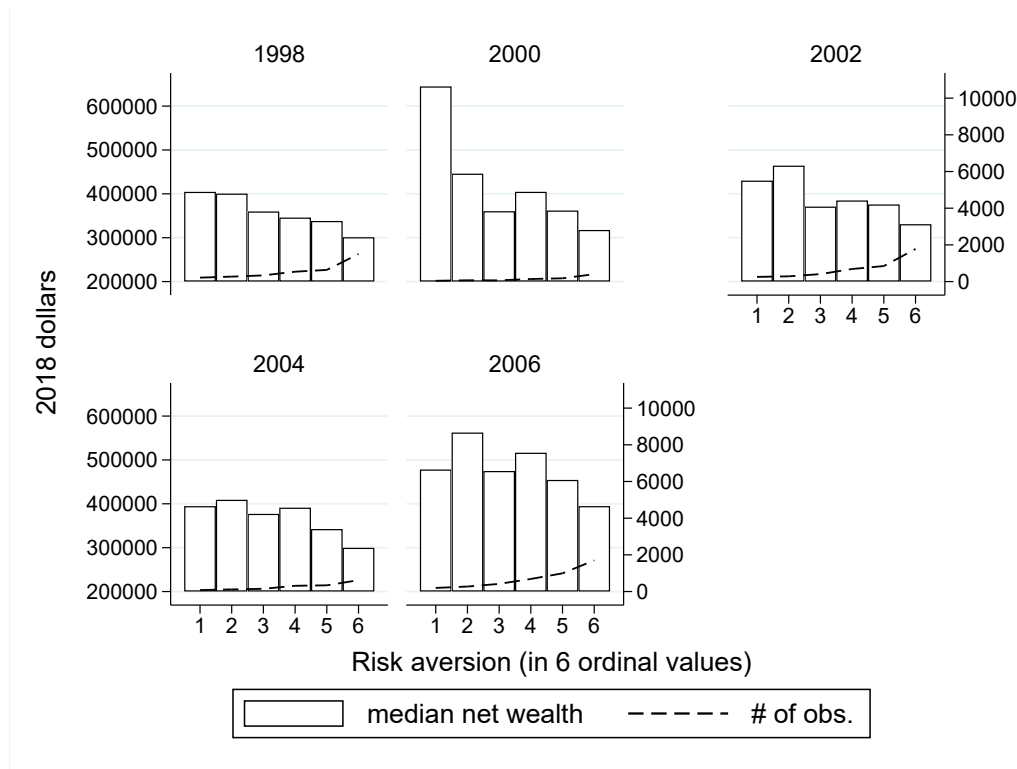
Figure 4: Median net wealth and risk aversion (1998-2006)

Indeed, Table 1 confirms that $\hat{\beta} < 0$, i.e. that more risk averse people save less, consistently with Proposition 2. Omitting to control for usual determinants of wealth overestimates the correlation between wealth and risk aversion, in absolute, and that correlation remains significantly negative at 1% even after controlling further for region-year fixed effects.

The relationship between wealth and cardinal risk aversion has the following interpretation: on average, a +1 shift in self-assessed risk aversion on the 1-6 numerical scale diminishes the rank in the wealth distribution by 0.4. Such a result is consistent with estimates from the unrestricted model where risk aversion is ordinal, see Figure 8c in Appendix. It is also robust to (i) the time period considered, (ii) the number of ordinal values taken by risk aversion, and (iii) the grouping of answers from 2014 to 2018 into 4 values (instead of 11): see columns 1, 2, and 4 of Table 1 as well as Figures 8a, 8b, and 8d. That result also remains after both income and mortality risks have been controlled for (see Column 1 of Table 2).

Focusing on single-headed households yields to an even more negative correlation between wealth and risk aversion, on top of neutralizing any measurement error due to the computation of wealth at the household level (see Table 6 in Appendix). When we restrict our attention to partnered or married individuals that

belong to households where information on both spouses' risk aversion is available, we still find that both spouses' risk aversion is negatively correlated with wealth, see Table 7 in Appendix. Interestingly, it is not possible to reject the null hypothesis that this correlation is the same at 5%.

4.3.3 Cross effect mortality × risk aversion

The cross effect of income and mortality risks, on the one hand, and risk aversion, on the other hand, is documented by Table 2.

When relying on our first measure of mortality risk, namely the 6 distinct subjective mortality risks, we obtain negative cross effects; three of them are significant at 10% while another one is significant at 5%, consistently with Proposition 3 ($\widehat{\beta_m} < 0$). By contrast, the cross effect of income risk and risk aversion turns out not to be significant: we cannot reject $H_0 : \widehat{\beta_i} = 0$ at 5%, regardless of whether cross effects of the 6 mortality risks and risk aversion are controlled for. This empirical evidence therefore suggests that the risk aversion operates on wealth through the mortality risk than through the income risk.

When relying on our second measure of mortality risk, namely the surmortality risk (Table 3), we still find concurring evidence that the channel through which risk aversion operates most is the mortality risk – more precisely, the surmortality risk defined as the difference between subjective (self-assessed) and objective (life-table) mortality risk. On top of being consistent with Proposition 3, it sounds rather conform to the rationale that agents take their consumption-saving decisions with respect to their own beliefs as regards death, rather than according to some cohort-specific prior.

4.4 Extensions and sensitivity analysis

Previous empirical analyses can be extended in several directions, especially to further verify that the channel through which risk aversion depresses wealth accumulation is the mortality risk. We here investigate whether the cross effect of mortality and risk aversion varies with age. We then check that our results are robust to alternate sample definitions and to measurement issues as regards both risk aversion (especially the grouping assumption) and mortality risk.

In order to assess the last part of Proposition 3, we examine how β_m behaves over ages, hence with the mortality risk. Figure 9 in Appendix suggests that this coefficient tends to be negative, regardless of age. It must yet be recalled that our working sample contains few individuals facing a severe objective mortality risk, i.e. for whom $p = 0$, since we select individuals aged 85 or more out of our sample. Remember also that the mortality risk increases exponentially with

Table 2: Cross effect of mortality risks and risk aversion

Dependent variable	rank in wealth distribution			
	(1)	(2)	(3)	(4)
Time period	2000-2006			
risk aversion (6-valued)	-0.424***	-0.460	-0.0161	0.336
	(-3.46)	(-0.36)	(-0.07)	(0.25)
income risk	5.787***	5.801***	5.789***	5.937***
	(18.61)	(8.89)	(18.63)	(8.97)
mortality risk at 80 (50-64)	-0.0316***		0.00487	0.00537
	(-3.86)		(0.23)	(0.25)
mortality risk at 85 (50-64)	-0.0256***		0.00814	0.00851
	(-2.63)		(0.35)	(0.37)
mortality risk at 80 (65-69)	0.0429*		0.103**	0.104**
	(1.94)		(2.45)	(2.46)
mortality risk at 85 (70-74)	-0.00337		0.221	0.223
	(-0.04)		(1.47)	(1.48)
mortality risk at 90 (75-79)	0.0242		0.0903	0.0923
	(0.39)		(0.91)	(0.92)
mortality risk at 95 (80-84)	0.00382		0.254**	0.256**
	(0.06)		(2.11)	(2.11)
risk aversion × income risk		0.00262		-0.0326
		(0.02)		(-0.27)
risk aversion × mortality risk at 80 (50-64)			-0.00787*	-0.00797*
			(-1.85)	(-1.86)
risk aversion × mortality risk at 85 (50-64)			-0.00715	-0.00723
			(-1.59)	(-1.60)
risk aversion × mortality risk at 80 (65-69)			-0.0125*	-0.0127*
			(-1.71)	(-1.72)
risk aversion × mortality risk at 85 (70-74)			-0.0481*	-0.0486*
			(-1.76)	(-1.78)
risk aversion × mortality risk at 90 (75-79)			-0.0130	-0.0135
			(-0.72)	(-0.74)
risk aversion × mortality risk at 95 (80-84)			-0.0520**	-0.0524**
			(-2.11)	(-2.11)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	10358	10358	10358	10358
R^2	0.322	0.322	0.322	0.322

Lecture. Column 1: For individuals aged 50-64, reporting a survival probability at 80 of +10pp is associated
with a +0.316 percentile rank in the wealth distribution (conditional on age).

Controls: 5-year age dummies (as well as an interaction between the last bracket and year 2006)
on top of those mentioned in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Cross effect of subjective surmortality risk and risk aversion

Dependent variable	rank in the wealth distribution					
	(1)	(2)	(3)	(4)	(5)	(6)
Time period	2000-2006					
risk aversion (6-valued)	-0.420***	-0.439	-0.400***	0.507	0.310	-0.212
	(-3.43)	(-0.34)	(-3.23)	(0.36)	(0.59)	(-0.16)
income risk	5.754***	5.746***	5.760***	5.845***	5.761***	5.840***
	(18.58)	(8.80)	(18.61)	(8.90)	(18.63)	(8.87)
life-table mortality risk	-0.00632	-0.00632	-0.00674	0.0667	0.0667	-0.00683
	(-0.19)	(-0.19)	(-0.20)	(1.05)	(1.05)	(-0.20)
surmortality risk	-0.0237***	-0.0237***	0.00703	0.0122	0.0119	0.00730
	(-3.48)	(-3.48)	(0.38)	(0.63)	(0.62)	(0.39)
risk aversion × income risk		0.00179		-0.0184		-0.0177
		(0.01)		(-0.15)		(-0.15)
risk aversion × life-table mortality risk				-0.0154	-0.0154	
				(-1.37)	(-1.37)	
risk aversion × surmortality risk			-0.00659*	-0.00765*	-0.00759**	-0.00664*
			(-1.75)	(-1.96)	(-1.96)	(-1.75)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10358	10358	10358	10358	10358	10358
R^2	0.320	0.320	0.320	0.320	0.320	0.320

Lecture. Column 1: A higher subjective surmortality risk of +10pp is associated with a
-0.237 percentile rank in the wealth distribution (conditional on age).

Note. Surmortality risk: difference between self-assessed (subjective) and life-table (objective) mortality risk.

Controls: same as in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

age: in particular, it does not exceed 0.17 at 85 in our sample. Hence it should be acknowledged that, based on our data, it is difficult to verify the part of the prediction that concerns individuals in the neighbourhood of $p = 0$.

We next proceed to a bunch of robustness checks.

First, we make sure that sample selection does not drive our results on the correlation between risk aversion and wealth, which remain unaltered when no longer restricting on the sole observations with a subjective mortality risk (compare column 4 of Table 1 with column 3 of Table 5 to this end). Starting in 2000 instead of 1998 is therefore innocuous in this regard.

Second, we check that this statistical correlation does not stem from the grouping assumption of, say, 11-valued into 6- or 4-valued risk aversion. We thus address a potential concerns of measurement error in this variable. Columns 2 to 4 of Table 5 do not rely on any grouping assumption (remember footnote 17), contrary to column 1 that displays estimates obtained on the whole 1992-2018 period. All these columns point out to some negative, significant relationship that is both qualitatively and quantitatively robust to the time period considered. If anything, the grouping procedure tends to augment the intensity of that relationship. In a conservative approach, our preferred specification is therefore that of column 3 of Table 5, the analogue of column 4 from Table 1: it does not rely on any grouping assumption, while relying on the largest and most homogeneous time period as regards the concept of risk aversion available in the survey (1998-2006).

