Can Longevity Risk Alleviate the Annuitization Puzzle? Empirical Evidence from Survey Data

Federica Teppa
De Nederlandsche Bank (DNB) and Netspar
Pierre Lafourcade
De Nederlandsche Bank (DNB)

December 13, 2013

Abstract

This paper provides new evidence on individual preferences over annuities and lump sum payments based on hypothetical questions posed in the DNB Household Survey in 2010. In contrast to the majority of papers in the annuitization puzzle literature, this study controls explicitly for the subjective survival probability (SSP) which, as a perceived measure of longevity risk, is key in deciding about whether to annuitize. We model this decision in a life-cycle framework in the spirit of Brown and Poterba (2000) and compute a utility-based measure of annuity value for singles and couples. However, we depart from them in the way we account for the uncertainty of the time horizons agents face in this decision. We find that people expecting to live longer claim to prefer the annuity. This finding is robust to controlling for bequest motives and for far-off target ages. In addition, we find that individual preferences are consistent with subjective survival probabilities but not with actuarial ones. Combined with the empirical evidence that individuals tend to underestimate systematically their life expectancy, our findings have strong policy implications. Most importantly, helping individuals better estimate their longevity risk may resolve the annuitization puzzle more effectively than forcing their actions.

Jel–Classification: C5; C8; D12; G11

Keywords: Longevity Risk; Annuitization Puzzle; Survey Data; Hypothetical Choices

Corresponding author: Federica Teppa - De Nederlandsche Bank, Economics and Research Division - Westeinde 1 1017ZN Amsterdam Netherlands

Phone: +31 20 5245841; Fax: +31 20 5142506

1 Introduction

Life expectancy has improved substantially since the past decades and it has accelerated in recent years in all advanced countries. According to the most recent World Health Statistics, life expectancy at birth in the Netherlands has increased between 1990 and 2008 from 74 to 78 years for males, and from 80 to 82 years for females. In the same period, the adult mortality rate, defined as the probability of dying between 15 and 60 years, has decreased from 11.6 percent to 7.8 percent for males, and from 6.7 percent to 5.7 percent for females. The declining female advantage in life expectancy is observed in the US as well (Vallin, 1991) and seems to be largely driven by behavioral factors (namely smoking) rather than biological factors (Pampel, 2002). Providing adequate insurance for late-life consumption has become a high priority item on the agenda of policy makers in ageing societies.

As the only contract that acts as insurance against longevity risk, the annuity should always be chosen by risky individuals, even in the presence of a bequest motive (Yaari 1965; Davidoff *et al.* 2005). Yet, empirical evidence from several countries shows that only a small fraction of individuals voluntarily buy annuities (James and Song 2001; Johnson *et al.* 2004; Beatrice and Drinkwater 2004). The combination of these two facts is known as the “annuitization puzzle”.

Several potential explanations for this puzzle have been suggested in the literature. They include both supply side reasons—e.g. highly priced annuities due to adverse selection and administrative costs (Brown *et al.* 1999, 2001; Cannon and Tonks 2004, Finkelstein and Poterba 2004)—and demand side motives—e.g. intra-family risk sharing (Kotlikoff and Spivak 1981), liquidity constraints and large out-of-pocket health expenditures (Palumbo 1999; De Nardi *et al.* 2010), and a preference for bequests (Friedman and Warshawsky 1990; Vidal-Melia and Lejarraga-Garcia 2006). More recently, alternative behavioral explanations have been suggested, such as framing or default effects (Bütler and Teppa 2007; Agnew *et al.* 2008; Brown *et al.* 2008).

This paper follows a different approach as it focuses on longevity risk, a likely key driver in the decision to annuitize that has been neglected in the literature to date. Information about life expectancy can be elicited directly, by asking individuals about their subjective survival probabilities (SSP from now on), and indirectly, by examining parental longevity. Both measures have drawbacks (e.g. focal points, rounding effects), but overall, they seem to convey meaningful information on individual longevity. There is evidence from the Health and Retirement Survey (HRS) that SSP contain useful information on survival expectations. They have been found to correlate with known mortality risk factors and to predict actual mortality—

although less well so once self-assessed health is controlled for (Siegel *et al.* 2003). Furthermore, they are claimed to approximate actuarial survival probabilities (Hurd and McGarry 1995; Smith *et al.* 2001; Hurd and McGarry 2002). The English Longitudinal Study of Ageing (ELSA) data have been used to test the predictive power of SSP for actual mortality, and it appears that such probabilities systematically underestimate those reported in actuarial life tables (Banks *et al.* 2004; O'Donnell *et al.* 2008). More recently, SSP for the Netherlands have been used to analyze retirement intentions and actual behavior (van Solinge and Henkens 2010).

In this paper, we use subjective survival probabilities as measures of perceived longevity risk in a simple life-cycle model of annuity choice based on hypothetical questions posed in the DNB Household Survey in 2010. This survey (henceforth DHS) is a longitudinal study on various economic and psychological aspects of the financial behavior of Dutch households. It is run at CentERdata, located at Tilburg University and sponsored by De Nederlandsche Bank. We compute a utility-based measure of annuity value for singles and couples in the spirit of Brown and Poterba (2001), but depart from them in the way we account for the uncertainty of the time horizons agents face in this decision. We find that people expecting to live longer prefer the annuity. This finding is robust to controlling for bequest motives, which is the other main determinant for the choice of lump sum payments. We also find that actuarial survival probabilities are insignificant determinants of the annuity demand, suggesting that individual preferences reflect subjective survival probabilities and not those implied by mortality tables. The relevance of this paper is twofold. First, it delivers an important empirical result on the role of the SSP that had not yet been directly tested in the literature. Second, combined with the empirical evidence that individuals on average tend to systematically underestimate their life expectancy, our findings have important policy implications. In particular, helping individuals better estimate their longevity risk may resolve the annuitization puzzle more effectively than forcing their actions. This issue is especially relevant in the Netherlands, where all retirement income has to be annuitized. Letting individuals choose the form of their retirement income might in fact lead to welfare improving outcomes.

The paper is organized as follows. Section 2 provides a brief overview of the Dutch pension system. Section 3 describes the data used in the empirical analysis. Particular emphasis is devoted to the subjective survival probability, its elicitation and its relation to major individual socio-economic characteristics. Section 4 develops our theoretical model for the annuitization choice and Section 5 describes the empirical model. Section 6 reports and discusses the empirical results. Section 7 concludes.

2 Institutional framework of the Dutch pension system

The pension system in the Netherlands consists of three pillars.

The first pillar is a general pay-as-you-go old age state pension (Algemene Ouderdomswet, AOW) first introduced in 1956. It aims at ensuring a minimum level of adequate income to the elderly. It is unrelated to labor history and to other income sources, but it depends on having lived in the Netherlands and on household composition.

The second pillar is a mandatory (between employer and employees) occupational career-average pension. This supplementary pension consists of pension fund and superannuation payments. Pension rights accrued during active working period are in many cases indexed to negotiated wage increases (without backloading accruals for career steps) and pension benefits are often indexed to consumer price inflation. However, full indexation of pension claims to cost-of-living increases is not guaranteed, and even nominal "guarantees" are conditional on the coverage ratio of the pension fund meeting the prudential supervisor's minimum requirement.

The third pillar consists of individual retirement savings schemes held on a purely voluntary basis. They mainly consist of annuities received by life insurance companies and represent a negligible fraction of total pension income.

According to the most recent figures from Statistics Netherlands (Centraal Bureau voor de Statistiek, or CBS), around 1.8 million households received old age social security benefits in 2010 (CBS, 2012). Nearly nine in ten households received supplementary pensions and approximately as many generated revenues from private property. The gross AOW pension averaged 1,070 euro a month for over-65 singles and 1,520 euro a month for over-65 couples. A much higher degree of dispersion is found for supplementary incomes. For example, some 5,000 over-65 households had no additional income sources and 170,0000 over-65 households received no more than 250 euro in supplementary retirement income on top of their AOW pension. On the other hand, more than half of over-65 households had supplementary monthly incomes of 1,000 euro or more.

Figure 1 about here

Second pillar pensions also vary significantly with respect to gender. Single women most often have lower supplementary incomes than males, mainly as a consequence of discontinuous or shorter working careers. The fraction of single women with supplementary incomes up to 250 euro a month has dropped significantly from

25 percent in 2000 to just over 17 percent in 2010. The number of over-65 households with supplementary incomes below 250 euro a month declined from 214,000 in 2000 to 170,000 in 2010.

On average, AOW accounts for nearly 40 percent of the gross incomes of over-65 households. Supplementary pensions and income from private property contribute 35 and 6 percent to the total gross income, respectively.

Figure 2 about here

For the purposes of this paper, it is important to notice that in the Netherlands, both old age state benefits and supplementary pensions are received in the form of an annuity. In a recent study, Brown and Nijman (2011) argue that, contrary to all other developed countries, pension income might be overannuitized in the Netherlands. Accordingly, allowing individuals some discretion over the disposition of the assets in their individual accounts could be welfare improving, as liquidity needs, precautionary motives, and bequests could be better addressed by a greater degree of flexibility.

3 The data

The analysis in this paper is based on data collected from households participating in the DNB Household Survey (DHS). The DHS is an annual panel survey of more than 2,000 households in the Netherlands that started in 1993. Panel members are aged 16 years and older. In case of attrition, CentERdata recruits new participants to maintain the panel size and to keep the panel as representative as possible on a number of relevant background characteristics such as age, gender, income, education, and region of residence. The DHS dataset further contains detailed information on employment status, pension arrangements, accommodation, wealth, as well as health status, and psychological concepts. The dataset thus provides the opportunity to combine both economic and psychological aspects of financial behavior.

3.1 The subjective survival probability (SSP)

This paper focuses on longevity risk and its impact on the choice between an annuity and a lump sum payment, using survey questions on subjective survival probabilities. The life-expectancy questions given to the respondents strictly follow the format used in the HRS and in the ELSA:

Please indicate your answer on a scale of 0 to 10, where 0 means "no chance at all" and 10 means "absolutely certain".
SSPXX : How likely is it that you will attain (at least) the age of XX?

The target age (denoted by XX) ranges between 75 and 95 and depends on the current age of the respondent. In particular, SSP75 is presented to people aged between 16 and 69; SSP80 is presented to people aged between 16 and 74; SSP85 is presented to people aged between 16 and 79; SSP90 is presented to people aged between 16 and 84; SSP95 is presented to people aged between 16 and 89. This implies that for the subgroup of individuals aged up to age 69 the full set of SSPs are available. Since the answers are on a 0-10 scale, we can interpret value 1 as "1 to 10 percent likely to attain (at least) the age of XX", value 2 as "11 to 20 percent likely to attain (at least) the age of XX", and so forth. This format is very similar to that used by van Solinge and Henkens (2010). Importantly, these probabilities are conditional on being alive at a certain age.

