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Quantitative impact of the application of the Matching Adjustment in the Portuguese market

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by Maria Inês Silva

Abstract

This report followed an internship at ASF, the Portuguese insurance supervisory authority, during which I worked closely with the new insurance supervisory regime (the Solvency II) and, in particular, the Matching Adjustment. This adjustment aims to mitigate the impact of spread movements in assets backing specific obligations. The main goal of this work was to quantify the impact of applying the Matching Adjustment in Portuguese Worker's Compensation annuities, through its application in eligible portfolios (real or notional).

In short, we concluded that, although the market is not yet prepared to apply the Matching Adjustment, in some cases, the adjustment can be advantageous to undertakings. Also, the main impacts of the adjustment can be found in Technical Provisions, where a decrease in the Best Estimate occurs due to the increase of the risk-free rates, and in the Solvency Capital Requirement, where an increase of this item is observed due to losses in diversification benefits. Lastly, by implementing the entire process in Excel, we aimed to automate the computations related with the Matching Adjustment and to make it easier to implement in the Portuguese insurance market.

KEYWORDS: *Solvency II, Long-term guarantees, Matching Adjustment, Workers' Compensation, Technical Provisions*

INSTITUTO SUPERIOR DE ECONOMIA E GESTÃO

Mestrado em Ciências Actuariais

Impacto quantitativo do Ajustamento de Congruência no mercado segurador Português

por Maria Inês Silva

Sumário

O presente relatório segue um estágio na ASF, a autoridade supervisora do mercado segurador Português, durante o qual eu trabalhei com o novo regime europeu de solvência (o Solvência II) e, em particular, com o Ajustamento de Congruência. Este ajustamento pretende mitigar o impacto de movimentos de spread em carteiras de rendas dos ramos Vida e Não Vida. O objectivo focal deste trabalho foi a quantificação do impacto do Ajustamento de Congruência no mercado de seguros de Acidentes de Trabalho em Portugal, através da sua aplicação em carteiras elegíveis.

Resumidamente, foi possível concluir que, apesar de o mercado ainda não estar preparado para aplicar o ajustamento de congruência, em alguns casos, o ajustamento pode ser vantajoso para as seguradoras. Além disso, os principais impactos do ajustamento traduzem-se nas Provisões Técnicas, onde ocorre uma diminuição na Melhor Estimativa provocada por um aumento nas taxas de juros sem risco, e no Requisito de Capital de Solvência, onde ocorre um aumento deste item devido à perda de benefícios de diversificação. Por fim, através da implementação do processo em Excel, objectivamos automatizar dos cálculos relativos ao Ajustamento de Congruência e torná-lo mais acessível ao mercado segurador Português.

PALAVRAS-CHAVE: *Solvência II, Garantias de longo prazo, Ajustamento de Congruência, Acidentes de trabalho, Melhor Estimativa*

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Abbreviations

AAER Assets Annual Effective Rate

ASF "Autoridade de Supervisão de Seguros e Fundos de Pensões"

BE Best Estimate

BOF Basic Own Funds

CQS Credit Quality Step

D&D Death and Disability

EIOPA European Insurance and Occupational Pensions Authority

FS Fundamental Spread

LAER Liabilities Annual Effective Rate

LTG Long-Term Guarantee

LTGA Long-Term Guarantee Assessment

MA Matching Adjustment

QIS Quantitative Impact Study

SCR Solvency Capital Requirement

SLT similar-to-life techniques

VA Volatility Adjustment

VBA Visual Basic for Applications

WC Workers' Compensation

Chapter 1

Introduction

This report follows an internship at "Autoridade de Supervisão de Seguros e Fundos de Pensões" (ASF), the Portuguese insurance supervisory authority. During 6 months, I worked with the Risk and Solvency Analysis team, called DRS. The team is responsible for the analysis and reporting on the solvency and financial state of the Portuguese insurance and pension funds market and for the institutional representation, which includes downscaling the European laws and guidelines, working within the committees and working groups of the European Insurance and Occupational Pensions Authority (EIOPA) and supporting the supervision teams by answering questions within its scope of knowledge.

Besides the main research work I developed, which was the aim of the internship and will be the focus of the report, I also integrated other daily activities of DRS, including the drafting and data analysis of the annual report on the Portuguese insurance and pension funds activity and the drafting of regulatory standards. It was very rewarding because it helped me understand the team's usual activities, apply the knowledge I acquired during my masters and learn more about insurance and finance. Due to the nature of DRS's role in ASF, the team works very closely with Solvency II, the new European solvency regime which will be discussed in Chapter 2. Being a new regulation which has not entered into force yet, there's still a lot to

be done to fully understand its future consequences, its advantages/disadvantages and the regime itself. This fact is specially relevant for the Long-term Guarantee package, which was added by an amendment to the regime approved in 2014 and is the motivation for my internship. Indeed, I was asked to develop a study on the quantitative impact of applying the Matching Adjustment (a measure within the Long-term Guarantee package) to the Portuguese Workers' Compensation insurance market and the main goals given to me were the following:

1. Do a brief overview of the subject, including the Solvency II regime and the Matching Adjustment;
2. Analyze the requirements to apply the Matching Adjustment and to select eligible portfolios which are representative of the Portuguese Workers' Compensation insurance market;
3. Measure the impact of applying the Matching Adjustment to real or notional portfolios, namely in Technical Provisions, Own Funds and Solvency Capital Requirements;
4. Extend the analysis to other measures in the Long-term Guarantee package, in particular, the Volatility Adjustment.

Thus, Chapter 2 includes a description of Solvency II, the Matching Adjustment and the Long-term Guarantee package, the Workers' Compensation insurance in Portugal and the general methodologies used to deal with the proposed problem. Chapter 3 presents a general analysis about the state of the Workers' Compensation insurance in Portugal during 2014. Chapter 4 explores the possibility of applying the Matching Adjustment in Portugal, including a revision of the eligibility criteria, the construction of eligible portfolios representative of market and the computation of the measure itself. Chapter 5 includes the valuation of the Best Estimate (a part of Technical Provisions), the computation of the Solvency Capital Requirement and the assessment of the general impact of applying the Matching Adjustment. Finally, Chapter 6 concludes the report by summarizing the main findings and setting the path for future developments.

Chapter 2

Theories, Regulations and Methodologies

2.1 Solvency II Overview

Since the 1970s, the European Union has been aiming for a harmonization of practices and a convergence of supervision for the insurance sector within the European Economic Area. That was the decade when the first directives were implemented and since then we have been walking towards that goal. Many revisions have been made, however they were unable to accompany the rapid changes occurring in the european insurance sector and the financial markets. Thus, the current framework, named Solvency I and regulated by the directives (Council, 1973) and (European Parliament and Council, 2002), although easily implemented and providing a relative protection to policyholders, remains short on some aspects. The problem is that these directives are insufficient in showing an insurer's true risk exposures, lead to a misalignment between capital requirements and the risks the insurer is exposed to, do not fully incentive insurers to have a risk-based management and finally do not provide sufficient tools for the supervisors to intervene.

Recognizing the need for a deep review of Solvency I, in 2001 began the development of the project Solvency II, which aimed for a completely new regime instead of a building-up on top of Solvency I. That was the kick-off year of many studies aimed to develop a framework for the new solvency regime, being the Sharma report one of them (Sharma, 2002). The main conclusion here was to base the new regime on Basel II, a set of international regulations for finance and banking which is also structured on three-pillars combining qualitative and quantitative measures. Then, following the Lamfalussy Process (well described by Raptis (2012)), the Solvency II Framework Directive was adopted (see European Parliament and Council, 2009). However, after the 2008 financial crisis, some issues about the EU supervisory structure and the impact of short-term market movements in long-tailed businesses arose, bringing a lot of debate and delaying the implementation of Solvency II. Some studies and reviews were made and finally, in 2014, the Omnibus II Directive (European Parliament and Council, 2014), amending the initial directive, and the Delegated Acts (European Commission, 2014), describing implementing measures, were approved. Presently, EIOPA is concluding its work on Technical Standards and Guidelines to ensure consistent implementation and cooperation within the EU. The process will be finished in 2016, time when the new regime will come into force.

Solvency II includes 2 important features - a global and integrated view of risks (with the 3 main pillars) and the principle of proportionality, which sets that the requirements should be proportionate to the risks' nature, size and complexity.

The 3 pillars where the framework is built upon cover quantitative requirements (Pillar 1), qualitative requirements (Pillar 2) and reporting and disclosure requirements (Pillar 3). Together, they give a complete risk-based overview of insurance companies, always encouraging undertakings to manage their risks and being transparent. The quantitative requirements in Pillar 1 contain the following main components:

Integrated view of the balance sheet - Both assets and liabilities are valued through market consistent principles in a total balance sheet approach, which

means that not only all assets and liabilities are valued, but also their interactions are considered in the valuation.

Technical provisions - They represent the amount necessary to cover all insurance liabilities in force at the valuation date and it's subdivided into the Best Estimate (present value of the liabilities cash-flows' expected value, discounted using the risk-free rates) and the risk margin (cost of holding regulatory capital sufficient to ensure the full run-off of liabilities).

Own funds - Financial resources available to create new business and to absorb unexpected losses. They're divided into Basic Own Funds (the excess of assets over liabilities plus subordinated liabilities) and Ancillary Own Funds (off-balance-sheet commitments that the insurer may call to increase its financial resources). They're classified in 3 tiers based on their loss-absorbing capacity and subordination.

Capital requirements - Represents the extra capital needed to sustain unexpected losses and has two levels: the Solvency Capital Requirement - the capital needed to sustain a shock corresponding to the value-at-risk 99.5% for one year time horizon - and the Minimum Capital Requirement - level from where the risk of insolvency is considered excessive. Both capital requirements must be covered by specific Own Funds items and any breach implies actions from the supervisor.

Despite being in its implementing stages and still having some areas in development, Solvency II is a very ambitious project. By being risk-based, taking an economic view and promoting group supervision, the new regime will encourage financial stability, a higher protection of policyholders and a more efficient operation of the insurance sector, aiming thus to deepen the current single market across the EU.