In a similar vein, we wonder whether that our results depend on the measure of risk aversion. Concerns have been expressed about the validity of self-declared risk aversion in surveys, though convincingly alleviated by Dohmen et al. (2011). Reassuringly, they established that different measures of risk aversion in the GSOEP (e.g. risk aversion with respect to financial matters, health, driving behavior, or in leisure activities such as sport) were both consistent with experimental evidence and correlated with each other. We have performed a similar exercise on the HRS survey, computing the correlation matrix between different measures of risk aversion, and estimating the statistical correlations between wealth and each of these measures of risk aversion, which are available upon request.

Third, it is possible to aggregate subjective mortality risks at distinct target ages into a single one by resorting to the so-called *proportional shift* method.[19] To that end, let us consider some baseline target age: say, 85. We then compute a predicted mortality risk at 85 by shifting every 5-year age-dependent mortality risk: we multiply those risks by the ratio of the life-table probability of dying at 85 over the life-table probability of dying at target ages 80, 90, or 95, depending on the respondent's 5-year age. Choosing the youngest target age available in the

---

[19]as in, e.g., Delavande and Rohwedder (2011a).

survey, namely 80, as the baseline would of course ensure that shifted mortality risks do not exceed 100%; however, individuals aged 80-84 in the sample would then have a null subjective mortality risk since those individuals have survived until 80. By definition, the life-table counterpart of the subjective probability of survival at target age $T = 80, 85, 90, 95$ is $P_T = \prod_{x=a}^{T-1}(1 - q_x)$, where q_a designates the life-table probability of dying between age a and $a + 1$, for any female or male cohort and for any age a within the $[0, 110]$ range. Table 8 in Appendix then enables us to further corroborate our previous diagnoses: in a wealth equation, risk aversion and subjective mortality risk coefficients have negative signs; the cross effect of income risk and risk aversion is not significant; the cross effect of that subjective mortality risk and risk aversion is negative (though significant at 10% only).

Fourth, we pay attention to focal points, namely subjective probabilities of 0, 0.5, or 1. In particular, Delavande and Rohwedder (2011a) and Hurd (2009) recommend to exclude 0.5 answers, which they refer to as evidence of *epistemic uncertainty*.[20] When we exclude any focal value (0.5, but also 0 and 1), not only do our results remain, but they even tend to be more significant (see Tables 9 and 10 in Appendix).

Fifth, we provide with a sensitivity analysis with respect to the choice of the threshold (P30) of the wealth distribution below which observations are selected out of our sample (see Tables 11 to 14 in Appendix). Overall, our results are rather robust to that truncation parameter.

5 Conclusion

[...still to be written...]

---

[20]As far as rounding is concerned, not much can be done here to address that issue, due to the absence of any convincing empirical strategy *à la* Manski and Molinari (2010).

References

ANGRISANI, M., M. HURD, AND S. ROHWEDDER (2019): "The effect of housing wealth losses on spending in the great recession," *Economic Inquiry*, 57, 972–996.

ANGRISANI, M., M. D. HURD, AND E. MEIJER (2012): "Investment decisions in retirement: The role of subjective expectations," *Michigan Retirement Research Center Research Paper No. WP*, 274.

ARROW, K. J. (1951): "Alternative approaches to the theory of choice in risk-taking situations," *Econometrica*, 19, 404–437.

BACH, L., L. E. CALVET, AND P. SODINI (2020): "Rich pickings? Risk, return, and skill in household wealth," *American Economic Review*, 110, 2703–47.

BARSKY, R. B., F. T. JUSTER, M. S. KIMBALL, AND M. D. SHAPIRO (1997): "Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study," *The Quarterly Journal of Economics*, 112, 537–579.

BARTZSCH, N. (2008): "Precautionary saving and income uncertainty in Germany–new evidence from microdata," *Jahrbücher für Nationalökonomie und Statistik*, 228, 5–24.

BEEN, J., S. ROHWEDDER, AND M. HURD (2020): "Does home production replace consumption spending? Evidence from shocks in housing wealth in the Great Recession," *Review of Economics and Statistics*, 102, 113–128.

BEHRENDS, E., S. GESCHKE, AND T. NATKANIEC (2007-2008): "Functions for which all points are a local minimum or maximum," *Real Analysis Exchange*, 33, 1–4.

BIGGS, A. J. AND G. R. SPRINGSTEAD (2008): "Alternate measures of replacement rates for social security benefits and retirement income," *Social Security Bulletin*.

BISSONNETTE, L., M. D. HURD, AND P.-C. MICHAUD (2017): "Individual survival curves comparing subjective and observed mortality risks," *Health Economics*, 26, e285–e303.

BLOOM, D. E., D. CANNING, M. J. MOORE, AND Y. SONG (2006): "The effect of subjective survival probabilities on retirement and wealth in the United States," NBER Working Paper 12688, National Bureau of Economic Research.

BOMMIER, A., A. CHASSAGNON, AND F. LE GRAND (2012): "Comparative risk aversion: A formal approach with applications to saving behavior," *Journal of Economic Theory*, 147, 1614–1641.

BOMMIER, A., D. HARENBERG, F. LE GRAND, AND C. O'DEA (2020): "Recursive Preferences, the Value of Life, and Household Finance," Discussion Paper 2231, Cowles Foundation.

BOMMIER, A., A. KOCHOV, AND F. LE GRAND (2017): "On monotone recursive preferences," *Econometrica*, 85, 1433–1466.

BOMMIER, A. AND F. LE GRAND (2019): "Risk aversion and precautionary savings in dynamic settings," *Management Science*, 65, 1386–1397.

BOYER, M., P. DE DONDER, C. FLUET, M.-L. LEROUX, AND P.-C. MICHAUD (2019): "Long-term care risk misperceptions," *The Geneva Papers on Risk and Insurance-Issues and Practice*, 44, 183–215.

CAMPBELL, J. Y. AND L. M. VICEIRA (2002): *Strategic Asset Allocation*, Oxford: Oxford University Press.

CHARNESS, G., T. GARCIA, T. OFFERMAN, AND M. C. VILLEVAL (2020): "Do measures of risk attitude in the laboratory predict behavior under risk in and outside of the laboratory?" *Journal of Risk and Uncertainty*, 60, 99–123.

CHETTY, R., N. HENDREN, P. KLINE, AND E. SAEZ (2014): "Where is the land of opportunity? The geography of intergenerational mobility in the United

States," *The Quarterly Journal of Economics*, 129, 1553–1623.

DELAVANDE, A. AND S. ROHWEDDER (2011a): "Differential mortality in Europe and the US: Estimates based on subjective probabilities of survival," *Demography*, 48, 1377–1400.

——— (2011b): "Individuals' uncertainty about future social security benefits and portfolio choice," *Journal of Applied Econometrics*, 26, 498–519.

DELPRAT, G., M.-L. LEROUX, AND P.-C. MICHAUD (2016): "Evidence on individual preferences for longevity risk," *Journal of Pension Economics & Finance*, 15, 160–179.

DOHMEN, T., A. FALK, D. HUFFMAN, U. SUNDE, J. SCHUPP, AND G. G. WAGNER (2011): "Individual risk attitudes: Measurement, determinants, and behavioral consequences," *Journal of the european economic association*, 9, 522–550.

EPPER, T., E. FEHR, H. FEHR-DUDA, C. T. KREINER, D. D. LASSEN, S. LETH-PETERSEN, AND G. N. RASMUSSEN (2020): "Time discounting and wealth inequality," *American Economic Review*, 110, 1177–1205.

EPSTEIN, L. G. AND S. E. ZIN (1989): "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework," *Econometrica*, 57, 937–969.

FAGERENG, A., L. GUISO, D. MALACRINO, AND L. PISTAFERRI (2020): "Heterogeneity and persistence in returns to wealth," *Econometrica*, 88, 115–170.

FAGERENG, A., M. B. HOLM, B. MOLL, AND G. NATVIK (2019): "Saving behavior across the wealth distribution: The importance of capital gains," Tech. rep., National Bureau of Economic Research.

FAGERENG, A., M. MOGSTAD, AND M. RØNNING (2021): "Why do wealthy parents have wealthy children?" *Journal of Political Economy*, 129, 703–756.

FALK, A., A. BECKER, T. DOHMEN, D. HUFFMAN, AND U. SUNDE (2022): "The preference survey module: A validated instrument for measuring risk, time, and social preferences," *Management Science*.

FRÉMEAUX, N. AND M. LETURCQ (2022): "Wealth accumulation and the gender wealth gap across couples' legal statuses and matrimonial property regimes in France," *European Journal of Population*, 1–37.

FUCHS-SCHÜNDELN, N. AND M. SCHÜNDELN (2005): "Precautionary savings and Self-Selection: Evidence from the German reunification "Experiment"," *The Quarterly Journal of Economics*, 120, 1085–1120.

GALIZZI, M. M., S. R. MACHADO, AND R. MINIACI (2016): "Temporal stability, cross-validity, and external validity of risk preferences measures: Experimental evidence from a UK representative sample," *Working paper*.

GAN, L., G. GONG, M. HURD, AND D. MCFADDEN (2015): "Subjective mortality risk and bequests," *Journal of Econometrics*, 188, 514–525.

GAN, L., M. D. HURD, D. MCFADDEN, ET AL. (2005): "Individual subjective survival curves," *Analyses in the Economics of Aging*, 377–412.

GHIRARDATO, P. AND M. MARINACCI (2001): "Risk, Ambiguity, and the Separation of Utility and Beliefs," *Mathematics of Operations Research*, 26, 864–890.

HARRATI, A. C. (2014): *Understanding Risk Aversion in Older Americans: New Approaches Using Genetic Data*, University of California, Berkeley.

HURD, M., D. MCFADDEN, AND L. GAN (1998): "9. Subjective survival curves and life cycle behavior," in *Inquiries in the Economics of Aging*, University of Chicago Press, 259–310.

HURD, M. D. (2009): "Subjective probabilities in household surveys," *Annu. Rev. Econ.*, 1, 543–562.

HURD, M. D. AND K. MCGARRY (1995): "Evaluation of the subjective probabili-

ties of survival in the health and retirement study," *Journal of Human resources*, S268–S292.

———— (2002): "The predictive validity of subjective probabilities of survival," *The Economic Journal*, 112, 966–985.

HURD, M. D., E. MEIJER, M. MOLDOFF, AND S. ROHWEDDER (2016): "Improved wealth measures in the Health and Retirement Study: asset reconciliation and cross-wave imputation," RAND Working Paper Series WR-1150.

HURD, M. D., J. P. SMITH, AND J. M. ZISSIMOPOULOS (2004): "The effects of subjective survival on retirement and social security claiming," *Journal of Applied Econometrics*, 19, 761–775.

