LISBON
SCHOOL OF
ECONOMICS &
MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

ACTUARIAL SCIENCE

MASTER FINAL WORK

PROJECT

A MORTALITY & LONGEVITY STUDY

THE PORTUGUESE CASE

TIAGO JOSÉ FARIA CORREIA

OCTOBER 2018

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SUPERVISION: ONOFRE ALVES SIMÕES

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Abstract

This work was developed with three main objectives: (i) to survey the current situation, regarding mortality/longevity in Portugal; (ii) to develop a brief study on the progress of mortality in the country, based on a similar project presented by Assia Billing in the Spring Meeting (Berlin 2018) of the International Actuary Association Mortality Working Group – a group that is dedicated to the study of mortality worldwide, paying particular attention to the impact it has on the insurance sector, namely on Life and Pensions [1]; (iii) to serve as support for the first Portuguese Country Report to be released by the Mortality Working Group,.

In the course of the study, demographic indicators, such as the evolution of the Portuguese resident population, the population pyramid, the aging index and the life expectancy, will be analyzed first.

Then, the focus will be set on the Portuguese insurance sector, with the analysis of indicators such as the production or the composition of investment portfolios. Next, we analyze Portugal's mostly sold insurance products, by type of contract. Regarding the mortality tables, it is worth mentioning those published annually by INE, as well as those that are most used by insurers operating in the national territory.

Finally, an analysis of the most recent progress in mortality in the country will be performed, following similar studies developed for other countries.

Keywords: Portugal; Mortality; Longevity; Solvency II; Retail Longevity; Protection Life; Investments**.**

[1] www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Agenda/MWG_Agenda_Berlin_May2018_Final.pdf

Resumo

Este trabalho foi desenvolvido com três objetivos principais: (i) fazer o survey da situação atual, no que diz respeito à mortalidade/longevidade no nosso país; (ii) desenvolver um estudo breve sobre os progressos registados na mortalidade em Portugal, com base num projeto semelhante apresentado por Assia Billing, no encontro da Primavera do *Mortality Working Group* da *International Actuarial Association* (Berlim, 2018) - grupo que se dedica ao estudo da mortalidade a nível mundial, dando particular atenção ao impacto que esta tem sobre o sector segurador, nomeadamente o ramo de Vida e Pensões; (iii) servir como suporte ao primeiro *Country Report* português, a ser divulgado pelo *Mortality Working Group*.

No decorrer do trabalho, e tendo em vista os três objetivos estabelecidos, irão ser primeiramente analisados indicadores demográficos, como a evolução da população residente portuguesa, a sua pirâmide populacional, o índice de envelhecimento e a esperança de vida.

Numa segunda parte, o foco incidirá sobre o sector segurador português, com a análise de indicadores como a produção ou a composição dos portfolios de investimento. Seguidamente, faz-se a análise dos produtos mais vendidos em Portugal, por tipo de contrato. No que diz respeito às tábuas de mortalidade, merecem destaque as que são publicadas anualmente pelo INE, bem como as que são mais utilizadas nas seguradoras que operam no território nacional.

Finalmente, desenvolver-se-á a análise dos progressos registados mais recentemente a nível da mortalidade no país, na senda de estudos similares desenvolvidos para outros países.

Palavras-Chave: Portugal; Mortalidade; Longevidade; Solvência II; Tipos de Contratos; Investimentos.

Acknowledgements

I am really grateful to my supervisor at ISEG, Professor Onofre Alves Simões, for all his precious attention, dedication and care for my work, giving me many of the support and motivation required to complete this work and consequently the Masters. Thank you, professor.

I want to thank my family, in particular to my aunt Dolores and my mother Gorete, for all the times I bored them talking about this work and for the support they gave me to finish it. I'm really grateful and sorry for taking so long to finish this.

I want to thank my boss Gorete for showing the utmost availability the various times I asked for vacations or time off the company to dedicate to this work.

And the bigger thank you goes to you, my girlfriend Yessica. Thank you for everything. Thank you for doing me food when I was working and didn't feel like eating. Thank you for hearing me when I was cursing everything (which were many times). Thank you for helping me while I was depressive (which were many times). Thank you for not letting me give up (which were many times). And above all, thank you for being who you are and what you are to me.

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Acronyms and Abbreviations

ASF – *Autoridade de Seguros e Fundos de Pensões*

EEA – European Economic Area

EIOPA – European Insurance and Occupational Pensions Authority

EoY – End of Year

EU – European Union

GDP – Gross Domestic Product

IAA – International Actuarial Association

IAA MWG – IAA Mortality Working Group

IAP – *Instituto dos Atuários Portugueses*

IMF – International Monetary Fund

INE – *Instituto Nacional de Estatística*

MCR – Minimum Capital Requirements

NRA – Normal Retirement Age

OLS – Ordinary Least Square

PPR – *Poupança para a Reforma*

SCR – Solvency Capital Requirements

SS – Social Security

US – United States

1. Introduction

1.1. Motivation

Mortality and longevity are topics of great interest all around the world. The understanding of the behavior of mortality rates from other countries can help demographers with the identification of their own countries current and future tendencies which, on another hand, can help them and actuaries to better execute their tasks. An accurate interpretation and forecasting of future mortality rates can bring many benefits to the society, including the disclosure of better population projection estimates and a more suitable estimation of the cost of pensions and annuities and of the resources required to finance them.

Throughout this work three main purposes will be addressed: (i) a survey of the current situation, regarding mortality/longevity in Portugal; (ii) a study on the progress of mortality in the country based on a similar project presented by Assia Billing[2] in a meeting[3], held in Berlin 2018, sponsored by the International Actuarial Association Mortality Working Group's (IAA MWG); and (iii) a basis for the first Portuguese Country Report to be released by the Mortality Working Group[4].

The IAA MWG is an international institution devoted to the worldwide study of mortality, and particularly to the impacts it has in the insurance sector, including life insurance and pension benefits. This organization can study either the general population of a country or its insured people. Many are the tasks of the MWG and one of the outputs they provide are the Country Reports. A Country Report is a country specific mortality study submitted to the MWG.

Many are the countries that have already submitted at least one Country Report – more than one is submitted to update the information given, for instance, in the New Research and Research in Progress sections – but Portugal is one of the countries that haven't. This is the reason why one of the aims of the project is to culminate this shortfall.

[2] https://www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Agenda/3_Recent_Trends_in_Mortality_Canada_ABillig.pdf
[3] www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Agenda/MWG_Agenda_Berlin_May2018_Final.pdf
[4] https://www.actuaries.org/iaa/IAA/Committees/Scientific/Mortality/IAA/Committees/Scientific/Mortality_Working_Group.aspx

1.2. Literature Review

Demography, as Leeson (2011) states, is the statistical study of human populations. This science primary objectives are to estimate the number of resident people in a certain area at a given point in time, notice what changed in the studied population from time to time and make future total resident population projections. According to Manuelli and Seshadri (2007), the most important variable dictating population growth rates is the economic development of the studied area, but its urbanization, migration, mortality, fertility characteristics and composition by each age group and gender are also important for understanding the study group and achieving quality projection results.

One of the main concerns of demographers nowadays is the population ageing, cf United Nations (2007). Population ageing happens when fertility rates decrease and the life expectancy of a population increases. Kannistö (1994) detailed that we were entering in an era of "delayed ageing", after pointing out that mortality in older age groups of developed countries reached levels lower than all previous records.

According to Wilmoth (2000), life expectancy improvements are the result of a drop-in mortality rates at all ages. Cheung *et al.* (2005) declared that the "rectangularization" effect of the more developed countries' survival curves is being replaced by a parallel shift to the right, implying mortality rate improvements at every age and not only in the older age groups.

Keilman (2008) concluded that since 1980 the European resident population projections became less accurate. The sudden drop in fertility rates and, most importantly, the remarkable increases in life expectancy took most demographers by surprise (Keilman and Phan (2004)). O'Brien *et al.* (2005) concluded that the more relevant Great Britain population projections at the time underestimated the life spans of males and females by four and six years, respectively.

According to Hajnal (1955), understanding the past of a population is an important part to theorize about future tendencies, but, as stated by Booth and Tickle (2008), mortality assumptions were too much based on past tendencies and so population forecasts became less accurate. Ensoy (2014) concluded that assuming overly simplistic assumptions for any demographic related variable will most likely lead to flawed

projections, arguing that more flexible models are required to obtain better forecasting results.

Increases in longevity bring some risks attached that can heavily affect the financial soundness of a pension system. Stallard (2006) defines longevity risk as the risk that a single or a group of individuals' lives longer than what they were assumed to, resulting in an insufficient provisioning, by firms and Social Security (SS) systems, made to care for this occurrence. Chapman (2008) observed that UK firms incurred in losses of about 75-billion-pounds sterling for having underestimated for how long people would live.

Naturally this has been a topic of discussion internationally, since many developed countries provide some retirement related pensions; in 1994 the World Bank already alerted for the need of a reform, as a measure to accommodate for the not foreseen longevity improvements, see World Bank (1994).

Measures were indeed taken, with OECD (2013) considering that nearly all its member countries had made some reforms to their pension systems, most of them focusing on the normal retirement age. This makes sense as, according to Rodway (2010), the cost of a pension plan can be greatly reduced by increasing the eligibility age. However, in spite of this being the most natural measure, according to Feldstein and Liebman (2002), it can to some extent benefit higher socio-economic groups in detriment of the lower ones, since people with higher incomes usually have longer life spans.

Another important topic of discussion relating longevity improvements is whether they will have an upper limit. There are both the optimistic and the pessimistic opinions relating this topic. An example of the optimist perspective is in Oeppen and Vaupel (2002), who found that the best-practice life expectancy has increased by 2.5 years per decade in the last century and half. Best practice life expectancy is the maximum life expectancy observed among nations during a particular year. An example of the pessimist view is in Fries (1989) who provided evidence that 85 years is the limit to human life expectancy. On the other hand, Bongaarts (2006) stated that the only way to break the natural limit of life expectancy is by the usage of medical interventions.

1.3. Portuguese Research

This section is reserved to grapple some recent Portuguese studies. Three different studies will be addressed: INE's Population Projection covering the 2015 – 2080 period, (INE (2017b)), which is of great general interest, and two works relating mortality to life insurance, Ferreira (2015) and Barradas (2016). It should also be remarked that INE publishes mortality and longevity data on an annual basis, covering the topic in a rather systematic way.

In 2017, see INE (2017,b), the projection of the resident Portuguese population, by age and sex, referring to the 2015-2080 period, has been published, Given the natural uncertainty of population projections, four different scenarios were set, based on different combinations of demographic related projected variables. These were named optimist, pessimist, central and no-migration scenarios. Only the central scenario results will be displayed in this paper due to dimension constraints.

This study concluded that the decreasing tendency of the Portuguese residential population will continue at least until 2080, without any growth between the years of 2016 and 2080. Table 1 shows the resulting projected population of this study split by young people aged between zero and 14 years old, the active population with ages between 15 and 64 and the elderly aged over 65. In 2015, the total Portuguese residential population was estimated to be around 10.3 million and in 2080, it is projected to have decreased by 27.7%, to around 7.5 million people. This decrease is contrasting with the 29.9% increase in people aged above 65 years. It should be remarked that this decreasing trend is present in all scenarios.

Table 1: 2080 Ageing Index and Sustainability Ratio Projection

Age Group	2015	2080	Variation (%)
0-14	1.460.832	876.510	-40,0%
15-64	6.739.674	3.819.812	-43,3%
65+	2.140.824	2.781.864	29,9%
Total Population	10.341.330	7.478.186	-27,7%
Ageing Index	**1,47**	**3,17**	**116,6%**
Sustainability Ratio	**3,15**	**1,37**	**-56,4%**

Source: INE's Population Database[5]

[5] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0009098&contexto=bd&selTab=tab2

Regarding the young population, according to INE (2017b), the reduction of women in fertile ages will greatly affect the number of new-births, despite the central scenario's projected improvement of the fertility rates and migratory balances. Indeed, throughout the 2015-2080 periods, the total population aged between 0 and 14 years old is projected to have decreased by 40,0%. Referring to the working population, the people aged between 15 and 64 years old, in the studied period, is projected to decrease by 43,3% of their 2015 total.

On the other hand, the increasing tendency of the elderly population will continue, with a total increase of 29.9%. According to the graph, the population with ages higher than 65 years old will only stabilize, and even decrease, after 2040. Following INE (2017b), this behavior is explained due to the lesser amount of population entering this age group, due to the minor number of new births projected.

According to the projected decrease of the number of youngsters and increase of the elderly, between 2015 and 2080, the ageing index is projected to more than double, from 147 to 317 elderly per 100 youngsters. The second measure that should be remarked is the sustainability ratio, calculated as the amount of people aged between 15 and 64 divided by the number of people with ages higher than 65. This ratio is projected to decrease from 315 to 137 active people per 100 elders, which will then increase the current strain on the Portuguese Social Security system. Table 1 summarizes all these results.

