LISBON SCHOOL OF ECONOMICS & MANAGEMENT
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MASTER

ACTUARIAL SCIENCE

MASTER´S FINAL WORK

INTERNSHIP REPORT

CHALLENGES TO LIFE INSURANCE IN TIMES OF LOW INTEREST RATES

MIGUEL MILHANO PINTO ELYSEU

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Abstract

A protracted low interest rate environment can significantly disrupt the financial stability and strategic planning of a life insurer. Consequently, new challenges arise for companies as interest rates reach historically low levels.

During periods of low returns on investment, the experience of insurance companies in other countries shows that companies that focused on selling protection-type products fared better than the companies that focused on investment guarantees. It is also important to notice that Portugal is experiencing an increase in life expectancy and has been facing demographic ageing over the years. As a consequence, the older population is getting exposed to more serious health conditions. Therefore, attention should be placed into developing new and innovative life insurance products, specifically for this share of the population. Accordingly, the main goal of the internship was to develop a product, new to the company, with these characteristics.

Critical illness insurance tries to meet present circumstances by offering covers in both the case of death of the policyholder and the case he/she is diagnosed with a critical illness. This product helps meet a family's income needs if any of the covered events occurs. After providing all details on the technical basis and methodology used for the pricing of the product and the profit testing, an analysis of the results is presented.

Keywords: life insurance, low interest rates, interest rate risk, ageing population, product development, profit testing.

Resumo

Um período prolongado de baixas taxas de juros pode prejudicar significativamente a estabilidade financeira e o planeamento estratégico de uma seguradora vida. Consequentemente, novos desafios surgem para estas empresas à medida que as taxas de juros atingem níveis historicamente baixos.

Durante períodos de baixo retorno ao investimento, a experiência de seguradoras noutros países mostra que empresas que se concentraram na venda de produtos de proteção obtiveram melhores resultados do que as empresas que se focaram em oferecer garantias de investimento. É também importante notar que Portugal está a experienciar um aumento da esperança de vida e que tem vindo a enfrentar envelhecimento demográfico ao longo dos anos. Como consequência, a população idosa está a ficar cada vez mais exposta a condições de saúde mais deterioradas. Portanto, o foco deve ser posto no desenvolvimento de novos e inovadores produtos de seguro de vida, especificamente para esta parte da população. Desta forma, o objetivo principal do estágio foi o desenvolvimento de um produto, novo para a empresa, com estas características.

Um seguro de doenças graves tenta atender às circunstâncias atuais, ao oferecer coberturas em caso de morte da pessoa segura ou no caso da mesma ser diagnosticada com uma doença grave. Este produto ajuda a satisfazer as necessidades monetárias, no caso de um dos eventos supramencionados ocorrer. Depois de apresentados todos os detalhes acerca das bases técnicas e metodologia utilizadas no *pricing* do produto e no teste de lucro, é feita uma análise aos resultados.

Palavras-chave: seguros de vida, baixas taxas de juro, risco de taxa de juro, envelhecimento populacional, desenvolvimento de produto, teste de lucro.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ASF	Autoridade de Supervisão de Seguros e Fundos de Pensões
BIS	Bank for International Settlements
BOF	Basic Own Funds
DT	Deferred Taxes
EIOPA	European Insurance and Occupational Pensions Authority
EU	European Union
GR	Gross Rate
IFoA	Institute and Faculty of Actuaries
INE	*Instituto Nacional de Estatística*
INEM	*Instituto Nacional de Emergência*
LTC	Long Term Care
MCR	Minimum Capital Requirement
NPV	Net Present Value
PP	Pure Premium
PPR	Pure Premium Rate
RSP	Retirement Savings Plan (*Plano de Poupança Reforma* in Portuguese)
SCR	Solvency Capital Requirement
TP	Technical Provisions
ULIP	Unit-Linked Insurance Plan
VaR	Value at Risk

Chapter I - Introduction

The following report is the result of a six-month internship at the Portuguese life insurance company Crédito Agrícola Vida, undertaken within its Actuarial Management Department. Its main objective is to study the impacts of a persistently low interest rate period on the life insurance business, and to explore the possibility of developing new products.

In the beginning of the internship I was introduced to all departments of the company, to have a real perception of the work a life insurance company undergoes. I was later introduced to the internal processes and specific programs used to develop routine actuarial activities, such as policy validations and the calculations of premiums and mathematical provisions. The practical immersion provided by the internship allowed me to complement my academic education and to better understand the life insurance business. After an initial period of training, I started my research on the impacts of low interest rates on life insurance companies.

1.1. Life insurance products

Life insurers offer a vast assortment of products to customers, depending upon their specific requirements. These products often vary in terms of coverage offered and investment opportunities. In general, life insurance policies can be categorized into traditional and non-traditional products. See for instance Dickson, Hardy and Waters (2013), a reference that covers this entire section.

1.1.1. Traditional life insurance

According to Dahl (2013), life insurance had its origin in ancient Rome, where citizens formed burial clubs that would meet the funeral expenses of its members as well as help survivors by making some payments.

Although these first actions took place in such a distant past, it was only in the 18th century that life insurance started to gain an increasing position. There are four main types of traditional life insurance products: whole life insurance, term life insurance, endowment insurance, and universal life insurance. In all of them, the insurer promises to pay a contingent benefit in exchange for receiving a premium (or a regular stream of contingent premiums).

A whole life insurance policy is the simplest form of a life insurance contract. The contingent benefit is payable on the death of the policyholder. The payment is therefore certain, but the time of payment and sometimes the amount of the benefit are uncertain. Although being a traditional product, whole life insurance usually also includes a savings element. Part of the premium is set aside for mortality coverage and the remainder, the so-called cash surrender

value, is paid into an investment fund, chosen by the policyholder according to his/her risk profile. After a specific grace period, the policy begins to accrue cash surrender value. In general, this cash amount grows according to a fixed schedule and accrual is typically slow in the first years but accelerates as the policy matures. This growth guarantees a minimum rate of return for the policyholder for each year the policy remains in force, intended to satisfy the policyholder's need for savings and to reduce lapse rate ("lapse in coverage", meaning the life insurance contract will no longer pay the death benefit, usually due to missed premium payments).

Another product is the term life insurance policy. Again, a death benefit is paid by the life insurer to the beneficiary upon the death of the policyholder, but term life policies have a fixed duration in which the policyholder is covered. If the death of the policyholder occurs whilst the policy is in force, the benefit is paid. If this is not the case, then there is no benefit payment. Given that only the death of the policyholder triggers a payment, term life insurance is purely a protection-type product.

Endowment insurance offers a lump sum benefit paid either on the death of the policyholder or at the end of a specified term, whichever occurs first. This is a mixture of a term insurance benefit and a savings element (a "pure endowment" contract). If the policyholder dies, the sum insured is paid just as under term insurance; if the policyholder survives, the sum insured is treated as a maturing investment.

According to Dickson et al (2013), in recent years, insurers have provided more modern and flexible products. These products combine the death benefit coverage with an investment element, as a way of competing with other institutions, such as banks, for policyholder's savings. Universal life insurance is one of them. It is very similar to a whole life policy in the sense that a cash surrender value can be collected upon surrender of the policy. However, premium payments are flexible. Premiums are fixed under a whole life, but under a universal life policy they are variable, which means that the cash surrender value is variable as well. This flexibility allows policyholders to purchase less insurance when their finances are tight, and then increase the insurance coverage when there is more money to invest.

Traditional life insurance products can also be categorized as "with-profit" and "without profit". Under with-profit contracts, the profits earned on the invested premiums are shared with the policyholders. Therefore, with-profit contracts may be used to offer policyholders a savings element with their life insurance. The with-profit arrangements may take the form of cash dividends, reduced premiums or an increased sum insured, through bonuses.

1.1.2. Non-traditional life insurance: Unit linked

One of the major aspects of non-traditional life insurance coverage is the explicit combination of insurance and investment under a single policy. Unit-Linked Insurance Plans (ULIPs) are the most common form of non-traditional policies, and they are relatively new compared to other types of life insurance products, dating back to the 1980s (Smith and Caslin, 2015).

