Master in Actuarial and Financial Sciences

MASTER THESIS

HETEROGENEITY IN THE AGE GAP OF SPANISH COUPLES AND ITS IMPACT IN THE SPAIN'S PENSION SYSTEM EQUITY

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Academic year: 2023-2024

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Acknowledgements

First and foremost, I would like to express my profound gratitude to my advisor, Mercedes Ayuso Gutiérrez, for her guidance, mentorship, and support. Her expertise, feedback, and patience have been instrumental in shaping the direction and quality of this research. Thank you for giving me the opportunity to undertake this comprehensive study under your supervision.

I also extend my heartfelt gratitude to Jorge Bravo, whose contributions were vital to the completion of this project. Without his support and guidance, this achievement would not have been possible.

Lastly, I must acknowledge my parents, Roberto and Olga, my brother Robert, and my partner Jordi, for their unwavering support throughout these years. Without you, this work would not have been possible. My deepest thanks for the great confidence you have placed in me. I hope you feel proud.

Abstract

In recent decades, Spanish society has experienced major transformations in the way couples formalize their marriage ties and in the number of years they actually cohabit. This thesis examines the impact of joint life expectancy on Spain's pension system, considering demographic changes and increasing longevity. We analyze age differences in heterosexual marriages from 1976 to 2021 and estimate joint life expectancy using the Coherent Functional Demographic Model (CFDM). Our findings highlight the importance of the age gap between spouses on household pension wealth, influencing retirement and widowhood pensions. We propose policies to reduce inequalities in the Spanish pension system, emphasizing gender and family structure considerations. The study underscores the need for reforms to ensure equity and sustainability in the context of ageing populations.

Keywords — joint life expectancy, concurrent pensions, home pension wealth and protection gap

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1 Introduction

In recent decades, Spanish society has experienced major transformations in the way couples formalize their marriage ties and in the number of years they actually cohabit. The latter is closely linked to increases in life expectancy after the age of 65, which as well as having a direct impact on the duration of a couple's cohabitation has also impacted such critical concerns as pensions, health and long-term care.

This concept of joint life expectancy – closely linked to demographic and actuarial calculations – refers to the average life expectancy of a group of people or, in the case that concerns us here, of a couple. In short, it is a statistical estimate that indicates how many years, on average, both partners are expected to live together from a certain point in time. The group is said to *dissolve* when the first death occurs and to *extinguish* when the second death occurs, that is, when both partners have died (Ayuso et al., 2001).

In ageing societies, the number of years people live together is likely to have a direct impact on critical areas of the welfare state. The literature, by adopting a number of different approaches, describes these effects of *joint life*, which is increasing significantly with rising longevity and having a marked impact on such elements as the concentration of income and wealth in older population intervals, the concurrent receipt of retirement and survivors' public pensions and the design of life insurance products, people's health, and the provision of long-term care, among others (Bravo et al., 2021; Compton and Pollak, 2021; Klerby et al., 2013; Ponthiere, 2007).

Recent studies by the Spanish Central Bank report that households headed by individuals aged 65 or older concentrate wealth most sharply (Banco de España, 2022). Likewise, in the member countries of the Organization for Economic Cooperation and Development (OECD), households headed by partners of pre-retirement or retirement age have, on average, the highest levels of real estate and financial wealth (OECD, 2021).

Actuarial studies conclude that there is a significant relationship between marital status and cohabitation, on the one hand, and probabilities of death and survival, on the other. The findings show, for instance, that the survival prospects of older people living alone, whether single or widowed, tend to be lower than those of people living as a couple (Alaminos and Ayuso, 2019; Hu and Goldman, 1990).

As far as the welfare state is concerned, the analysis of the impact of joint life expectancy has focused on a number of specific areas. For example, in the field of public and private pension schemes, attention has, for some time now, concentrated on the design and reform of survivors' pensions (Alaminos and Ayuso, 2015, 2016; Brown and Poterba, 1999), given their increasing share in total pension expenditure and the arrival at retirement age of cohorts of women with full contribution careers. This applies above all to countries such as Spain or Portugal, where survivors' pensions can be received simultaneously with old-age pensions.

As for health, the mutual help provided by the partners of a couple illustrates how marital closeness can impact both their mental and physical wellbeing. Although challenges may arise when one partner faces health problems, couples' relationships can be leveraged to improve treatment outcomes (Kiecolt-Glaser and Wilson, 2017; Kumar and Williams, 2021; Monden, 2007). Moreover, when faced with the need for help in performing activities of daily living, it is typically the partner that provides this type of support within the framework of informal care (Alemany et al., 2023).

In analyses of long-term care, empirical evidence points to the importance of including

gender in both research studies and policy designs, due to the specific preferences of men and women as regards such care services. Carvalho et al. (2019) conclude that people are more prone to institutionalization as the severity of a disorder increases, and when there is no spouse capable of providing aid. It also appears that men prefer to receive care exclusively from their spouse in a home setting, even when faced with increasing levels of disability. In contrast, women are more likely to seek assistance and care from professionals, sheltered homes or institutionalization. There are public policy concerns here related to the adequacy of community support in the case of women, who tend to exhibit higher prevalence rates of disability, and who may be particularly vulnerable and at risk of poverty due to the greater likelihood of their living alone with limited financial resources (Katz et al., 2000)). Compared to heterosexual adults, same sex couples are expected to require greater long-term formal care in the future, particularly if they are of similar ages and present similar health conditions. Some studies suggest that homosexual adults may rely more on formal care systems than on traditional family support (Furlotte et al., 2016; Henning-Smith et al., 2015).

A complete analysis of joint life expectancy requires, first and foremost, a study of a couples' makeup, prioritizing analyses of their respective ages and sexes. Age analysis is critical, because the age gap will impact the number of years a couple can be expected to cohabit. Generally, the greater the couple's age gap, the lower their expected joint survivorship is likely to be. Moreover, given the well-documented sex gap in life expectancy, the expected number of years of joint life will differ between heterosexual and same sex couples. To this, recent research has identified a socioeconomic gradient in life expectancy with longevity prospects varying, for instance, according to level of education, occupation, income and wealth (Ayuso et al., 2017a,b).

Thus, it is essential to address the demographic and financial factors associated with the life expectancy of couples in ageing societies, given the likelihood that both partners will

survive beyond the age of 65. Given the paucity of studies in the extant literature, here, we specifically seek to measure the effects of joint life expectancy after this age. Indeed, even a small generation gap in this regard may require changes in family and care planning. In financial terms, a couple's age gap can have an impact on their long-term economic and savings needs. Moreover, as far as pensions are concerned – especially in classic defined-benefit, pay-as-you-go (PAYG) systems with concurrence of retirement and survivors' pensions – disparities in age can influence the long-term sustainability of a system, insofar as the younger spouse could potentially be eligible for a widowhood pension for a longer period in the event of the death of an older spouse.

In this work, we first present an evolutionary analysis of age differences in marriages registered in Spain between 1976 and 2021. Here, we are specifically concerned with measuring the heterogeneity in the age gap of heterosexual couples, considering the age at which marriage occurs and the previous marital status of the partners. It is, undoubtedly, essential to consider this heterogeneity in any analysis of joint survival – a characteristic which, to the best of our knowledge, has been paid little attention to date – as it is likely to have a significant impact on associated estimates. Second, to illustrate the impact of these empirical findings on pension design and reform, we estimate the impact of the age gap presented by couples in Spain on household pension wealth across different age gaps and couple structures. To do so, we jointly model both old-age and survivors' (widowhood) pensions within the framework of the concurrence of pensions in the Spanish PAYG system. Our study also aims to draw comparisons with those individuals that do not have the right to receive a survivor's pension, because they have not formed a couple, and with those individuals that are only entitled to this pension, because they do not have the right to receive a retirement pension.

The rest of this master thesis is structured as follows. Section 2 presents an evolutionary analysis of age differences in heterosexual marriages registered in Spain between 1976 and

2021 and answers questions as: How has the age difference between spouses evolved over this period? Is the age gap between spouses affected by their respective ages at the time of marrying? Does their previous marital status affect the age gap between partners? In Section 3, we present the statistical methodology used to estimate joint life expectancy until the group is dissolved; that is, we outline the process of calculating the number of years a couple cohabits until one or other of the spouses dies, a process in which the respective ages and sexes of the couple are fundamental. In this same section, we present our estimates of joint life expectancy in Spanish couples, based on the proposed actuarial methodology and the gap in the ages of the partners. In Section 4, we quantify expected differences in income from retirement and survivors' pensions in Spanish households in which at least one of the partners is aged 65, and compare this outcome with that of single households and households in which only one of the partners has worked. In Section 5, we propose several policies to reduce the inequalities in the Spanish pension system. Finally, in Section 6 we discuss the impact of the heterogeneity in a couple's ages and sex at the time of retirement on their retirement and widowhood pensions, and the impact this can have on the design of public policies that seek equity within and between generations.

2 Descriptive analysis: age gap in Spanish heterosexual couples

In this section, we examine the age gap in couples married in recent decades, drawing on public records, and also analyze the sociodemographic characteristics of the spouses. To do so, we use microdata files containing marriage data from 1976 to 2021 provided by the National Institute of Statistics (INE). These show that, in Spain, between 1976 and 2021, 9,075,739 heterosexual marriages were celebrated and, that between 2005 and 2021, 34,376 gay and 28,177 lesbian couples contracted marriage.

The microdata files contain individual data per marriage without aggregation and duly anonymized, for each year. These microdata constitute ASCII files that collect, for every single record in the survey, the values taken by each variable considering all possible values. The source of information is the Civil Registry, which sends marriage bulletins to the INE every month. The demographic elements used in preparing these publications remained virtually the same across the whole period. However, since the legalization of same-sex marriages in 2005, information on the contracting parties is no longer recorded according to male/female categories, but rather according to the sex of each contracting party.

To determine the age gap in married heterosexual couples, we define the gap value as the difference between the age of the man and the age of the woman. Hence, the gap value shows the age difference between spouses regardless of whether the man is older than the women or vice versa.

The composition of these heterosexual couples is further examined by relating the gap variable with a marital status variable. The latter can take one of three values: (1) if the partner was single before marriage, (2) if the partner was widowed before marriage, and (3) if the partner was divorced before marriage. Here, 88.5% of heterosexual marriages were between partners that had been single before marriage (i.e. in 88.5% of the cases it was a first marriage). We select this percentage for our research (see Appendix A for detailed R code enabling analysis in this section).

Figure 2.1 illustrates the average age gap at first marriage between heterosexual couples for the period 1976–2021. Specifically, it shows that the average age gap value between men and women for the entire period ranges from 1.89 to 2.71 years with a mean of 2.18 years (median equal to 2.09 years).

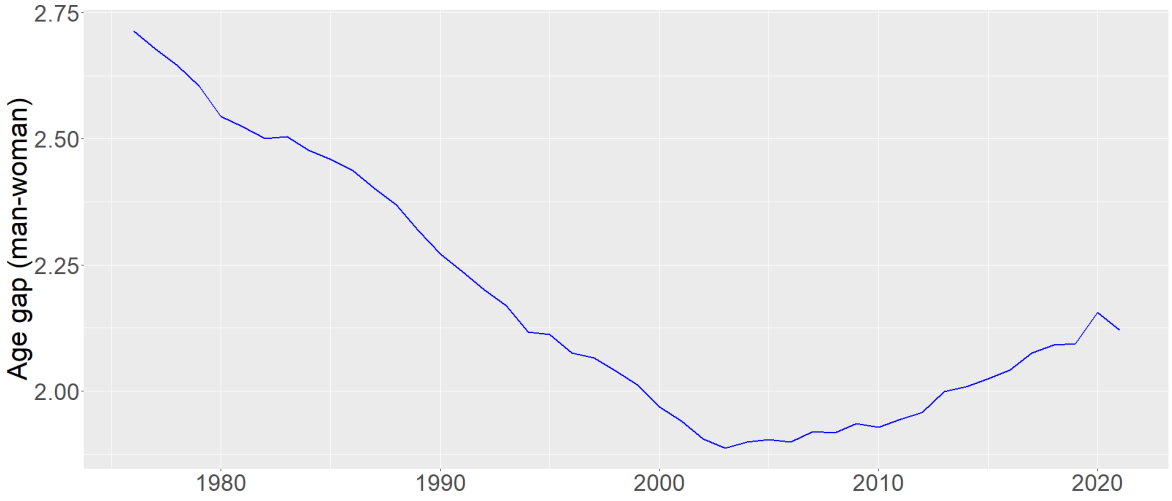


FIGURE 2.1: Heterosexual couples' average age gap value at first marriage between 1976 and 2021. Source: own elaboration.

If we analyze the age gap between heterosexual couples at first marriage for each of the last five decades (see Table 2.1), the mean for the period 1976–2021 falls, reaching a minimum in the 2010s. However, from this decade on, the gap gradually increases, reaching a maximum mean of 2.16 in 2020. Note, the quartiles remain constant over the period.

Thus, in 25% of heterosexual marriages in Spain, there is less than a one-year age difference between spouses, while in another 25%, the age gap is 4 years or more. In the remaining 50%, the age difference ranges between 0 and 4 years, with a median of 2 years.

	1980	**1990**	**2000**	**2010**	**2020**	**2021**
min	-60	-67	-69	-55	-34	-55
Q1	1	0	0	0	0	0
median	2	2	2	2	2	2
mean	2.54	2.27	1.97	1.93	2.16	2.12
Q3	4	4	4	4	4	4
max	61	63	54	52	45	51

TABLE 2.1: Descriptive statistics of heterosexual couples' age gap value at first marriage by decade. Source: own elaboration.

The average age gaps at first marriage between heterosexual couples by age group and by sex – male and female – are shown in Figures 2.2 and 2.3, respectively. Figure 2.2 shows that men below the age of 20 tend to marry women that are 1.42 years older; however, from this age onwards, they tend to marry younger women (e.g. men aged 20–29 tend to marry women 0.95 years younger, and men aged 30–39 tend to marry women 3.36 years younger than themselves). Table 2.2 shows this mean age gap value and the number of marriages contracted by men by age range. Note that, in aggregate terms, the most frequent age range among men for contracting marriage is between 20 and 29 years, these marriages accounting for 59% of all marriages celebrated since 1976, while those contracted by men between the ages of 30 and 39 account for 34%.

Figure 2.3 shows that women below the age of 39 tend to marry men older than themselves (e.g. for women under the age of 20 the gap is up to 5.37 years). However, after the age of 40, the trend reverses as these women tend to marry men younger than themselves (e.g. women over the age of 60 tend to marry men 4.98 years younger, but note that in this case the frequency of outliers is high). Table 2.3 shows this mean average age gap value and

the number of marriages contracted by women by age range. Note that, in aggregate terms, the most frequent age range among women for contracting marriage is between 20 and 29 years, these marriages accounting for 66% of all marriages celebrated since 1976, while those contracted by women between the ages of 30 and 39 represent 24% of the total.

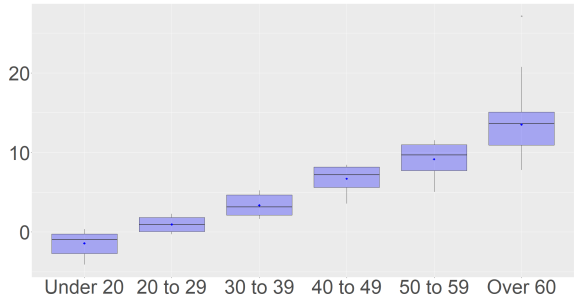


FIGURE 2.2: Heterosexual couples' gap value at first marriage by age range (men). Source: own elaboration.

Interval	Mean	N	%
Under 20	-1.42	114,397	1.42
From 20 to 29	0.95	4,717,890	58.74
From 30 to 39	3.36	2,726,301	33.94
From 40 to 49	6.69	381,291	4.75
From 50 to 59	9.16	66,312	0.83
Over 60	13.51	26,272	0.33

TABLE 2.2: Descriptive analysis of heterosexual couples' age gap value at first marriage (men). Source: own elaboration.

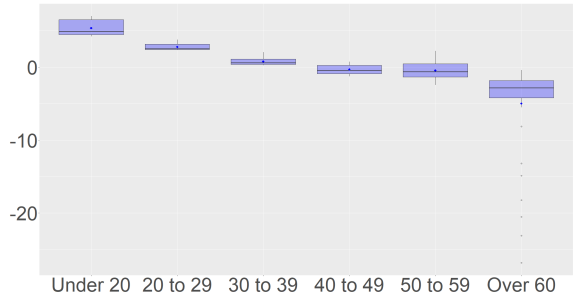


FIGURE 2.3: Heterosexual couples' gap value at first marriage by age range (women). Source: own elaboration.

Interval	Mean	N	%
Under 20	5.37	524,845	6.53
From 20 to 29	2.77	5,306,465	66.06
From 30 to 39	0.79	1,911,275	23.79
From 40 to 49	-0.31	233,893	2.91
From 50 to 59	-0.46	41,696	0.52
Over 60	-4.98	14,289	0.18

TABLE 2.3: Descriptive analysis of heterosexual couples' age gap value at first marriage (women). Source: own elaboration.

A further point to consider in our analysis is the evolution taken by age at first marriage for both men and women. Figure 2.4 shows that, at the beginning of the study period, the average age at first marriage for men was three years higher than that for women. This difference was narrowed over the period, reaching an average difference close to two years. However, a notable rise can be observed in the average age at first marriage across the whole

period (1976–2021): from 26 to 37 in the case of men and from 23 to 35 in that of women. This has led to a significant increase in the number of marriages being contracted at ages between 30 and 39. Thus, in 1976, while 82% of marriages involved men between the ages of 20 and 29, only 12% involved men between the ages of 30 and 39; whereas, in 2021, this trend had undergone a significant change, as only 12% of marriages involved men between the ages of 20 and 29, while 58% involved men between the ages of 30 and 39. In the case of women, 77% of marriages in 1976 involved women aged between 20 and 29, while this figure fell to 22% in 2021. As for marriages involving women aged between 30 and 39, only 6% took place in 1976, while this percentage had risen to 57% in 2021.

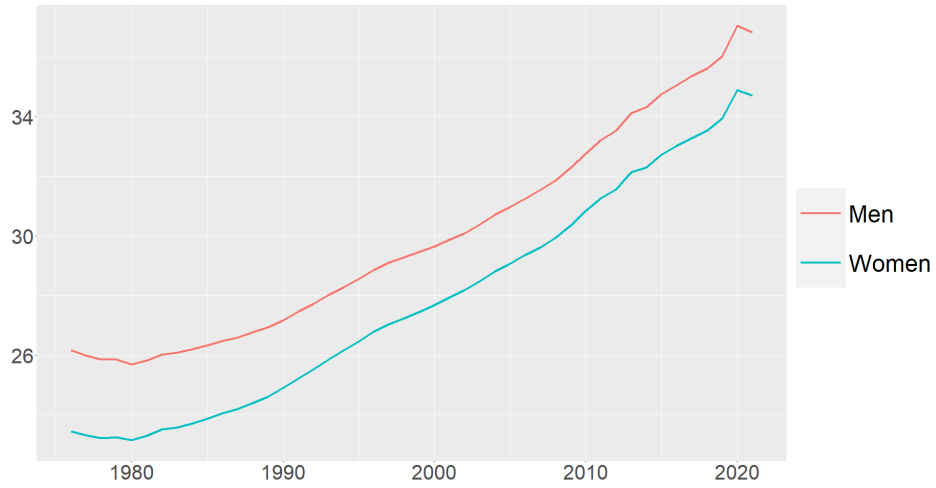


FIGURE 2.4: Evolution of age at first marriage by sex.
Source: own elaboration.

3 Section I: Methodology

In this section, we summarize the statistical methods used to analyze heterosexual couples, with particular emphasis on joint life expectancy and the Coherent Functional Demographic Model (CFDM). This section also highlights the main conclusions that can be drawn from the results that we obtain, and describes the statistical approaches used to estimate period and cohort joint life expectancy until dissolution (death of the first member of the couple) and until extinction (death of the last survivor of the couple).

3.1 Joint life expectancy

The joint life expectancy concept is closely related to demographic and actuarial calculations. It refers to the average life expectancy for a couple, indicating how many years both members are expected to live together from a specific point in time. The group dissolves when the first member dies and extinguishes when the last member passes away. In other words, the group ceases to exist when both members of the couple have passed away.

Two primary methodologies are used to calculate joint life expectancy: one based on period life tables and the other on cohort life tables.

Period Life Expectancy (PLE) assumes that the mortality rates observed at a specific moment remain constant throughout an individual's life, regardless of any anticipated changes in the population's longevity prospects. While PLE is useful for comparing mortality trends

across different factors such as gender, socioeconomic status, temporal periods, geographical regions, or countries, it does not accurately represent the life expectancy of individuals born in a given year.

In contrast, Cohort Life Expectancy (CLE) characterizes the mortality experienced by a cohort of individuals born within a relatively brief period, typically one year, throughout their entire lifetime. Unlike PLE indicators, CLE measures incorporate both observed and projected longevity improvements for the cohort over its remaining lifetime, making it a more appropriate metric for assessing an individual's future longevity prospects. The difference between period and cohort tables lies in how they handle population mortality during a specific period. However, many countries do not offer official cohort tables due to the ambitious nature of this approach and the numerous assumptions it requires.

In the following subsections, we define the statistical methods used in this work to estimate period and cohort joint life expectancy until dissolution (death of the first member of the couple) and until extinction (death of the last survivor of the couple).

3.1.1 Joint life expectancy until dissolution

Let $T_{xy}(t)$ be the remaining lifetime of a group until dissolution, where $T_x(t)$ and $T_y(t)$ are the remaining lifetime of the individuals aged x and y in the calendar year t, respectively:

$$T_{xy}(t) = min\left(T_x(t), T_y(t)\right) \tag{3.1}$$

being the distribution function,

$$\begin{aligned} F_{T_{xy}}(t) &= P[T_{xy} \leq t] = {}_tq_{xy} = 1 - {}_tp_{xy} = 1 - {}_tp_x \cdot {}_tp_y \\ &= 1 - exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds\right) \end{aligned} \tag{3.2}$$

and its density function,

$$
\begin{aligned}
f_{T_{xy}}(t) &= \frac{\partial}{\partial t} F_{T_{xy}}(t) = -\frac{\partial}{\partial t}\left({}_tp_x \cdot {}_tp_y \right) \\
&= -[{}_tp_x \cdot \frac{\partial_t p_y}{\partial t} + {}_tp_y \cdot \frac{\partial_t p_x}{\partial t}] = {}_tp_{xy} \cdot [\mu(x+t) + \mu(y+t)] \\
&= exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds \right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \right) \cdot [\mu(x+t) + \mu(y+t)] \\
&= exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds \right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \right) \cdot \mu(x+t, y+t)
\end{aligned}
\tag{3.3}
$$

where ${}_tp_{xy}$ denotes the temporary joint survivability probability and $\mu(x+t, y+t) = \mu_{x+t} + \mu_{y+t}$ represents the joint instantaneous force of mortality.