Ferreira (2015) analyzed the homogeneity/heterogeneity of the Portuguese population in line with the work of Vaupel *et al.* (1979) and Su & Sherris (2012). The unobservable heterogeneity question is addressed as the frailty of individuals, which are unobservable risk factors and consequently not evidenced in casual mortality tables. Following Knox and Tomil (1997), an inappropriate allowance for a mortality heterogeneity assumption may lead to annuities only becoming attractive to higher socio-economic groups or, according to Meyricke and Sherris (2013), to an insufficient funding of annuity obligations.

In Ferreira (2015), the frailty models were applied to 1950-1960 Portuguese population data, introducing this qualitative variable. The key conclusion is that heterogeneity is mainly present in the younger age groups, since the natural selection of

individuals takes care of removing the more fragile lives, leaving the less fragile alive, which explains why the older age groups are less heterogeneous. The mortality table resulting from the study was compared to other three different mortality tables, INE 2011/2013, TV88/90 and GRF95, using $\ddot{a}_{65}$, the actuarial value of a life annuity paying 1 each year to a live currently aged 65. The results show that INE 2011/2013 tables supply amounts substantially lower for both genders, TV 98/90 tables also, but with a better adjustment for males, and GKM/F 95 tables give values closer to those of the table including heterogeneity, for both genders.

Barradas (2016) explored the adverse selection explanation to the "annuitization puzzle" problem and tried to reach some conclusions regarding the mortality of impaired lives using SHARE. SHARE is a cross-national longitudinal panel database providing information on health about people, aged 50 or older, from nineteen European countries, including Portugal, and Israel. It stores information on all respondents and of all currently released data collection waves in one single dataset.

Barradas (2016) explained that life insurers charge higher premiums than supposed, assuming that only people with a higher than average life span will buy life annuities, making the prices to be unfair, and maybe unpayable, to people with shorter life spans, in particular those who have been diagnosed with some critical illness.

The first step of this study was to estimate the survival curve of impaired lives with different medical conditions. Two approaches were followed in order to calculate the mortality rates, one more hypothetical and the other more realistic. The first considered that the individuals may only die from the medical condition they were diagnosed with and the second assumes that all possible causes of death are possible. It was possible to conclude that largest gaps in mortality rates are only significant for elderly individuals, which means that the mortality of younger age groups is mostly explained by the diagnosed disease. This makes sense as older age groups tend to be more affected by more health problems than the younger age groups.

On the second stage of the study, the survival curves for the impaired lives were compared to those in GKM95 and GKF95 mortality tables, which are some of the most used mortality tables in the Portuguese life insurance system. It was found, not surprisingly, that the survival rates of impaired lives are generally lower than those

obtained with the GKM/F95 tables, with this gap increasing with age and time from diagnosis.

1.4. Organization of the Text

The outline of the text is as follows. After this introductory Chapter 1, Chapter 2 presents historical Portuguese demographic data, alongside with some conclusions that can be taken from it. Next, more mortality related data will be addressed as well as the expected life expectancy improvements underlying the Portuguese general population mortality rates.

Chapter 3 focuses on the Portuguese Life Insurance market as a whole, covering topics such as the current national, international and regulatory environments surrounding the Portuguese Life Insurance Market and how it has been performing under this environment, in terms of production and assets.

Chapter 4 classifies life insurance contracts into protection life and retail longevity and provides an analysis of the types of insurance contracts currently commercialized in Portugal, and their characteristics. A breakdown of the most used mortality tables is also given. Additionally, there is an enumeration of the insurance sector most relevant Portuguese organizations.

Chapter 5 contains an original study on the past and current progresses of longevity and mortality improvements in Portugal, following a similar project for Canada presented by Assisa Billing[6] in the Berlin 2018 meeting of the WMG[7].

[6] https://www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Agenda/3_Recent_Trends_in_Mortality_Canada_ABillig.pdf

[7] https://www.actuaries.org/iaa/IAA/Committees/Scientific/Mortality/IAA/Committees/Scientific/Mortality_Working_Group.aspx

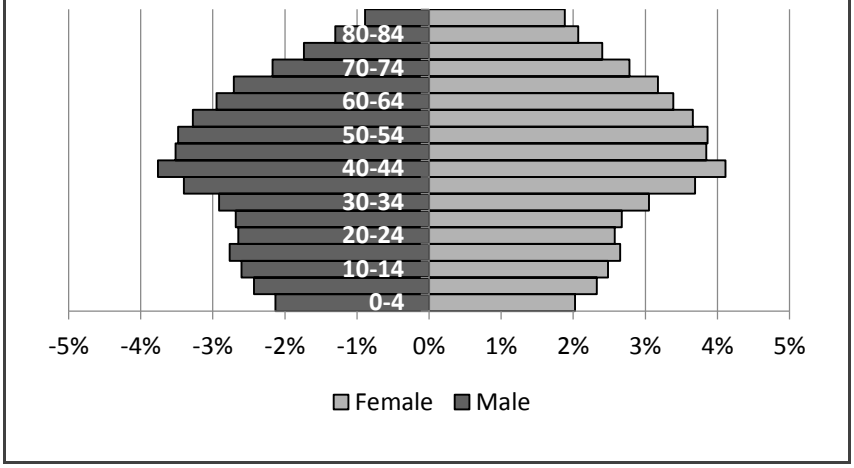
2. General Population

2.1. Basic 2016 Demographic Statistics

At the end of 2016, the Portuguese resident population was estimated to be of 10.309.573 individuals, 4.882.456 males and 5.427.117 females. It is estimated that their overall life expectancy at birth is 80.6 years, 77,6 years for males and 83,3 years for females. The Portuguese people can expect to live more 19,3 years after reaching 65 years old, men 17,4 years and women 20,7 years. Following the usual methodology, a breakdown by gender of these statistics is presented in Table 2, alongside with a graph showing the country's population pyramid by age group.

Table 2: Portugal Basic Information

Current population (31/12/2016 estimate)	Overall: 10.309.573 Males: 4.882.456 Females: 5.427.117
Current period life expectancy (years)	
At birth: - Overall: 80,6 - Males: 77,6 - Females 83,3	**At 65:** - Overall: 19,3 - Males: 17,4 - Females: 20,7
Population Pyramid	



Source: INE's Population[8] and Mortality Database[9]

[8] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0007307&contexto=bd&selTab=tab2
[9] Life Expectancy at Birth: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0001724&contexto=bd&selTab=tab2
Life Expectancy at 65: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0001723&contexto=bd&selTab=tab2

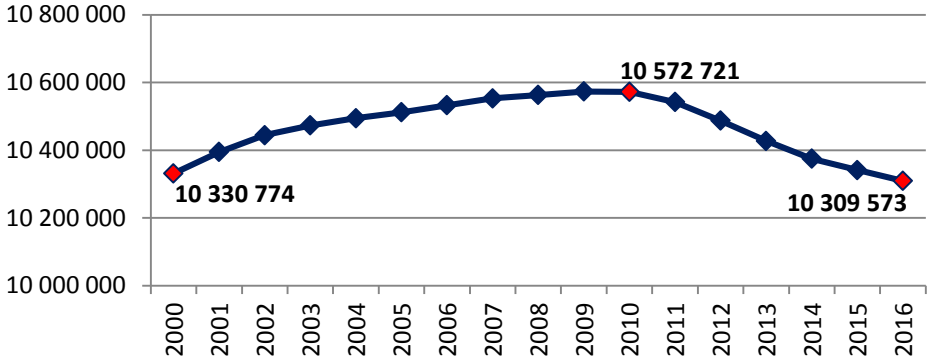
Comparing the Portuguese demographic pyramid with that of the European Union, see Appendix 1, some conclusions can be taken. Starting from the bottom of the pyramid, the total percentage of the Portuguese population aged between 0 and 19 years old is 19,4%. For the EU member countries, the percentage is 20,9%, a difference of 1,5 percentage points. These figures can be explained by the low Portuguese fertility rate, which, according to EUROSTAT[10] is the second lowest of all the 28 EU countries, just after Poland.

On the other hand, it is important to notice what happens in the non-working ages higher than 70, with the Portuguese total of 21,1% compared to the EU 19,4%, a difference of 1,7 percentage points. These figures make the Portuguese ageing index the third highest of the EU, according to EUROSTAT statistics[4], after Italy and Germany.

2.2. Evolution of the Resident Portuguese Population - 2001-2016

To make future population projections it is necessary to understand how the structure of the resident population of a country has been changing. With this intuition, Graph 1 shows how the Portuguese population has been developing since 2001, with end of year (EOY) resident population estimates. Between 2001 and 2016 it is estimated that the Portuguese population has decreased by 21.201 individuals representing a total decrease of 0,2%. As it can be seen in the graph, in the inter censitary periods from 2001 the population has increased 2,34% in the first 11-year period, and decreased by 2,4%, in the next 6-year period. The necessary data to build Graph 1, by gender break, is in Appendix 2.

Graph 1: Portuguese Resident Population 2001-2016



Source: INE's Population Database[11]

[10] http://ec.europa.eu/eurostat/statistics-explained/index.php/People_in_the_EU_-_statistics_on_an_ageing_society
[11] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0007307&contexto=bd&selTab=tab2

According to INE (2017a), the reductions of both the natural growth rate and the migratory balance characterize the dynamics of the current negative population growth observed in Portugal.

Carrilho and Craveiro (2015) stated that the increase in female autonomy (women starting working outside home, not just taking care of children), the difficulty in finding a good work-life balance and the increased generalized accessibility to safe contraceptive methods are all reasons to postpone the decision of having children. Additionally, the late entry of the young into the employment market and the growing unemployment rate observed in younger age groups are all factors that heavily weight on a family's decision to have children and contribute to the weak Portuguese natural growth rate.

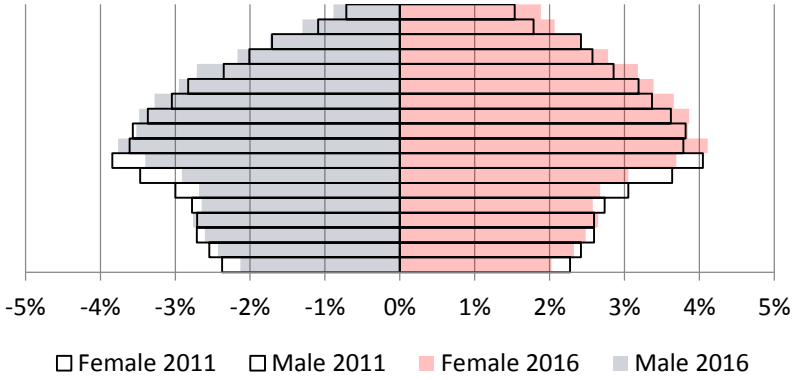
2.3. Portuguese Population Age Structure

The United Nations report (2015) shows that the whole world is currently facing the challenge of population ageing. This phenomenon started in developed countries but more recently it is starting to spread to the less developed ones. This phenomenon is the consequence of the reduced fertility rates that are observed worldwide and the improvement of the individuals' standard of living, which leads to the extension of life expectancy. Of course, this is the ultimate goal of a society, but there are consequences and some problems arise when a country's population lives longer. According to Lima-Costa (2003), the biggest challenge faced by countries is the growing demand for healthcare and financial resources required by the elderly, with the goal of helping them to preserve their standards of living.

Following Ramos, Veras and Kalache (1987), the dimension of population ageing can be observed analyzing the age pyramid. A country facing this challenge has its population pyramid transformed from a growing population model, with a pyramidal shape, with bigger columns at the bottom and smaller columns at the top, to a "stabilized" model, having a more "barrel" or rectangular shape, with a smaller bottom, and more evenly distributed. These patterns are observed in Graph 2, where the Portuguese population pyramid in 2011 is compared to that of 2016. The bottom columns referring to the ages 0 to 40 are smaller in 2016 than they were in 2011, with their relative importance spreading throughout higher ages. The older age groups, referring to ages above 65 verified the

largest relative growth, corresponding to a 27,1% total increase, which visibly represents Portugal's population ageing challenge.

Graph 2: 2016-2011 Portuguese Population Pyramid



Source: INE's Population Database[12]

A decrease in both the total percentage of the young and the working populations is also observed, which, in turn, puts even more pressure in the country's Social Security system, having to finance retirement of more elderly people with less financial resources. The total amount of population with ages between 0 and 14 years reduced by 13.6%, and the number of the aged 15 to 64 noted a decrease of 3.6%, from 2001 to 2016.