In unit-linked insurance, the benefit is linked to the performance of an investment fund. The premium is, consequently, divided into two parts. One part is used for the payment of the insurance coverage and the other is allocated to an investment fund. This means that the latter is pooled with premiums from other policyholders and invested in a fund, composed of equities, bonds and/or other investment instruments. The fund is divided into units of equal value, calculated based on the valuation of its assets and the number of outstanding units. Each policyholder holds a certain number of units and, just like in a stock market, the value of the units will change depending on the fund's performance.

For the life insurer, the main advantage of unit-linked insurance is that the interest rate risk is passed onto the policyholder. For this reason, and to limit the level of exposure resulting from a large portfolio of traditional policies, there has been an increase in the marketing of this product over the years. However, a low interest rate environment creates a problem, as it is more difficult for life insurers to attract policyholders and to increase the number of underwritings.

For the policyholder, there are advantages and disadvantages as well. Unit-linked products provide mortality coverage, that is, if the policyholder dies whilst the contract is in force, the beneficiary can claim the death benefit. When possible, the policyholder can shift his/her investment to a different fund or portfolio, according to his/her risk profile and depending on how the market is performing; thus, these products provide greater flexibility and the possibility of higher returns on the policy. As for the downsides, in some contracts there is no minimum return guaranteed by the insurance company. In other cases, the money invested is not guaranteed also. And again, because of current market conditions, more specifically, low interest rates, returns on investment are expected to be very low. Hence, many policyholders are discouraged to invest in unit-linked products as the expected return is too small to make up for the risk held.

1.2. Recent challenges and innovation for life insurance

The era of ultra-low and finally negative interest rates in Europe began when the European Central Bank was battling the global financial crisis triggered by the collapse of US bank Lehman Brothers in 2008, and the European sovereign debt crisis that followed in 2010.

Low interest rates are advantageous when financing for a new house or car. But when it comes to savings accounts and other types of investments, they are not. A protracted low interest rate environment can significantly disrupt the financial stability and strategic planning of a life insurer. New challenges arise for the companies as interest rates reach historically low levels.

According to Berdin, Kok, Mikkonen, Pancaro and Vendrel (2015), there are two channels through which low yields affect life insurers: the “income channel” and the “balance sheet channel”.

The first one refers to the sector’s high exposure to long-term fixed income assets. The investment income will suffer, as the net cash flow from paid premiums and maturing investments needs to be gradually re-invested at lower rates. Small and medium-sized, non-diversified life insurers are typically more exposed, particularly if they have sold policies with high levels of guarantees.

The so-called "balance sheet channel" is related to the fact that low interest rates will tend to have an impact on the balance sheet via a valuation effect. Low rates induce increases in the values of both assets and liabilities (liabilities increase because the expected present value of death benefit payments is calculated at a lower rate).

The market-consistent valuation of assets and liabilities increases the amount of capital requirements imposed by Solvency II, as the magnitude of assets invested in fixed-income instruments is a fraction of the total liabilities. In addition, because life insurance contracts are usually in force for decades, the duration of liabilities is often longer than that of the assets. Thus, whereas the impact on profitability through the investment income channel takes time, a low-yield environment can affect the solvency of the insurers directly and immediately through the balance sheet channel, with those insurers with large duration mismatches being the most vulnerable to it.

According to Nieder (2016), the experience of insurance companies in Japan and Germany, during the period of low investment returns, shows that companies that focused on selling protection-type products fared better than the companies that focused on investment guarantees. Portugal is experiencing demographic ageing, according to INE (2020b). Given the two factors, attention should be put into developing innovative life insurance products specific to older population. Different types of coverage offered can be an important factor.

1.3 Structure of the text

Chapter II focuses on providing context about the evolution of longevity, life expectancy, and the life insurance sector in Portugal. Also, in the same chapter, the Solvency II regime is introduced. In Chapter III, the impacts of low interest rates on the life insurance sector are described and explained, and two case studies are presented. In Chapter IV, the technical basis and methodology used in the development of a new protection-type product are presented, as well as the discussion of results. Chapter V highlights the main conclusions from this report.

Chapter II - Setting the Context

This Chapter will focus on providing some context to better understand the research problem. Firstly, analysis on the evolution of life expectancy and the life insurance sector in Portugal will be conducted, then, Solvency II will be briefly introduced.

2.1. Evolution of longevity and life expectancy in Portugal

According to INE (2020b), in 2019, the resident population in Portugal was estimated at 10 295 909, comprising 4 859 977 men and 5 435 932 women. This corresponds to 19 292 more inhabitants than in 2018, meaning that Portugal recorded a positive effective growth rate of about 0,19%, which had not happened since 2009. This growth resulted from an increase in migratory balance, from 11 570 in 2018 to 44 506 in 2019, as the natural balance remained negative, at -25 214.

Changes in the size and composition, by sex and age, of the population residing in Portugal, due to the low birth rate and the increase in longevity in the past decades, indicate the continuation of demographic ageing. In the last ten years, the double demographic ageing is visible through the overlap of the age pyramids (see Figure 1): the base of the pyramid narrows, while its top widens. In this period, the number of elderly people, aged 65 and over, increased by 350 028 and the number of young people, under 15 years old, decreased by 221 008. The number of people of working age, aged 15 to 64, has also decreased, by 406 590.

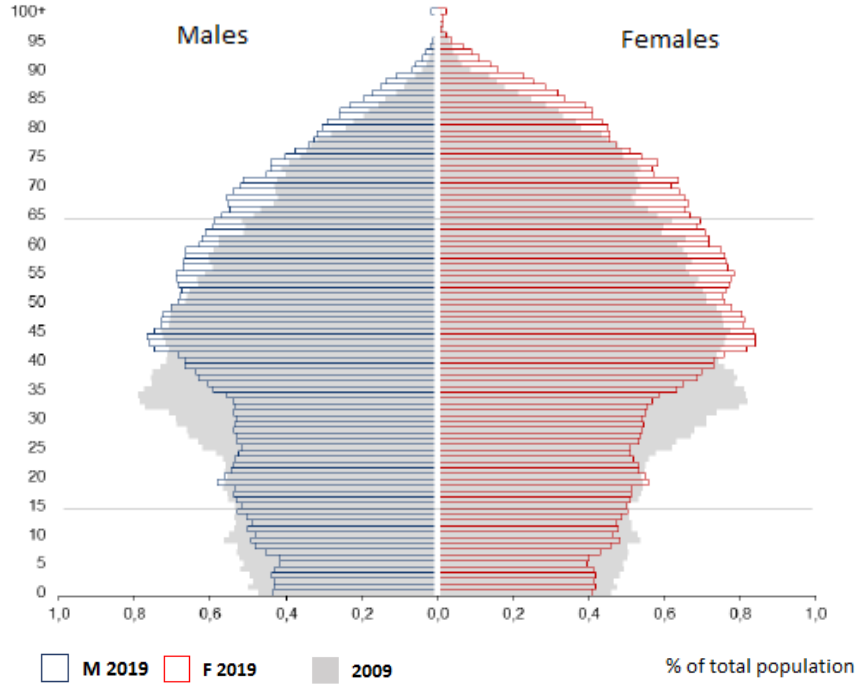

Figure 1. Age Pyramids, Portugal (2009 vs 2019)
Source: INE (2020b)

As stated by INE (2020a), life expectancy at birth in the period 2017-2019 was estimated at 80,93 years, 77,95 years for men and 83,51 years for women. These figures represent, relative to 2016-2018, an increase of about 2 months for men and 1 month for women. In the past ten years, there was an increase of 1,99 years of life for the total population, 2,11 years for men and 1,64 years for women (Figure 2).