KE, D. (2021): "Who wears the pants? Gender identity norms and intrahousehold financial decision-making," *The Journal of Finance*, 76, 1389–1425.

KIHLSTROM, R. E. AND L. J. MIRMAN (1974): "Risk Aversion with many Commodities," *Journal of Economic Theory*, 8, 361–388.

KIMBALL, M. S., C. R. SAHM, AND M. D. SHAPIRO (2008): "Imputing risk tolerance from survey responses," *Journal of the American Statistical Association*, 103, 1028–1038.

KREPS, D. M. AND E. L. PORTEUS (1978): "Temporal resolution of uncertainty and dynamic choice theory," *Econometrica*, 185–200.

LIMOSANI, M. AND E. MILLEMACI (2014): "Precautionary savings of agents with heterogeneous risk aversion," *Applied Economics*, 46, 2342–2361.

LUSARDI, A., P.-C. MICHAUD, AND O. S. MITCHELL (2017): "Optimal financial knowledge and wealth inequality," *Journal of Political Economy*, 125, 431–477.

MANSKI, C. F. AND F. MOLINARI (2010): "Rounding probabilistic expectations in surveys," *Journal of Business & Economic Statistics*, 28, 219–231.

NOUSSAIR, C. N., S. T. TRAUTMANN, AND G. VAN DE KUILEN (2014): "Higher order risk attitudes, demographics, and financial decisions," *Review of Economic Studies*, 81, 325–355.

POTERBA, J., S. VENTI, AND D. A. WISE (2018): "Longitudinal determinants of end-of-life wealth inequality," *Journal of Public Economics*, 162, 78–88.

SAHM, C. R. (2012): "How much does risk tolerance change?" *The Quarterly Journal of Finance*, 2, 1250020.

SALM, M. (2010): "Subjective mortality expectations and consumption and saving behaviours among the elderly," *Canadian Journal of Economics/Revue canadienne d'économique*, 43, 1040–1057.

SCHUNK, D. (2009): "What Determines Household Saving Behavior: An Examination of Saving Motives and Saving Decisions 06.01. 2009," *Journal of Economics and Statistics (Jahrbuecher fuer Nationaloekonomie und Statistik)*, 229, 467–491.

VIEIDER, F. M., M. LEFEBVRE, R. BOUCHOUICHA, T. CHMURA, R. HAKIMOV, M. KRAWCZYK, AND P. MARTINSSON (2015): "Common components of risk and uncertainty attitudes across contexts and domains: Evidence from 30 countries," *Journal of the European Economic Association*, 13, 421–452.

VISCUSI, W. K. (2018): *Pricing lives: Guideposts for a safer society.*, Princeton: Princeton University Press.

YAARI, M. E. (1969): "Some Remarks on Measures of Risk Aversion and Their Uses," *Journal of Economic Theory*, 1, 315–329.

Appendix

A Supplementary figures
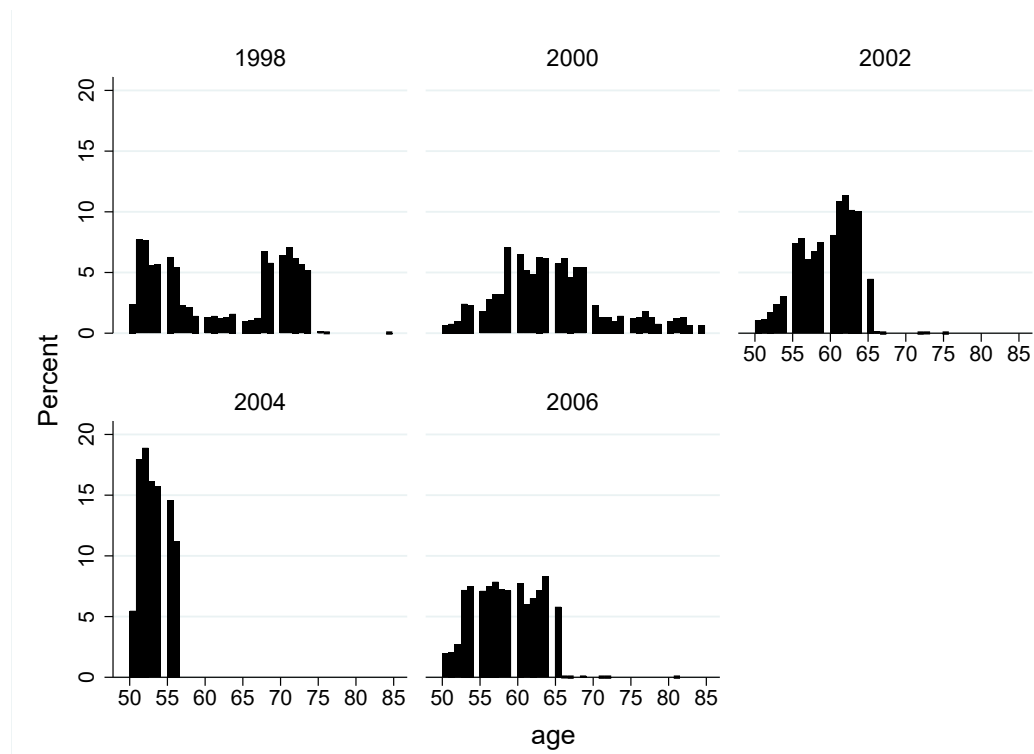
Figure 5: Age of respondents to risk aversion question
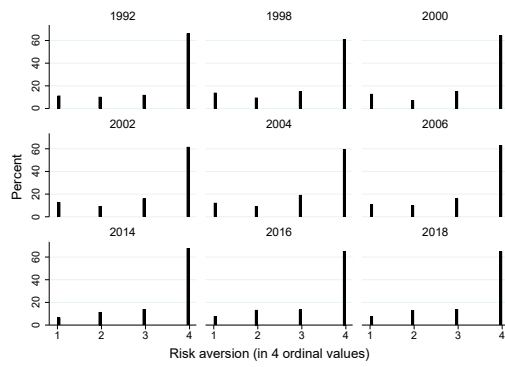
(a) 4-valued (1992-2018; grouping from 2014 to 2018)
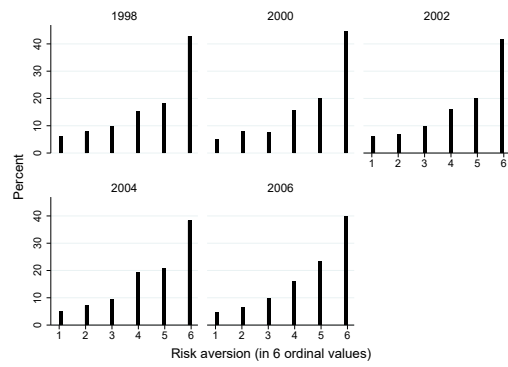
(b) 6-valued (1998-2006)
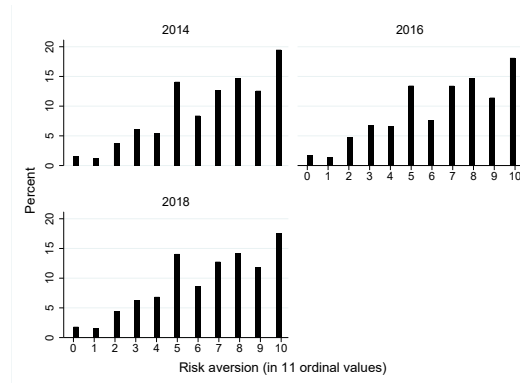
(c) 11-valued (2014-2018)

Figure 6: Distribution of risk aversion
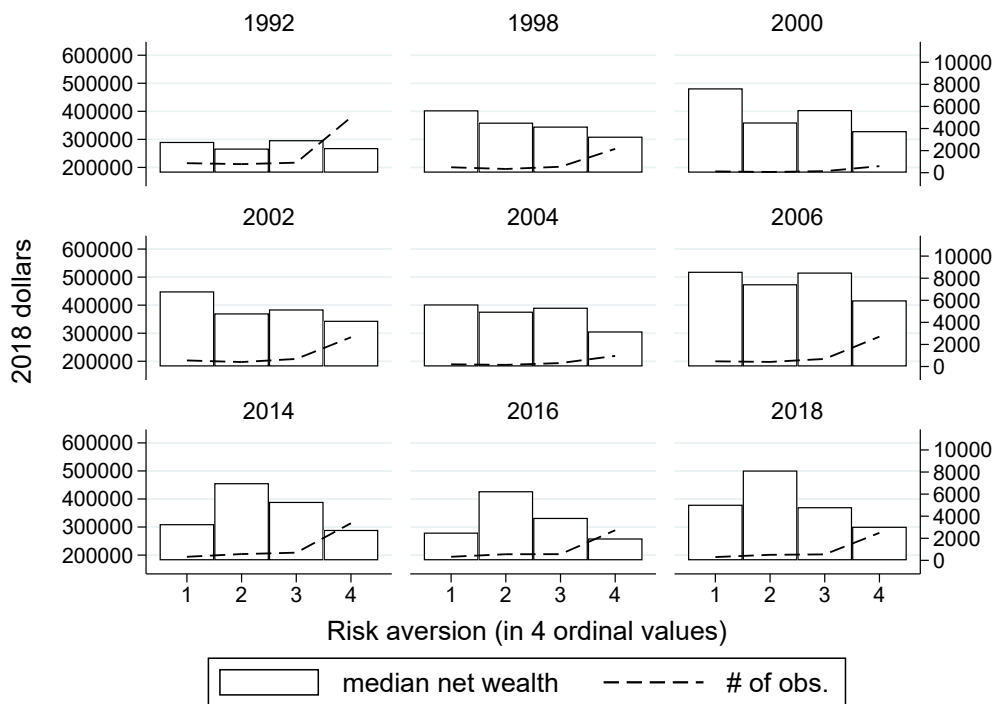
(a) 4-valued (1992-2018)
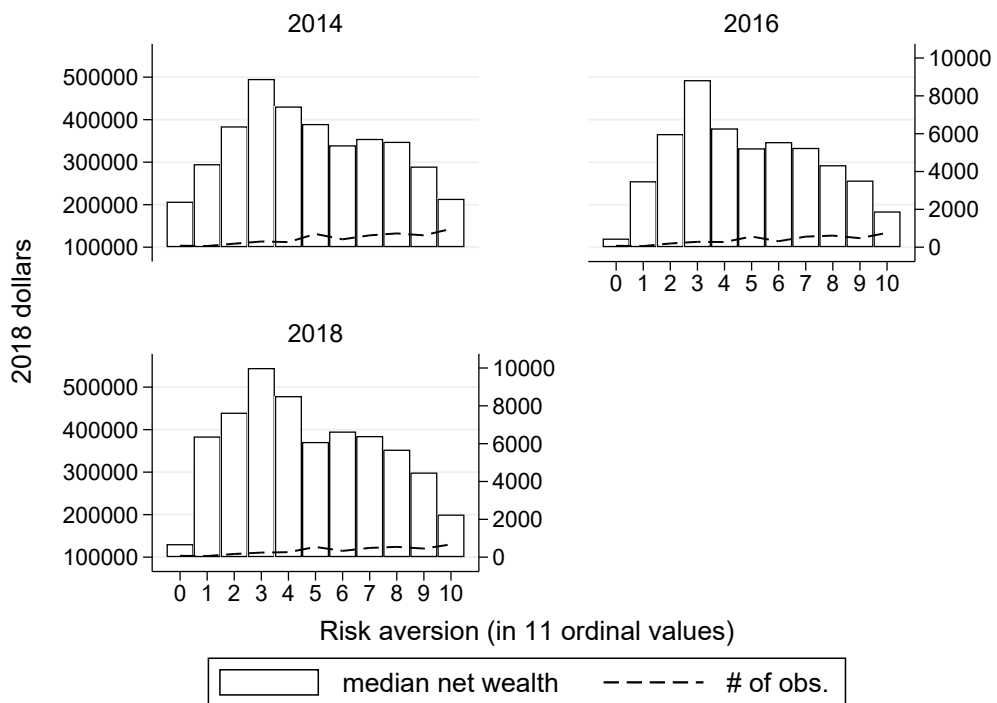
(b) 11-valued (2014-2018)

