The gender longevity gap: Explaining the difference between singles and couples

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Abstract

In the OECD, women, on average, live 6 years longer than men. This paper studies the female to male longevity gap in different social settings. Based on the concept of the value of life, it derives the gender gap in longevity among singles, utilitarian and altruistic couples, resp., and analyses the effect of wealth on longevity. The following hypotheses are derived: i) the gender longevity gap is smaller within couples than among singles; ii) marriage increases longevity of men but decreases longevity of women; and iii) the gender longevity gap decreases with an increase in wealth. The hypotheses are tested using a complete data set of the Swiss deceased of age 65+ in 2001 and 2002, with information on the individuals' age at death and their average earnings over the life cycle.

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1 Introduction

It is common knowledge that life expectancy of women exceeds that of men. In 1999 the respective average life expectancy at birth in the OECD countries was 79.54 years for women and 73.55 for men, which implies a gender gap in longevity in favor of women equal to 6 years. Forty years ago, the average gender longevity gap amounted to 5 years. It steadily increased during the sixties and seventies, peaked in 1979 at 6.75 years, and has declined since then (Source, OECD, 2002). A simple OLS regression of the gender gap on GDP, the year and the year squared confirms the first increasing, then decreasing time trend. The size of GDP has a significant negative effect on the gender gap, which also holds for the cross-section of 1999.

Biological explanations for the greater female longevity are sparse. Hazzard (1989) points to the difference in sex hormon status between men and women, which drives the difference in lipoprotein metabolism and other biological mechanism. This may affect the cardiovascular system, leading to a higher rate of deaths of coronary artery disease among men. The epidemiological literature stresses occupational choices and detrimental behaviors such as smoking and drinking as important factors for the lower longevity of men (Wilkinson, 1996).

A recent paper by Leung et al. (2004) provided an economic analysis of the gender gap in longevity. In the context of a neoclassical growth model they addressed the rise in full time earnings of women and the female labor participation and the declining gender gap in life expectancy in the USA since the late 1970s. Their model extends the basic structure in Galor and Weil (1996) by including health investment in life extension as in Grossman (1972) and postulates that as the economy grows, a narrowing gender gap in wages will reduce the longevity advantage of women.

The focus of this paper is on the difference in the gender longevity gap between social groups, in particular between singles and couples. It elaborates on an argument presented by Posner (1995) for transferring government spending for health care from old women to old men. Posner writes that shortening the gender gap "would give elderly women a greater prospect of male companionship, something many of them greatly value" (Posner, 1995, p. 277). Rasmusen (1996) took up this argument and showed formally that the utility of marriage, indeed, results in an increase in social welfare if the gender gap in life expectancy shrinks.

This paper provides a theory of the gender longevity gap between singles and couples, based on the concept of the value of life. It differentiates between three social settings: single households, utilitarian couples, and altruistic couples. The singles and utilitarians differ with respect to their budget sets. While a single is bounded by his/her individual wealth, the utilitarian couple shares its respective wealth and, therefore, maximizes the utility subject to a joint budget. The altruistic couple is distinguished from the two other social settings that it not only shares wealth, but also its respective preferences depend on each other in that the woman's utility is higher if her husband is still alive and vice versa.

The rest of the paper is organized as follows. Sections 2 and 3 deal with the gender gap in the value of life when there is an exogenous longevity gap in favor of women. Section 2 derives the gender gap in the value of life among singles, utilitarian and altruistic couples. Section 3 studies the effect of wealth on the gender gap in the value of life. Section 4 endogenizes longevity by introducing gender-specific costs of preserving life. The greater vulnerability of men compared to women suggests higher marginal cost to maintain men's health capital stock. This assumption allows me to calibrate the model to the observed gender longevity gap and to compare the gender gap in optimal longevity for the three social settings. Section 5 tests the hypotheses based on age and income data of roughly 100,000 Swiss of age 65+ that died in 2001 and 2002, and Section 6 concludes.

2 The value of life gender gap: Differences between singles, utilitarian and altruistic couples

In all social settings considered below, women and men, $i = w, m$, are assumed to exhibit an increasing and strictly concave utility function $u(c_i)$, $u'(c_i) > 0$, $u''(c_i) < 0$. W_i denotes wealth of the individual i at birth and T_i his/her lifetime in years. In accordance to the empirical evidence, let women, on average, enjoy a longer life than men, $T_w > T_m$. For demonstrative purpose, I assume no stochastic lifetime and no discounting.

Singles (s), utilitarian couples (u) and altruistic couples (a) will be distinguished through their objective functions and budget sets. Let k_i^j denote the value of life of an individual i in the social setting $j = s, u, a$, and g_k^j be the male to female gender gap in the value of life:

$$g_k^j = k_m^j - k_w^j, \qquad \text{for } j = s, u, a. \tag{1}$$

2.1 Singles

The singles' decision program is to maximize

$$\int_0^{T_i} u\left(c_i\left(t\right)\right) dt \tag{2}$$

subject to the budget constraint

$$\int_0^{T_i} c_i\left(t\right) dt \leq W_i. \tag{3}$$

The solution to this consumption problem is well known; it involves perfect smoothing of consumption, with wealth equally split across years to result in the annual consumption level $c_i\left(t\right) = W_i/T_i$. Substituting in this consumption level, one finds the singles' indirect utility function, relating maximal lifetime utility to the exogenous variables wealth and length of life:

$$V_i^s\left(W_i, T_i\right) = T_i u\left(\frac{W_i}{T_i}\right). \tag{4}$$

Therefore, at any given level of wealth, there is a trade-off between the quantity and quality of life, represented by the overall lifetime T_i and the yearly consumption level c_i. As the individuals may allocate their wealth towards consumption or life extension, health investments allow them to convert quality of life into quantity of life.

