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Abstract

The paper discusses the impact of longevity extension on aggregate wealth accumulation, accounting for changes in individual behaviors as well as changes in population age structure. It departs from the standard literature by adopting risk-sensitive preferences. Human impatience is then closely related to mortality rates and aggregate wealth accumulation appears to be much more sensitive to demographic factors than usually found. Illustrations are provided using historical mortality data from different countries.

JEL codes : J1, E21, D91.
Keywords : longevity, life-cycle savings, wealth accumulation, risk-sensitive preferences, risk aversion.

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1 Introduction

Recent human history is characterized by rapid changes in mortality that are likely to have major economic consequences. A number of articles have emphasized that longevity extension may have had a significant impact on economics growth due to its impact on (physical or human) capital accumulation[1].

The present paper discusses the impact of longevity extension on aggregate wealth accumulation, accounting for changes in individual behavior as well as changes in population age structure. Its originality is that it relies on risk-sensitive preferences which makes it possible to discuss the role of risk aversion. It is found that properly accounting for risk aversion leads to significantly revise the qualitative and quantitative conclusions about the impact of mortality decline. In particular, applications using historical demographic data indicate that mortality decline may have generated a much larger increase in wealth accumulation than what is found with more common models. This is due to an impatience effect that arises when relaxing the assumption of additive separability of preferences.

Risk-sensitive preferences extend the standard additive life-cycle model while maintaining the assumption of preference stationarity. In short, instead of assuming that the agent's utility function fulfills the following recursion:

$$V_t^{\text{add}} = u(c_t) + \beta E[V_{t+1}^{\text{add}}]$$

as is done when using the additive model with exponential discounting, we will assume that

$$V_t = u(c_t) - \frac{\beta}{k} \log\left(E[e^{-kV_{t+1}}]\right) \tag{1}$$

where k is a constant.

These so called risk-sensitive preferences belong to the class of preferences introduced by Kreps and Porteus (1978). They are similar to those of Epstein and Zin (1989) but rely on a different aggregator function. They were first introduced by Hansen and Sargent (1995)[2]. Risk-sensitive preferences were shown in

[1]References in this literature include Blanchard (1985), Auerbach and Kotlikoff (1992), De la Croix and Licandro (1999), Kalemli-Ozcan, Ryder and Weil (2000), Boucekkine De la Croix and Licandro (2002), Zhang, Zhang and Lee (2001, 2003), Lee, Mason and Miller (2002 and 2003), Bloom, Canning and Graham (2003), Cervellati and Sunde (2005), Sheshinsky (2006), Echevarria and Iza (2006), Hazan and Zoabi (2006), Lorentzen, McMillan and Wacziarg (2008), Hazan (2009), among many others.

[2]An interesting overview of non-additive preferences, including risk-sensitive preferences, can be found in Backus, Routledge and Zin (2005).

Bommier and Le Grand (2013) to be the only ones, among Kreps and Porteus stationary preferences, to fulfill a natural property of monotonicity with respect to first-order stochastic dominance and be well ordered in term of risk aversion. The constant k that enters into the formulation of individual utility (1) has a straightforward interpretation in terms of risk aversion. The larger k, the larger risk aversion. Two individuals who only differ by the constant k have the same ranking of deterministic consumption paths but different degrees of risk aversion. This class of preferences allow therefore to disentangle the intertemporal elasticity of substitution, determined by the curvature of the function $u(.)$, and risk aversion, related to the scalar k. The standard additive model is obtained as the limit case where $k \to 0$.

Accounting for risk aversion is crucial for understanding life-cycle consumption smoothing of human (and therefore mortal) beings, since the combination of risk aversion and lifetime uncertainty generates impatience. This effect was first highlighted in Bommier (2006) in a contribution focusing on the expected utility framework. The intuition is that risk aversion provides incentives to consume a lot when young in order to avoid the particularly bad outcome which consists in having a short life with low consumption levels. In other words, "*Carpe diem*" is a rational precept for risk averse individuals. Impatience being closely related to mortality, one may naturally expect that mortality decline induces significant changes in human impatience.

The present paper makes contributions in two directions. Firstly, it discusses how changes in mortality rates impact time discounting. In particular, it is shown that, although there is a strong theoretical relation between mortality risk and human impatience, it is not necessarily the case that lower mortality implies lower impatience. The story is more complex since mortality contributes to several terms that impact human impatience in opposite directions. Whether mortality decline eventually leads to an increase or a decrease in human impatience depends on how mortality at young ages falls compared to mortality at old ages. Moreover, the impact mortality changes is found to crucially depends on the degree of risk aversion. This explains why predictions about the relation between longevity and wealth accumulation significantly changes when we depart from the usual additive model in order to consider greater levels of risk aversion.

Secondly, in order to highlight the role of the impatience effect generated by temporal risk aversion, the paper introduces a simple method for assessing the impact of mortality decline on aggregate wealth accumulation. The method makes it possible to break down the impact of mortality decline into several components, reflecting aggregation, income dilution and impatience effects. This method is implemented with historical mortality data taken from different countries. It is found that the impatience effect, which vanishes when relying on the standard additive model, may actually be the most important one once accounting for temporal risk aversion. The paper suggests therefore a significant shift in the assessment of the impact of mortality decline. It emphasizes that the main impact of mortality decline on wealth accumulation may not be caused by the changes in population age structure (population aging) -as usually found- but related to its impact on individual behavior.

The paper is structured as follows. In Section 2, we introduce risk-sensitive preferences and apply them to the case where agents face a mortality risk. Section 3 discusses how changes in mortality rates impact time discounting. Section 4 is about life-cycle behavior of agents with risk-sensitive preferences. Section 5 deals with the aggregation of individuals' wealth. We suggest a breakdown of the impact of mortality changes on aggregate wealth accumulation into three components reflecting aggregating, income dilution and impatience effects. Section 6 develops and discusses illustrations based on mortality rates observed over the period 1950-2008 in different countries. Concluding comments are set forth in Section 7.

2 Setting and individual preferences

We consider agents who consume a single consumption good and face exogenous mortality risks. To make it simple, we will assume that mortality risks are the only source of uncertainty and can be described by a simple transition process where death is an absorbing state. An agent alive at age t has a probability μ_t to be dead at age $t+1$ and a probability $(1-\mu_t)$ to remain alive. An agent who is dead at age t is dead for sure at age $t+1$. To avoid potential technical problems of convergence, it will be assumed that for all mortality patterns $(\mu_t)_{t\geq 0}$ there is an age T such that $\mu_T = 1$.