Figure 7: Median net wealth and risk aversion (4- and 11-valued)
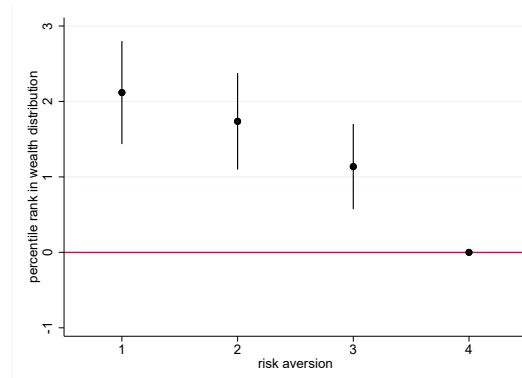
(a) 4-valued (1992-2018; grouping from 2014 to 2018)
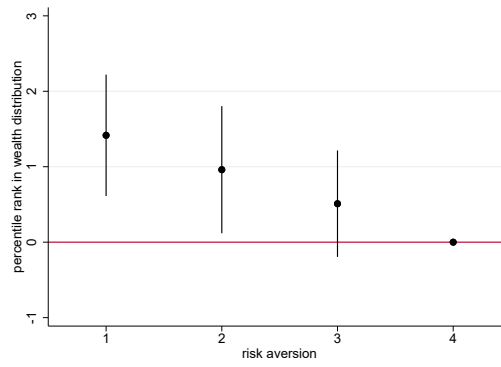
(b) 4-valued (1998-2006)
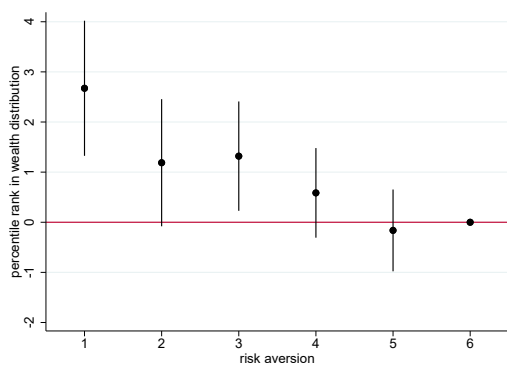
(c) 6-valued (1998-2006)
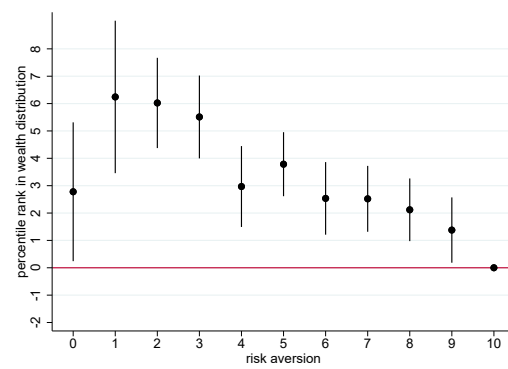
(d) 11-valued (2014-2018)

Figure 8: Unrestricted estimatesof risk aversion coefficients β_k t
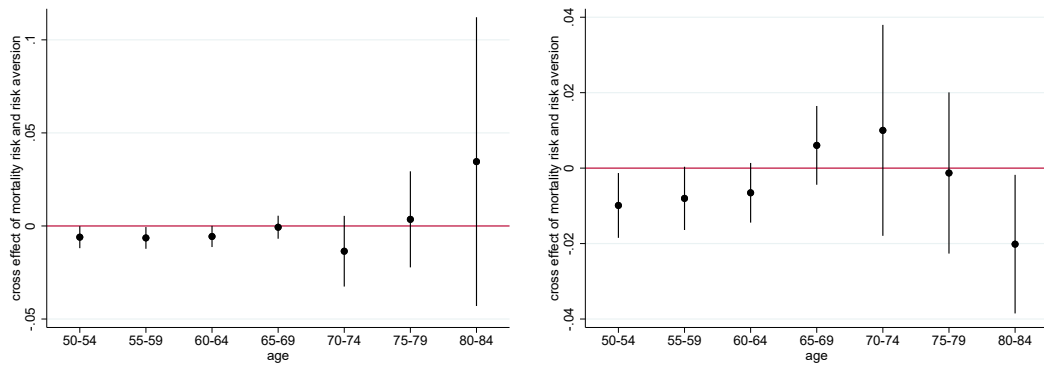
(a) Subjective mortality risk (proportional shift method)

(b) Surmortality risk (subjective-objective mortality risk)

Figure 9: Cross effect of mortality risk and risk aversion (by 5-year age interval)

B Supplementary tables

Table 4: Determinants of percentile rank of wealth

	all respondents	risk aversion respondents
Time period	1992-2018	1998-2006
Constant	16.30***	-1.879
	(11.81)	(0.69)
Income (rank)	0.194***	0.130***
	(40.02)	(12.03)
Income risk	4.041***	5.809***
	(32.36)	(21.85)
Marital status (ref: married)		
spouse absent	-1.490	4.634
	(-1.26)	(1.17)
partnered	-1.819***	-2.008
	(-2.90)	(-1.64)
separated	-1.504*	-2.439
	(-1.68)	(-1.13)
divorced	-3.815***	-3.647***
	(-9.73)	(-5.14)
separated/divorced	-12.41	-
	(-1.64)	
widowed	-0.560*	-0.535
	(-1.83)	(-0.72)
never married	-0.613	-2.296*
	(-0.90)	(-1.85)
Female	0.678***	1.157***
	(6.29)	(4.61)
Nb. of children	-0.654***	-0.545***
	(-9.06)	(-4.06)
Education (ref: dropout)		
vocational	-1.574***	-2.541**
	(-2.79)	(-2.45)
high-school graduate	3.545***	2.468***
	(10.23)	(3.54)
some college	5.300***	4.785***
	(14.03)	(6.45)
college graduate	9.425***	8.816***
	(22.73)	(11.13)
Religion (ref: protestant)		
catholic	1.293***	2.089***
	(4.06)	(3.87)
jewish	4.855***	4.754***
	(5.58)	(3.43)
none/no pref	1.099**	1.174
	(2.52)	(1.52)
other	1.326	-2.115
	(1.63)	(-1.14)
Ethnicity (ref: white/caucasian)		
black/african american	-8.859***	-8.141***
	(-24.13)	(-11.23)
other	-0.992*	-1.921*
	(-1.93)	(-1.93)
Hispanic dummy	-4.464***	-4.807***
	(-9.00)	(-5.25)
Region-year FE	Yes	Yes
Observations	103406	14188
R^2	0.323	0.302

t statistics in parentheses
Clustered standard errors at the household level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effect of risk aversion

Dependent variable	rank in wealth distribution			
	(1)	(2)	(3)	(4)
Time period	1992-2018	1992-2006	1998-2006	2014-2018
4-valued risk aversion	-0.769***	-0.475***		
	(-7.51)	(-3.85)		
6-valued risk aversion			-0.443***	
			(-4.19)	
11-valued risk aversion				-0.585***
				(-8.64)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	33217	20990	14061	12227
R^2	0.332	0.321	0.326	0.382

Lecture. A higher risk aversion (on a 1-6 scale) is associated with a -0.443 percentile rank in the wealth distribution (conditional on age).

Controls: income (rank), income risk, gender, marital status, number of children, spouse's age (5-year dummies), (education, ethnicity, religion) interacted with spouse's.

Note. Column (1) combines 1992-2006 with 2014-2018: see footnote 17 for details.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Single-headed households

Dependent variable	rank in wealth distribution			
Time period	1992-2018	1992-2006	1998-2006	2014-2018
risk aversion (4-valued)	-1.261***	-0.727**		
	(-5.55)	(-2.52)		
risk aversion (6-valued)			-0.488**	
			(-2.13)	
risk aversion (11-valued)				-0.777***
				(-6.09)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	6802	3490	2613	3312
R^2	0.286	0.279	0.268	0.317

Lecture. A higher risk aversion (on a 1-6 scale) is associated with a -0.488 percentile rank in the wealth distribution (conditional on age).

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Partnered or married households

Dependent variable	rank in wealth distribution	
Time period	1992-2006	1998-2006
risk aversion (4-valued)	-0.443***	
	(-3.13)	
spouse's risk aversion (4-valued)	-0.449***	
	(-3.19)	
risk aversion (6-valued)		-0.398***
		(-3.11)
spouse's risk aversion (6-valued)		-0.368***
		(-2.83)
Controls	Yes	Yes
Region-year FE	Yes	Yes
Observations	13810	8272
R^2	0.311	0.317

Lecture. A higher risk aversion (on a 1-6 scale) is associated with a -0.398 percentile
rank in the wealth distribution (conditional on age).
Clustered standard errors at the household level.
t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Cross effect of subjective mortality risk and risk aversion

Dependent variable	rank in the wealth distribution			
	(1)	(2)	(3)	(4)
Time period	2000-2006			
risk aversion (6-valued)	-0.423***	-0.461	-0.0974	0.0672
	(-3.45)	(-0.36)	(-0.44)	(0.05)
income risk	5.756***	5.740***	5.763***	5.832***
	(18.67)	(8.80)	(18.70)	(8.86)
subjective mortality risk	-0.0170***	-0.0170***	0.00714	0.00730
	(-3.43)	(-3.43)	(0.51)	(0.51)
risk aversion × income risk		0.00357		-0.0153
		(0.03)		(-0.13)
risk aversion × subjective mortality risk			-0.00516*	-0.00520*
			(-1.84)	(-1.83)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	10358	10358	10358	10358
R^2	0.320	0.320	0.320	0.320

Lecture. Column 1: A higher subjective mortality risk of +10pp is associated with a -0.17
percentile rank in the wealth distribution (conditional on age).

Note. Subjective mortality risk computed from proportional shifts to previous mortality risks,
based on HMD life-tables.