The willingness to pay for extending life or the value of life of a person with lifetime T_i and initial wealth W_i is defined as

$$k_i^s\left(W_i, T_i\right) = \frac{dW_i}{dT_i} = \frac{\partial V_i^s/\partial T_i}{\partial V_i^s/\partial W_i}. \tag{5}$$

From (4) one finds $\partial V_i^s / \partial W_i = u'$ and $\partial V_i^s / \partial T_i = u - u' c_i$, and thus:

$$k_i^s (W_i, T_i) = \frac{u(c_i)}{u'(c_i)} - c_i. \tag{6}$$

Accordingly, the value of life corresponds to a consumer surplus: it equals the difference between the utility of consumption u and the costs of consumption valued in utility terms, $u'c$.

Strict concavity of the utility function ensures that the value of life increases with the level of consumption:

$$\frac{\partial k_i^s}{\partial c_i} = -\frac{u(c_i) u''(c_i)}{(u'(c_i))^2} > 0. \tag{7}$$

Proposition 1. *At the same wealth level, the male to female gap in the value of life in singles is positive,* $g_k^s = k_m^s - k_w^s > 0$.

Proof. With $T_w > T_m$ and $W_w = W_m$, the budget constraint (3) implies that the women's annual consumption level is smaller than the men's, $c_m^s > c_w^s$, and hence, following (7), $k_m^s > k_w^s$. □

If life expectancy is short (long), the willingness to pay for extending life is high (low) due to a low (high) marginal utility of consumption. Strict concavity also implies that length of life is a normal good: the elasticity of the value of life with respect to wealth is positive, $\frac{d \ln k}{d \ln W} > 0$.

2.2 Utilitarian and alturistic couples

The maximization program of couples is to maximize

$$\int_0^{T_m} (u(c_m(t)) + u(c_w(t)))\, dt + \theta \int_{T_m}^{T_w} u(c_w(t))\, dt \tag{8}$$

subject to the common budget

$$\int_0^{T_w} c_w(t)\, dt + \int_0^{T_m} c_m(t)\, dt \leq W_w + W_m. \tag{9}$$

The initial period may be represented by the date of marriage. The fact that men are about three years older than women when they marry will have no effect on the results, if one assumes an exogenous choice of the date of marriage. $0 < \theta < 1$ provides for mutual altruistic preferences between the spouses. It implies that for every consumption level per capita utility when both are alive is higher than utility of the survivor when one spouse has passed away. $\theta = 1$ corresponds to the welfare function of a utilitarian couple, maximizing the (unweighted) sum of their respective lifetime utilities.

Consider first the optimal solution for the utilitarian couple. Since the utility functions are uniform, it opts for the same consumption level for both individuals:

$$c^u = \frac{W_w + W_m}{T_w + T_m}. \tag{10}$$

The indirect utility function in this case is

$$V^u (W_w, W_m, T_w, T_m) = (T_w + T_m)\, u\left(\frac{W_w + W_m}{T_w + T_m}\right), \tag{11}$$

and the value of life is

$$k^u (W_w, W_m, T_w, T_m) = \frac{d(W_m + W_w)}{dT_w} = \frac{d(W_m + W_w)}{dT_m} = \frac{u(c^u)}{u'(c^u)} - c^u. \qquad (12)$$

Proposition 2. *In a utilitarian marriage, the value of life gender gap is zero,* $g_k^u = 0$.

Proof. Follows immediately from (12). □

Sharing wealth and income has an implication for the value of life in utilitarian couples compared to the value of life of singles:

Proposition 3. *With* $T_w > T_m$*, the value of life of a person in the utilitarian marriage is below the value of life of a male single and above the value of a female single with the same wealth:* $k_m^s (W, T_m) > k^u (2W, T_w, T_m) > k_w^s (W, T_w)$.

Proof. With $W := W_w^s = W_m^s = W^u/2$, the budget constraints of singles yield $c_i^s = W/T_i$. From $2T_w > T_w + T_m > 2T_m$ and (10) it follows that $c_m^s > c^u > c_w^s$, which in turn, by (7) implies $k_m^s > k^u > k_w^s$. □

Corollary 1. *The value of life in the utilitarian marriage is above the average value of life of a (heterosexual) pair of singles with the same wealth.*

Proof. The proposition follows directly from the strict concavity of the utility function. □

Corollary 1 compares well with the welfare property of a utilitarian allocation. If utility functions are uniform across individuals, an egalitarian allocation of resources maximizes social welfare. Similarly, if two individuals share their income, the sum of their lifetime utilities is larger than when they spend their income separately. Corollary 1 adds to this well known result that the sum of the values of life is maximized in the utilitarian community.

Turn then to the altruisitc couple. Its optimal solution satisfies:

$$\begin{aligned} c_w = c_m := c^a \qquad &\text{for} \qquad 0 \le t \le T_m, \\ c_w := c^h,\ c_m = 0 \qquad &\text{for} \qquad T_m < t \le T_w, \end{aligned}$$

where h indicates widowhood. Utility maximization requires marginal utility to be equalized across life periods and spouses, $u'(c_w) = u'(c_m) =: u'(c^a)$, $u'(c^a) = \theta u'(c^h)$. Hence, in order to compensate for the lower utility weight in widowhood, $u'(c^h) > u'(c^a)$. Strict concavity of the utility function, then, implies $c^h < c^a$.