Agents are endowed with risk-sensitive preferences as introduced by Hansen and Sargent (1995) and derived by Bommier and Le Grand (2013) as the only Kreps and Porteus preferences fulfilling the assumptions of stationarity, weak separability and monotonicity. Formally, denoting V_t the continuation utility of the agent in period t we have the recursion:

$$V_t = u_t - \frac{\beta}{k} \log(E_t[\exp(-kV_{t+1})])$$

where $\beta > 0$, $k \in \mathbb{R}$, $u_t = d \in \mathbb{R}$ in the case where the agent is dead and $u_t = u(c_t) \in \mathbb{R}$ in the case where the agent is alive and consumes c_t. By normalization, it can be assumed that $d = 0$, which implies that the continuation utility of a dead agent is 0. We will assume that for all consumptions levels that are considered in the paper, we have $u(c_t) > 0$. In other words, with these consumption levels, being alive is considered as preferable to being dead[3].

Risk-sensitive preferences includes the standard additive model with exponential time discounting, obtained when $k = 0$, and the multiplicative model of Bommier (2011) obtained when $\beta = 1$.[4]

Denoting by U_t the continuation utility at age t conditional on being alive in period t, we have:

$$U_t = u(c_t) - \frac{\beta}{k} \log((1 - \mu_t)e^{-kU_{t+1}} + \mu_t) \tag{2}$$

In the particular cases where $k = 0$ or where $\beta = 1$ one can provide a simple expression of the utility U_t as a function of future consumption and mortality rates[5]. However, apart from these two particular cases, there is no simple way to derive from the recursion (2) a simple expression lifetime utility U_t . This is not

[3] Depending on the specification of the utility function $u()$, assuming that $u(c_t) > 0$ may require to assume that consumption does not go below an extreme poverty treshold that would make life worse than death.

[4] In both these particular cases ($k = 0$ or $\beta = 1$) agents are in fact expected utility maximizers and, therefore, indifferent to the timing of the resolution of uncertainty. Preferences for the timing arise when $k \neq 0$ and $\beta \neq 1$,with preferences for an early resolution of uncertainty when $k > 0$ and $\beta < 1$ (see Section 6 in Bommier and Le Grand, 2013).

[5] One can show that

$$k = 0 \Longrightarrow U_t = \sum_{\tau=t}^{+\infty} \left(\prod_{i=t}^{\tau-1} (1 - \mu_i) \right) \beta^{\tau-t} u(c_t)$$

where one can easily recognize the expression of expected lifetime utility associated with the standard additive model.

An explicit expression of lifetime utility can also be obtained when $\beta = 1$. We have then:

$$\beta = 1 \Longrightarrow U_t = -\frac{1}{k} \log \left(\sum_{\tau=t}^{+\infty} \mu_\tau \left(\prod_{i=t}^{\tau-1} (1 - \mu_i) \right) \exp(-k \sum_{j=t}^{\tau} u(c_i)) \right)$$

which corresponds to the multiplicative model of Bommier (2011).

a major inconvenience since first order conditions in consumption/savings optimization problems can be derived directly from the recursive equation, without needing to have an explicit expression of lifetime utility.

3 Mortality and time discounting

In order to better understand how mortality impacts life-cycle behavior, and in particular human impatience, we look at the relation between mortality rates and the rate of time discounting. We first formalize what is meant by "rate of time discounting":

Definition 1 *The rate of time discounting at time t is given by:*

$$RD_t = \frac{\frac{\partial U_t}{\partial c_t}}{\frac{\partial U_t}{\partial c_{t+1}}}\Big|_{c_{t+1}=c_t} - 1.$$

The rate of time discounting measures how rapidly the marginal utility of consumption decreases with time, when controlling for variations in consumption. In the case of risk-sensitive preferences the rate of time discounting has a fairly simple expression. Indeed, from equation (2), one obtains

$$\frac{\partial U_t}{\partial c_t} = u'(c_t) \tag{3}$$

and using equations (2) and (3) together:

$$\frac{\partial U_t}{\partial c_{t+1}} = \frac{\beta}{1 + \frac{\mu_t}{(1-\mu_t)}\exp(kU_{t+1})}\frac{\partial U_{t+1}}{\partial c_{t+1}} = \frac{\beta}{1 + \frac{\mu_t}{(1-\mu_t)}\exp(kU_{t+1})}u'(c_{t+1}) \tag{4}$$

Combining (3) and (4) one gets:

$$RD_t = \frac{1}{\beta}\left(1 + \frac{\mu_t}{(1-\mu_t)}\exp(kU_{t+1})\right) - 1 \tag{5}$$

We find that the rate of time discounting thus depends on pure time preferences (β), mortality rate at time t, risk aversion (k) and continuation utility. In absence of mortality (i.e. when $\mu_t = 0$) we would have $RD_t = \frac{1}{\beta} - 1$, corresponding to the well-known formula for infinitely long lived agents. Mortality however contributes to time discounting through two channels. The first one is due to the presence of μ_t in (5), and the second to the fact that continuation utility (U_{t+1})

depends on mortality rates. Continuation utility being independent on mortality at ages smaller or equal than t but decreasing with mortality at ages larger than t, we can state the following result:

Proposition 1 *The rate of time discounting at age t is such that:*

- it is independent of mortality rates at ages smaller than t (i.e. $\tau < t \Rightarrow \frac{\partial RD_t}{\partial \mu_\tau} = 0$)

- it increases with mortality at age t.(i.e. $\frac{\partial RD_t}{\partial \mu_t} > 0$)

- if $k = 0$, it is independent of mortality at ages larger than t. (i.e. $k = 0$ and $\tau > t \Rightarrow \frac{\partial RD_t}{\partial \mu_\tau} = 0$)

- if $k > 0$, it decreases with mortality at ages larger than t (i.e. $k > 0$ and $\tau > t \Rightarrow \frac{\partial RD_t}{\partial \mu_\tau} < 0$)

Proof. One has:

$$\frac{\partial RD_t}{\partial \mu_t} = \frac{\exp(kU_{t+1})}{\beta(1-\mu_t)^2} > 0 \tag{6}$$

while

$$\frac{\partial RD_t}{\partial \mu_\tau} = \frac{\mu_t}{\beta(1-\mu_t)} \exp(kU_{t+1}) \frac{\partial U_{t+1}}{\partial \mu_\tau} < 0 \text{ if } k > 0 \tag{7}$$

■

The intuition behind this result is as follows. A temporally risk averse agent uses consumption smoothing to reduce the risk resulting from lifetime uncertainty. Indeed, by consuming earlier in the life-cycle she reduces the risk of having a low level of lifetime utility, which would result from the combination of a short life duration and a low level of consumption. The more likely is the occurrence of death at the end of the period (the larger μ_t) and the more she has to loose in case of death (the larger U_{t+1}) the greater is her willingness to use this risk reduction device. As a consequence, both μ_t and U_{t+1} positively contribute to time discounting, as can be seen from equation (5). Now, the result of Proposition 1 stems from that the fact that continuation utility is independent of past mortality rates and negatively related to future mortality rates.

An important insight brought by equations (6) and (7) is that the impact of mortality changes is amplified by the degree of risk aversion (k). This explains the strength of the impatience effect that will be documented later on.