Table 1 presents the main summary statistics and Figure 3 shows the histograms for each subjective survival probability. A careful analysis of these statistics is needed in order to assess their informative content and to validate the overall quality of the various SSPs.

Table 1 and Figure 3 about here

The number of observations increases slightly as the target age increases, as a consequence of the routing in the question design. We can infer that both the mean and the median value of the SSPs monotonically decline with respect to the target age. The standard deviation is highest for SSP85 and SSP90, lowest for SSP75 and roughly stable for the other SSPs. Several dispersion measures, such as the variance and the standard error of the mean, suggest that the respondents report lower chances of attaining higher target ages, but the dispersion of dispersion measures is itself high (!), except for reaching the age of 95.

The distributions of the subjective survival probabilities are all asymmetric but differ in skewness, which is negative for the three lowest target ages and positive for the three highest target ages. Obviously, the most left-skewed distribution is SSP75 and the most right-skewed distribution is SSP95. In addition, the skewness monotonically increases with the target age; for SSP85, the distribution has roughly zero skewness and is unimodal (mean = median = mode = 5).

Finally, we report the kurtosis to assess whether the data are peaked or flat relative to a normal distribution. We observe that the histogram with the highest kurtosis is that for SSP75, with a distinct peak near the mean value.

3.2 SSPs and socio-economic variables

The DHS contains information on several background and socio-economic characteristics at the individual and household levels. In this section, we examine how the SSPs relate to some of these variables, in particular to those for which it is reasonable to expect a meaningful relationship. We know for example from mortality tables that females have on average a higher life expectancy than males. Similarly, some empirical international evidence suggests a positive correlation between life expectancy and level of education on the one hand, and financial situation on the other. We also expect SSP to be associated with health status. With these ideas in mind, we select gender, educational level, self-assessed health (SAH from now on), long-term illness, smoking behaviour, drinking habits, and household income. Table 2 reports the mean values for the background and socio-economic factors of each SSP.

Table 2 about here

The findings for gender are mixed. Women tend to report higher survival probabilities than men on average, but only in three out of the five SSP values is this difference statistically significant, and only at the 10-percent level. This finding contrasts with international evidence of women living longer than men. We thus examine this more extensively in the next subsection.

The evidence for the level of education is more consistent with previous studies, as the respondents with higher education tend to have higher survival probabilities on average for all target ages. This health protective role of education is in line with the results reported by Cutler, Lleras-Muney and Vogl (2010). In addition, the difference for SSP75 is marginally significant (10-percent level) whereas that for SSP80 is more significant (5-percent level). For the highest target ages, the difference turns out to be insignificant. This finding is rather counterintuitive, but could be (partly) explained by selective mortality. The individuals who have survived to very high ages might be the strongest within their cohort and thus more likely to reach even higher ages. This fact could be of first-order importance and offset the role of education on survival probabilities.

The picture for self-assessed health is much sharper. For all target ages, the individuals reporting good or very good SAH systematically report higher average survival probabilities than those with fair, bad or very bad SAH. The differences are always strongly significant (1-percent level). Similar evidence is found for long-term (LT) illness. The respondents who claim to suffer for LT illness report on average significantly lower survival probabilities than those who claim otherwise. Again the differences are always strongly significant (1-percent level).

Both smoking and drinking behaviour seems to be related to SSPs. As expected, higher survival probabilities are reported by respondents who declare they neither drink nor smoke, with the difference being strongly significant (at the 1-percent level) for the three lowest target ages.

Finally, the SSP measures seem to correlate weakly with household income. High income earners report higher survival probabilities for SSP85, SSP90 and SSP95 only, and the differences have an increasing significance level. We experimented with several cut-off points in household income but the findings of weak correlation are fairly robust. When interpreting this result, we need to take into account that it comes from bivariate analysis which is not fully informative. In particular, low income may indicate the earner is young and hence badly informed about life expectancy (alternatively, young people may be worried about the probability of dying before reaching 65). With this in mind, however, the weak correlation between SSPs and income appears in line with Deaton's findings that education matters more than income when analyzing controllable vs. non-controllable diseases (e.g. cardiovascular vs. all cancer types). In particular, Deaton finds that education is health protective for controllable diseases only, whereas income is never so.

3.3 Subjective vs. actuarial survival probabilities

Do individuals perceive their longevity risk—and consequently form their subjective probabilities—correctly? To answer this question, we compare the *subjective* survival probabilities from survey data to the *actuarial* survival probabilities from official mortality tables.

Actuarial survival probabilities are computed from mortality rates provided by CBS. Since the DHS data refer to 2009, we focus on the actuarial mortality rates tabulated by age and gender for that year. To compare the two series, we construct the subjective survival probabilities implied by the SSPs by transforming the SSPs from the 1-10 scale into percentages.

Figure 4 reports the two series for the probability of reaching (at least) the several target ages. We only consider individuals aged 50 and over, for whom this kind of comparison is not affected by potential cohort effects. The upper panel refers to target ages 75, 80 and 85; the lower panel refers to target ages 90, 95 and 100.

The figure clearly shows that for the lowest target ages, namely 75 and 80, both males and females underestimate their survival probabilities at all ages. In addition, this underestimation is quantitatively very strong for some ages (around 25 percentage points for females aged 53 and 69). Perozek (2008) reports similar evidence from the HRS data for the United States.

As the target ages increase, individuals seem to estimate much better their survival probabilities. Males report remarkably accurate subjective survival probabilities for target age 85, while females perform better for target age 95. Interestingly, all individuals report higher subjective than actuarial survival probabilities for very distant target ages, even if the difference between the two is not large. This result—pessimism at short horizons and optimism at long horizons—is in line with Bucher-Koenen and Kluth's (2012) and Wu's *et al.* (2013) findings on German and Australian data, respectively.

Longevity risk is considerably misperceived across the board, but males appear to perceive it better at it than females. This fact explains the surprisingly mixed picture that emerges from Table 2 above. The life expectancy gap in favor of females is not mirrored in the subjective probability gap by gender, mainly as a consequence of the stronger misperception of the actuarial probabilities by females than by males.

Overall, the empirical evidence documented so far suggests that the SSPs, despite some limitations, convey meaningful information on individual longevity and correlate on average relatively closely with several important background and socio-economic characteristics. These findings are fully in line with the results reported by van Solinge and Henkens (2010).

At the same time, comparing subjective and actuarial survival probabilities shows that individuals systematically underestimate their longevity, in some cases very strongly, especially for females. These findings accord closely with international evidence (e.g. O'Donnell *et al.*, 2008 for the UK).

Figure 4 about here

4 Theoretical model for the annuitization choice

We use a life-cycle model to compute the annuity equivalent wealth (AEW) of a single or a couple, as in Brown and Poterba (2000). However, we depart from their set-up by treating survival probabilities differently. To recall, these probabilities are discounting terms applied to the felicity functions (the u's below) over and above the standard discount factor related to time-preference (the β's). They are meant to capture the 'expected' part of the expected utility maximization program, where the source of uncertainty is about the time of death. However, there is a fundamental disconnect between the problem at hand—insuring against the probability of dying later than expected—and the solution method they apply—backward induction, in that the latter presupposes that the last period of life is known. It seems more appropriate to consider life-cycle consumers computing value functions under various scenarios about their lifespan and weighting them by the scenario probabilities. That is, instead of evaluating expected discounted felicity functions, we evaluate the expected value of the lifespan-indexed value functions themselves. The appendix highlights the issue at hand by comparing these alternatives within a simpler, two-period version of this section's model.

Consider first the objective function of a couple without access to annuity markets. Suppose that the times of death of the wife T_f and the husband T_m are known and, with no loss of generality, that the husband survives his wife $T_f < T_m$. The couple then wishes to maximize

$$V(w_0, T_m, T_f) = \sum_{t=0}^{T_f} \beta^t \left(u(c_{mt} + \lambda c_{ft}) + u(\lambda c_{mt} + c_{ft})\right) + \sum_{t=T_f+1}^{T_m} \beta^t u(c_{mt}),$$

subject to

$$\begin{aligned} w_{t+1} &= R(w_t + y_t - c_{mt} - c_{ft}) \\ w_{T_m+1} &= 0, \end{aligned}$$

where β is the discount factor, w_0 the couple's initial wealth, and λ the consumption spillover parameter capturing the 'joy of sharing'. We index the value function by the couple's initial wealth and the spouses' lifespan. We also assume for simplicity that $\beta R = 1$ (the model in the appendix relaxes this).

Optimal intra-temporal consumption sharing between spouses when both are alive yields

$$c_{mt} = c_{ft},$$

implying that the couple's consumption is

$$c_t = c_{mt} + c_{ft} = 2c_{mt}.$$

For the inter-temporal allocations, it is clear that for $t \neq T_f$, consumption is constant

$$c_t = c_{t+1}.$$

However, for $t = T_f$,

$$(1+\lambda)\, u'\left(\frac{1+\lambda}{2} c_t\right) = u'\left(c_{t+1}\right),$$

implying,

$$c_{t+1} = \frac{1+\lambda}{2} u'^{-1}\left[(1+\lambda)\right] c_t \equiv \varphi c_t.$$

Therefore, the consumption path is a step function with step φ when the wife dies.

The inter-temporal budget constraint is the sum of the per-period ones

$$w_0 + \sum_{t=0}^{T_m} \beta^t \left(y_t^m + y_t^f\right) = \sum_{t=0}^{T_m} \beta^t c_t.$$

Substituting the optimal consumption path yields

$$w_0 + \left\{ \sum_{t=0}^{T_f} \beta^t \left(y_t^m + y_t^f\right) + \sum_{t=T_f+1}^{T_m} \beta^t y_t^m \right\} = c_0 \left\{ \sum_{t=0}^{T_f} \beta^t + \sum_{t=T_f+1}^{T_m} \beta^t \varphi \right\}.$$

Suppose individual incomes $y^{m,f}$ are known and constant, as we will assume when taking the model to the data. Using indicator functions to characterize which periods the spouses are alive, we can re-write optimal consumption in matrix form

$$w_0 + \tilde{y} B = c_0 \tilde{\varphi} B,$$

where

$$\begin{aligned} \tilde{y} &= \begin{bmatrix} y^m & y^f & y^m + y^f \end{bmatrix} \\ \tilde{\varphi} &= \begin{bmatrix} \varphi & \varphi & 1 \end{bmatrix} \end{aligned}$$

and

$$B = \underbrace{\begin{bmatrix} \mathbf{1}(m=1) & \mathbf{1}(f=1) & \mathbf{1}(c=1) \end{bmatrix}'}_{3\times T} \underbrace{\begin{bmatrix} 1 & \beta & \ldots & \beta^T \end{bmatrix}'}_{T\times 1}.$$

The column vector $\mathbf{1}(i=1)$ is the zero-one indicator vector for the state (male, or female, or couple), and $T \geq \max(T_m, T_f)$. Of course, B is a function of T_m and T_f.