The indirect utility of the altruistic couple is

$$V^a (W_w, W_m, T_w, T_m) = 2T_m u(c^a) + (T_w - T_m)\theta u(c^h), \qquad (13)$$

with the budget constraint $T_m c^a + (T_w - T_m) c^h = W_w + W_m$, and the consumption levels optimally chosen. Respective derivation with respect to the men's and women's lifetime, yields:

$$\frac{\partial V^a}{\partial T_m} = 2u(c^a) - \theta u(c^h) + \lambda c^h, \qquad (14)$$

$$\frac{\partial V^a}{\partial T_w} = \theta u(c^h) - \lambda c^h. \qquad (15)$$

Marginal utility of wealth obeys $\partial V^a/\partial W := \lambda = u'(c^a) = \theta u'\left(c^h\right)$, which leads to:

$$k_w^a = \frac{u\left(c^h\right)}{u'\left(c^h\right)} - c^h, \tag{16}$$

$$k_m^a = 2\frac{u\left(c^a\right)}{u'\left(c^a\right)} - k_w^a. \tag{17}$$

Proposition 4. *In the altruistic marriage, the male to female gap in the value of life is positive,* $g_k^a > 0$.

Proof. From (16) and (17) one obtains:

$$\begin{aligned} g_k^a &= k_m^a - k_w^a \\ &= 2\left[\frac{u\left(c^a\right)}{u'\left(c^a\right)} - \frac{u\left(c^h\right)}{u'\left(c^h\right)} + c^h\right]. \end{aligned} \tag{18}$$

Since $c^a > c^h$, the proof again follows from the concavity of the utility function. □

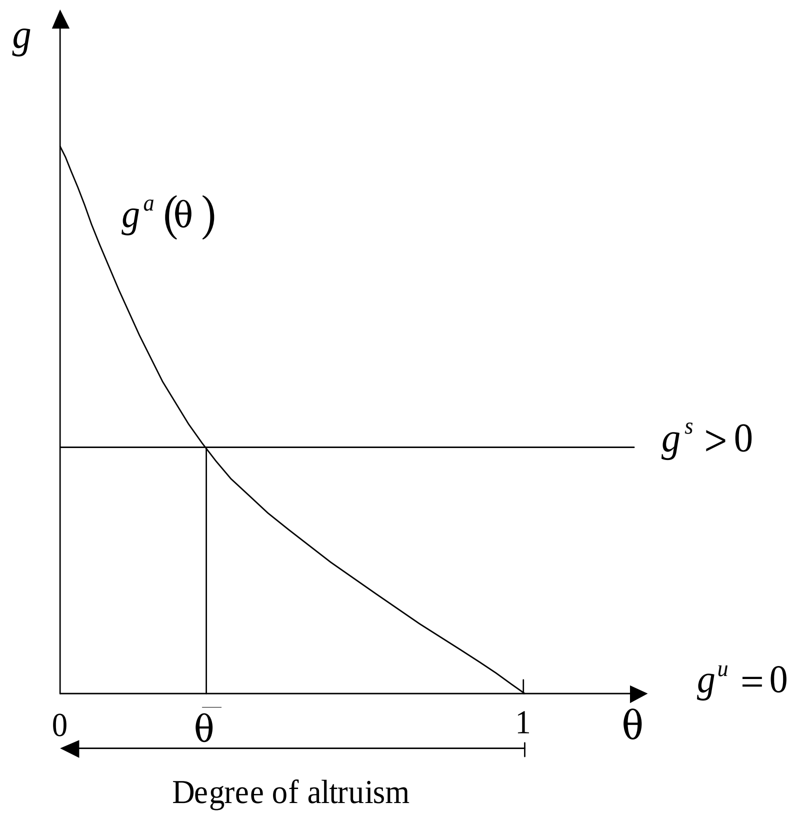

Figure 1: The gender gap in the value of life g_k^j as a function of the degree of altruism

Proposition 5. T*he average value of life within the altruistic couple is higher than within the utilitarian couple:* $k_m^a(2W, T_w, T_m) + k_w^a(2W, T_w, T_m) > 2k^u(2W, T_w, T_m)$.

Proof. When altruistic and utilitarian couples are endowed with the same wealth, $c^a > c^h$ implies $c^a > c^u > c^h$. Since $c^a > c^u$, one derives from (16) and (17):

$$\frac{k_m^a + k_w^a}{2} = \frac{u(c^a)}{u'(c^a)} > \frac{u(c^u)}{u'(c^u)} - c^u = k^u. \square \tag{19}$$

It follows from propositions 5 and 6 that the value of life within the utilitarian couple is smaller than men's and larger than women's value of life within the altruistic couple.

Proposition 6. *There exists $\theta = \overline{\theta}$ such that*

$$\theta \lesseqqgtr \overline{\theta} \Longleftrightarrow g_k^a \gtreqqless g_k^s. \tag{20}$$

Proof. See Appendix.

Figure 1 illustrates the proof. Utilitarian couples value the life of the spouses on a par ($g_k^u = 0$). By contrast, both among singles and altruistic couples there is a gender gap in the value of life in favor of men ($g_k^s, g_k^a > 0$). Since $g_k^a(\theta = 0) \geq g_k^s$, $g_k^a(\theta = 1) = g_k^u = 0$, and $\partial g_k^a / \partial \theta < 0$, there is a lower bound of the degree of altruism, for which the value of life gender gap within an altruistic marriage exceeds the corresponding gap in a heterosexual pair of singles. As the degree of altruism decreases with an increase in θ, this lower bound translates in an upper bound of θ, i.e. $\overline{\theta}$.