4 Life-cycle behavior

Assume that a mortality pattern $(\mu_t)_{t\geq 0}$ and an income profile $(y_t)_{t\geq 0}$ are exogenously given. Assume also that intertemporal markets are perfect with an exogenous rate of interest r. In the presence of a perfect annuity market, and without utility of bequests, the agents invest all their wealth in annuities whose gross return between periods t and $t+1$ is $\frac{(1+r)}{(1-\mu_t)}$. Thus, an individual's wealth has the following dynamic:

$$w_{t+1} = \frac{(1+r)}{(1-\mu_t)} w_t + y_t - c_t \tag{8}$$

We assume that individuals have no initial wealth. The budget constraints impose:

$$w_0 = 0 \text{ and } w_{+\infty} \geq 0 \tag{9}$$

Agents alive at age t make plans on their future consumption profile $(c_\tau)_{\tau\geq t}$ in order to maximize their utility U_t. Preferences being stationary, agents' behaviors are time consistent. The first order conditions are:

$$\frac{\frac{\partial U_t}{\partial c_{t+1}}}{\frac{\partial U_t}{\partial c_t}} = \frac{(1-\mu_t)}{(1+r)}$$

However from (3) and (4):

$$\frac{\frac{\partial U_t}{\partial c_{t+1}}}{\frac{\partial U_t}{\partial c_t}} = \frac{\beta}{1 + \frac{\mu_t}{(1-\mu_t)} \exp(kU_{t+1})} \frac{u'(c_{t+1})}{u'(c_t)}$$

so that:

$$\frac{u'(c_{t+1})}{u'(c_t)} = \frac{1 + \mu_t(e^{kU_{t+1}} - 1)}{(1+r)\beta} \tag{10}$$

The first order conditions lead therefore to the following result:

Lemma 1 *Under the assumption of a constant intertemporal elasticity of substitution equal to σ, the optimal consumption profile is such that, for all $t > 0$:*

$$\frac{c_{t+1}}{c_t} = \left[\frac{\beta(1+r)}{1 + \mu_t(e^{kU_{t+1}} - 1)}\right]^\sigma \tag{11}$$

Proof. If the elasticity of substitution equals σ one must have $u'(c) = Kc^{-\frac{1}{\sigma}}$ for some constant K. Then Lemma 1 directly follows from equation (10). ■

An immediate consequence of Lemma 1 is:

Corollary 1 *When $k = 0$, the optimal consumption profile is such that $\forall t > 0$:*

$$\frac{c_{t+1}}{c_t} = (\beta(1+r))^{\sigma}$$

Thus, in the case where the intertemporal elasticity of substitution is constant, and $k = 0$, the consumption growth rate is independent of age and of the mortality pattern, as has been known since Yaari (1965). In such a case, an explicit solution can be given to the consumption problem:

$$c_t^{\text{add}} = c_0 \left(\beta(1+r)\right)^{\sigma t} \text{ with } c_0 = \frac{\sum_{t=0}^{+\infty} \frac{s_t}{(1+r)^t} y_t}{\sum_{t=0}^{+\infty} \frac{s_t \beta^{\sigma t}}{(1+r)^{(1-\sigma)t}}} \tag{12}$$

where

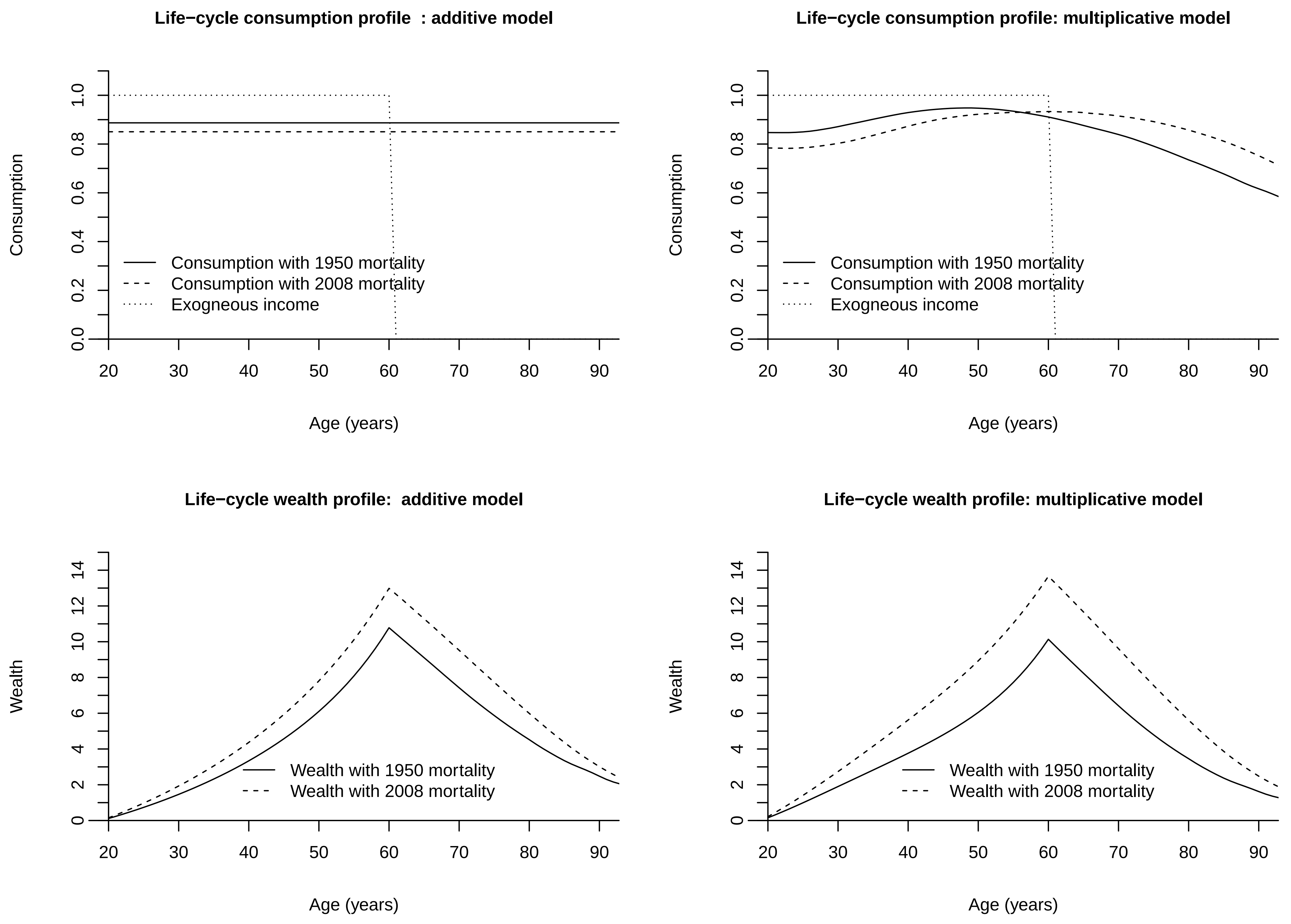
$$s_t = \prod_{\tau=0}^{t-1} (1 - \mu_\tau)$$

is the probability of being alive at age t.