2.2 Matching Adjustment

As discussed before, one of the reasons why the implementation of Solvency II was delayed was the intense debate around the valuation of long-term liabilities and the long-term guarantees problem. Because Solvency II is risk-based and sensitive to market conditions, it was failing to address situations where insurance products with long-term guarantees were being affected by artificial volatility and pro-cyclicality.

To solve this, during 2013, EIOPA carried out a Quantitative Impact Study (QIS) on long-term guarantees, the Long-Term Guarantee Assessment (LTGA). The study tested 6 different measures feasible to be included in the new framework, namely the Counter-Cyclical Premium, some versions of the Matching Adjustment, extrapolation methods and the extension of recovery period. The goal was to quantify the impact of these measures in the valuation of liabilities and the calculation of capital requirements. Some measures were rejected while others suffered some modifications and finally, in 2014, Omnibus II adopted the definitive Long-Term Guarantee (LTG) package within the Pillar 1 requirements, which includes now the current Matching Adjustment (MA).

The MA was especially built for life and non-life annuity products, aiming to mitigate the impact of spread movements in the value of Technical Provisions and capital requirements for some special portfolios. In fact, because those products' liabilities are predictable and can be fully matched by assets held until maturity, undertakings are not forced to sell their assets to meet their liabilities and thus they are not exposed to short-term market volatility. Also, because the MA is tailor-made for each undertaking, even in its early stages, the LTGA report acknowledged the Matching Adjustment as "the most effective tool within the LTG package with regards to mitigating short-term volatility from Solvency II balance sheets of portfolios eligible for the measure" (EIOPA, 2014).

Any undertaking wishing to apply this measure must comply with several eligibility criteria addressing the portfolio of assets, the portfolio of liabilities and the management of both portfolios. Summarily, their purpose is to ensure that:

- Both portfolios are managed separately from the rest of the business;
- Liabilities do not give rise to future premiums and allow no options for policyholders, except for surrender options where the surrender value does not exceed the value of the assets;
- The only underwriting risks to which liabilities are exposed to are expense, revision, longevity and immaterial mortality;
- The asset portfolio is composed of bonds or similar cash-flows instruments which are held until maturity and have fixed cash-flows;
- The cash-flows of the asset portfolio replicate the liabilities cash-flows and any mismatch doesn't give rise to material risks.

Since the asset portfolio is only exposed to the risks of downgrade and default and since the eligible liabilities are fully covered by that portfolio, the undertaking is given the benefit of discounting those liabilities at a higher rate than the risk-free rate. This higher rate is given by the risk-free rate plus a flat adjustment (the so-called MA) based on the asset portfolio's spread adjusted to account for the two risks it is in fact exposed to. In other words, the MA is a parallel shift of the risk-free interest rate term structure used to discount the Best Estimate (BE) of the portfolio of eligible liabilities and it is equal to the asset portfolio market yield minus the risk-free rate and the Fundamental Spread (FS). This FS reflects the assets' probability of default plus the expected loss due to downgrade and it's computed quarterly by EIOPA, using long-term statistics. For more details regarding the computation of all needed statistics by EIOPA can be found in the Technical Specifications by EIOPA (2015).

Lastly, an undertaking can only apply this measure under approval by the supervisory authority, following a specific application process. The application should

contain the methods used by the undertaking to manage both portfolios and to apply the measure. Once approved, the undertaking cannot revert back to an approach where the MA is not applied, even in cases of extremely low spreads when the MA could become negative. Also, the scope of such approval may cover all future item in the matching portfolio, provided the undertaking can prove that the matching portfolio continues to meet all relevant requirements and that those new items have the same features as the current matching portfolio.

2.3 Workers' Compensation

Workers' Compensation (WC) is a program which provides medical benefits and/or income replacement in case of occupational illnesses and injuries. In 1884, Germany was the first country to introduce a WC program. After that, many countries adopted it, although each one with its own particularities.

WC is divided in 3 main program types. WC programs can be integrated within a wider social insurance program, also providing, for instance, retirement pensions. They can be within a WC compulsory insurance system, where employers are liable to insure its WC liabilities. And they can be within a voluntary WC insurance system, where employers are responsible for all WC obligations but are not obliged to secure those obligations via insurance. Portugal can be considered to have a mixed security system, since there's a clear division between occupational accidents and occupational illness. While for the first, it is a compulsory insurance system, for the second, the responsibility falls in the public security system. Thus, when working within WC insurance, undertakings in Portugal only deal with occupational accidents.

The Portuguese law defines an occupational accident as any sudden and unforeseen event which occurs in the workplace and during working time, that causes, directly or indirectly, bodily injury, functional disorder or illness and results in a reduction

in the person's earning/working capabilities or in death. The sudden nature of accidents is the main difference between them and occupational illnesses, which arise from a long and continued exposure to a certain occupational risk.

The WC insurance for occupational accidents provides two main groups of benefits - benefits in kind and benefits in cash. The first includes essentially medical treatments, while the second mainly relates to income replacement. Contained in the cash benefits are the Death and Disability (D&D) pensions. In Portugal, disability pensions are granted to victims who have already been submitted to all relevant treatments and whose disability is considered permanent. This doesn't mean that the disability won't change. In fact, it's not uncommon to see the medical condition evolve either for better or worse and, in these cases, both beneficiary and undertaking may ask for exactly one legal disability revision per year. Disability pensions are perpetual and are computed according with the victim's yearly income and disability, which means that disability revisions lead to changes in pension values. Finally, disability pensions undergo three legal states - provisional, defined and definitive. In the first, there's no legal agreement on the disability and yearly income, in the second, the disability is legally established, and in the third everything is legally established and the pension's value is fully determined. With respect to the death pensions, specific types of beneficiaries receive fixed percentages of the victims' yearly income. Usually, these pensions are fixed and perpetual, but there are some exceptions. For instance, orphans receive pensions only until they're 18 years old or until they are 22 or 25 and still attending school, while spouses receive an extra 10% when they complete 65 years of age.

There's also a public fund for WC in Portugal, the "Fundo de Acidentes de Trabalho". It is managed by ASF and has two main roles - it is responsible for covering obligations when the entity responsible for those obligations cannot meet them (for instance, in case of insolvency) and it reimburses undertakings for the yearly inflation updates on pensions' values (this way, undertakings only pay fixed pension amounts).

More information on WC in Portugal can be consulted in Alegre (2011), which includes all the relevant Portuguese laws explained. In conclusion, although the MA was not originally designed for the WC insurance business, given the particularities of this line of business in Portugal, not only D&D pensions are well suited for the measure's application, but also it may be the line of business where the measure will have the most relevant impact.

2.4 Proposed problem and methodologies

As discussed before, the internship aimed to study the quantitative impact of applying the Matching Adjustment to the Portuguese WC insurance market. Therefore, the following plan was devised:

1. Cluster all 15 undertakings operating in the Portuguese WC sector into three groups according with their market shares. They are the Big Dimension (BD) group, the Medium Dimension (MD) group and the Small Dimension (SM) group. They represent 81%, 17% and 2% of the market, respectively, and include 6,5 and 4 undertakings, respectively.
2. Compute the yearly expected liabilities cash-flows, related with each group's current D&D pensions.
3. Study the composition of each group's assets portfolio covering the respective liabilities.
4. Check the requirements to apply the MA for each group.
5. Find assets portfolios that fully match each group's liabilities and are representative of the groups' original assets portfolio. They'll be called Matching portfolios.
6. Compute the MA for each set of portfolios.
7. Compute the Best Estimate for each group's portfolios, with and without MA, and assess its impact.

8. Compute the Solvency Capital Requirement (SCR) for each group's portfolios, estimate the SCR such undertakings would have, with and without MA, and assess its impact.

In order to make steps 5 to 8 as faster to run and as automated as possible, we implemented them in Excel workbooks which included functions programmed in Visual Basic for Applications (VBA). Appendix D contains parts of the workbooks and VBA's coding. The full content can be available upon request.

In the end, we hope to evaluate the full impact of applying the MA to three notional undertakings - the BD, MD and SM groups, which are representative of three different types of Portuguese insurers.

Chapter 3

Workers' Compensation in the Portuguese insurance market

Chapter 3 analyses the current state of WC insurance in Portugal, bearing in mind it only includes occupational accidents. Also, since the MA is specially built for annuities, we just considered D&D pensions. In order to perform this analysis, we used two sets of data, namely:

Liabilities portfolio - Information reported to ASF on all current beneficiaries, according with the regulatory standard issued by Instituto de Seguros de Portugal (2007).

Assets portfolio - Details concerning the assets belonging to the assets portfolio covering all WC liabilities, which is called "Carteira 5" in Portugal. The aforementioned data is annually reported to ASF and was backed by data provided by Bloomberg.

All data refers to the year 2014, although we also used information on the liabilities portfolio for the years 2012 and 2013 to estimate some parameters. As explained in the previous chapter, the cash-flows of each specific undertaking were aggregated through their market shares' weighted average.

3.1 Liabilities portfolio

The main goal of this analysis was to project the full run-off of all pensions' cash-flows. For each beneficiary, we had information on the insurance company, gender, actuarial age, type of beneficiary, pension value, pension state and existence and reason for revisions of the pension value. Thus, assuming that pensions are paid at the beginning of the year, we built an iterative formula to compute the basic pension value P_x^y for all beneficiaries aged (x) during the year y:

$$P_x^y = P_{x-1}^{y-1} \cdot p_{x-1} \text{ for } y > 2015 \text{ and } P_x^{2015} = P_x^{initial} \tag{3.1}$$

where p_x is the one-year survival function for a person aged (x) and $P_x^{initial}$ is the sum of all pensions paid during the year 2014 for the beneficiaries aged (x) and alive by the end of 2014. To compute p_x, we chose the specific mortality tables used by each undertaking for computing their current provisions and, for simplicity, we assumed that pensions were paid at the beginning of the year.