Therefore, the joint life expectancy until the dissolution is,

$$
\begin{aligned}
E[T_{xy}] = \bar{e}_{xy} &= \int_0^\infty t \cdot f_{T_{xy}}(t) \cdot dt \\
&= \int_0^\infty t \cdot exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds \right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \right) \cdot \mu(x+t, y+t) \cdot dt \\
&= \int_0^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds \right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \right) \cdot dt
\end{aligned}
\tag{3.4}
$$

Under the assumption of a uniform distribution of deaths within the year (Ayuso et al., 2001) and the use of the previous formula (3.4), the complete life expectancy until dissolution is approximated by,

$$\begin{aligned}\mathring{e}_{xy}(t) &= \frac{1}{2} + \sum_{t=1}^{\infty} {}_tp_{xy} \\ &= \frac{1}{2} + \sum_{t=1}^{\infty} exp\left(-\int_0^{\tau} \mu_{x+s}(s)\cdot ds\right)\cdot exp\left(-\int_0^{\tau} \mu_{y+s}(s)\cdot ds\right)\end{aligned} \tag{3.5}$$

For the discretized stochastic process, we assume that the age-specific forces of mortality are constant within yearly bands of time and age. Formally, given any integer age x and calendar year t, we assume that $\mu_{x+\xi}(t+\epsilon) = \mu_x(t)$ for any $0 \leq \xi < 1$. Under this assumption, the mortality intensities are approximated by the central deaths rates $m_x(t)$ and $m_y(t)$ and the one year survival probabilities are given by $p_x(t) = exp(-m_x(t))$ and $p_y(t) = exp(-m_y(t))$.

Analogous, the complete cohort joint life expectancy until dissolution belonging to population g in year t is given by the expected remaining lifetime of a group until dissolution at time t, i.e.,

$$\mathring{e}^{C}_{xy,g}(t) = \frac{1}{2} + \sum_{k=1}^{\omega-x}\sum_{k=1}^{\omega-y}\left(exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t+j)\right)\cdot exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t+j)\right)\right) \tag{3.6}$$

whereas the corresponding complete period joint life expectancy until the dissolution, $\mathring{e}^{P}_{xy,g}(t)$, is given by

$$\mathring{e}^{P}_{xy,g}(t) = \frac{1}{2} + \sum_{k=1}^{\omega-x}\sum_{k=1}^{\omega-y}\left(exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t)\right)\cdot exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t)\right)\right) \tag{3.7}$$

Given $\mathring{e}^{C}_{xy,g}(t)$ and $\mathring{e}^{P}_{xy,g}(t)$, the concept of joint life expectancy gap until dissolution, $\mathring{e}^{Gap}_{xy,g}(t)$ corresponds to the systematic differences between the (complete) cohort and period joint life expectancy measures for a given population at age x and y in year t and is deffined

by:

$$\mathring{e}^{Gap}_{xy,g}(t) = \mathring{e}^{C}_{xy,g}(t) - \mathring{e}^{P}_{xy,g}(t) \tag{3.8}$$

3.1.2 Joint life expectancy until extinction

Let $T_{\overline{xy}}(t)$ be the remaining lifetime of a group until the extinction, where $T_x(t)$ and $T_y(t)$ are the remaining lifetime of the individuals aged x and y in the calendar year t, respectively:

$$T_{\overline{xy}}(t) = max\left(T_x(t), T_y(t)\right) \tag{3.9}$$

being the distribution function,

$$\begin{aligned} F_{T_{\overline{xy}}}(t) = P[T_{\overline{xy}} \leq t] = {}_tq_{\overline{xy}} = {}_tq_x \cdot {}_tq_y = 1 - {}_tp_x - {}_tp_y + {}_tp_{xy} \\ = 1 - exp\left(-\int_0^\tau \mu_{x+s}(s)\right) - exp\left(-\int_0^\tau \mu_{y+s}(s)\right) + \\ exp\left(-\int_0^\tau \mu_{x+s}(s)\cdot ds\right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s)\cdot ds\right) \end{aligned} \tag{3.10}$$

and its density function,

$$
\begin{aligned}
f_{T_{\overline{xy}}}(t) &= \frac{\partial}{\partial t} F_{T_{\overline{xy}}}(t) = -\frac{\partial}{\partial t}({}_tq_x \cdot {}_tq_y) \\
&=_t q_x \cdot \frac{\partial_t q_y}{\partial t} + {}_tq_y \cdot \frac{\partial_t q_x}{\partial t} \\
&= {}_tq_x \cdot \frac{\partial\left(1 - {}_tp_y\right)}{\partial t} + {}_tq_y \cdot \frac{\partial\left(1 - {}_tp_x\right)}{\partial t} \\
&= {}_tq_x \cdot {}_tp_y \cdot \mu(y+t) + {}_tq_y \cdot {}_tp_x \cdot \mu(x+t) \\
&= {}_tp_x \cdot \mu(x+t) + {}_tp_y \cdot \mu(y+t) - {}_tp_{xy} \cdot \mu(x+t, y+t) \\
&= exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot \mu(x+t) + \\
& exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds\right) \cdot \mu(y+t) - \int_0^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot \\
& exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \cdot dt\right) \cdot \mu(x+t, y+t)
\end{aligned}
\tag{3.11}
$$

Therefore, the joint life expectancy until the extinction is,

$$
\begin{aligned}
E[T_{\overline{xy}}] = \bar{e}_{\overline{xy}} &= \int_0^\infty t \cdot f_{T_{\overline{xy}}}(t) \cdot dt \\
&= \int_0^\infty t \cdot {}_tp_x \cdot \mu(x+t) \cdot dt + \int_0^\infty t \cdot {}_tp_y \cdot \mu(y+t) \cdot dt - \int_0^\infty t \cdot {}_tp_{xy} \cdot \mu(x+t, y+t) \cdot dt \\
&= \bar{e}_{\overline{x}} + \bar{e}_{\overline{y}} - \bar{e}_{\overline{xy}} = \int_0^\infty {}_tp_x \cdot dt + \int_0^\infty {}_tp_y \cdot dt - \int_0^\infty {}_tp_{xy} \cdot dt \\
&= \int_0^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot dt + \int_0^\infty exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds\right) \cdot dt - \\
&\int_0^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds \cdot dt\right) \cdot dt
\end{aligned}
\tag{3.12}
$$

Under the assumption of a uniform distribution of deaths within the year (Ayuso et al., 2001) and the use of the previous formula (3.12), the complete life expectancy until extinction is approximated by,

$$
\begin{aligned}
\mathring{e}_{\overline{xy}}(t) = \frac{1}{2} + \sum_{t=1}^\infty {}_tp_{\overline{xy}} &= \frac{1}{2} + \sum_{t=1}^\infty \left({}_tp_x + {}_tp_y - {}_tp_{xy}\right) \\
&= \frac{1}{2} + \sum_{t=1}^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) + \sum_{t=1}^\infty exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds\right) - \\
&\sum_{t=1}^\infty exp\left(-\int_0^\tau \mu_{x+s}(s) \cdot ds\right) \cdot exp\left(-\int_0^\tau \mu_{y+s}(s) \cdot ds\right)
\end{aligned}
\tag{3.13}
$$

Analogous, the complete cohort joint life expectancy until extinction belonging to population g in year t is given by the expected remaining lifetime of a group until the extinction at time t, i.e.,

$$\mathring{e}^{C}_{\overline{xy},g}(t) = \frac{1}{2} + \sum_{k=1}^{\omega-x} exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t+j)\right) + \sum_{k=1}^{\omega-y} exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t+j)\right) - \sum_{k=1}^{\omega-x}\sum_{k=1}^{\omega-y}\left(exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t+j)\right)\cdot exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t+j)\right)\right) \tag{3.14}$$

whereas the corresponding complete period joint life expectancy until the extinction, $\mathring{e}^{P}_{xy,g}(t)$, is given by

$$\mathring{e}^{P}_{\overline{xy},g}(t) = \frac{1}{2} + \sum_{k=1}^{\omega-x} exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t)\right) + \sum_{k=1}^{\omega-y} exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t)\right) - \sum_{k=1}^{\omega-x}\sum_{k=1}^{\omega-y}\left(exp\left(-\sum_{j=0}^{k-1} m_{x+j,g}(t)\right)\cdot exp\left(-\sum_{j=0}^{k-1} m_{y+j,g}(t)\right)\right) \tag{3.15}$$

The concept of joint life expectancy gap until the extinction will be now the systematic difference between the corresponding cohort and period joint life expectancy as:

$$\mathring{e}^{Gap}_{\overline{xy},g}(t) = \mathring{e}^{C}_{\overline{xy},g}(t) - \mathring{e}^{P}_{\overline{xy},g}(t) \tag{3.16}$$

3.2 Coherent functional demographic model (CDFM)

The CFDM (Hyndman et al., 2012) uses Functional Principal Components (FPC) models to create simple and understandable rate functions that ease to forecast of coherent mortality rates in two or more subpopulations. The product-ratio functional forecasting method involves modeling the geometric mean of subpopulation rates, and the ratio of subpopulation rates to product rates. In Hyndman et al. (2012), authors demonstrate that their coherent forecasts are as accurate as comparable independent forecasts when homogenizing forecasts accuracy across subpopulations.

In this thesis, we model and forecast the age-specific mortality rates for men and women in Spain, considering the joint dynamics of the population.

The male and female mortality rates for age x and year t, denoted by $m_{t,M}(x)$ and $m_{t,F}(x)$ respectively, are included in this study for the years $t = 1, ..., n$. The logarithmic death rate will be modeled as $y_{t,m}(x) = log[m_{t,M}(x)]$ and $y_{t,f}(x) = log[m_{t,F}(x)]$.

In this scenario, assuming the existence of a smooth underlying function that we observe with error, then

$$y_{t,M}(x_i) = log[f_{t,M}(x_i)] + \sigma_{t,M}(x_i)\varepsilon_{t,M,i} \tag{3.17}$$

$$y_{t,F}(x_i) = log[f_{t,F}(x_i)] + \sigma_{t,F}(x_i)\varepsilon_{t,F,i} \tag{3.18}$$

where x_i is the center of age group i ($i = 1, ..., p$), $\varepsilon_{t,M,i}$ and $\varepsilon_{t,F,i}$ are independent and identically distributed standard normal random variables, and $\sigma_{t,M}(x_i)$ and $\sigma_{t,F}(x_i)$ are the observational variances for male and female respectively that allows the error to vary with age x.

Square roots of products ($p_t(x)$) and ratios ($r_t(x)$) of smoothing rates per sex are defined as:

$$p_t(x) = \sqrt{f_{t,M}(x) f_{t,F}(x)} \tag{3.19}$$

$$r_t(x) = \sqrt{\frac{f_{t,M}(x)}{f_{t,F}(x)}} \tag{3.20}$$

Instead of modeling per-sex original mortality rates, authors model the product and the ratio of the smoothed mortality rates. The advantage of this approach is that the product and ratio are roughly independent of one another as long as the subpopulations have roughly

equal variances. On the logarithmic scale, these are sums and differences that are roughly uncorrelated. Moreover, using products and ratios is an easy and interpretable way to impose coherence on projections, and it greatly simplifies modeling compared to using rates directly because the two functions are uncorrelated.

Functional time series models are used to model both $p_t(x)$ and $r_t(x)$:

$$log[p_t(x)] = \mu_p(x) + \sum_{k=1}^{K} \beta_{t,k}\phi_k(x) + e_t(x) \tag{3.21}$$

$$log[r_t(x)] = \mu_r(x) + \sum_{l=1}^{L} \gamma_{t,l}\psi_l(x) + w_t(x) \tag{3.22}$$

where the function $\mu_p(x)$ is the mean of the set of curves $\{p_t(x)\}$ and $\mu_r(x)$ is the mean of $\{r_t(x)\}$, $\beta_{t,k}$ and $\gamma_{t,l}$ denote the respective principal component values, and the functions $\{\phi_k(x)\}$ and $\{\psi_l(x)\}$ are the principal components obtained from the decomposition of $\{p_t(x)\}$ and $\{r_t(x)\}$, respectively. The error terms, denoted as $e_t(x)$ and $w_t(x)$, have zero mean and are not serially correlated.

The models are estimated using the weighted principal components algorithm of Hyndman and Shang (2009), which gives more weight to recent data and thus avoids the problem of the functions $\{\phi_k(x)\}$ and $\{\psi_l(x)\}$ changing over time.

The coefficients $\{\beta_{t,1}, ..., \beta_{t,K}\}$ and $\{\gamma_{t,1}, ..., \gamma_{t,L}\}$ are independently predicted using time series models. Because the coefficients $\beta_{t,k}$ and $\gamma_{t,l}$ are all uncorrelated by construction, there is no need to consider vector models. Due to the use of products and ratios, they are also roughly uncorrelated with each other.

Unbounded Autoregressive Integrated Moving Average (ARIMA) models are used to forecast the coefficients of the product model. Ratio model coefficients are each forecast using any stationary Autoregressive Fractionally Integrated Moving Average (ARFIMA)(p,d,q)

process. We require the coefficients $\{\gamma_{t,l}\}$ to be stationary processes to ensure that the forecast coefficients are coherent.

Multiplying the predicted coefficients by the basis function yields the predicted curves $p_t(x)$ and $r_t(x)$ for future time t. Hence, considering $p_{n+h|n}(x)$ and $r_{n+h|n}(x)$ as h-step forecasts of the product and ratio functions, respectively, we can obtain the forecast of the sex-specific mortality rates using $f_{n+h|n,M}(x) = p_{n+h|n}(x)r_{n+h|n}(x)$ and $f_{n+h|n,F}(x) = \frac{p_{n+h|n}(x)}{r_{n+h|n}(x)}$ and thus the predicted life expectancy.

3.3 Results for Spanish heterosexual couples

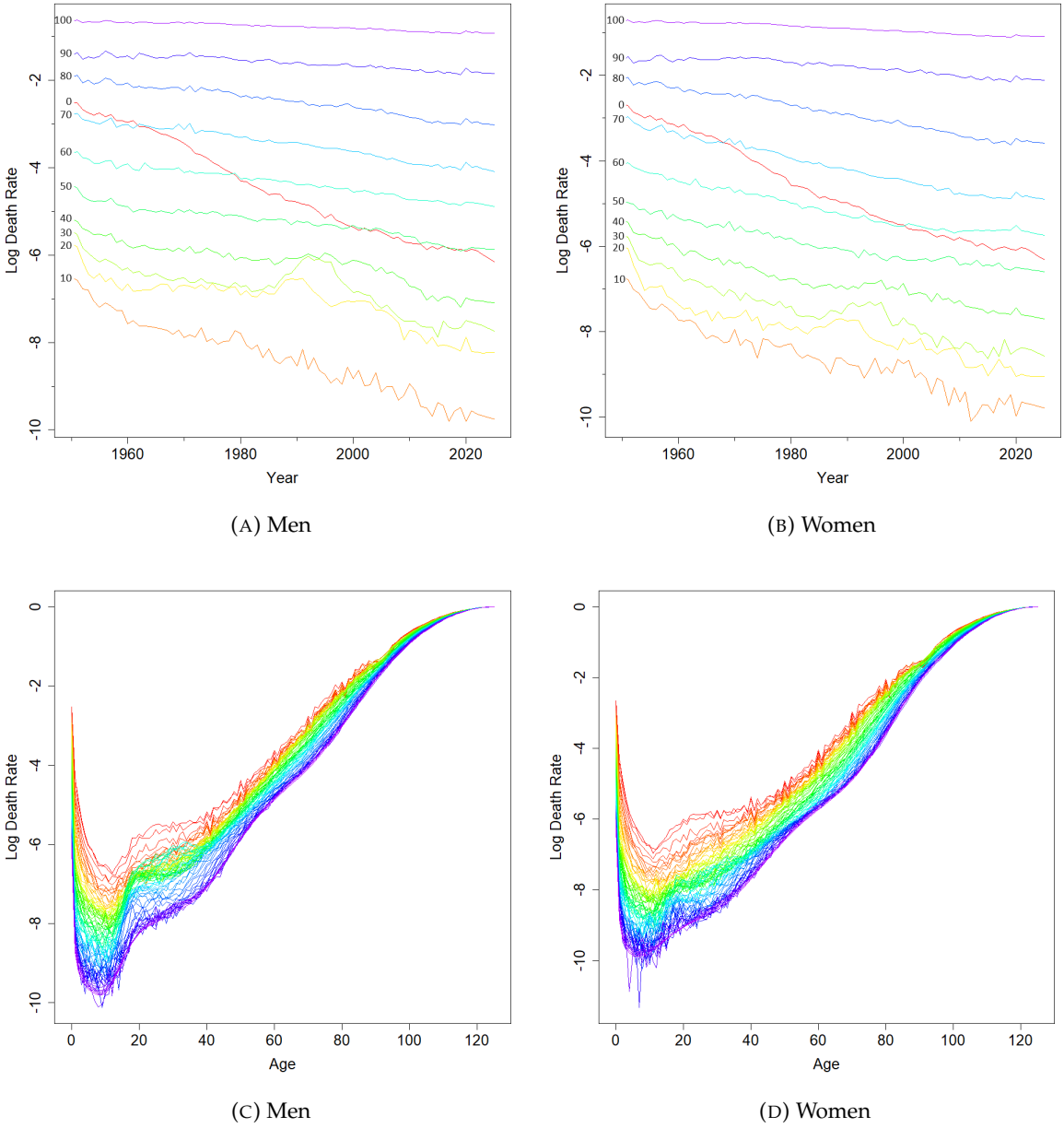
3.3.1 Log death rates for males and females

Figures 3.1 and 3.2 5 show the mortality rates (period and cohort, respectively) on a logarithmic scale for men and women at selected ages (see Appendix B for R code details enabling these results). The upper panels (A and B) present the data as a univariate time series, while the lower panels (C and D) represent these data as a series of functional observations. The specific mortality data for both figures span from the year 1950 to 2025, from the age of 0 to 125 years. For data representation, rainbow plots are utilized, with the order of curves indicated by the colors of the rainbow, from red to violet.

As we analyze mortality rates derived from the period methodology (see Figure 4), we observe that individuals born more recently exhibit lower mortality rates throughout their lives. For instance, we notice a more pronounced decrease in mortality among children (i.e. ages of 0 and 10 years). Similarly, we also see a reduction in mortality among older individuals, even as each group reaches 50 years of age. Particularly for women, mortality has steadily decreased across most ages. However, for men, the decline stagnated in most adult ages during the 1960s and early 1970s. In recent years, mortality for both men and

women at ages 20 and 30 is no longer decreasing, and small numbers of deaths result in relatively notable fluctuations at age 10.

If we compare these results with those obtained through the cohort methodology (see Figure 3.2), we observe how mortality for men and women has consistently decreased across most ages, with this reduction notably higher than that experienced by mortality rates derived from the period method. Specifically, we note a more pronounced decrease in mortality among older individuals, becoming significant even as each group reaches 60 or 70 years of age. This discrepancy between period and cohort mortality rates implies the underestimation of the period methodology in calculating individual life expectancy, which directly impacts the calculation of aggregate life expectancy.



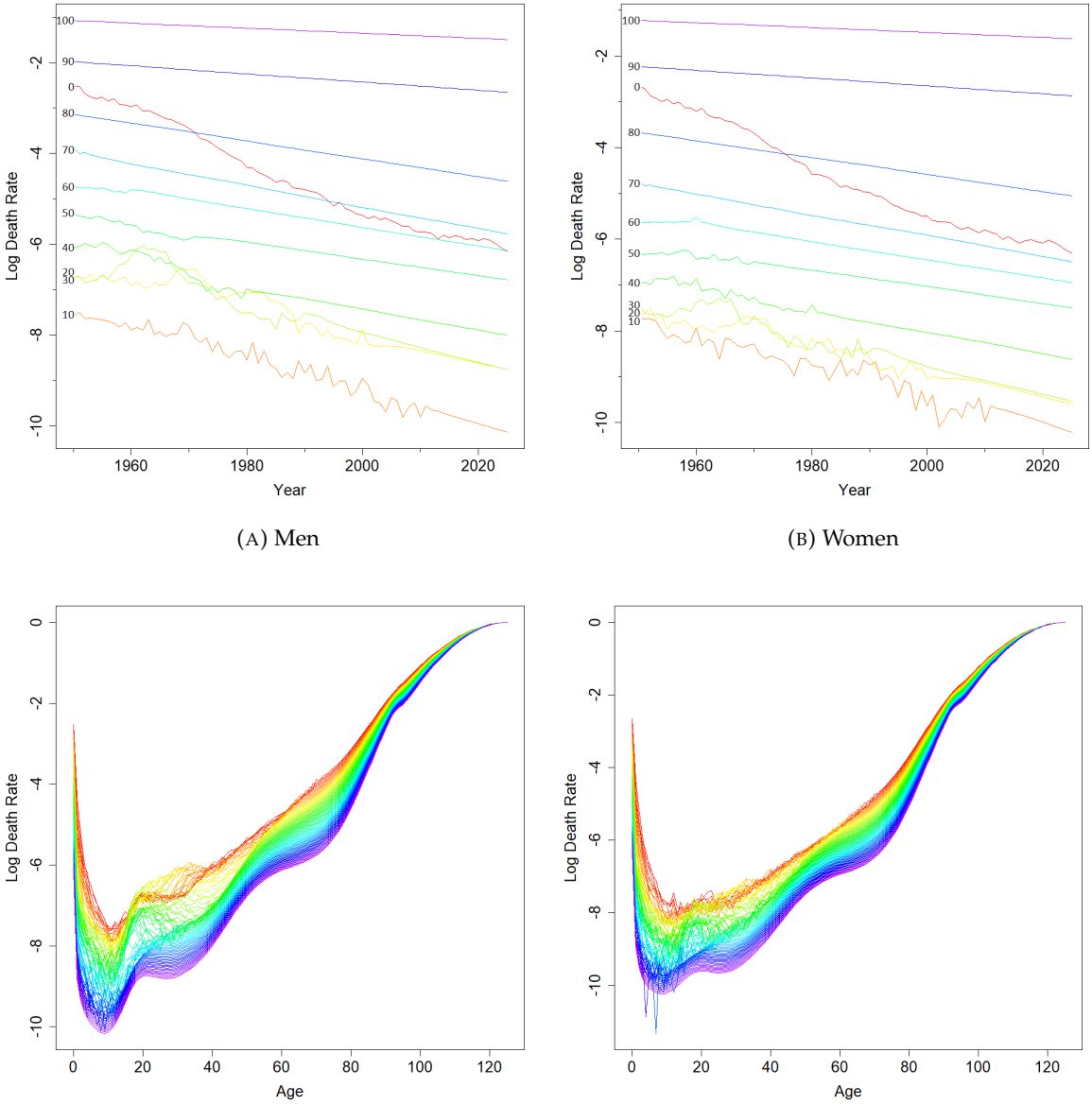
(A) Men

(B) Women

(C) Men

(D) Women

FIGURE 3.1: Log death rates for men and women in Spain according to the period approach for various ages as univariate time series (top panels) and smoothed log death rates for men and women viewed as functional time series, observed from 1950 to 2025 (bottom panels). Source: own elaboration.