When $k \neq 0$, however, equation (11) does not provide an explicit solution to the consumer problem, since the right hand side of the equality depends on future consumption. Still, it does suggest a fairly simple way to derive the optimum consumption profile by backward induction. A noteworthy feature of the solution, when $k \neq 0$, is that the shape of the consumption profile depends on current mortality rate (μ_t) as well as future mortality rates (through their impact on continuation utility). Thus, even if markets are perfect, different mortality patterns will generate different shapes of optimal consumption profiles, and hence different savings behavior. This is the reason why mortality decline is the source of an impatience effect that arises when $k \neq 0$.

As an illustration, we provide in Figure 1 simulated life-cycle consumption profiles that are obtained for different mortality patterns and different model specifications. More precisely, we compare how life-cycle consumption would have changed as a consequence of mortality decline, while keeping all other parameters (income, retirement age, rate of interest, individual preferences) constant. This is done using both the additive specification ($k = 0$ and $\beta < 1$) and the multiplicative specification ($k > 0$, $\beta < 1$), the exact parametrizations being detailed in Section 6.2, below. The decline in mortality that is considered is obtained by

Figure 1: The impact of mortality decline on life cycle consumption and savings



using 1950 US and 2008 US life tables[6].

On the left hand side of Figure 1, we see that, according to the additive model, mortality decline generates a scaling down of consumption, without affecting the shape of the consumption profile. This is consistent with the results of Corollary 1 that states that when $k = 0$ -and the intertemporal elasticity of substitution is constant- the consumption growth rate should be independent of the mortality patterns. In Figure 1, consumption growth rate is equal to zero, because it was assumed $\beta(1+r) = 1$, so that the effects of time preference and the rate of interest compensate each other. For other choices of β and r, a similar scaling-down of consumption would be observed, but instead of being flat, consumption would grow exponentially if $\beta(1 + r) > 1$ or decrease exponentially if $\beta(1 + r) < 1$. While agents keep a consumption profile of the same form, they have to adjust its level to match the budget constraint. They consume less with 2008 mortality, as they have to sustain a longer retirement period. Mortality decline induces what we will call an "income dilution effect", with a positive impact on savings.

The right hand side of Figure 1 shows what is obtained when assuming multiplicative preferences. The results contrast with those obtained with the additive model in two key aspects: Firstly, the optimal consumption profile is no longer monotonic. Secondly, the shape obtained when using 2008 mortality table is different from the one we get with 1950 mortality rates. Both features result from the fact that, when $k \neq 0$, the optimal consumption growth rate is related to mortality rates, as is shown in Lemma 1. Because mortality rates vary with age, we obtain that the consumption growth rate is non-constant. Since mortality rates typically increase with age, at least for ages above 40, consumption growth rates eventually turn out to be negative at old age, providing the hump-shaped consumption profiles shown in Figure 1. Moreover, as already mentioned, the exact shape of the consumption profile depends on the life table that is used. Mortality in 2008 being significantly lower than in 1950, we observe that the "2008-agents" look significantly less impatient that the "1950-agents", consuming less at young ages and more at old age. As in the additive case, agents have to adapt their consumption level to match the budget constraint. But, on top of that, mortality decline generates an impatience effect, with a positive impact on wealth accumulation.

[6] Several indicators (life expectancy and mortality rates at various ages) illustrating the magnitude of mortality decline that occured between 1950 and 2008 are provided in Tables 1 and 2.

Looking at the bottom graphs in Figure 1, we observe that the predicted increase in savings related to mortality decline is larger when using the multiplicative model than when using the additive one. Actually, if we focus on savings at age 62 (retirement age in our simulation) we observe that savings would have increased by 21.9 % according to the additive model, and 37.6% according to the multiplicative model. In that particular example, the impatience effect amplifies the impact of mortality decline by a factor of 1.7. The following sections will evaluate the magnitude of this impatience effect when considering different patterns of mortality decline. We will discuss how it compares, when aggregated over the whole population, with other effects - as, for example, those related to the changes in population age structure.

5 Aggregate wealth accumulation

Consider now a population composed of individuals of different ages. More precisely, denote by N_a the fraction of individuals of age a, the whole population size being normalized to 1. In the case of a steady-state population, N_a would be proportional to $\frac{s_a}{(1+n)^a}$ where n is the population growth rate and s_a the survival probability at age a. Still, in order to be able to consider historical demographic data on population age structure, we do not make such an assumption. In what follows, the only restriction that we make on the population age structure is that for a large enough, $N_a = 0$. This is consistent with the fact that nobody has ever observed a human being living more than 123 years.

From (8) and (9) we can compute individual's wealth at age a:

$$\begin{aligned} w_a &= \frac{1}{s_a}\sum_{t=0}^{a-1} s_t(1+r)^{a-t}(y_t - c_t) \\ &= \frac{1}{s_a}\sum_{t=a}^{+\infty} s_t(1+r)^{a-t}(c_t - y_t) \end{aligned}$$

where s_t is the survival probability at age t. The aggregate wealth in the population is:

$$W = \sum_{a=0}^{+\infty} N_a w_a = \sum_{a=0}^{+\infty} N_a \frac{1}{s_a}\sum_{t=a}^{+\infty} s_t(1+r)^{a-t}(c_t - y_t)$$

Reordering the sum signs, we get:

$$W = \sum_{t=0}^{+\infty} \Omega_t^{N,s}(y_t - c_t) \tag{13}$$

where:

$$\Omega_t^{N,s} = \sum_{a=0}^{t} \frac{s_t}{s_a} N_a (1+r)^{a-t}$$

Note that the numbers $\Omega_t^{N,s}$ depend on survival probabilities, the population age structure and the rate of interest, but are independent of individual preferences and the income and consumption profiles. These numbers $\Omega_t^{N,s}$ can therefore be computed from demographic data and the rate of interest. As we will see in Section 5.1 below, equation (13) then proves to be quite practical to compute and discuss the determinants of aggregate wealth accumulation, disentangling what is due to purely demographic factors from what is related to saving behaviors.

The ratio of aggregate wealth over aggregate income is:

$$\frac{W}{Y} = \frac{\sum_{t=0}^{+\infty} \Omega_t^{n,s}(y_t - c_t)}{\sum_{t=0}^{+\infty} N_t y_t} \tag{14}$$

This is the variable on which we will focus in order to assess the impact of mortality decline. The choice to focus on W/Y rather than on W was guided by the fact that in the case where aggregate capital equals aggregate wealth (no asset bubbles or capital owned by foreigners), the ratio $\frac{W}{Y}$ equals the capital/labor income ratio.