Consider now the same objective function, but for a couple who decides to annuitize its wealth, such that the annuity payment is

$$b_t = \gamma w_0$$

if either the couple or the annuity owner alone is alive at t, and

$$b_t = \gamma \tau w_0$$

if the survivor is not the policy owner. Thus γ is the annuitization ratio and $\tau \leq 1$ is the dependent payout ratio, both of which we take as given. The set of period budget constraints is

$$\begin{aligned} w_1 &= R\left(b_0 + y_0 - c_{m0} - c_{f0}\right) \\ w_{t+1} &= R\left(w_t + b_t + y_t - c_{mt} - c_{ft}\right), \qquad t \geq 2 \\ w_{T_m+1} &= 0, \end{aligned}$$

where the first line indicates that initial wealth is traded for the annuity payment. The same Euler equations go through as above, yielding a step function for the couple's consumption path. However, the inter-temporal budget constraint is now

$$\sum_{t=0}^{T_m} \beta^t \left(b_t + y_t^m + y_t^f\right) = \sum_{t=0}^{T_m} \beta^t c_t.$$

Again, we substitute the consumption path in the constraint. In matrix form, this yields

$$\left(\gamma w_0 \tilde{\tau} + \tilde{y}\right) B = c_0 \tilde{\varphi} B$$

where, without loss of generality,

$$\tilde{\tau} = \begin{bmatrix} 1 & \tau & 1 \end{bmatrix}$$

if the husband is the policy-holder.

Finally, the value function takes a simple form

$$V\left(w_0\right) = \sum_{t=0}^{T_f} \beta^t 2u\left(\frac{1+\lambda}{2} c_0\right) + \sum_{t=T_f+1}^{T_m} \beta^t u\left(\varphi c_0\right).$$

Assuming constant relative risk aversion,

$$u\left(c\right) = \frac{c^{1-\rho}}{1-\rho},$$

we have

$$\varphi = \frac{1}{2}\left(1+\lambda\right)^{1-\frac{1}{\rho}}$$

and

$$V\left(w_0\right) = \frac{1}{\varphi} u\left(\varphi c_0\right) \left\{ \sum_{t=0}^{T_f} \beta^t + \varphi \sum_{t=T_f+1}^{T_m} \beta^t \right\},$$

which we can write in matrix form as

$$V(w_0) = \frac{1}{\varphi} u(\varphi c_0) \tilde{\varphi} B.$$

We can then evaluate value functions for all configurations of $B = B(T_m, T_f)$. If the maximum survival length is $T = \max(T_m, T_f)$, we have T^2 such configurations to compute. The case of a single life-cycler is obtained by setting $\varphi = \tau = 1$ and $T_f = 0$.

Consider first the case of a single. His value function when choosing the lump sum option is

$$V_L(w_0) = u\left(\frac{w_0}{B_T} + y\right) B_T,$$

with $B_T = \sum_{t=0}^{T} \beta^t$. His value function if he annuitizes is

$$V_A(w_0) = u(\gamma w_0 + y) B_T.$$

Clearly, the annuity equivalent wealth x conventionally defined as the extra wealth needed to generate indifference,

$$V_L(w_0(1+x)) \equiv V_A(w_0),$$

takes the simple form

$$1 + x = \gamma B_T.$$

For couples, we have the equivalent definitions

$$\begin{aligned} V_L(w_0) &= u\left(\varphi \frac{w_0 + \tilde{y}B}{\tilde{\varphi}B}\right) \frac{1}{\varphi} \tilde{\varphi} B \\ V_A(w_0) &= u\left(\varphi \frac{\gamma w_0 \tilde{\tau} B + \tilde{y}B}{\tilde{\varphi}B}\right) \frac{1}{\varphi} \tilde{\varphi} B, \end{aligned}$$

yielding the expression

$$1 + x = \gamma \tilde{\tau} B,$$

where again, B and thus V_A and V_L are understood to depend on T_m and T_f.

Several comments on this analytical result are in order. As expected, the AEW depends on the terms of the contract γ and τ and on discounting. However, the AEW does not depend on the independent income flow y, which we would have expected to matter because it partly substitutes for annuity income. Furthermore, it would not depend on survival probabilities if these were compounded in the utility discounting, because they net out when comparing utilities with and without annuitization (the short model in the appendix makes this explicit). Quite crucially, it does not depend on risk aversion. The reason is clear when comparing V_L and V_A and has a flavor of the envelope theorem: the annuitization choice is all about the size of the pie, while risk aversion is about how to slice it optimally. This last point runs counter to the main result in Brown and Poterba (2000), and Bütler and Teppa (2007), where these authors find with numerical methods that the AEW is sensitive to the risk aversion parameter.

As argued above, we believe it is more useful to consider lotteries over survival times. Thus, if we define lotteries for singles as

$$\begin{aligned} L_L(w_0) &= \sum_{t=0}^{T} p_t V_L(w_0, t) \\ L_A(w_0) &= \sum_{t=0}^{T} p_t V_A(w_0, t), \end{aligned}$$

where the p_t's are the probabilities of surviving until t, we can define the AEW as satisfying

$$L_L(w_0(1+x)) \equiv L_A(w_0)$$

This implies, with $B_t = \sum_{i=0}^{t} \beta^i$, that

$$\sum_{t=0}^{T} p_t B_t u\left(\frac{w_0(1+x)}{B_t} + y\right) = \sum_{t=0}^{T} p_t B_t u(\gamma w_0 + y).$$

Calling $z_t \equiv \frac{yB_t}{w_0}$ the fraction of lifetime income out of initial wealth, we can write this as

$$\sum_{t=0}^{T} p_t B_t^{\rho}\left[((1+x)+z_t)^{1-\rho} - (\gamma B_t + z_t)^{1-\rho}\right] = 0,$$

which defines an implicit function for x. It is essentially a present discounted value version of the simpler definition of AEW, but it reflects the determinants we would intuitively associate with annuitization choice. In particular, comparative statics show that x depends positively on risk aversion ρ and on a first-order stochastic dominance shift in p, and negatively on the fraction of lifetime income z and discounting β.

Similarly, define lotteries for couples as

$$\begin{aligned} L_L(w_0) &= \sum_{t_m=0}^{T_m} \sum_{t_f=0}^{T_f} p(t_m, t_f) V_L(w_0, t_m, t_f) \\ L_A(w_0) &= \sum_{t_m=0}^{T_m} \sum_{t_f=0}^{T_f} p(t_m, t_f) V_A(w_0, t_m, t_f), \end{aligned}$$

where p is the associated joint probability of survival, and the functional dependence on survival times is explicit. The newly-defined AEW over lotteries satisfies

$$\sum_{t_m=0}^{T_m}\sum_{t_f=0}^{T_f} p(t_m,t_f)\left(\tilde{\varphi}B(t_m,t_f)\right)^{\rho}\left[\left((1+x)+z(t_m,t_f)\right)^{1-\rho}-\left(\gamma\tilde{\tau}B(t_m,t_f)+z(t_m,t_f)\right)^{1-\rho}\right]=0$$

where the fraction of lifetime income out of initial wealth depends on the survival paths:

$$z\left(t_m,t_f\right)=\frac{\tilde{y}B\left(t_m,t_f\right)}{w_0}.$$

When taking this model to the data, we parameterize γ, β, and τ. We have income and wealth data for singles and couples, as well as their actuarial and subjective duration, namely

$$p_{mt}=p\left(T_m\geq t\right).$$

To compute the AEW, we require instead hazard rates, which we can back out from the duration data as follows

$$\begin{aligned} p\left(T_m=t\right) &= p\left(t\leq T_m<t+1\right) \\ &= p\left(T_m\geq t\right)p\left(T_m<t+1\right) \\ &= p_{mt}\left(1-p_{mt+1}\right) \end{aligned}$$

and

$$\begin{aligned} p\left(t_m,t_f\right) &= p\left(T_m=t_m,T_f=t_f\right) \\ &= p\left(T_m=t_m\right)p\left(T_f=t_f\right) \\ &= p_{mt}p_{ft}\left(1-p_{mt+1}\right)\left(1-p_{ft+1}\right) \end{aligned}$$

Recall that the subjective duration data are obtained from respondents who are asked to estimate their probabilities of survival to ages 75 to 95 in five-year increments. We either interpolate or fit these probabilities with a second-order polynomial to obtain annual estimates of subjective probabilities. We then compute the AEW for all couples and singles in our data set that are younger than 65 and have positive wealth (for there to be a meaningful choice of annuitization), according to the formulas above.

5 The empirical model

5.1 The dependent variable

The dependent variable in our empirical approach is derived from hypothetical questions on preferences over a full annuity or a partial lump sum payment upon retirement. The first question reads as follows:

Imagine you are 65 years old, and you are receiving € 1,000 per month in state pension. Suppose you were given the choice to lower that benefit by half, to € 500 per month. This one-half benefit reduction would continue for as long as you live. In return you would be given a one-time, lump sum payment of [€ 93,000 (for females) / € 81,000 (for males)].
Would you take the € 1,000 monthly benefit for life, or the lower monthly benefit combined with the lump sum payment?

This initial question is asked to all respondents in the sample, irrespective of their working status and age. At this stage, the respondents are given a fair deal. The lump sum payment is computed to be actuarially fair and thus the amount differs by gender: Females are confronted with a payment of 93,000 euros, males with 81,000 euros. The choice is then between a full annuity and a partial lump sum payment. For simplicity, from now on we omit the words "full" and "partial" when referring to the annuity and the lump sum payment, respectively. However, it is important to keep in mind, especially when interpreting the empirical results, that the other polar case of full lump sum payment is never offered to the individuals in this exercise.

Depending on the answer given to this question, the respondents are asked a follow-up question, where the lump sum payments is made more (less) attractive to those individuals who had preferred the annuity (the lump sum payment) in the first round. Figure 5 reports the structure of the question sequence. Table 3 reports the mean values of the choice between the annuity and the lump sum payments for the full sample, as well as by gender and by the presence of children.

Figure 5 and Table 3 about here

The annuity is preferred by slightly more than half of respondents (53 percent) in Question 1.[1] Conditional on having chosen the annuity in Question 1, the annuity is still largely preferred to the lump sum payment in Question 2a (68 percent vs. 32 percent, respectively). Similarly, conditional on having chosen the lump sum in Question 1, the annuity is preferred only by 43 percent of individuals in Question 2b. There is evidence of persistent preferences as only 17 percent of individuals switch from the annuity to the lump sum payment (262 out of 1,564), and only 20 percent of individuals switch from the lump sum payment to the annuity (315 out of 1,564).