Another index worth analyzing is the ageing index. This index is defined as the ratio between the number of people with more than 65 years divided by the number of people aged 14 or less. It is usually interpreted as the number of elderly people by one hundred juveniles. Table 3 shows the ageing index figures between 1970 and 2016. In 2016, there were 151 elders for each 100 youngsters. Since 2001, this index increased by 47,1%. To be noted also the 344,2% remarkable increase observed since 1970. In 1970 there were only 34 elders for each 100 youngsters, reflecting the high fertility and mortality at the time.

Table 3: Portuguese Ageing Index 1970-2016

Year	Ageing Index (‰)	Year	Ageing Index (‰)	Year	Ageing Index (‰)	Year	Ageing Index (‰)
1970	34,0	**2002**	104,0	**2007**	113,8	**2012**	131,1
1980	44,9	**2003**	105,5	**2008**	116,4	**2013**	136,0
1990	68,1	**2004**	107,6	**2009**	119,3	**2014**	141,3
2000	100,6	**2005**	109,3	**2010**	123,9	**2015**	146,5
2001	102,6	**2006**	111,5	**2011**	127,6	**2016**	150,9

Source: INE's Population Database[13]

[12] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0007307&contexto=bd&selTab=tab2
[13] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008851&contexto=bd&selTab=tab2

2.4. General Population Mortality Tables

Following Arias (2002) description, there are two types of mortality tables: the cohort mortality table and the period mortality table:

- The cohort table follows the total lifetime of a cohort (a sample of individuals), through consecutive ages in successive calendar years, without allowance for new entries or exits other than death. The death rates arising from this experience are the actual age-specific rates observed in that sample. To prepare cohort mortality tables, it is required the collection of data throughout many years, and all observed members must die. When this finally occurs, the observed death rates may not be the current ones, given the worldwide increase in life expectancy.
- Period tables do not rely in the observation of a real cohort. Instead, they present what would happen to a hypothetical cohort if it experienced, throughout its lifespan, the mortality conditions observed in a particular period of time, representing then a "snapshot" of the current mortality experience.

INE publishes annually two-yearly types of period life tables with total and gender specific mortality rates, in two versions: complete and abridged. Complete tables contain information about each age individually, from 0 to 100, whereas the abridged ones present mortality rates for age groups. In Appendix 3, the mortality tables published in 2017 are displayed.

The life tables published by INE require the collection of data from three consecutive civil years: t, $t+1$, $t+2$, registering information about each year's number of deaths, new births and resident population estimates. Appendix 4 contains a full description of how these are calculated.

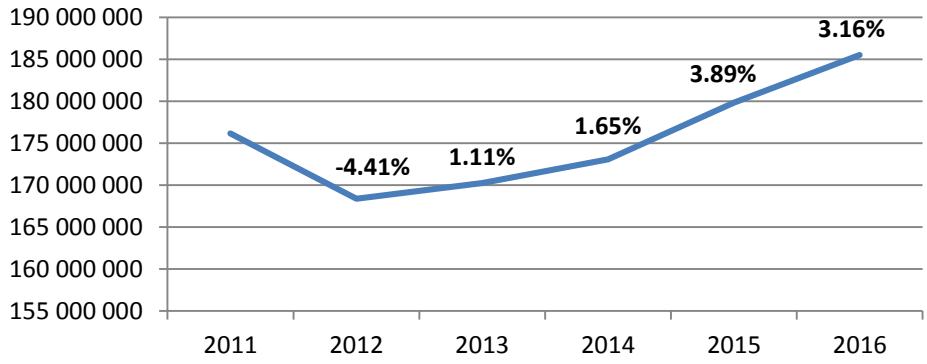
3. The Portuguese Life Insurance Market

3.1. National and International Environments

Following ASF (2016a), the year of 2016 was definitely a turbulent year. The UK's decision to leave the EU, the election of Donald Trump as the President of the United States (US), the terrorist attacks and the new wave of refugees entering the EU were all events that are having financial and economic repercussions which will certainly be felt in the medium-long term.

Naturally, all this political instability impacted the Portuguese economy. Graph 3 plots how the Gross Domestic Product (GDP) developed throughout the 2011-2016 period, in 2011 prices. Portugal's GDP has been steadily increasing since 2013, but in 2016, it recorded a growth of 3,16%, 0,73% lower than the one registered in 2015.

Graph 3: Portuguese GDP 2011-2016



Source: INE's National Account Database[14]

The Associação Portuguesa de Seguradores (2017) identifies the good performance of the Portuguese domestic demand, and mostly of its exports component, as the main responsible for the dynamics observed in Graph 3. The observed growth of the country's private consumption should also be remarked, as it was potentiated by the consecutive increases of the minimum salary wage after 2014. However, this variable grew more than the disposable income, which implies a reduction of the household's savings rate. Since many life insurance products depend on savings, a decrease on these will often lead to a production decrease of the life insurance sector.

[14] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=cn_quadros&boui=220636512

Moreover, according to Associação Portuguesa de Seguradores (2014), in 2016, the European Central Bank continued with its accommodative stance regarding the monetary policy, maintaining the current low and volatile interest rate regime, which has been characterizing the European financial markets over the last years. This regime poses a serious challenge to the insurance business as a whole, given that an insurer's profitability heavily depends on the performance of the investment's portfolio.

In particular, given the size and long-term nature of the life insurance segment responsibilities, more assets and with higher maturities need to be allocated, meaning that the investment portfolio is exposed to market fluctuations for longer periods.

Furthermore, many life-insurance products contain some kind of financial guarantees, dependent on interest rates. The lower the interest rate regime, the lower the guarantees the insurance companies can provide, the lower the attractiveness of their products and the more difficult it becomes to create new successful products.

3.2. Solvency II

The year of 2016 was also the year of the coming into force of the new European regulation regime named Solvency II. Following ASF (2016a), Solvency II forced the inclusion of new prudential requirements that restructured the national insurance sector as a whole with the goal of reinforcing its stability, competitiveness and good functioning, the ultimate objective being the protection of policyholders.

Correia (2017) explains that this regulation came as a way to ensure the financial soundness of the insurance sector, boosting its transparency, encouraging superior management and greatly harmonizing the supervisory practices of the EU's insurance sector. It is a regulation more sensible to the risks effectively assumed by the insurance companies, with a strong emphasis on internal government, transparency and market discipline.

Following the Delegated Regulation 2015/35, the Solvency II regime characterizes itself by having three different components named "Pillars". Pillar I defines the quantitative requirements and is addressed in detail throughout this section. Pillar II defines the qualitative requirements of the regime, focusing more on governance, risk management, internal controls and on the supervisory review process. Pillar III establishes the disclosure and market discipline procedures, comprising the guidelines

about the reporting and disclosure of information, transparency and harmonized reporting procedures to the supervisors.

First, Pillar I gives orientation on how to calculate two different capital requirements: the Solvency Capital Requirements (SCR) and the Minimum Capital Requirements (MCR). According to the European Union (2015), the SCR is defined as the amount of own funds the insurer needs to hold to be able to absorb losses resulting from unexpected events with a 99.5% confidence level over a one year time horizon. The MCR is the minimum amount of own funds the insurer needs to hold, under which it is considered that the policyholders are on an unacceptable level of risk and immediate supervisory action should be taken.

Second, this Pillar also specifies which kind of own funds are eligible to cover the SCR and the MCR. The own funds are classified in three tiers depending on their quality/limitations to cover losses, ranked from I (highest quality) to III (lowest quality) depending on the availability to cover for losses, of the financial instruments which they are constituted. Tier I correspond mainly to unrestricted usage funds like stocks, since this financial instrument is always available to cover for insurance losses. Tier III are the lowest quality funds with the more restrictions to their usage and cannot cover the MCR.

This Pillar further requires that insurers must value their assets and liabilities on a market value basis instead of on an accounting basis. Under this regime, the technical provisions are divided into the Best Estimate and the Risk Margin components. The Best Estimate represents the present value of the liabilities and should be discounted using the risk-free yield curve published by the European Insurance and Occupational Pensions Authority (EIOPA). This new requirement normally leads to an increase of the liabilities, especially of the life technical provisions since, on an accounting basis, they are usually discounted at a rate higher than the risk-free interest rate. The Risk Margin should be equivalent to the extra amount another insurer would be expected to want to receive, in order to take over and meet the insurer's obligations to the beneficiaries and policyholders.

Following Bølviken (2016), the SCR formula attempts to find an amount of capital requirements that is sensitive to all the risks an insurer can face and will also take into consideration any risk mitigation techniques adopted, such as the diversification

technique. This amount may be calculated either with the European Standard Formula or with an internal model, developed by the insurer and validated by the supervisory authority.

The most relevant risks in the life insurance sector are the market risk and the life underwriting risk, which make the most of the total amount of the SCR. The SCR is also more sensitive to the risks of financial guarantees than the previous regulatory regime, discouraging the offer of high guarantees and hampering the innovation of new insurance products. The reason for the SCR's inclusion of this component is that if in some year the insurer's investments profitability greatly underperforms, when compared to the minimum guarantees offered, the insurer will incur in a big loss and may not be able to meet all its responsibilities towards the policyholders.

On the other hand, the MCR is the result of a linear formula that, for life insurance, includes the amounts of the technical provisions and capital at risk multiplied by specified factors defined in the Solvency II legislation. The MCR is limited between 25% and 45% of the SCR, as a way of ensuring that both capital requirements remain in appropriate ranges.

The market value valuation approach leaves the insurer's balance more volatile, given the increased exposure to interest rate variations and, in particular, to the instable characteristics of a low interest rate regime. As the amount of own funds is mainly the amount of equity of an insurance company, they also depend on the insurers' total assets and liabilities since $Equity = Assets - Liabilities$. This means that, under this valuation approach, the coverage ratio of the SCR and of the MCR also becomes more instable, given that it is calculated as follows: $Coverage\ Ratio = \frac{Eligible\ Own\ Funds}{Capital\ Requirements}$.

3.3. Life Insurance Production

Before showing how the performance of the Portuguese life insurance business developed all over the years, it is important to make a distinction between the main types of contracts commercialized in Portugal. These can be categorized into investment, insurance and "*Poupança para a Reforma"* (PPR) contracts.

The International Actuarial Association (2005) defines an investment contract as "any contract that gives rise to both a financial asset of one entity and a financial liability or

equity instrument of another entity". The main difference between this and an insurance contract is that the investment contract does not contain any significant coverage of an insurance risk like mortality, longevity, disability or sickness. Despite not having any specific coverage, investment contracts are usually only possible to be claimed during the lifespan of the beneficiary.

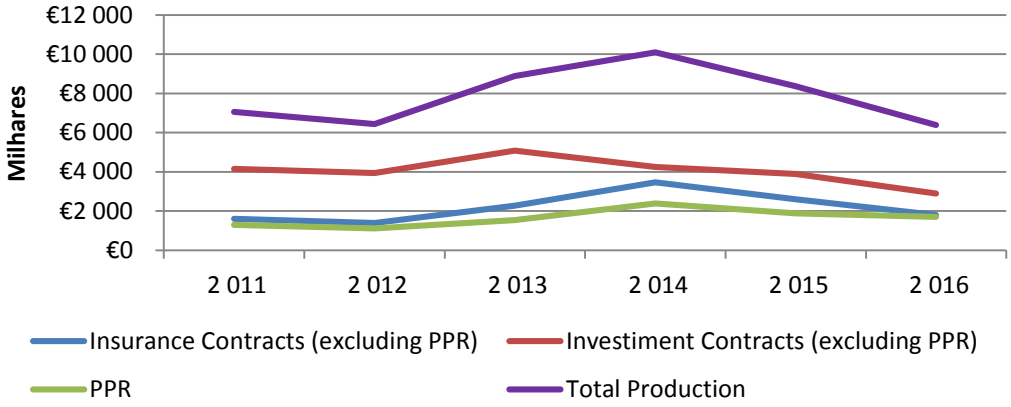
Associação Portuguesa de Seguradores (2009) states that a PPR is a Government defined long-term savings product, with its specific legislation – Portuguese Decree Law 158/2002 – with the goal of financing the retirement of purchasers. The contributions to this kind of contract are usually made by the participant or its employer. Despite being a savings contract proposed to enhance the income of retirees, retirement is usually not the only way the participant has to make a claim. The conditions to be able to claim may be, for example, after the policyholder hits 60 years old or if he/she incurs in long term unemployment, permanent disability or a serious disease. Additionally, a PPR usually offers a minimum guaranteed yearly return on the policyholder's investment. Depending on the covers offered, a PPR contract can be subdivided into investment or insurance contract. Depending also on the amount to be received, a PPR can be either claimed as a lump sum or as an annuity. Throughout this section, given their dimension in the Portuguese life insurance market, all PPR contracts are aggregated and differentiated of other investment and insurance contracts. In Portugal these contracts are called: *Seguros de Capitalização*.