5.1 Impact of mortality changes

Compare now two demographic states A and B which are characterized by different survival patterns, $(s_t^A)_{t\geq 0}$ and $(s_t^B)_{t\geq 0}$, and different population age structures, $(N_t^A)_{t\geq 0}$ and $(N_t^B)_{t\geq 0}$. We consider a partial equilibrium (or a small open economy), so that wealth accumulation has no effect on labor income and the rate of interest. We denote by r and $(y_t)_{t\geq 0}$ the rate of interest and age specific income profile which, by assumption, are the same in states A and B. The optimal consumption profiles in states A and B are respectively denoted $(c_t^A)_{t\geq 0}$ and $(c_t^B)_{t\geq 0}$. We are interested in the difference between $\frac{W_A}{Y_A}$ and $\frac{W_B}{Y_B}$, that is the difference between the ratio of aggregate wealth over aggregate income in states A and B. Using (14), applied to both populations A and B, we may break down the variation of this ratio into three terms:

$$\frac{W_B}{Y_B} - \frac{W_A}{Y_A} = I_1 + I_2 + I_3$$

with

$$\begin{aligned}
I_1 &= \frac{\sum_{t=0}^{+\infty} \Omega_t^{N^B,s^A}(c_t^A - y_t)}{\sum_{t=0}^{+\infty} N_t^B y_t} - \frac{\sum_{t=0}^{+\infty} \Omega_t^{N^A,s^A}(c_t^A - y_t)}{\sum_{t=0}^{+\infty} N_t^A y_t} \\
I_2 &= \frac{\sum_{t=0}^{+\infty} \Omega_t^{N^B,s^B}(\alpha c_t^A - y_t)}{\sum_{t=0}^{+\infty} N_t^B y_t} - \frac{\sum_{t=0}^{+\infty} \Omega_t^{N^B,s^A}(c_t^A - y_t)}{\sum_{t=0}^{+\infty} N_t^B y_t} \\
I_3 &= \frac{\sum_{t=0}^{+\infty} \Omega_t^{N^B,s^B}(c_t^B - \alpha c_t^A)}{\sum_{t=0}^{+\infty} N_t^B y_t}
\end{aligned}$$

where the scalar α is given

$$\alpha = \frac{\sum_{t=0}^{+\infty} \frac{s_t^B}{(1+r)^t} y_t}{\sum_{t=0}^{+\infty} \frac{s_t^B}{(1+r)^t} c_t^A}$$

The three terms that appear above can be interpreted as follows:

1. I_1 reflects a **demographic aggregation effect.** This term shows how the ratio of aggregate wealth over aggregate income would have shifted, if the only factor to change was the population age structure. More precisely, we consider wealth accumulation that would be obtained by aggregating the wealth of individuals earning $(y_t)_{t\geq 0}$ and consuming $\left(c_t^A\right)_{t\geq 0}$, when using either population age structure of A (i.e. using the numbers N_t^A) or that of population B (i.e. using the numbers and N_t^B), but maintaining survival probabilities as in population A. By making the difference between the two, we get therefore a pure "demographic aggregation effect". As retired people hold assets but do not work, this demographic aggregation effect is typically positive if the fraction of elderly is larger in population B than in population A.

2. I_2 is an **income dilution effect.** This terms shows how $\frac{W}{Y}$ would have changed if the only consequence of longevity extension was a shift from consumption c_A to αc_A, that is a simple rescaling of individual consumption in order to match the new budget constraint. This terms therefore represents

an income dilution effect associated with the fact that, when longevity increases, agents have to change their instantaneous consumption in order to cover a greater life duration. In the usual case where consumption occurs at greater ages than labor income, on average, the scalar α is smaller than one if survival probabilities are higher in population B than in population A. People reduce their consumption by anticipating that they have to live longer, and this induces a positive effect on wealth accumulation.

3. I_3 is an **impatience effect**. It measures the consequences of the changes in the shape of the life-cycle consumption profiles following a change in mortality rates. Both the consumption patterns αc_t^A and c_t^B fulfill the individual budget constraints when using the survival probabilities of population B. However, when mortality changes, people may want to change the shape of their consumption profile and move to an optimal consumption pattern c_t^B that is different from αc_t^A. This is the case as soon as k is different from zero. Thus, unless $k = 0$, we obtain an impatience effect. Theoretically speaking, the sign of this impatience effect is ambiguous, due to the opposing effects shown in Proposition 1. However, in practice we find that mortality decline makes people become significantly less impatient, as illustrated in Figure 1. Therefore, this impatience effect ends up being positive when mortality is lower in population B than in population A.

6 Implementation with historical demographic data

We illustrate the above framework using realistic demographic data provided by the Human Mortality Database, covering the period from 1950 to 2008 for twenty-four countries[7]. These data gather life tables as well as accurate data on the population age structure. It is thus possible to implement the above computation with accuracy.

6.1 Demographic facts

Tables 1 and 2 provide information on mortality for all twenty-four countries. As mortality at young and old ages may play different roles, we report information on

[7] Country selection was determined by data availability. More precisely, we considered all countries for which the Human Mortality Database provided the 1950 and 2008 life tables.

adulthood and old-age mortality. More precisely, Table 1 provides life expectancies at ages 20 and 60, when computed according to the 1950 and 2008 life tables. Table 2 reports the mortality ratios between ages 30 and 50 (${}_{30}q_{50}$) and between ages 70 and 80 (${}_{70}q_{80}$) according to the same life tables. For all countries, these indicators unanimously indicate a decline in mortality between years 1950-2008. This corresponds to the well documented trend of longevity extension that has been observed in developed countries. The decline is substantial on average, but the data show quite significant variations. At the bottom-end, we find countries like Bulgaria, where mortality has hardly declined (this is mainly due to a deterioration in the last two decades of the twentieth century) or Slovakia, Hungary and Denmark, where mortality did noticeably decline, but relatively little compared to what happened in other countries. At the other extreme, we find Japan, which is characterized by a huge decline in mortality. The fall is particularly spectacular for middle aged adults, since ${}_{30}q_{50}$, the mortality ratio between ages 30 and 50, was almost divided by 5 between 1950 and 2008. As a consequence, Japan which had the lowest life expectancy at age 20 (and the greatest mortality rates) in 1950, became the country in our dataset with the greatest life expectancy in 2008.