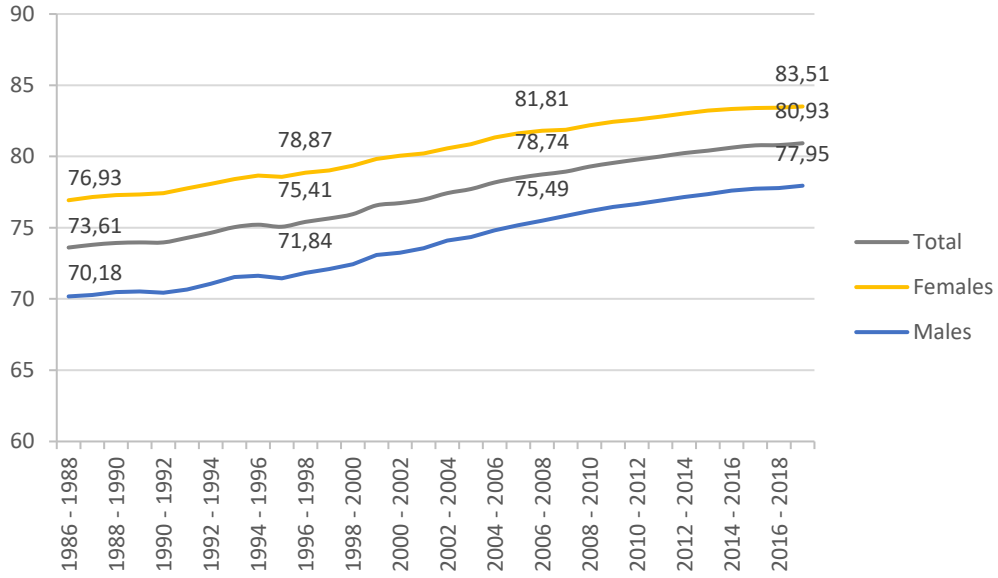

Figure 2. Life Expectancy at Birth (1968-2019)
Source: INE's Population Database

Life expectancy at 65 reached 19,61 years for the total population. At 65 years of age, men can expect to live 17,7 years and women 21 years, corresponding to gains of 1,22 years and 1,26 years, respectively, in the last ten years (Figure 3).

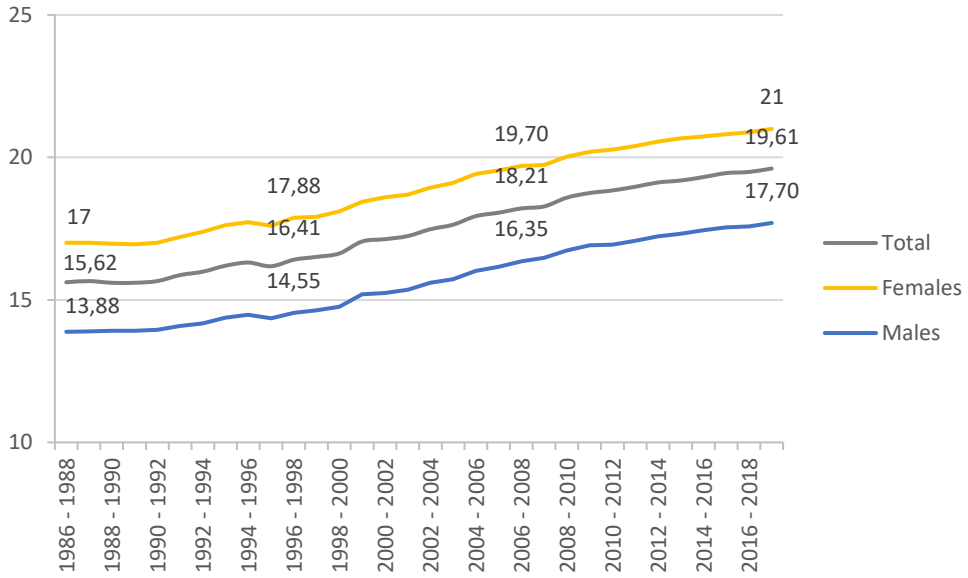

Figure 3. Life Expectancy at 65 (1968-2019)
Source: INE's Population Database

Table 1 summarizes all this information.

Resident Population (2019)	Overall - 10 295 909 Males - 4 859 977 Females - 5 435 932
Current Life Expectancy (years)	
At birth	At 65
Overall - 80,93 Males - 77,95 Females - 83,51	Overall - 19,61 Males - 17,7 Females - 21

Table 1. Current Population Indicators, Portugal 2019
Source: INE's Population Database

2.2. Evolution of life insurance sector in Portugal

Following ASF (2020a, 2020b), in 2019, the amount of insurance gross premiums in Portugal reached 12 203 million euros, corresponding to a decrease of 5,7% when compared to the value recorded in 2018. Life insurance gross premiums amount for 2019 is almost 6 993 million euros, accounting for 57,3% of total premiums (Table 2). Production of life insurance decreased 13,9%, having been relevant, for this decrease, the decrease in non-linked life insurance, both in Retirement Savings Plans (RSP), -12,6%, and traditional life protection products, -21,1%.

	2016	**%**	**2017**	**%**	**2018**	**%**	**2019 ***	**%**
Life	6 677 410	61,42	7 089 251	61,20	8 122 717	62,73	6 992 859	57,30
Non-life	4 194 198	38,58	4 493 706	38,80	4 825 262	37,27	5 210 682	42,70
Total	10 871 608		11 582 957		12 947 979		12 203 541	

*provisional figures

Table 2. Insurance Gross Premiums (in thousands of euros), Portugal 2016-2019
Source: ASF Insurance Statistics Database

Life protection products (whole life insurance, term life insurance, pure endowment insurance, endowment insurance, and universal life insurance) represent more than 75% of total life premiums. The remainder comes from insurance linked to investment funds and capitalization operations. The distribution of premiums that come from life protection contracts is illustrated in Figure 4, with pure endowment and temporary life contracts being the most representative.

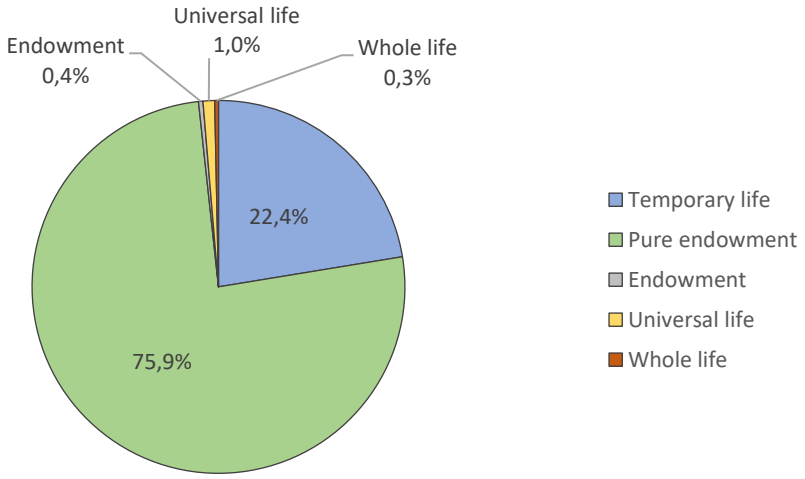

Figure 4. Distribution of Life Protection Products, Portugal 2019
Source: ASF Insurance Statistics Database

The decrease in life insurance production, together with demographic ageing, generates new market needs. This creates an opportunity for life insurers to design innovative products to adapt to the new market conditions and population characteristics.

2.3. Solvency II

Solvency II[1] is the prudential regime for insurance and reinsurance undertakings in the European Union (EU). It introduces a more rigorous supervisory regime that seeks to recognize more accurately the complexity of insurance companies and the risks that they run, on the regulatory balance sheet and in the reporting to supervisors and other stakeholders. In doing so, Solvency II aims to increase both policyholder protection and capital efficiency and encourage insurance companies' management to make more use of modern risk management techniques.

Figure 5 below shows a standardized structure of a balance sheet according to Solvency II. On the left-hand side, there are the assets. These are required to be valued at market value, based on current market prices of transactions between informed parties acting voluntarily, i.e., quoted market prices in active markets.