3 Wealth and the gender gap in the value of life

The utilitarian couple is indifferent with respect to the allocation of life years, it is only interested in the sum. Thus, the value of life gender gap in this setting is unaffected by a marginal change in wealth of both individuals:

$$\frac{\partial g_k^u}{\partial W} = \frac{\partial k^u}{\partial W_m} - \frac{\partial k^u}{\partial W_w} = 0. \tag{21}$$

For singles, derivating the value of life with respect to wealth $\partial k_i^s / \partial W_i$, taking into account that $c_i^s = W_i / T_i$, and calculating the difference $\partial k_m^s / \partial W_m - \partial k_w^s / \partial W_w$ yields:

$$\begin{aligned}
\frac{\partial g_k^s}{\partial W} &= \frac{u(c_w^s)\, u''(c_w^s)}{T_w (u'(c_w^s))^2} - \frac{u(c_m^s)\, u''(c_m^s)}{T_m (u'(c_m^s))^2}, \\
&= A(c_m^s) \frac{u(c_m^s)}{T_m u'(c_m^s)} - A(c_w^s) \frac{u(c_w^s)}{T_w u'(c_w^s)} \quad \text{or} && (22) \\
&= R(c_m^s) \frac{u(c_m^s)}{T_m c_m^s u'(c_m^s)} - R(c_w^s) \frac{u(c_w^s)}{T_w c_w^s u'(c_w^s)}, && (23)
\end{aligned}$$

where $A(c_i) = \frac{-u''(c_i)}{u'(c_i)}$ and $R(c_i) = \frac{-c_i u''(c_i)}{u'(c_i)}$ are measures for the curvature of the utility function at the consumption level c_i. A and R can be interpreted as absolute and relative inequality aversion, i.e. aversion against a gender gap in the consumption level.

Proposition 7. *With a constant absolute or relative inequality aversion, the gender gap in the value of life among singles increases with wealth, $\partial g_k^s / \partial W > 0$.*

Proof. With a constant absolute risk aversion A, one has from (22):

$$\frac{\partial g_k^s}{\partial W} = A \left[\frac{u(c_m^s)}{T_m u'(c_m^s)} - \frac{u(c_w^s)}{T_w u'(c_w^s)} \right] > 0, \text{ since } c_m^s > c_w^s,\ T_w > T_m, \tag{24}$$

and strict concavity of the utility function.

When relative inequality aversion R is constant, the relative size of the two ratios (see (23)) cannot be signed as the denominators entail the consumption levels. The proposition holds if one restricts the utility function to the classical constant elasticity of substitution class:

$$u(c_i) = \frac{c^{1-R}}{1-R}, \quad \text{for } 0 < R < 1, \qquad = \ln c_i, \quad \text{for } R = 1. \tag{25}$$

$R > 1$ is excluded as this would imply a negative value of life (see Rosen, 1988). Then, the elasticity of utility is constant as well: $\frac{u'(c_i^s)}{u(c_i^s)} c_i^s = 1 - R$. Thus, by (23)

$$\frac{\partial g_k^s}{\partial W} = \frac{R}{1-R}\left(\frac{1}{T_m} - \frac{1}{T_w}\right) > 0, \text{ since } T_w > T_m. \square \tag{26}$$

An increase in wealth augments the gender difference in consumption. With a constant absolute tolerance to the gender difference in consumption, an increase in the difference translates into a utility loss. This, in turn, increases the gender gap in the value of life. With a constant relative aversion against gender differences, the tolerance increases with wealth. However, the increase in the gender difference of consumption is too large to keep the value of life gender gap constant.

Regarding the altruistic couple, one finds:

$$\frac{\partial g_k^a}{\partial W} = 2\left[\left(1 - \frac{u(c^a)\, u''(c^a)}{(u'(c^a))^2}\right)\frac{\partial c^a}{\partial W} + \frac{u(c^h)\, u''(c^h)}{(u'(c^h))^2}\frac{\partial c^h}{\partial W}\right]. \tag{27}$$

Proposition 8. *With a constant absolute or relative inequality aversion, the value of life gender gap within the altruistic couple increases with wealth, provided that the per capita consumption increase during marriage is higher than in widowhood,* $\partial c^a/\partial W \geq \partial c^h/\partial W$.

Proof. See Appendix.

I conclude that as long as the consumption level of the surviving spouse does not decrease relative to the joint consumption level during marriage, the female to male gap in the value of life will increase with the altruistic couple's wealth.

4 The gender gap in optimal longevity

Section 2 has already pointed to a fundamental trade-off between the quantity and the quality of life. The opportunity cost of the quantity of life is not limited to a foregone consumption but also extends to the cost of maintaining the health capital stock. This cost increases with age and may well be higher for men due to their higher physiological fragility as compared to women. Assume that this is, indeed, the case; let $p_i(t_i)$ be the marginal cost of maintainig life at age t, with $\partial p_i/\partial t > 0$ for $i = w, m$, and $p_m(t) \geq p_w(t)$. The indirect utility function for singles, then, is $\widetilde{V}_i^s\left(T_i, \widetilde{W}_i\right) = T_i u\left(\widetilde{W}_i/T_i\right)$ where $\widetilde{W}_i = W_i - \int_0^{T_i} p_i(t)\, dt$ is wealth net of expenditure for maintaining the health capital stock over the life cycle. At the optimal lifetime, $\partial\widetilde{V}_i^s/\partial T_i = 0$,

$$\begin{aligned} u(c_i) - u'(c_i)(p_i(T_i) + c_i) &= 0 \text{ or} \\ \widetilde{k}_i^s(c_i) &= p_i(T_i), \end{aligned} \tag{28}$$

with $c_i = \widetilde{W}_i/T_i$; the willingness to pay for extending life equals the marginal cost of preserving life.