Besides the general formula, we had to take into account some specificities of the D&D pensions:

- The beneficiaries had to be divided by gender because the mortality tables differ from male to female.
- Since, for the purpose of applying the MA, we are only interested in annuities, we excluded all redeemable (i.e. paid as a lump sum), suspended and extinct pensions, leaving only the active and non redeemable pensions.
- As seen in Chapter 2, different types of beneficiaries have different rules concerning the pensions' run-off and so we divided all types into 4 groups and adjusted the general formula to $(P_x^y)^*$:

  General annuity - these are the plain vanilla pensions, i.e., constant pensions granted until the beneficiaries' death. The formula is the same $(P_x^y)^* = P_x^y$.

+5% annuity - also perpetual but when the beneficiary completes 65 years of age, the pension is increased by 5%. The pension is given by the general formula until age 65 and after that is equal to $(P_x^y)^* = P_x^y \cdot 1.05$.

+10% annuity - the same as the +5% annuity, but has an increase of 10%. After 65 years of age, the pension is $(P_x^y)^* = P_x^y \cdot 1.10$.

Orphan annuity - term annuity that stops when the beneficiary completes 25 years of age. The pension is the same $(P_x^y)^* = P_x^y$ until 25 years of age and after that is zero.

- Disability pensions suffer changes in their values due to revisions of the disability attributed to the beneficiary and due to changes of state from provisional to definitive. To include this in the projections, we computed the annual aggravation rates for 2012, 2013 and 2014 (using the data for these years) and, for prudence, chose the highest rate - 4.52% (the results are in appendix A, Table A.1). Thus, the formula to compute pensions' value was again adjusted to $(P_x^y)^{**} = (P_x^y)^* \cdot 1.0452$.
- Based on the available data, it was possible to conclude that the amount of expenses related to D&D pensions were immaterial, and thus we didn't include expenses in the cash-flows' projection.

After obtaining the annual pensions for each actuarial age (x), we added these pensions to find the total nominal pension amount for each year. Then, for each year, we aggregate these cash-flows by computing their weighted average according with the undertakings' market shares. The results are displayed in Figure 3.1. As expected, the BD group has a significantly higher amount of yearly liabilities cash-flows, when compared with the other two groups. Also, its liabilities are more condensed in earlier maturities than the MD group. In fact, the BD group has its peak of cash-flows around the year 2035, while the MD group has its peak around 2047 and presents smaller relative values of cash-flows in the first years. Although it is much smaller, the SD group presents a structure of its liabilities yearly cash-flows more similar to the BD group's.

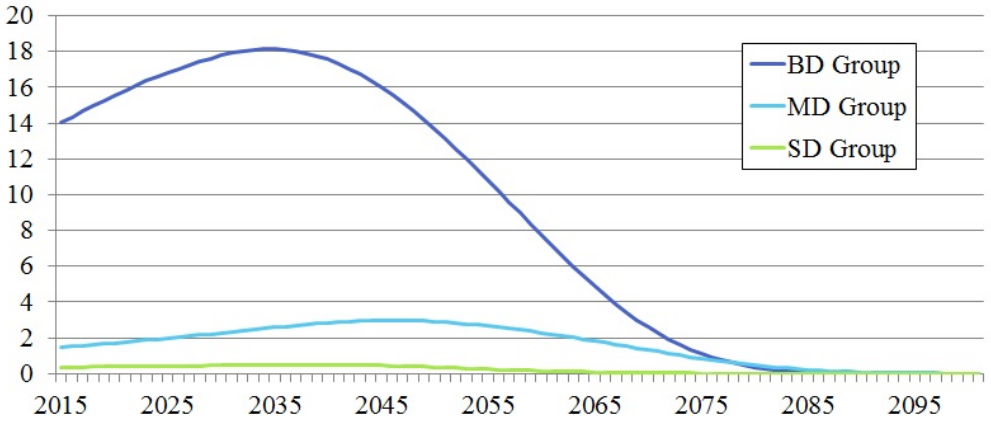


FIGURE 3.1: Liabilities yearly cash-flows in million euros

These are the cash-flows which were later used to build Matching Portfolios and to compute Technical Provisions and SCR.

3.2 Assets portfolio

There were two main goals for this analysis. Firstly, we wanted to understand the portfolio's composition and main features and, secondly, we wanted to know if the assets matched the liabilities, i.e., if, at any given year, the nominal value of liabilities was equal to the nominal value of assets, which is a requirement for the MA's application. From the first part of the analysis, we drew the following conclusions:

General portfolio composition - All portfolios are majorly composed of sovereign and corporate debt (bonds), adding always up to more than 60% in all the 3 groups. The BD group is the most diverse with material investment in equity, property, real estate investment trusts and deposits. It is followed by the SD group, with material investment also in property. Finally, the MD group is the less diverse without material investment other that sovereign and corporate debt.

Bonds' coupon type - The most common coupon type is the fixed coupon (all groups have more than 90% of this type), which pays a fixed coupon amount. The other two material types are the floating coupon, where the coupon depends on a money-market index, and the variable coupon, where the coupon depends on other indexes or specified formulas which are based on market conditions.

Bonds' maturity type - The BD group is again the more diverse, with 83% of the "at maturity" type (the plain vanilla bonds) and both callable (the issuer has the option of early redemption) and puttable (the holder has the option of early redemption) types still material but below 6%. The MD group has 99% of "at maturity" bonds and the SD group has 95% of "at maturity" and a material amount of callable bonds.

Bonds' actuarial basis - This is the day count convention used to accrue interest. The most common is the ACT/ACT with all groups with more than 88%. Both ISMA-30/360 and ACT/360 are material.

Bonds' Credit Quality Step (CQS) - This is a Solvency II convention that characterizes the credit worthiness of assets. It is an integer scale from 0 to 6 where the lower the CQS, the higher the rating. More information on this mapping can be found at (Joint Committee, 2015). The BD group has an average CQS of 4.10, the MD group has 2.86 and the SD group has 3.37.

Bonds' yield - The BD group has an average bond yield of 1.9930, the MD has 1.4114 and the SD has 1.1927. For this analysis, for obvious reasons, we excluded bonds with variable and floating coupons.

MA eligibility - Within "Carteira 5", the assets eligible for the MA's application are bonds (Corporate and Sovereign) with fixed cash-flows (mainly fixed and zero-coupon) which allow no options for issuers. In the BD group these assets correspond to 57.67% of the total portfolio, while in the MD group they correspond to 91.64% and in the SD group correspond to 62.75%.

Then, for the second part of this study, we had to project the cash-flows of all

eligible assets. Knowing the bonds' coupon yield, coupon type, frequency, maturity date and redemption amount, we built the payoff matrix $\boldsymbol{C} \in \mathcal{M}_{n\times m}$, where each row corresponds to the cash-flows of a specific bond and each column corresponds to the cash-flows of a specific year. We made some assumptions for simplicity:

- To project the liabilities, we assumed that they were paid in the beginning of each year. Therefore, in order to be coherent, we discounted all cash-flows of a certain year to the beginning of that year using the forward rates related to the risk-free interest rates published by EIOPA. In this way, the payoff matrix represented the value of assets' cash-flows at the beginning of each year.
- Since the ACT/ACT was the actual basis more frequent, we used it for all bonds.

With the payoff matrix $\boldsymbol{C}$ and the column vector $\mathbf{w}$ containing the number of units invested in each bond[1], the annual assets cash-flows were simply the row vector $\boldsymbol{C}\mathbf{w}$. The results are shown in Figure 3.2.

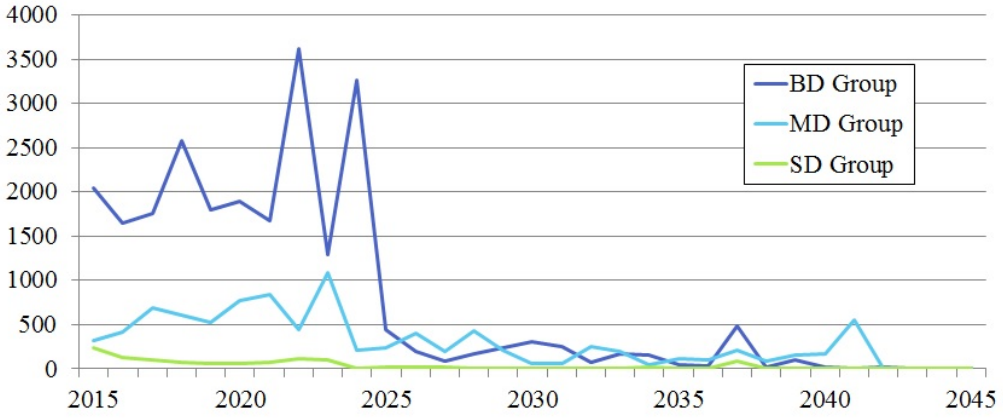


FIGURE 3.2: Assets yearly cash-flows in million euros

Once again, the BD group presents higher values in its cash-flows than the other groups. However, the gap between them is lower in this case. Also, assets' cash-flows are much more irregular and concentrated in earlier years than the liabilities' cash-flows.

[1]Information included in the data reported to ASF

A more attentive eye may notice that the assets' cash-flows are much higher than the liabilities' cash-flows. The reason behind this considerable mismatch is the fact that, even though for the purpose of applying the MA we are only considering active and non redeemable pensions, the portfolio "Carteira 5" is used to cover all future WC obligations, including redeemable pensions, medical expenses, claims reported but not settled and claims incurred but not reported.

Chapter 4

Matching Adjustment Application

4.1 Eligibility criteria

In order to apply the MA to specific portfolios of assets and liabilities, they need to comply a set of criteria defined in the amendment made to the Solvency II Directive by the European Parliament and Council (2014), the Omnibus II Directive. For each group of undertakings (BD, MD and SM), we checked the fulfillment of all criteria and, in the end, all groups failed the same requirements. Indeed, this outcome was expected as undertakings have no reason to adapt their asset portfolios to comply with such criteria in the current regime. The results for all groups are summarized in Table 4.1.