According to ASF data[8], the production dimension of capitalization operations and certain annuities in the Portuguese life insurance market is minimal, so they were excluded from this analysis. In these two types of contracts the insurer promises to pay the policyholder a certain pre-defined amount, after a certain period of years, in exchange for single or periodic premiums, irrespective of the life status of the policyholder. The difference between a capitalization operation and an annuity certain lies in their payment schemes, which are lump sums, in the case of capitalization operations and as series of payments, in the case of certain annuities.

Graph 4 plots the total production of direct life insurance by: (i) insurance, (ii) investment and (iii) PPR type of contracts, throughout the 2011-2016 periods. The total production of the contracts sold by insurers is measured by the amount of gross premium collected. Direct insurance contracts are contracts made between an insurance company

and a policyholder. Indirect insurance contracts are made between an insurer and a reinsurer. Throughout this text, when production is referred, it stands for direct insurance production. The necessary data to build Graph 4 is presented on Appendix 5.

Graph 4: Life Insurance Production 2011-2016



Source: ASF Insurance Statistics Database[15]

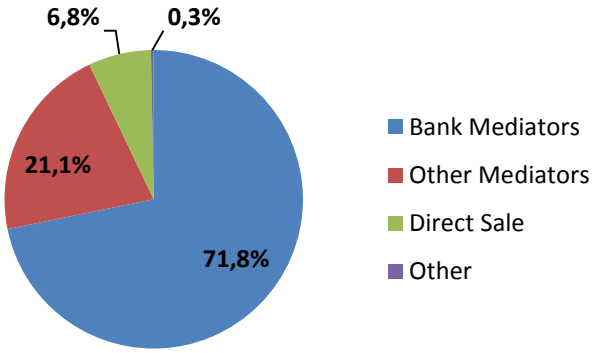
The life insurance sector accompanied the GDP recovery in 2013, registering a production growth of 38,2%. However, in 2014, this growth decelerated to 13,6% leading up to a production drop of 17,3% in 2015 and 23,5% in 2016. These results were potentiated by the low attractiveness of the offered insurance guarantees and the low Portuguese savings rates, as mentioned by ASF (2016b), which greatly affect the amount of premiums collected. The total production of investment contracts registered a decrease of 8,5% and 25,5% in 2015 and 2016 respectively. On the other hand, insurance contracts registered a decrease of 25,0% in 2015 and 30,8% in 2016. Last, the production of PPR contracts also experienced a decrease in the premium collection of 21,6% in 2015 and 9,4% in 2016, less than the reduction in the investment and insurance contracts.

It can be seen that that the investment type of contracts accounts for the biggest share of the total Portuguese life insurance production in 2016 and PPR contracts have equivalent shares of gross premium collected. While analyzing these results, it is important to keep in mind that in 2016 the total production of life insurance was of 6.388.365 thousand of euros. The investment contracts accounted for 45,3% of the total life insurance production. Insurance and PPR accounted for 28,2% and 26,5% respectively.

[15] http://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm

Regarding the commercialization of life insurance in Portugal, Graph 5 shows the percentage of total production divided by the distribution channel that was responsible for it. The banks traditionally have a big share in the commerce of life insurance, and in 2016 they were responsible for 71,8% of the total production underwritten. The other mediators, such as insurance brokers, agents or reinsurers, which are not bank related, commercialized 21,1%. Only 6,8% of the total production was commercialized directly through the insurer's counters or by telephone.

Graph 5: 2016 Life Insurance Distribution Channels



Source: Associação Portuguesa dos Seguradores[16]

3.4. Investments

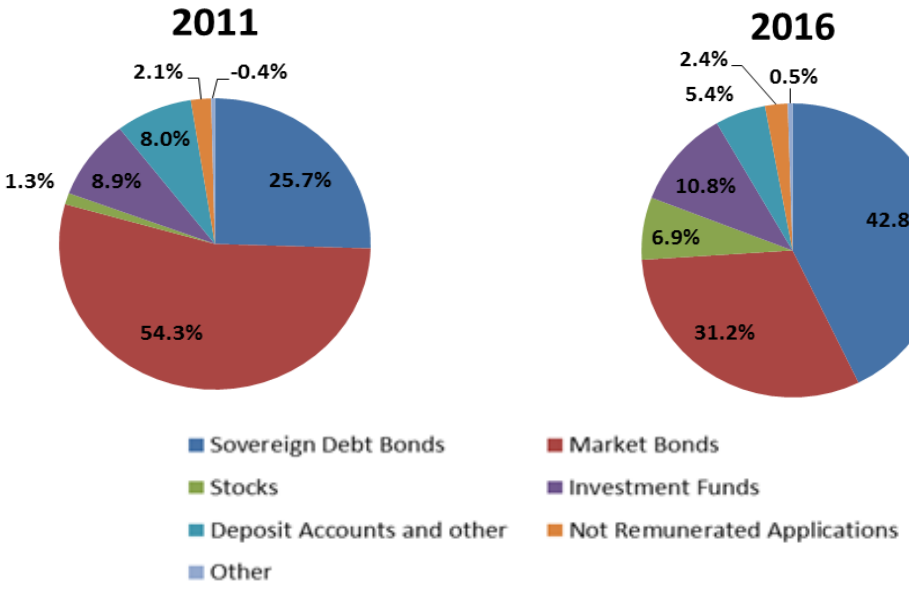
According to *Autoridade de Seguros e Fundos de Pensões* (ASF) data[17], at the end of 2016, the total life investment portfolio was close to 40.4 billion, corresponding to 21,7% of that year's GDP. This value, see Associação Portuguesa de Seguradores (2014), places the life insurance segment among the top institutional investors in Portugal and proves the large importance that this business has in the Portuguese economy. An institutional investor is a nonbank, singular or collective, person that trades such a large amount of financial instruments, (in currency or quantity) that qualifies for preferred regulation treatment and the possibility of benefiting from lower trading taxes and commissions[18].

Disregarding all constraints, life insurers still try to manage their financial applications seeking the best possible profit but, with the emergence of the Solvency II regime, they have also to consider the minimization of capital requirements. Graph 6

[16] http://apseguradores.org/encontroresseguros/wp-content/uploads/2018/01/Seguros-em-Portugal-2016-2017.pdf
[17] http://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm
[18] https://www.investopedia.com/terms/i/institutionalinvestor.asp

shows how the investments of life insurance companies were structured at the end of 2011 and 2016.

Graph 6: Investments - Life Insurance Sector 2011-2016



Source: ASF Insurance Statistics Database[19]

The main type of financial instrument the Portuguese life insurers invest in are bonds, with total investment portfolio's shares of 80,0% and 74,0%, in 2011 and 2016 respectively. Between these periods, there was a total decrease in the share of the investment on this financial instrument of 6,0%, contrasting with a relative increase of 5,6% in the stock investment. As stocks usually have a higher expected return than bonds, since they are riskier, investing more in stocks rather than in bonds may be a consequence of the current low interest rates. A note should be made about the need an insurer has of making its investments profitable. If the investment performance is lower than the offered guarantees they may incur in big losses, depending on the differential. The total share of the investment on this kind of security ascended to 6,9% in 2016 and the investment funds accounted for 10,8% of the total portfolio, an increase of 1,9%, when compared to 2011.

Attention should be given to the structure of the bond investment. In 2011, the investment in sovereign debt bonds totaled 25,7% of the life insurers' portfolio. In 2016, this percentage increased to 42,8%, despite the 6,0% relative decrease of the total bond investment. This growth contrasted with the disinvestment in corporate bonds, since, between 2016 and 2011, the total share of this investment decreased by 23,2%, to 31,2%

[19] http://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm

in 2016. In Appendix 6 there are the amounts, in euros, invested by the Portuguese life insurers, by type of financial instrument.

The instability of the level of capital requirements and of the eligible own funds to cover them brought by the Solvency II regime, lead to an increased adoption of risk mitigation techniques, that would decrease the former and increase the later. According to ASF (2016b), two of the most applied de-risking strategies applied by the Portuguese insurers were the increased exposure to the Portuguese sovereign debt bonds and the matching of the durations of assets and liabilities.

There is no market risk capital requirement on holding sovereign debt bonds from countries within the European Economic Area (EEA), which explains the first strategy. . This also encourages the exposure to such financial products, despite their low expected profitability, and contributes to the diversification of the insurer's portfolio, further explaining the increment of the investment share in government bonds observed in Graph 6, throughout the 2011-2016 period.

The second de-risking strategy is justified by the fact that the SCR standard formula penalizes cases where the duration of insurer investments is higher than the duration of its liabilities.

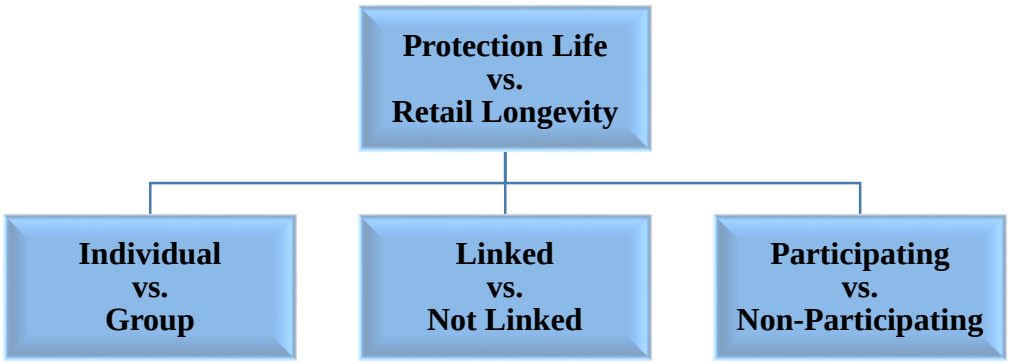
4. Protection Life and Retail Longevity Contract Types

Exploring further the life insurance segment, this can be divided into two sub-segments, protection life and retail longevity. The difference between these two lies in the payment scheme in case a claim happens. In the first types of contracts, the insured capitals are paid fully in a single payment and in the second they are paid in a series of payments.

In Portugal, no kind of life protection or retail longevity contracts are compulsory. Additionally, according to Associação Portuguesa de Seguradores (2009), the underwriting of these contracts is normally made through the filling of questionnaires, containing questions about the health, financial and professional status of the insured person. The insurer may also ask for additional information, such as current medical tests, in cases that the insured person is at an advanced age or that the capital to be insured is of a too large amount.

The protection life contracts suffer from mortality risk, which is the risk that the policyholder dies early and the premiums already received haven't got enough time to sufficiently capitalize in the investment market to cover the contracted sum assured that has to be paid, which will lead to a loss. The opposite happens with the retail longevity contracts. These suffer from longevity risk, the risk that the policyholder lives too long and the insurer has to pay the annuity far more times than expected, meaning that the premiums received were not enough to cover for all the annuity payments that have to be made. Graph 7 shows how these two types of contracts can be further broken down and it is followed by a brief description of each contract designation displayed in it.

Graph 7: Types of Life Insurance Contracts



Source: Own Schematization

The protection life and retail longevity contracts can be classified as individual or group policies. An individual policy covers the risks of a single person, a single family or a group of persons all linked at the inception of the contract. On the other hand, group policies are contracts where the insurer agrees to cover the risk of a whole set of people who are linked to the policyholder by a separate relationship than the insurance contract. An example of this relationship can be when some company offers group life insurance to its workers.

A contract may be linked to an investment fund. When this is the case its insured capital is variable. In these types of contracts, it is said that the beneficiary receives the total amount of his/hers policy's participating units, which are the total share of the policyholder's investment on the investment fund. In investment fund linked contracts, the policyholder bears all the financial risk, existing then the possibility of obtaining no profitability and even of losing all premiums. This investment risk may also be shared between the policyholder and the insurer if a minimum guaranteed financial return, or capital to be paid at the end of the contract, is offered in the contract. But, as already seen, guaranteed benefits can be very dangerous to companies.

An insurance policy can also be participating or non-participating. When it is participating, the policyholder has the right to receive some of the yearly results generated by its insurance policy, although he/she may only access them when a claim occurs. This means that when the insured person dies, the beneficiary will claim the insured capital plus all results that have been attributed to the policy.

4.1. Protection Life Contracts

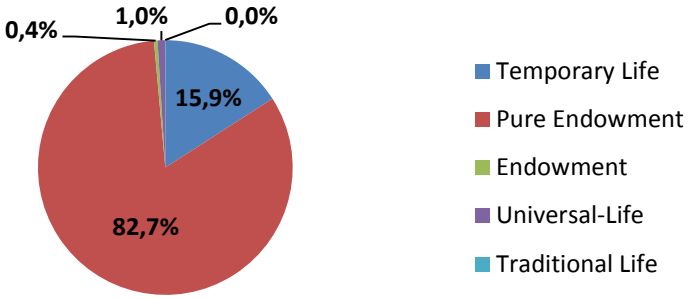
The definitions that appear throughout this and the next sections are mainly based on ASF's insurance guide, see ASF (2015), which was published to help consumers, given the insurance sector's complexity. The results presented are based on ASF's insurance data. Appendix 7 contains the necessary figures to obtain the presented life protection results. It should be remarked that there is no death or survival state cover paid in a lump sum format.