The effect of wealth on optimal longevity is governed by the wealth effect on the value of life. As long as the value of life increases with wealth, optimal longevity increases with wealth as well. The higher cost of maintaining health decreases men's value of life. Thus, with the same wealth, women's value of life at a given lifetime is larger than the men's. Still, as the optimal longevity will differ between men and women, the value of life may be higher for men. For the change of the value of life as a function of the quantity of life from (6):

$$\frac{\partial\widetilde{k}_i^s}{\partial T_i} = \frac{u(c_i)\, u''(c_i)}{(u'(c_i))^2} \frac{\widetilde{W}_i}{(T_i)^2} < 0. \tag{29}$$

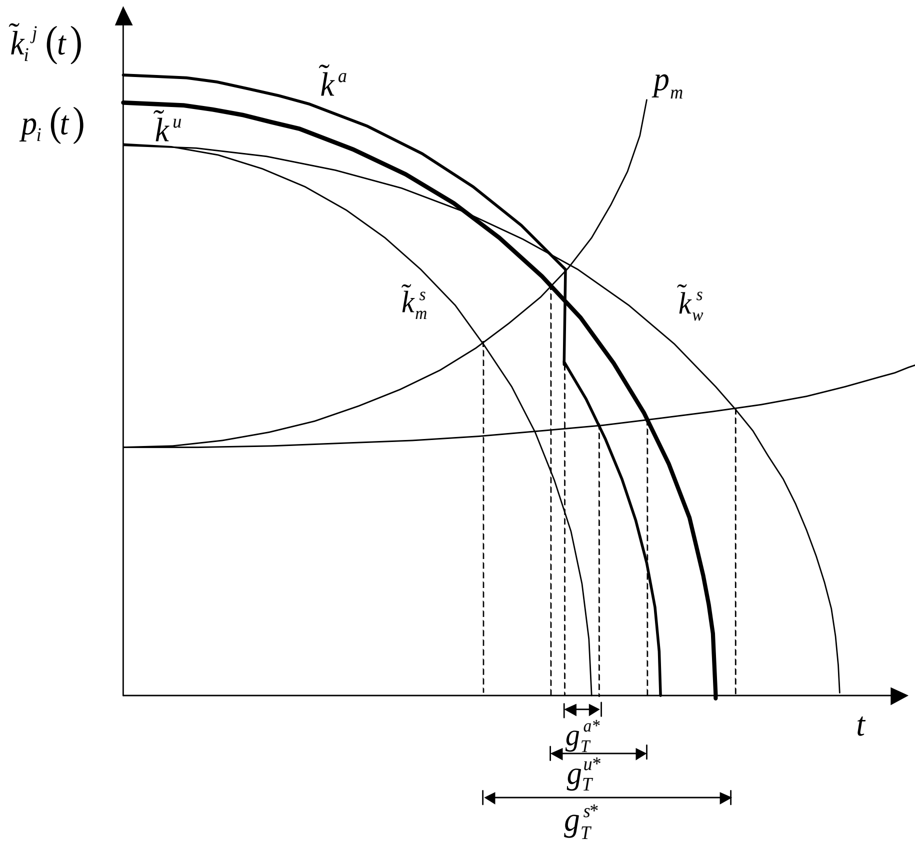

Figure 2: The gender gap in optimal longevity $g_T^{j^*}$ for singles (s), utilitarian couples (u) and altruistic couples (a)

Figure 2 illustrates the optimal longevity for men and women, and the implied longevity gap in the three social settings. The male single's willingness to pay for extending life is lower at any lifetime as expenditure for maintaining the health capital stock to reach this lifetime is higher for men than for single women. The marginal cost is higher as well; hence optimal longevity for men is shorter. With no difference in the cost of preserving life, optimal longevity would be the same for both sexes.

For the utilitarian couple, the first order condition for optimal longevity writes

$$\begin{aligned} u\left(c^u\right) - u'\left(c^u\right) c^u &= u'\left(c^u\right) p_i\left(T_i\right) \text{ or} \\ \widetilde{k}^u\left(c^u\right) &= p_i\left(T_i\right). \end{aligned} \tag{30}$$

Thus, the utilitarian couple takes into account that the price of preserving life is different between men and women (see *Jacobsen*, 2000 for a generalization of this condition within a dynamic optimization problem of health capital investments). Men benefit from sharing wealth, as women take part in the higher cost of maintaining their husband's life. For short lifetimes, the value of life within the utilitarian couple is above that of both male and female singles (see corollary 1) and always above the value of life of a male single (see Figure 2). For long lifetimes, the value of life of a female single is higher. This results in higher longevity for men and lower longevity for women. Hence, the gender gap in longevity will be lower within the utilitarian couple than among singles. As with singles, with the same cost of preserving life, there will be no gender gap within utilitarian couples.

For altruistic couples, one derives the first order condition for optimal longevity analoguously to (14) and (15):

$$\begin{aligned} 2u\left(c^a\right) - \theta u\left(c^h\right) + u'\left(c^a\right) c^h &= u'\left(c^a\right) p\left(T_m\right) \text{ and} \\ \theta u\left(c^h\right) - \theta u'\left(c^h\right) c^h &= \theta u'\left(c^h\right) p\left(T_w\right) \text{ or} \\ \widetilde{k}_i^a\left(c_i\right) &= p_i\left(T_i\right). \end{aligned} \tag{31}$$

Figure 2 gives the inner solution for the optimal gender gap within the altruistic couple. $\widetilde{k}_m^a\left(T_m\right) > \widetilde{k}^u\left(T_m\right)$ and $\widetilde{k}_w^a\left(T_w\right) < \widetilde{k}^u\left(T_w\right)$ hold by proposition 5, provided that $T_w^{a^*} > T_m^{a^*}$; hence, the optimal gender gap within altruistic couples is shorter than within utilitarian couples. Two corner solutions are possible as well, where the first order condition holds for one sex only. In these cases, the gender gap disappears in the optimum.

5 Hypotheses and tests

The data refer to the Swiss population of age 65+ that died in 2001 or 2002, roughly 100,000 persons. The average age at death beyond 65 corresponds to the remaining life expectancy at age 65. The gender gap in longevity of the Swiss elderly population is 3.63 years (see Table 1). The gender gap for singles is 6.52 years, twice as high as for couples (individuals that were either married, widowed or divorced at their date of death). Women have a 1.71 years higher life expectancy being single rather than married, while men, on average, live 1.54 years longer being married.