In general, all criterion related with the liabilities portfolio is satisfied because the nature of the D&D pensions' business in Portugal fits perfectly within the scope of the MA. It includes non-life annuities only exposed to the underwriting risks of longevity, expenses and revision, and such that no future premium payments are generated by them. However, the same does not happen with the assets portfolio, since it fails every criteria. First of all, the portfolio "Carteira 5" is used to cover all WC liabilities, which disagrees with the requirement setting that assets cannot be

used to cover losses from other activities. Also the aforementioned portfolio is very diversified, including investment in stocks and properties, which are asset types not allowed for the MA's application. Then, considering only the investment on bonds, there are material investments in floating and variable coupon bonds, which fails the criteria requiring assets with fixed cash-flows. Finally, if we only used the eligible types of assets in the assets portfolio, it would not replicate the liabilities' cash-flows because there's a huge gap between the maturities of the two portfolios. Actually, all assets mature before 2044, while liabilities ultimately run past the year 2100.

Criteria	**Compliance**
Assets portfolio	
Consists of bonds and other assets with similar cash-flow characteristics	No
Is maintained over the lifetime of obligations	No
Cannot be used to cover losses arising from other activities	No
Its expected cash-flows replicate the expected cash-flows of liabilities and any mismatch does not give rise to material risks	No
Its cash-flows are fixed and cannot be changed by issuers or third parties (a dependence on inflation is allowed provided that those assets are used to cover liabilities that depend on inflation)	No
Liabilities portfolio	
Includes life insurance obligations and/or non-life annuities	Yes
All contracts underlying this portfolio cannot give rise to future premium payments	Yes
The only underwriting risks connected with this portfolio are longevity, expense, revision and mortality	Yes
When there's an exposure to mortality risk, the BE cannot increase by more than 5% under a specified mortality risk stress	Not Applicable
Includes no options for policyholders except a surrender option where the surrender value does not exceed the value of assets	Yes
Obligations of a single contract cannot be split into different parts when composing this portfolio	Yes
Both portfolios	
Are identified, organized and managed separately from other activities of the undertaking	No

Table 4.1: Eligibility criteria for the Matching Adjustment's application

Therefore, we conclude that the market is not yet prepared to apply this measure. Nevertheless, we still want to estimate what would be the MA's impact in the Portuguese market, assuming it could indeed be applied. Since the problem resides in the assets portfolio, we can build eligible assets portfolios for the market's real liabilities portfolios and continue the analysis from there.

4.2 Building eligible assets portfolios

The process of building eligible portfolios of assets consisted of three main steps:

1. Find a set of eligible assets with maturities ranging from 2015 to 2074;
2. Select one asset for each different maturity year depending on specified criteria;
3. For each asset, compute the amount of units that should be held in order to replicate the liabilities' cash-flows.

Our aim was to build portfolios as close as possible to the real portfolios the undertakings already held and to use always real assets being traded in the market by the end of 2014. Thus, for step one, we gathered all eligible assets from the original portfolios and, for maturities not present in those portfolios, we added all eligible assets quoted in Bloomberg and exchanged in euro currency. In the end, we had 3 sets of eligible assets, one for each specific group of undertakings.

For step two, we considered two distinct investment strategies - the portfolio with the highest yield and the portfolio with the highest rating. The first is quite obvious - for each maturity we chose the assets with the highest yield to maturity computed from the 31st of December, 2014. For the second, we didn't use the assets' rating, but instead their CQS. For each maturity, we chose the asset with the lowest CQS and, to break a tie, we chose the asset with the highest yield.

Then, for step 3, we used the following method:

Consider n different bonds, with market prices $B_1, B_2, ..., B_n$, and their payoff matrix defined as $\mathbf{C} = [c_{ij}]_{n\times n}$, where c_{ij} is the cash-flow of bond i at time t_j. Consider also the liabilities vector $\mathbf{L} = [l_j]_{n\times 1}$ where l_j is the expected liabilities cash-flow at time t_j. Now, for the portfolio $\mathbf{w} = [w_i]_{n\times 1}$, where w_i is the number of bonds i held in it, we have that the vector of the assets cash-flows is given by $\mathbf{w}^T\mathbf{C}$.

The condition is both liabilities and assets having the same cash-flows at all times. Thus $\mathbf{w}$ has to be such that $\mathbf{w}^T\mathbf{C} = \mathbf{L}^T$, which is equivalent to $\mathbf{w}^T = \mathbf{L}^T\mathbf{C}^{-1}$ if and only if $\mathbf{C}$ is invertible. Since both investment strategies define portfolios with exactly one asset per maturity year, from 2015 to 2074, the payoff matrix $\mathbf{C}$ is lower triangular, which implies that $\mathbf{C}$ is invertible. Therefore, $\mathbf{w}^T = \mathbf{L}^T\mathbf{C}^{-1}$ is the portfolio that perfectly matches $\mathbf{L}$.

However, this method has some drawbacks and thus some adjustments were made:

- As explained in chapter 3, liabilities' cash-flows were computed assuming all pensions were paid at the beginning of the year. However bonds can mature at any time during the year. Since we need the assets first to be able to pay the liabilities, we considered that any bond maturing in a certain year would be used to cover the cash-flows of the next year. For instance, all bonds maturing in 2015 will be used to cover the liabilities of 2016.
- Although liabilities run past the maturity year 2100, the current market does not contain eligible assets with so long maturities. Therefore, to solve this issue, we considered that the highest maturity year would be 2075 and the assets maturing in that year would have to cover all future liabilities cash-flows. In other words, we added the nominal value of all cash-flows being paid after the year 2075 and assigned that value to the year 2075.
- Although one can only hold an integer number of bonds, this method may lead to non integer values for w_i. In these cases, we rounded the value obtained to the nearest integer. Despite the approximation provoking a certain degree of

mismatch between the assets and liabilities cash-flows, the mismatch was not material.

- The method may also lead to negative values of w_i, which is not acceptable. In these cases, we considered w_i to be zero. Again, the approximation leads to mismatches. However, the only portfolios where we had to apply it were the two covering the MD group and even in those the mismatch was not material.

Finally, when valuing assets' cash-flows for applying and computing the MA, the Directive states that those cash-flows must be adjusted to take into account the risk of default. In particular, $\tilde{c}_{ij} = c_{ij} \cdot (1 - \text{PD}_i) + 0,3 \cdot c_{ij} \cdot \text{PD}_i$[1], where PD_i is the probability of default for bond i, which is provided by EIOPA and depends on the bond's CQS, maturity and type of issuer (i.e., whether it is Governmental, Financial or Non-financial). Thus, the payoff matrix $\mathbf{C}$ was adjusted in step 3 according to the presented formula.

In the end, after implementing the entire process in Excel using functions programmed in VBA, we built 6 different eligible portfolios (two for each group of undertakings), that match the correspondent cash-flows of liabilities. The full content of these Matching portfolios is in Appendix B and their general features are presented in Table 4.2.

Group	**Portfolio**	**Average Yield**	**Average CQS**	**Average Duration**	**% Invested in Government**	**% of Mismatch**
BD	H. Yield	0.0365	4.40	18.62	51.12%	0.12%
	H. Rating	0.0194	1.70	19.91	47.03%	0.04%
MD	H. Yield	0.0332	4.32	24.76	46.26%	0.36%
	H. Rating	0.0186	1.70	25.35	45.37%	0.58%
SD	H. Yield	0.0352	4.10	18.24	37.05%	3.37%
	H. Rating	0.0168	1.16	19.54	37.98%	2.72%

TABLE 4.2: Information on Matching portfolios' general features

[1] the formula is given in EIOPA (2015)

4.3 Matching Adjustment computation

In the Directive's amendment by European Parliament and Council (2014), the Omnibus II Directive, the MA is defined to be the difference between two annual effective rates, the Assets Annual Effective Rate (AAER) and the Liabilities Annual Effective Rate (LAER), minus the portfolio's Fundamental Spread (FS). The directive outlines these concepts as:

AAER - The annual effective rate, calculated as the single discount rate that, where applied to the cash-flows of the portfolio of insurance or reinsurance obligations, results in a value that is equal to the market value of the portfolio of assigned assets.

LAER - The annual effective rate, calculated as the single discount rate that, where applied to the cash flows of the portfolio of insurance or reinsurance obligations, results in a value that is equal to the value of the BE of the portfolio of insurance or reinsurance obligations.

Fundamental Spread- the sum of two credit spreads, the one corresponding to the probability of default of assets and the one corresponding to the expected loss resulting from downgrading of the assets. Both spreads and the FS are provided by EIOPA and depend on the assets' CQS, maturity and type of issuer. Moreover, the FS used to subtract from the MA must include only the portion of the FS that has not already been reflected in the adjustment to the cash-flows of the assigned portfolio of assets. And finally, the FS of each asset must be at least 30% (for exposures to Member States' central governments and central banks) or 35% (for any other exposures) of the correspondent long-term average of spread over the risk-free interest rate. These long-term average of spread is also computed by EIOPA periodically.

In practice, we computed the MA by applying the following 7 steps in Excel, with the support of functions programmed in VBA:

1. Compute the market value of the Matching portfolio as the sum over all assets of their real market value multiplied by the number of units invested in them, w_i;
2. Compute the BE of the liabilities portfolio as the present value of all liabilities' cash-flows using the risk-free rate term-structure published by EIOPA;
3. Compute both AAER and LAER, as described in the directive, using the Excel's add-in named Solver;
4. For each asset, get its FS and credit spread corresponding to the probability of default of assets and compute its remaining FS as the difference of the two;
5. Compute each asset's duration;
6. Compute the weighted average of the assets' remaining FS, using the amounts invested in each asset and their duration;
7. Finally, compute the MA as the AAER minus the LAER and minus the weighted average remaining FS.

4.4 Remarks and Results

Group	**Portfolio**	**AAER**	**-**	**LAER**	**-**	**FS**	**=**	**MA**
BD	H. Yield	274.08	-	170.13	-	2.68	=	101.27
	H. Rating	173.20	-	170.13	-	1.28	=	1.79
MD	H. Yield	251.11	-	196.63	-	3.40	=	51.08
	H. Rating	164.31	-	196.63	-	2.01	=	-34.34
SD	H. Yield	274.91	-	166.03	-	2.66	=	106.23
	H. Rating	153.58	-	166.03	-	1.06	=	-13.51

TABLE 4.3: MA and relevant spreads for its computation, in basis points (1 basis point equals 0.0001)

First of all, it is clear that the Highest Yield portfolios have consistently higher MA's than the Highest Rating portfolios. This trend seems to be caused by the influence the yields have on AAER's and the fact that lower ratings don't influence in the same degree the FS.