[1]This is in line with Brown (2001) who finds that 48 percent of the HRS sample reports that they will annuitize their DC plan.

The overall picture does not change when choices are differentiated by gender and by the presence of children. We notice however that males and childless respondents prefer the annuity the most in Question 1 (55 and 58 percent, respectively). The difference between males and females is significant at the 5-percent level and the difference between respondents with and without children is significant at the 1-percent level in Question 1. No significant differences for respondents having children is found for the follow-up questions. However, females have a significantly stronger preference for the annuity in Question 2a (at the 5-percent level), where the lump sum payment is made more attractive. We also analyzed whether the presence of a partner and household income matter; in these cases, the differences are insignificant (the results are available upon request).

We model the decision to annuitize with a standard ordered choice model. The dependent variable takes value 1 if the annuity is refused both in Question 1 and in Question 2b; 2 if the annuity is refused in Question 1 and accepted in Question 2b; 3 if the annuity is accepted in Question 1 and refused in Question 2a; 4 if the annuity is accepted both in Question 1 and in Question 2a. We then run ordered probit regressions.

In contrast to Bütler and Teppa (2007), who provide empirical evidence on actual choices, this paper is based on purely hypothetical choices between the annuity and the lump sum. In fact, the institutional characteristics of the Dutch pension system prevent us from collecting any actual choices because in the Netherlands all retirement income has to be annuitized. However, in order to map this hypothetical choice to reality as tightly as possible, we focus primarily on the sub-sample of the respondents below age 65. This subgroup consists of 70 percent of the initial sample, and includes the individuals for whom this hypothetical choice might be more meaningful. In reality, this choice is typically given upon retirement or some years prior to retirement. We therefore exclude the oldest fraction of the sample altogether.

6 Empirical findings

6.1 Does the annuity demand respond to longevity risk?

Table 4 reports the first set of empirical findings. The initial specification (regression I) includes longevity risk only (via the subjective probability of survival to age 75, SSP75). Specification II includes age (in dummies in order to capture non linearities in the age function), gender (as a female indicator), household gross income (in classes), and bequest motives. In particular, we consider answers given to the following question:

What is the chance that you will leave an inheritance (including possessions and valuable items) of more than € 10,000?

We then split the sample of respondents between those who viewed any of the following statements as important or very important (Regression IIa), and those who viewed otherwise (Regression IIb):

(-) To save so that I can help my children if they have financial difficulties;
(-) To save so that I can give money or presents to my children and/or grandchildren.

The idea behind this specification is to capture more adequately the role of bequest motives and to control for preference for *inter vivos* transfers. Both elements imply choosing a lump sum payment over an annuity; accordingly, we expect a negative estimated coefficient for these variables. Furthermore, we are interested in whether and how the significance of subjective survival probabilities in the annuitization choice is affected when controlling for these determinants with a priori offsetting influence.

Finally, regression III controls for an interaction term between the bequest motive variable and the importance of bequests and *inter vivos* transfers.

Table 4 about here

The baseline scenario (Regression I) shows that, in the absence of any other controls, the individual choice between the annuity and the lump sum payment responds to longevity risk with the expected positive sign and very significantly so. The respondents reporting higher probabilities to survive until age 75 (included) are more likely to opt for the annuity, at the 1-percent significance level. The marginal effect is such that for any additional 10 percent-point increase in the SSP75, the annuitization probability (in both rounds of choice) increases by 4.1 percent on average. As an example, if the likelihood of being alive at age 75 increases from 30 to 40 percent, the probability of choosing to annuitize increases by 4.1 percentage points. An individual whose survival expectations at age 75 jump from 0 percent to 100 percent increases her annuitization probability by 41 percentage points.

Controlling for all other variables (Regression II) does not affect the impact of the subjective survival probability: individuals with greater expectations of surviving past 75 are more likely to annuitize. The marginal effect of SSP75 remains robust (4.5 percent for every 10 percent change in SSP75), the significance level is as strong as in the baseline specification (1-percent level).

In addition, age dummies are significant at the 1-percent level. As the age class of individuals aged between 61 and 64 years serves as reference category, the negative sign of the estimated coefficients of the age dummies indicates that younger respondents are less likely to annuitize than those around retirement age. This finding is in line with the analysis conducted on real choices between the lump sum versus annuity payout made by retirement-age participants in two Fortune 500 defined benefit plans in the US (one a traditional final-average-pay plan, the other a cash balance plan), where older participants were much more likely to annuitize than their younger counterparts. Approximately half of the participants aged 70 and older chose an annuity, compared with less than 20 percent for participants between ages 55 and 60 (Mottola and Utkus, 2007). There may be several reasons behind the young's stronger preference for lump sum payments. First, young respondents might not yet be particularly interested in pension-related issues, thus exhibiting a higher discount rate than older respondents and leading them to prefer to cash out. Second, liquidity constraints typically bind more earlier in the life cycle. Third, the young might be less risk averse and thus face higher opportunity costs in forgoing the lump sum than the elderly. The marginal effect decreases monotonically with age: for any additional 10 percent-point increase in the SSP75, the annuitization likelihood (in both rounds of choice) decreases by 17 percent for individuals younger than 30; by 16.2 percent for respondents in their thirties; by 11.7 percent for respondents in their forties; by 9.8 percent for respondents in their fifties.

Females annuitize significantly less than males, by 7.7 percent at the probability margin. The higher cash-out rates for women are fully consistent with the findings of Bütler and Teppa (2007) and can be rationalized by the availability of alternative sources of income and insurance (husband, family). In fact, household gross income is inversely related to annuitization intentions, albeit not significantly so.

The variable for bequest motives takes the expected negative coefficient but it is only significant at the 10-percent level.

When refining the concept of leaving a bequest and restricting the sample to the individuals who value *inter vivos* transfers (Regression IIa), the effect of the bequest motive remains negative and its significance level increases (to the 5-percent level), despite the drop in the number of observations. Similarly, the longevity risk retains its positive sign and remains strongly significant (at the 1-percent level). All the other regressors remain robust and household gross income becomes significant at the 10-percent level. However, running the same specification for the sub-sample of respondents who do not value *inter vivos* transfers (Regression IIb), we find no significant role for the bequest-related variable, while the subjective survival probability remains strongly relevant.

For robustness purposes, we run an alternative specification (Regression III) where we interact the probability of leaving a bequest with the self-reported level of importance for *inter vivos* transfer. As expected, the interaction term is significant (at the 10-percent level) and the negative estimated coefficient indicates that bequest motives decrease the annuitization probability only for those respondents who are willing to transfer resources to their offspring.

Overall, our findings suggest that the choice between an annuity and a (partial) lump sum payment is mainly driven by the longevity risk (with a fairly robust marginal effect) and by the bequest motive. The SSP75 remains very significant even when controlling for the intention to leave a bequest and its marginal effect is always larger in all three specifications. The desire to bequeath is the other significant determinant on the annuitization choice, though of a much smaller magnitude. These two drivers pull the choice in opposite directions, and the empirical findings show that the bequest motive does not dominate the longevity risk.

As further robustness checks, we run several specifications by including additional background characteristics (e.g. level of education, marital status, number of children), financial assets (e.g. household wealth, both net and gross), and health variables (e.g. self-assessed health, number of visits to the medical doctor). All these controls turned out to be insignificant; we therefore decided not to report these regressions, but concentrate on the above mentioned specifications.

6.2 Do different time horizons in measuring longevity risk matter?

The empirical evidence described in the previous subsection is based on the subjective survival probabilities to age 75 (SSP75). This subsection focuses on the effect of longer horizons, which policy makers may arguably be more concerned about. We perform the same exercise for any of the other SSPs available, namely SSP80, SSP85, SSP90 and SSP95. Table 5 presents the empirical findings for the subjective survival probability of reaching the highest target age (SSP95). The model specifications are also the same as those used in Table 4. Although the question on SSP95 is asked to the entire age distribution, the models in Table 5 have been estimated for the same sub-sample of respondents as for Table 4, namely the respondents aged less than 65. The rationale behind this age restriction is that we aim at exploring whether different time horizons have a different impact on the annuitization choice.

Table 5 about here

The picture that emerges from this set of regressions is fairly similar to the one presented above. The SSP95 is again a very highly significant determinant of the preference between the annuity and the lump sum payment. Lengthening considerably the horizon (e.g. asking about survival probability 20 years further) does not diminish predictive power. We only notice a somewhat lower marginal effect than for SPP75. This finding is very relevant for policy makers, as it suggests that individual can make consistent choices even when confronted with the risk of reaching very high ages.

The preference for leaving a bequest turns out to be the other strongly significant factor affecting annuitization intensions, with a fairly robust magnitude effect.

As a robustness check, we perform the same analysis also for any other SPPs available. The overall picture remains unchanged (results available upon request).

6.3 Are actuarial survival probabilities superior predictors of the annuity demand?

Up to this point, we used survival probabilities as direct control variables in the annuitization choice. In this section, we run the same specifications as before but control for the AEW developed in Section 4 in place of the direct survival probabilities. Table 6 reports the empirical findings. We focus on three alternative measures of AEW. We consider an AEW based on actuarial survival probabilities (Regressions Ia to IIIa), one based on interpolated subjective probabilities (Regressions Ib to IIIb) and a third based on second-order polynomial fitted probabilities (Regressions Ic to IIIc). We assume log-utility (ρ=1), an annuitization ratio γ of 8%, a utility spill-over λ of 0.25, an interest rate R of 3% (recall $\beta R = 1$) and a dependent payout ratio τ of 70%.

Table 6 about here

Since the mechanism used to compute the AEW requires information on income, wealth and SSPs for both spouses, missing values reduce the number of observations dramatically (about half) in these regressions compared to the previous ones. Nevertheless several interesting results stand out.

All measures of AEW are estimated with the expected positive sign. However the AEW based on actuarial survival probabilities is never significant in any of the regressions, whereas the AEW computed with the SSPs enters significantly (at least at the 10-percent level) in all regressions. Second-order polynomial fitted subjective survival probabilities are slightly better predictors than interpolated SSPs. It is interesting to notice also that the marginal effects are lower for AEWs based on actuarial survival probabilities than for AEWs based on the subjective ones. As an example, we find that a one percentage point increase in the annuity equivalent wealth leads to a 0.19 percentage point increase in the probability of choosing the annuity in regression Ia, and that a one percentage point increase in the annuity equivalent wealth leads to a 0.30 percentage point increase in the probability of choosing the annuity in regressions IIa and IIIa. Similar results are found for specifications b and c.

Taken together, these findings suggest that preferences for or against annuities reflect consistently individuals' genuine subjective beliefs about survival rather than actuarially tabulated probabilities.