Controls: same as in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Cross effect of mortality risks and risk aversion - Excluding focal answers

Dependent variable			rank in wealth distribution	
	(1)	(2)	(3)	(4)
Time period			2000-2006	
risk aversion (6-valued)	-0.456***	-0.0365	0.254	1.394
	(-3.07)	(-0.02)	(0.86)	(0.81)
income risk		-0.0398		-0.105
		(-0.26)		(-0.69)
mortality risk at 80 (50-64)	-0.0320***		0.0258	0.0275
	(-2.94)		(0.91)	(0.96)
mortality risk at 85 (50-64)	-0.0229*		0.0500*	0.0511*
	(-1.88)		(1.71)	(1.74)
mortality risk at 80 (65-69)	0.0469		0.0963*	0.0985*
	(1.62)		(1.72)	(1.75)
mortality risk at 85 (70-74)	0.0425		0.508***	0.515***
	(0.42)		(3.61)	(3.66)
mortality risk at 90 (75-79)	0.0508		0.944**	0.953**
	(0.42)		(2.28)	(2.30)
mortality risk at 95 (80-84)	0.0125		0.865***	0.883***
	(0.12)		(3.34)	(3.36)
risk_aversion6 × mortality_risk_80_65			-0.0127**	-0.0131**
			(-2.26)	(-2.29)
risk_aversion6 × mortality_risk_85_65			-0.0157***	-0.0160***
			(-2.77)	(-2.79)
risk_aversion6 × mortality_risk_80			-0.0108	-0.0113
			(-1.09)	(-1.13)
risk_aversion6 × mortality_risk_85			-0.0983***	-0.100***
			(-4.34)	(-4.40)
risk_aversion6 × mortality_risk_90			-0.161**	-0.163**
			(-2.29)	(-2.32)
risk_aversion6 × mortality_risk_95			-0.153***	-0.157***
			(-2.80)	(-2.84)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	6649	6649	6649	6649
R^2	0.322	0.320	0.324	0.324

Lecture. Column 1: For individuals aged 50-64, reporting a survival probability at 80 of +10pp is associated
with a +0.32 percentile rank in the wealth distribution (conditional on age).

Controls: 5-year age dummies (as well as an interaction between the last bracket and year 2006)
on top of those mentioned in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Cross effect of subjective surmortality risk and risk aversion - Excluding focal answers

Dependent variable	rank in the wealth distribution					
	(1)	(2)	(3)	(4)	(5)	(6)
Time period	2000-2006					
risk aversion (6-valued)	-0.445***	0.0221	-0.409***	1.822	0.997	0.359
	(-2.99)	(0.01)	(-2.72)	(1.02)	(1.52)	(0.22)
income risk	5.650***	5.848***	5.657***	6.011***	5.663***	5.983***
	(16.53)	(7.51)	(16.56)	(7.62)	(16.58)	(7.59)
life-table mortality risk	0.00923	0.00898	0.0101	0.152*	0.152*	0.00973
	(0.19)	(0.19)	(0.21)	(1.85)	(1.85)	(0.20)
surmortality risk	-0.0228***	-0.0228***	0.0255	0.0372	0.0361	0.0265
	(-2.65)	(-2.65)	(1.03)	(1.46)	(1.43)	(1.06)
risk aversion × income risk		-0.0437		-0.0765		-0.0718
		(-0.29)		(-0.50)		(-0.47)
risk aversion × life-table mortality risk				-0.0306**	-0.0305**	
				(-2.19)	(-2.18)	
risk aversion × surmortality risk			-0.0106**	-0.0130**	-0.0128**	-0.0108**
			(-2.11)	(-2.52)	(-2.51)	(-2.13)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6649	6649	6649	6649	6649	6649
R^2	0.320	0.320	0.320	0.321	0.321	0.320

Lecture. Column 1: A higher subjective surmortality risk of +10pp is associated with a
-0.228 percentile rank in the wealth distribution (conditional on age).
Note. Surmortality risk: difference between self-assessed (subjective) and life-table (objective) mortality risk.
Controls: same as in Table 1.
Clustered standard errors at the household level.
t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Cross effect of mortality risks and risk aversion - Keeping individual-year observations above P35 (instead of P30) of wealth distribution

Dependent variable	rank in wealth distribution			
	(1)	(2)	(3)	(4)
Time period		2000-2006		
risk aversion (6-valued)	-0.370***	-0.0619	-0.0395	0.563
	(-3.10)	(-0.05)	(-0.18)	(0.42)
income risk	5.560***	5.730***	5.562***	5.814***
	(18.29)	(8.95)	(18.31)	(8.97)
mortality risk at 80 (50-64)	-0.0376***		-0.00778	-0.00689
	(-4.65)		(-0.38)	(-0.33)
mortality risk at 85 (50-64)	-0.0243**		0.00294	0.00356
	(-2.54)		(0.13)	(0.16)
mortality risk at 80 (65-69)	0.0331		0.0837**	0.0851**
	(1.54)		(2.10)	(2.12)
mortality risk at 85 (70-74)	-0.00890		0.165	0.168
	(-0.11)		(1.09)	(1.11)
mortality risk at 90 (75-79)	-0.0239		0.0184	0.0219
	(-0.41)		(0.19)	(0.23)
mortality risk at 95 (80-84)	0.0839		0.205*	0.209*
	(1.60)		(1.83)	(1.84)
risk aversion × income risk		-0.0294		-0.0556
		(-0.25)		(-0.46)
risk aversion × mortality risk at 80 (50-64)			-0.00645	-0.00664
			(-1.56)	(-1.59)
risk aversion × mortality risk at 85 (50-64)			-0.00579	-0.00593
			(-1.31)	(-1.33)
risk aversion × mortality risk at 80 (65-69)			-0.0106	-0.0108
			(-1.51)	(-1.54)
risk aversion × mortality risk at 85 (70-74)			-0.0379	-0.0388
			(-1.39)	(-1.42)
risk aversion × mortality risk at 90 (75-79)			-0.00831	-0.00915
			(-0.47)	(-0.51)
risk aversion × mortality risk at 95 (80-84)			-0.0262	-0.0269
			(-1.19)	(-1.21)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	9612	9612	9612	9612
R^2	0.300	0.297	0.300	0.300

Lecture. Column 1: For individuals aged 50-64, reporting a survival probability at 80 of +10pp is associated
with a +0.376 percentile rank in the wealth distribution (conditional on age).
Controls: 5-year age dummies (as well as an interaction between the last bracket and year 2006)
on top of those mentioned in Table 1.
Clustered standard errors at the household level.
t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 12: Cross effect of subjective surmortality risk and risk aversion - Keeping individual-year observations above P35 (instead of P30) of wealth distribution

Dependent variable	rank in the wealth distribution					
	(1)	(2)	(3)	(4)	(5)	(6)
Time period	2000-2006					
risk aversion (6-valued)	-0.369***	-0.0792	-0.354***	0.738	0.269	0.106
	(-3.09)	(-0.06)	(-2.94)	(0.53)	(0.52)	(0.08)
income risk	5.528***	5.651***	5.533***	5.732***	5.533***	5.728***
	(18.26)	(8.84)	(18.29)	(8.92)	(18.31)	(8.89)
life-table mortality risk	0.00481	0.00470	0.00437	0.0682	0.0682	0.00418
	(0.15)	(0.14)	(0.13)	(1.10)	(1.10)	(0.13)
surmortality risk	-0.0268***	-0.0268***	-0.00303	0.00193	0.00123	-0.00235
	(-4.02)	(-4.02)	(-0.17)	(0.10)	(0.07)	(-0.13)
risk aversion × income risk		-0.0272		-0.0438		-0.0431
		(-0.23)		(-0.37)		(-0.36)
risk aversion × life-table mortality risk				-0.0135	-0.0135	
				(-1.23)	(-1.23)	
risk aversion × surmortality risk			-0.00511	-0.00615	-0.00600	-0.00526
			(-1.40)	(-1.62)	(-1.59)	(-1.42)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9612	9612	9612	9612	9612	9612
R^2	0.298	0.298	0.298	0.298	0.298	0.298

Lecture. Column 1: A higher subjective surmortality risk of +10pp is associated with a
-0.268 percentile rank in the wealth distribution (conditional on age).

Note. Surmortality risk: difference between self-assessed (subjective) and life-table (objective) mortality risk.

Controls: same as in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: Cross effect of mortality risks and risk aversion - Keeping individual-year observations above P25 (instead of P30) of wealth distribution

Dependent variable	rank in wealth distribution			
	(1)	(2)	(3)	(4)
Time period	2000-2006			
risk aversion (6-valued)	-0.409***	-1.241	0.0502	-0.454
	(-3.26)	(-0.96)	(0.21)	(-0.33)
income risk	6.178***	5.862***	6.182***	5.969***
	(19.44)	(8.85)	(19.48)	(8.89)
mortality risk at 80 (50-64)	-0.0362***		0.00594	0.00516
	(-4.39)		(0.27)	(0.24)
mortality risk at 85 (50-64)	-0.0323***		0.00800	0.00741
	(-3.28)		(0.34)	(0.31)
mortality risk at 80 (65-69)	0.0463**		0.107**	0.106**
	(2.08)		(2.54)	(2.49)
mortality risk at 85 (70-74)	0.0206		0.255*	0.252*
	(0.27)		(1.73)	(1.71)
mortality risk at 90 (75-79)	0.0210		0.0130	0.00846
	(0.34)		(0.13)	(0.09)
mortality risk at 95 (80-84)	-0.0149		0.0523	0.0497
	(-0.21)		(0.28)	(0.26)
risk aversion × income risk		0.0774		0.0469
		(0.64)		(0.38)
risk aversion × mortality risk at 80 (50-64)			-0.00907**	-0.00891**
			(-2.12)	(-2.06)
risk aversion × mortality risk at 85 (50-64)			-0.00851*	-0.00838*
			(-1.86)	(-1.82)
risk aversion × mortality risk at 80 (65-69)			-0.0128*	-0.0125*
			(-1.72)	(-1.67)
risk aversion × mortality risk at 85 (70-74)			-0.0500*	-0.0493*
			(-1.89)	(-1.86)
risk aversion × mortality risk at 90 (75-79)			0.00168	0.00265
			(0.09)	(0.14)
risk aversion × mortality risk at 95 (80-84)			-0.0144	-0.0139
			(-0.42)	(-0.40)
Controls	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Observations	11030	11030	11030	11030
R^2	0.346	0.344	0.346	0.346

Lecture. Column 1: For individuals aged 50-64, reporting a survival probability at 80 of +10pp is associated
with a +0.362 percentile rank in the wealth distribution (conditional on age).