The main types of protection life products commercialized in Portugal are:

- Traditional Whole Life Insurance
- Temporary (Term) Life Insurance
- Pure Endowment Insurance
- Endowment Insurance
- Universal Life Insurance

Graph 8 shows the share of the 2016 production by each type of insurance product. The biggest share of premiums collected from these types of contracts came from temporary life insurance products with 82,7% of the total. Temporary life contracts had the second biggest share with 15,9%. The share of Universal-Life products was only of 1,0%. In 2016, the production of endowment and traditional life insurance contracts was negligible since premiums collected only accounted for 0,4% and 0,0% respectively, of the total production. The total production of life protection contracts corresponds to 70,1% of the 2016 Portuguese life insurance total production, with 4.550.826 thousand of euros.

Graph 8: 2016 Life Protection Production



Source: ASF Insurance Statistics Database[20]

Traditional whole life contracts are contracts where the insurer agrees to pay the insured capital to the beneficiaries when the insured person dies, irrespective of when this happens. In these contracts, the main coverage is the death risk but they can also have some supplementary covers, such as disability, serious disease or unemployment. In 2016, these products were only commercialized as participating, non-investment fund linked policies sold as an insurance contract; 66,1% of their total production came from individual policies and 33,9% from group policies.

[20] http://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm

Temporary life contracts are alike the traditional life ones, with the difference that the insured capital is only possible to be claimed if the insured person dies within the term of the contract. If he/she survives the term, beneficiaries will not have the right to claim. In 2016, 90,0 of the total production of these products were non-participating policies and only 10,0% were participating. There were no investment type of contracts and 27,7% were individual policies (72,3% group policies).

Pure endowment contracts are contracts were the insurer promises to pay the insured capital if the insured person is alive at the end of the contract's term. In Portugal, in 2016, these were the only life protection contracts which some were reinsured, and it was only for a few individual policies. Regarding individual policies, these made up for 73,9% of the total production of pure endowment products. The group policies made the remaining 26,1%. Non-participating policies were responsible for 77,6% of this same total, while the participant policies accounted for 22,4%. Of this total production 23,1% were insurance contracts and 76,9% investment contracts.

Endowment contracts are contracts were the insurer promises to pay a certain capital whether the insured person dies during the term of the contract or is alive at the end of it. Usually, the amount the insurer has to pay is different depending on the claim contingency. In 2016, the participating policies made up 66,6% of this contract's total production, while the non-participating only 33,4%. The individual policies accounted for 54,0% of the total premium collection and the group policies 46,0%. There were no investment type contracts, classified as endowment products, sold in 2016.

Universal Life contracts are highly flexible contracts where the policyholder has the possibility of choosing the contract's premium payment scheme, the contract coverages and the existence of any guarantees. This product is normally engineered in an individual account format, where its total equals the paid premiums, plus their profitability minus the account maintenance expenses, the chosen guarantees cost and any early withdrawal amounts. These products were only sold as participating, insurance policies in 2016. Only 0,8% of these contracts total production were group policies, while 99,2% were individual policies.

4.2. Retail Longevity Contracts

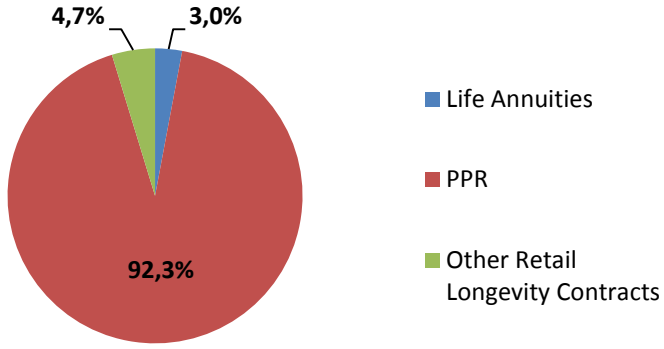
Regarding retail longevity contracts, Appendix 8 contains the results presented throughout this section.

The main types of retail longevity products commercialized in Portugal are the following:

- Life Annuities
- PPR Contracts

Graph 9 shows the share of the 2016 production by each type of retail longevity product. This graph shows that the biggest share of collected premiums came from the PPR contracts, with 92,3% of the total. On the other hand, life annuities products were responsible for 3,0% of the total retail longevity production. The remaining 4,7% premium collection came from other special retail longevity contracts, for which individual productions were not statistically significant. The total production of retail longevity contracts made 29,9% of the 2016 Portuguese life insurance segment's total production with 1.837.539 thousand of euros.

Graph 9: 2016 Retail Longevity Production



Source: ASF Insurance Statistics Database[21]

Whole life annuities are contracts where the insurer agrees to pay an annuity to the beneficiary as long as he/she is alive. The annuity payments may start at the inception of the contract or they may be deferred for a certain period of time. In Portugal, these types of products are only commercialized as insurance contracts, and, in 2016, 79,6% of their total production came from individual policies and the remaining 20,4% from group

[21] http://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm

policies. Of the total production, 32,7% were participating policies and 67,3% were non-participating.

PPR contracts are the traditional Portuguese retirement savings contracts as explained in section 5. These were only sold as individual policies and, in 2016, 66,7% of them were sold as investment contracts and 33,3% as insurance contracts. Additionally, 33,2% were participating policies and 66,8% were non-participating.

4.3. Portuguese Social Security Retirement Pension

According to the Portuguese Social Security website[22], the SS system guarantees pensions in cases of disability, widowhood and retirement, given that the individual has contributed enough and claims them according to the procedures. These contributions are compulsory to any active person as a certain percentage of his/her monthly salary, depending on the working status. The higher the contributions the higher the pensions.

The most usually claimed pension is the SS retirement pension since, as the name suggests, all people who retire at the Normal Retirement Age (NRA) are able to claim it, given that they have at least 15 years of registered contributions. This is a defined benefit retirement pension as it is calculated based on a specific formula, dependent on the participant's earnings and independent of individual investment returns. The Portuguese NRA was 66 years and 3 months in 2016. Appendix 9 gives a detailed description of how the Portuguese SS pension is calculated.

4.4.Life Insurance Mortality Tables

Canas Rodrigues *et al.* (2007) explain that mortality tables play a central role in the life insurance sector, as they are used for the calculation of insurance premiums and future liability reserves. In protection life contracts, they are used to know, in average, at what age the participant will claim the lump sum payment. In retail longevity contracts, they are used to calculate the average total amount of payments the insurer will have to make. This is why the choice of a mortality table that most appropriately reflects the mortality of the insurer's portfolio is so important.

[22] http://www.seg-social.pt/pensao-de-velhice

Mortality tables are usually constructed separately for men and women given their substantially different mortality rates, but in 2008, the Portuguese Law 14/2008 prohibited premium differentiation by gender, making the Portuguese insurance pricing procedure more complex. Other characteristics such as the smoking status, occupation and social economic class can also be used to distinguish different risks.

To collect information about the mortality tables currently being used in the Portuguese life insurance sector, the following methodology was used:

- Enumeration of all life insurance related companies operating in Portugal;
- Collection of all 2016 life insurers Management and Accounts Reports;
- Inspection of all mortality/longevity related topics disclosed;
- Grouping of the unique mortality tables by kind of product they are used on;
- Further grouping of the mortality tables by protection life and retail longevity types of contract.

Of all the 19 life or mixed – insurance companies selling both life and non-life products – insurance companies operating in Portugal, only one of them didn't disclose any information regarding the mortality tables in use. Regarding how they were disclosed, many companies affirmed to use modifications of the mortality tables presented on this section. Some affirmed to apply different percentages, smaller than 100%, to the mortality tables rates; other subtracted some number of years to the participant's age in order to use smaller mortality rates and other just mentioned that some modification was used. These methods of reducing the rates used for the pricing and reserve calculations, are a way of allowance for longevity improvements, given the outdated nature of some of the mortality tables disclosed, see Dickson et al. (2013).

A clear differentiation of the mortality tables used for life protection and retail longevity products was evident in the management and accounts reports. Indeed, it was not possible to break this usage for two companies only, which affirmed to use one or two mortality tables for their entire portfolio. A further investigation was performed and it was discovered that they currently are not selling any retail longevity products.

Four companies affirmed that they use mortality tables based on five-year historical data of deaths, occurred in their own insurance portfolios. Four companies disclosed the usage of very different mortality tables in their PPR contracts, comparing to the ones used

in the rest of the retail longevity products. Two of them also did the same for pure endowment contracts. Still, these were grouped into their respective life protection and retail longevity categories.

Table 4 shows the mortality tables referenced in the Management and Account Reports and the number of times they appear in different reports (not in different products) for each protection life and retail longevity type of product, respectively. They were also grouped by table, irrespective if the reference was to a male or female table. This procedure was followed as some companies disclosed the usage of only male or female rates depending on the different types of commercialized products.

Table 4: Life Protection Mortality Tables Usage

Life Protection Tables	Counts	Retail Longevity Tables	Counts
GKM/F 80	11	GRM/F95	6
PM/F 60/64	8	PASEM2010	6
GKM/F 95	6	GKM/F 95	5
GRM/F 95	2	TV 73/77	5
GRM/F 80	2	GKM/F 80	4
PASEM 2010	2	GRM/F 95	3
AF	2	DAV94 MR	1
SIM/F 2006	1	PERMF2000P	1
PM/F 46/49	1	RF	1
		Tábua Portuguesa 2010-2012	1
		TPRV 93	1
		TV 88/90	1

Source: Own Schematization

It can be seen that the most referenced mortality tables regarding protection life contracts were the GKM/F 80, PM/F 60/64 and the GKM/F 95 with eleven, eight and six mentions respectively. The ones referring retail longevity type of contracts included the usage of a wider number of different mortality tables and references were more equally spread. Still, the most referenced mortality tables were the PASEM 2010 and the GRM/F 95 both with six mentions, the GKM/F 95 and the TV 73/77 with five and the GKM/F 80 with four references.

Regarding the life protection mortality tables, it was clear the predominance of mentions regarding the usage of only male mortality tables against female ones. This makes sense, as these kinds of contracts suffer from mortality risk and, for these, a more

conservative premium valuation lies in the usage of heavier mortality rates. There were nineteen mentions of male mortality tables and five of female tables.

On the other hand, the gender specific table mentions regarding retail longevity products were more balanced, with nine male mentions and twelve female mentions. Contrasting with life protection contracts, there were more female table mentions in these types of contracts, which implies the usage of lower mortality rates, reflecting a longevity risk concern to which these contracts are exposed.

4.5. Relevant Organizations

This section is reserved to provide information about relevant organizations that effectively work with mortality in Portugal. The organizations that will be covered are: INE as the national government statistics body, the Portuguese actuarial society *Instituto dos Actuários Portugueses* (IAP), ASF as the insurer regulator and APS which is a non-profit organization with main purpose of defending and promoting the interests of the insurance companies, nationally and internationally.

According to the website[23] of INE, its mission is to produce and disclose relevant statistical information that is effective, efficient, independent and credible. Two of the main goals are to promote the statistical literacy in the Portuguese society and to promote international cooperation. These are achieved by the disclosure of its data, results and methods and by following the internationally established statistical quality standards on the methodologies, as a way of guaranteeing comparability across borders.

According to IAP's website[24], its mission is to represent the actuarial profession, in Portugal and abroad, and promote the reputation and acknowledgement of the actuarial profession as a way of attaining sustainable development of the financial sector and of the society as a whole. Additionally, the IAP aims to contribute for the formation and professional development of its associates, encouraging research, development and promotion of actuarial related studies and by promoting essential actuary values, such as professionalism, integrity, transparency, quality, objectivity, ethics and social responsibility.

[23] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_cont_inst&ine_smenu.boui=13918434&INST=53866&xlang=en
[24] https://www.iap.org.pt/index.php/iap1/missao1

According to ASF's website[25], its mission is to regulate and promote the good functioning of the Portuguese insurance and pension funds markets as a way of enhancing protection of policyholders, beneficiaries and participants. This mission can be decomposed into two, the prudential and behavioral components. The prudential component has the purpose of guaranteeing that all companies under the supervision of ASF have sufficient financial resources to cover their responsibilities and efficiently manage the risks they are exposed to. The purpose of this component is, then, to promote financial stability and healthiness. The behavioral component has the purpose of guaranteeing high conduct patterns from the supervised companies towards their clients.