(A) Men

(B) Women

(C) Men

(D) Women

FIGURE 3.2: Log death rates for men and women in Spain according to the cohort approach for various ages as univariate time series (top panels) and smoothed log death rates for men and women viewed as functional time series, observed from 1950 to 2025 (bottom panels). Source: own elaboration.

3.3.2 Joint life expectancies

If we focus on joint life expectancy estimation analysis, we use the CFDM (see Section 3.2) as our forecasting method, in line with previous reports in Bravo et al. (2023). First, we estimate the individual survival probabilities for both spouses aged x and y, and then we use them to calculate the temporal probabilities of joint survival.

Tables 3.1 and 3.2 present the period and cohort estimates of joint life expectancy until dissolution (e_{xy}), as well as individual life expectancies from the time of dissolution ($x + e_{xy}$; $y + e_{xy}$), for a heterosexual marriage composed of two individuals of ages x and y in Spain, with the requirement that at least one of them reaches the age of 65. The most common age gaps between the partners of couples in Spain (see section 2 above) are taken into consideration.

As is expected, joint life expectancy increases when one of the spouses is younger than the other. Moreover, the longer life expectancy of women significantly affects the number of years they will live alone following the death of their husband (last column of Table 3.1, and comparison with the previous column, showing the number of years the husband will live alone following the death of his wife). For example, for a couple where both partners are aged 65, it is estimated they will live together for approximately 16 years; if the man dies first, it is estimated that the woman will live almost 2.3 times the number of years that the man will live if the woman dies first (6.89 and 2.95 years, respectively). When one of the spouses is younger than the other (especially when the woman is younger), the differences in how long each partner will live alone once the couple is dissolved increase significantly. The ramifications of these outcomes for social policy design are self-evident and should be given more prominence today at a time when the longevity of individuals is rising systematically.

Age		Joint status	Beneficiary	
Man (x)	Woman (y)	e_{xy}	$x + e_{xy}$	$y + e_{xy}$
65	65	15.90	2.95	6.89
65	64	16.18	2.68	7.50
65	63	16.43	2.43	8.15
65	62	16.65	2.20	8.82
65	58	17.36	1.49	11.74
65	56	17.62	1.23	13.32
65	51	18.07	0.78	17.54
60	65	17.89	4.95	4.90
62	65	17.15	4.07	5.64
63	65	16.75	3.67	6.04
64	65	16.34	3.29	6.45

TABLE 3.1: Joint (until dissolution) and individual annuities (until extinction) for heterosexual couples at retirement age by period approach. Source: own elaboration.

Age		Joint status	Beneficiary	
Man (x)	Woman (y)	e_{xy}	$x + e_{xy}$	$y + e_{xy}$
65	65	17.40	3.28	6.92
65	64	17.72	2.95	7.58
65	63	18.02	2.65	8.28
65	62	18.29	2.38	9.01
65	58	19.12	1.55	12.22
65	56	19.41	1.26	13.98
65	51	19.90	0.77	18.69
60	65	19.62	5.70	4.70
62	65	18.81	4.62	5.51
63	65	18.36	4.13	5.96
64	65	17.89	3.69	6.43

TABLE 3.2: Joint (until dissolution) and individual annuities (until extinction) for heterosexual couples at retirement age by cohort approach. Source: own elaboration.

4 Section II: Applications

4.1 Main areas: pensions and others

The analysis of joint life expectancy emerges as a fundamental field of research within the framework of contemporary demographic and social transformations, as it plays a direct role in achieving the various Sustainable Development Goals (SDGs). Over the past decades, Spanish society has experienced significant changes that have had a profound impact on the dynamics of marital relationships, reflected in the way and the timing in which couples establish their marital unions.

In this context of social transformation, the calculation of joint life expectancy becomes critically relevant, especially with the increase in life expectancy after 65 years, leading couples to share a greater amount of time. The demographic evolution towards an increasingly ageing population in Spain underscores the urgency of implementing economic and social policies that guarantee a dignified life in old age.

The study of joint life expectancy can provide information on how socioeconomic disparities affect joint life expectancy. In this sense, retirement and widowhood pensions play a fundamental role in the fight against poverty in old age (SDG 1). The financial stability provided by these pensions can be crucial in ensuring a decent standard of living for older people and their families.

However, in Spain, pensions face challenges related to financial sustainability and adequacy of amounts. Specifically, participation in the labor market (SDG 8) of the couple throughout their lives has a direct impact on the access to and amount of pensions. For example, couples in which both members have worked usually have entitlement to higher pension benefits compared to those in which only one spouse has worked. This phenomenon perpetuates old-age poverty for those who have not been able to fully participate in the labor market due to family dynamics, creating an even wider poverty gap in these households.

In this situation, joint life expectancy analysis can provide information on how economic and labor decisions throughout life affect financial security in old age and their influence on poverty reduction, which should contribute to the formulation of more effective policies to reduce poverty among the most vulnerable elderly and thus ensure a dignified retirement for all citizens.

Similarly, by considering how the age disparity between members of a couple can affect their joint life expectancy, we can identify specific challenges faced by women regarding longevity and financial security in old age (SDG 5). The age difference between members of the couple can influence the distribution of roles and responsibilities, as well as access to economic and social resources, which can directly impact the quality of life and financial stability of women as they age.

Furthermore, the study of joint life expectancy in different couple compositions allows us to observe how policies and social protection systems must adapt to ensure equitable access to retirement and widowhood pensions, regardless of sexual orientation or couple composition. This implies considering the specific needs of each type of couple and adopting measures to eliminate any discrimination in accessing social security benefits, thus promoting equality of rights and opportunities for all individuals, regardless of their particularities.

Similarly, joint life expectancy study indirectly can provide crucial information about

the nutritional and physical status (SDG 2) of the older population. Although adequate nutrition is a fundamental factor in ensuring health and well-being at all stages of life, its importance is magnified in old age, when people may face additional difficulties in accessing quality food due to economic or mobility limitations. In this sense, the analysis of joint life expectancy allows us to analyze the socioeconomic and health conditions that influence the nutrition and physical activity of older people, which can help formulate policies and programs aimed at minimizing food insecurity, preventing malnutrition, and promoting active and healthy lifestyles in old age. Likewise, couple relationships also play a crucial role in the health and well-being (SDG 3) of older people. The emotional and social benefits derived from mutual support and companionship can have a positive impact on physical and mental health. However, challenges can also arise, especially when a couple faces health problems or dependency. Stress and caregiving burden can significantly affect the health and well-being of both the older person and their caregiver.

In this context, joint life expectancy analysis can also contribute to a better understanding of how couple dynamics affect the health and access to medical care of older people. In particular, it allows for identifying opportunities to improve health and well-being in this stage of life, considering the need to consider the proportion of older adults in areas with different population densities (SDG 9). These areas may be characterized by relevant differences in terms of access to services and benefits to meet the needs of older adults. This implies the development of support programs aimed at couples facing health challenges, as well as the implementation of policies that facilitate equitable access to healthcare services for all older people, regardless of their marital status or socioeconomic level.

Moreover, joint life expectancy study can also highlight the socioeconomic and health inequalities present in various population groups (SDG 10), to understand how different factors, such as age and gender, influence longevity and quality of life in old age. In this context, its study facilitates the design of policies and programs aimed at addressing the

socioeconomic and health disparities faced by older people, including measures to ensure equitable access to healthcare services, long-term care, and social protection systems, among others.

On the other hand, the relevance of studying joint life expectancies can address fundamental aspects of the social integration and participation of older adults, analyzing the intensity of their social and public life in society (SDG 16). Social relationships and active participation in society are central elements in defining active aging, as established by the United Nations. Joint life expectancy study can assess the degree of participation of older adults in social and community activities, as well as their involvement in decisions and activities affecting the community at large.

Finally, the analysis of joint life expectancies can also facilitate collaboration between different sectors and actors, including governments, international organizations, civil society, and the private sector (SDG 17). These partnerships will be essential for implementing coordinated and sustainable measures that address the specific needs and challenges related to population ageing, as well as ensuring comprehensive and dignified care for people at all stages of life.

In conclusion, the study of joint life expectancy in the context of the SDGs can provide a comprehensive framework for understanding and addressing the socioeconomic and health challenges faced by older people in Spanish society. By considering how couple dynamics impact longevity and well-being, we can develop more effective policies and programs that promote dignified and sustainable aging for all.

4.2 Effects of joint life expectancy on pension concurrence in a defined benefit, pay-as-you-go system

The concurrence of retirement and widowhood pensions in a defined benefit, PAYG system, such as those operated by Spain and Portugal, impacts on pension wealth in households whose head is 65 years of age or older. This concurrence refers to the possibility of individuals receiving both pensions simultaneously, with a benefit limit that corresponds, in the case of Spain, to that of the maximum retirement pension. The right to access a widowhood pension is subject to the condition of having contracted marriage or being a de facto partner. The probability of either spouse receiving this pension is dependent on several factors, including the age gap between them, given that this difference influences the probability of survival associated with each age. It is, therefore, critical to undertake a rigorous analysis of pension concurrence and its impact on pension wealth, comparing outcomes with households for which there is no such concurrence, either because individuals have not married or, despite being married, they have not generated the right for their partner to receive a widowhood pension (for example, because they have not contributed to the social security system and are not entitled to a retirement pension). Estimating differences by household in terms of expected pensions should help in the design of appropriate policies and strategies that promote intra- and intergenerational equity, ensuring the economic security and well-being of households during retirement. In general, and in adherence with Spanish and Portuguese regulations, the widowhood pension corresponds to between approximately 52 and 60% of the retirement pension of the partner that dies.

The macros and calculations utilized for the results outlined in this section can be found in Appendix C.

4.2.1 Expected pension wealth of couple with concurrence of pensions

We seek to quantify the expected pension wealth of a married couple made up of two individuals aged x and y, respectively, from the time of retirement of one or both partners. In this analysis, the concurrence of retirement and widowhood pensions is assumed, as is the fact that both individuals meet the necessary requirements to receive independently a contributory retirement pension, to which the corresponding widowhood pension will be added (up to the maximum limit established) in the event of the death of one or other of the spouses.

In this analysis, we consider the age gap between spouses in Spain as presented in section 2 and Table 3.1. We assume that this disparity is maintained in those couples who both meet the requirements to access the retirement pension. This age gap is relevant to understanding the dynamics of pensions and their impact on household wealth during retirement. Having defined the ages of man (age x) and woman (age y), we then use their joint life expectancy until dissolution (e_{xy}) (Table 3.1), that is, the number of years the couple will live together until one or other of them dies. Throughout this period, the corresponding retirement pension is allocated to each spouse taking into consideration whether or not his/her age is higher than that of retirement (i.e. 65 years old). In the event that one of the partners is under the age of 65 (i.e. only one has reached retirement age), the calculation is deferred until he or she retires.

In terms of the survivor's pension, we establish two possible scenarios:

- First, man dies and the marriage is dissolved. In this case, the individual life expectancy of woman is used (last column Table 3.1) by assigning her the payments corresponding to the retirement and widowhood pensions for the entire period remaining until her death.

- Second, the dissolution of the couple occurs owing to the death of woman. In this

case, the individual life expectancy of man is used (penultimate column Table 3.1) by assigning the corresponding payments to the concurrence of the retirement and widowhood pension until his death.

In completing this analysis, we used the average retirement pension received by a man in Spain in 2022, which amounts to 1,368.77 euros, and the average pension for a woman, which stands at 915.33 euros (Spanish Social Security, 2023). The widowhood pension in the same year is 523.86 euros for a man and 759.21 euros for a woman (that is, as discussed, approximately 55% of the retirement pension of the spouse who dies).

Table 4.1 presents the expected pension income upon retirement of at least one of the two individuals, considering the age gap between spouses and the corresponding life expectancies until dissolution and extinction of the couple, as detailed in Table 3.1. Note that if the man (age x) dies first, the woman simultaneously receives both the retirement pension and the widow's pension for the entire period until her own death. Conversely, if the woman (age y) dies first, the man receives both pensions jointly until his own death. During the years of joint survival (e_{xy}), both collect their respective contributory retirement pensions. In making these calculations, we assume that the annual pension revaluation rate is equal to the interest rate used in the update process.

Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65	65	304.706,40	203.764,63	508.471,03	78.180,36	161.472,71	586.651,39	669.943,74
65	64	309.960,04	194.463,24	504.423,28	70.910,59	175.900,96	575.333,87	680.324,25
65	63	314.756,00	184.855,80	499.611,80	64.272,82	190.986,63	563.884,62	690.598,43
65	62	319.114,46	174.955,79	494.070,26	58.239,32	206.699,87	552.309,58	700.770,13
65	58	332.708,48	132.787,96	465.496,44	39.411,39	275.157,33	504.907,84	740.653,77
65	56	337.624,23	110.446,01	448.070,24	32.598,91	312.259,62	480.669,15	760.329,86
65	51	346.221,27	52.121,96	398.343,23	20.680,43	411.276,95	419.023,67	809.620,18
60	65	247.052,15	229.282,92	476.335,07	131.162,50	114.789,40	607.497,57	591.124,48
62	65	271.201,23	219.802,76	491.003,99	107.704,91	132.135,26	598.708,90	623.139,25
63	65	282.728,20	214.696,50	497.424,70	97.116,42	141.476,68	594.541,12	638.901,38
64	65	293.894,37	209.348,98	503.243,36	87.279,40	151.258,53	590.522,75	654.501,88

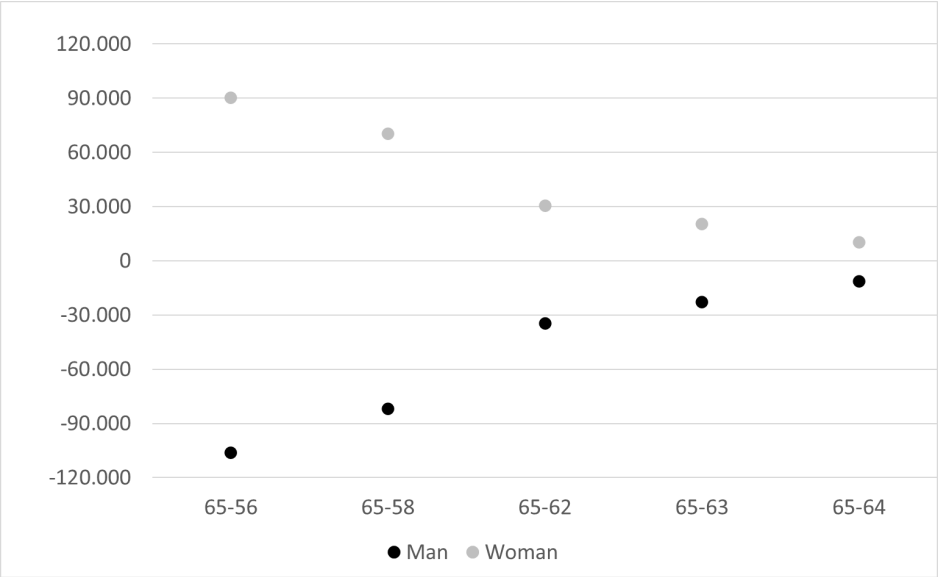
Note: a_{xy} represents the sum of the expected retirement pension for the man and woman during the years they are expected to live together; a_x represents the pension if the man survives (retirement + widowhood), while a_y the pension if the woman survives (retirement + widowhood). The last two columns represent the total pension wealth for the couple assuming, in the first case, that the woman dies first and, in the second, that the man dies first.

TABLE 4.1: Expected pension wealth for a heterosexual couple (from retirement until death of both partners). Source: own elaboration.

As can be seen, in the case of a marriage between a man and a woman both aged 65, for whom joint life expectancy is estimated at approximately 16 years, the total retirement payments to both spouses (considering the average pensions mentioned at the beginning of this section) amounts to approximately 508 thousand euros. Once this period has elapsed, and considering the dissolution of the group as being due to the death of the woman, it is estimated that the man's individual life expectancy is 3 years, and the aggregate cost of his retirement and widower's pensions reaches approximately 78 thousand euros. This brings the total amount received until the group's extinction to approximately 586 thousand euros. On the other hand, in a second scenario, if the dissolution of the group occurs due to the death of the man, the individual life expectancy of the woman is higher, at an estimated 7 years. During this period, payments related to the retirement and widow's pensions are

projected to amount to approximately 161 thousand euros, bringing the total amount of pension payments until the couple's extinction to approximately 670 thousand euros, that is, 14.3% more than in the previous scenario. An analogous interpretation can be provided for the other scenarios, which cover various age gaps between spouses.

To facilitate our analysis of how the age gap in a couple impacts total couple wealth derived from pensions, the relative differences between the estimated amounts attributed to each of the scenarios are shown graphically (Figures 4.1 and 4.2) when varying the age of one of the spouses compared to our reference, that is, a couple comprising a 65-year-old man and woman. The results in Figure 4.1 correspond to couples in which the man is 65 years old, while those in Figure 4.2 correspond to couples in which the woman is of that age.

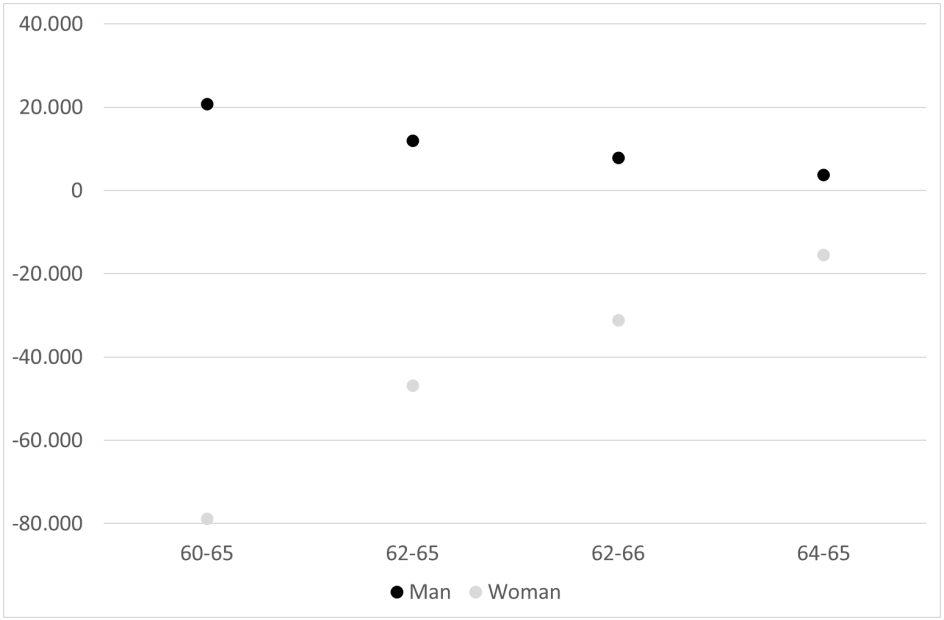


Note: Based on composition of marriages by age in Spain during period 1976-2021. Reference category (value 0 in ordinates): 65-year-old man and woman. Black dots: male beneficiary of widower's pension (the woman dies first); grey dots: female beneficiary of widow's pension (the man dies first). Pension benefits from the age of 65 and onwards for both partners.

FIGURE 4.1: Relative difference in total pension wealth for heterosexual couples compared to a couple formed by a 65-year-old man and woman (male age = 65 years; female age variable). Source: own elaboration.

As can be seen in Figure 4.1, as the age gap between the partners at the time of retirement narrows, total pension wealth converges more closely with that of the reference couple (65, 65). Specifically, when the wife is younger than the husband, if the dissolution of the marriage is caused by the death of the woman, the cost to the social security system falls. In contrast, if the dissolution is a consequence of the husband's death, the cost is higher due to the woman's greater life expectancy and the increase in the reversion obtained from the widow's pension. For example, in the case of a couple formed by a 65-year-old man and a 56-year-old woman, if the dissolution of the marriage is caused by the death of the wife, total pension wealth until the death of both partners suffers a decrease of 105,982€ compared to that of the reference couple (65, 65). In contrast, if the dissolution is the result of the man's death, total pension wealth increases by 90,386€ in relation to that of the reference.

Figure 4.2 illustrates notably divergent behavior in this regard. Generally, a woman's advanced age results in a decrease in pension wealth compared to that of the reference couple (65, 65). For example, in a marriage in which the man is 62 and the woman is 65 years old, if the marriage is dissolved as a consequence of the death of the wife, the total pension wealth accumulated until extinction is just 12,058€ higher than that of the reference couple. In contrast, if the dissolution occurs as a result of the husband's death, total pension wealth is 46,804€ lower than that of the reference couple.



Note: Based on composition of marriages by age in Spain during period 1976-2021. Reference category (value 0 in ordinates): 65-year-old man and woman. Black dots: male beneficiary of widower's pension (the woman dies first); grey dots: female beneficiary of widow's pension (the man dies first). Pension benefits from the age of 65 and onwards for both partners.

FIGURE 4.2: Relative difference in total pension wealth for heterosexual couples compared to a couple formed by a 65-year-old man and woman (female age = 65 years; male age variable). Source: own elaboration.

4.2.2 Comparison with non-concurrence of pensions (I): Single people

To analyze the impact of the widowhood pension on the system, it is especially insightful to compare the expected pension wealth of individuals who form a couple and have the right to a survivor's pension with that of pensioners who are single and, therefore, not entitled to a widowhood pension. To make this comparison, the part corresponding to each individual in relation to the retirement and widowhood pensions is computed individually, considering them as a whole. Subsequently, this result is compared with the total pension wealth of an individual that shares the same characteristics but has single marital status.

Table 4.2 shows that for a couple in which both spouses are aged 65, the expected pension wealth of the married man is 5% higher than that of a single man, thanks to the income from

the widower's pension [1]. In the case of a 65-year-old married woman, when performing a similar exercise, we find that the total pension expected is significantly higher (24%) than that of a single woman. When examining the other scenarios in which the man's age is kept constant at 65, our results continue to show that the total pension wealth of the married man is higher than that of a single man of the same age. However, the respective amounts tend to be more similar because the influence of the widowhood pension is not so great. However, in the case of women, the impact of the widow's pension becomes increasingly more evident: the younger the wife of a 65-year-old man, the greater is the difference (up to 66%) in the expected retirement pension with that of a single woman of the same age.