Table 3 reports data on population age structure in order to reflect the population aging phenomenon. More precisely, what are shown are "old-age dependency ratios" (OADR) that were observed in years 1950 and 2008. These OADR were defined as the ratio of the population of age greater than 62 (retirement age in our simulations) to the ratio of the population of age 20-62. In all countries but Ireland, the OADR increased between 1950 and 2008. However, mortality is just one determinant of this OADR, which also depends on past birth rates and migration. As a result, the pattern that arises from Table 3, with respect to the OADR, does not closely replicate the patterns found in Tables 1 and 2 relating to mortality. Japan, which was characterized by a huge mortality decline is characterized by a huge increase of the OADR (+239%). But a strong increase (+138%) is also found in Bulgaria, although there were only minor mortality changes in that country. Meanwhile, the OADR decreased in Ireland (-16%) and only slightly increased in New Zealand (+23%), although mortality did substantially decline in both countries.

6.2 Assumptions and model calibration

The aim of this section, in which we implement the method developed in Section 5, is to provide an idea of what may be the orders of magnitude of the terms I_1, I_2 and I_3 when considering realistic patterns of mortality decline. This is an illustrative exercise which does not aim at replicating historical trends of wealth accumulation, but serves for emphasizing the potential role of risk aversion[8]. For that purpose, we preferred to use to an extremely stylized representation of reality, rather than introducing a complex model based on assumptions that would have to be country-specific in order to account for the variety of institutional settings. Thus, we focused on demographic heterogeneity, and deliberately decided to ignore all other (economic, cultural, etc.) aspects that may differ between countries or that may have changed between 1950 and 2008. In order to avoid confusing over-interpretation of the results, one should simply consider that country names such as "Australia" or "Denmark", that appear in the discussion and tables that follow, do not refer to actual countries with specific institutions, but simply to different patterns of demographic changes.

Given that the objective is purely illustrative, a number of simplifying assumptions are made. We assume that, as far as savings are concerned, individuals' economic life begins at age 20. In other words, individuals do not save before that age. Such an assumption can be viewed as corresponding to the case where children have stringent liquidity constraints that compel them to consume all they receive from their parents until they reach age 20.

Labor income is supposed to be exogenous, constant up to age 62, and equaling zero afterwards. We therefore rule out the existence of an unfunded Social Security systems as well as the endogeneity of retirement age. This is of course an assumption which is at odd with what happened in many countries. However, Social Security and retirement regulations being extremely heterogeneous across countries, it would have been quite hazardous to suggest a universal model that would have covered all the countries under consideration. Age specific variations in productivity are also ignored.

The rate of interest is assumed to be exogenous and equal to 3%. Of course, this may be open to discussion, especially when encountering changes in aggregate

[8]A model aiming at providing a plausible explanation of historical trends should include number of features such as technological progress, endogenous labor supply, changes in labor regulation, bequests, social security, political factors, etc. This is not the type of work which is undertaken is this paper.

wealth of substantial magnitude. In a close economy, an increase of accumulated wealth should push down the rate of interest: such a general equilibrium adjustment is not taken into account in our illustrations.

As for demographic data, we consider cross-sectional life-tables, and imagine societies where agents would live according to these cross-sectional mortality rates. This is of course a thought experiment since cross-sectional mortality data do not reflect longitudinal mortality data. A 50 year old agent alive in year 2008 did not face the 2008 mortality rates in his youth, and certainly does not expect to face these same 2008 rates in the future. The use of historical cross-sectional mortality data does not aim therefore at reproducing the life of real agents, but simply at providing demographic patterns that are fairly reasonable.

Two specifications for individuals' preferences are considered. The first one, called additive model, assumes that agents are temporally risk neutral ($k = 0$). This specification was suggested by Yaari (1965), and is now found in almost all economic papers that discuss the impact of mortality decline. The second one, called multiplicative model, assumes that agents have no pure time preferences ($\beta = 1$) but allows for positive temporal risk aversion ($k > 0$)[9]. In both cases, we assume that the intertemporal elasticity of substitution is constant and equal to 1/1.1. We then have $u(c) = u_0 + \frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$ with $\sigma = 1/1.1$ and u_0 a constant. The constant u_0, which matters as soon as $k \neq 0$, determines the value of life. Calibration of u_0 was performed so that with $r = 3\%$ and with 2008 US mortality rates, the value of a statistical life of a 40 year old individual is about 250 times its annual income. A 40 year old individual earning 20,000 dollars per year would then have a value of statistical life of about 5 million dollars, in the range of what is suggested by empirical estimates derived from US data (see Viscusi and Aldy, 2003).

In order to have models that are reasonably comparable, we chose the parameters β in the additive model and the parameter k in the multiplicative model, so that both models would predict exactly the same wealth/income ratio when $r = 3\%$ and demographic data corresponds to that of the 1950 US life table.

[9]This model is called multiplicative since, when $\beta = 1$, agents aims in fact at maximizing the expectation of the following product:

$$-\prod_{t=0}^{+\infty} \exp(-ku_t)$$

where $u_t = u(c_t)$ in case of life and $u_t = 0$ in case of death. The ability of the multiplicative model to fit empirical life-cycle consumption profiles is discussed in Bommier (2011).

More precisely, the value of β has been chosen equal to $\frac{1}{1+r}$ so that the additive model predicts a steady consumption level over the life-cycle. The constant k was then chosen so as to simulate the same wealth/income income ratio with the 1950 US life table while the constant u_0 was simultaneously adjusted to obtain the target value of life mentioned above. The choice to rely on the 1950 US life table for calibration is of course arbitrary. But, again, the point is not provide accurate predictions, but to emphasize how important it is to properly account for risk aversion.

In terms of numerical values, we have $k = 0.038$ and $u_0 = 0.14$. In order to get an intuition of the degree of risk aversion implied by this value of k, one may compute that when $c = 0.85$ -a median consumption level in our simulations- we have $ku(c) = 0.077$. This means that an agent with a flat consumption of 0.85 has a coefficient of (absolute) risk aversion with respect to life duration of 0.077 per year. Such an agent would then be indifferent between living 70 or 80 years with equal probability, or living 74 years and three weeks with probability one.

The additive and multiplicative models suggest two polar forms in the class of models we consider. With the additive model ($\beta < 1$ and $k = 0$) human impatience is exogenous and mortality plays a minor role. According to the multiplicative model ($\beta = 1$ and $k > 0$), agents' impatience exclusively results from risk aversion and lifetime uncertainty. Intermediate positions where human impatience would result both from pure time preferences and from temporal risk aversion would involve choosing a model with both $\beta < 1$ and $k > 0$. Results obtained with such intermediate models typically fall in between those of the additive and multiplicative cases and are not reported in the present paper.

6.3 The ratio of aggregate wealth over aggregate income

For each of the twenty-four patterns of demographic changes (each one corresponding to country specific observations), we computed the (theoretical) ratio of aggregate wealth over aggregate income W/Y, using either the additive or the multiplicative model of individual preferences. Results are reported in Table 3. The first two columns give the ratio in years 1950 and 2008. The third column, computes the relative increase. This latter is then broken down into three components, representing aggregating, income dilution and impatience effects, respectively. For example, with the Australian pattern of demographic change, according to the multiplicative model, the ratio of aggregate wealth over aggregate (yearly) income would have been 5.66 in 1950 and 10.52 in year 2008 (columns 1 and 2). It would thus have increased by 85.76% (column 3). Out of these 85.76%, there are 14.46 percentage points that come from the aggregating effect (and hence from the change in population age structure), 29.93 from the income dilution effect, and 41.36 from the impatience effect (columns 4, 5 and 6).