Table 1: Residual life expectancy at age 65 and average annual lifetime earnings of the deceased in Switzerland, 2001 and 2002

Social setting		**n**	**age at death**	**earnings**
	women	56,102	84.26	49,106
All individuals	men	42,245	80.63	53,425
	difference		3.63	-4,319
	women	48,948	84.04	50.779
Couples	men	38,143	80.78	54,656
	difference		3.26	-3.877
	women	7,154	85.75	37,654
Singles	men	4,102	79.24	41,980
	difference		6.52	-4,326

The data from the Federal Social Insurance Office, which administers payments within the pay-as-you-go system, contains the average level of annual earnings income over the life cycle. For married or widowed individuals, these earnings in principle reflect half of the couple's joint labour income. Women, on average, have about 9% lower earnings than men, the difference is 7% among couples and 10% among singles. Singles earn a 25% lower income than married individuals. Single women have the highest life expectancy and the lowest income.

In order to simultaneously analyze the effect of gender, marital status and income on residual life expectancy, the following equation was estimated by OLS with T_i as the age at death of an individual i as dependend variable:

$$\begin{aligned} T_i &= \beta_0 + \beta_1 F_i + \beta_2 C_i + \beta_3 (F_i \cdot C_i) + \beta_4 I_i + \beta_5 (I_i)^2 + \beta_6 (I_i \cdot F_i) \\ &\quad + \beta_7 (I_i \cdot C_i) + \beta_8 (I_i \cdot F_i \cdot C_i) + \sum_{j=1}^{25} \beta_{9j} R_{ij} + \beta_{10} A + \epsilon_i, \end{aligned} \tag{32}$$

where the constant reflects the average age of death of single men, F is a dummy variable for gender ($F = 1$ for a woman, $F = 0$ for a man), C is a dummy indicating marital status ($C = 1$ if the person was married, divorced or widowed, $C = 0$ if single at the date of death), I are the person's average annual earnings, and the Rs are dummy variables for 25 Swiss Cantons (one serves as reference region), A indicating foreigners ($A = 1$ if foreign, $A = 0$ if Swiss). The specification with respect to I includes a linear and a quadratic term to allow for a non-linear relationship between longevity and income. Interaction terms are also included.

I will evaluate the differences in the average age at death, differentiated with respect to gender and marital status, at zero income as well as at average income in the groups that are being compared. The degree of altruism between spouses is empiricially not distinguishable; thus, there is no differentiation between utilitarian and altruistic couples in the empirical model. I consider couples as non-singles as this category includes married, widowed and divorced individuals. The propositions of Sections 2-4 provide the following five hypotheses on longevity in general and the gender gap in particular.

Hypothesis 1. *With the same income, men live longer, women live shorter in couples than among singles.*

At zero income the hypothesis states $\beta_2 > 0$ for men and $\beta_2 + \beta_3 < 0$ for women, while at average income of men $\beta_2 + \beta_7 E[I; F = 0] > 0$ and at average income of women $\beta_2 + \beta_3 + (\beta_7 + \beta_8) E[I; F = 1] < 0$.

Hypothesis 2. *The larger wealth, the higher longevity will be. This is true for both women and men, irrespective of the marital status.*

Here one has to differentiate (32) with respect to income, to derive the desired inequalities: One obtains $\beta_4 + 2\beta_5 E[I; F = 0, C = 0] > 0$ and $\beta_4 + 2\beta_5 E[I; F = 0, C = 1] + \beta_6 > 0$ for single men and married men, $\beta_4 + 2\beta_5 E[I; F = 1, C = 0] + \beta_6 > 0$ and $\beta_4 + 2\beta_5 E[I; F = 1, C = 1] + \beta_6 + \beta_7 + \beta_8 > 0$ for single and married women.

Hypothesis 3. *The gender gap is positive among singles and for couples, when evaluated at the same income of the individuals.*

At zero income the hypothesis is $\beta_1 > 0$ for singles and $\beta_1 + \beta_3 > 0$ for couples. At average income, the hypothesis is $\beta_1 + \beta_6 E[I; C = 0] > 0$ for singles and $\beta_1 + \beta_3 + (\beta_6 + \beta_8) E[I; C = 1] > 0$ for couples.

Hypothesis 4. *With the same income, the gender gap in longevity is smaller in couples than among singles.*

At zero income this states $\beta_3 < 0$, at average income $\beta_3 + \beta_8 E[I] < 0$.

Hypothesis 5. *The gender gap in longevity is smaller, the larger wealth is. This holds for both singles and couples.*

In terms of the coefficients of (32) the hypothesis states $\beta_6 < 0$ for singles and $\beta_6 + \beta_8 < 0$ for couples.

Table 2 presents the OLS estimation results. The intercept is 80.6 years, indicating the extrapolated longevity of single men with zero income. By comparison, married, widowed or divorced men live 2.5 years longer, single women 7 years, while women within couples live only 3.1 years (= 7 − 3.9) longer than single women.

Table 2: OLS estimates - Swiss mortality data 2001 and 2002

Variables	age at death	
Constant	80.578**	(0.225)
Women	7.064**	(0.270)
Couple	2.478**	(0.230)
Woman·Couple	-3.964**	(0.291)
Income	-0.431**	(0.045)
Income^2	0.023**	(0.001)
Income·Woman	-0.169**	(0.057)
Income·Couple	-0.145**	(0.045)
Income·Woman·Couple	0.161**	(0.060)
Foreigner	-3.836**	(0.125)
n		98,348
R^2		0.073

Standard errors are in parentheses ** $p < .01$

Dummies for 26 Cantons were also included

Foreigners beyond 65 living in Switzerland die 3.8 years earlier than the Swiss. Most dummies for the Cantons are significant. On average, individuals in French or Italian speaking regions have a higher residual life expectancy, the difference being about two months compared to German speaking regions. Urban Cantons such as Basle, Geneva and Zurich likewise show a higher average age at death among the retired population.