Another important difference with respect to previous subsections is that the bequest motive vanishes completely. However, the number of children (added as additional control) can be interpreted as a proxy for bequests. Having more children is associated with lower probabilities of claiming a preference for annuities when subjective survival probabilities are involved (at the 10-percent level significance level only).

7 Conclusions

This paper provides new evidence on individual preferences over annuities and lump sum payments based on hypothetical questions posed in the DNB Household Survey in 2010. In contrast to the majority of papers in the annuitization puzzle literature, this study controls explicitly for the subjective survival probability which, as a perceived measure of longevity risk, is key in deciding about whether to annuitize.

The main results can be summarized as follows. First, we find that the SSPs convey reasonably meaningful information on individual longevity, and on average correlate relatively closely with a number of background and socio-economic characteristics. Second, individuals make their choices consistently in line with their survival expectations. In particular, people expecting to live longer prefer the annuity. This finding is very robust to a number of alternative specifications, including regressions that account explicitly for bequest motives. Overall, the choice seems to be significantly driven by these two opposite forces. All the other controls are totally irrelevant for the choice: education level, household wealth (net and gross), children, and marital status play no significant role in the annuitization choice. Third, extending the horizon in measuring longevity risk does not diminish the predictive power of subjective survival probabilities. Our finding of a very strong role for SSPs is robust when far-off ages are involved and represents very relevant evidence on the longevity risk policy makers are ultimately concerned about. Fourth, actuarial survival probabilities are insignificant determinants of the annuity demand, implying that individual preferences reflect the subjective survival probabilities and not those implied by mortality tables.

The relevance of this paper is twofold. First, it delivers an important empirical result on the role of the SSP that has not been directly tested in the literature about the annuitization puzzle. In addition, given that individuals tend to underestimate their life expectancy systematically, especially for lower target ages, the finding that people choose the annuity in line with their survival probabilities has strong policy implications. The annuitization puzzle may be better alleviated by helping individuals assess correctly their perceived longevity risk, rather than by forcing their actions.

We plan to extend this paper in a number of directions. One idea is to frame the choice between the annuity and the lump sum differently and test for the presence of framing/wording effects. Another idea is to investigate the role of the SSPs in real rather than in hypothetical choices. These extensions are left for future research.

8 Appendix

This appendix streamlines the models in Brown and Poterba and in this paper to highlight the differences in the treatment of survival probabilities. Thus, consider a single agent with initial wealth w, facing a discount rate β, a return R, a probability of surviving two periods p, and choosing between annuitization and lump-sum payments to insure against longevity risk. Brown and Poterba's approach is to model the problem as choosing between the optimized values of

$$V_2^L(w) = u(w - s) + \beta p u(Rs)$$

if the agent does not annuitize, and

$$V_2^A(w) = u(\gamma w - s) + \beta p u(\gamma w + Rs)$$

if he does, where saving s is the choice variable and γ the annuity ratio. Staring at these two definitions long enough should convince that the choice must be independent of the preferences environment (the functional elements of the objective function), since the terms of inter-temporal allocation are the same in both cases. But the choice must depend on the budget constraint, namely replacing an initial, one-period stock w with a two-period flow γw. Thus, what matters is the size of the pie, not the way it is sliced. More formally, consider that if the agent chooses to go lump sum, optimal allocation requires

$$u'(w - s) = R\beta p u'(Rs)$$

implying

$$s = \frac{1}{1+\phi R}\gamma w$$

and the value function (the objective function evaluated at the optimal choice of saving) is

$$V_2^L(w) = u\left(\frac{\phi}{1+\phi R}Rw\right) + \beta p u\left(\frac{1}{1+\phi R}Rw\right)$$

where $\phi = u'^{-1}(R\beta p)$. If the agent chooses annuitization instead, then

$$u'(\gamma w - s) = R\beta p u'(\gamma w + Rs)$$

implying

$$s = \frac{1-\phi}{1+\phi R}\gamma w$$

and

$$V_2^A(w) = u\left(\frac{\phi}{1+\phi R}(1+R)\gamma w\right) + \beta p u\left(\frac{1}{1+\phi R}(1+R)\gamma w\right)$$

The annuity equivalent wealth x is a compensating variation measure such that

$$V_2^L(w(1+x)) = V_2^A(w)$$

or

$$\begin{aligned} u\left(\frac{\phi}{1+\phi R}Rw(1+x)\right) &+ \beta p u\left(\frac{1}{1+\phi R}Rw(1+x)\right) \\ &= u\left(\frac{\phi}{1+\phi R}(1+R)\gamma w\right) + \beta p u\left(\frac{1}{1+\phi R}(1+R)\gamma w\right) \end{aligned}$$

from which it is clear that

$$(1+x) = \gamma\left(1+\frac{1}{R}\right)$$

In particular, x is independent of u, β, and p. In the model of section 4, we assumed $\beta R = 1$, so the dependence therein on discounting β (which is a preference parameter) is in fact dependence on the market return R (a feature of hard resource constraint). Note furthermore that the structure of the model is not suited to address the question at hand: we assume away uncertainty about lifespans by constructing a two-period model from the get go.

Consider the following alternative. Suppose the agent with initial wealth w has no access to annuitization and lives only one period. Then, trivially,

$$V_1^L(w) = u(w)$$

If he lives two periods, his objective function is

$$V_2^L(w) = u(w - s) + \beta u(Rs)$$

the value function is, with $\phi \equiv u'^{-1}(R\beta)$

$$V_2^L(w) = u\left(\frac{\phi}{1+\phi R} Rw\right) + \beta u\left(\frac{1}{1+\phi R} Rw\right)$$

Suppose now he decides to annuitize. If he lives only one period, then

$$V_1^A(w) = u(\gamma w)$$

where γ is the replacement ratio. If he lives two periods,

$$V_2^A(w) = u(\gamma w - s) + \beta u(\gamma w + Rs)$$

and along the optimal path

$$V_2^A(w) = u\left(\frac{\phi}{1+\phi R}(1+R)\gamma w\right) + \beta u\left(\frac{1}{1+\phi R}(1+R)\gamma w\right)$$

Therefore, if

$$\gamma^* < \gamma < 1$$

where γ^* satisfies

$$\frac{u(\phi(1+R)\gamma^* z) - u(\phi R z)}{u((1+R)\gamma^* z) - u(Rz)} = \beta$$

we have

$$\begin{aligned} V_1^A(w) &< V_1^L(w) \\ V_2^A(w) &> V_2^L(w) \end{aligned}$$

In words, if the agent expects to survive two periods, he annuitizes, otherwise, he opts for lump sum. We therefore have a meaningful trade-off. Consider then two lotteries

$$\begin{aligned} L^A &= pV_1^A + (1-p)V_2^A \\ L^L &= pV_1^L + (1-p)V_2^L \end{aligned}$$

The agent prefers annuitization if

$$L^A > L^L$$

Define the compensating variation x over the lotteries

$$L^A(w) = L^N(w(1+x))$$

Specializing to CRRA utility, after some manipulation, we can solve for this newly-defined AEW as

$$1 + x = \gamma \left[\frac{p + (1-p)\left(\beta^{\frac{1}{\rho}} + R^{1-\frac{1}{\rho}}\right)^{\rho} \left(1 + \frac{1}{R}\right)^{1-\rho}}{p + (1-p)\left(\beta^{\frac{1}{\rho}} + R^{1-\frac{1}{\rho}}\right)^{\rho}} \right]^{\frac{1}{1-\rho}}$$

which re-introduces all preference parameters (ρ, β, and p) with the intuitive comparative statics

$$\frac{dx}{d\rho} > 0, \frac{dx}{d\beta} < 0, \frac{dx}{dp} < 0.$$

That is, preference for annuitization increases with risk aversion and decreases with discounting and expected shorter lifespans. The model in the main text is a multi-period version of this two-period model applied to both singles and couples, with the simplification that $\beta R = 1$.

Acknowlegments: We thank Maarten van Rooij for providing us with the data on the choice between the annuity and the lump sum payment, and CentERdata at Tilburg University for supplying the data of the DNB Household Survey. The paper has benefited from useful comments by Jakob de Haan and Arie Kapteyn, and from discussions at the 14th International Business Research conference (Dubai, UAE, April 2011 - Best Paper Award), 9th International Workshop on Pension, Insurance and Saving (Paris, May 2011), International Journal of Arts & Sciences conference (Bad Hofgastein, Austria, May 2011), 17th conference of the Society of Computational Economics - Computing in Economics and Finance (San Francisco, June 2011), 4th Society for the Study of Economic Inequality Conference (Catania, July 2011), Singapore Economic Review Conference (Singapore, August 2011), 67th International Institute of Public Finance Congress (Ann Arbor, Michigan, August 2011), Longevity 8: Eighth International Longevity Risk and Capital Markets Solutions Conference (Waterloo, Ontario, September, 2012) and at DNB seminars. The views expressed in this paper are those of the author and do not necessarily reflect those of the institutions she belongs to. Any remaining errors are her own responsibility.

References

[1] Agnew, J., Anderson, L., Gerlach, J. and Szykman, L. (2008), "Who chooses annuities? An experimental investigation of gender, framing and defaults", *American Economic Review*, 98(2), 418-422.

[2] Banks, J., Emmerson, C. et al. (2004), "Not so brief lives: longevity expectations and wellbeing in retirement", *Seven Ages of Man and Woman: A Look at Life in Britain in the Second Elizabethan Era* I. Stewart and R. Vaitlingam. Swindon, ESRC.

[3] Beatrice, D., Drinkwater, M. (2004), "The 2003 individual annuity market: Sales and assets", Tech. rep., LIMRA International, Inc, Windsor, CT.

[4] Brown, J. (2001), "Private pensions, mortality risk, and the decision to annuitize", *Journal of Public Economics* 89, 1299-1318.

[5] Brown, J., Mitchell, O., Poterba, J. and Warshawsky, M. (1999), "New evidence on the money's worth of individual annuities", *American Economic Review* 89, 1299-1318.

[6] Brown, J., Mitchell, O., Poterba, J. and Warshawsky, M. (2001), *The Role of Annuity Markets in Financing Retirement*, MIT press, Cambridge, USA.

[7] Brown, J., Kling, J., Mullainathan, S. and Wrobel, M. (2008), "Why don't people insure late-life consumption? A framing explanation of the under-annuitization puzzle", *American Economic Review* 98(2), 304–309.

[8] Brown, J. and Nijman, T. (2011), "Opportunities for improving pension wealth decumulation in the Netherlands", Netspar Discussion Paper 01/2011-008.

[9] Brown, J. and Poterba, T. (2000), "Joint life annuities and annuity demand by married couples", *The Journal of Risk and Insurance* 67, 527-554.

[10] Bütler, M. and Teppa, F. (2007), "The choice between an annuity and a lump sum: Results from Swiss pension funds", *Journal of Public Economics* 91, 1944-1966.