For all patterns of demographic change, the ratio of aggregate wealth over aggregate income is found to be greater in year 2008 than in year 1950. But results significantly differ depending on the pattern and the model that is considered.

The additive model constrains the impatience effect to equal zero since the shape of the optimal consumption profile $(c_t^{\mathrm{add}})_{t\geq 0}$ is independent of mortality rates. The multiplicative model, with which there is a strong link between mortality and time discounting generates an impatience effect, which is anything but negligible. In all but three patterns of demographic changes (Bulgaria, Denmark and Netherlands), this impatience effect happens to be the largest of the three reported effects. In many cases, its size is comparable to the sum of the other two effects, indicating that accounting for this impatience effect would be as important as taking into account the other aspects together. Quantitatively speaking, the standard approach based on the additive model, which focuses on the aggregation and income dilution effects, might have led half of the story to be forgotten. This sometimes amounts to more, as with the Japanese, Portuguese or Spanish patterns, sometimes to less, as with the Hungarian, Danish or Dutch patterns, but in all cases it represents a non negligible part.

One important point is that the impatience effect cannot be correctly assessed without looking at the age-specific changes in mortality. The Bulgarian pattern of demographic change provides an interesting example. In Bulgaria, life expectancy at age 20 only increased by 5.7% between years 1950 and 2008. Still, the impatience effect is found to be substantial. In fact, in Bulgaria mortality declined more at young ages than at old ages, where it changed very little. As most deaths occur at old ages, the mean age at death increased only slightly. However, the risk of an early death was significantly reduced, inducing changes in impatience. This therefore provides an example where characterizing mortality by life expectancy (as is often done in empirical studies) may be a poor strategy.

7 Conclusion

The paper has discussed the impact of longevity extension on aggregate wealth accumulation. It has highlighted the potential role of an aspect of individual preferences that has hitherto been ignored: that of risk aversion. When considering individuals that are more risk averse than in the usual additive model, a novel interesting relation emerges linking mortality and time discounting. Mortality changes may then lead individuals to modify their saving behaviors, with consequences on the aggregate wealth accumulation.

Illustrations based on historical mortality data show that the corresponding effects are of very significant magnitude. Once accounting properly for risk aversion, the impatience effect is found to be much larger than the aggregation effect in most of the cases we considered. That means that accounting for the relation between mortality and impatience is more important than accounting for changes in population age structure. While the economics of ageing has long emphasized the role of population ageing, it may have missed an even more important aspect related to the individual response to a decline in mortality.

Although, the paper focused on a specific question - the determinant of wealth accumulation- it can be seen as having a larger scope, emphasizing the need to revisit the field of the economics of ageing with an approach that properly accounts for risk aversion. The impatience effect that has been highlighted is indeed very general and would have significant consequences whenever the time discounting dimension matters. Further applications could include issues related to human capital investment, retirement behavior, fertility choice, economic growth, which are all likely to be much more sensitive to changes in mortality than the usual additive life-cycle model would predict.

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Table 1: Changes in life expectancy

Country	Life expectancy at age 20			Life expectancy at age 60		
	in year 1950	in year 2008	Variation 1950-2008	in year 1950	in year 2008	Variation 1950-2008
Australia	52.4	62.6	19.4 %	17.4	24.9	42.9 %
Austria	51.4	61.4	19.5 %	16.9	23.9	41.2 %
Belgium	51.6	60.6	17.4 %	17.1	23.5	37.1 %
Bulgaria	52	54.9	5.7 %	18.4	19.3	4.9 %
Canada	53	62.1	17.2 %	18	24.6	36.9 %
Czech	50.9	58.1	14.3 %	16.4	21.3	30 %
Denmark	53.9	59.8	10.9 %	18	22.5	25.5 %
Finland	49.1	60.7	23.6 %	15.9	23.8	49.9 %
France	51.8	62.1	20 %	17.5	25.1	43.3 %
Hungary	50.5	55.3	9.4 %	16.9	20.1	18.6 %
Iceland	54.3	62.4	14.9 %	19.5	24.1	23.9 %
Ireland	50.6	60.9	20.4 %	16.9	23.3	38.4 %
Italy	52.8	62.6	18.5 %	17.9	24.7	37.6 %
Japan	47	63.7	35.5 %	15.7	26	65.4 %
Netherlands	54.9	61.4	11.9 %	18.6	23.6	27.2 %
New Zeland	53	61.7	16.3 %	17.8	24.1	35.4 %
Norway	55.3	61.6	11.6 %	19.2	23.9	24.5 %
Portugal	50.2	60.3	20.2 %	17.4	23.3	34 %
Slovakia	51.1	56.1	9.9 %	17.3	20.1	16.2 %
Spain	50.6	62.2	22.9 %	17.4	24.6	41.9 %
Sweden	54	62	14.8 %	18.1	24.1	33.3 %
Switzerland	52.7	63	19.5 %	17.5	25.1	43.1 %
UK	52.3	60.8	16.4 %	17.1	23.4	37.2 %
USA	51.8	59.6	15.1 %	17.6	23.3	32.3 %

Table 2: Changes in mortality rates

Country	Mortality between 30 and 50 (%)			Mortality between 70 and 80 (%)		
	in year 1950	in year 2008	Ratio 1950/2008	in year 1950	in year 2008	Ratio 1950/2008
Australia	6.3	2.4	2.68	50.7	22.8	2.23
Austria	7.2	2.3	3.15	52.8	24.4	2.17
Belgium	7.3	2.9	2.55	51.7	25.7	2.01
Bulgaria	7.7	5.2	1.5	48.3	41.2	1.17
Canada	6.4	2.4	2.63	47.4	24.2	1.96
Czech	7.3	3.3	2.24	55.6	32.8	1.7
Denmark	5.3	2.8	1.86	49.2	30.5	1.61
Finland	9.2	3.2	2.84	57.3	24.8	2.32
France	7.9	3	2.59	50.2	21.3	2.35
Hungary	8.5	5.6	1.5	52.6	37.3	1.41
Iceland	7.3	1.7	4.2	42.1	25.6	1.64
Ireland	8.2	2.5	3.24	53.9	27.8	1.94
Italy	6.7	2.1	3.26	49.2	22.9	2.15
Japan	12.2	2.3	5.41	57.1	20.6	2.77
Netherlands	4.4	2.2	2.03	46.5	26.4	1.76
New Zeland	6	2.4	2.45	49.3	25	1.97
Norway	4.7	2.2	2.19	43.8	25.3	1.73
Portugal	9.8	3.4	2.87	51.5	26.8	1.93
Slovakia	7.8	4.6	1.72	51.1	38.3	1.33
Spain	8.9	2.5	3.52	51.7	23.1	2.23
Sweden	5	1.9	2.59	48.5	24	2.02
Switzerland	6.1	1.9	3.14	50.5	20.8	2.43
UK	6.1	2.8	2.19	52.4	27.2	1.93
USA	7.7	4	1.94	48.4	27.4	1.77