When analyzing scenarios in which the woman's age remains constant at 65 and her husband is younger (bottom of Table 4.2), our results show that the difference between the total pension wealth of married and single men is about 10%. In the case of women, the impact of the widow's pension, although significant, is not as great as when allowing the woman's age to vary, with increases just over 22% (as opposed to the 66% observed in the scenarios in which the woman's age was not constant). Note that in these calculations, we use the most frequent age gaps between Spanish couples (see section 2). If we select, for example, a 62-year-old woman with a positive gap of 3 years with her husband – i.e. couple (62, 65), we find that her total pension wealth is 19% higher than that of a single 62-year-old woman.

[1] Note that in this case we do not include considerations of the longer life expectancy expected for married people, as reported in the literature (Alaminos and Ayuso, 2016).

Age		Individual pension wealth (A)		Single's pension wealth (B)		Comparison ((A-B)/B)	
Man (x)	Woman (y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65	65	382.886,77	365.237,34	364.700,36	295.641,83	5%	24%
65	64	380.870,62	370.364,21	364.700,36	294.102,85	4%	26%
65	63	379.028,82	375.842,43	364.700,36	292.549,65	4%	28%
65	62	377.353,78	381.655,67	364.700,36	291.135,98	3%	31%
65	58	372.119,87	407.945,29	364.700,36	286.071,59	2%	43%
65	56	370.223,14	422.705,63	364.700,36	283.964,50	2%	49%
65	51	366.901,71	463.398,91	364.700,36	279.695,98	1%	66%
60	65	378.214,65	344.072,32	344.628,07	295.641,83	10%	16%
62	65	378.906,14	351.938,02	351.973,09	295.641,83	8%	19%
63	65	379.844,62	356.173,18	355.986,96	295.641,83	7%	20%
64	65	381.173,77	360.607,51	360.323,33	295.641,83	6%	22%

Note: "A" represents the individual pension wealth for each partner making up the couple. "B" represents the expected pension of an unattached individual (therefore, ineligible for a widowhood pension) computed from age of reference (x=65 or y=65).

TABLE 4.2: Total pension wealth for a married individual compared to that of a single individual by gender and age. Source: own elaboration.

4.2.3 Comparison with non-concurrence of pensions (II): Only one partner has the right to a retirement pension

In what follows, we compare the pension wealth of a married couple in which both spouses have made the necessary contributions to the social security system to entitle them both to a retirement pension with that of a couple in which one of the two partners has not earned this right (Table 4.3).

An initial analysis comparing the joint pension in a couple (65, 65) in which both spouses have had a full working career with that of a couple in which only the wife has earned this right shows that total pension wealth on dissolution as a consequence of the wife's death is 160% higher for the first couple. When the dissolution is a consequence of the husband' death, total pension wealth is 77% higher for the first couple than for a couple in which

only the man has paid his contributions to the social security system. The last column in Table 4.3 highlights a situation that is still very common in Spain: that is, many women are entitled solely to a widow's pension, because they do not meet the necessary requirements to access a retirement pension. As a result, differences in total pension wealth of these couples compared to that of couples in which both partners are entitled to a retirement pension are marked. Indeed, the former's total lifetime pension wealth can be between 52 and 98% lower, depending on the age gap with their husband.

Age		Home pension wealth (C)		Home pension wealth (D)		Comparison ((C-D)/D)	
Men (x)	Women (y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65	65	586.651,39	669.943,74	225.404,13	377.915,58	160%	77%
65	64	575.333,87	680.324,25	214.090,55	389.710,76	169%	75%
65	63	563.884,62	690.598,43	202.645,84	401.346,32	178%	72%
65	62	552.309,58	700.770,13	191.075,82	412.828,92	189%	70%
65	58	504.907,84	740.653,77	143.696,62	457.460,47	251%	62%
65	56	480.669,15	760.329,86	119.469,04	479.197,81	302%	59%
65	51	419.023,67	809.620,18	57.846,09	532.687,75	624%	52%
60	65	607.497,57	591.124,48	265.587,32	299.095,86	129%	98%
62	65	598.708,90	623.139,25	249.614,34	331.109,27	140%	88%
63	65	594.541,12	638.901,38	241.577,30	346.871,49	146%	84%
64	65	590.522,75	654.501,88	233.507,00	362.472,60	153%	81%

Note: "C" represents total pension wealth for a couple in which both spouses have the right to a retirement pension. "D" represents total pension wealth for a couple in which one of the two partners does not have access to a retirement pension. Computed from age of reference (x=65 or y=65).

TABLE 4.3: Total pension wealth according to contributions to the social security system by both or just one of the partners in a couple. Source: own elaboration.

5 Policies to reduce the inequities in the Spanish pension system

Survivors' pensions, i.e. widowhood pensions, were adopted in countries such as Spain and Portugal when women had not yet entered the labor market, as a way of guaranteeing them some income on the death of their husbands, typically recipients of contributory retirement pensions. Today, increasing numbers of women have accessed the labor market, which means they generate their own retirement pensions. In Spain, contributory widow's pensions currently represent 24% of total pensions, and while the number of recipients of both a retirement and widowhood pension is not that high (concurrence of pensions being permissible), an increase is expected due to the greater longevity of married partners and both members generating the right to a retirement pension (Alaminos and Ayuso, 2016). The question that needs to be addressed here is whether it continues to be necessary to retain the widowhood pension in cases in which an individual already receives a retirement pension. What is clear, however, is that the name "survivor's pension" should no longer be deemed appropriate, insofar as it represents a supplementary pension. A further concern is the extent to which the widowhood pension is a factor that undermines the equity of Spain's pension system. Consider, for example, two individuals accessing the pension system at the same time with similar contributory histories, one with the right to receive two benefits (retirement and widowhood) because they married or formed a de facto couple, the other

without this entitlement because they remained single. The current state of affairs, moreover, aggravates other situations that are becoming increasingly evident in ageing societies such as Spain's, including the need for resources to provide long-term care, a need that is often more marked in singletons and the childless.

A survival pension policy that is better adapted to current reality is therefore persuasive both in terms of reducing public expenditure on pensions and providing more equitable pensions for all, especially those disadvantaged groups characterized by lower pensions, as is the case of women, who, moreover, tend to live more time alone. Below we summarize various possible lines of action for advancing in the design of equitable pension policies that should, moreover, act in favour of a reorganization of available pension resources and guarantee the system's sufficiency and sustainability.

To delineate the various potential courses of action, we have established the following foundational assumptions to generate the sample:

1. We gather data on the occupation of individuals in Spain, aged between 40 and 64, by gender. Additionally, we determine the number of unemployed individuals within this age group, relative to the active population, with information as of December 31, 2023.

2. We calculate the percentage of married, single, and widowed individuals in the age range of 40 to 64, disaggregated by gender, compared to the total population, with information as of December 31, 2023. These data help us define the necessary groups for our scenarios.

3. We calculate the number of married, single, and widowed individuals, both employed and unemployed, within the age range of 40 to 64, using the percentages of marital status and employment data.

4. We determine the percentage of married, single, and widowed individuals who are employed or unemployed relative to the active population, based on the previous hypotheses.

5. We generate a hypothetical cohort of 1,000,000 individuals to estimate the specific number of married, single, and widowed individuals who are employed and unemployed by gender. This is done by applying the calculated percentages from the previous stages.

It's worth noting that to exemplify the different policies, we will assume a marriage consisting of a 65-year-old man and a 63-year-old woman.[1] This age gap between spouses is defined based on the analysis presented in Section 2.

5.1 Using men's widowhood pensions (total or a percentage thereof), when they have concurrent pensions, to increase the sufficiency of women's pensions

The action would involve creating a mutual fund from the surplus obtained by reducing the percentage of the widowhood pension received by those men that have a retirement pension and who are entitled to a widowhood pension because their wives have also worked. The action is underpinned by the higher average amount of men's retirement pensions, which would be further increased by the receipt of the widowhood pension generated on the death of their wives. To evaluate this proposal, its impact on specific groups of individuals needs to be analysed, taking into consideration any deviations from average values and making the required corrections. To that end, we work with the differences highlighted in the current study between the total pension wealth of couples in which both partners are

[1] These calculations have been conducted for all analyzed couples; however, only the assumption of the 65-63 marriage has been included here for brevity.

entitled to a retirement pension, the corresponding wealth in couples in which only the man is entitled to such a pension (and, as such, is not entitled to a widower's pension), and total pension wealth when the man receiving the retirement pension is a singleton. These calculations also take into consideration the impact of age heterogeneity, as discussed herein. The mutual fund could be destined for use as follows.

5.1.1 For women that only receive a widow's pensions

One option resulting from a possible consolidation of men's widowhood pensions into a common mutual fund would be to direct the resources thus generated to those women who have the widowhood pension as their sole source of income. This would not only help alleviate pension gender inequality, but would also recognize the value of the unpaid work that many women provide as caregivers and homemakers, a role that often leaves them in a more precarious financial situation in retirement. Specifically, the proposal would see the surplus resources of those households in which both partners of the couple have worked being redirected to more vulnerable households in which the woman has not had a paid career.

The methodology employed to develop the policy and calculate the surplus of resources focuses on determining how to redistribute the widower's pension from married employed men to married women without employment history (see Appendix C for detailed macros and calculations utilized for the results outlined in this section). Below is how the policy under study has been defined:

1. We calculate the pension difference between a man whose wife has worked assuming he is entitled to receive the current widower's pension, and another man whose wife has not worked.

2. We define the percentage of widower's pension that will be maintained for married men with employed wives.

3. Using the established percentage of the widower's pension, we determine the new total amount of the widower's pension that the married man with an employed wife will receive.

4. We create a reserve with the surplus amount that has not been allocated to the new widower's pension for men, generated from the total sum of the remaining amounts of all married employed men.

5. We make a contribution to the pension in favor of married women who have not worked. This contribution is equal to the amount obtained by dividing the total reserve by the number of married women who have not had paid employment.

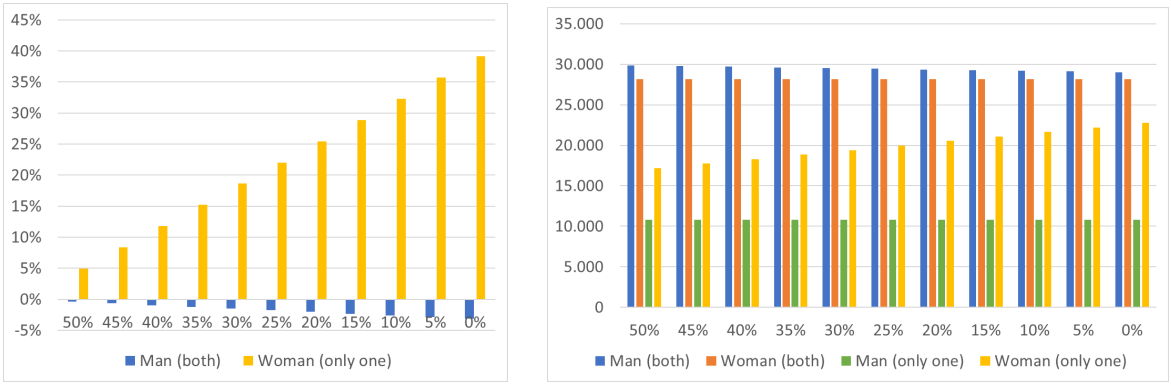
According to the data presented in Table 5.1, the implementation of the redistributive policy would result in a 25% increase in the widower's pension for married women who have not worked, compared to their situation before the policy application. However, reducing the widower's pension percentage to 20% for married men with employed wives would only result in a 2% decrease in the total pension amount (retirement + widower's) for this group. Hence, these results suggest that the policy would effectively redistribute resources without significantly affecting male pensions in this specific group.

Additionally, Figure 5.1 complements this example by showing how the annual pension would change in relative terms after applying the correction, and what the resulting annual pension would be for each group, considering different percentages of widower's pension retention for married men with employed wives. In Figure's 5.1 legend, "both" indicates that the individual is entitled to receive both retirement and widower's pension, while "only one" indicates that the individual is only entitled to receive the widower's pension in case of their spouse's death.

It can be observed that as the percentage of widower's pension for married men with employed wives decreases (X-axis), the widower's pension for women who depend exclusively on this benefit increases (Y-axis). However, this variation in annual pensions for the different groups is not proportional. The reason lies in the fact that the group of married men with employed wives is considerably larger than the group of non-employed women, meaning that small changes in men's pensions generate large changes in women's total pensions. Hence, the increase in pensions would contribute to reducing the gender gap between both groups, resulting in a more equitable redistribution of resources and a fairer pension system.

20%	Married (both members have pension rights)		Married (only one member have pension rights)	
	Man (x)	Woman (y)	Man (x)	Woman (y)
N	599.156	577.725	47.520	67.885
PW (before correction)	563.885	690.598	202.646	401.346
PW/year	29.977	28.152	10.773	16.361
PW (after correction)	552.311	690.598	202.646	503.492
PW/year	29.362	28.152	10.773	20.524
Variation	-2,05%	0,00%	0,00%	25,45%

TABLE 5.1: Using men's widowhood pensions to increase the sufficiency of women's pensions for women that only receive a widow's pension. Source: own elaboration.



(A) Annual pension variation

(B) Annual pension after correction

FIGURE 5.1: Using men's widowhood pensions to increase the sufficiency of women's pensions –for women that only receive a widow's pension–. Source: own elaboration.

5.1.2 For single women

A second option would be to use the mutual fund to increase the pensions of single women, thereby addressing a notorious inequality within the pension system. Single women, who depend exclusively on their own retirement pension, may find themselves in a more vulnerable financial position in retirement than married women, whose widow's pension provides an additional source of income on the death of their husbands. If opting for this action, the pension calculation would have to be optimized by correcting the inequalities apparent in total pension wealth depending on whether or not the married woman has generated the right to a retirement pension.

In this case, the methodology employed to design the policy and determine the surplus of resources focuses on finding a way to redistribute the widower's pension from married employed men to single women (see Appendix C for detailed macros and calculations utilized for the results outlined in this section). Below is the definition of the policy:

1. We calculate the pension difference between a man whose wife has worked, assuming he is entitled to receive the current widower's pension and a single man.

2. We define the percentage of widower's pension that will be maintained for married men with employed wives.

3. Using the established percentage of the widower's pension, we determine the new total amount of the widower's pension that the married man with an employed wife will receive.

4. We create a reserve with the surplus amount that has not been allocated to the new widower's pension for men, generated from the total sum of the remaining amounts of all married employed men.

5. We make a contribution to the pension in favor of single women. This contribution is equal to the amount obtained by dividing the total reserve by the number of single women.

According to the data presented in Table 5.2, the implementation of the redistributive policy would result in a 10% increase in the widower's pension for single women compared to their situation before the policy was applied. Conversely, reducing the percentage of widower's pension to 20% for married men with employed wives would only cause a 2% decrease in the total pension amount for this group. Hence, these results suggest that the policy could effectively redistribute resources without significantly affecting male pensions in this specific group.

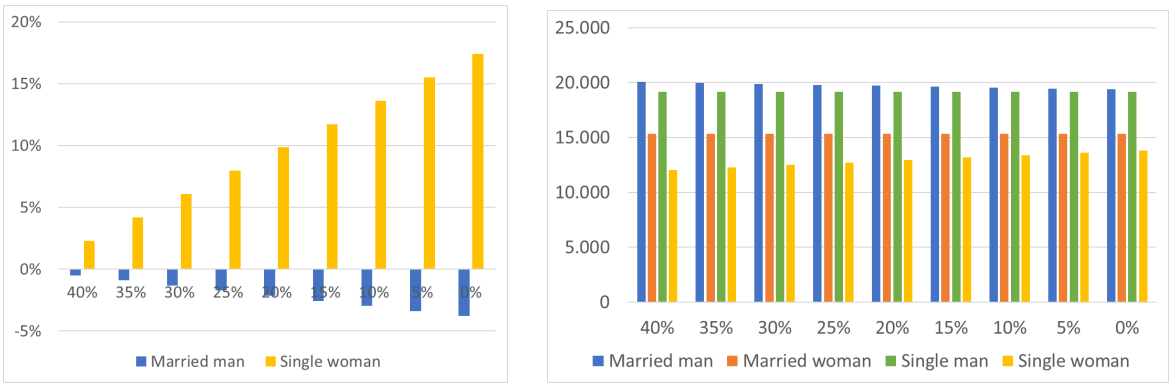
Additionally, Figure 5.2 complements this example by showing how the annual pension varies in relative terms after applying the policy, as well as the resulting annual pension for each group, considering different percentages of widower's pension retention for married men with employed wives.

As the percentage of widower's pension for married men with employed wives decreases (X-axis), an increase in the pension for single women is observed (Y-axis). This increase in pensions would help mitigate the disparity in pensions based on the marital

status of the recipient, thus promoting a more equitable distribution of available resources in the pension system.

20%	Married		Single	
	Man (x)	Woman (y)	Man (x)	Woman (y)
N	599.156	577.725	227.185	168.651
PW (before correction)	379.029	375.842	364.700	292.550
PW/year	20.150	15.321	19.163	11.782
PW (after correction)	370.917	375.842	364.700	321.367
PW/year	19.719	15.321	19.163	12.943
Variation	-2,14%	0,00%	0,00%	9,85%

TABLE 5.2: Using men's widowhood pensions to increase the sufficiency of women's pensions for single women. Source: own elaboration.



(A) Annual pension variation

(B) Annual pension after correction

FIGURE 5.2: Using men's widowhood pensions to increase the sufficiency of women's pensions for single women. Source: own elaboration.

5.2 Reducing the percentatge of widowhood pension with respect to the retirement pension of the person who dies

The action would involve reducing the percentage that the widowhood pension represents with respect to the regulatory base of the retirement pension of the person that dies, both for men and women (although not necessarily by the same percentage). Such an action

would usher in more equitable levels of total pension wealth than those associated with the retirement pension received by single men and women, who are not entitled to a widowhood pension (see Appendix C for detailed macros and calculations utilized for the results outlined in this section).

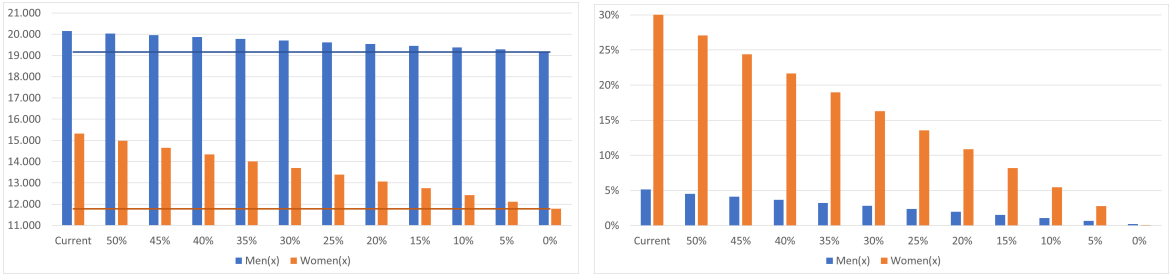
Figure 5.3a contrasts the total pension for men and women in different scenarios, comparing them with the amount received by a 65-year-old single man (blue line) and a 63-year-old single woman (orange line). It is observed that the reduction in the widower's pension for men does not generate significant changes in their total pension amount due to their shorter life expectancy once the wife passes away. However, this reduction significantly affects the total pension amount for women, as in many cases the widower's pension constitutes a substantial supplement to their pension once their husband has passed away. Comparing these amounts with those of single individuals, it is noticeable that the pension received by women, whether married or single, is considerably lower than that of men. In this context, the widower's pension directed towards women plays a crucial complementary role, mitigating the disparity between men's and women's pensions.

In Figure 5.3b, the percentage of surplus represented by the total pension for men and women in different situations is shown concerning the pension of a 65-year-old single man and a 63-year-old single woman, respectively. Currently, the widower's pension allows men to receive 5% more than the pension of single men, while for women this percentage increases to 30% of the pension received by a single woman. The values related to the pension of married men and women compared to singles vary significantly depending on the percentage of widower's pension maintained.

Taking these results into account and aiming to achieve a more equitable pension system, a viable measure would be to reduce the pension percentage for men to 20%, while for women it could be adjusted to a range between 45% and 50%. Under this policy, a heterosexual couple composed of a 65-year-old man and a 63-year-old woman would annually

receive 19,535€ and 14,973€ , respectively.

This action would directly reduce the gender gap between married men and women. Likewise, the surplus generated with the application of this policy (approximately 77,514€ per couple) could be allocated to pension contributions benefiting single women, for example.



(A) Annual pension

(B) Married vs. single

FIGURE 5.3: Annual pension based on the percentage of widower's pension retained on the deceased spouse's retirement pension compared to a single individual with the same characteristics. Source: own elaboration.

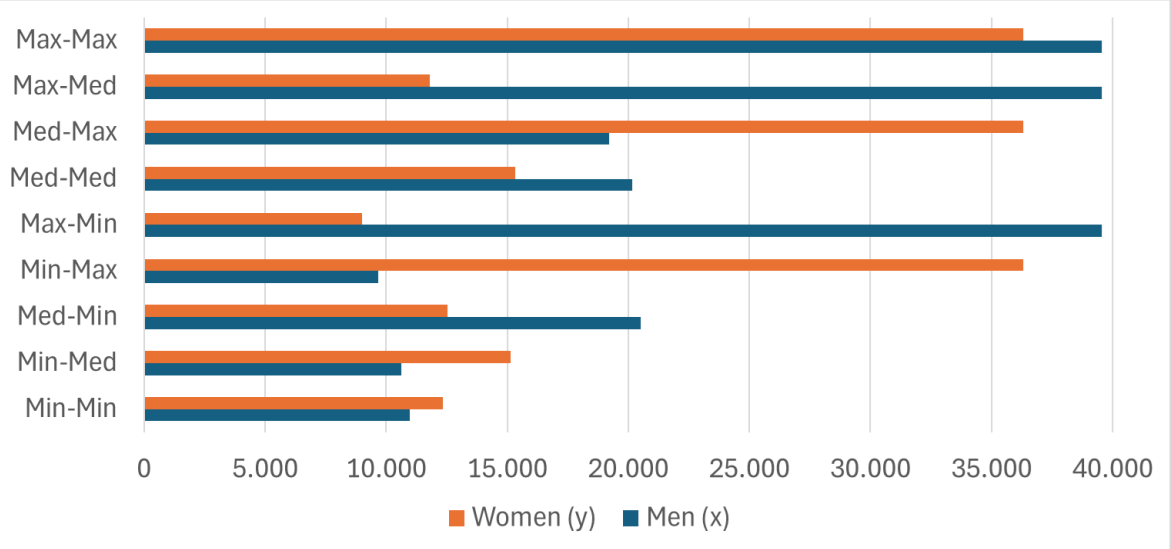
Once the various proposed policies have been formulated, it is crucial to highlight that the results obtained do not fully represent the reality of pensions in Spain. Although these policies have been designed considering average pensions, it is essential to consider the protection gap existing in each household.