[11] Bucher-Koenen, T. and Kluth, S. (2013), "Subjective life expectancy and private pensions", MEA Discussion Paper 265.

[12] Cannon, E. and Tonks, I. (2004), "UK annuity rates, money's worth and pension replacement ratios, 1957-2002", *The Geneva Papers on Risk and Insurance* 29(3), 394-416.

[13] CBS (2012), http://www.cbs.nl/en-GB/menu/themas/inkomen-bestedingen/publicaties/artikelen/archief/2012/2012-3586-wm.htm?Languageswitch=on

[14] Cutler, D., Lleras-Muney, A. and Vogl, T. (2010), "Socioeconomic status and health: Dimensions and mechanisms", *Oxford Handbook of Health Economics* forthcoming.

[15] Davidoff, T., Brown, J. and Diamond, P. (2005), "Annuities and individual welfare", *American Economic Review* 95(5), 1573-1590.

[16] De Nardi, M., French, E. and Jones, J. (2010), "Why do the elderly save? The role of medical expenses", *Journal of Political Economy* 118(1), 39-75.

[17] James, E., Song, X. (2001), "Annuities markets around the world: Money's worth and risk intermediation", CeRP WP16.

[18] Johnson, R., Burman, L., Kobes, D. (2004), "Annuitized wealth at older ages: Evidence from the Health and Retirement Study", Final Report to the Employee Benefits Security Administration, U.S. Department of Labor 9142, The Urban Institute, Washington, DC.

[19] Finkelstein, A. and Poterba, J. (2004), "Adverse selection in insurance markets: Policyholder evidence from the U.K. annuity market", *Journal of Political Economy* 112(1), 183-208.

[20] Friedman, B. and Warshawsky, M. (1990), "The cost of annuities: Implications for saving behavior and bequests", *The Quarterly Journal of Economics* 105(1), 135-154.

[21] Hurd, M. and McGarry, K. (1995), "Evaluating subjective probabilities of survival in the Health and Retirement Study", *Journal of Human Resources* S268-S292.

[22] Hurd, M. and McGarry, K. (2002), "The predictive validity of subjective probabilities of survival", *Economic Journal* 112(442), 966-985.

[23] Kotlikoff, L. and Spivak, A. (1981), "The family as an incomplete annuities market", *Journal of Political Economy* 89(2), 372-391.

[24] Mottola, G. and Utkus, S. (2007), "Lump sum or annuity? An analysis of choice in DB pension payouts", *Vanguard Center for Retirement Research* 30. 89(2), 372-391.

[25] O'Donnell, O., Teppa, F. and van Doorslaer, E. (2008), "Can subjective survival expectations explain retirement behaviour?", DNB WP188.

[26] Palumbo, M. (1999), "Uncertain medical expenses and precautionary saving near the end of the life cycle", *Review of Economic Studies* 66(2), 395-421.

[27] Pampell, F. (2002), "Cigarette use and the narrowing sex differential in mortality", *Population and Development Review*, 28(1), 77–104.

[28] Perozek, M. (2008), "Using subjective expectations to forecast longevity: Do survey respondents know something we don't know?", *Demography*, 45(1), 95–113.

[29] Siegel, M., Bradley, E. et al. (2003) "Self-rated life expectancy as a predictor of mortality: Evidence from the HRS and AHEAD surveys", *Gerontology* 49, 265-71.

[30] Smith, V., Taylor, D. et al. (2001) "Longevity expectations and death: Can people predict their own demise?", *American Economic Review* 91(4), 1126-1134.

[31] Solinge, H. van and Henkens, K. (2010), "Living longer, working longer? The impact of subjective life expectancy on retirement intentions and behaviour", *European Journal of Public Health* 20(1), 47-51.

[32] Vallin, J. (1991), "Mortality in Europe from 1720 to 1914: long-term trends in patterns by age and sex", in R. Schofield, D. Reher, and A. Bideau, eds., *The decline of mortality in Europe*, Oxford University Press.

[33] Vidal-Melia, C. and Lejarraga-Garcia, A. (2006), "Demand for life annuities from married couples with a bequest motive", *Journal of Pension Economics and Finance* 5(2), 197-229.

[34] Yaari, M. (1965), "Uncertain lifetime, life insurance, and the theory of consumer", *Review of Economic Studies* 32, 137-150.

[35] Wu, S., Stevens, R. and Thorp, S. (2013), "Die young or live long: Modeling subjective survival probabilities", ARC Centre of Excellence in Population Ageing Research Working Paper 19.

Table 1: Summary statistics for SSPs

Statistics	**SSP75**	**SSP80**	**SSP85**	**SSP90**	**SSP95**
Mean	6.66	5.64	4.58	3.27	2.22
Median	7	6	5	3	2
Std.Dev.	1.79	2.06	2.18	2.25	2.08
Variance	3.23	4.26	4.78	5.09	4.32
Std.Err.(mean)	0.05	0.06	0.06	0.06	0.05
Skewness	-0.81	-0.50	-0.20	0.32	0.87
Kurtosis	4.11	3.14	2.45	2.25	3.08
N.Obs.	1,188	1,285	1,366	1,401	1,407

Table 2: SSPs and socio-economic factors (mean values)

Variable	**SSP75**	**SSP80**	**SSP85**	**SSP90**	**SSP95**
GENDER					
Female	6.84	5.75	4.52	3.10	2.09
Male	6.72	5.49	4.25	2.86	1.90
Difference	*0.12*	*0.26 **	*0.27 **	*0.24 **	*0.19*
EDUCATION LEVEL					
Low level	6.64	5.42	4.25	2.89	1.92
Mid/high level	6.84	5.70	4.42	3.00	2.01
Difference	*-0.20 **	*-0.29 ***	*-0.17*	*-0.11*	*-0.09*
SAH					
Good/Very good	6.99	5.87	4.63	3.20	2.16
Fair/Bad/Very bad	6.03	4.67	3.46	2.16	1.37
Difference	*0.96 ****	*1.20 ****	*1.17 ****	*1.04 ****	*0.79 ****
LT ILLNESS					
Yes	6.48	5.25	3.92	2.60	1.66
No	6.90	5.75	4.55	3.12	2.12
Difference	*-0.42 ****	*-0.50 ****	*-0.63 ****	*-0.52 ****	*-0.46 ****
SMOKE					
Yes	6.32	5.18	4.08	2.70	1.83
No	6.89	5.71	4.43	3.03	2.02
Difference	*-0.57 ****	*-0.53 ****	*-0.35 ***	*-0.33 **	*-0.19*
DRINK					
Yes	6.15	4.64	3.52	2.37	1.60
No	6.83	5.68	4.44	3.02	2.02
Difference	*-0.68 ****	*-0.94 ****	*-0.92 ****	*-0.65 ***	*-0.42 **
HOUSEHOLD INCOME					
Larger than 40,000 euros	6.59	5.53	4.50	3.25	2.32
Lower than 40,000 euros	6.82	5.63	4.32	2.88	1.88
Difference	*-0.23*	*-0.10*	*0.18*	*0.37 **	*0.44 ***
*** denotes significant at 1-percent level					
** denotes significant at 5-percent level					
* denotes significant at 10-percent level					

Table 3: Mean values of the choice between annuity and lump sum payments

Choice	Question 1		Question 2a		Question 2b	
	Percent	**N.Obs.**	**Percent**	**N.Obs.**	**Percent**	**N.Obs.**
FULL SAMPLE						
Annuity	52.75	825	68.24	563	42.63	315
Lump sum	47.25	739	31.76	262	57.37	424
Total	*100*	*1,564*	*100*	*825*	*100*	*739*
GENDER						
FEMALE						
Annuity	50.29	344	71.80	247	40.52	207
Lump sum	49.71	348	28.20	97	59.48	141
Total	*100*	*692*	*100*	*344*	*100*	*348*
MALE						
Annuity	55.16	481	65.70	316	44.50	174
Lump sum	44.84	391	34.30	165	55.50	217
Total	*100*	*872*	*100*	*481*	*100*	*391*
Difference	*-5.45 ***		*6.10 ***		*-3.98*	
CHILDREN						
WITH CHILDREN						
Annuity	43.28	235	67.66	159	39.94	123
Lump sum	56.72	308	32.34	76	60.06	185
Total	*100*	*543*	*100*	*235*	*100*	*308*
NO CHILDREN						
Annuity	57.79	590	68.47	404	44.55	192
Lump sum	42.21	431	31.53	186	55.45	239
Total	*100*	*1,021*	*100*	*590*	*100*	*431*
Difference	*-14.51 ****		*-0.81*		*-4.61*	

*** denotes significant at 1-percent level
** denotes significant at 5-percent level
* denotes significant at 10-percent level

Table 4: Annuity choice and SSP75 - ordered probit estimates

Variable	**I**	**II**	**IIa**	**IIb**	**III**
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
	[Marg.eff.]	[Marg.eff.]	[Marg.eff.]	[Marg.eff.]	[Marg.eff.]
	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)
SSP75	0.116 ***	0.132 ***	0.128 ***	0.117 ***	0.134 ***
	[0.041]	[0.045]	[0.043]	[0.041]	[0.045]
	(0.019)	(0.021)	(0.031)	(0.026)	(0.022)
Age 17-30 years		-0.493 ***	-0.942 **	-0.741 ***	-0.735 ***
		[-0.170]	[-0.315]	[-0.258]	[-0.250]
		(0.164)	(0.429)	(0.272)	(0.254)
Age 31-40 years		-0.470 ***	-0.492 ***	-0.476 ***	-0.482 ***
		[-0.162]	[-0.164]	[-0.165]	[-0.164]
		(0.130)	(0.176)	(0.156)	(0.131)
Age 41-50 years		-0.339 ***	-0.381 **	-0.406 ***	-0.365 ***
		[-0.117]	[0.127]	[-0.141]	[-0.124]
		(0.121)	(0.170)	(0.145)	(0.122)
Age 51-60 years		-0.284 **	-0.190	-0.392 ***	-0.307 ***
		[-0.098]	[-0.063]	[-0.136]	[-0.104]
		(0.115)	(0.161)	(0.138)	(0.115)
Female indicator		-0.226 ***	-0.265 **	-0.266 **	-0.273 ***
		[-0.077]	[-0.088]	[-0.092]	[0.093]
		(0.086)	(0.128)	(0.104)	(0.092)
HH gross income (categories)		-0.022	-0.036 *	-0.021	-0.030 *
		[-0.007]	[-0.012]	[-0.007]	[-0.010]
		(0.015)	(0.022)	(0.018)	(0.016)
Chances of bequest (in %)		-0.019 *	-0.034 **	-0.013	-0.012
		[-0.006]	[-0.011]	[-0.004]	[-0.004]
		(0.010)	(0.015)	(0.012)	(0.011)
Chances of bequest*					-0.024 *
Importance of bequest					[-0.008]
					(0.013)
Log-likelihood	-1327.029	-1142.190	-533.684	-783.121	-1054.773
Pseudo R^2	0.013	0.024	0.032	0.024	0.030
N.Obs.	1000	871	411	596	808