Table 3: Changes in population age structure

Country	Old Age Dependency Ratio		
	in year 1950	in year 2008	Variation 1950-2008
Australia	0.19	0.28	45.4 %
Austria	0.23	0.34	48.8 %
Belgium	0.24	0.35	47.8 %
Bulgaria	0.15	0.36	138 %
Canada	0.19	0.28	49.3 %
Czech	0.18	0.3	62 %
Denmark	0.21	0.35	69.3 %
Finland	0.16	0.35	118 %
France	0.26	0.35	35.2 %
Hungary	0.18	0.33	84.9 %
Iceland	0.18	0.24	33.2 %
Ireland	0.27	0.23	-16.3 %
Italy	0.19	0.4	110.9 %
Japan	0.14	0.46	239.1 %
Netherlands	0.19	0.31	65 %
New Zeland	0.22	0.27	22.7 %
Norway	0.21	0.32	53.7 %
Portugal	0.17	0.35	103.8 %
Slovakia	0.16	0.23	48.2 %
Spain	0.17	0.32	87.9 %
Sweden	0.22	0.39	76.5 %
Switzerland	0.21	0.34	60.4 %
UK	0.24	0.34	43.4 %
USA	0.19	0.27	43.2 %

Table 4: Ratio of aggregate wealth other aggregate income

Country + model	1 W/Y in year 1950	2 W/Y in year 2008	3 Variation 1950-2008	4 Aggreg. Effect	5 Dilution Effect	6 Impatience. Effect
Australia additive	5.18	8.06	55.67 %	17.23 %	38.44 %	0 %
Australia multiplicative	5.66	10.52	85.76 %	14.46 %	29.93 %	41.36 %
Austria additive	5.79	8.56	47.88 %	11.65 %	36.23 %	0 %
Austria multiplicative	5.89	11.18	89.82 %	10 %	30.02 %	49.8 %
Belgium additive	5.78	8.66	49.85 %	15.75 %	34.11 %	0 %
Belgium multiplicative	5.83	10.68	83.06 %	13.81 %	28.41 %	40.84 %
Bulgaria additive	4.76	7.6	59.54 %	55.48 %	4.06 %	0 %
Bulgaria multiplicative	4.06	8.44	107.87 %	58.36 %	4.98 %	44.53 %
Canada additive	5.05	8.21	62.62 %	26.7 %	35.92 %	0 %
Canada multiplicative	5.46	10.47	91.9 %	23.35 %	28.18 %	40.37 %
Czech additive	5.02	7.62	51.95 %	22.49 %	29.46 %	0 %
Czech multiplicative	5.12	9.4	83.68 %	19.84 %	24.45 %	39.38 %
Denmark additive	5.57	8.65	55.22 %	29.07 %	26.15 %	0 %
Denmark multiplicative	6.58	10.87	65.19 %	24.76 %	19.43 %	21 %
Finland additive	4.44	9.16	106.37 %	48.55 %	57.82 %	0 %
Finland multiplicative	3.89	10.79	177.08 %	48.38 %	53.55 %	75.15 %
France additive	5.98	9	50.52 %	12.59 %	37.93 %	0 %
France multiplicative	5.81	10.72	84.6 %	11.18 %	32.36 %	41.06 %
Hungary additive	5	7.39	47.85 %	28.53 %	19.33 %	0 %
Hungary multiplicative	4.54	8.01	76.54 %	27.42 %	17.2 %	31.92 %
Iceland additive	5.38	7.38	37.17 %	16.33 %	20.84 %	0 %
Iceland multiplicative	5.16	10.68	107.14 %	15.83 %	19.29 %	72.01 %
Ireland additive	5.71	6.76	18.52 %	-9.22 %	27.74 %	0 %
Ireland multiplicative	5.16	8.98	73.88 %	-9.45 %	25.81 %	57.52 %
(continued)						

Table 4: (continued)

Country + model	1 W/Y in year 1950	2 W/Y in year 2008	3 Variation 1950-2008	4 Aggreg. Effect	5 Dilution Effect	6 Impatience. Effect
Italy additive	5.2	9.45	81.61 %	40.18 %	41.43 %	0 %
Italy multiplicative	5.4	12.55	132.42 %	36.66 %	34.21 %	61.55 %
Japan additive	3.96	10.74	171.5 %	81.61 %	89.89 %	0 %
Japan multiplicative	2.52	13.44	433.37 %	103.6 %	109.87 %	219.9 %
Netherlands additive	5.36	8.51	58.77 %	31.21 %	27.56 %	0 %
Netherlands multiplicative	6.59	11.44	73.44 %	26.84 %	20.2 %	26.39 %
New Zeland additive	5.48	7.87	43.5 %	12.56 %	30.95 %	0 %
New Zeland multiplicative	5.98	10.15	69.6 %	10.97 %	24.49 %	34.14 %
Norway additive	5.76	8.42	46.04 %	22.74 %	23.31 %	0 %
Norway multiplicative	6.74	11.1	64.87 %	19.81 %	17.99 %	27.07 %
Portugal additive	4.76	8.37	75.92 %	39.81 %	36.11 %	0 %
Portugal multiplicative	3.72	10.24	175.66 %	43.29 %	39.02 %	93.35 %
Slovakia additive	4.67	6.36	36.11 %	20.34 %	15.77 %	0 %
Slovakia multiplicative	4.29	7.52	75.08 %	20.03 %	14.61 %	40.43 %
Spain additive	4.76	8.15	71.3 %	29.98 %	41.32 %	0 %
Spain multiplicative	3.95	10.6	168.5 %	30.41 %	41.52 %	96.57 %
Sweden additive	5.8	9.32	60.75 %	27.64 %	33.11 %	0 %
Sweden multiplicative	6.8	12.43	82.88 %	23.18 %	25.06 %	34.65 %
Switzerland additive	5.54	8.93	61.23 %	20.99 %	40.25 %	0 %
Switzerland multiplicative	6.08	12.04	98.04 %	18.11 %	31.5 %	48.43 %
UK additive	5.68	8.39	47.64 %	14.18 %	33.46 %	0 %
UK multiplicative	6.24	10.55	69.22 %	11.6 %	26.03 %	31.59 %
USA additive	5.15	7.71	49.79 %	19.33 %	30.46 %	0 %
USA multiplicative	5.15	8.66	68.1 %	16.69 %	25.25 %	26.16 %

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