The "protection gap" refers to the significant differences in pensions experienced by married couples based on their incomes derived from their previous employment situation. For example, it is not the same for a couple to be composed of two individuals receiving minimum pensions as for one individual to receive the maximum pension and another to receive the minimum pension (see Appendix D for detailed macros and calculations utilized for the results outlined hereafter).

Figure 5.4 reflects the individual annual pension received by each individual based on the type of pension, whether minimum, medium, or maximum.

For instance, in the case of a couple composed of a 65-year-old man and a 63-year-old woman where both receive the minimum pension (Min-Min), the man would receive

10,980€ per year while the woman would receive 12,350€ per year. In contrast, in the case of a couple where the man receives the maximum pension and the woman receives the minimum pension (Max-Min), the man would receive 39,559€ per year while the woman would receive 11,791€ per year.



Note: The values on the Y-axis pairs indicate whether the men (first value of the pair) or the women (second value of the pair) perceives a maximum (Max), medium (Med), or minimum (Min) pension amount. For example, a Max-Min pair indicates instances where the man perceives the maximum pension while the woman perceives the minimum pension.

FIGURE 5.4: Individual annual pension. Source: own elaboration.

In summary, Figure 5.4 shows that retirement pensions and associated widower's pensions can vary significantly depending on the type of pension received by both members of the couple. This variability in pension wealth has a direct impact on the vulnerability of marriages to the consequences of aging, such as health, nutrition, and long-term care. Therefore, to develop more equitable and effective widower's pension policies, it is essential to consider these disparities in "pension wealth," taking into account the different individual and couple circumstances. In other words, the implementation of redistributive measures requires adopting more flexible and personalized approaches that address the specific needs

of each group of beneficiaries, thus ensuring a fairer and more equitable pension system for all citizens.

6 Discussion

Spain, like other European countries, is undergoing a demographic transformation characterized by increasing life expectancy. This trend, along with other factors, poses significant challenges in key areas such as pensions, healthcare policies, and long-term care. Addressing these challenges is crucial to maintain the sustainability of both public and private systems and ensure equitable distribution of wealth and opportunities.

In this context, this thesis aims to enhance equity in Spain's pension system by addressing the interplay between retirement and widowhood pensions amidst increasing joint life expectancy. To achieve this, an evolutionary analysis of age differences in heterosexual marriages registered in Spain between 1976 and 2021 is presented, highlighting the importance of considering heterogeneity in age gap among couples to better understand joint survival. Additionally, a statistical methodology is proposed to estimate joint life expectancy through the Coherent Functional Demographic Model (CFDM). The impact of these age differences on household pension wealth is also estimated, and policies are proposed to reduce inequalities in the Spanish pension system. The discussion explores how widowhood pensions affect equity in the pension system and suggests the need for reforms to adapt to current realities, especially concerning gender and family structure. It emphasizes the importance of considering these disparities in the design of public policies, aligning them with the Sustainable Development Goals. Moreover, various future lines of research are summarized to advance equity and sustainability in the pension system.

The discussion on widowhood pensions in Spain highlights a series of challenges and

disparities that need to be addressed to ensure a more equitable and effective system. The implementation of redistributive policies emerges as a crucial measure to mitigate these disparities and provide greater protection to couples facing the consequences of ageing. However, it's important to notice that solutions are not universal and must be tailored to diverse individual and couple circumstances.

This thesis demonstrates how retirement and widowhood pensions can vary drastically depending on the type of pension received by both members of a couple. This variability in pension wealth directly impacts the vulnerability of couples to ageing consequences such as health, nutrition, and long-term care, which are fundamental aspects for achieving the Sustainable Development Goals (SDGs). Therefore, addressing these disparities is essential to ensure adequate financial security for all citizens, especially for women who often face higher risks of poverty in old age.

One of the main challenges is the concept of the protection gap, reflecting significant disparities in pensions experienced by couples due to their individual incomes and work histories. This gap can have devastating consequences, especially for households where one or both spouses have had precarious careers or have been subject to socioeconomic inequalities. It's crucial to recognize these disparities and adopt flexible and personalized approaches in policy formulation to ensure that no couple is left unprotected in their old age.

Furthermore, these pension disparities can affect the achievement of various Sustainable Development Goals (SDGs), especially SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), and SDG 10 (Reduced Inequalities). Inadequate protection in old age can exacerbate poverty, affect the health and well-being of older persons, and perpetuate gender inequality.

The study also shows that women, both single and married, tend to receive considerably lower pensions than men in similar situations. Widowhood pensions play a crucial

role in addressing this gender disparity, as they constitute an important supplement to these women's retirement pensions once their husbands pass away. To address this gender gap in pensions, it's necessary to review and reform pension policies, ensuring they provide an adequate level of protection for all women, regardless of their marital status or work history. In this context, this thesis introduces two primary redistributive measures to mitigate gender disparities and promote greater equity in the pension system, thereby advancing the Sustainable Development Goals (SDGs) related to gender equality and reducing inequalities. Furthermore, the surplus resulting from these measures could be directed towards additional contributions for single women, enhancing financial security for this vulnerable group and aligning with the SDGs on reducing inequalities and social protection (SDG 1 and SDG 10).

In conclusion, the discussion on widowhood pensions in Spain has highlighted the need to address disparities in pension wealth and design more equitable and effective policies. To advance in this direction and contribute to the development of a fairer and more sustainable pension system, the following lines of research are proposed:

1. Impact of redistributive policies: Investigate the long-term impact of proposed redistributive policies in terms of gender equity, financial security, and social welfare.

2. Socioeconomic effects of the protection gap: Deepen the study of the causes and consequences of the protection gap in pensions, focusing on how socioeconomic and labour disparities influence household financial vulnerability.

3. Adaptation of policies to different demographic contexts: Analyse how widowhood pension policies can be adapted to different demographic contexts, including urban and rural areas, as well as populations with different family structures and income levels.

4. Inclusion of an intersectional perspective: Examine how factors such as age, gender, social class, ethnicity, and sexual orientation intersect to influence pension distribution and financial vulnerability in old age.

5. Impact of policies on quality of life and well-being: Investigate how widowhood pension policies affect the quality of life, health, and well-being of beneficiaries and their families.

By focusing on these research areas, we can advance our understanding of the complexities of retirement and widowhood pensions and develop more effective and equitable policies that promote dignified and sustainable ageing for all citizens.

A Couples Marriages Analysis

```r
if(!require("tidyverse")) install.packages("tidyverse")
if(!require("corrplot")) install.packages("corrplot")
if(!require("writexl")) install.packages("writexl")
if(!require("readxl")) install.packages("readxl")
if(!require("psych")) install.packages("psych")
if(!require("fs")) install.packages("fs")
library(tidyverse)
library(corrplot)
library(writexl)
library(readxl)
library(psych)
library(fs)

path <- "C:/Unix/Microdatos/Data.xlsx"
data <- path %>% excel_sheets() %>% set_names() %>% map_df(read_excel,
 ↪  path=path) %>% transform(GAP=-GAP)

# Separate data of heterosexuals, gays and lesbians:
d1 <- data %>% filter(SEXOCM==1) #Heterosexuals
d01 <- data %>% filter(SEXOCM==0,SEXOCA==1) #Gays
```

```r
d06 <- data %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

########################
# Heterosexual couples #
########################
tot1 <- d1 %>% group_by(ANOCM) %>% reframe(N = n())
med1 <- d1 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q2 = quantile(GAP, 0.5),
Q3 = quantile(GAP, 0.75), max(GAP)) #DDA

med1 %>% ggplot() +
aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
labs(y= "", x = "") #gap graphic

edad.1 <- d1 %>%group_by(ANOCM) %>% reframe(M1 = mean(EDADCA), M6 = mean(EDADCB))

ggplot(edad.1, aes(x = ANOCM)) +
geom_line(aes(y = M1, color = "Men"), linewidth = 0.75) +
geom_line(aes(y = M6, color = "Women"), linewidth = 0.75) +
labs(x = "", y = "", color = "")

# Tables by age rangers:
d1.1 <- d1 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
```

```
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d1.6 <- d1 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

# Interval average:
med1.1 <- d1.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
med1.6 <- d1.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

tot1.1 <- med1.1 %>% group_by(INTER) %>% reframe(M = mean(M))
tot1.6 <- med1.6 %>% group_by(INTER) %>% reframe(M = mean(M))
```

```
68 med1.1 %>% ggplot() +
69 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
    ↪  "From 40 to 49",
70 "From 50 to 59", "Over 60"), y = M) +
71 geom_boxplot(fill="blue", alpha=0.3) +
72 labs(y= "", x = "") +
73 stat_summary(fun = mean, geom="point", shape=18,
74 size=3, color="blue") #men gap graphic
75
76 med1.6 %>% ggplot() +
77 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
    ↪  "From 40 to 49",
78 "From 50 to 59", "Over 60"), y = M) +
79 geom_boxplot(fill="blue", alpha=0.3) +
80 labs(y= "", x = "") +
81 stat_summary(fun = mean, geom="point", shape=18,
82 size=3, color="blue") #women gap graphic
83
84 ###############
85 # Gay couples #
86 ###############
87 med01 <- d01 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP), N
    ↪  = n(),
88 min(GAP), Q1 = quantile(GAP, 0.25),
89 Q3 = quantile(GAP, 0.75), max(GAP)) #DDA
90
```

```r
medO1 %>% ggplot() +
aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
ylim(1.8, 3) +
labs(y= "", x = "") #gap graphic

# Tables by age rangers:
dO1.A <- dO1 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

dO1.B <- dO1 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

# Interval average:
medO1.A <- dO1.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
medO1.B <- dO1.B %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
```

```
115 Q3 = quantile(GAP, 0.75), max(GAP))
116
117 tot01.A <- med01.A %>% group_by(INTER) %>% reframe(M = mean(M))
118 tot01.B <- med01.B %>% group_by(INTER) %>% reframe(M = mean(M))
119
120 med01.A %>% ggplot() +
121 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
    ↪  "From 40 to 49",
122 "From 50 to 59", "Over 60"), y = M) +
123 geom_boxplot(fill="blue", alpha=0.3) +
124 labs(y= "", x = "") +
125 stat_summary(fun = mean, geom="point", shape=18,
126 size=3, color="blue") #spouse A gap graphic
127
128 ###################
129 # Lesbian couples #
130 ###################
131 med06 <-d06 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP), N =
    ↪  n(),
132 min(GAP), Q1 = quantile(GAP, 0.25),
133 Q3 = quantile(GAP, 0.75), max(GAP)) #DDA
134
135 med06 %>% ggplot() +
136 aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
137 ylim(-0.2, 1.2) +
138 labs(y= "", x = "") #gap graphic
```

```
# Tables by age rangers:
d06.A <- d06 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d06.B <- d06 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

# Interval average:
med06.A <- d06.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
med06.B <- d06.B %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

tot06.A <- med06.A %>% group_by(INTER) %>% reframe(M = mean(M))
tot06.B <- med06.B %>% group_by(INTER) %>% reframe(M = mean(M))

```

```
163 med06.A %>% ggplot() +
164 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
    ↪  "From 40 to 49",
165 "From 50 to 59", "Over 60"), y = M) +
166 geom_boxplot(fill="blue", alpha=0.3) +
167 labs(y= "", x = "") +
168 stat_summary(fun = mean, geom="point", shape=18,
169 size=3, color="blue") #spouse A gap graphic
170
171 ##############################################################################
172 # Analysis of educational level and occupational sector from 2016 to 2021 #
173 ##############################################################################
174 path <- "C:/Unix/Microdatos/Data.xlsx"
175 data <- path %>% excel_sheets() %>% set_names() %>% map_df(read_excel,
    ↪  path=path) %>% transform(GAP=-GAP)
176 d2 <- data %>% filter(ANOCM>=2016)
177
178 # Separate data of heterosexuals, gays and lesbians:
179 d21 <- d2 %>% filter(SEXOCM==1) #Heterosexuals
180 d201 <- d2 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
181 d206 <- d2 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians
182
183 # HETEROSEXUAL COUPLES:
184
185 # Tables by age rangers:
186 d21.1 <- d21 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
```

```
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

est.1 <- d21.1 %>% group_by(ESTUDIOCA, ESTUDIOCB) %>% reframe(N=n()) %>%
filter(ESTUDIOCA<=12,ESTUDIOCB<=12) #Educational level

ggplot(est.1, aes(x = ESTUDIOCA, y = ESTUDIOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = est.1$ESTUDIOCA) +
scale_y_continuous(breaks = est.1$ESTUDIOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Men", y = "Women")+
theme_classic()

est.1 <- as.matrix(est.1)
mat <- matrix(0, 12, 12)
for (i in 1:NROW(est.1))
{
        mat[est.1[i,2],est.1[i,1]] <- est.1[i,3]
}

```

```
colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

caut.1 <- d21.1 %>% group_by(CAUTOCA, CAUTOCB) %>% reframe(N=n()) %>%
filter(CAUTOCA<=9,CAUTOCB<=9) #Occupation sector

ggplot(caut.1, aes(x = CAUTOCA, y = CAUTOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = caut.1$CAUTOCA) +
scale_y_continuous(breaks = caut.1$CAUTOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Men", y = "Women")+
theme_classic()
```

```
235 caut.1 <- as.matrix(caut.1)
236 mat <- matrix(0, 10, 10)
237 for (i in 1:NROW(caut.1))
238 {
239         mat[caut.1[i,2]+1,caut.1[i,1]+1] <- caut.1[i,3]
240 }
241
242 colnames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
    ↪  "Var.6", "Var.7", "Var.8", "Var.9")
243 rownames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
    ↪  "Var.6", "Var.7", "Var.8", "Var.9")
244
245 ct <- corr.test(mat, adjust = "none")
246 corr <- ct$r
247 p.mat <- ct$p
248
249 corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
    ↪  'upper',
250 sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
251 insig = 'label_sig', pch.col = 'white')
252
253 rela.1 <- d21.1 %>% group_by(RELACA, RELACB) %>% reframe(N=n()) %>%
254 filter(RELACA<=7,RELACB<=7) %>%
255 mutate(RELACA=ifelse(RELACA==4,3,
256 ifelse(RELACA==5,4,
257 ifelse(RELACA==6,5,
```

```
ifelse(RELACA==7,6,RELACA))))) %>%
mutate(RELACB=ifelse(RELACB==4,3,
ifelse(RELACB==5,4,
ifelse(RELACB==6,5,
ifelse(RELACB==7,6,RELACB))))) #Occupational relationship

ggplot(rela.1, aes(x = RELACA, y = RELACB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = rela.1$RELACA) +
scale_y_continuous(breaks = rela.1$RELACB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Men", y = "Women")+
theme_classic()

rela.1 <- as.matrix(rela.1)
mat <- matrix(0, 6, 6)
for (i in 1:NROW(rela.1))
{
        mat[rela.1[i,2],rela.1[i,1]] <- rela.1[i,3]
}

colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")

```

```
ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
 ↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

# GAY COUPLES:

# Tables by age rangers:
d201.A <- d201 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

est.01 <- d201.A %>% group_by(ESTUDIOCA, ESTUDIOCB) %>% reframe(N=n()) %>%
filter(ESTUDIOCA<=12,ESTUDIOCB<=12) #Educational level

ggplot(est.01, aes(x = ESTUDIOCA, y = ESTUDIOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = est.01$ESTUDIOCA) +
```

```
scale_y_continuous(breaks = est.01$ESTUDIOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
theme_classic()

est.01 <- as.matrix(est.01)
mat <- matrix(0, 12, 12)
for (i in 1:NROW(est.01))
{
        mat[est.01[i,2],est.01[i,1]] <- est.01[i,3]
}

colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
 ↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
 ↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
 ↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