The table reports ordered probit coefficients, standard errors and marginal effects on the probability of choosing the annuity at both rounds.
The dependent variable takes value 1 if annuity is refused at both rounds; 2 if annuity is refused at first round and chosen at second round; 3 if annuity is chosen at first round and refused at second round; 4 if annuity is chosen at both rounds.
All regressions are based on the subsample of respondents aged 17-64 years.
Regression IIa : respondents who intend to bequeath or to give inter-vivos transfers
Regression IIb : respondents who do not intend to bequeath nor to give inter-vivos transfers
*** denotes significant at 1-percent level; ** denotes significant at 5-percent level
* denotes significant at 10-percent level

Table 5: Annuity choice and SSP95 - ordered probit estimates

Variable	**I** Coefficient [Marg.eff.] (Std. Err.)	**II** Coefficient [Marg.eff.] (Std. Err.)	**IIa** Coefficient [Marg.eff.] (Std. Err.)	**IIb** Coefficient [Marg.eff.] (Std. Err.)	**III** Coefficient [Marg.eff.] (Std. Err.)
SSP95	0.097 ***	0.109 ***	0.108 ***	0.084 ***	0.106 ***
	[0.034]	[0.037]	[0.036]	[0.029]	[0.036]
	(0.016)	(0.018)	(0.026)	(0.022)	(0.018)
Age 17-30 years		-0.478 ***	-1.026 **	-0.771 ***	-0.772 ***
		[-0.164]	[-0.340]	[-0.269]	[-0.262]
		(0.168)	(0.430)	(0.274)	(0.255)
Age 31-40 years		-0.575 ***	-0.623 ***	-0.556 ***	-0.591 ***
		[-0.197]	[-0.206]	[-0.194]	[-0.201]
		(0.132)	(0.180)	(0.160)	(0.134)
Age 41-50 years		-0.415 ***	-0.483 ***	-0.472 ***	-0.443 ***
		[-0.142]	[0.160]	[-0.165]	[-0.150]
		(0.123)	(0.172)	(0.149)	(0.124)
Age 51-60 years		-0.307 ***	-0.202	-0.417 ***	-0.334 ***
		[-0.105]	[-0.067]	[-0.145]	[-0.113]
		(0.116)	(0.163)	(0.141)	(0.117)
Female indicator		-0.214 **	-0.271 ***	-0.241 **	-0.248 ***
		[-0.073]	[-0.090]	[-0.084]	[0.084]
		(0.087)	(0.130)	(0.105)	(0.092)
HH gross income (categories)		-0.013	-0.029	-0.013	-0.019
		[-0.004]	[-0.009]	[-0.004]	[-0.006]
		(0.015)	(0.022)	(0.018)	(0.016)
Chances of bequest (in %)		-0.015	-0.040 ***	-0.007	-0.008
		[-0.005]	[-0.013]	[-0.002]	[-0.002]
		(0.010)	(0.015)	(0.012)	(0.011)
Chances of bequest*					-0.027 **
Importance of bequest					[-0.009]
					(0.013)
Log-likelihood	-1298.135	-1115.798	-528.483	-767.741	-1035.474
Pseudo R^2	0.013	0.025	0.037	0.021	0.029
N.Obs.	978	851	407	583	793

The table reports ordered probit coefficients, standard errors and marginal effects on the probability of choosing the annuity at both rounds.
The dependent variable takes value 1 if annuity is refused at both rounds; 2 if annuity is refused at first round and chosen at second round; 3 if annuity is chosen at first round and refused at second round; 4 if annuity is chosen at both rounds.
All regressions are based on the subsample of respondents aged 17-64 years.
Regression IIa : respondents who intend to bequeath or to give inter-vivos transfers.
Regression IIb : respondents who do not intend to bequeath nor to give inter-vivos transfers.
*** denotes significant at 1-percent level; ** denotes significant at 5-percent level;
* denotes significant at 10-percent level.

Table 6: Annuity choice and AEW - ordered probit estimates

	(Ia) Coeff. [Marg.eff.] (Std.Err.)	(IIa) Coeff. [Marg.eff.] (Std.Err.)	(IIIa) Coeff. [Marg.eff.] (Std.Err.)	(Ib) Coeff. [Marg.eff.] (Std.Err.)	(IIb) Coeff. [Marg.eff.] (Std.Err.)	(IIIb) Coeff. [Marg.eff.] (Std.Err.)	(Ic) Coeff. [Marg.eff.] (Std.Err.)	(IIc) Coeff. [Marg.eff.] (Std.Err.)	(IIIc) Coeff. [Marg.eff.] (Std.Err.)
AEW (actuarial)	0.508	0.618	0.634						
	[0.185]	[0.224]	[0.233]						
	(0.58)	(0.66)	(0.64)						
AEW (subj. interpolated)				0.824*	0.983*	1.188**			
				[0.300]	[0.356]	[0.436]			
				(2.21)	(2.55)	(2.95)			
AEW (subj. 2nd -order pol.)							0.846*	1.021**	1.220**
							[0.308]	[0.370]	[0.448]
							(2.24)	(2.61)	(2.99)
Age 17-30 years		-0.573	-0.552		-0.606	-0.579		-0.621	-0.595
		[-0.177]	[-0.176]		[-0.185]	[-0.182]		[-0.188]	[-0.186]
		(-1.73)	(-1.65)		(-1.83)	(-1.73)		(-1.87)	(-1.77)
Age 31-40 years		-0.347	-0.338		-0.360	-0.342		-0.364	-0.346
		[-0.119]	[-0.118]		[-0.122]	[-0.119]		[-0.124]	[-0.120]
		(-1.60)	(-1.51)		(-1.68)	(-1.55)		(-1.70)	(-1.56)
Age 41-50 years		-0.0742	-0.0704		-0.0590	-0.0337		-0.0615	-0.0355
		[-0.026]	[-0.025]		[-0.021]	[-0.012]		[-0.022]	[-0.013]
		(-0.37)	(-0.33)		(-0.31)	(-0.17)		(-0.32)	(-0.18)
Age 51-60 years		-0.296	-0.333		-0.266	-0.295		-0.268	-0.298
		[-0.105]	[-0.120]		[-0.094]	[-0.106]		[-0.095]	[-0.107]
		(-1.70)	(-1.83)		(-1.54)	(-1.65)		(-1.55)	(-1.66)
N. children		-0.107	-0.110		-0.123*	-0.130*		-0.123*	-0.130*
		[-0.038]	[-0.040]		[-0.044]	[-0.047]		[-0.044]	[-0.047]
		(-1.95)	(-1.88)		(-2.21)	(-2.20)		(-2.22)	(-2.21)
HH gross income (cat.)		0.0123	0.0204		0.009	0.0174		0.00847	0.0175
		[0.004]	[0.007]		[0.003]	[0.006]		[0.003]	[0.006]
		(0.61)	(0.95)		(0.42)	(0.82)		(0.42)	(0.82)
Chances of bequest (%)			-0.0249			-0.0306			-0.0304
			[-0.009]			[-0.011]			[-0.011]
			(-1.48)			(-1.82)			(-1.81)
Chances of bequest* *Importance of bequest			0.008			0.007			0.008
			[0.003]			[0.003]			[0.003]
			(0.41)			(0.39)			(0.42)
Log-likelihood	-558.516	-547.455	-504.949	-556.237	-544.414	-500.776	-556.163	-544.243	-500.648
Pseudo R^2	0.0003	0.013	0.015	0.004	0.018	0.023	0.005	0.019	0.025
N.Obs.	418	415	386	418	415	386	418	415	386

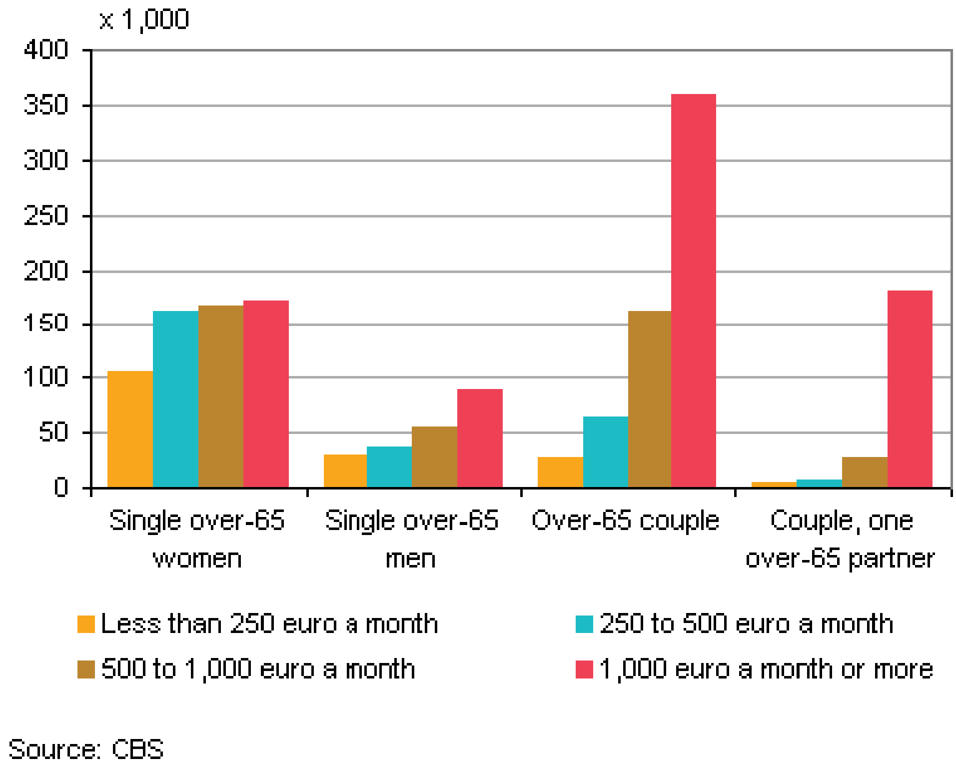


Figure 1: *Number of over-65 households by supplementary incomes in addition to AOW, 2010.*