Controls: 5-year age dummies (as well as an interaction between the last bracket and year 2006)
on top of those mentioned in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Cross effect of subjective surmortality risk and risk aversion - Keeping individual-year observations above P25 (instead of P30) of wealth distribution

Dependent variable	rank in the wealth distribution					
	(1)	(2)	(3)	(4)	(5)	(6)
Time period	2000-2006					
risk aversion (6-valued)	-0.412***	-1.232	-0.387***	-0.0581	0.519	-0.976
	(-3.28)	(-0.95)	(-3.05)	(-0.04)	(0.96)	(-0.74)
income risk	6.137***	5.785***	6.142***	5.897***	6.144***	5.889***
	(19.39)	(8.74)	(19.43)	(8.85)	(19.46)	(8.81)
life-table mortality risk	-0.00974	-0.00947	-0.0102	0.0831	0.0831	-0.0100
	(-0.28)	(-0.27)	(-0.30)	(1.27)	(1.27)	(-0.29)
surmortality risk	-0.0288***	-0.0288***	0.00429	0.00964	0.0106	0.00335
	(-4.21)	(-4.20)	(0.23)	(0.49)	(0.54)	(0.17)
risk aversion × income risk		0.0775		0.0543		0.0555
		(0.64)		(0.44)		(0.45)
risk aversion × life-table mortality risk				-0.0196*	-0.0196*	
				(-1.70)	(-1.71)	
risk aversion × surmortality risk			-0.00707*	-0.00817**	-0.00837**	-0.00687*
			(-1.87)	(-2.07)	(-2.15)	(-1.79)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11030	11030	11030	11030	11030	11030
R^2	0.344	0.344	0.344	0.344	0.344	0.344

Lecture. Column 1: A higher subjective surmortality risk of +10pp is associated with a
-0.288 percentile rank in the wealth distribution (conditional on age).

Note. Surmortality risk: difference between self-assessed (subjective) and life-table (objective) mortality risk.

Controls: same as in Table 1.

Clustered standard errors at the household level.

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C   Proofs for the 2 period-framework

This section contains the proofs and additional results of the two-period model of Section 2.

C.1   A representation result

We assume that preferences are monotone with respect to first-order stochastic dominance in the sense of Assumption 1. We start with stating a representation result, stating the utility function $\phi(c_1, c_2, p)$ can equivalently be expressed in terms of lifetime utilities.

Lemma 2. *Consider a preference relation $\succeq$ over $X \times [0,1]$ represented by a continuous utility function $\phi(c_1, c_2, p)$. If this preference relation is monotone, there exists a (unique) real-valued function ψ defined on the domain $D \times [0,1]$ defined as:*

$$D = \{(u_1, u_2) \in \mathbb{R}_+^2 : u_1 = \phi(c_1, c_2, 0) \text{ and } u_2 = \phi(c_1, c_2, 1) \text{ for some } (c_1, c_2) \in X\},$$

such that for all $(c_1, c_2, p) \in X \times [0,1]$:

$$\phi(c_1, c_2, p) = \psi(\phi(c_1, c_2, 0), \phi(c_1, c_2, 1), p).$$

For any $p \in [0,1]$, the function $(u_1, u_2) \in D \mapsto \psi(u_1, u_2, p)$ is increasing.

Proof. Let $(c_1, c_2) \in \mathbb{R}_+$. We set $u_1 = \phi(c_1, c_2, 0)$ and $u_2 = \phi(c_1, c_2, 1)$ and define for all $p \in [0,1]$:

$$\psi(u_1, u_2, p) = \phi(c_1, c_2, p).$$

Let consider $(c_1', c_2') \in \mathbb{R}_+$ (that potentially differ from (c_1, c_2)) such that $(c_1, c_2, 0) \sim (c_1', c_2', 0)$ and $(c_1, c_2, 1) \sim (c_1', c_2', 1)$. Monotonicity implies that $(c_1, c_2, p) \sim (c_1', c_2', p)$ for all p and ψ is well defined. We indeed have $\psi(u_1, u_2, p) = \phi(c_1, c_2, p) = \phi(c_1', c_2', p)$ for all p. In other words, ψ does not depend on the choice of the the consumption bundle representing the lifetime utility pair (u_1, u_2). The function ψ is unique up to an increasing transformation. By construction, the set of definition of ψ is D.

Let us show that $(u_1, u_2) \in D \mapsto \psi(u_1, u_2, \cdot)$ is increasing. Let $(u_1, u_2) \geq (u_1', u_2')$ be two elements of D and $p \in [0,1]$. By definition, there exists (c_1, c_2) and (c_1', c_2') in X, such that

$$u_1 = \phi(c_1, c_2, 0) \text{ and } u_2 = \phi(c_1, c_2, 1),$$
$$u_1' = \phi(c_1', c_2', 0) \text{ and } u_2' = \phi(c_1', c_2', 1),$$

and which verify $(c_1, c_2, 0) \succeq (c_1', c_2', 0)$ and $(c_1, c_2, 1) \succeq (c_1', c_2', 1)$ because $u_1 \geq u_1'$ and $u_2 \geq u_2'$. Because of Monotonicity (Assumption 1), we have $(c_1, c_2, p) \succeq (c_1', c_2', p)$ for all $p \in [0, 1]$, or equivalently, $\phi(c_1, c_2, p) \geq \phi(c_1', c_2', p)$. This implies that $\psi(u_1, u_2, p) \geq \psi(u_1', u_2', p)$, which proves that $(u_1, u_2) \in D \mapsto \psi(u_1, u_2, \cdot)$ is increasing. $\qquad\square$

Lemma 2 therefore states that a preference relationship that is monotone in the sense of Definition 1 can be represented by a utility function ψ defined over lifetime utilities (when alive for one and two periods respectively). The definition set of ψ is denoted D thereafter.

C.2 Comparative risk aversion

To investigate comparative risk aversion, we consider two agents, denoted by A and B, who are endowed with monotone preferences over X. We assume that their preferences can be represented by continuous utility functions, ϕ_A and ϕ_B, defined over X.

We are interested only in how A and B differ along their preferences in the presence of risk. As is standard (Kihlstrom and Mirman, 1974, Epstein and Zin, 1989), we assume that agents make identical choices when comparing consumption bundles when the mortality risk is resolved. Formally, we can state the following assumptions.

Assumption 3. *Agents A and B are said to have the same ordinal preferences if and only if for all $(c_1, c_2), (c_1', c_2') \in X$ and $(p, p') \in \{0, 1\}^2$:*

$$\left(\phi_A(c_1, c_2, p) \geq \phi_A(c_1', c_2', p')\right) \Leftrightarrow \left(\phi_B(c_1, c_2, p) \geq \phi_B(c_1', c_2', p')\right). \qquad (16)$$

In other words, if the lifetime utility associated to (c_1, c_2, p) is preferred for A to lifetime utility associated to (c_1', c_2', p'), then this also the case for B. Observe that p and p' can only be 0 or 1, reflecting that there is no uncertainty with respect to survival and that the comparison involves lifetime utilities.

Assumption 3 implies that we normalize the lifetime utility functions of both agents such that they are identical.

Lemma 3. *Agents A and B are said to have the same ordinal preferences if and only if we can renormalize ϕ_A and ϕ_B such that for all $(c_1, c_2) \in X$ and $p \in \{0, 1\}$:*

$$\phi_A(c_1, c_2, p) = \phi_B(c_1, c_2, p). \qquad (17)$$

Proof. We denote by $LT^i = \{\phi_i(c_1, c_2, p) : (c_1, c_2, p) \in X \times [0, 1]\}$ ($i = A, B$ and $p \in \{0, 1\}$) the set of lifetime utility levels of agent i.

When LT^A is reduced to a singleton, inequality (16) used twice implies that LT^B is also a singleton. In other words, ϕ_A and ϕ_B are constant, and without loss of generality, we can assume that these constants are identical, which proves the result. We henceforth assume that LT^A contains at least two distinct elements.

We define the function $f : LT^A \to \mathbb{R}$ as: for any $u \in LT^A$, $f(u) = \phi_B(c_1, c_2, p)$, where $(c_1, c_2, p) \in X \times \{0, 1\}$ verify $\phi_A(c_1, c_2, p) = u$. By definition of LT^A, such a triplet (c_1, c_2, p) exists for any $u \in LT^A$ – it may be non unique, though. Let us check that f is well-defined. Let $u \in LT^A$ and (c_1, c_2, p) and (c'_1, c'_2, p') in $X \times \{0, 1\}$, such that $u = \phi_A(c_1, c_2, p) = \phi_A(c'_1, c'_2, p')$. Using inequality (16) twice, we deduce that $\phi_B(c_1, c_2, p) = \phi_B(c'_1, c'_2, p')$ and that $f(u)$ is independent of the choice of the element in the pre-image set $(\phi_B)^{-1}(\{u\})$. Hence f is well-defined.

Let us prove that f is increasing on LT^A. Let $u > u'$ in LT^A that contains at least two distinct elements. By definition of LT^A, we have $u = \phi_A(c_1, c_2, p) > \phi_A(c'_1, c'_2, p') = u'$ for (c_1, c_2, p) and (c'_1, c'_2, p') in $X \times \{0, 1\}$. Inequality (16) implies $\phi_B(c_1, c_2, p) > \phi_B(c'_1, c'_2, p')$ – indeed shall we have $\phi_B(c_1, c_2, p) \leq \phi_B(c'_1, c'_2, p')$, (16) would imply $\phi_A(c_1, c_2, p) \leq \phi_A(c'_1, c'_2, p')$, which contradicts $u > u'$. By definition of f, we obtain $f(u) > f(u')$. We thus deduce that f is increasing.

Therefore, $f \circ \phi_A$ represents the same preferences as ϕ_A. We can thus assume that equality (17) holds. $\qquad\square$

We denote by ψ_A and ψ_B the utility functions representing the preferences of agents A and B, constructed using Lemma 2. A direct corollary of Lemma 3 is the following one.

Lemma 4. *If Agents A and B have the same ordinal preferences, then the functions ψ_A and ψ_B defined in the sense of Lemma 2 can be assumed to be defined on the same set $D \times [0, 1]$.*

Proof. Lemma 2 implies that ψ_A and ψ_B can be defined on two sets denoted by D_A and D_B. Each of the set, D_i, can be seen as the Cartesian product $\phi_i(X, 0) \times \phi_i(X, 1)$ (where $\phi_i(X, p)$ for $p \in \{0, 1\}$ is the set of lifetime utilities either in case of certain survival, with $p = 1$ or in case of certain death with $p = 0$). Since both agents are assumed to have the same ordinal preferences, Lemma 3 implies that ϕ^A and ϕ^B can be assumed to be identical (up to some harmless renormalization). Hence the sets $\phi_i(X, 0) \times \phi_i(X, 1) = D_i$ are identical. $\qquad\square$

We assume henceforth that ψ_A and ψ_B are defined on the same set D. We make the following assumption.

Assumption 4. *We assume that:*

- the functions ψ_A and ψ_B are continuously differentiable,

- the partial derivatives of ψ_A and ψ_B verify for all $(u_1, u_2) \in D$:

$$\frac{\partial \psi_i}{\partial u_1}(u_1, u_2, p) \geq 0 \text{ and } \frac{\partial \psi_i}{\partial u_2}(u_1, u_2, p) \geq 0.$$

Assumption 4 is weaker than the one made in the main text, where we impose strict positivity of partial derivatives of ψ. We can similarly derive a result that extends Lemma 1.