```

```r
caut.01 <- d201.A %>% group_by(CAUTOCA, CAUTOCB) %>% reframe(N=n()) %>%
filter(CAUTOCA<=9,CAUTOCB<=9) #Occupation sector

ggplot(caut.01, aes(x = CAUTOCA, y = CAUTOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = caut.01$CAUTOCA) +
scale_y_continuous(breaks = caut.01$CAUTOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
theme_classic()
caut.01 <- as.matrix(caut.01)
mat <- matrix(0, 10, 10)
for (i in 1:NROW(caut.01))
{
        mat[caut.01[i,2]+1,caut.01[i,1]+1] <- caut.01[i,3]
}

colnames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
 ↪  "Var.6", "Var.7", "Var.8", "Var.9")
rownames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
 ↪  "Var.6", "Var.7", "Var.8", "Var.9")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
```

```
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
 ↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

rela.01 <- d201.A %>% group_by(RELACA, RELACB) %>% reframe(N=n()) %>%
filter(RELACA<=7,RELACB<=7) %>%
mutate(RELACA=ifelse(RELACA==4,3,
ifelse(RELACA==5,4,
ifelse(RELACA==6,5,
ifelse(RELACA==7,6,RELACA))))) %>%
mutate(RELACB=ifelse(RELACB==4,3,
ifelse(RELACB==5,4,
ifelse(RELACB==6,5,
ifelse(RELACB==7,6,RELACB))))) #Occupational relationship

ggplot(rela.01, aes(x = RELACA, y = RELACB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = rela.01$RELACA) +
scale_y_continuous(breaks = rela.01$RELACB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
```

```
theme_classic()

rela.01 <- as.matrix(rela.01)
mat <- matrix(0, 6, 6)
for (i in 1:NROW(rela.01))
{
        mat[rela.01[i,2],rela.01[i,1]] <- rela.01[i,3]
}

colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
 ↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

# LESBIAN COUPLES:

# Tables by age rangers:
d206.A <- d206 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
```

```
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

est.06 <- d206.A %>% group_by(ESTUDIOCA, ESTUDIOCB) %>% reframe(N=n()) %>%
filter(ESTUDIOCA<=12,ESTUDIOCB<=12) #Educational level

ggplot(est.06, aes(x = ESTUDIOCA, y = ESTUDIOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = est.06$ESTUDIOCA) +
scale_y_continuous(breaks = est.06$ESTUDIOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
theme_classic()

est.06 <- as.matrix(est.06)
mat <- matrix(0, 12, 12)
for (i in 1:NROW(est.06))
{
        mat[est.06[i,2],est.06[i,1]] <- est.06[i,3]
}

colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")
```

```
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6",
↪  "Var.7", "Var.8", "Var.9", "Var.10", "Var.11", "Var.12")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

caut.06 <- d206.A %>% group_by(CAUTOCA, CAUTOCB) %>% reframe(N=n()) %>%
filter(CAUTOCA<=9,CAUTOCB<=9) #Occupation sector

ggplot(caut.06, aes(x = CAUTOCA, y = CAUTOCB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = caut.06$CAUTOCA) +
scale_y_continuous(breaks = caut.06$CAUTOCB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
theme_classic()
caut.06 <- as.matrix(caut.06)
mat <- matrix(0, 10, 10)
```

```
for (i in 1:NROW(caut.06))
{
        mat[caut.06[i,2]+1,caut.06[i,1]+1] <- caut.06[i,3]
}

colnames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
 ↪  "Var.6", "Var.7", "Var.8", "Var.9")
rownames(mat) <- c("Var.0", "Var.1", "Var.2", "Var.3", "Var.4", "Var.5",
 ↪  "Var.6", "Var.7", "Var.8", "Var.9")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
p.mat <- ct$p

corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
 ↪  'upper',
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'white')

rela.06 <- d206.A %>% group_by(RELACA, RELACB) %>% reframe(N=n()) %>%
filter(RELACA<=7,RELACB<=7) %>%
mutate(RELACA=ifelse(RELACA==4,3,
ifelse(RELACA==5,4,
ifelse(RELACA==6,5,
ifelse(RELACA==7,6,RELACA))))) %>%
mutate(RELACB=ifelse(RELACB==4,3,
```

```
ifelse(RELACB==5,4,
ifelse(RELACB==6,5,
ifelse(RELACB==7,6,RELACB))))) #Occupational relationship

ggplot(rela.06, aes(x = RELACA, y = RELACB, fill = N)) +
geom_tile(color = "black") +
geom_text(aes(label = N), color = "white", size = 4) +
scale_fill_gradientn(colors = hcl.colors(20, "RdYlBu")) +
scale_x_continuous(breaks = rela.06$RELACA) +
scale_y_continuous(breaks = rela.06$RELACB) +
guides(fill = guide_colourbar(barwidth = 1,
barheight = 20)) + labs(x = "Spouse A", y = "Spouse B")+
theme_classic()

rela.06 <- as.matrix(rela.06)
mat <- matrix(0, 6, 6)
for (i in 1:NROW(rela.06))
{
        mat[rela.06[i,2],rela.06[i,1]] <- rela.06[i,3]
}

colnames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")
rownames(mat) <- c("Var.1", "Var.2", "Var.3", "Var.4", "Var.5", "Var.6")

ct <- corr.test(mat, adjust = "none")
corr <- ct$r
```

```
504 p.mat <- ct$p
505
506 corrplot(corr, p.mat = p.mat, method = 'color', diag = FALSE, type =
    ↪  'upper',
507 sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
508 insig = 'label_sig', pch.col = 'white')
509
510 ##############################
511 # Analysis of marital status #
512 ##############################
513 path <- "C:/Unix/Microdatos/Data.xlsx"
514 data <- path %>% excel_sheets() %>% set_names() %>% map_df(read_excel,
    ↪  path=path) %>% transform(GAP=-GAP)
515
516 # ECIVCA = ECIVCB = 1
517 d3 <- data %>% filter(ECIVCA==1, ECIVCB==1)
518
519 # Separate data of heterosexuals, gays and lesbians:
520 d31 <- d3 %>% filter(SEXOCM==1) #Heterosexuals
521 d301 <- d3 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
522 d306 <- d3 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians
523
524 # HETEROSEXUAL COUPLES
525
526 tot3 <- d31 %>% group_by(ANOCM) %>% reframe(N = n())
```

```
527 med3 <- d31 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP), N =
    ↪  n(),
528 min(GAP), Q1 = quantile(GAP, 0.25),
529 Q2 = quantile(GAP, 0.5),
530 Q3 = quantile(GAP, 0.75), max(GAP)) #DDA
531
532 med3 %>% ggplot() +
533 aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
534 labs(y= "Age gap (man-woman)", x = "") +
535 theme(axis.text = element_text(size = 25), axis.title = element_text(size =
    ↪  30)) #gap graphic
536
537 edad.3 <- d31 %>%group_by(ANOCM) %>% reframe(M1 = mean(EDADCA), M6 =
    ↪  mean(EDADCB))
538
539 ggplot(edad.3, aes(x = ANOCM)) +
540 geom_line(aes(y = M1, color = "Men"), linewidth = 1.5) +
541 geom_line(aes(y = M6, color = "Women"), linewidth = 1.5) +
542 labs(x = "", y = "", color = "") +
543 theme(legend.key.size = unit(3, units = "cm")) +
544 theme(axis.text = element_text(size = 35),legend.text = element_text (size =
    ↪  40))
545
546 d31.1 <- d31 %>% mutate(INTER = if_else(EDADCA>=60,"Over 60",
547 if_else(EDADCA>=50,"50 to 59",
548 if_else(EDADCA>=40,"40 to 49",
```

```
549 if_else(EDADCA>=30,"30 to 39",
550 if_else(EDADCA>=20, "20 to 29","Under 20"))))))
551
552 d31.6 <- d31 %>% mutate(INTER = if_else(EDADCB>=60,"Over 60",
553 if_else(EDADCB>=50,"50 to 59",
554 if_else(EDADCB>=40,"40 to 49",
555 if_else(EDADCB>=30,"30 to 39",
556 if_else(EDADCB>=20, "20 to 29","Under 20"))))))
557
558 med31.1 <- d31.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
    ↪  sd(GAP), N = n(),
559 min(GAP), Q1 = quantile(GAP, 0.25),
560 Q3 = quantile(GAP, 0.75), max(GAP))
561
562 med31.6 <- d31.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
    ↪  sd(GAP), N = n(),
563 min(GAP), Q1 = quantile(GAP, 0.25),
564 Q3 = quantile(GAP, 0.75), max(GAP))
565
566 val31.1 <- med31.1 %>% group_by(INTER) %>% reframe(M = mean(M))
567 n31.1 <- d31.1 %>% group_by(INTER) %>% reframe(N = n())
568 rel31.1 <- n31.1 %>% reframe('%' = (N/sum(N))*100)
569 tot31.1 <- data.frame(merge(val31.1,n31.1), '%' = rel31.1)
570
571 val31.6 <- med31.6 %>% group_by(INTER) %>% reframe(M = mean(M))
572 n31.6 <- d31.6 %>% group_by(INTER) %>% reframe(N = n())
```

```
rel31.6 <- n31.6 %>% reframe('%' = (N/sum(N))*100)
tot31.6 <- data.frame(merge(val31.6,n31.6), '%' = rel31.6)

med31.1 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "20 to 29", "30 to 39", "40 to 49",
"50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") +
theme(axis.text = element_text(size = 54)) #men gap graphic

med31.6 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "20 to 29", "30 to 39", "40 to 49",
"50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") +
theme(axis.text = element_text(size = 54)) #women gap graphic

# Under 20
med31.1.19 <- med31.1 %>% filter(INTER == "Under 20")
range(med31.1.19$M)*1000
range(med31.1.19$N)
factor <- 1000
```

```
599 ggplot(med31.1.19, aes(x=ANOCM, y=N))+
600 geom_bar(stat="identity", fill="skyblue")+
601 theme_test()+
602 geom_line(aes(y=M*factor), color = "blue")+
603 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
604 labs(x="Year", y="# cases")+
605 theme (axis.text.x = element_text(size=rel(2)),
606 axis.text.y = element_text(size=rel(2)))+
607 theme (axis.title = element_text(size=rel(1.5)))
608
609 med31.6.19 <- med31.6 %>% filter(INTER == "Under 20")
610 range(med31.6.19$M)*5000
611 range(med31.6.19$N)
612 factor <-5000
613
614 ggplot(med31.6.19, aes(x=ANOCM, y=N))+
615 geom_bar(stat="identity", fill="skyblue")+
616 theme_test()+
617 geom_line(aes(y=M*factor), color = "blue")+
618 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
619 labs(x="Year", y="# cases")+
620 theme (axis.text.x = element_text(size=rel(2)),
621 axis.text.y = element_text(size=rel(2)))+
622 theme (axis.title = element_text(size=rel(1.5)))
623
624
```

```
# From 20 to 29
med31.1.20 <- med31.1 %>% filter(INTER == "From 20 to 29")
range(med31.1.20$M)*100000
range(med31.1.20$N)
factor <- 100000

ggplot(med31.1.20, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

med31.6.20 <- med31.6 %>% filter(INTER == "From 20 to 29")
range(med31.6.20$M)*50000
range(med31.6.20$N)
factor <-50000

ggplot(med31.6.20, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
```

```
651 labs(x="Year", y="# cases")+
652 theme (axis.text.x = element_text(size=rel(2)),
653 axis.text.y = element_text(size=rel(2)))+
654 theme (axis.title = element_text(size=rel(1.5)))
655
656 # From 30 to 39
657 med31.1.30 <- med31.1 %>% filter(INTER == "From 30 to 39")
658 range(med31.1.30$M)*10000
659 range(med31.1.30$N)
660 factor <- 10000
661
662 ggplot(med31.1.30, aes(x=ANOCM, y=N))+
663 geom_bar(stat="identity", fill="skyblue")+
664 theme_test()+
665 geom_line(aes(y=M*factor), color = "blue")+
666 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
667 labs(x="Year", y="# cases")+
668 theme (axis.text.x = element_text(size=rel(2)),
669 axis.text.y = element_text(size=rel(2)))+
670 theme (axis.title = element_text(size=rel(1.5)))
671
672 med31.6.30 <- med31.6 %>% filter(INTER == "From 30 to 39")
673 range(med31.6.30$M)*40000
674 range(med31.6.30$N)
675 factor <-40000
676
```

```
677 ggplot(med31.6.30, aes(x=ANOCM, y=N))+
678 geom_bar(stat="identity", fill="skyblue")+
679 theme_test()+
680 geom_line(aes(y=M*factor), color = "blue")+
681 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
682 labs(x="Year", y="# cases")+
683 theme (axis.text.x = element_text(size=rel(2)),
684 axis.text.y = element_text(size=rel(2)))+
685 theme (axis.title = element_text(size=rel(1.5)))
686
687 # From 40 to 49
688 med31.1.40 <- med31.1 %>% filter(INTER == "From 40 to 49")
689 range(med31.1.40$M)*2000
690 range(med31.1.40$N)
691 factor <- 2000
692
693 ggplot(med31.1.40, aes(x=ANOCM, y=N))+
694 geom_bar(stat="identity", fill="skyblue")+
695 theme_test()+
696 geom_line(aes(y=M*factor), color = "blue")+
697 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
698 labs(x="Year", y="# cases")+
699 theme (axis.text.x = element_text(size=rel(2)),
700 axis.text.y = element_text(size=rel(2)))+
701 theme (axis.title = element_text(size=rel(1.5)))
702
```

```
703 med31.6.40 <- med31.6 %>% filter(INTER == "From 40 to 49")
704 range(med31.6.40$M)*10000
705 range(med31.6.40$N)
706 factor <-10000
707
708 ggplot(med31.6.40, aes(x=ANOCM, y=N))+
709 geom_bar(stat="identity", fill="skyblue")+
710 theme_test()+
711 geom_line(aes(y=M*factor), color = "blue")+
712 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
713 labs(x="Year", y="# cases")+
714 theme (axis.text.x = element_text(size=rel(2)),
715 axis.text.y = element_text(size=rel(2)))+
716 theme (axis.title = element_text(size=rel(1.5)))
717
718 # From 50 to 59
719 med31.1.50 <- med31.1 %>% filter(INTER == "From 50 to 59")
720 range(med31.1.50$M)*400
721 range(med31.1.50$N)
722 factor <- 400
723
724 ggplot(med31.1.50, aes(x=ANOCM, y=N))+
725 geom_bar(stat="identity", fill="skyblue")+
726 theme_test()+
727 geom_line(aes(y=M*factor), color = "blue")+
728 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
```

```
729 labs(x="Year", y="# cases")+
730 theme (axis.text.x = element_text(size=rel(2)),
731 axis.text.y = element_text(size=rel(2)))+
732 theme (axis.title = element_text(size=rel(1.5)))
733
734 med31.6.50 <- med31.6 %>% filter(INTER == "From 50 to 59")
735 range(med31.6.50$M)*1000
736 range(med31.6.50$N)
737 factor <-1000
738
739 ggplot(med31.6.50, aes(x=ANOCM, y=N))+
740 geom_bar(stat="identity", fill="skyblue")+
741 theme_test()+
742 geom_line(aes(y=M*factor), color = "blue")+
743 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
744 labs(x="Year", y="# cases")+
745 theme (axis.text.x = element_text(size=rel(2)),
746 axis.text.y = element_text(size=rel(2)))+
747 theme (axis.title = element_text(size=rel(1.5)))
748
749 # Over 60
750 med31.1.60 <- med31.1 %>% filter(INTER == "Over 60")
751 range(med31.1.60$M)*50
752 range(med31.1.60$N)
753 factor <- 50
754
```

```
ggplot(med31.1.60, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

med31.6.60 <- med31.6 %>% filter(INTER == "Over 60")
range(med31.6.60$M)*30
range(med31.6.60$N)
factor <- 30

ggplot(med31.6.60, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))
```

```r
# GAY COUPLES

med3.01 <- d301 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP),
 ↪  N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP)) #DDA


med3.01 %>% ggplot() +
aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
ylim(1.4, 2.8) +
labs(y= "", x = "") #gap graphic

d301.A <- d301 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med301.A <- d301.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val301.A <- med301.A %>% group_by(INTER) %>% reframe(M = mean(M))
n301 <- d301.A %>% group_by(INTER) %>% reframe(N = n())
```

```
805 tot301<- merge(val301.A,n301)
806
807 med301.A %>% ggplot() +
808 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
    ↪  "From 40 to 49",
809 "From 50 to 59", "Over 60"), y = M) +
810 geom_boxplot(fill="blue", alpha=0.3) +
811 labs(y= "", x = "") +
812 stat_summary(fun = mean, geom="point", shape=18,
813 size=3, color="blue") #spouse A gap graphic
814
815 # Under 20
816 med301.19 <- med301.A %>% filter(INTER == "Under 20")
817 range(med301.19$M)*0.5
818 range(med301.19$N)
819 factor <- 0.5
820
821 ggplot(med301.19, aes(x=ANOCM, y=N))+
822 geom_bar(stat="identity", fill="skyblue")+
823 theme_test()+
824 geom_line(aes(y=M*factor), color = "blue")+
825 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
826 labs(x="Year", y="# cases")+
827 theme (axis.text.x = element_text(size=rel(2)),
828 axis.text.y = element_text(size=rel(2)))+
829 theme (axis.title = element_text(size=rel(1.5)))
```

```
# From 20 to 29
med301.20 <- med301.A %>% filter(INTER == "From 20 to 29")
range(med301.20$M)*45
range(med301.20$N)
factor <- 45

ggplot(med301.20, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

# From 30 to 39
med301.30 <- med301.A %>% filter(INTER == "From 30 to 39")
range(med301.30$M)*250
range(med301.30$N)
factor <- 250

ggplot(med301.30, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
```

```
856 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
857 labs(x="Year", y="# cases")+
858 theme (axis.text.x = element_text(size=rel(2)),
859 axis.text.y = element_text(size=rel(2)))+
860 theme (axis.title = element_text(size=rel(1.5)))
861
862 # From 40 to 49
863 med301.40 <- med301.A %>% filter(INTER == "From 40 to 49")
864 range(med301.40$M)*100
865 range(med301.40$N)
866 factor <- 100
867
868 ggplot(med301.40, aes(x=ANOCM, y=N))+
869 geom_bar(stat="identity", fill="skyblue")+
870 theme_test()+
871 geom_line(aes(y=M*factor), color = "blue")+
872 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
873 labs(x="Year", y="# cases")+
874 theme (axis.text.x = element_text(size=rel(2)),
875 axis.text.y = element_text(size=rel(2)))+
876 theme (axis.title = element_text(size=rel(1.5)))
877
878 # From 50 to 59
879 med301.50 <- med301.A %>% filter(INTER == "From 50 to 59")
880 range(med301.50$M)*45
881 range(med301.50$N)
```

```
882 factor <- 45
883
884 ggplot(med301.50, aes(x=ANOCM, y=N))+
885 geom_bar(stat="identity", fill="skyblue")+
886 theme_test()+
887 geom_line(aes(y=M*factor), color = "blue")+
888 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
889 labs(x="Year", y="# cases")+
890 theme (axis.text.x = element_text(size=rel(2)),
891 axis.text.y = element_text(size=rel(2)))+
892 theme (axis.title = element_text(size=rel(1.5)))
893
894 # Over 60
895 med301.60 <- med301.A %>% filter(INTER == "Over 60")
896 range(med301.60$M)*25
897 range(med301.60$N)
898 factor <- 25
899
900 ggplot(med301.60, aes(x=ANOCM, y=N))+
901 geom_bar(stat="identity", fill="skyblue")+
902 theme_test()+
903 geom_line(aes(y=M*factor), color = "blue")+
904 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
905 labs(x="Year", y="# cases")+
906 theme (axis.text.x = element_text(size=rel(2)),
907 axis.text.y = element_text(size=rel(2)))+
```

```
908 theme (axis.title = element_text(size=rel(1.5)))+
909 theme (axis.text.x = element_text(size=rel(2)),
910 axis.text.y = element_text(size=rel(2)))+
911 theme (axis.title = element_text(size=rel(1.5)))
912
913 # LESBIAN COUPLES
914
915 med3.06 <- d306 %>% group_by(ANOCM) %>% reframe(M = mean(GAP), SD = sd(GAP),
    ↪  N = n(),
916 min(GAP), Q1 = quantile(GAP, 0.25),
917 Q3 = quantile(GAP, 0.75), max(GAP)) #DDA
918
919 med3.06 %>% ggplot() +
920 aes(x = ANOCM, y = M) + geom_line(color = "blue", linewidth = 0.75) +
921 ylim(-0.2, 1.2) +
922 labs(y= "", x = "") #gap graphic
923
924 d306.A <- d306 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
925 ifelse(EDADCA>=50,"From 50 to 59",
926 ifelse(EDADCA>=40,"From 40 to 49",
927 ifelse(EDADCA>=30,"From 30 to 39",
928 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
929
930 med306.A <- d306.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
    ↪  sd(GAP), N = n(),
931 min(GAP), Q1 = quantile(GAP, 0.25),
```

```
Q3 = quantile(GAP, 0.75), max(GAP))

val306.A <- med306.A %>% group_by(INTER) %>% reframe(M = mean(M))
n306 <- d306.A %>% group_by(INTER) %>% reframe(N = n())
tot306<- merge(val306.A,n306)

med306.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# Under 20
med306.19 <- med306.A %>% filter(INTER == "Under 20")
range(med306.19$M)*0.5
range(med306.19$N)
factor <- 0.5

ggplot(med306.19, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
```

```
957 labs(x="Year", y="# cases")+
958 theme (axis.text.x = element_text(size=rel(2)),
959 axis.text.y = element_text(size=rel(2)))+
960 theme (axis.title = element_text(size=rel(1.5)))
961
962 # From 20 to 29
963 med306.20 <- med306.A %>% filter(INTER == "From 20 to 29")
964 range(med306.20$M)*60
965 range(med306.20$N)
966 factor <- 60
967
968 ggplot(med306.20, aes(x=ANOCM, y=N))+
969 geom_bar(stat="identity", fill="skyblue")+
970 theme_test()+
971 geom_line(aes(y=M*factor), color = "blue")+
972 scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
973 labs(x="Year", y="# cases")+
974 theme (axis.text.x = element_text(size=rel(2)),
975 axis.text.y = element_text(size=rel(2)))+
976 theme (axis.title = element_text(size=rel(1.5)))
977
978 # From 30 to 39
979 med306.30 <- med306.A %>% filter(INTER == "From 30 to 39")
980 range(med306.30$M)*500
981 range(med306.30$N)
982 factor <- 500
```

```
ggplot(med306.30, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

# From 40 to 49
med306.40 <- med306.A %>% filter(INTER == "From 40 to 49")
range(med306.40$M)*100
range(med306.40$N)
factor <- 100

ggplot(med306.40, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))
```

```
# From 50 to 59
med306.50 <- med306.A %>% filter(INTER == "From 50 to 59")
range(med306.50$M)*40
range(med306.50$N)
factor <- 40

ggplot(med306.50, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

# Over 60
med306.60 <- med306.A %>% filter(INTER == "Over 60")
range(med306.60$M)*10
range(med306.60$N)
factor <- 10

ggplot(med306.60, aes(x=ANOCM, y=N))+
geom_bar(stat="identity", fill="skyblue")+
theme_test()+
geom_line(aes(y=M*factor), color = "blue")+
```

```
scale_y_continuous(sec.axis = sec_axis(trans= ~./factor, name = "Mean"))+
labs(x="Year", y="# cases")+
theme (axis.text.x = element_text(size=rel(2)),
axis.text.y = element_text(size=rel(2)))+
theme (axis.title = element_text(size=rel(1.5)))

# ECIVCA = ECIVCB = 3
d4 <- data %>% filter(ECIVCA==3, ECIVCB==3)

# Separate data of heterosexuals, gays and lesbians:
d41 <- d4 %>% filter(SEXOCM==1) #Heterosexuals
d401 <- d4 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d406 <- d4 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d41.1 <- d41 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d41.6 <- d41 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
```

```
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med41.1 <- d41.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med41.6 <- d41.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val41.1 <- med41.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n41.1 <- d41.1 %>% group_by(INTER) %>% reframe(N = n())
tot41.1<- merge(val41.1,n41.1)

val41.6 <- med41.6 %>% group_by(INTER) %>% reframe(M = mean(M))
n41.6 <- d41.6 %>% group_by(INTER) %>% reframe(N = n())
tot41.6<- merge(val41.6,n41.6)

med41.1 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
```

```
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #men gap graphic

med41.6 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #women gap graphic

# GAY COUPLES

d401.A <- d401 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med401.A <- d401.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val401.A <- med401.A %>% group_by(INTER) %>% reframe(M = mean(M))
```

```
n401 <- d401.A %>% group_by(INTER) %>% reframe(N = n())
tot401<- merge(val401.A,n401)

med401.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# LESBIAN COUPLES

d406.A <- d406 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med406.A <- d406.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val406.A <- med406.A %>% group_by(INTER) %>% reframe(M = mean(M))
```

```
n406 <- d406.A %>% group_by(INTER) %>% reframe(N = n())
tot406<- merge(val406.A,n406)

med406.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# ECIVCA = ECIVCB = 4
d5 <- data %>% filter(ECIVCA==4, ECIVCB==4)

# Separate data of heterosexuals, gays and lesbians:
d51 <- d5 %>% filter(SEXOCM==1) #Heterosexuals
d501 <- d5 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d506 <- d5 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d51.1 <- d51 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
```

```
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d51.6 <- d51 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med51.1 <- d51.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med51.6 <- d51.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
val51.1 <- med51.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n51.1 <- d51.1 %>% group_by(INTER) %>% reframe(N = n())
tot51.1<- merge(val51.1,n51.1)

val51.6 <- med51.6 %>% group_by(INTER) %>% reframe(M = mean(M))
n51.6 <- d51.6 %>% group_by(INTER) %>% reframe(N = n())
tot51.6<- merge(val51.6,n51.6)

med51.1 %>% ggplot() +
```

```
1181 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1182 "From 50 to 59", "Over 60"), y = M) +
1183 geom_boxplot(fill="blue", alpha=0.3) +
1184 labs(y= "", x = "") +
1185 stat_summary(fun = mean, geom="point", shape=18,
1186 size=3, color="blue") #men gap graphic
1187
1188 med51.6 %>% ggplot() +
1189 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1190 "From 50 to 59", "Over 60"), y = M) +
1191 geom_boxplot(fill="blue", alpha=0.3) +
1192 labs(y= "", x = "") +
1193 stat_summary(fun = mean, geom="point", shape=18,
1194 size=3, color="blue") #women gap graphic
1195
1196 # GAY COUPLES
1197
1198 d501.A <- d501 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1199 ifelse(EDADCA>=50,"From 50 to 59",
1200 ifelse(EDADCA>=40,"From 40 to 49",
1201 ifelse(EDADCA>=30,"From 30 to 39",
1202 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1203
```

```
1204 med501.A <- d501.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1205 min(GAP), Q1 = quantile(GAP, 0.25),
1206 Q3 = quantile(GAP, 0.75), max(GAP))
1207
1208 val501.A <- med501.A %>% group_by(INTER) %>% reframe(M = mean(M))
1209 n501 <- d501.A %>% group_by(INTER) %>% reframe(N = n())
1210 tot501<- merge(val501.A,n501)
1211
1212 med501.A %>% ggplot() +
1213 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1214 "From 50 to 59", "Over 60"), y = M) +
1215 geom_boxplot(fill="blue", alpha=0.3) +
1216 labs(y= "", x = "") +
1217 stat_summary(fun = mean, geom="point", shape=18,
1218 size=3, color="blue") #spouse A gap graphic
1219
1220 # LESBIAN COUPLES
1221
1222 d506.A <- d506 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1223 ifelse(EDADCA>=50,"From 50 to 59",
1224 ifelse(EDADCA>=40,"From 40 to 49",
1225 ifelse(EDADCA>=30,"From 30 to 39",
1226 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1227
```

```
1228 med506.A <- d506.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1229 min(GAP), Q1 = quantile(GAP, 0.25),
1230 Q3 = quantile(GAP, 0.75), max(GAP))
1231
1232 val506.A <- med506.A %>% group_by(INTER) %>% reframe(M = mean(M))
1233 n506 <- d506.A %>% group_by(INTER) %>% reframe(N = n())
1234 tot506<- merge(val506.A,n506)
1235
1236 med506.A %>% ggplot() +
1237 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1238 "From 50 to 59", "Over 60"), y = M) +
1239 geom_boxplot(fill="blue", alpha=0.3) +
1240 labs(y= "", x = "") +
1241 stat_summary(fun = mean, geom="point", shape=18,
1242 size=3, color="blue") #spouse A gap graphic
1243
1244 # ECIVCA = 1 and ECIVCB = 3
1245 d6 <- data %>% filter(ECIVCA==1, ECIVCB==3)
1246
1247 # Separate data of heterosexuals, gays and lesbians:
1248 d61 <- d6 %>% filter(SEXOCM==1) #Heterosexuals
1249 d601 <- d6 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
1250 d606 <- d6 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians
1251
```

```
# HETEROSEXUAL COUPLES

d61.1 <- d61 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d61.6 <- d61 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med61.1 <- d61.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med61.6 <- d61.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
val61.1 <- med61.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n61.1 <- d61.1 %>% group_by(INTER) %>% reframe(N = n())
tot61.1<- merge(val61.1,n61.1)
```

```
1276 val61.6 <- med61.6 %>% group_by(INTER) %>% reframe(M = mean(M))
1277 n61.6 <- d61.6 %>% group_by(INTER) %>% reframe(N = n())
1278 tot61.6<- merge(val61.6,n61.6)
1279
1280 med61.1 %>% ggplot() +
1281 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1282 "From 50 to 59", "Over 60"), y = M) +
1283 geom_boxplot(fill="blue", alpha=0.3) +
1284 labs(y= "", x = "") +
1285 stat_summary(fun = mean, geom="point", shape=18,
1286 size=3, color="blue") #men gap graphic
1287
1288 med61.6 %>% ggplot() +
1289 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1290 "From 50 to 59", "Over 60"), y = M) +
1291 geom_boxplot(fill="blue", alpha=0.3) +
1292 labs(y= "", x = "") +
1293 stat_summary(fun = mean, geom="point", shape=18,
1294 size=3, color="blue") #women gap graphic
1295
1296 # GAY COUPLES
1297
1298 d601.A <- d601 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1299 ifelse(EDADCA>=50,"From 50 to 59",
```

```
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med601.A <- d601.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val601.A <- med601.A %>% group_by(INTER) %>% reframe(M = mean(M))
n601 <- d601.A %>% group_by(INTER) %>% reframe(N = n())
tot601<- merge(val601.A,n601)

med601.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# LESBIAN COUPLES

d606.A <- d606 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
```

```
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med606.A <- d606.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
 ↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val606.A <- med606.A %>% group_by(INTER) %>% reframe(M = mean(M))
n606 <- d606.A %>% group_by(INTER) %>% reframe(N = n())
tot606<- merge(val606.A,n606)

med606.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic


# ECIVCA = 1 and ECIVCB = 4
d7 <- data %>% filter(ECIVCA==1, ECIVCB==4)