Also, there are evident differences between the three groups of undertakings. Firstly, the MD group seems to have a generally lower MA than the other groups, not only due to higher FS's, but also due to higher LAER's and, in some cases, lower AAER's. Secondly, the SD group presents a higher variation between the Highest Yield and Highest Rating portfolios, variation which is experienced both in the AAER and the FS.

However, are these phenomena happening just in these 6 portfolios or are some trends caused by intrinsic features of the groups and their sets of eligible assets? Also, in broader approach, what impact do the portfolios' specific features have in the value of the MA? In order to answer these questions, we tried to characterize the distribution of the MA. We already had a Excel workbook that automated the process of computing the MA and thus we changed it to include two functions:

1. Similarly to the functions that find the Highest Yield and Highest Rating portfolios, we build a function that finds a random portfolio.
2. To be able to capture the distribution of the measure, we would have to compute it for many random portfolios. Thus, we build an iterative function that runs the MA's computation process for 1000 random Matching portfolios and stores that information in a Excel spreadsheet.

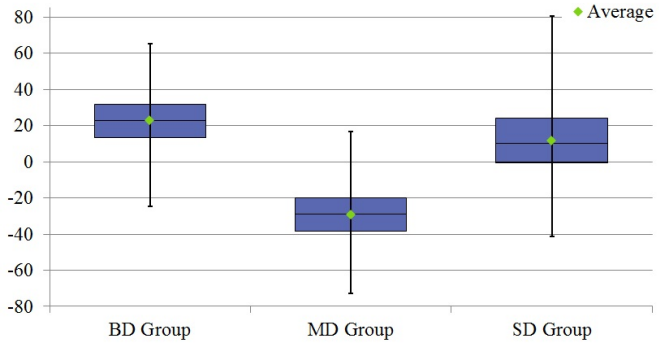


FIGURE 4.1: General distribution of the MA, in basis points, per group

Figure 4.1 contains box-plots with the general MA's distribution for all the three groups. The data clearly supports the trends previously observed. Moreover, Tables

4.4 and 4.5 present the average values and the standard error of all major portfolio' features and all relevant figures influencing the MA's calculation.

Group	Measure	Average Yield	Average CQS	Average Duration	% Invested in Government	% of Mismatch
BD	Average	2.38	3.64	19.72	60.85%	0.08%
	S. Error	0.13	0.22	0.23	7.00%	0.05%
MD	Average	2.09	3.59	25.34	54.05%	0.48%
	S. Error	0.11	0.22	0.22	6.79%	0.35%
SD	Average	2.03	3.13	19.29	48.59%	3.69%
	S. Error	0.13	0.23	0.26	7.37%	1.87%

Table 4.4: MA distribution's general features

Group	Measure	AAER	-	LAER	-	FS	=	MA
BD	Average	194.75	-	170.13	-	2.12	=	22.50
	S. Error	13.54		0.00		0.71		13.95
MD	Average	170.28	-	196.63	-	3.12	=	-29.46
	S. Error	13.20		0.00		0.91		13.91
SD	Average	179.74	-	166.03	-	2.09	=	11.63
	S. Error	18.93		0.00		0.77		19.30

Table 4.5: MA distribution and relevant spreads, in basis points

Analyzing all the data in detail, we conclude the following:

- The MD group shows a consistently lower MA when compared with the other groups. This is caused by the particular features of the portfolio, particularly, its longer maturities and low yields.
- The SD group experienced the higher MA's standard error, which corroborates the initial suggestion of higher variation. The same happens for almost all its portfolio's features.
- The AAER expresses the assets portfolios' yield. Thus, higher average yields lead to higher AAER's. There is an exception, though. Since this spread is computed based on the liabilities cash-flows, any mismatch between assets and liabilities may cause unexpected fluctuations in the value of the AAER. This

was particularly the case of the Highest Yield portfolios of the groups BD and MD.

- Since the method doesn't change the value of liabilities, the LAER is constant. Thus, the initial trend is maintained, where the average SD portfolio has the lowest LAER, followed by the BD's and finally the MD's. This spread corresponds to the single rate which, when discounting the corresponding liabilities, is equivalent to the risk-free rates published by EIOPA. Thus, the LAER can be acknowledged as the "liabilities' maturity-weighted" average of the risk-free rates, which implies that longer tails in the liabilities cash-flows lead to higher LAER's (the higher the maturity date, the higher is risk-free rate). Indeed, this is consistent with the work developed in Chapter 3, in which the SD group showed the smallest tail, followed by the BD group and the MD group.
- In terms of the FS, the MD group has the highest average, followed by the BD group and then the SD group (although the BD and SD groups are very close and, in some cases, the BD group has lower FS's). The measure is complex and many portfolio's features have impact on its value. Firstly, assets with longer maturities have higher risks of default and downgrade, and thus higher FS's. Secondly, assets with high credit worthiness are considered less risky and so have generally lower FS's (lower CQS leads to lower FS's). The same happens with the investment in central Government and central banks debt - is is considered less risky and has generally lower FS, which helps explain why the BD group has a lower average FS than the MD's and, at the same time, a higher average CQS.
- The percentage of mismatch remains acceptable. Furthermore, the average SD portfolio has the lowest mismatch, followed by the MD's and finally the SD's. This is due to the dimension of the liabilities. Actually, once the percentage of mismatch is computed using the total value of liabilities, the lower it is, the higher is the impact of the rounding done in the number of units invested in each asset, which increases the percentage of mismatch.

Chapter 5

Quantitative Impact

5.1 Best Estimate

Under the Solvency II regime, all undertakings have to hold enough assets to cover all Technical Provisions, and thus, changes in the value of Technical Provisions have implications in the undertakings' solvency position. This is the relevance of the BE, which is the part of Technical Provisions that corresponds to the expected present value of all future cash-flows. The cash-flows include premiums, benefits, expenses, and so on. However, in our case, we only considered benefits because the D&D liabilities portfolios do not include material expenses nor premium payments. Thus, in order to compute the BE, we just needed the liabilities cash-flows and the relevant interest rate term structure.

In Chapter 3, we computed the liabilities' yearly cash-flows since 2015 and, in Chapter 4, we computed the value of the MA's for all six portfolios. Then, we computed the adjusted interest rate as the MA plus the relevant risk-free interest rate term structure published by EIOPA. For each group of undertakings, Table 5.1 describes the values of the BE for the two portfolios constructed in chapter 4 and for a situation without the application of the MA, which is identified as the baseline.

Group	Portfolio	MA (in basis points)	Best Estimate (in million euros)	Relative Impact
BD	Baseline	0.00	512.50	0.00%
	H. Yield	101.27	427.70	-16.55%
	H. Rating	1.79	510.79	-0.33%
MD	Baseline	0.00	79.84	0.00%
	H. Yield	51.08	71.13	-10.91%
	H. Rating	-34.34	86.56	8.42%
SD	Baseline	0.00	13.17	0.00%
	H. Yield	106.23	10.90	-17.19%
	H. Rating	-13.51	13.50	2.55%

TABLE 5.1: Quantitative impact in the Best Estimate

As expected, there's a direct relation between the MA and the impact of its application in the BE - the higher the MA, the lower the BE and the more favorable it is for an undertaking. In fact, the higher the MA, the higher is the interest rate term structure and consequently the lower is the liabilities' present value. Also, a negative value in the MA generates an increase in the BE, which is disadvantageous for the undertaking.

The more favorable impact can be seen in the Highest Yield portfolios, with a decrease in the BE varying between 17,19% and 10,91%, while in the Highest Rating portfolios there's a variation from -0,33% to 8,42%. This fact seams to indicate that, for the purpose of building the Matching portfolios, choosing profitability over security would be preferable. Nevertheless, the impact on the SCR may revert this scenario.

The group of undertakings where the application of the measure is more favorable in terms of the BE is the BD group, with all portfolios showing a decrease in the BE. The less favorable is the MD group, with all portfolios increasing the value of the BE unless the Highest Yield portfolio.

5.2 Solvency Capital Requirement

The SCR is the measure corresponding to the capital needed to sustain a shock corresponding to the 99.5% value-at-risk for an one year time horizon. Undertakings have to compute their SCR at least once a year and should hold enough Basic Own Funds (BOF) to fully cover that value. Therefore, changes in the SCR's value have implications in the undertakings' solvency position.

In order to compute the SCR, undertakings are given two options - either use the SCR standard formula set out in the Directive or use an internal model, which is a formula built by the undertaking and approved by the supervisory authority. For the purpose of the quantitative impact analysis, we chose to use the SCR standard formula.

In the standard formula, whose full structure is represented in appendix C, the SCR is computed as the sum of 3 modules, namely the adjustment for the loss absorbing capacity of Technical Provisions and deferred taxes, the operational risk and the Basic SCR. The first two have a specific formula set out in the Delegated Acts, while the Basic SCR is itself divided into 6 modules, some of them divided into sub-modules. Each module/sub-module represents a specific risk an undertaking may be exposed to and its calculation is based on the impact of a stressed scenario in the BOF. All stressed scenarios are set as specific shocks calibrated at European level to reflect the aggregated 99.5% value-at-risk for the one year time horizon. In particular, the basic SCR is computed through the following steps:

1. The whole balance sheet is valued in normal conditions, using proper methods based on market consistent principles. The BOF are computed as the excess of assets over liabilities, taking into account the eligible subordinated liabilities.
2. Given a specific module/sub-module, a shock relating the risk considered in that module/sub-module is applied and the balance sheet is revalued. The

stressed BOF item is again computed. During the revaluation, the Risk Margin is assumed not to change and the loss-absorbing capacity of Technical Provisions and deferred taxes is not accounted for.