On the right-hand side, equity and liabilities, the latter including Technical Provisions (TP). These consist of a best estimate liability and a risk margin. The best estimate liability is the present value of expected future cashflows, discounted using a risk-free yield curve, and the risk margin represents an additional compensation for the risk of future experience being higher than expected according to the best estimate assumptions. Technical provisions should represent the

[1] https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0138

amount that the insurance company would have to pay to transfer its obligations immediately to another insurance company.

Moving over to the equity side, under Solvency II, there are two distinct capital requirements: Solvency Capital Requirement (SCR) and Minimum Capital Requirement (MCR). Both the SCR and the MCR represent capital requirements that must be held in addition to the technical provisions. And together with any excess capital they make up for the Basic Own Funds (BOF).

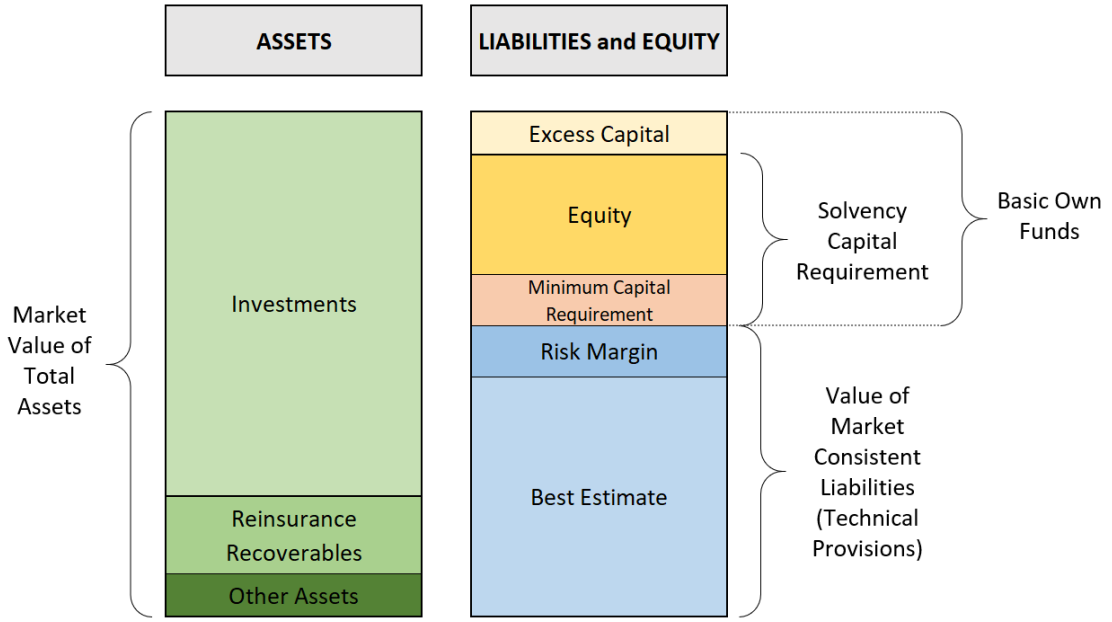

Figure 5. Basic Structure of the Solvency II Balance Sheet
Sources: IFoA (2016), Borginho (2019)

The SCR is a Value at Risk (VaR) measure based on a 99,5% confidence interval of the variation over one year of the amount of BOF. In other words, the SCR is set at a level that ensures that insurers can meet their obligations to policyholders with 99,5% probability. It can be calculated using standard prescribed stress tests, which are then aggregated using prescribed correlation matrices. This approach is known as the standard formula. It takes a modular approach, meaning that the individual exposure to each risk category is assessed and then aggregated. There is a prescribed list of risk groups that the SCR must cover: insurance underwriting (separately for life, health, and non-life business), market, counterparty default, intangible assets, and operational risks. The SCR for each individual risk is then determined as the difference between the net asset value in the unstressed balance sheet and the net asset value in the stressed balance sheet. Each individual stress test is performed separately according to detailed rules.

Having obtained the SCR for each module, a further specified correlation matrix is used to combine them to give the Basic SCR (BSCR). By correlating all risk modules, diversification

benefits are gained, lowering the previous amount. To obtain the overall SCR, three adjustments are made to the BSCR: a capital amount for operational risk and allowances for both the loss absorbing capacity of TP and deferred taxes (DT). These last two combined and the benefits of diversification contribute negatively to the overall SCR, lowering its value.

The capital requirements, by year-end 2017, of Portuguese life insurers for each individual exposure are depicted in Figure 6. The most representative are the market and life underwriting risk modules.

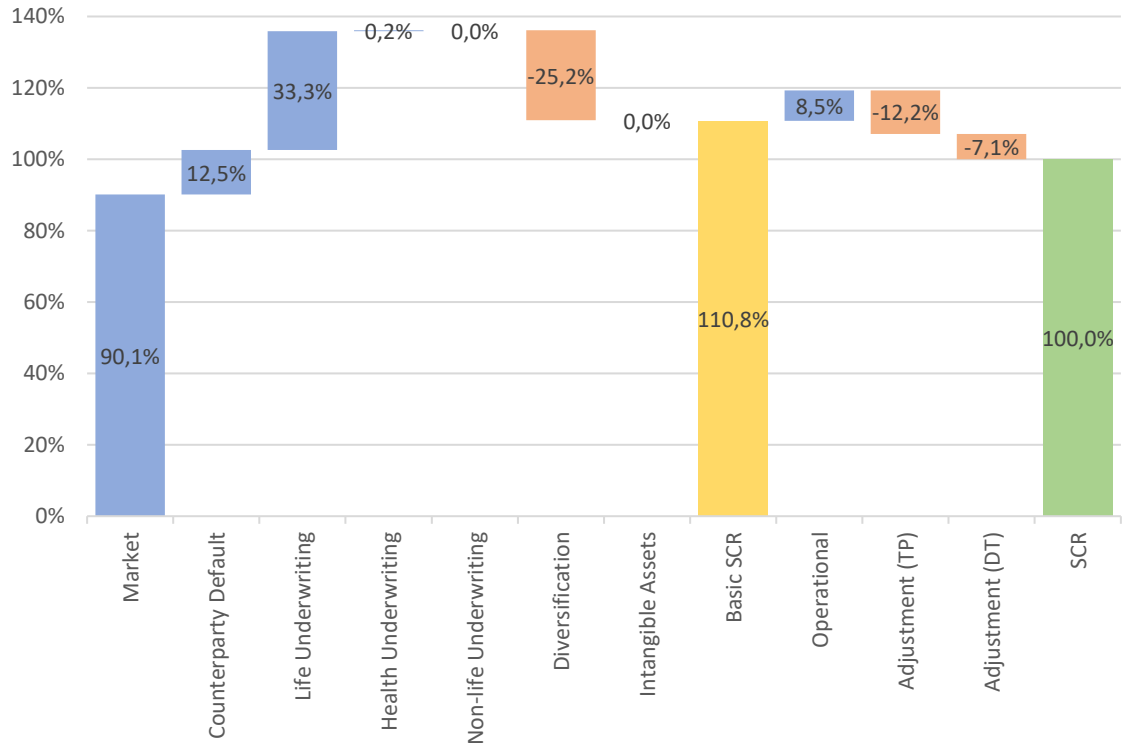

Figure 6. Decomposition of the SCR for Portuguese Life Insurers by year-end 2017
Source: Borginho (2019)

For a reference that covers this entire section see, for instance, IFoA (2016).

Some of the concepts and risks introduced in this Chapter will be discussed more in-depth in Chapter III, as well as their implications on life insurance companies.

Chapter III - Impacts of Low Interest Rates on the Life Insurance Sector

As explained in the previous Chapter, insurance companies are exposed to different types of risk: counterparty default, intangible assets, operational, market and, specifically for life insurers, life underwriting risk.