```

```
# Separate data of heterosexuals, gays and lesbians:
d71 <- d7 %>% filter(SEXOCM==1) #Heterosexuals
d701 <- d7 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d706 <- d7 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d71.1 <- d71 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d71.6 <- d71 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med71.1 <- d71.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med71.6 <- d71.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
```

```
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
val71.1 <- med71.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n71.1 <- d71.1 %>% group_by(INTER) %>% reframe(N = n())
tot71.1<- merge(val71.1,n71.1)

val71.6 <- med71.6 %>% group_by(INTER) %>% reframe(M = mean(M))
n71.6 <- d71.6 %>% group_by(INTER) %>% reframe(N = n())
tot71.6<- merge(val71.6,n71.6)

med71.1 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #men gap graphic

med71.6 %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
```

```
size=3, color="blue") #women gap graphic

# GAY COUPLES

d701.A <- d701 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med701.A <- d701.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val701.A <- med701.A %>% group_by(INTER) %>% reframe(M = mean(M))
n701 <- d701.A %>% group_by(INTER) %>% reframe(N = n())
tot701<- merge(val701.A,n701)

med701.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
```

```
size=3, color="blue") #spouse A gap graphic

# LESBIAN COUPLES

d706.A <- d706 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med706.A <- d706.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val706.A <- med706.A %>% group_by(INTER) %>% reframe(M = mean(M))
n706 <- d706.A %>% group_by(INTER) %>% reframe(N = n())
tot706<- merge(val706.A,n706)

med706.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
```

```
size=3, color="blue") #spouse A gap graphic

# ECIVCA = 3 and ECIVCB = 1
d8 <- data %>% filter(ECIVCA==3, ECIVCB==1)

# Separate data of heterosexuals, gays and lesbians:
d81 <- d8 %>% filter(SEXOCM==1) #Heterosexuals
d801 <- d8 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d806 <- d8 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d81.1 <- d81 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d81.6 <- d81 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med81.1 <- d81.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
```

```
1469 min(GAP), Q1 = quantile(GAP, 0.25),
1470 Q3 = quantile(GAP, 0.75), max(GAP))
1471
1472 med81.6 <- d81.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1473 min(GAP), Q1 = quantile(GAP, 0.25),
1474 Q3 = quantile(GAP, 0.75), max(GAP))
1475
1476 val81.1 <- med81.1 %>% group_by(INTER) %>% reframe(M = mean(M))
1477 n81.1 <- d81.1 %>% group_by(INTER) %>% reframe(N = n())
1478 tot81.1<- merge(val81.1,n81.1)
1479
1480 val81.6 <- med81.6 %>% group_by(INTER) %>% reframe(M = mean(M))
1481 n81.6 <- d81.6 %>% group_by(INTER) %>% reframe(N = n())
1482 tot81.6<- merge(val81.6,n81.6)
1483
1484 med81.1 %>% ggplot() +
1485 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1486 "From 50 to 59", "Over 60"), y = M) +
1487 geom_boxplot(fill="blue", alpha=0.3) +
1488 labs(y= "", x = "") +
1489 stat_summary(fun = mean, geom="point", shape=18,
1490 size=3, color="blue") #men gap graphic
1491
1492
```

```
1493 med81.6 %>% ggplot() +
1494 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1495 "From 50 to 59", "Over 60"), y = M) +
1496 geom_boxplot(fill="blue", alpha=0.3) +
1497 labs(y= "", x = "") +
1498 stat_summary(fun = mean, geom="point", shape=18,
1499 size=3, color="blue") #women gap graphic
1500
1501 # GAY COUPLES
1502
1503 d801.A <- d801 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1504 ifelse(EDADCA>=50,"From 50 to 59",
1505 ifelse(EDADCA>=40,"From 40 to 49",
1506 ifelse(EDADCA>=30,"From 30 to 39",
1507 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1508
1509 med801.A <- d801.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1510 min(GAP), Q1 = quantile(GAP, 0.25),
1511 Q3 = quantile(GAP, 0.75), max(GAP))
1512
1513 val801.A <- med801.A %>% group_by(INTER) %>% reframe(M = mean(M))
1514 n801 <- d801.A %>% group_by(INTER) %>% reframe(N = n())
1515 tot801<- merge(val801.A,n801)
1516
```

```
1517 med801.A %>% ggplot() +
1518 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1519 "From 50 to 59", "Over 60"), y = M) +
1520 geom_boxplot(fill="blue", alpha=0.3) +
1521 labs(y= "", x = "") +
1522 stat_summary(fun = mean, geom="point", shape=18,
1523 size=3, color="blue") #spouse A gap graphic
1524
1525 # LESBIAN COUPLES
1526
1527 d806.A <- d806 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1528 ifelse(EDADCA>=50,"From 50 to 59",
1529 ifelse(EDADCA>=40,"From 40 to 49",
1530 ifelse(EDADCA>=30,"From 30 to 39",
1531 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1532
1533 med806.A <- d806.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1534 min(GAP), Q1 = quantile(GAP, 0.25),
1535 Q3 = quantile(GAP, 0.75), max(GAP))
1536
1537 val806.A <- med806.A %>% group_by(INTER) %>% reframe(M = mean(M))
1538 n806 <- d806.A %>% group_by(INTER) %>% reframe(N = n())
1539 tot806<- merge(val806.A,n806)
1540
```

```
med806.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# ECIVCA = 3 and ECIVCB = 4
d9 <- data %>% filter(ECIVCA==3, ECIVCB==4)

# Separate data of heterosexuals, gays and lesbians:
d91 <- d9 %>% filter(SEXOCM==1) #Heterosexuals
d901 <- d9 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d906 <- d9 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d91.1 <- d91 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
```

```
d91.6 <- d91 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med91.1 <- d91.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med91.6 <- d91.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val91.1 <- med91.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n91.1 <- d91.1 %>% group_by(INTER) %>% reframe(N = n())
tot91.1<- merge(val91.1,n91.1)

val91.6 <- med91.6 %>% group_by(INTER) %>% reframe(M = mean(M))
n91.6 <- d91.6 %>% group_by(INTER) %>% reframe(N = n())
tot91.6<- merge(val91.6,n91.6)
```

```
1590 med91.1 %>% ggplot() +
1591 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1592 "From 50 to 59", "Over 60"), y = M) +
1593 geom_boxplot(fill="blue", alpha=0.3) +
1594 labs(y= "", x = "") +
1595 stat_summary(fun = mean, geom="point", shape=18,
1596 size=3, color="blue") #men gap graphic
1597
1598 med91.6 %>% ggplot() +
1599 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1600 "From 50 to 59", "Over 60"), y = M) +
1601 geom_boxplot(fill="blue", alpha=0.3) +
1602 labs(y= "", x = "") +
1603 stat_summary(fun = mean, geom="point", shape=18,
1604 size=3, color="blue") #women gap graphic
1605
1606 # GAY COUPLES
1607
1608 d901.A <- d901 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1609 ifelse(EDADCA>=50,"From 50 to 59",
1610 ifelse(EDADCA>=40,"From 40 to 49",
1611 ifelse(EDADCA>=30,"From 30 to 39",
1612 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1613
```

```
1614 med901.A <- d901.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1615 min(GAP), Q1 = quantile(GAP, 0.25),
1616 Q3 = quantile(GAP, 0.75), max(GAP))
1617
1618 val901.A <- med901.A %>% group_by(INTER) %>% reframe(M = mean(M))
1619 n901 <- d901.A %>% group_by(INTER) %>% reframe(N = n())
1620 tot901<- merge(val901.A,n901)
1621
1622 med901.A %>% ggplot() +
1623 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1624 "From 50 to 59", "Over 60"), y = M) +
1625 geom_boxplot(fill="blue", alpha=0.3) +
1626 labs(y= "", x = "") +
1627 stat_summary(fun = mean, geom="point", shape=18,
1628 size=3, color="blue") #spouse A gap graphic
1629
1630 # LESBIAN COUPLES
1631
1632 d906.A <- d906 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1633 ifelse(EDADCA>=50,"From 50 to 59",
1634 ifelse(EDADCA>=40,"From 40 to 49",
1635 ifelse(EDADCA>=30,"From 30 to 39",
1636 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1637
```

```
1638 med906.A <- d906.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1639 min(GAP), Q1 = quantile(GAP, 0.25),
1640 Q3 = quantile(GAP, 0.75), max(GAP))
1641
1642 val906.A <- med906.A %>% group_by(INTER) %>% reframe(M = mean(M))
1643 n906 <- d906.A %>% group_by(INTER) %>% reframe(N = n())
1644 tot906<- merge(val906.A,n906)
1645
1646 med906.A %>% ggplot() +
1647 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1648 "From 50 to 59", "Over 60"), y = M) +
1649 geom_boxplot(fill="blue", alpha=0.3) +
1650 labs(y= "", x = "") +
1651 stat_summary(fun = mean, geom="point", shape=18,
1652 size=3, color="blue") #spouse A gap graphic
1653
1654 # ECIVCA = 4 and ECIVCB = 1
1655 d10 <- data %>% filter(ECIVCA==4, ECIVCB==1)
1656
1657 # Separate data of heterosexuals, gays and lesbians:
1658 d101 <- d10 %>% filter(SEXOCM==1) #Heterosexuals
1659 d1001 <- d10 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
1660 d1006 <- d10 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians
1661
```

```
# HETEROSEXUAL COUPLES

d101.1 <- d101 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d101.6 <- d101 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med101.1 <- d101.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

med101.6 <- d101.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val101.1 <- med101.1 %>% group_by(INTER) %>% reframe(M = mean(M))
n101.1 <- d101.1 %>% group_by(INTER) %>% reframe(N = n())
```

```
1686 tot101.1<- merge(val101.1,n101.1)
1687
1688 val101.6 <- med101.6 %>% group_by(INTER) %>% reframe(M = mean(M))
1689 n101.6 <- d101.6 %>% group_by(INTER) %>% reframe(N = n())
1690 tot101.6<- merge(val101.6,n101.6)
1691
1692 med101.1 %>% ggplot() +
1693 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1694 "From 50 to 59", "Over 60"), y = M) +
1695 geom_boxplot(fill="blue", alpha=0.3) +
1696 labs(y= "", x = "") +
1697 stat_summary(fun = mean, geom="point", shape=18,
1698 size=3, color="blue") #men gap graphic
1699
1700 med101.6 %>% ggplot() +
1701 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1702 "From 50 to 59", "Over 60"), y = M) +
1703 geom_boxplot(fill="blue", alpha=0.3) +
1704 labs(y= "", x = "") +
1705 stat_summary(fun = mean, geom="point", shape=18,
1706 size=3, color="blue") #women gap graphic
1707
1708
1709
```

```
# GAY COUPLES

d1001.A <- d1001 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med1001.A <- d1001.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD
 ↪  = sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val1001.A <- med1001.A %>% group_by(INTER) %>% reframe(M = mean(M))
n1001 <- d1001.A %>% group_by(INTER) %>% reframe(N = n())
tot1001<- merge(val1001.A,n1001)

med1001.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

```

```
1734 # LESBIAN COUPLES
1735
1736 d1006.A <- d1006 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
1737 ifelse(EDADCA>=50,"From 50 to 59",
1738 ifelse(EDADCA>=40,"From 40 to 49",
1739 ifelse(EDADCA>=30,"From 30 to 39",
1740 ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))
1741
1742 med1006.A <- d1006.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD
     ↪  = sd(GAP), N = n(),
1743 min(GAP), Q1 = quantile(GAP, 0.25),
1744 Q3 = quantile(GAP, 0.75), max(GAP))
1745
1746 val1006.A <- med1006.A %>% group_by(INTER) %>% reframe(M = mean(M))
1747 n1006 <- d1006.A %>% group_by(INTER) %>% reframe(N = n())
1748 tot1006<- merge(val1006.A,n1006)
1749
1750 med1006.A %>% ggplot() +
1751 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1752 "From 50 to 59", "Over 60"), y = M) +
1753 geom_boxplot(fill="blue", alpha=0.3) +
1754 labs(y= "", x = "") +
1755 stat_summary(fun = mean, geom="point", shape=18,
1756 size=3, color="blue") #spouse A gap graphic
1757
```

```r
# ECIVCA = 4 and ECIVCB = 3
d11 <- data %>% filter(ECIVCA==4, ECIVCB==3)

# Separate data of heterosexuals, gays and lesbians:
d111 <- d11 %>% filter(SEXOCM==1) #Heterosexuals
d1101 <- d11 %>% filter(SEXOCM==0,SEXOCA==1) #Gays
d1106 <- d11 %>% filter(SEXOCM==0,SEXOCA==6) #Lesbians

# HETEROSEXUAL COUPLES

d111.1 <- d111 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

d111.6 <- d111 %>% mutate(INTER=ifelse(EDADCB>=60,"Over 60",
ifelse(EDADCB>=50,"From 50 to 59",
ifelse(EDADCB>=40,"From 40 to 49",
ifelse(EDADCB>=30,"From 30 to 39",
ifelse(EDADCB>=20, "From 20 to 29","Under 20"))))))

med111.1 <- d111.1 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
↪  sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))
```

```
1783 med111.6 <- d111.6 %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD =
     ↪  sd(GAP), N = n(),
1784 min(GAP), Q1 = quantile(GAP, 0.25),
1785 Q3 = quantile(GAP, 0.75), max(GAP))
1786
1787 val111.1 <- med111.1 %>% group_by(INTER) %>% reframe(M = mean(M))
1788 n111.1 <- d111.1 %>% group_by(INTER) %>% reframe(N = n())
1789 tot111.1<- merge(val111.1,n111.1)
1790
1791 val111.6 <- med111.6 %>% group_by(INTER) %>% reframe(M = mean(M))
1792 n111.6 <- d111.6 %>% group_by(INTER) %>% reframe(N = n())
1793 tot111.6<- merge(val111.6,n111.6)
1794
1795 med111.1 %>% ggplot() +
1796 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1797 "From 50 to 59", "Over 60"), y = M) +
1798 geom_boxplot(fill="blue", alpha=0.3) +
1799 labs(y= "", x = "") +
1800 stat_summary(fun = mean, geom="point", shape=18,
1801 size=3, color="blue") #men gap graphic
1802
1803 med111.6 %>% ggplot() +
1804 aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
     ↪  "From 40 to 49",
1805 "From 50 to 59", "Over 60"), y = M) +
```

```
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #women gap graphic

# GAY COUPLES

d1101.A <- d1101 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med1101.A <- d1101.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD
 ↪  = sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val1101.A <- med1101.A %>% group_by(INTER) %>% reframe(M = mean(M))
n1101 <- d1101.A %>% group_by(INTER) %>% reframe(N = n())
tot1101<- merge(val1101.A,n1101)

med1101.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
```

```
geom_boxplot(fill="blue", alpha=0.3) +
labs(y= "", x = "") +
stat_summary(fun = mean, geom="point", shape=18,
size=3, color="blue") #spouse A gap graphic

# LESBIAN COUPLES

d1106.A <- d1106 %>% mutate(INTER=ifelse(EDADCA>=60,"Over 60",
ifelse(EDADCA>=50,"From 50 to 59",
ifelse(EDADCA>=40,"From 40 to 49",
ifelse(EDADCA>=30,"From 30 to 39",
ifelse(EDADCA>=20, "From 20 to 29","Under 20"))))))

med1106.A <- d1106.A %>% group_by(ANOCM,INTER) %>% reframe(M = mean(GAP), SD
 ↪  = sd(GAP), N = n(),
min(GAP), Q1 = quantile(GAP, 0.25),
Q3 = quantile(GAP, 0.75), max(GAP))

val1106.A <- med1106.A %>% group_by(INTER) %>% reframe(M = mean(M))
n1106 <- d1106.A %>% group_by(INTER) %>% reframe(N = n())
tot1106<- merge(val1106.A,n1106)

med1106.A %>% ggplot() +
aes(x = fct_relevel(INTER,"Under 20", "From 20 to 29", "From 30 to 39",
 ↪  "From 40 to 49",
"From 50 to 59", "Over 60"), y = M) +
```

```
1854 geom_boxplot(fill="blue", alpha=0.3) +
1855 labs(y= "", x = "") +
1856 stat_summary(fun = mean, geom="point", shape=18,
1857 size=3, color="blue") #spouse A gap graphic
```

B Death rates

```
if(!require("tidyverse")) install.packages("tidyverse")
if(!require("corrplot")) install.packages("corrplot")
if(!require("rainbow")) install.packages("rainbow")
if(!require("writexl")) install.packages("writexl")
if(!require("readxl")) install.packages("readxl")
if(!require("Hmisc")) install.packages("Hmisc")
if(!require("psych")) install.packages("psych")
if(!require("ftsa")) install.packages("ftsa")
if(!require("zoo")) install.packages("zoo")
library(tidyverse)
library(corrplot)
library(rainbow)
library(writexl)
library(readxl)
library(Hmisc)
library(psych)
library(ftsa)
library(zoo)

path <- "C:/Unix/rates.xlsx"
```

```
##########
# PERIOD #
##########
par(mfrow=c(1, 2))

# MEN
qxt_men <- as.data.frame(read_excel(path, sheet = "qxt Men"))

for(i in 2:length(qxt_men)) {
        qxt_men[i] <- log(qxt_men[i])
        i <- i + 1
}

i <- 2; j <- 1; c <- NULL
while (i <= length(qxt_men)) {
        c[j] <- i
        j <- j + 1
        i <- i + 1
}

period_men <- as.data.frame(qxt_men[,c(1,c)])

period_men <- period_men[1:77]

time <- period_men[c(1,11,21,31,41,51,61,71,81,91,101),]

```

```
47 period_men <- rainbow::fts(x = period_men$Age, y =
   ↪  as.matrix(period_men[,-1]))
48
49 plot(period_men, plot.type = "functions", plotlegend = FALSE, xlab = "Age",
50 ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
51
52 time <- rainbow::fts(x = time$Age, y = as.matrix(time[,-1]))
53
54 plot(time, plot.type = "time", plotlegend = TRUE, xlab = "Year",
55 ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
56 minor.tick(nx = 2, ny = 2, tick.ratio = 0.5)
57
58 # WOMEN
59 qxt_women <- as.data.frame(read_excel(path, sheet = "qxt Women"))
60
61 for(i in 2:length(qxt_women)) {
62         qxt_women[i] <- log(qxt_women[i])
63         i <- i + 1
64 }
65
66 i <- 2; j <- 1; c <- NULL
67 while (i <= length(qxt_women)) {
68         c[j] <- i
69         j <- j + 1
70         i <- i + 1
71 }
```

```r
period_women <- as.data.frame(qxt_women[,c(1,c)])

period_women <- period_women[1:77]

time <- period_women[c(1,11,21,31,41,51,61,71,81,91,101),]
period_women <- rainbow::fts(x = period_women$Age, y =
 ↪  as.matrix(period_women[,-1]))

plot(period_women, plot.type = "functions", plotlegend = FALSE, xlab =
 ↪  "Age",
ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)

time <- rainbow::fts(x = time$Age, y = as.matrix(time[,-1]))

plot(time, plot.type = "time", plotlegend = TRUE, xlab = "Year",
ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
minor.tick(nx = 2, ny = 2, tick.ratio = 0.5)

##########
# COHORT #
##########
par(mfrow=c(1, 2))

# MEN
qxt_men <- as.data.frame(read_excel(path, sheet = "qxt Men"))

```

```
96  for(i in 2:length(qxt_men)) {
97          qxt_men[i] <- log(qxt_men[i])
98          i <- i + 1
99  }
100
101 i <- 1; j <- 1; m <- matrix(NA, nrow=126, ncol=length(c))
102 for (j in 1:length(c)) {
103         i <- 1
104         for (i in 1:126) {
105                 if (c[j]+i-1 <= 202) {
106                         m[i, j] <- qxt_men[i, c[j]+i-1]
107                         i <- i +1
108                 }
109                 else {
110                         i <- 126
111                 }
112         }
113         j <- j + 1
114 }
115
116 cohort_men <- cbind(qxt_men[,1],m)
117
118 colnames(cohort_men) <- c("Age",colnames(qxt_men[,c]))
119 cohort_men <- as.data.frame(cohort_men)
120
121 cohort_men <- cohort_men[1:77]
```

```
time <- cohort_men[c(1,11,21,31,41,51,61,71,81,91,101),]

cohort_men <- rainbow::fts(x = cohort_men$Age, y =
 ↪  as.matrix(cohort_men[,-1]))

plot(cohort_men, plot.type = "functions", plotlegend = FALSE, xlab = "Age",
ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)

time <- rainbow::fts(x = time$Age, y = as.matrix(time[,-1]))

plot(time, plot.type = "time", plotlegend = TRUE, xlab = "Year",
ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
minor.tick(nx = 2, ny = 2, tick.ratio = 0.5)

# WOMEN
qxt_women <- as.data.frame(read_excel(path, sheet = "qxt Women"))

for(i in 2:length(qxt_women)) {
        qxt_women[i] <- log(qxt_women[i])
        i <- i + 1
}

i <- 1; j <- 1; m <- matrix(NA, nrow=126, ncol=length(c))
for (j in 1:length(c)) {
        i <- 1
        for (i in 1:126) {
```

```
147                 if (c[j]+i-1 <= 202) {
148                         m[i, j] <- qxt_women[i, c[j]+i-1]
149                         i <- i +1
150                 }
151                 else {
152                         i <- 126
153                 }
154         }
155         j <- j + 1
156 }
157
158 cohort_women <- cbind(qxt_women[,1],m)
159
160 colnames(cohort_women) <- c("Age",colnames(qxt_women[,c]))
161 cohort_women <- as.data.frame(cohort_women)
162
163 cohort_women <- cohort_women[1:77]
164 time <- cohort_women[c(1,11,21,31,41,51,61,71,81,91,101),]
165
166 cohort_women <- rainbow::fts(x = cohort_women$Age, y =
    ↪  as.matrix(cohort_women[,-1]))
167
168 plot(cohort_women, plot.type = "functions", plotlegend = FALSE, xlab =
    ↪  "Age",
169 ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
170
```

```
171 time <- rainbow::fts(x = time$Age, y = as.matrix(time[,-1]))
172
173 plot(time, plot.type = "time", plotlegend = TRUE, xlab = "Year",
174 ylab = "Log Death Rate", cex.lab= 1.5, cex.axis = 1.5)
175 minor.tick(nx = 2, ny = 2, tick.ratio = 0.5)
```

C Period results

Joint life expectancy until dissolution (death of one of the partners) and life expectancy until extinction (individual life expectancy for the surviving individual) for a heterosexual couple.