According to APS's website[26], the total group of its associates represents more than 99% of the total insurance market, either in business volume or in total number of employees. The main goals are to promote the cooperation between all the companies of the Portuguese insurance sector, contribute to their modernization and defend their prestige. This is achieved by the disclosure of good information to insurance clients, the promotion of transparency in insurance contracts, the elaboration of insurance studies and the negotiation of insurance specific questions that go in accordance to the sector best interest.

[25] http://www.asf.com.pt/NR/exeres/B69D840E-3BFA-47E1-A7A7-332CC2D9F553.htm
[26] https://www.apseguradores.pt/Portal/portal.aspx?MicrositeId=1&PageId=3

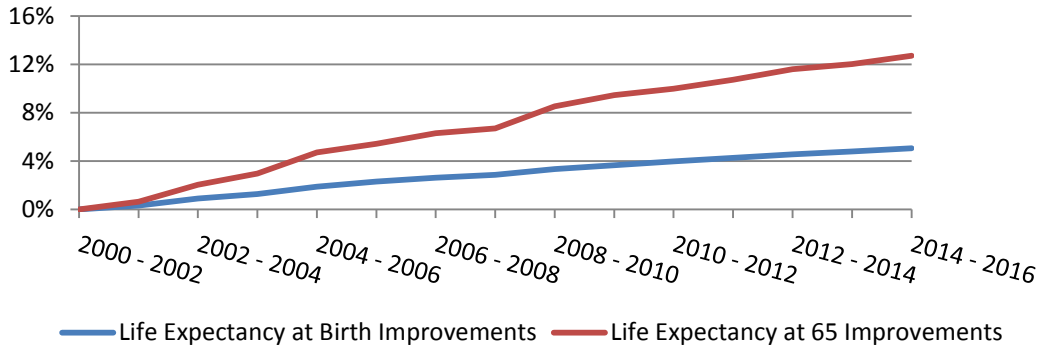
5. Mortality Improvements in Portugal

The population ageing challenge is a consequence of the higher levels of life expectancy – and reduced mortality – achieved by a country. Life expectancy improvements have been observed at every age, but this challenge only constitutes a problem if it is mainly verified in older age groups.

According to Carrilho and Craveiro (2015), mortality improvements and the way deaths spread throughout ages explain the shape of the population pyramid in Graph 2. Mortality improvements resulted in a higher lifespan for all people and in a growing number of elderly people. In fact, analyzing the table in Appendix 10, one can conclude that deaths are becoming more concentrated in older age groups. Comparing 2001 with 2016, the number of deaths verified in ages smaller than 19 decreased by 61,2% and in ages bigger than 65, increased by 12,9%, which greatly reflects the population ageing. In 2016, 110.535 deaths were registered.

Graph 10 displays improvements in life expectancy at birth and life expectancy at 65 years old, published in INE's life tables, from the 2000 to 2016 period. In these periods, there was a total improvement of 12,7% (2.2 years) in the life expectancy at 65 years old. On the other hand, the improvement in life expectancy at birth was only of 5,1% (3,9 years). The data required to build Graph 10, by break is presented in Appendix 11.

Graph 10: Life Expectancy Improvements 2000-2016 (%)



Source: INE's Population Database[27]

[27] Life Expectancy at Birth:
https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0001724&contexto=bd&selTab=tab2
Life Expectancy at 65:
https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0001723&contexto=bd&selTab=tab2

However, despite high mortality improvements having been a certain fact in the past, and most relevant ones, as seen in Graph 10, from 2000 to 2010, now, doubts of their sustainability are being brought to the table. Many are the countries that already noticed a slowdown in their longevity improvements. Examples of these are the US, UK, Canada, Australia, Germany, Austria, Netherlands, Sweden, etc[28].

It is of tremendous importance for life insurers to monitor and comprehend mortality behaviors, as these greatly affect their liabilities portfolios all around, whether being these composed of retail longevity (longevity risk) or protection life (mortality risk) products. Given this, insurance companies require up to date information to continually understand trends that aid in the assessment of risk, help in their decision making regarding their risk tolerance and in the development of new insurance products, aligned with their profitability expectations.

National Social Security systems are also greatly impacted by life expectancy improvements since one of the most important factors to accurately calculate the cost of a SS pension plan is the setting of a good longevity assumption to determine how long a participant is expected to live. In Graph 10 it was seen that mortality improvements for ages bigger than 65 were higher than for the general population meaning that, in Portugal, longevity improvements varied by age. A further analysis of this is of critical importance for SS systems as they benefit from longevity improvements in younger age groups, given that it is the younger people who financially contribute to this system. On the other hand, it is the people in older age groups who receive the larger part of the system's payments, and so, mortality improvements for these people worsen the SS financial balance, for it has to pay benefits to longer living individuals.

Table 5 shows how mortality rates have been developing in Portugal by age group. This table uses INE's calculated mortality rates, averaged by age group, gender and studied period. It contains also a comparison of the variation of their improvement between the periods of 2000-2010 and 2010-2016.

28 https://www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Minutes/Session1_Presentations/3g_What_Happened_to_Improving_Mortality_BRidsdale.pdf

Table 5: Average Mortality Rates by age group and period

	Gender	24-	25-34	35-44	45-54	55-64	65-74	75-84	85+
2000-2010	**Male**	0,00064	0,00147	0,00276	0,00547	0,01097	0,02720	0,07908	0,36491
	Female	0,00037	0,00048	0,00105	0,00228	0,00478	0,01351	0,05146	0,31463
2010-2016	**Male**	0,00039	0,00074	0,00177	0,00473	0,00987	0,02158	0,06392	0,35356
	Female	0,00024	0,00030	0,00079	0,00189	0,00393	0,01027	0,04005	0,30046
Difference	**Male**	-39,7%	-49,6%	-35,9%	-13,5%	-10,0%	-20,7%	-19,2%	-3,1%
	Female	-34,7%	-36,5%	-25,1%	-17,3%	-17,9%	-24,0%	-22,2%	-4,5%

Source: INE's Population Database[29]

Considering Table 5, it is possible to see that, in Portugal, longevity improvements are also slowing down for all ages. The bigger slowdowns were verified from ages 0 to 44, age group which comprised 55,0%[30] of the total working population in 2016. The slowdown is verified both in males and females, and the biggest slowdown verified happened in the 25-34 age group, for both genders. To a certain extent, this is not favorable to the Portuguese Social Security System, since, as previously explained, it benefits from longevity improvements in lower age groups and suffers from improvements in bigger age groups.

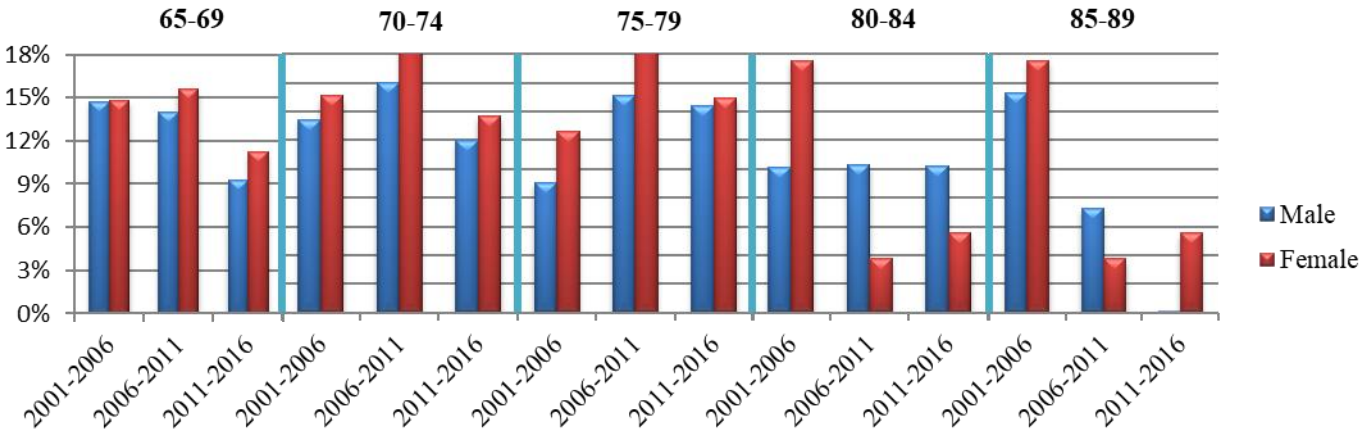
But, rather than focusing and analyzing only past mortality improvements, it is important to understand if one can find a past trend that may influence the future or be projected to it.

In this sense, Graph 11 shows how the Portuguese mortality rates have been developing throughout the 2001-2016 period. The rates were grouped by age and by the periods they correspond to. In this graph, rates were organized in groups of five ages and five years. Then, the total improvement verified throughout the studied period was taken. It should be noted that the 2001-2006 improvement refers to observations from the 1996-2001 period.

According to Graph 10, the bigger Portuguese life expectancy gains, in the studied period, occurred above the age of 65, and so, Graph 11 only shows data for ages beyond 65, in order to make it easier to visually spot possible trends. Additionally, data for ages bigger than 90 is too instable due to the lack of people living beyond their 90th anniversary. Given this fact, Graph 11 only shows data from ages 65 until 89 years.

[29] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0004158&contexto=bd&selTab=tab2
[30] www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0006136&contexto=bd&selTab=tab2

Graph 11: Mortality Improvement Rates 2001-2016



Source: INE's Population Database[31]

Analyzing Graph 11, it can be seen that in the age group 65-79, in the 2006-2011 period, the mortality rates improved more than they did in the 2001-2006 period. Maybe due to the higher influence of the mortality table closing method used in the calculation of Portuguese mortality tables, this pattern can't be seen in ages over 80 years.

Comparing the 2011-2016 period – more recent data – with the previous periods, a slowdown in mortality improvements can be observed in every age group except the 80-84 ages, and even in this age group, it roughly maintained the growth of 2006-2011, which was well below the registered in 2001-2006.

Concluding, the years between 2000 and 2010, in Portugal, were marked with big mortality improvements but, from this period until 2016, although still increasing, they are showing sure signs of a slowdown. Will this be a new trend and mortality rate improvements will really stall in the future? Are the most advanced countries close to reach the limit human life expectancy? The answer to these questions will greatly impact the setting of future mortality assumptions.

Mortality rates are of extreme importance for life insurers and pension systems, as mortality greatly affects their strategies and technical bases. A close monitoring of its evolution is always due, but it is of even greater importance to do it in times of great uncertainty, such as the current. Mortality assumption setting in this environment should have a forward-looking view and not be one that tries to mimic current and past mortality behavior.

[31] https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0004158&contexto=bd&selTab=tab2

6. Conclusion

This work has been developed with three main objectives: (i) to survey the current situation, regarding mortality/longevity in Portugal; (ii) to develop a brief study on the progress of mortality in the country, based on a similar project for the Canadian population, by Assia Billing[32]; (iii) to serve as support for the first Portuguese Country Report to be released by the MWG[33].

Portugal is a small country, estimated to have 10 309 573 resident individuals at the end of 2016 and, according to the data shown throughout this work it is also an aged one, with the prospects of becoming even smaller and even older. An aged country faces a number of SS related problems since it has to finance retirement of more elderly people with less financial resources.

Throughout the course of this work it was seen that Portugal, in 2016, had the third highest ageing ratio of the entire EU, mainly because of the low fertility rate (second lowest of all EU) and high improvements of life expectancy at 65.

Although the country suffered deeply from the effects of the 2008 crisis, the Portuguese GDP has been steadily increasing since 2013, but, despite this good performance, the current environment is not the best for sustainable production growths in the life insurance sector. The low level of savings, the current European monetary policy and the new Solvency II regulatory regime are all complex variables that have to be dealt with by the Portuguese life insurance sector.

Protection life contracts accounted for 71% of the total 2016 life insurance sector's production contrasting with the 29% of the retail longevity contracts. The mostly sold products, in 2016, of protection life and retail longevity kind of contracts are temporary life insurance and PPR contracts, respectively. It should be noted that the Portuguese SS system guarantees a retirement pension to those who have met the eligibility requirements.

[32] https://www.actuaries.org/IAA/Documents/WG_MWG/Meetings/Berlin_2018/Agenda/3_Recent_Trends_in_Mortality_Canada_ABillig.pdf

[33] https://www.actuaries.org/iaa/IAA/Committees/Scientific/Mortality/IAA/Committees/Scientific/Mortality_Working_Group.aspx

Relating mortality tables, INE produces mortality tables for the general Portuguese population on an annual basis. On the other hand, insurers use a vast diversity of mortality tables, being the GKM/F 80, PM/F 60/64 and the GKM/F 95 the most used for protection life contracts and the PASEM 2010, GRM/F 95, GKM/F 95, TV 73/77 and the GKM/F 80 for retail longevity contracts. Given the outdated nature of these tables and the significant life expectancy improvements registered in Portugal, many insurers reported the usage of some kind of modification to the base mortality rates provided by these tables.