Counterparty default risk is the risk that any party involved in a transaction might default on its contractual obligation. Intangible asset risk comprises all risks related to intangible assets, for example, the risk of obsolescence. Operational risk is the risk of loss resulting from inadequate or failed internal processes, human error and systems, or from external events. It refers to the inherent risk of operating a company, as well as the strategies employed and corporate policies implemented. The market risk module covers the risk of loss in the financial situation resulting, directly or indirectly, from fluctuations in the level and in the volatility of market prices of assets, liabilities, and financial instruments. This includes risks related to interest rate, equity, property, credit spread, currency, and concentration risks. Life underwriting risk contains all risks arising from life insurance obligations, i.e., risks that the life insurer assumes when selling insurance contracts. These are mortality, longevity, disability and morbidity, lapse, expenses, revision, and catastrophe (e.g. pandemic) risks.

For an alternative risk classification see, for instance, Krenn and Oschischnig (2003); according to these authors, the key risk factors in the insurance industry can be classified into three groups: underwriting risk, investment risk, and non-technical risk.

3.1. Market risk module

From the observation of Figure 6, the most representative risk module for a life insurance company's SCR corresponds to market risk. For that reason, some risks included in this category will be further described.

3.1.1. Interest rate risk

Interest rate risk is the risk of change in the value of an asset, liability, or financial instrument, due to unexpected fluctuations in interest rates. Owing to their balance sheet structure and to the specific characteristics of its products, life insurers are exposed to these fluctuations.

On the investment side, interest rate risk is mostly associated with fixed-income assets, such as bonds, as opposed to equity-type investments. This is true because interest rates and bond prices have an inverse relationship, i.e., when the interest rate decreases the price of a bond increases. Bonds make up for most of a life insurer's investment portfolio, contributing to more demanding interest rate risk management techniques.

Also, all life insurance products involve policyholders paying in funds before, often well before, insurers make any payments. This pattern also exposes insurers to interest rate risk.

3.1.2. Reinvestment risk

Reinvestment risk is the risk that an investor will not be able to reinvest cash flows from an investment at a rate equal to the investment's current rate of return. For example, if an investor buys a 10 000 governmental bond with a coupon rate of 5%, 500 of interest are expected every year. At the maturity of the bond, interest rates fall to 3%. If the investor buys another 10 000 governmental bond, the amount of interest will decrease to 300 per year.

Callable bonds, bonds that the issuer may redeem in a set of different possible dates, are especially vulnerable to reinvestment risk. These bonds can be, and frequently are, redeemed when interest rates decline, allowing the issuer to re-borrow at a more beneficial rate.

For example, a company issues callable bonds with a 5% interest rate. Shortly after, rates drop to 2% giving the company an opportunity to borrow at a lower rate. Consequently, the company calls the bonds as soon as possible and issues new callable bonds at 2% interest rate. The investor may reinvest at this new lower rate or look for securities with higher interest rates.

3.1.3. Credit risk

Credit risk is the possibility of loss due to a borrower defaulting on a loan or not meeting contractual obligations. However, credit risk is not limited exclusively to default risk. For instance, two other factors can impact bond prices, based on the perceived risk: downgrading the bond's credit rating or changing its spread. Default risk is the risk of the borrower failing to repay a debt including interest or principal on a loan or security. Credit spread risk is the risk that the spread will widen or narrow, hence decreasing or increasing the market value of a bond. Credit rating is a measure of creditworthiness of a borrower.

These three components are related. Credit quality will decline as the risk of default goes higher, and this higher risk will cause spreads to widen above the spread of an equivalent treasury security, to compensate an investor for taking on more risk.

Not all bonds are assumed to have credit risk. Credit risk is only applied to bonds that the market assumes to have a positive (non-zero) probability of defaulting. This can include bonds from both governments and corporations, but generally bonds issued by very developed countries, such as U.S. treasuries and German *bunds*, are excluded.

3.1.4. The risk of "gambling for redemption"

There is a specific risk associated with protracted low interest rate periods and the search for higher yields. It is the risk of "gambling for redemption". BIS (2004) mentioned the following: "*However, a more disturbing effect of the lower bond yields is that they may have induced a growing appetite for risk. In the case of insurance companies, with contractual obligations to pay high rates of return on their liabilities, such behavior became almost a matter of survival"* (p. 5). *"After a period of declining interest rates, the guaranteed rates started to exceed the yields available on highly rated government bonds. The resulting funding gap led such institutions to invest in higher-yielding, higher-risk instruments. Even in those countries with no guaranteed rates, changes in the value of liabilities tended to lead to risk-seeking behavior*" (p. 119).

Antolin, Schich, and Yermo (2011) alert to the fact that life insurance companies might face the temptation to shift portfolio allocations, particularly when the yields of lower-rated government bonds are higher than those of higher-rated European sovereigns. Solvency II does not distinguish between different EU countries in terms of capital requirements, so insurers would not require additional capital buffers to offset the higher risk exposure.

3.2. Low interest rates and life insurance products

First, one must distinguish between protracted low interest rate period and a period where interest rates are constantly moving up and down, caused by the normal volatility of financial markets. A scenario of persistent low interest rates requires interest rates to fall to a level where they stay for some time.

Owing to their balance sheet structure, life insurers are exposed to an increase or a decline in interest rates: a fall in interest rates reduces future return margins, as the return on new assets may be insufficient to meet interest payments at the rate guaranteed by contracts issued prior to this decline; a rise in interest rates reduces the market value of the assets, in particular those of bond portfolios, and simultaneously triggers contract terminations, in particular in the case of those with guaranteed returns lower than those offered by new contracts.

Due to the particularly long-term nature of life insurance products, these are sensitive to changes in the interest rate as well. Taking a whole life insurance contract as an example, changes in interest rates alter the expected value of future claim payments. A decrease in the interest rate causes the benefit amount to carry more weight and thus creates bigger liabilities for the life insurer, as these are discounted at a lower rate.

Exposure to interest rate risk varies with the specific characteristics of products. Many life insurance and annuity products have embedded guarantees or attached riders that promise policyholders a minimum return over the duration of their policies. Several types of riders may be purchased, but they all fulfill the common function of guaranteeing a minimum rate of growth on the policy's cash value. For example, a typical rider might promise that the cash value of an annuity policy will grow by some minimum percentage each year, irrespective of the actual returns on policy assets. The impact of a low interest rate environment depends also on the level and type of guarantees offered by life insurers. Policies guaranteeing a high minimum-interest-rate will be the most affected. However, for policies where guarantees are reset on a regular basis, the impact will be much softer. As interest rates decrease, these guarantees, or riders can affect how sensitive these products are to interest rate changes.

This presents a problem for life insurance companies because the variable annuity riders' guarantees are backed by the insurer's own assets. Therefore, they constitute an investment risk faced by the insurer; if the insurer cannot generate sufficient investment income to satisfy the guarantees, it must fund the guarantees using surplus capital. Variable annuity riders' guarantees are currently a significant issue for the life insurance industry because of the weakness of equity market returns since 2000 and today's environment of low interest rates.

Hartley, Paulson, and Rosen (2016) refer that another important factor in evaluating interest rate risk is that life insurers can be exposed to it through the behavior of policyholders, especially through products with guaranteed returns. Some insurance products offer policyholders the option to contribute additional funds at their discretion (possibly only in specific circumstances) or to close out a contract in return for a predetermined payment. When interest rates change, it is more likely that policyholders will act on these options. For example, they may contribute more to an annuity with a high guaranteed return when interest rates are low or surrender an annuity with a low return guarantee when interest rates rise significantly. The key is that the combined effect of guarantees and policyholder behavior can make hedging interest rate risk much more complex. This can cause life insurers to be more exposed to changes in interest rates that are large enough to affect policyholder's behavior.

3.3. Case studies

The Japanese and German life insurance markets serve as good case studies because in the past, life insurance companies sold policies with guaranteed fixed interest rates that exceeded the interest yield that can be earned today.