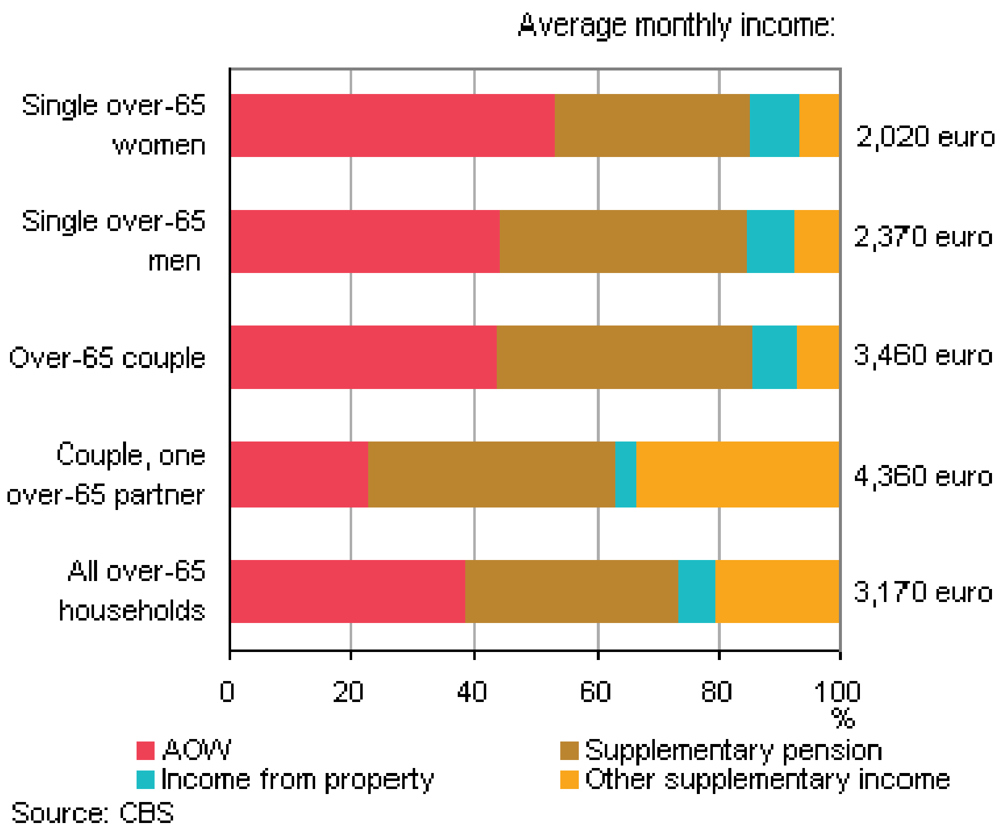


Figure 2: *Gross income components over-65 households, 2010.*

Figure 3: *Distributions of the SSPs.*

Please indicate your answer on a scale of 0 to 10, where 0 means "no chance at all" and 10 means "absolutely certain".

SSPXX How likely is it that you will attain (at least) the age of XX?

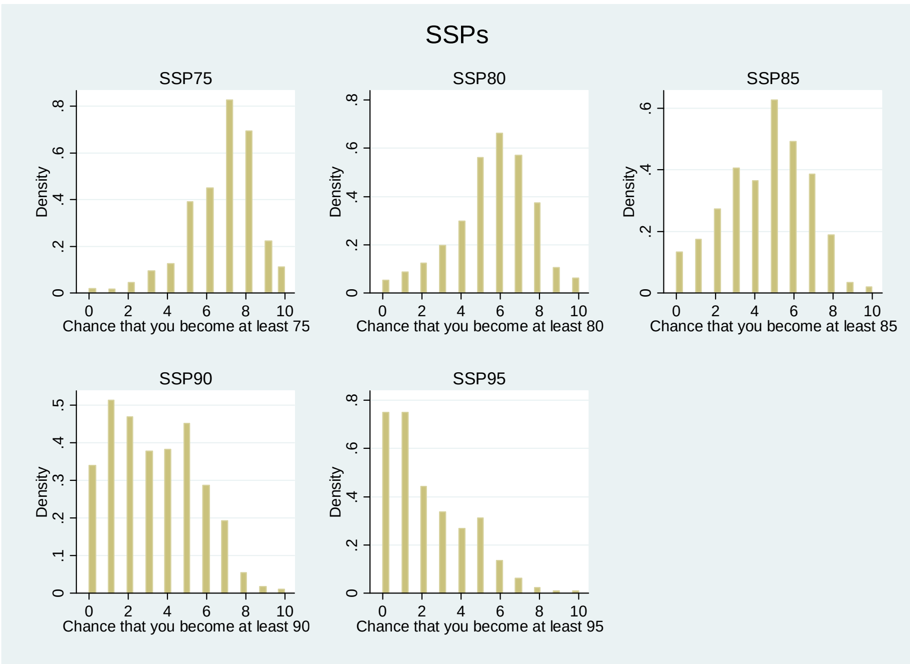
SSP75 is presented to people aged 16 through 64

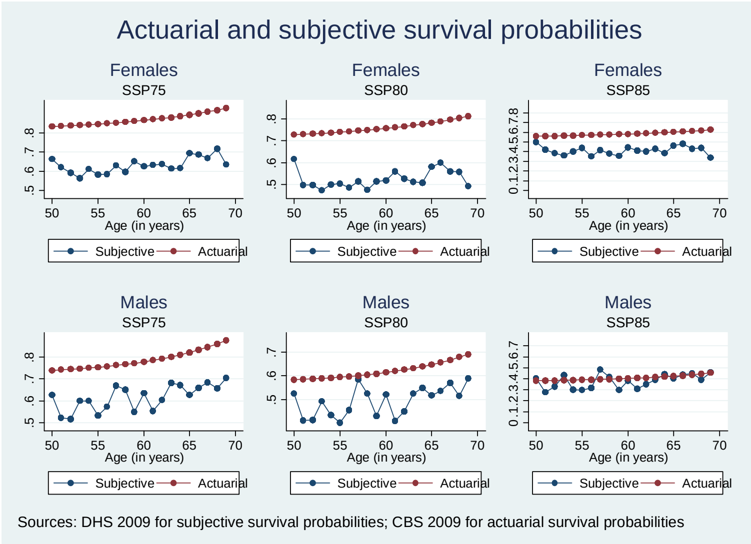
SSP80 is presented to people aged 16 through 74

SSP85 is presented to people aged 16 through 79

SSP90 is presented to people aged 16 through 84

SSP95 is presented to people aged 16 through 89





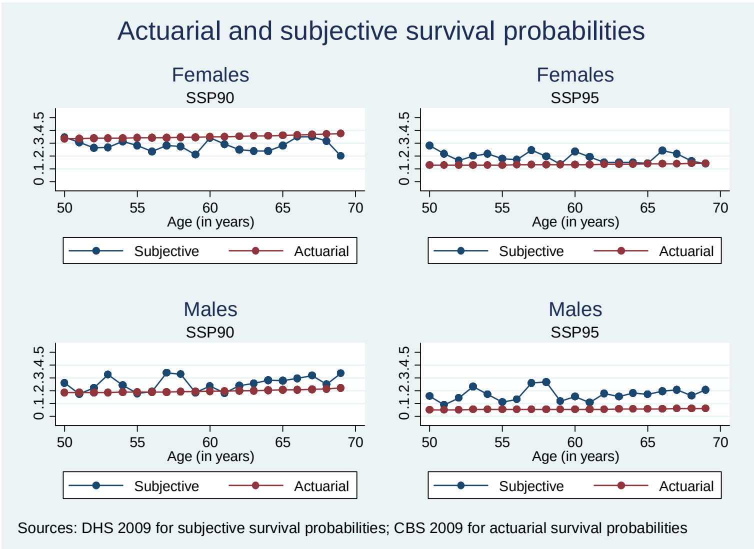


Figure 4: *Survival probabilities to reach several target ages - Actuarial vs. subjective.*

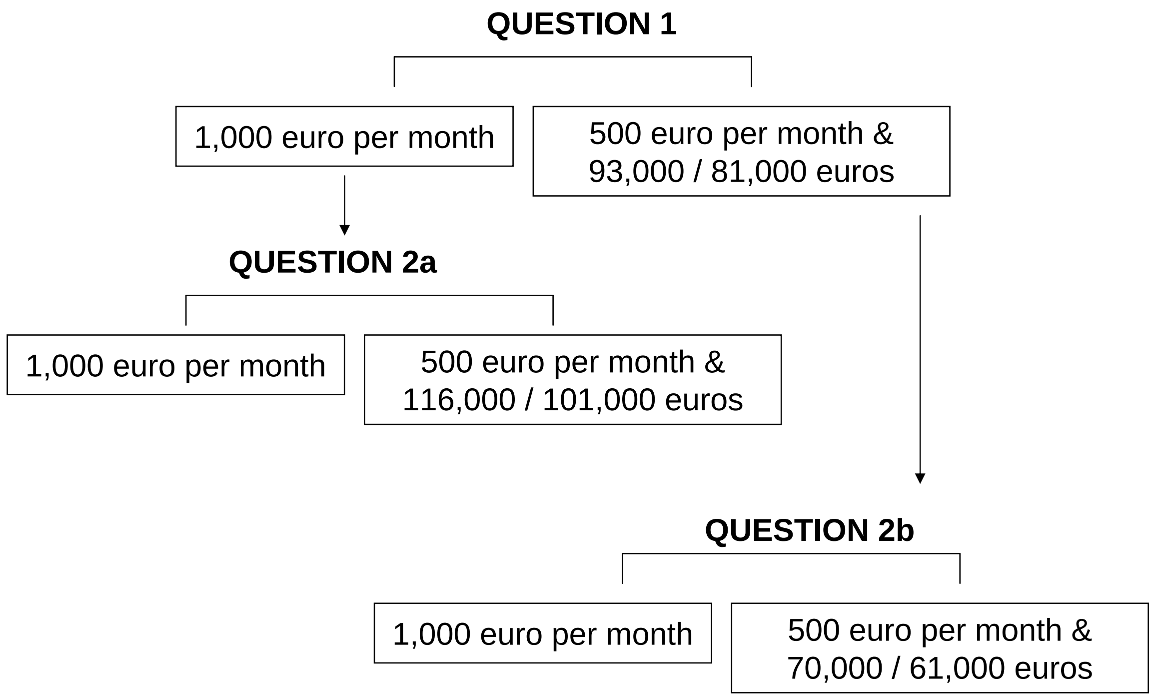


Figure 5: *Choice between annuity and (partial) lump sum payment.*
Question 1 is asked to all respondents in the sample, irrespective of their working status and for all ages. At this stage, the respondents are given a fair deal. The lump sum payment is computed to be actuarially fair and thus the amount differs by gender: Males are confronted with a payment of 81,000 euros, females with 93,000 euros. Depending on the answer given to this question, the respondents are asked a follow-up question. Question 2a is given to the individuals who had preferred the annuity in the first round: the lump sum payments is made more attractive to them. Question 2b is given to the individuals who had preferred the lump sum payment in the first round: the lump sum payments is made less attractive to them.