3. The capital charge for that module/sub-module is computed as the difference between the normal conditions' and the stressed BOF. Negative variations in BOF are recognized as positive capital charges. If the variation in BOF has a positive sign, then the capital charge is set to zero.
4. After the capital charges for all shocks are computed, they are aggregated assuming Normal distributions and using linear correlation matrices published in the Delegated Acts (European Commission, 2014).

The SCR is a very complex and sophisticated formula, built to quantify all the risks to which an undertaking is exposed to. It is not the purpose of this thesis to go into much detail on this topic. Therefore, we tried to simplify the computation as much as possible, always taking into account that the end-goal is to compute the impact of applying the MA to a general Portuguese undertaking.

5.2.1 SCR in Matching Adjustment Portfolios

All six portfolios presented in chapter 4 are similar in terms of risk exposure for all three groups of undertakings. On the market risks' side, because the Matching portfolios have a very special composition of eligible assets, the only material risk exposures are the interest rate, spread and concentration risks. On the side of the underwriting risks, because the liabilities only include D&D pensions, the only material risk exposure is the similar-to-life techniques (SLT) health underwriting risk, more specifically, the corresponding longevity and revision risks. Both counterparty default's and intangible asset's risks are considered non-existent. Finally, we included the adjustment for deferred taxes module and the operational risk module.

As before, we built an Excel workbook which includes VBA programmed functions in order to make the calculations as automated as possible. We also computed two SCR's for each portfolio - one considering application of the MA and another not considering it, which we called the baseline portfolio. Table 5.2 resumes the computed values and the relative impact of the MA's application.

Group	Portfolio	MA (in basis points)	SCR (in million euros)	Baseline SCR (in million euros)	Relative Impact
BD	H. Yield	101.27	60.40	107.83	-43.98%
	H. Rating	1.79	61.28	75.56	-18.90%
MD	H. Yield	51.08	17.08	27.31	-37.49%
	H. Rating	-34.34	23.01	20.19	13.98%
SD	H. Yield	106.23	1.53	3.46	-55.68%
	H. Rating	-13.51	2.86	2.92	-1.91%

Table 5.2: SCR for MA Portfolios and corresponding baselines

The results indicate that there's a benefit in terms of SCR when applying the MA, since almost every portfolio had a reduction in their SCR's, even the SD group's Highest Rating portfolio, which has a negative MA. This impact is more accentuated in the Highest Yield portfolios and indicates that higher values of MA lead to more beneficial impacts. Moreover, when computing risk modules based on shock scenarios, we must not take into account the MA and thus the impact here is null. The exception, and reason behind the reduction experienced, is the market spread risk sub-module, which includes a specific adjustment in case of applying the MA. This is logical and expected, since, as discussed earlier, the criteria to build eligible MA portfolios mitigates the risk of losses due to spread fluctuations.

5.2.2 Approximation for an undertaking applying the MA

In Solvency II, when computing the SCR, undertakings applying the MA have to treat the corresponding portfolios as an independent undertaking. Until now, we've

analyzed the impact of applying the MA only on those portfolios. However, no undertaking deals exclusively on D&D pensions and thus, to fully access this impact, we need to consider the rest of the undertaking's business. Specially in terms of the SCR, because there's a loss of diversification benefits, analyzing the entire business may lead to different conclusions.

In order to perform this analysis, we used data from the quantitative report for the preparatory phase of Solvency II carried out by ASF in the Portuguese insurance market, which included the value and computation of each undertaking's SCR. However, due to many problems with the reported data, we had to exclude some companies from the initial sample set. In particular, for both MD and SD groups, we ended with just one undertaking, which is considered to represent well the group and has an acceptable report quality. Then, for the BD group, we considered all undertakings and thus, we aggregated each specific SCR's sub-module by taking the weighted average according with the market shares. The goal here was to adapt the sub-modules' reported values to simulate the application of the MA in an undertaking and, for that, we had to make some assumptions, namely:

- In a real situation, an undertaking intending to apply the MA and who does not have an asset portfolio which replicates the correspondent liabilities, has to buy new assets that meet all the requirements. Thus, to simulate this trade, we chose EU government bonds with fixed cash-flows from the undertaking's original assets portfolio, which, when sold at their quoted market value in the end of 2014, were enough to buy the correspondent Matching portfolio. In terms of the rest of the business' SCR, this sale only affects the interest rate and the concentration sub-modules, although in the case of the concentration sub-module, the sale would be likely immaterial and reduce the capital charge. Therefore, we only considered the impact of the sale in the interest rate risk sub-module.
- The lines of business incorporated in the SLT health underwriting risk sub-module are mainly the D&D pensions and the Portuguese specific life-long

assistance. However, in the Portuguese market, the second is so much less significant than the D&D pensions that we can consider it immaterial. Thus, in terms of the rest of the business' SCR, we assume that removing this sub-module would be same as removing the exact underwriting risks related with the D&D pensions' liabilities portfolio.

And finally, the method used was the following:

- Collect the value of each SCR Standard Formula's module or sub-module;
- Annul the SLT Health sub-module and subtract the amount of the interest rate risk sub-module corresponding to assets chosen to be sold in exchange for the Matching portfolio;
- Aggregate the resulting modules/sub-modules according with the Standard Formula's rules, obtaining the henceforth called SCR of the rest of the business;
- Add the SCR of the rest of the business with the SCR of the Matching portfolio, obtaining the final SCR with the application of the MA.

5.3 Final results and remarks

5.3.1 General impact of the Matching Adjustment

In order to measure the impact of applying the MA in an undertaking, we chose 3 metrics relating with an undertakings' available assets, risk exposure and solvency position. Respectively, they are:

Basic Own Funds - Using again the quantitative report for the preparatory phase of Solvency II, we extracted the amount of BOF eligible to cover the SCR of each undertaking considered in the analysis of the SCR (i.e., all companies from the BD group and one company for both the MD and SD groups). It corresponded to each group's initial value of BOF eligible to cover the SCR.

Then, to compute this measure after the application of the MA, we subtracted the impact observed in the BE from Table 5.1, adjusted to take into account the increase in deferred taxes. The formula was:

$$BOF_{afterMA} = BOF_{initial} - (BE_{afterMA} - BE_{initial})(1 - 0.23) \tag{5.1}$$

SCR - All the computations were already done here. We used the initial SCR of each group and their final SCR including the application MA.

Solvency Ratio - This ratio measures the solvency of an undertaking, that is, its ability of meeting future liabilities. It is computed as the ratio of BOF to cover the SCR over the SCR itself.

The relative impact on the three metrics is presented in Table 5.3.

Group	Portfolio	MA (basis points)	BOF	SCR	Solvency Ratio
BD	H. Yield	101.27	14.21%	12.01%	1.97%
	H. Rating	1.79	0.29%	6.85%	-6.14%
MD	H. Yield	51.08	5.64%	17.42%	-10.03%
	H. Rating	-34.34	-4.35%	23.35%	-22.46%
SD	H. Yield	106.23	14.84%	12.64%	1.96%
	H. Rating	-13.51	-2.20%	21.71%	-19.65%

TABLE 5.3: Relative impact on solvency of the Matching Adjustment

And finally, the main conclusions are the following:

- First of all, it is clear that the higher the value of the MA, the higher is the value of BOF, which is favorable for an undertaking. In fact, with the MA, the Best Estimate decreases, and thus, the undertaking is considered to have a lower expected value of liabilities, which increases the undertaking's available capital. However, due to a loss in deferred taxes, this benefit is slightly reduced.

- In terms of the SCR, the groups were always penalized for applying the MA. Despite the reduction in the market's spread risk submodule, the loss of diversification benefits when applying the MA caused the SCR to increase in every portfolio, which implies an increase in the assets allocated to sustain unexpected losses.
- On one hand, the MA was beneficial because it increased the undertaking's available capital. Yet, on the other hand, the MA was disadvantageous because it increased the capital needed to sustain unexpected losses, which decreased the accessible capital an undertaking has to expand and/or create new business. This duality is the reason why we chose to analyze the solvency ratio - since it balances both BOF and SCR, it represents the general impact in an undertaking. According to this metric, there are only two portfolios where it was advantageous to apply the MA. They are the BD and SD groups' Highest Yield portfolios. In these portfolios, the relative increase in own funds was higher than the relative increase in the SCR, which led to an improvement in the solvency position of the undertaking.

5.3.2 General impact of the Volatility Adjustment

The last goal proposed to the internship was to compare the MA with other LTG measures, in particular, the Volatility Adjustment (VA). This measure was built by EIOPA to mitigate pro-cyclical investment behaviors when markets deteriorate due to wide bonds' spreads and bonds' low liquidity. The VA is a risk-corrected spread which is added to the risk-free interest rate term structure used to discount Technical Provisions and is calculated based on reference portfolios for each currency.

It corresponds to the difference between the rates obtained from a reference portfolio and the basic risk-free rates. All computations are performed periodically and published by EIOPA.

Similarly to the MA, we assessed the impact of applying the VA on three items - the BOF, the SCR and the Solvency ratio. The results are summarized in Table 5.4.

Group	BOF	SCR	Solvency Ratio
BD	2.26%	0.00%	2.26%
MD	1.94%	0.00%	1.94%
SD	2.56%	0.00%	2.56%

TABLE 5.4: Relative impact on solvency of the Volatility Adjustment

In terms of the BOF, the impact was computed using formula 5.1, where the index *"MA"* is replaced by *"VA"*. Similarly to the MA, because there's a rise in the interest rates used to discount Technical Provisions, when applying the VA, the BE decreases, which increases the value of Own Funds and results in a favorable impact for the undertaking. Secondly, in terms of the SCR, the measure has no impact on the standard formula's modules computed by stressed scenarios and thus, for every group of undertakings, the impact observed in the SCR was null and the impact experienced in the Solvency Ratio is same as the BOF's.

Finally, comparing these results with the ones on Table 5.3, we conclude that for all groups, the VA was more favorable than the MA, since it caused higher positive impacts. Nevertheless, the VA is very dependent on market conditions and it is only relevant for insurers in cases of market instability. Thus, with different market conditions, even if an undertaking is allowed to apply the VA, it is not certain that the VA will always be more favorable then the MA to undertakings.