According to Table 2 the tests vindicate four of the five hypotheses. Hypothesis 1 is confirmed: At average income of men, married men at age 65 have a 1.7 years higher residual life expectancy compared to single men. Women's life expectancy is 1.4 years shorter being married than being single. Hypothesis 3 and 4 are confirmed as well. There is a female to male gap of 6.4 years among singles and of 3.1 years within couples (hypothesis 3). The difference in the longevity gender gap between singles and couples is 3.1 years when evaluated at average income (hypothesis 4). Hypothesis 5 is confirmed for singles. The gender gap decreases with an inrease in income. For couples, the sign is as expected but not significanly different from zero.

Table 3: Results of the hypothesis tests

Hypotheses		**Zero income**		**At average income**	
		H_A	Value	H_A	Value
1	Men	$\beta_2 > 0$	2.48** (0.23)	$\beta_2+\beta_7 E\left[I;F=0\right]>0$	1.70** (0.14)
	Women	$\beta_2+\beta_3 < 0$	-1.49** (0.19)	$\beta_2+\beta_3+\left(\beta_7+\beta_8\right)E\left[I;F=1\right]<0$	-1.41** (0.11)
2	Single men			$\beta_4+2\beta_5 E\left[I;F=0,C=0\right]>0$	-0.24** (0.04)
	Married men			$\beta_4+2\beta_5 E\left[I;F=0,C=1\right]+\beta_6>0$	-0.32** (0.02)
	Single women			$\beta_4+2\beta_5 E\left[I;F=1,C=0\right]+\beta_6>0$	-0.43** (0.04)
	Married women			$\beta_4+2\beta_5 E\left[I;F=1,C=1\right]+\beta_6+\beta_7+\beta_8>0$	-0.35** (0.02)
3	Singles	$\beta_1 > 0$	7.06** (0.27)	$\beta_1+\beta_6 E\left[I;C=0\right]>0$	6.40** (0.15)
	Couples	$\beta_2+\beta_3 > 0$	3.10** (0.11)	$\beta_1+\beta_3+\left(\beta_6+\beta_8\right)E\left[I;C=1\right]>0$	3.05** (0.05)
4		$\beta_3 < 0$	-4.0** (0.29)	$\beta_3+\beta_8 E\left[I\right]<0$	-3.15** (0.18)
5	Singles	$\beta_6 < 0$	-0.15** (0.04)		
	Couples	$\beta_6+\beta_8 < 0$	-0.01 (0.02)		

Standard errors are in parentheses ** $p < .01$

Hypothesis 2 fails: The income gradient for longevity is negative. Figure 3 illustrates the longevity income relationship in the different settings. For incomes above 100,000 SFr one observes the expected slope. However, at the mean income the slope is negative.

This rather surprising finding may be explained as follows: First, the income variable only includes earnings, while income from savings, capital gains and from other sources are not incorporated. Then, one would like to take into account inheritances, in order to accurately assess the wealth status of the individuals. This is not feasible with the data available. The second reason why the results with respect to the income effect have to be interpreted cautiously is that the data is cross-sectional. Individuals from different cohorts (e.g. individuals born in 1900 compared to individuals born in 1930) may value a given income stream not in the same way and, thus, solve the trade-off between quantity and quality of life differently. This could explain why one observes (many) low income individuals with a very high age at death. Still, it is noteworthy that beyond a high income level, the results indicate that the importance of the quantity aspect of life rises with an increase in income. In particular with single men, one observes a strong increase in the residual life expectancy when income rises.

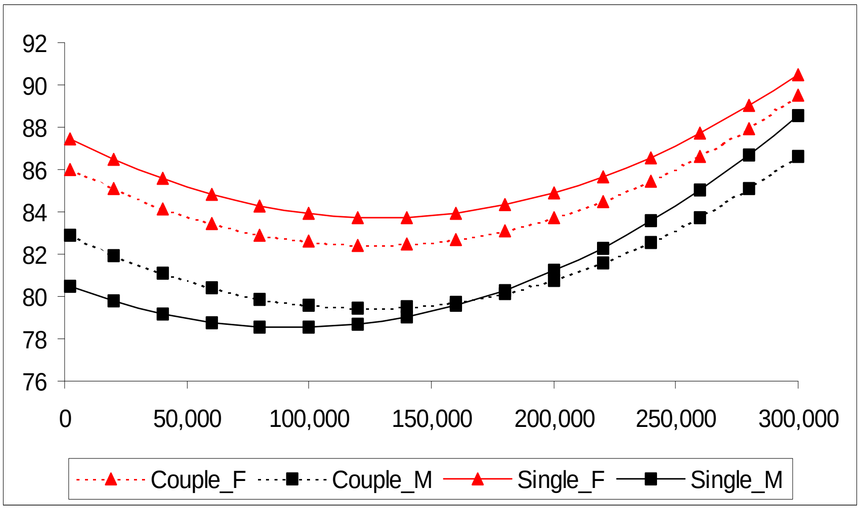

Figure 3: Income (in SFr) and life expectancy

6 Conclusion

Women live longer than men. Gerontologists point to the quantitatively greater immune response of women than of men as one reason for the female to male longevity gap (*Arkin*, 1989). Although women have more illnesses than men, their disorders are less likely to be fatal. *Posner* (1996, p. 274) argued that "to the extent that men are inherently more vulnerable than women, expenditure on fighting the diseases of men may have a lower payoff in years of life saved", providing an economic reason why men live shorter than women. Starting from this notion, the present paper introduced higher marginal cost for preserving men's life to calibrate the model to the observed gender longevity gap.