3.3.1. Japan

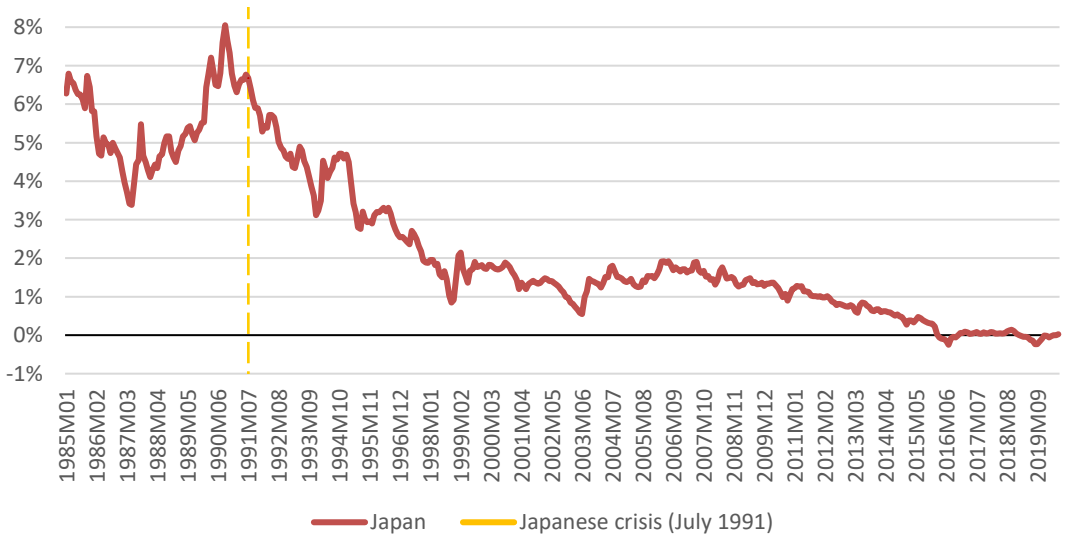

Figure 7. Ten-year Government Bond Yields in Japan (1985-2020)
Sources: World Bank, Eurostat

At the beginning of the 1990s, financial markets in Japan collapsed. Consequently, real estate values dropped, stock prices plummeted, and record-low interest rates appeared. The start of the new millennium was marked by a continued low interest environment, with rates ranging from 1,92% to -0,25% (Figure 7). Japan is the real-life example that a scenario of protracted low interest rates is not unlikely.

According to a technical publication, see Nieder (2016), there were three major actions that helped overcome the challenges presented by a long-lasting low interest rate period.

1 - Shifts in the investment portfolio: investment portfolio allocation shifted towards fixed-income securities, such as bonds, and assets with longer maturities to shorten the duration gap between liabilities and assets. Moreover, investment in foreign currency denominated assets surged to avoid the low, and sometimes negative, returns of government-issued bonds.

2 - Changes in the product mix: the product mix has also seen some changes over the years, mainly focused on transferring investment risk to the policyholder. Increased marketing of variable life insurance products, introduction of foreign-currency denominated assets that

promised a higher return and variable annuity contracts. The development of the Third Sector, which includes Long Term Care (LTC) products, was perhaps the most significant trend.

3 - Creation of new distribution channels: this period was also marked by new distribution channels. So-called “Insurance Shops” were established, they offered information on products from a larger number of insurance companies and operated on a commission basis. Banks were permitted to sell insurance products and companies selling through the internet were experiencing significant growth on sales.

3.3.2. Germany

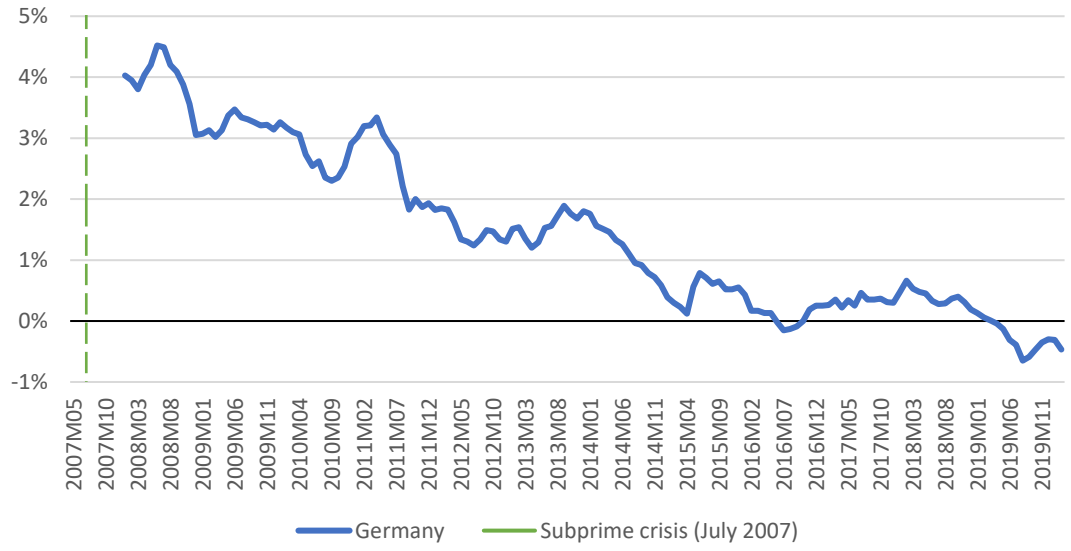

Figure 8. Ten-year Government Bond Yields in Germany (2008-2020)
Sources: World Bank, Eurostat

In Germany, rates fell below 1% on August of 2014 (Figure 8). Two main measures were taken to face the challenges of the low interest rate period.

1 - Changes in the allocation of the investment portfolio: historically, the investment strategy of German life insurers has been conservative, with bonds accounting for most of the portfolio. A shift towards riskier assets would increase capital requirements so, instead, life insurers began investing in less liquid investments, such as infrastructures projects, and took advantage of the increased return of the liquidity premium.

2 - A new product strategy: alike Japan, German life insurers focused on LTC products and other protection-type products. They further replaced traditional savings-type products, such as deferred annuities, with alternative guarantee conditions.

Chapter IV – Critical Illness Insurance

Demographic ageing, together with increasing life expectancy, is creating new market and policyholder needs. In this sense, the following sections will focus on the development of a new life insurance product.

4.1. The product

As a consequence of increased life expectancy, older population is getting exposed to more serious health conditions. The new product the company is considering launching tries to meet present circumstances, by offering covers in both the case of death of the policyholder and the case he/she is diagnosed with a critical illness. Please note that for confidentiality concerns, some information and data will not be disclosed in this report.

In case of death (by any cause), the policy offers a lump sum benefit payment. The critical illness cover also pays a lump sum, after the diagnosis of a disease from a pre-specified list. This list includes cardiovascular, neurological, and oncological diseases, as well as paralysis and blindness. However, when the policyholder reaches 75 years old, oncological diseases are excluded and the premium is recalculated accordingly.

There is the possibility of having two different sum insured amounts. Sum insured cannot be less than 2 500€ or higher than 50 000€, for either the death benefit, *D*, or the diagnosis benefit, *C*.

Critical illness insurance is expected to be available to policyholders aged 50 to 70 years old. The policy will automatically annul in case of death, diagnosis of a critical disease or in the day of the policyholder's 80^{th} birthday. In case of the latter, no benefit payment is to be made to the policyholder by the insurer.

This product helps meet a family's income needs if any of the covered events occurs, providing the means, for instance, to pay for funeral costs or expenses related to treatment, home support or house adaptations.

4.2. Pricing

Pricing refers to the process of determining what rates, or premiums, are to be charged to policyholders for insurance. A rate is the price per monetary unit assured. The insurance premium is the rate multiplied by the capital sum assured.