	Age		Joint status		Beneficiary	
	Man (x)	Woman (y)	exy	axy	x + exy	y + exy
65-65	65	65	15,901	15,860	2,951	6,888
65-64	65	64	16,175	16,134	2,676	7,503
65-63	65	63	16,425	16,385	2,426	8,147
65-62	65	62	16,653	16,612	2,198	8,817
65-58	65	58	17,362	17,323	1,487	11,737
65-56	65	56	17,619	17,580	1,230	13,320
65-51	65	51	18,067	18,030	0,780	17,543
60-65	60	65	17,892	17,851	4,950	4,896
62-65	62	65	17,152	17,111	4,065	5,636
63-65	63	65	16,754	16,713	3,665	6,035
64-65	64	65	16,337	16,296	3,294	6,452

Individual life expectancy according to age and sex of the individual.

	Age		Life expectancy	
	Man (x)	Woman (y)	Men	Women
65-65	65	65	19,032	23,071
65-64	65	64	19,032	23,951
65-63	65	63	19,032	24,829
65-62	65	62	19,032	25,719
65-58	65	58	19,032	29,324
65-56	65	56	19,032	31,159
65-51	65	51	19,032	35,826
60-65	60	65	22,984	23,071
62-65	62	65	21,368	23,071
63-65	63	65	20,577	23,071
64-65	64	65	19,803	23,071

Individual retirement pension for each individual until dissolution. Joint life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of dissolution until extinction. Individual life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of retirement until extinction.

	Pensions	
	Men	Women
Retirement	19.162,78	12.814,62
Widow	7.334,04	10.628,94

Heterosexual couples

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65-65	65	65	304.706,40	203.764,63	508.471,03	78.180,36	161.472,71	586.651,39	669.943,74
65-64	65	64	309.960,04	194.463,24	504.423,28	70.910,59	175.900,96	575.333,87	680.324,25
65-63	65	63	314.756,00	184.855,80	499.611,80	64.272,82	190.986,63	563.884,62	690.598,43
65-62	65	62	319.114,46	174.955,79	494.070,26	58.239,32	206.699,87	552.309,58	700.770,13
65-58	65	58	332.708,48	132.787,96	465.496,44	39.411,39	275.157,33	504.907,84	740.653,77
65-56	65	56	337.624,23	110.446,01	448.070,24	32.598,91	312.259,62	480.669,15	760.329,86
65-51	65	51	346.221,27	52.121,96	398.343,23	20.680,43	411.276,95	419.023,67	809.620,18
60-65	60	65	247.052,15	229.282,92	476.335,07	131.162,50	114.789,40	607.497,57	591.124,48
62-65	62	65	271.201,23	219.802,76	491.003,99	107.704,91	132.135,26	598.708,90	623.139,25
63-65	63	65	282.728,20	214.696,50	497.424,70	97.116,42	141.476,68	594.541,12	638.901,38
64-65	64	65	293.894,37	209.348,98	503.243,36	87.279,40	151.258,53	590.522,75	654.501,88

Retirement and widow's pension for each married partner up to the time of the group's extinction.

Retirement pension for a single person.

Heterosexual couples

	Age		Individual pension wealth (A)		Single's pension wealth (B)		Comparison ((A-B)/B)	
	Man (x)	Woman (y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65-65	65	65	382.886,77	365.237,34	364.700,36	295.641,83	5%	24%
65-64	65	64	380.870,62	370.364,21	364.700,36	294.102,85	4%	26%
65-63	65	63	379.028,82	375.842,43	364.700,36	292.549,65	4%	28%
65-62	65	62	377.353,78	381.655,67	364.700,36	291.135,98	3%	31%
65-58	65	58	372.119,87	407.945,29	364.700,36	286.071,59	2%	43%
65-56	65	56	370.223,14	422.705,63	364.700,36	283.964,50	2%	49%
65-51	65	51	366.901,71	463.398,91	364.700,36	279.695,98	1%	66%
60-65	60	65	378.214,65	344.072,32	344.628,07	295.641,83	10%	16%
62-65	62	65	378.906,14	351.938,02	351.973,09	295.641,83	8%	19%
63-65	63	65	379.844,62	356.173,18	355.986,96	295.641,83	7%	20%
64-65	64	65	381.173,77	360.607,51	360.323,33	295.641,83	6%	22%

Joint retirement and widow's pension for a married couple where both members have been employed.

Joint retirement and widow's pension for a married couple where only one of the partners has been employed.

	Age		Home pension wealth (C)		Home pension wealth (D)		Comparison ((C-D)/D)	
	Man (x)	Woman (y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65-65	65	65	586.651,39	669.943,74	225.404,13	377.915,58	160%	77%
65-64	65	64	575.333,87	680.324,25	214.090,55	389.710,76	169%	75%
65-63	65	63	563.884,62	690.598,43	202.645,84	401.346,32	178%	72%
65-62	65	62	552.309,58	700.770,13	191.075,82	412.828,92	189%	70%
65-58	65	58	504.907,84	740.653,77	143.696,62	457.460,47	251%	62%
65-56	65	56	480.669,15	760.329,86	119.469,04	479.197,81	302%	59%
65-51	65	51	419.023,67	809.620,18	57.846,09	532.687,75	624%	52%
60-65	60	65	607.497,57	591.124,48	265.587,32	299.095,86	129%	98%
62-65	62	65	598.708,90	623.139,25	249.614,34	331.109,27	140%	88%
63-65	63	65	594.541,12	638.901,38	241.577,30	346.871,49	146%	84%
64-65	64	65	590.522,75	654.501,88	233.507,00	362.472,60	153%	81%

Pension by sex and marital status after the implementation of a redistributive reserve.

	Man (x)	Woman (y)	
Analyzed couple:	**65**	**63**	**65-63** ← Couple to be analyzed

Heterosexual couples

Percentage to be maintained as widow's pension for men married with an employed woman.

20%	Married (both members have pension rights)		Married (only one member have pension rights)	
	Man (x)	Woman (y)	Man (x)	Woman (y)
N	599.156	577.725	47.520	67.885
PW (before correction)	563.885	690.598	202.646	401.346
PW/year	**29.977**	**28.152**	**10.773**	**16.361**
PW (after correction)	552.311	690.598	202.646	503.492
PW/year	**29.362**	**28.152**	**10.773**	**20.524**
Variation	-2,05%	0,00%	0,00%	25,45%

Sample

Individual pension per year (after correction)

Pension vs. NO pension	17.790
Widowed Man	6.217
Reserve	6.934.157.519
Reserve/ women (not employed)	102.146

Correction:

1) We calculate the pension difference between a man whose wife has worked assuming he is entitled to receive the current widower's pension, and another man whose wife has not worked.
2) We define the percentage of widower's pension that will be maintained for married men with employed wives.
3) Using the established percentage of the widower's pension, we determine the new total amount of the widower's pension that the married man with an employed wife will receive.
4) We create a reserve with the surplus amount that has not been allocated to the new widower's pension for men, generated from the total sum of the remaining amounts of all married employed men.
5) We make a contribution to the pension in favor of married women who have not worked. This contribution is equal to the amount obtained by dividing the total reserve by the number of married women who have not had paid employment.

Pension by sex and marital status after the implementation of a redistributive reserve.

	Man (x)	Woman (y)	
Analyzed couple:	**65**	**63**	**65-63**

Couple to be analyzed

Heterosexual couples

Percentage to be maintained as widow's pension for married men.

Sample

Individual pension per year (after correction)

20%	Married		Single	
	Man (x)	Woman (y)	Man (x)	Woman (y)
N	599.156	577.725	227.185	168.651
PW (before correction)	379.029	375.842	364.700	292.550
PW/year	**20.150**	**15.321**	**19.163**	**11.782**
PW (after correction)	370.917	375.842	364.700	321.367
PW/year	**19.719**	**15.321**	**19.163**	**12.943**
Variation	-2,14%	0,00%	0,00%	9,85%

Married vs. Single	14.328
Widowed Man	6.217
Reserve	4.860.134.066
Reserve/single women	28.818

Correction:

1) We calculate the pension difference between a man whose wife has worked, assuming he is entitled to receive the current widower's pension and a single man.
2) We define the percentage of widower's pension that will be maintained for married men with employed wives.
3) Using the established percentage of the widower's pension, we determine the new total amount of the widower's pension that the married man with an employed wife will receive.
4) We create a reserve with the surplus amount that has not been allocated to the new widower's pension for men, generated from the total sum of the remaining amounts of all married employed men.
5) We make a contribution to the pension in favor of single women. This contribution is equal to the amount obtained by dividing the total reserve by the number of single women.

Individual retirement pension for each individual until dissolution. Joint life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of dissolution until extinction. Individual life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of retirement until extinction.

30% ← Widowhood pension

	Pensions	
	Men	Women
Retirement	19.162,78	12.814,62
Widow	3.844,39	5.748,83

Heterosexual couples

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65-65	65	65	304.706,40	203.764,63	508.471,03	67.883,94	127.859,90	576.354,97	636.330,93
65-64	65	64	309.960,04	194.463,24	504.423,28	61.571,60	139.284,71	565.994,88	643.707,99
65-63	65	63	314.756,00	184.855,80	499.611,80	55.808,04	151.230,09	555.419,84	650.841,88
65-62	65	62	319.114,46	174.955,79	494.070,26	50.569,15	163.672,39	544.639,41	657.742,65
65-58	65	58	332.708,48	132.787,96	465.496,44	34.220,88	217.879,47	499.717,32	683.375,91
65-56	65	56	337.624,23	110.446,01	448.070,24	28.305,60	247.258,40	476.375,84	695.328,64
65-51	65	51	346.221,27	52.121,96	398.343,23	17.956,80	325.663,88	416.300,04	724.007,12
60-65	60	65	247.052,15	229.282,92	476.335,07	113.888,28	90.894,38	590.223,36	567.229,45
62-65	62	65	271.201,23	219.802,76	491.003,99	93.520,08	104.629,45	584.524,07	595.633,44
63-65	63	65	282.728,20	214.696,50	497.424,70	84.326,10	112.026,32	581.750,80	609.451,02
64-65	64	65	293.894,37	209.348,98	503.243,36	75.784,62	119.771,94	579.027,98	623.015,30

Retirement and widow's pension for each married partner up to the time of the group's extinction.

Retirement pension for a single person until his death.

Heterosexual couples

	Age		Individual pension wealth (A)		Single's pension wealth (B)		Comparison ((A-B)/B)	
	Man (x)	Woman (y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65-65	65	65	372.590,34	331.624,53	364.700,36	295.641,83	2%	12%
65-64	65	64	371.531,64	333.747,95	364.700,36	294.102,85	2%	13%
65-63	65	63	370.564,04	336.085,89	364.700,36	292.549,65	2%	15%
65-62	65	62	369.683,62	338.628,19	364.700,36	291.135,98	1%	16%
65-58	65	58	366.929,36	350.667,43	364.700,36	286.071,59	1%	23%
65-56	65	56	365.929,84	357.704,41	364.700,36	283.964,50	0%	26%
65-51	65	51	364.178,08	377.785,84	364.700,36	279.695,98	0%	35%
60-65	60	65	360.940,44	320.177,30	344.628,07	295.641,83	5%	8%
62-65	62	65	364.721,31	324.432,21	351.973,09	295.641,83	4%	10%
63-65	63	65	367.054,30	326.722,83	355.986,96	295.641,83	3%	11%
64-65	64	65	369.679,00	329.120,92	360.323,33	295.641,83	3%	11%

	50%		45%		40%		35%		30%		25%		20%		15%		10%		5%		0%	
	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)	PW(x)	PW(y)
65-65	4%	21%	4%	19%	3%	17%	3%	14%	2%	12%	2%	10%	1%	8%	1%	5%	0%	3%	0%	1%	-1%	-1%
65-64	4%	23%	3%	21%	3%	18%	2%	16%	2%	13%	1%	11%	1%	9%	0%	6%	0%	4%	0%	1%	-1%	-1%
65-63	3%	26%	3%	23%	2%	20%	2%	18%	2%	15%	1%	12%	1%	10%	0%	7%	0%	4%	-1%	2%	-1%	-1%
65-62	3%	28%	3%	25%	2%	22%	2%	19%	1%	16%	1%	13%	1%	11%	0%	8%	0%	5%	-1%	2%	-1%	-1%
65-58	2%	38%	1%	34%	1%	30%	1%	27%	1%	23%	0%	19%	0%	15%	0%	11%	0%	7%	-1%	3%	-1%	-1%
65-56	1%	44%	1%	39%	1%	35%	1%	30%	0%	26%	0%	21%	0%	17%	0%	12%	-1%	8%	-1%	3%	-1%	-1%
65-51	0%	59%	0%	53%	0%	47%	0%	41%	0%	35%	0%	29%	0%	23%	-1%	17%	-1%	11%	-1%	5%	-1%	-1%
60-65	8%	15%	7%	13%	7%	11%	6%	10%	5%	8%	4%	7%	3%	5%	2%	4%	1%	2%	0%	0%	-1%	-1%
62-65	7%	17%	6%	15%	5%	13%	4%	12%	4%	10%	3%	8%	2%	6%	1%	4%	1%	2%	0%	1%	-1%	-1%
63-65	6%	18%	5%	16%	4%	14%	4%	12%	3%	11%	2%	9%	2%	7%	1%	5%	0%	3%	0%	1%	-1%	-1%
64-65	5%	20%	4%	18%	4%	16%	3%	13%	3%	11%	2%	9%	1%	7%	1%	5%	0%	3%	0%	1%	-1%	-1%

D Protection gap

Individual retirement pension for each individual until dissolution. Joint life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of dissolution until extinction. Individual life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of retirement until extinction.

	Minimum pensions	
	Men (x)	Women (y)
Retirement (with non-dependent spouse)	9.590,00	9.590,00
Retirement (without spouse)	10.103,80	10.103,80
Widow	10.103,80	10.103,80

Minimum pensions

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65-65	65	65	152.490,11	152.490,11	304.980,22	59.623,67	139.184,32	364.603,88	444.164,53
65-64	65	64	155.119,29	145.529,29	300.648,58	54.079,42	151.621,01	354.728,00	452.269,59
65-63	65	63	157.519,42	138.339,42	295.858,84	49.017,18	164.624,38	344.876,03	460.483,22
65-62	65	62	159.700,61	130.930,61	290.631,23	44.415,78	178.168,69	335.047,00	468.799,92
65-58	65	58	166.503,73	99.373,73	265.877,46	30.056,80	237.176,83	295.934,26	503.054,29
65-56	65	56	168.963,81	82.653,81	251.617,63	24.861,31	269.157,82	276.478,94	520.775,45
65-51	65	51	173.266,20	39.006,20	212.272,39	15.771,78	354.507,60	228.044,17	566.779,99
60-65	60	65	123.637,08	171.587,08	295.224,16	100.030,09	98.944,80	395.254,25	394.168,96
62-65	62	65	135.722,47	164.492,47	300.214,94	82.140,34	113.896,37	382.355,27	414.111,31
63-65	63	65	141.491,13	160.671,13	302.162,26	74.065,10	121.948,38	376.227,37	424.110,64
64-65	64	65	147.079,24	156.669,24	303.748,47	66.562,97	130.380,02	370.311,45	434.128,49

Individual retirement pension for each individual until dissolution. Joint life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of dissolution until extinction. Individual life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of retirement until extinction.

	Medium pensions	
	Men (x)	Women (y)
Retirement	19.162,78	12.814,62
Widow	10.628,94	7.334,04

Medium pensions

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65-65	65	65	304.706,40	203.764,63	508.471,03	78.180,36	161.472,71	586.651,39	669.943,74
65-64	65	64	309.960,04	194.463,24	504.423,28	70.910,59	175.900,96	575.333,87	680.324,25
65-63	65	63	314.756,00	184.855,80	499.611,80	64.272,82	190.986,63	563.884,62	690.598,43
65-62	65	62	319.114,46	174.955,79	494.070,26	58.239,32	206.699,87	552.309,58	700.770,13
65-58	65	58	332.708,48	132.787,96	465.496,44	39.411,39	275.157,33	504.907,84	740.653,77
65-56	65	56	337.624,23	110.446,01	448.070,24	32.598,91	312.259,62	480.669,15	760.329,86
65-51	65	51	346.221,27	52.121,96	398.343,23	20.680,43	411.276,95	419.023,67	809.620,18
60-65	60	65	247.052,15	229.282,92	476.335,07	131.162,50	114.789,40	607.497,57	591.124,48
62-65	62	65	271.201,23	219.802,76	491.003,99	107.704,91	132.135,26	598.708,90	623.139,25
63-65	63	65	282.728,20	214.696,50	497.424,70	97.116,42	141.476,68	594.541,12	638.901,38
64-65	64	65	293.894,37	209.348,98	503.243,36	87.279,40	151.258,53	590.522,75	654.501,88

Individual retirement pension for each individual until dissolution. Joint life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of dissolution until extinction. Individual life expectancies are used for the calculation.

Individual retirement and widow's pension from the time of retirement until extinction.

	Maximum pensions	
	Men (x)	Women (y)
Retirement	39.474,00	39.474,00
Widow	0,00	0,00

Maximum pensions

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)
65-65	65	65	627.674,09	627.674,09	1.255.348,18	116.470,27	271.885,91	1.371.818,45	1.527.234,09
65-64	65	64	638.496,22	599.022,22	1.237.518,44	105.640,01	296.180,04	1.343.158,46	1.533.698,48
65-63	65	63	648.375,56	569.427,56	1.217.803,13	95.751,32	321.581,13	1.313.554,45	1.539.384,25
65-62	65	62	657.353,70	538.931,70	1.196.285,40	86.762,82	348.038,90	1.283.048,23	1.544.324,30
65-58	65	58	685.356,43	409.038,43	1.094.394,87	58.713,66	463.306,78	1.153.108,53	1.557.701,65
65-56	65	56	695.482,54	340.216,54	1.035.699,08	48.564,67	525.779,20	1.084.263,75	1.561.478,28
65-51	65	51	713.191,85	160.555,85	873.747,71	30.808,96	692.503,45	904.556,66	1.566.251,16
60-65	60	65	508.910,33	706.280,33	1.215.190,66	195.401,12	193.281,09	1.410.591,78	1.408.471,75
62-65	62	65	558.655,76	677.077,76	1.235.733,51	160.454,86	222.487,84	1.396.188,37	1.458.221,36
63-65	63	65	582.400,51	661.348,51	1.243.749,02	144.680,51	238.216,82	1.388.429,53	1.481.965,84
64-65	64	65	605.402,06	644.876,06	1.250.278,12	130.025,67	254.687,39	1.380.303,80	1.504.965,52

Men (x)	Women (y)
Maximum	Medium

Couple to be analyzed

	Age		Couple pension wealth (joint status)			Pension wealth until extinction		Individual pension wealth		Home pension wealth	
	Man (x)	Woman (y)	ax	ay	axy	ax	ay	PW(x)	PW(y)	PW(x)	PW(y)
65-65	65	65	627.674,09	203.764,63	831.438,72	116.470,27	88.263,53	744.144,36	292.028,16	947.908,99	919.702,25
65-64	65	64	638.496,22	194.463,24	832.959,47	105.640,01	96.150,24	744.136,23	290.613,49	938.599,48	929.109,71
65-63	65	63	648.375,56	184.855,80	833.231,36	95.751,32	104.396,31	744.126,88	289.252,11	928.982,68	937.627,67
65-62	65	62	657.353,70	174.955,79	832.309,50	86.762,82	112.985,41	744.116,53	287.941,21	919.072,32	945.294,91
65-58	65	58	685.356,43	132.787,96	818.144,40	58.713,66	150.405,34	744.070,10	283.193,30	876.858,06	968.549,74
65-56	65	56	695.482,54	110.446,01	805.928,55	48.564,67	170.686,04	744.047,21	281.132,05	854.493,22	976.614,59
65-51	65	51	713.191,85	52.121,96	765.313,81	30.808,96	224.810,47	744.000,81	276.932,43	796.122,77	990.124,29
60-65	60	65	508.910,33	229.282,92	738.193,25	195.401,12	62.745,70	704.311,45	292.028,62	933.594,37	800.938,95
62-65	62	65	558.655,76	219.802,76	778.458,52	160.454,86	72.227,22	719.110,62	292.029,98	938.913,38	850.685,73
63-65	63	65	582.400,51	214.696,50	797.097,01	144.680,51	77.333,39	727.081,02	292.029,89	941.777,53	874.430,40
64-65	64	65	605.402,06	209.348,98	814.751,04	130.025,67	82.680,30	735.427,74	292.029,28	944.776,72	897.431,34

Individual pension wealth

	Men (x)	Women (y)
Min-Min	206.537	302.964
Min-Med	199.818	371.564
Med-Min	385.747	307.242
Min-Max	182.028	891.009
Max-Min	744.127	220.652
Med-Med	379.029	375.842
Med-Max	361.239	891.009
Max-Med	744.127	289.252
Max-Max	744.127	891.009

Individual annual pension wealth

	Men (x)	Women (y)
Min-Min	10.980	12.350
Min-Med	10.623	15.147
Min-Max	20.507	12.524
Med-Med	9.677	36.321
Med-Min	39.559	8.995
Med-Max	20.150	15.321
Max-Max	19.204	36.321
Max-Min	39.559	11.791
Max-Med	39.559	36.321

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