Lemma 5 (Generalizing Lemma 1). *Agent A is more risk averse than agent B, if and only if for all $(u_1, u_2) \in D$:*

$$\frac{\partial \psi_A(u_1, u_2, p)}{\partial u_2}\frac{\partial \psi_B(u_1, u_2, p)}{\partial u_1} \leq \frac{\partial \psi_A(u_1, u_2, p)}{\partial u_1}\frac{\partial \psi_B(u_1, u_2, p)}{\partial u_2}. \tag{18}$$

Proof. We start with proving that A more risk averse than B implies inequality (18). Let $p \in [0, 1]$, and $(u_1, y), (u'_1, u'_2) \in D$ such that, $u'_1 \leq u'_2$, $u_1 = u'_1 - \varepsilon_1$ and $u_2 = u'_2 + \varepsilon_2$ (with $\varepsilon_1, \varepsilon_2 > 0$). Let assume that $\frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p) = 0$. In that case, since ψ_A and ψ_B are nondecreasing in u_1 and u_2, we deduce that

$$(u'_2 - u'_1)\frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p)\frac{\partial \psi_B}{\partial u_1}(u'_1, u'_2, p) = 0 \leq (u'_2 - u'_1)\frac{\partial \psi_A}{\partial u_1}(u'_1, u'_2, p)\frac{\partial \psi_B}{\partial u_2}(u'_1, u'_2, p),$$

and inequality (18) holds. We now assume that $\frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p) > 0$. We have:

$$\psi_i(u_1, u_2, p) = \psi_i(u'_1, u'_2, p) - \varepsilon_1\frac{\partial \psi_i}{\partial u_1}(u'_1, u'_2, p) + \varepsilon_2\frac{\partial \psi_i}{\partial u_2}(u'_1, u'_2, p) + o(\varepsilon_1, \varepsilon_2),$$

where $o(\varepsilon_1, \varepsilon_2)$ is a generic function such that $\varepsilon_i^{-1}o(\varepsilon_1, \varepsilon_2) \to_{(\varepsilon_1, \varepsilon_2) \to (0,0)} 0$. Since A is more risk averse than B and $u_1 \leq u'_1 \leq u'_2 \leq u_2$, equation (5) is equivalent to:

$$\varepsilon_2\frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p) \geq \varepsilon_1\frac{\partial \psi_A}{\partial u_1}(u'_1, u'_2, p) \Rightarrow \varepsilon_2\frac{\partial \psi_B}{\partial u_2}(u'_1, u'_2, p) \geq \varepsilon_1\frac{\partial \psi_B}{\partial u_1}(u'_1, u'_2, p).$$

We choose ε_2 such that $\varepsilon_2 = \varepsilon_1\frac{\partial \psi_A}{\partial u_1}(u'_1, u'_2, p)(\frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p))^{-1} > 0$. The above inequality implies:

$$\frac{\partial \psi_A}{\partial u_1}(u'_1, u'_2, p)\frac{\partial \psi_B}{\partial u_2}(u'_1, u'_2, p) \geq \frac{\partial \psi_A}{\partial u_2}(u'_1, u'_2, p)\frac{\partial \psi_B}{\partial u_1}(u'_1, u'_2, p),$$

which proves (18) with $u'_1 \leq u'_2$. The case $u'_1 \geq u'_2$ is symmetric.

Let us prove the other implication and assume that (18) holds. We define $u_k(t) = u'_k(1 - t) + tu_k$ with $k = 1, 2$, such that $u_1(0) = u'_1$, $u_2(0) = u'_2$, $u_1(1) = u_1$, $u_2(1) = u_2$. We consider the function $h_A : t \in [0, 1] \mapsto \inf_{s \in [t,1]} \psi_A(u_1(s), u_2(s), p)$. Because ψ_A is continuous on $[0, 1]$, ψ_A reaches its infimum on $[t, 1]$ on a point of $[t, 1]$. We thus define as s_t the smallest [21] element of $[t, 1]$, where ψ_A reaches its

---

[21]Its existence follows from $\arg\min_{s \in [t,1]} \psi_A(s)$ being the pre-image of a singleton and being closed; it is also a subset of $[t, 1]$, which is compact, hence it is compact.

minimum. Formally:

$$\forall t \in [0,1], \bar{s}_t = \min\{s \in [t,1], \ h_A(t) = \psi_A(u_1(s_t), u_2(s_t), p)\}.$$

Then we define:

$$\forall s \in [t, \bar{s}_t], \ \tilde{u}_k(s) = u_k(s_t),$$
$$\hat{h}_A(s) = h_A(s_t).$$

Note that since ψ_A is continuous and non-constant, it admits at most a countable number of local minima (see Behrends et al., 2007-2008). Hence there is a (at most) countable set of points $0 \leq t_1 < t_2 < \ldots \leq 1$ and a countable set of segments $[\underline{s}_{t_n}, \bar{s}_{t_n}]$ of strictly positive size such that for any n:

$$\forall s \in [\underline{s}_{t_n}, \bar{s}_{t_n}], \tilde{u}_k(s) = u_k(s_t),$$
$$\hat{h}_A(s) = h_A(s_t).$$

For any $t \in [0,1] \setminus \bigcup_{n \geq 1}[\underline{s}_{t_n}, \bar{s}_{t_n}]$, we have:

$$\tilde{u}_k(t) = u_k(t),$$
$$\hat{h}_A(t) = h_A(t).$$

It is then immediate to check that: (i) $\tilde{u}_1(0) = u_1'$, $\tilde{u}_2(0) = u_2'$, $\tilde{u}_1(1) = u_1$, $\tilde{u}_2(1) = u_2$, (ii) $\tilde{u}_k(\cdot)$ is increasing and piecewise continuous (with at most a countable number of jumps), that admits left and right derivatives everywhere (both may differ along a countable set), (iii) the function $\hat{h}_A$ is continuous, left and right differentiable everywhere (both derivatives may differ along a countable set). Let define $0 \leq d_1 < d_2 < \ldots < 1$ the countable set of points such that $\tilde{u}_k$ and $\hat{h}_A$ are differentiable on every (d_j, d_{j+1}). Then for any j and any $t \in (d_j, d_{j+1})$, we have:

$$u_1'(t)\psi_{A,1}(u_1(t), u_2(t), p) + u_2'(t)\psi_{A,2}(u_1(t), u_2(t), p) \geq 0$$

If $\frac{\psi_{A,1}(u_1(t), u_2(t), p)}{\psi_{A,2}(u_1(t), u_2(t), p)} \geq \frac{\psi_{B,1}(u_1(t), u_2(t), p)}{\psi_{B,2}(u_1(t), u_2(t), p)}$ we obtain (since $u_1'(t) \leq 0$ and $u_2'(t) \geq 0$)

$$u_1'(t)\psi_{B,1}(u_1(t), u_2(t), p) + u_2'(t)\psi_{B,2}(u_1(t), u_2(t), p) \geq 0$$

and by integration over (d_j, d_{j+1}) and summing over j, $\psi_B(u_1, u_2, p) \geq \psi_B(u_1', u_2', p)$.
□

Lemma 5 directly implies equality (6) – and hence Lemma 1 – when the partial derivatives of ψ^i are further assumed to be non-zero.

C.3 Saving behavior: Proofs

C.3.1 Proof of Proposition 2

Proof. Let $p \in (0,1)$. For the sake of simplicity, we denote for $k = 1, 2$ and for all $s \in [0, W]$:

$$\tilde{U}_k(s) = U_k(W - s, Rs), \ k = 1, 2, \tag{19}$$

$$\tilde{\psi}_i(s) = \psi_i(U_1(W - s, Rs), U_2(W - s, Rs), p), \ i = A, B, \tag{20}$$

$$\frac{\partial \tilde{\psi}_i}{\partial u_k}(s) = \frac{\partial \psi_i}{\partial u_k}(U_1(W - s, Rs), U_2(W - s, Rs), p) \tag{21}$$

which interprets as the lifetime utility as a function of saving choices. Assumption 2 guarantees that the function $\tilde{U}_i$ is strictly concave.

The first point of Proposition 2 is a direct implication of monotonicity and the strict concavity of lifetime utility functions. Indeed, let for instance assume that $s_A^* < \underline{s} \leq \overline{s}$. In that case, because of the strict concavity of lifetime utilities, we have:

$$\tilde{U}_1(\underline{s}) > \tilde{U}_1(s_A^*) \text{ and } \tilde{U}_2(\underline{s}) > \tilde{U}_2(s_A^*).$$

Monotonicity implies then that agent A strictly prefers saving $\underline{s}$ rather than s_A^*. The same reasoning applies for B. One could similarly show that $s_A^*, s_B^* < \overline{s}$.

A corollary of this first point is that if $s_A^* = \underline{s}$, the second point of Proposition 2 holds since $s_A^* = \underline{s} \leq s_B^*$. We can thus assume that $s_A^* > \underline{s}$.

As a preliminary to the second point, observe that we must have $\tilde{U}_1'(\underline{s}) \leq 0$. Indeed, since $\underline{s} \in [0, W]$ and $\underline{s} < \overline{s}$, we deduce that either $\underline{s} = 0$ (and $\tilde{U}_1'(\underline{s}) > 0$ otherwise contradicts $\underline{s} = 0$) or $\underline{s}$ is interior (and $\tilde{U}_1'(\underline{s}) = 0$). The strict concavity of $\tilde{U}_1$ then implies $\tilde{U}_1'(s) < 0$ for all $s > \underline{s}$. We symmetrically prove that $\tilde{U}_2'(s) > 0$ for all $s < \overline{s}$.

Assumption 4 implies that $\frac{\partial \psi_i}{\partial u_1} > 0$ and $\frac{\partial \psi_i}{\partial u_2} > 0$. Let us start with assuming that the solution to the saving program (8) for agent A is a corner solution: $s_A^* = \overline{s}$. In that case, with notation (20) the FOC of the saving program is:

$$\tilde{U}_1'(\overline{s})\frac{\partial \tilde{\psi}_A}{\partial u_1}(\overline{s}) + \tilde{U}_2'(\overline{s})\frac{\partial \tilde{\psi}_A}{\partial u_2}(\overline{s}) \geq 0.$$

or equivalently, using previous remarks ($\frac{\partial \tilde{\psi}_A}{\partial u_2}(\overline{s}) > 0$ and $\tilde{U}_1'(\overline{s}) < 0$):

$$\frac{\frac{\partial \tilde{\psi}_A}{\partial u_1}(\overline{s})}{\frac{\partial \tilde{\psi}_A}{\partial u_2}(\overline{s})} \leq -\frac{\tilde{U}_2'(\overline{s})}{\tilde{U}_1'(\overline{s})}. \tag{22}$$

Since A is more risk averse than B and since $\tilde{U}_2(\overline{s}) > \tilde{U}_1(\overline{s})$, inequality (6) holds and implies with (22): $\tilde{U}_1'(\overline{s})\frac{\partial \tilde{\psi}_B}{\partial u_1}(\overline{s}) + \tilde{U}_2'(\overline{s})\frac{\partial \tilde{\psi}_B}{\partial u_2}(\overline{s}) \geq 0$, which means that $s_B^* = \overline{s}$ and

the second point of Proposition 2 holds. We can next assume that s_A^* is interior, and similarly that s_B^* is interior (either $s_B^* = \overline{s}$ and this is direct, or $s_B^* = \underline{s}$ and we then prove that $s_A^* = \underline{s}$). The two saving levels are thus characterized by the following FOCs:

$$\frac{\frac{\partial \tilde{\psi}_A}{\partial u_1}(s_A^*)}{\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_A^*)} = -\frac{\tilde{U}_2'(s_A^*)}{\tilde{U}_1'(s_A^*)} \text{ and } \frac{\frac{\partial \tilde{\psi}_B}{\partial u_1}(s_B^*)}{\frac{\partial \tilde{\psi}_B}{\partial u_2}(s_B^*)} = -\frac{\tilde{U}_2'(s_B^*)}{\tilde{U}_1'(s_B^*)}. \tag{23}$$

Furthermore, since s_A^* is unique by assumption, we must have:

$$\tilde{U}_1'(s)\frac{\partial \tilde{\psi}_A}{\partial u_1}(s) + \tilde{U}_2'(s)\frac{\partial \tilde{\psi}_A}{\partial u_2}(s) > 0 \text{ for } s < s_A^*, \tag{24}$$

Indeed, consider $s \mapsto \tilde{U}_1'(s)\frac{\partial \tilde{\psi}_A}{\partial u_1}(s) + \tilde{U}_2'(s)\frac{\partial \tilde{\psi}_A}{\partial u_2}(s)$ on $s < s_A^*$. It cannot change sign or cancel unless contradicting the uniqueness of s_A^*. If strictly negative, it means that utility can be strictly increased by considering $s < s_A^*$ and close to s_A^* – which contradicts the optimality of s_A^*.