My focus is on the difference in the gender longevity gap between couples and singles. Studying the average age at death of the Swiss population above 65 in the years 2001 and 2002, I find a higher residual life expectancy of married men compared to single men, the difference being 1.7 years. By contrast, women above 65 live longer if they remain single, the difference is 1.4 years when evaluated at average lifetime income. I explain these findings with a model where an altruistic couple shares its wealth and aims at a long companionship. In this setting, the woman will also share the higher cost of preserving her husband's life and to put up with a shorter life. The model can, furthermore, explain the lower gender longevity gap within couples. For the Swiss of age 65+, the gender gap among singles is 6.4 years compared to only 3.1 years within couples.

The model also allows me to study the impact of wealth on the gender longevity gap. If one restricts utility to the classes with constant or relative risk aversion − which can be reinterpreted in the context of a couple's decision on consumption as inequality aversion − the gender longevity gap decreases with wealth. Using earnings data of the deceased, I find this relationship confirmed for singles. For couples, the income gradient for the gender longevity gap is also negative, but not significant. Regarding the impact of income on residual life expectancy, the results are mixed. At the mean income, longevity decreases with an income increase in all settings, while for higher income one observes the expected positive sign. The results, however, may be subject to cohort effects that cannot be identified in the data set, covering the deceased of only two years.

To the extent that healthy individuals have a greater chance to get married, comparing life expectancy between couples and singles may be subject to a selection bias. However, a potential selection bias cannot explain the opposite sign in the single-couple longevity difference between men and women. It remains to be seen, whether future research on gender and marital status specific patterns of life expectancy in other countries will confirm the findings for Switzerland that married men live longer than single men, while married women live shorter than single women.

7 Appendix

Proof of proposition 6

From propositions 1, 2 and 5 one gets:

$$g_k^s = \frac{u\left(c_m^s\right)}{u'\left(c_m^s\right)} - \frac{u\left(c_w^s\right)}{u'\left(c_w^s\right)} + c_w^s - c_m^s > 0, \tag{33}$$

$$g_k^u = 0, \tag{34}$$

$$g_k^a = 2\left[\frac{u\left(c^a\right)}{u'\left(c^a\right)} - \frac{u\left(c^h\right)}{u'\left(c^h\right)} + c^h\right] > 0. \tag{35}$$

The strategy is to show that i) $g_k^a(\theta = 0) \geq g_k^s$, ii) $\partial g_k^a/\partial\theta < 0$, and iii) $g_k^a(\theta = 1) = 0$.

i) For $\theta = 0$, yearly consumption in widowhood is zero, $c^h = 0$, which implies that the value of the woman's life in the altruistic marriage, thus, is zero (see (15)). Furthermore, one gets $c^a = c_m^s$. It follows that $g_k^a(\theta = 0) = 2\frac{u(c_m^s)}{u'(c_m^s)}$. Inserting in the difference between the gender gap, results in:

$$g_k^a - g_k^s = \frac{u\left(c_m^s\right)}{u'\left(c_m^s\right)} + \frac{u\left(c_w^s\right)}{u'\left(c_w^s\right)} + c_m^s - c_w^s > 0, \tag{36}$$

due to $c_m^s > c_w^s$, and the strict concavity of the utility function.

ii) From (35) one derives:

$$\frac{\partial g_k^a}{\partial \theta} = 2\left[\left(1 - \frac{u\left(c^a\right)u''\left(c^a\right)}{\left(u'\left(c^a\right)\right)^2}\right)\frac{\partial c^a}{\partial \theta} + \frac{u\left(c^h\right)u''\left(c^h\right)}{\left(u'\left(c^h\right)\right)^2}\frac{\partial c^h}{\partial \theta}\right]. \tag{37}$$

A decrease in the degree of altruism lowers per capita consumption during marriage, and increases consumption for the surviving spouse, i.e. $\partial c^a/\partial\theta < 0$ and $\partial c^h/\partial\theta > 0$ (which derives from the comparative statics of the altruistic couple's maximization program). Strict concavity of the utility function, then, gives $\partial g_k^a/\partial\theta < 0$.

iii) If $\theta = 1$, altruism is absent, and thus $g_k^a(\theta = 1) = g_k^u$. From $g_k^u = 0$ follows $g_k^a(\theta = 1) = 0$. □

Proof of proposition 8

In the constant absolute inequality aversion case (27) writes

$$\begin{aligned}\frac{\partial g_k^a}{\partial W} &= 2\left[\left(1 + A\frac{u\left(c^a\right)}{u'\left(c^a\right)}\right)\frac{\partial c^a}{\partial W} - A\frac{u\left(c^h\right)}{u'\left(c^h\right)}\frac{\partial c^h}{\partial W}\right] \\ &= 2\left[\frac{\partial c^a}{\partial W} + A\left(\frac{u\left(c^a\right)}{u'\left(c^a\right)}\frac{\partial c^a}{\partial W} - \frac{u\left(c^h\right)}{u'\left(c^h\right)}\frac{\partial c^h}{\partial W}\right)\right].\end{aligned} \tag{38}$$

$c^a > c^h$ and $\partial c^a/\partial W > \partial c^h/\partial W > 0$ then yield the desired result.

With a constant relative inequality aversion, one derives:

$$\begin{aligned}\frac{\partial g_k^a}{\partial W} &= 2\left[\left(1 + \frac{R}{1-R}\right)\frac{\partial c^a}{\partial W} - \frac{R}{1-R}\frac{\partial c^h}{\partial W}\right] \\ &= \frac{2}{1-R}\left[\frac{\partial c^a}{\partial W} - R\frac{\partial c^h}{\partial W}\right].\end{aligned} \tag{39}$$

$\partial c^a/\partial W \geq \partial c^h/\partial W > 0$ and $0 < R < 1$ ensure $\partial g_k^a/\partial W > 0$. □

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