The Pure Premium (*PP*), which is determined by actuarial studies, is the portion of the premium necessary to pay for losses and loss related expenses. The loading is the part of the premium necessary to cover other expenses, particularly sales expenses, and to allow for a profit. The

sum of the pure premium rate (*PPR*) with the load rate equals the Gross Rate (*GR*). For the calculation of the *GR*, the following charges were applied: acquisition charge of 10% (*a*), premium collection charge of 2,5% (*c*), management charge of 15% (*m*), technical fee of 3% (*TF*), and the Nacional Emergency Institute's fee of 2,5% (*INEM*). The *GR* for each age *x* is calculated as follows:

$$GR_x = \frac{PPR_x(1+m)}{(1+TF)^{\frac{1}{2}}\,[1-(a+c)]}(1+INEM) \quad (1)$$

The Gross Premium, P_t, is the premium charged to the policyholder aged *x* at the beginning of contract year *t*. It is equal to the gross rate multiplied by the capital insured:

$$P_t = Gross\ Rate_{x+t} \times Capital\ Sum\ Insured \quad (2)$$

4.3. Technical basis

Mortality:

The mortality assumptions used in the projection of cash flows were defined considering market and company data (Table 3). Mortality was set to 30% of the GKM80 Table:

Age	30% GKM80	Age	30% GKM80	Age	30% GKM80
50	0,00201167	60	0,00532469	70	0,01404493
51	0,00221467	61	0,00587249	71	0,01544287
52	0,00243913	62	0,00647617	72	0,01696937
53	0,00268727	63	0,00714098	73	0,01863383
54	0,00296156	64	0,00787268	74	0,02044590
55	0,00326466	65	0,00867746	75	0,02241540
56	0,00359947	66	0,00956195	76	0,02455170
57	0,00396921	67	0,01053319	77	0,02686440
58	0,00437743	68	0,01159870	78	0,02936280
59	0,00482784	69	0,01276648	79	0,03205500

Table 3. Mortality Assumptions, 2020
Source: CA Vida (2020a)

Surrender Rates:

Surrender rates are calculated through yearly studies, in which the number of policies canceled is compared to the number of policies in force at any given moment. The surrender rate assumptions used for the profit testing of this product were defined as the average of lapse rates of 3 pure life insurance products, in 2018 and 2019 (Table 4). Remark that the surrender rates do not depend on the age of the policyholder.

Contract Year	1	2	3	4	5	6	7	8	9	≥10
Lapse Rate	6,92%	9,69%	9,20%	10,09%	11,26%	10,79%	10,14%	9,20%	8,61%	8,11%

Table 4. Surrender Rate Assumptions, 2020
Source: CA Vida (2020a)

Interest rate:

The discount rate, i_t, used to discount cash flows corresponds to the interest rate curve derived by the European Insurance and Occupational Pensions Authority (EIOPA) as of 31 December 2019, in which the volatility adjustment is included (Table 5). The rates used are the following:

Year	Rate	Year	Rate	Year	Rate
1	-0,351%	11	0,234%	21	0,623%
2	-0,321%	12	0,283%	22	0,685%
3	-0,268%	13	0,338%	23	0,753%
4	-0,215%	14	0,391%	24	0,824%
5	-0,159%	15	0,432%	25	0,897%
6	-0,094%	16	0,459%	26	0,971%
7	-0,014%	17	0,479%	27	1,044%
8	0,052%	18	0,501%	28	1,117%
9	0,117%	19	0,530%	29	1,188%
10	0,183%	20	0,570%	30	1,257%

Table 5. Interest Rate Assumptions, 2020
Source: CA Vida (2020a)

Expenses:

The expense assumptions used in the cash flow projections were defined as the average of expenses verified in previous years. These include, among other, commissions on premiums and mathematical provisions, personnel expenses, interest paid, taxes, and other fees. Acquisition expense refers to the first year of contract, and renewal expense to the subsequent years (Table 6). The expenses, *e*, per policy, in euros, are the following:

Acquisition	59,07
Renewal	20,09

Table 6. Expense Assumptions, 2020
Source: CA Vida (2020a)

4.4. Portfolio analysis

A portfolio analysis was conducted to better understand the distribution of the age of policyholders and the average term duration. Mortgage and credit protection insurance, as well as capitalization products, were overlooked in this analysis, given that their characteristics differ largely from those of the proposed product.

The total number of insured people under pure life insurance contracts is 23 683. The number of policyholders aged 50 or more at the outset of the contract is 2 208, corresponding to 9,3% of the portfolio. The distribution of policyholders over the age of 50 is represented in Table 7:

Age Group	%
50-54	67,44%
55-59	25,86%
60-70	6,70%

Table 7. Policyholder Distribution by Age Group, 2020
Source: CA Vida (2020b)

The average term duration for all policyholder ages is just over 19 years. The average for insured policyholders over the age of 50 is 8,4 years.

However, critical illness insurance's maximum entry age (70) is higher than the limit for the other products in the portfolio (56 and 65). This product also covers policyholders up to age 80, whereas, in other products, that age is limited to 70 years old. For the purpose of profit testing, the term durations assumed, in years, were the following, after adjusting the durations observed for the portfolio (Table 8):

Entry Age	Term Duration
50	12
55	9
60	6
65	4
70	4

Table 8. Term Duration Assumptions, 2020
Source: CA Vida (2020c)

4.5. Profit testing

The purpose of a profit test is to identify the profit an insurer can claim from the contract at the end of each contract year. The first step in the profit testing of a contract is the construction of the projected revenue accounts for each policy year. All cash flows related to the policy are components of the projected revenue account. The calculation of cash flows will also require establishing the technical basis.

Firstly, a multiple decrement table is constructed, as the population is subject to more than one decrement. In this case, the table will contain data about mortality rates, surrender rates, and the probability of diagnosis of a critical illness. These are therefore the relevant decrements: death (*d*), surrender (*s*), and critical illness (*i*); q_x^d is the independent rate of decrement *d* at age *x*, which corresponds to 30% of the GKM80 Table, q_t^s is the independent rate of decrement *s* at

contract year *t*, corresponding to the surrender rate assumptions, and q_x^i is the independent rate of decrement *i* at age *x*. The values of q_x^d, q_t^s and q_x^i result from assuming that each decrement is operating in isolation.

However, the number of lives removed due to each decrement will depend on the preceding population as well as the number of lives removed by every other decrement. This is why a multi-decrement table with dependent rates needs to be built. The value of the dependent rate of each decrement depends on the effect of the other decrements operating on the population.

For the three-decrement (α, β, γ) case, the dependent rates are calculated according to the following formula:

$$(aq)_x^{\propto} = q_x^{\propto}\left[1 - \frac{1}{2}\left(q_x^{\beta} + q_x^{\gamma}\right)\right] \tag{3}$$

The calculation of the dependent rates of *d*, *s* and *i* follows the same structure. Therefore, $(aq)_x^d$, $(aq)_t^s$, $(aq)_x^i$ are the dependent rates of decrements *d*, *s*, *i*, respectively.

The probability of a policy "surviving" a policy year *t* is:

$$(ap)_{x+t} = 1 - [(aq)_{x+t}^d + (aq)_t^s + (aq)_{x+t}^i] \tag{4}$$

The probability that a policy, started at age *x*, remains in force after *t* years is calculated in the following way:

$${}_tp_x \;=\; (ap)_{x+t} \times {}_{t-1}p_x \tag{5}$$

The vector $(PRO)_t$ is called the profit vector. The elements of this vector are the expected profit at the end of each year given that the policy is in force at the start of the year.

$$PRO_t = P_t - e_t - D(aq)_{x+t}^d - C(aq)_{x+t}^i \tag{6}$$

Multiplying $(PRO)_t$ by the surviving probabilities, the result equals the profit signature, $(PS)_t$. The elements of this are the expected profit at the end of each year given that the contract was in force at age *x*.

$$PS_t = PRO_t \times {}_{t-1}p_x \tag{7}$$

Further details can be found in IFoA (2018).

The profit signature will be used in the next section for the calculation of profit margins.