Let assume that $s_A^* > s_B^*$. We deduce from (23) and (24):

$$\tilde{U}_1'(s_B^*)\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_B^*)\left(\frac{\frac{\partial \tilde{\psi}_A}{\partial u_1}(s_B^*)}{\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_B^*)} - \frac{\frac{\partial \tilde{\psi}_B}{\partial u_1}(s_B^*)}{\frac{\partial \tilde{\psi}_B}{\partial u_2}(s_B^*)}\right) > 0,$$

which, with $\tilde{U}_1'(s_B^*) < 0$ and $\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_B^*) > 0$, implies:

$$\frac{\frac{\partial \tilde{\psi}_A}{\partial u_1}(s_B^*)}{\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_B^*)} < \frac{\frac{\partial \tilde{\psi}_B}{\partial u_1}(s_B^*)}{\frac{\partial \tilde{\psi}_B}{\partial u_2}(s_B^*)},$$

which contradicts inequality (6) and A more risk averse than B. $\qquad\square$

C.3.2 A formal definition of consequentialism

We provide here a formal definition of consequentialism that underlies inequality (2) for marginal rate of substitution.

Definition 2. We will say that agent i is consequentialist if and only if for all $(u_1, u_2), (u_1', u_2') \in D$ such that $u_1 \leq u_1' \leq u_2' \leq u_2$ and $p, p' \in [0, 1]$ we have:

$$p' \geq p \Rightarrow (\psi_i(u_1, u_2, p) \geq \psi_i(u_1', u_2', p)) \Rightarrow (\psi_i(u_1, u_2, p') \geq \psi_i(u_1', u_2', p')). \tag{25}$$

Definition 2 states that if a spread of utilities u_1, u_2 is preferred to u_1', u_2' for a survival probability p, then it is also preferred for any higher survival probability.

Definition 2 implies inequality (2), as can be seen in the following lemma – which is a slight generalization of (2) that does not require strictly positive derivatives for ψ^i.

Lemma 6. *Agent i is consequentialist if and only if for all $(u_1, u_2) \in D$ and all $p, p' \in [0,1]$:*

$$(p' - p)\frac{\partial \psi_i(u_1, u_2, p')}{\partial u_1}\frac{\partial \psi_i(u_1, u_2, p)}{\partial u_2} \leq (p' - p)\frac{\partial \psi_i(u_1, u_2, p')}{\partial u_1}\frac{\partial \psi_i(u_1, u_2, p')}{\partial u_2}. \quad (26)$$

Proof. Let $(u_1', u_2') \in D$, such that $u_2' > u_1'$, $0 \leq p \leq p' \leq 1$, and $\varepsilon_x > 0$. We set $\varepsilon_y = \frac{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_1}}{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_2}}\varepsilon_x > 0$. We have:

$$\psi_i(u_1' - \varepsilon_x, u_2' + \varepsilon_y, p) = \psi_i(u_1', u_2', p) - \varepsilon_x\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_1} + \varepsilon_y\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_2} + o(\varepsilon_x, \varepsilon_y)$$

$$= \psi_i(u_1', u_2', p) + o(\varepsilon_x).$$

The term in $o(\varepsilon_x)$ could be made arbitrarily small and we hence deduce from (25) and from a similar first-order development that:

$$-\varepsilon_x\frac{\partial \psi_i(u_1', u_2', p')}{\partial u_1} + \frac{\partial \psi_i(u_1', u_2', p')}{\partial u_2}\frac{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_1}}{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_2}}\varepsilon_x + o(\varepsilon_x) \geq 0.$$

Dividing by ε_x and taking the limit $\varepsilon_x \to 0$, we obtain:

$$\frac{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_1}}{\frac{\partial \psi_i(u_1', u_2', p)}{\partial u_2}} \geq \frac{\frac{\partial \psi_i(u_1', u_2', p')}{\partial u_1}}{\frac{\partial \psi_i(u_1', u_2', p')}{\partial u_2}}.$$

$\square$

C.3.3 Proof of Proposition 1

Proof. Let $p, p' \in (0,1)$ with $p' \geq p$. We can assume that $s_p^* > \underline{s}$. Let us start with assuming that $s_p^* = \overline{s}$. In that case, with notation (20) the FOC of the saving program is:

$$\tilde{U}_1'(\overline{s})\frac{\partial \tilde{\psi}_p}{\partial u_1}(\overline{s}) + \tilde{U}_2'(\overline{s})\frac{\partial \tilde{\psi}_p}{\partial u_2}(\overline{s}) \geq 0,$$

where we make the dependence in p explicit. Equivalently, using the remarks of the proof of Proposition 2 ($\frac{\partial \tilde{\psi}_p}{\partial u_2}(\overline{s}) > 0$ and $\tilde{U}_1'(\overline{s}) < 0$):

$$\frac{\frac{\partial \tilde{\psi}_p}{\partial u_1}(\overline{s})}{\frac{\partial \tilde{\psi}_p}{\partial u_2}(\overline{s})} \leq -\frac{\tilde{U}_2'(\overline{s})}{\tilde{U}_1'(\overline{s})}. \quad (27)$$

Since $p' \geq p$ and since $\tilde{U}_2(\overline{s}) > \tilde{U}_1(\overline{s})$, inequality (2) holds and implies with (27): $\tilde{U}_1'(\overline{s})\frac{\partial \tilde{\psi}_{p'}}{\partial u_1}(\overline{s}) + \tilde{U}_2'(\overline{s})\frac{\partial \tilde{\psi}_{p'}}{\partial u_2}(\overline{s}) \geq 0$, which means that $s_{p'}^* = \overline{s}$ and the second point of Proposition 2 holds. We now consider that s_p^* is interior, and similarly that $s_{p'}^*$

also is. The two saving levels are thus characterized by the following FOCs:

$$\frac{\frac{\partial \tilde{\psi}_p}{\partial u_1}(s_p^*)}{\frac{\partial \tilde{\psi}_p}{\partial u_2}(s_p^*)} = -\frac{\tilde{U}_2'(s_p^*)}{\tilde{U}_1'(s_p^*)} \text{ and } \frac{\frac{\partial \tilde{\psi}_{p'}}{\partial u_1}(s_{p'}^*)}{\frac{\partial \tilde{\psi}_{p'}}{\partial u_2}(s_{p'}^*)} = -\frac{\tilde{U}_2'(s_{p'}^*)}{\tilde{U}_1'(s_{p'}^*)}. \tag{28}$$

Furthermore, since s_p^* is unique by assumption, we must have:

$$\tilde{U}_1'(s)\frac{\partial \tilde{\psi}_p}{\partial u_1}(s) + \tilde{U}_2'(s)\frac{\partial \tilde{\psi}_p}{\partial u_2}(s) > 0 \text{ for } s < s_p^*, \tag{29}$$

Indeed, consider $s \mapsto \tilde{U}_1'(s)\frac{\partial \tilde{\psi}_p}{\partial u_1}(s) + \tilde{U}_2'(s)\frac{\partial \tilde{\psi}_p}{\partial u_2}(s)$ on $s < s_p^*$. It cannot change sign or cancel unless contradicting the uniqueness of s_p^*. If strictly negative, it means that utility can be strictly increased by considering $s < s_p^*$ and close to s_p^* – which contradicts the optimality of s_p^*.

Let assume that $s_p^* > s_{p'}^*$. We deduce from (28) and (29):

$$\tilde{U}_1'(s_{p'}^*)\frac{\partial \tilde{\psi}_p}{\partial u_2}(s_{p'}^*)\left(\frac{\frac{\partial \tilde{\psi}_p}{\partial u_1}(s_{p'}^*)}{\frac{\partial \tilde{\psi}_p}{\partial u_2}(s_{p'}^*)} - \frac{\frac{\partial \tilde{\psi}_{p'}}{\partial u_1}(s_{p'}^*)}{\frac{\partial \tilde{\psi}_{p'}}{\partial u_2}(s_{p'}^*)}\right) > 0,$$

which, with $\tilde{U}_1'(s_{p'}^*) < 0$ and $\frac{\partial \tilde{\psi}_A}{\partial u_2}(s_{p'}^*) > 0$, implies:

$$\frac{\frac{\partial \tilde{\psi}_p}{\partial u_1}(s_{p'}^*)}{\frac{\partial \tilde{\psi}_p}{\partial u_2}(s_{p'}^*)} < \frac{\frac{\partial \tilde{\psi}_{p'}}{\partial u_1}(s_{p'}^*)}{\frac{\partial \tilde{\psi}_{p'}}{\partial u_2}(s_{p'}^*)},$$

which contradicts inequality (2) and that i is p-monotone. $\qquad\square$

C.3.4   Proof of Proposition 3

We start with inequality (9). Since agents A and B have identical ordinal preferences, their behavior in the absence of risk is identical and their savings, when survival is certain, is the same: $s_A(1) = s_B(1)$. We thus obtain from Proposition 3 that for any $\varepsilon > 0$:

$$s_A(1 - \varepsilon) - s_A(1) \leq s_B(1 - \varepsilon) - s_B(1) \leq 0, \tag{30}$$

which shows that the increase ε in mortality probability implies a higher reduction in savings for the more risk averse agent. We deduce the formal result (9) from inequality (30) by dividing by $-\varepsilon < 0$ and taking the limit $\varepsilon \to 0^+$.

Let us turn to inequality (10). Since we also have $s_A(0) = s_B(0)$, we deduce $s_A(\varepsilon) - s_A(0) \leq s_B(\varepsilon) - s_B(0)$ for any $\varepsilon > 0$ and the result is then direct.