Chapter 6

Conclusion

The work developed during my internship at ASF was aimed to assess the impact of applying the MA in a specific line of business in Portugal - the Workers' Compensation insurance. In particular, we focused on the Death and Disability pensions due to their features, which are well suited for applying the MA.

In order to better represent the market, we decided to divide all undertakings with business in WC insurance and supervised by ASF in 3 groups, according with their market shares – the BD group represented 81% of the market, the MD group had 17% of the market and the SD group constituted 2% of the market. In fact, we considered the market shares weighted average of each group's undertakings, creating thus notional undertakings that were representative of the respective groups. Then, using the 3 groups, we did a series of computations and analysis based on real data reported to ASF. Our main conclusions were the following:

- As expected, the current WC insurance market is not yet prepared to apply the MA since the assets portfolios don't fulfill the mandatory criteria and the liabilities and assets cash-flows are not matched at all times (assets cash-flows are higher the the first maturity years and have much shorter maturities then the liabilities cash-flows).

- The MD group presents generally lower values of MA than the other two groups, mainly due to its liabilities' longer tail and its assets' yields. Also, the BD and SD groups are similar in terms of main portfolio features and MA value. However, the SD group presents a higher variability and higher value of mismatch between assets and liabilities. This is caused by the difference of their liabilities' dimension.
- In terms of Technical Provisions, the Best Estimate is the component that experiences the most relevant impact. In fact, there's a direct relation between the measure and the MA - the higher the MA the lower is the relative value of the Best Estimate and the more beneficial it is for the undertaking.
- Own Funds are directly influenced by changes in Technical Provisions. Approximately, the BOF are simply the excess of assets over liabilities and, since a decrease in the Best Estimate causes a decrease in liabilities, the higher the value of the MA, the higher are the BOF. Therefore, in terms of BOF, even after the adjustments due to the loss in deferred taxes, we observed an improvement when applying the MA.
- In the case of the SCR, there are two different situations. Firstly, when we only consider the SCR of the D&D related portfolios, due to the decrease in the spread risk sub-module, the application of the MA reduces the value of the SCR, which is beneficial for an undertaking. However, when we look at the global impact in an undertaking, the application of the MA increases the value of the SCR, because the benefit in the spread risk sub-module isn't high enough to offset the loss of diversification benefits. Thus, in terms of the SCR, applying the MA is disadvantageous for an undertaking.
- In order to measure the global impact of applying the MA in an undertaking, we looked at the Solvency ratio, which considers both SCR and BOF. According with this metric, only two portfolios would lead to a benefit - the BD's and SD's Highest Yield portfolios. In all the others, the value of the MA wasn't high enough to lead to a relative increase in BOF higher than the one observed in the SCR. This fact seems to imply that, when building

the Matching portfolio, an undertaking should choose profitability over credit quality, which appears to be counter-intuitive. Nevertheless, the use of the MA in each portfolio has to be approved by the supervisory authority and thus, in practice, an undertaking will have to guarantee a certain degree of safety in credit worthiness. Also, the measure appears to be more beneficial to either undertakings with a large business or to undertakings with an very representative WC business, since, in both cases, the loss in diversification benefits would be relatively lower.

- Finally, in the current market conditions, the impact of applying the VA is more favorable in every group of undertakings than the impact of applying the MA. However, this result doesn't mean that the VA is always more favorable than the MA, since it is very dependent on market conditions and can be only applied in specific cases where the markets are unstable.

Clearly, applying the MA can be advantageous to an undertaking. However, due to the fact that, once applying the measure, an undertaking cannot revert back to not applying it, it's essential to do a complete study of the MA's behavior in the specific undertaking under various market scenarios. Also, the results indicate that in undertakings with a similar profile to the MD group it wouldn't be advantageous to apply the MA. Nonetheless, the MA is so tailor-made that small differences in the undertaking's business and in the D&D portfolios may cause huge differences in the final impact. Therefore, an interesting development of this work would be to focus on a specific Portuguese undertaking and do a thorough analysis.

Finally, by implementing the process in Excel and VBA, we hoped to contribute to the analysis on the LTG problem and to make the MA easier to implement in the Portuguese market. An undertaking can base their computation on this work, built upon it and use the automated Excel workbook to test various market situations. Also, we chose very specific investment strategies for building the Matching portfolios and there is no reason why an undertaking shouldn't experiment different strategies, which would be a great development of this work.

Appendix A

Technical Specification for the Liabilities Portfolio

A.1 Annual aggravation rates

Table A.1 contains the percentage of revisions on D&D pensions observed in the data corresponding to years 2012, 2013 and 2014, contains the average percentage of the pension's aggravation, in case a revision has occurred, and the final aggravation rate, which is give by the product of the two.

	Percentage of revisions			**Average Aggravation**			**Aggravation rate**		
Year	2012	2013	2014	2012	2013	2014	2012	2013	2014
Disability Revision	2,89%	3,49%	2,55%	54,19%	54,55%	22,09%	1,57%	1,90%	0,56%
State change to Definitive	2,29%	2,46%	2,57%	10,08%	21,39%	20,83%	0,23%	0,53%	0,54%
Total	5,18%	5,95%	5,12%	64,27%	75,94%	42,92%	3,33%	4,52%	2,20%

Table A.1: Aggravation Analysis

Appendix B

Matching Portfolios

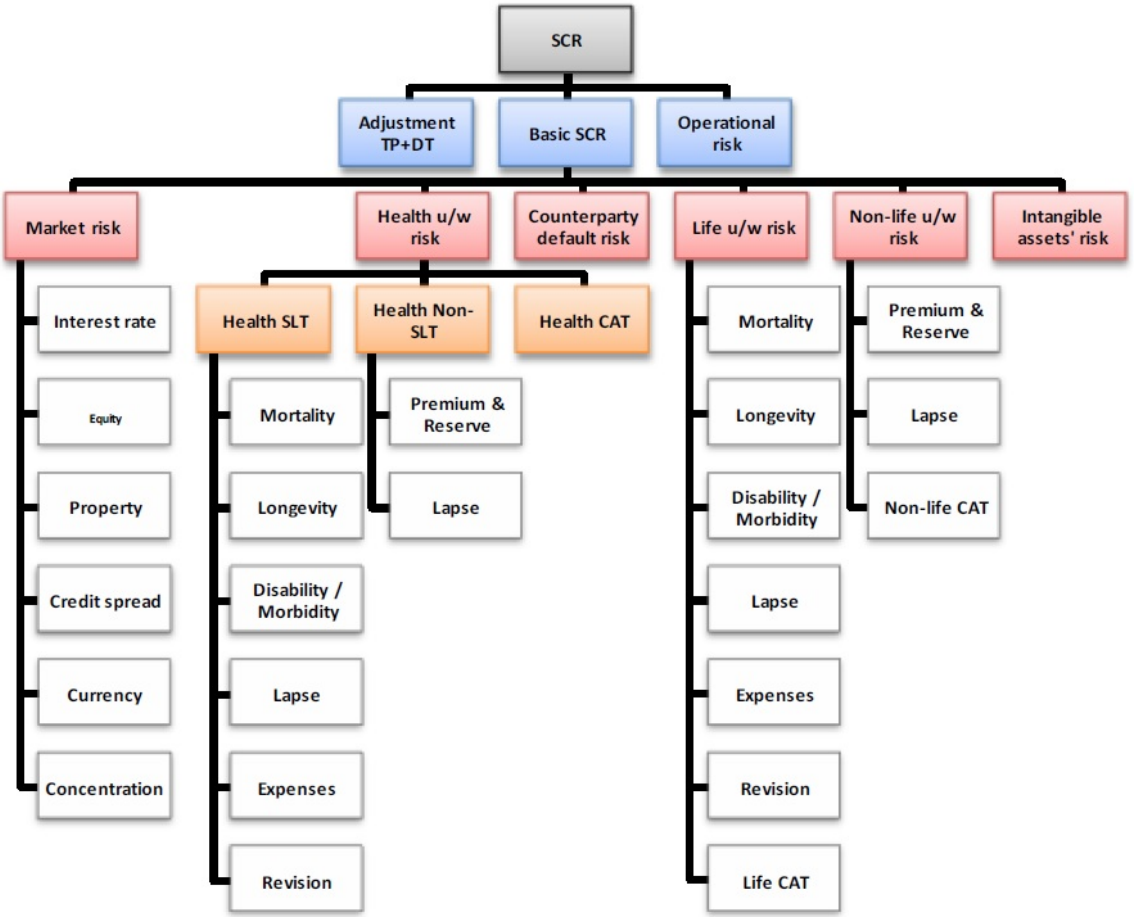
BD Group							
Highest Yield portfolio				**Highest Rating portfolio**			
ISIN	**Yield**	**Rating**	**Units**	**ISIN**	**Yield**	**Rating**	**Units**
XS0503253345	1,617	NR	35	AT0000386198	-0,099	AA+	2313
PTRELYOE0002	1,116	NR	2270	XS0457688215	0,454	AAA	2704
XS0276455937	7,462	BB+	2598	XS0282445336	0,288	AA-	3115
XS0716979249	5,601	BB+	3067	XS0695461458	0,344	AA-	3550
PTCFPAOM0002	2,452	NR	83	XS0801654558	0,344	AAA	3978
XS0906946008	6,721	BB+	4056	XS0478074924	0,582	AA-	4348
XS0919581982	8,617	BB+	4553	XS1130487868	0,608	AAA	4803
XS0716979595	6,447	BB+	5067	XS1135334800	0,825	AA+	5101
XS0835890350	6,092	BB+	5717	FR0011486067	0,584	AA+	5379174
PTOTEQOE0015	2,654	NR	563223397	XS1121229402	1,442	A-	5780
XS0221854200	4,562	BB	7038	ES0413211071	1,061	A+	61
IT0001086567	2,188	NR	2576	ES00000123C7	1,933	BBB	6471
XS0862347852	2,562	BBB	7742	FR0011370386	1,441	AAA	71
ES00000124C5	2,235	BBB	7761	ES00000124C5	2,235	BBB	7416
ES0000011868	2,239	BBB	833014315	ES0000011868	2,239	BBB	796748662
PTOTEROE0014	3,424	NR	896146075	PTOTEROE0014	3,424	NR	857704483
IT0001444378	2,612	NR	9409	XS0129547948	2,225	AAA	182
ES0000012411	2,4	BBB	10037	ES0000012411	2,4	BBB	9631
FR0010014845	5,15	BB-	13785	FR0010014845	5,15	BB-	13230
IT0003535157	2,904	NR	11288	IT0003535157	2,904	NR	10833
XS0223484345	4,308	BBB-	11818	BE0002436112	1,508	AAA	115
ES0001350125	3,823	BB+	122	BE0002440155	1,478	AAA	118
PTOTE5OE0007	3,678	NR	1257742228	ES0000012932	2,651	BBB	11824
XS1069178686	2,928	BBB	148	BE0002431063	1,594	AAA	124
IT0004286966	3,105	NR	13219	IT0004286966	3,105	NR	12322
IT0004976764	3,687	NR	1364837521	XS0884635524	1,503	AAA	12707
XS0442127063	5,827	NR	19612	XS0881486657	2,18	AA+	132
IT0004976806	3,741	NR	1307135988	XS0752034206	1,521	AAA	12823
XS0208362961	6,006	NR	19049556	LU0962396452	1,616	AAA	129
IT0004976830	3,657	NR	1296132730	FR0012039931	1,722	AA	129
AT0000A0CJE9	2,576	NR	1890555314	XS1107247725	1,577	AAA	12866
AT0000A0CJF6	2,578	NR	1824334921	DE0001102341	1,384	AAA	1265161677
XS0295018070	4,952	BB+	17502	XS1061430051	2,045	AA	133
XS0181673798	4,193	NR	11741	XS0352558422	0,365	AA	127
AT0000A0CJJ8	2,578	NR	1784321610	DE0002942448	1,582	AAA	25130
AT0000A0CJK6	2,578	NR	1702521919	DE000NRW0DB8	1,538	AA	11623
AT0000A0CJL4	2,578	NR	1617699310	AT0000A0CJL4	2,578	NR	1716977641
XS1055501974	5,619	NR	15305	XS1055501974	5,619	NR	16298
XS0970703772	3,605	NR	96	XS0877035765	1,743	AA+	107
AT0000A0CJP5	2,578	NR	1423555861	AT0000A0CJP5	2,578	NR	1450044008
XS0214965963	5,214	BB+	133	FR0010292169	2,002	AA+	9428
AT0000A0CJR1	2,578	NR	1308995536	AT0000A0CJR1	2,578	NR	1318198906
XS0292467775	11,065	CCC	8	AT0000A0CJS9	2,578	NR	1225358072
AT0000A0CJT7	2,578	NR	1147791620	AT0000A0CJT7	2,578	NR	1133028239
AT0000A0CJU5	2,578	NR	1055990280	AT0000A0CJU5	2,578	NR	1041226898
XS0515753183	3,347	NR	6408	FR0010870956	2,005	AA+	6309528
AT0000A0CJW1	2,578	NR	923148208	AT0000A0CJW1	2,578	NR	899590778
AT0000A0CJX9	2,578	NR	836300289	XS0757586267	2,256	AA	58
XS0936805612	3,649	NR	50	XS0939098363	2,089	AA	54
ES00000126D8	3,162	BBB	4695	ES00000126D8	3,162	BBB	4695
AT0000A0CK09	2,578	NR	658148790	AT0000A0CK09	2,578	NR	658148790
AT0000A0CK17	2,578	NR	584984876	AT0000A0CK17	2,578	NR	584984876
AT0000A0CK25	2,578	NR	516058512	AT0000A0CK25	2,578	NR	516058512
AT0000A0CK33	2,578	NR	451763098	AT0000A0CK33	2,578	NR	451763098
AT0000A0CK41	2,578	NR	392180463	AT0000A0CK41	2,578	NR	392180463
AT0000510102	2,578	NR	337578676	AT0000510102	2,578	NR	337578676
AT0000A0CK66	2,578	NR	288167526	AT0000A0CK66	2,578	NR	288167526
AT0000A04ER3	2,578	NR	243586455	AT0000A04ER3	2,578	NR	243586455
AT0000A0CK82	2,578	NR	203941062	AT0000A0CK82	2,578	NR	203941062
AT0000A0BNE3	2,578	NR	801207982	AT0000A0BNE3	2,578	NR	801207982