4.6. Profit margins

The profit margin is the expected Net Present Value (NPV) of the profit signature, expressed as a percentage of the expected NPV of the premium income. Despite fractional payment being a possibility, the premium P_t is assumed to be fully paid at the beginning of the policy year. Profit margin is calculated in the following way:

$$Profit\ Margin = \frac{\sum_{t=1}^{n} \frac{(PS)_t}{(1+i_t)^t}}{\sum_{t=1}^{n} \frac{{}_tp_t \times P_t}{(1+i_t)^{(t-1)}}} \quad (8)$$

The profit criterion used was already incorporated in the pricing of the product, being equal to the loading part of the GR, i.e., the difference between the *GR* and the *PPR*.

The expected profit margins, for a single policy starting at entry age *x*, are shown in Table 9.

Entry Age	Profit Margin
50	11,86%
55	15,91%
60	18,58%
65	21,10%
70	25,47%

Table 9. Critical Illness Insurance's Projected Profit Margins
Source: CA Vida (2020c)

The pricing of the product and the profit testing were done in a very conservative way, due to scarce data relative to older policyholder ages. The profit margins reflect that.

For instance, the profit margin for entry age 50 is 11,86%. This is due to the probability of a claim being relatively low when compared to those of older ages and, therefore, the premium being relatively low too. And also, because it was assumed that the policy would be in force for 12 years. If a term of 20 years had been assumed the profit margin would then be close to 15%.

For entry age 70 the expected profit margin is just over 25%. Despite having fewer premium payments throughout the term, the profit margin is explained by the starting level of premiums being quite high. This is, again, due to conservative pricing.

The profit margin of a portfolio of policies starting at the aforementioned entry ages, using the data from Table 7, is 15,24%. This margin is lower than those of other pure life insurance products. However, due to the product's innovative characteristics and given its development stage, the profit criterion is less rigorous.

The results shown in Table 9 are the product of calculations performed using Excel. There are illustrations of the templates that were used in the Appendix. Please note that no data is actually displayed to protect sensitive information.

Chapter V – Conclusion

During times in which interest rates were higher than those of today's markets, it was a good strategy for life insurance companies to focus on providing savings solutions to their policyholders through guarantees. Nowadays, as interest rates remain low, a different option must be found. According to past experience, developing new products appears to be a suitable solution.

In Portugal, due to rising life expectancy and demographic ageing, there is a vast market segment that is not being explored by life insurers. Critical illness insurance can address the lack of life insurance products available to the older population.

In this report it was determined that a product with such characteristics is profitable, although profit margins do not seem very reassuring. However, the work done in the last section was limited to the amount of data available and, as such, the projected margins might be lower than the real experience.

The suggestion for future work on this topic is to gather more information and data on the behavior of mortality and, specially, the frequency of the covered critical diseases for ages 70 and higher. This will allow for a more adequate set of technical basis, and, ultimately, a fairer pricing of the product and more accurate profit testing.

My overall experience throughout my internship at CA Vida has been very rewarding. This report allowed me to complement my academical education and it was a pleasure contributing to the company’s work and successfulness.

References

Antolin P., Schich S., Yermo J. (2011, September). *The Economic Impact of Protracted Low Interest Rates on Pension Funds and Insurance Companies*. OECD Journal: Financial Market Trends, Vol 2011 – Issue 1, pp. 237-44. https://www.researchgate.net/publication/227349840_The_Economic_Impact_of_Protracted_Low_Interest_Rates_on_Pension_Funds_and_Insurance_Companies

ASF (2020a). *Insurance Statistics 2019*. https://www.asf.com.pt/NR/exeres/34CBFBFE-40B5-4ECF-AA75-5934E13A57E4.htm

ASF (2020b). *Insurance Activity Report, 4th quarter 2019*. https://www.asf.com.pt/NR/exeres/92A76659-523B-4576-A8C5-75431CC87E41.htm

Berdin, E., Kok, C., Mikkonen, K., Pancaro, C., Vendrel, J.M. (2015, November). *Euro area insurers and the low interest rate environment*. Financial Stability Review. https://www.ecb.europa.eu/pub/pdf/fsr/financialstabilityreview201511.en.pdf

BIS (2004, June 28). *74th Annual Report*, pp. 5,119. https://www.bis.org/publ/arpdf/ar2004e.pdf.

Borginho, H. (2019). Solvency II, lecture notes, Solvency Models MSOLV, Lisbon University, delivered September 2019

Crédito Agrícola Vida (2020a). *Pressupostos e Metodologia 2019* [Internal Document]

Crédito Agrícola Vida (2020b). *Análise da Carteira de Produtos de Risco* [Internal Document]

Crédito Agrícola Vida (2020c) [Internal Document]

Dahl, C. (2013, September 9). *A brief history of life insurance*. https://www.thinkadvisor.com/2013/09/09/a-brief-history-of-life-insurance/

Dickson, D., Hardy, M., & Waters, H. (2013). *Actuarial Mathematics for Life Contingent Risks*. 2nd ed, Cambridge University Press.

Hartley, D., Paulson, A., Rosen, R. (2016, January). *Measuring Interest Rate Risk in the Life Insurance Sector: the U.S. and the U.K.* ‖ Federal Reserve Bank of Chicago. https://www.chicagofed.org/publications/working-papers/2016/wp2016-02

IFoA (2016). *Solvency II – Life Insurance.* https://www.actuaries.org.uk/system/files/field/document/IandF_SA2_SolvencyII_2016.pdf

IFoA (2018). Core Reading for the 2019 exams - CM1 Actuarial Mathematics, Institute and Faculty of Actuaries

INE (2020a, May). *Mortality Tables for Portugal 2017-2019*. Destaque Press Release. https://www.ine.pt/xportal/xmain?PORTLET_ID=JSP&xpgid=ine_destaques&xpid=INE&PORTLET_NAME=ine_cont_header_dest&PORTLET_UID=%23JSP%3Aine_cont_header_dest%23&DESTAQUEStema=55466&DESTAQUESdata_inicial=&DESTAQUESdata_final=&DESTAQUESfreeText=

INE (2020b, June). *Resident Population Estimates in Portugal 2019*. Destaque Press Release. https://www.ine.pt/xportal/xmain?PORTLET_ID=JSP&xpgid=ine_destaques&xpid=INE&PORTLET_NAME=ine_cont_header_dest&PORTLET_UID=%23JSP%3Aine_cont_header_dest%23&DESTAQUEStema=55466&DESTAQUESdata_inicial=&DESTAQUESdata_final=&DESTAQUESfreeText=

Krenn, G., Oschischnig, U. (2003, December). *Systematic Risk Factors in the Insurance Industry and Methods for Risk Assessment*. Financial Stability Report 6, ONB, pp. 62-7. https://www.oenb.at/en/Publications/Financial-Market/Financial-Stability-Report/2003/Financial-Stability-Report-06.html

Nieder, D. (2016, November 9). *The Impact of the Low Interest Rate Environment on Life Insurance Companies*. Risk Insights. https://www.genre.com/knowledge/publications/ri16-9-en.html

Smith, C., Caslin, P. (2015, May) *Unit Linked Fund Structures Past, Present and Future*. Institute and Faculty of Actuaries. https://www.actuaries.org.uk/system/files/documents/pdf/b02-unit-linked-investments.pdf

Appendix A - Templates for Profit Testing

Age *x*	*q^d_x*	*q^s_t*	*q^i_x*	*(aq)^d_x*	*(aq)^s_t*	*(aq)^i_x*	*(ap)_x*	*t-1_p_x*
55								
56								
57								
58								
59								
60								
61								
62								
63								

Figure A1. Template for the Multiple Decrement Table
Source: CA Vida (2020c)

Age *x*	Premium	Death Claim	Diagnosis Claim	Profit Vector	Profit Signature	PV Profit Signature	Discount Factor	PV Premium
55								
56								
57								
58								
59								
60								
61								
62								
63								
					Total		Total	
							Profit Margin	

Figure A2. Template for the Profit Testing
Source: CA Vida (2020c)