In the first decade of the new millenium, longevity improvements were addressed as a given fact. But, more recently, this has not been so true. In fact, a slowdown of these improvements was already observed in most developed countries and it was seen that the same is happening in the Portuguese country. In Portugal, the biggest slowdowns were observed in younger age groups. Whether this will be a new trend is uncertain, but if it does, it will put even more strain on the Portuguese Social Security system and contribute to an even further aged country.

For further research it would be relevant to measure the degree of accuracy of INE's 2080 resident population projection throughout the years and study how the indices presented develop beyond the year of 2016, as a way to be alert for mortality developments. It would also be relevant to see if the slowdown behavior verified in Portugal develops to become a new tendency or whether if what happened in current years was just a blip.

Concluding, a constant study on mortality and interpretation of its tendencies is imperative given the wide importance that this subject has throughout numberless areas of expertise. For this reason, foreseeing mortality and its developments is so critical and it is always important for a country to study and be updated.

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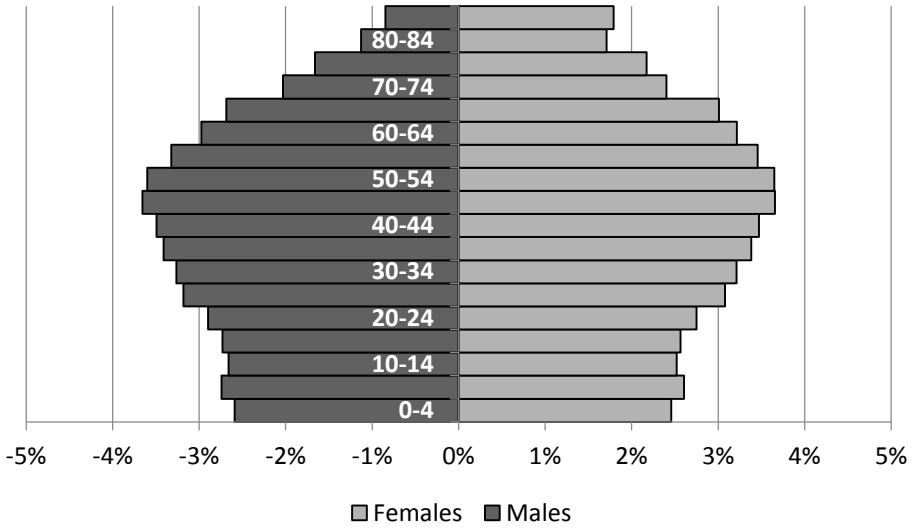
APPENDICES

Appendix 1 – 2016 European Demographic Table



Source: Eurostat Population Database

Appendix 2 – EoY Portuguese Population 2000 – 2016

Year	End of Year Population	Men	Women
2000	10.330.774	4.986.458	5.344.316
2001	10.394.669	5.019.374	5.375.295
2002	10.444.592	5.037.340	5.407.252
2003	10.473.050	5.047.329	5.425.721
2004	10.494.672	5.053.722	5.440.950
2005	10.511.988	5.058.813	5.453.175
2006	10.532.588	5.064.395	5.468.193
2007	10.553.339	5.069.747	5.483.592
2008	10.563.014	5.066.239	5.496.775
2009	10.573.479	5.063.745	5.509.734
2010	10.572.721	5.053.543	5.519.178
2011	10.542.398	5.030.437	5.511.961
2012	10.487.289	4.995.697	5.491.592
2013	10.427.301	4.958.020	5.469.281
2014	10.374.822	4.923.666	5.451.156
2015	10.341.330	4.901.509	5.439.821
2016	10.309.573	4.882.456	5.427.117

Appendix 3 – Portuguese Mortality Table 2014 – 2016

(x)	(qx)	(lx)	(dx)	(Lx)	(Tx)	(ex)
0	0,002895	100.000	290	99.822	8.062.380	80.62
1	0,000200	99.710	20	99.701	7.962.558	79.86
2	0,000168	99.691	17	99.682	7.862.858	78.87
3	0,000140	99.674	14	99.667	7.763.176	77.89
4	0,000123	99.660	12	99.654	7.663.509	76.90
5	0,000102	99.648	10	99.642	7.563.855	75.91
6	0,000097	99.637	10	99.633	7.464.213	74.91
7	0,000081	99.628	8	99.624	7.364.580	73.92
8	0,000075	99.620	8	99.616	7.264.956	72.93
9	0,000063	99.612	6	99.609	7.165.340	71.93
10	0,000077	99.606	8	99.602	7.065.731	70.94
11	0,000110	99.598	11	99.593	6.966.129	69.94
12	0,000084	99.587	8	99.583	6.866.536	68.95
13	0,000093	99.579	9	99.574	6.766.953	67.96
14	0,000112	99.570	11	99.564	6.667.379	66.96
15	0,000152	99.559	15	99.551	6.567.815	65.97
16	0,000196	99.543	19	99.534	6.468.264	64.98
17	0,000172	99.524	17	99.515	6.368.730	63.99
18	0,000296	99.507	29	99.492	6.269.215	63.00
19	0,000323	99.477	32	99.461	6.169.723	62.02
20	0,000341	99.445	34	99.428	6.070.261	61.04
21	0,000350	99.411	35	99.394	5.970.833	60.06
22	0,000330	99.377	33	99.360	5.871.439	59.08
23	0,000310	99.344	31	99.328	5.772.079	58.10
24	0,000353	99.313	35	99.295	5.672.751	57.12
25	0,000365	99.278	36	99.260	5.573.455	56.14
26	0,000364	99.242	36	99.224	5.474.196	55.16
27	0,000366	99.205	36	99.187	5.374.972	54.18
28	0,000426	99.169	42	99.148	5.275.785	53.20
29	0,000451	99.127	45	99.105	5.176.637	52.22
30	0,000459	99.082	45	99.059	5.077.532	51.25
31	0,000525	99.037	52	99.011	4.978.473	50.27
32	0,000445	98.985	44	98.963	4.879.462	49.30
33	0,000498	98.941	49	98.916	4.780.499	48.32
34	0,000575	98.891	57	98.863	4.681.583	47.34
35	0,000690	98.834	68	98.800	4.582.720	46.37
36	0,000653	98.766	65	98.734	4.483.920	45.40
37	0,000777	98.702	77	98.663	4.385.186	44.43
38	0,000886	98.625	87	98.581	4.286.522	43.46
39	0,000918	98.538	90	98.492	4.187.941	42.50
40	0,001108	98.447	109	98.393	4.089.449	41.54
41	0,001351	98.338	133	98.272	3.991.056	40.59
42	0,001433	98.205	141	98.135	3.892.784	39.64
43	0,001514	98.065	148	97.990	3.794.649	38.70
44	0,001770	97.916	173	97.829	3.696.659	37.75
45	0,001896	97.743	185	97.650	3.598.829	36.82
46	0,002235	97.557	218	97.448	3.501.179	35.89
47	0,002485	97.339	242	97.218	3.403.731	34.97
48	0,002556	97.098	248	96.973	3.306.512	34.05
49	0,002781	96.849	269	96.715	3.209.539	33.14
50	0,003077	96.580	297	96.431	3.112.824	32.23
51	0,003390	96.283	326	96.120	3.016.393	31.33
52	0,003810	95.956	366	95.774	2.920.273	30.43

53	0,004003	95.591	383	95.400	2.824.499	29.55
54	0,004191	95.208	399	95.009	2.729.100	28.66
55	0,004845	94.809	459	94.579	2.634.091	27.78
56	0,005212	94.350	492	94.104	2.539.512	26.92
57	0,005318	93.858	499	93.608	2.445.408	26.05
58	0,005842	93.359	545	93.086	2.351.799	25.19
59	0,006015	92.813	558	92.534	2.258.713	24.34
60	0,006977	92.255	644	91.933	2.166.179	23.48
61	0,007249	91.612	664	91.280	2.074.245	22.64
62	0,007576	90.947	689	90.603	1.982.966	21.80
63	0,008323	90.258	751	89.883	1.892.363	20.97
64	0,008446	89.507	756	89.129	1.802.480	20.14
65	0,009461	88.751	840	88.331	1.713.351	19.31
66	0,010203	87.911	897	87.463	1.625.020	18.48
67	0,011002	87.014	957	86.536	1.537.557	17.67
68	0,012540	86.057	1079	85.518	1.451.021	16.86
69	0,013825	84.978	1175	84.391	1.365.503	16.07
70	0,014871	83.803	1246	83.180	1.281.113	15.29
71	0,016259	82.557	1342	81.886	1.197.932	14.51
72	0,018199	81.215	1478	80.476	1.116.047	13.74
73	0,019415	79.737	1548	78.963	1.035.571	12.99
74	0,021985	78.189	1719	77.329	956.608	12.23
75	0,024638	76.470	1884	75.528	879.279	11.50
76	0,027518	74.586	2052	73.559	803.751	10.78
77	0,031008	72.533	2249	71.409	730.192	10.07
78	0,034924	70.284	2455	69.057	658.783	9.37
79	0,039108	67.829	2653	66.503	589.726	8.69
80	0,044872	65.177	2925	63.714	523.223	8.03
81	0,051277	62.252	3192	60.656	459.509	7.38
82	0,058069	59.060	3430	57.345	398.853	6.75
83	0,069382	55.630	3860	53.701	341.508	6.14
84	0,083950	51.771	4346	49.598	287.807	5.56
85	0,104535	47.425	4958	44.946	238.209	5.02
86	0,123315	42.467	5237	39.849	193.263	4.55
87	0,144310	37.230	5373	34.544	153.415	4.12
88	0,166309	31.858	5298	29.208	118.871	3.73
89	0,190213	26.559	5052	24.033	89.663	3.38
90	0,218458	21.507	4698	19.158	65.629	3.05
91	0,246129	16.809	4137	14.740	46.471	2.76
92	0,275957	12.672	3497	10.923	31.731	2.50
93	0,307898	9.175	2825	7.762	20.807	2.27
94	0,341868	6.350	2171	5.265	13.045	2.05
95	0,377743	4.179	1579	3.390	7.780	1.86
96	0,415355	2.600	1080	2.060	4.391	1.69
97	0,454495	1.520	691	1.175	2.330	1.53
98	0,494907	829	410	624	1.155	1.39
99	0,536297	419	225	307	531	1.27
100	0,578326	194	112	138	225	1.16

Appendix 4 – Mortality Tables Published by INE

The life tables published by INE require the collection of data from three consecutive civil years: t, $t+1$, $t+2$, registering information about each year's number of deaths, new births and resident population estimates. According to INE (2015), the following estimation methodology is used:

$q_x =$ the probability of a person aged x to die before age $x+1$ (death rate at age x):

$$\begin{cases} \hat{q}_x = \dfrac{d_{x,t,g} + d_{x,t+1,g} + d_{x,t+1,g+1} + d_{x,t+2,g+1}}{NB_t + NB_{t+1}}, & x = 0 \\ \hat{q}_x = \dfrac{d_{x,t,g} + d_{x,t+1,g} + d_{x,t+1,g+1} + d_{x,t+2,g+1}}{E_{x,t,g} + E_{x,t+1,g+1}}, & x = 1,2,\dots,74 \end{cases};$$

where:

- $d_{x,t,g}$ represents the number of deaths at time t, of individuals aged x, from the g generation;
- NB_t and NB_{t+1} represent the numbers of new births at time t and at time $t+1$ respectively;
- $E_{x,t,g}$ represents the initial aged x individuals exposed at risk at time t, from the g generation.

For ages bigger than 75, due to scarce data, a method to close the mortality table is adopted. This method uses the OLS (Ordinary Least Square) methodology to minimize the following expression:

$$\ln(\hat{q}_x) = a + bx + cx^2 + \varepsilon_x, \qquad \varepsilon_x \sim N(0, \sigma^2), \qquad x = 75,76,\dots;$$

where a, b and c are constant and subject to the following constraints

$$\begin{cases} q_{xmax} = 1 \\ q'_{xmax} = 0 \end{cases};$$

$xmax$ represents the maximum age the cohort is allowed to live, for estimation purposes, and q'_{xmax} represents the derivative of q_{xmax}, in order to x.

A series smoothing methodology is also used in order to ensure a smooth transition between the crude estimates. This methodology is based on the geometric average of q_x at each age $x = (x-5), \dots, (x+5)$.

$l_x =$ expected number of survivors at age x, from the initial 100.000 cohort:

$$\begin{cases} l_x = 100.000, & x = 0 \\ l_x = l_{x-1} * q_{x-1}, & x = 1,2,\dots \end{cases};$$

$d_x =$ expected number of individual deaths between ages x and $x+1$:

$$d_x = l_x * q_x, \qquad x = 1,2,\dots;$$

L_x expected number of whole years to live by the l_x, between ages x and $x+1$:

$$L_x = l_x - d_x + a_x * d_x;$$

$a_x =$ average number of years lived by those who die at age x, that is to say, who die in the $[x, x+1]$ age interval:

$$a_x = \begin{cases} \dfrac{\frac{1}{3} * \left(d_{x,t,g} + d_{x,t+1,g+1}\right) + \frac{2}{3} * \left(d_{x,t+1,g} + d_{x,t+2,g+1}\right)}{d_{x,t,g} + d_{x,t+1,g} + d_{x,t+1,g+1} + d_{x,t+2,g+1}}, & x = 0 \\ 0{,}5, & x = 1,2,3,\dots \end{cases};$$

$T_x =$ expected number of years that the l_x lives will still live:

$$T_x = \sum_{t=0}^{xmax-1} L_{x+t};$$

$e_x =$ future life expectancy at age x:

$$e_x = \frac{T_x}{l_x}.$$

Appendix 5 – Life Insurance Production 2011 – 2016

Year	Insurance Contracts (excluding PPR)	Investment Contracts (excluding PPR)	PPR Insurance Contracts	PPR Investment Contracts	Total PPR	Total Production
2011	1.608.054	4.143.912	661.993	634.346	1.296.339	7.048.305
2012	1.390.118	3.928.877	536.449	575.556	1.112.005	6.430.999
2013	2.266.080	5.075.113	766.076	777.923	1.544.000	8.885.192
2014	3.466.438	4.241.874	747.052	1.641.896	2.388.948	10.097.260
2015	2.600.401	3.882.997	667.953	1.204.023	1.871.976	8.355.374
2016	1.800.085	2.892.318	564.439	1.131.523	1.695.962	6.388.365

(Thousands of Euros)

Appendix 6 – Investment Portfolios of Life Insurers

Financial Instrument	2016	2011
Sovereign Debt Bonds	17.287.924	10.298.725
Market Bonds	12.599.187	21.786.599
Stocks	2.767.414	509.376
Investment Funds	4.364.018	3.584.495
Deposit Accounts and others	2.192.822	3.221.005
Not Remunerated Applications	978.610	848.019
Others	204.066	-155.750
Total	40.394.042	40.092.468

Appendix 7 – 2016 Life Protection Production

Contract Type	Insurance Contracts			
	Not Investment Fund Linked			
	Individual		Group	
	Participating	Non-Participating	Participating	Non-Participating
Temporary Life Insurance	6.921	193.289	65.635	458.017
Endowment Insurance	10.397	571	3.140	6.206
Traditional Life Insurance	794	-9	402	0
Universal-Life Insurance	43.057	0	337	0
Pure Endowment	342.908	724	491.738	208

Contract Type	Insurance Contracts			
	Investment Fund Linked			
	Individual		Group	
	Participating	Non-Participating	Participating	Non-Participating
Temporary Life Insurance	0	0	0	0
Endowment Insurance	0	0	0	0
Traditional Life Insurance	0	0	0	0
Universal-Life Insurance	0	77	0	0
Pure Endowment	7.149	26.950	0	0

Contract Type	Investment Contracts			
	Not Investment Fund Linked		Investment Fund Linked	
	Individual	Group	Individual	Group
Temporary Life Insurance	0	0	0	0
Endowment Insurance	0	0	0	0
Traditional Life Insurance	0	0	0	0
Universal-Life Insurance	0	0	0	0
Pure Endowment	1.375.954	41.464	1.025.638	449.262

Appendix 8 – 2016 Retail Longevity Production

Contract Type	Insurance Contracts			
	Not Investment Fund Linked			
	Individual		Group	
	Participating	Non-Participating	Participating	Non-Participating
Life Annuities	17.198	26.008	555	10.498
Certain Annuities	4	479	0	32
Survival Annuities	0	0	0	0
PPR	563.138	1.301	0	0
Other Retail Longevity Contracts	75	83.224	39	3.464

Contract Type	Investment Contracts			
	Not Investment Fund Linked		Investment Fund Linked	
	Individual	Group	Individual	Group
Life Annuities	0	0	0	0
Certain Annuities	0	0	0	0
Survival Annuities	0	0	0	0
PPR	985.752	0	145.772	0
Other Retail Longevity Contracts	0	0	0	0

Appendix 9 – Portuguese SS Pension Calculation

Following the Portuguese Decree-Law 187/2007, if a Portuguese SS retirement pension is claimed at the NRA, its monthly amount is calculated as follows:

$$SS_{pension} = \max\big(SS_{minpension}, N * [\max(RE, 1.1 * IAS) * 2.3\% + \max(0, RE - 1.1 * IAS) * 2.25\% + \max(0, RE - 2 * IAS) * 2.2\% + \max(0, RE - 4 * IAS) * 2.1\% + \max(0, RE - 8 * IAS) * 2\%]\big)$$

where:

- N is the total number of completed years of contributions, limited to 40;
- $SS_{minpension}$ is an amount depending on the participant's years of service and refers to the minimum pension a participant who retires can receive, without pension cuts;
- IAS is a yearly updated social support reference figure, which in 2016 was 419.22 euros;
- RE are the reference earnings and it should be remarked that the Portuguese receive 14 monthly salaries per year. The RE is calculated as follows:

$$RE = \sum_{i=1}^{n} S_i * RQ_i / n$$

where:

- n is the total number of salaries the participant received, from which contributions to the SS have been made;
- S_i is the i^{th} monthly salary received;
- RQ_i is the revaluation quotient referring to the year the S_i was received. The RQ_i's are published annually by the Portuguese government and depend on inflation and productivity earnings. The revaluation quotients from the year 2016 until 1975 are presented at the end of this appendix.

In certain specific cases, the participant may be able to claim the SS retirement pension sooner than the NRA with no pension cuts, if:

- Having already 65 years old, the participant proves that he/she is unable to continue working;
- The participant has a working career of over 40 years, since for every additional civil year worked over 40, the retirement age is reduced by four months;
- Being at least 62 years old, the participant has been unemployed for five years;
- Being at least 60 years old, the participant has already 48 years of contributions;
- Being at least 60 years old and having started contributions to the SS before the age of 14 years old, the participant has already 46 years of contributions.

With the exception of these cases, a regular participant may still ask for an early retirement SS pension at the expense of two cuts on its normal retirement pension value:

- The first is a cut of 0.5% per each month of early retirement, for participants over 60 years old. In cases that, with more than 57 years, the participant has already been unemployed for 5 years, the cut is calculated based on a retirement age of 62.
- The second cut is the application of the sustainability factor (SF) on the calculation of the participant's pension. This factor is calculated as follows:

$$SF = \frac{LE65_{2000}}{LE65_{PSY-1}};$$

Where $LE65_{2000}$ stands for the Portuguese life expectancy at 65 at the year 2000 and it is equal to 16.92 years. $LE65_{PSY-1}$stands for the Portuguese life expectancy at 65 in the year before retirement. These life expectancy figures are calculated based on INE's data. The sustainability factor is also applied on all cases of early retirement based on long-term unemployment.

Reavaluation Quotient - RQ_i 2016-1975

Year	RQ
2016	1,0000
2015	1,0000
2014	1,0047
2013	1,0047
2012	1,0072
2011	1,0354
2010	1,0739
2009	1,0889
2008	1,0889
2007	1,1173
2006	1,1440
2005	1,1796
2004	1,2055
2003	1,2334
2002	1,2741
2001	1,3187
2000	1,3765
1999	1,4151
1998	1,4476
1997	1,4868
1996	1,5194
1995	1,5665
1994	1,6307
1993	1,7156
1992	1,8270
1991	1,9896
1990	2,2165
1989	2,5136
1988	2,8301
1987	3,1019
1986	3,3934
1985	3,7904
1984	4,5220
1983	5,8471
1982	7,3380
1981	8,9818
1980	10,7782
1979	12,5674
1978	15,6086
1977	19,0582
1976	24,2800
1975	29,1360

Appendix 10 – Deaths by age Group 2001 - 2016

Age Group	2001	2002	2003	2004	2005	2006	2007	2008
Total [1]	105.092	106.258	108.795	102.012	107.464	101.990	103.512	104.280
<1	567	574	466	420	384	349	353	340
1-4	162	167	126	142	94	115	86	79
5-9	114	104	103	95	96	84	62	63
10-14	142	140	121	104	84	93	86	93
15-19	400	340	298	275	285	247	212	196
20-24	681	584	553	475	459	388	380	318
25-29	941	813	760	685	579	499	479	452
30-34	1.049	986	993	913	926	774	740	720
35-39	1.395	1.351	1.272	1.203	1.197	1.175	1.083	948
40-44	1.859	1.874	1.751	1.704	1.731	1.690	1.581	1.520
45-49	2.354	2.383	2.386	2.288	2.292	2.287	2.272	2.276
50-54	2.890	3.019	3.044	2.962	3.048	2.895	3.007	2.982
55-59	3.737	3.807	3.883	3.722	3.956	3.847	3.800	3.849
60-64	5.546	5.325	5.223	4.943	4.911	4.932	4.916	4.852
65-69	8.559	8.469	8.379	7.809	7.899	7.189	6.921	6.706
70-74	12.763	12.398	12.641	11.852	11.954	11.332	11.125	10.730
75-79	17.046	17.242	17.634	16.290	17.055	15.828	15.747	15.955
80-84	17.228	18.087	19.342	18.975	20.576	19.340	20.011	20.059
85 e +	27.659	28.595	29.820	27.155	29.938	28.900	30.632	32.122

Age Group	2009	2010	2011	2012	2013	2014	2015	2016
Total [1]	104.434	105.954	102.848	107.612	106.554	104.843	108.539	110.535
<1	362	256	302	303	243	236	250	278
1-4	89	70	70	64	73	55	58	52
5-9	59	65	65	57	45	45	49	30
10-14	69	71	53	70	58	50	45	50
15-19	187	157	163	125	121	135	120	128
20-24	314	294	259	232	212	182	182	183
25-29	393	364	308	279	265	257	226	208
30-34	617	610	521	463	393	382	333	260
35-39	1.004	965	843	827	753	701	610	579
40-44	1.487	1.495	1.348	1.320	1.213	1.168	1.136	1.127
45-49	2.259	2.184	2.134	2.083	1.999	1.848	1.828	1.710
50-54	3.089	2.989	3.090	2.941	2.964	2.902	2.732	2.835
55-59	3.750	3.851	3.881	3.815	3.843	3.881	3.717	3.922
60-64	5.095	4.970	5.018	4.986	5.213	4.827	5.086	5.194
65-69	6.585	6.509	6.448	6.632	6.665	6.567	6.690	6.920
70-74	10.371	10.283	9.624	9.385	9.051	8.717	8.939	9.150
75-79	15.536	15.382	14.901	15.054	14.514	13.925	13.876	13.845
80-84	20.175	20.252	19.239	20.337	20.058	19.614	20.331	20.162
85 e +	32.963	35.154	34.567	38.631	38.847	39.336	42.317	43.892

Appendix 11 – Life Expectancy 2001 – 2016

Period	Life Expectancy at Birth- Both Sexes	Life Expectancy at Birth - Males	Life Expectancy at Birth - Females
2000 - 2002	76,73	73,25	80,05
2001 - 2003	76,98	73,55	80,21
2002 - 2004	77,43	74,10	80,56
2003 - 2005	77,72	74,35	80,86
2004 - 2006	78,18	74,81	81,33
2005 - 2007	78,50	75,18	81,63
2006 - 2008	78,74	75,49	81,81
2007 - 2009	78,94	75,84	81,87
2008 - 2010	79,29	76,17	82,19
2009 - 2011	79,55	76,47	82,43
2010 - 2012	79,78	76,67	82,59
2011 - 2013	80,00	76,91	82,79
2012 - 2014	80,24	77,16	83,03
2013 - 2015	80,41	77,36	83,23
2014 - 2016	80,62	77,61	83,33

Period	Life Expectancy at 65- Both Sexes	Life Expectancy at 65 - Males	Life Expectancy at 65 - Females
2000 - 2002	17,13	15,24	18,60
2001 - 2003	17,24	15,35	18,69
2002 - 2004	17,48	15,60	18,94
2003 - 2005	17,64	15,72	19,11
2004 - 2006	17,94	16,02	19,42
2005 - 2007	18,06	16,16	19,55
2006 - 2008	18,21	16,35	19,70
2007 - 2009	18,28	16,48	19,74
2008 - 2010	18,59	16,74	20,03
2009 - 2011	18,75	16,92	20,20
2010 - 2012	18,84	16,94	20,27
2011 - 2013	18,97	17,07	20,40
2012 - 2014	19,12	17,23	20,55
2013 - 2015	19,19	17,32	20,67
2014 - 2016	19,31	17,44	20,73