MD Group							
Highest Yield portfolio				**Highest Rating portfolio**			
ISIN	**Yield**	**Rating**	**Units**	**ISIN**	**Yield**	**Rating**	**Units**
ES0413900103	0,236	AA	0	ES0413900103	0,236	AA	0
FR0011512417	1,647	NR	0	FR0010717785	0,055	AAA	0
PTBITIOM0057	2,656	BB-	0	XS0282588952	0,258	AA+	0
XS0982711631	5,441	BB+	9	ES0413900327	0,343	AA	0
XS0184373925	2,294	BB+	1	XS0193640629	0,275	AAA	0
XS0970695572	2,062	BB+	120	XS0237323943	0,618	AA-	68
PTOTEYOE0007	1,943	NR	16923543	XS0526606537	0,59	AA-	123
IT0004848831	1,597	NR	226	FR0011337880	0,518	AA+	177601
XS0971213201	3,516	BB+	321	DE000A0PM5F0	0,483	AAA	235
PTCPEJOM0004	3,524	NR	10	FR0011521319	0,693	AA	300
XS0994991411	1,34	AA-	4	XS0994991411	1,34	AA-	4
ES0413900129	1,169	AA	5	ES0413900129	1,169	AA	4
XS0306646042	1,993	BBB	620	XS0288429532	1,358	AA-	10
IT0004889033	2,46	NR	684	XS0093667334	1,25	AAA	74246
ES0000011868	2,239	BBB	77925871	FR0000571218	1,256	AA+	689875
XS0506861243	4,248	BB	889	XS0506264315	1,75	AAA	16
XS0137905153	4,745	BB	12	XS0129547948	2,225	AAA	18
ES0000012965	2,705	NR	1118099	FR0000187635	1,472	AA+	997687
IT0003256820	2,757	NR	1180	XS0162869076	2,504	BBB	1225
XS0191352847	9,571	CCC	1307	BE0002421932	1,572	AAA	13
BE0000304130	1,611	AA-	143145990	BE0000304130	1,611	AA-	133547590
ES0414950644	2,322	A	32	ES0414950644	2,322	A	30
PTOTE5OE0007	3,678	NR	167321149	AT0000A04967	1,343	AA+	1568
FR0010371401	1,752	AA+	1788440	FR0010371401	1,752	AA+	1679981
DE0001135325	1,295	NR	190348658	DE0001135325	1,295	NR	179068929
IT0004976764	3,687	NR	202252522	XS0884635524	1,503	AAA	1905
XS0442127063	5,827	NR	3010	XS0881486657	2,18	AA+	21
IT0004976806	3,741	NR	207817797	XS0752034206	1,521	AAA	2066
XS0208362961	6,006	NR	3134405	LU0962396452	1,616	AAA	22
IT0004976830	3,657	NR	220831904	FR0012039931	1,722	AA	22
AT0000A0CJE9	2,576	NR	333306444	XS1107247725	1,577	AAA	2296
AT0000A0CJF6	2,578	NR	332189244	DE0001102341	1,384	AAA	232845293
XS0295018070	4,952	BB+	3302	XS1061430051	2,045	AA	25
XS0181673798	4,193	NR	2293	XS0352558422	0,365	AA	25
AT0000A0CJJ8	2,578	NR	360003205	DE0002942448	1,582	AAA	5100
AT0000A0CJK6	2,578	NR	355777961	DE000NRW0DB8	1,538	AA	2441
AT0000A0CJL4	2,578	NR	349521904	AT0000A0CJL4	2,578	NR	372121581
XS1055501974	5,619	NR	3418	XS1055501974	5,619	NR	3644
XS0970703772	3,605	NR	22	XS0877035765	1,743	AA+	25
AT0000A0CJP5	2,578	NR	341443461	AT0000A0CJP5	2,578	NR	347184276
XS0214965963	5,214	BB+	33	FR0010292169	2,002	AA+	2335
AT0000A0CJR1	2,578	NR	337733942	AT0000A0CJR1	2,578	NR	339151653
XS0292467775	11,065	CCC	2	AT0000A0CJS9	2,578	NR	327010968
AT0000A0CJT7	2,578	NR	319519828	AT0000A0CJT7	2,578	NR	314521075
AT0000A0CJU5	2,578	NR	307277312	AT0000A0CJU5	2,578	NR	302278560
XS0515753183	3,347	NR	1955	FR0010870956	2,005	AA+	1921983
AT0000A0CJW1	2,578	NR	294288842	AT0000A0CJW1	2,578	NR	286586955
AT0000A0CJX9	2,578	NR	279917388	XS0757586267	2,256	AA	19
XS0936805612	3,649	NR	18	XS0939098363	2,089	AA	19
ES00000126D8	3,162	BBB	1760	ES00000126D8	3,162	BBB	1760
AT0000A0CK09	2,578	NR	260466510	AT0000A0CK09	2,578	NR	260466510
AT0000A0CK17	2,578	NR	246089124	AT0000A0CK17	2,578	NR	246089124
AT0000A0CK25	2,578	NR	231955906	AT0000A0CK25	2,578	NR	231955906
AT0000A0CK33	2,578	NR	216291338	AT0000A0CK33	2,578	NR	216291338
AT0000A0CK41	2,578	NR	201851342	AT0000A0CK41	2,578	NR	201851342
AT0000510102	2,578	NR	186481847	AT0000510102	2,578	NR	186481847
AT0000A0CK66	2,578	NR	171754251	AT0000A0CK66	2,578	NR	171754251
AT0000A04ER3	2,578	NR	157225433	AT0000A04ER3	2,578	NR	157225433
AT0000A0CK82	2,578	NR	141622055	AT0000A0CK82	2,578	NR	141622055
AT0000A0BNE3	2,578	NR	976229911	AT0000A0BNE3	2,578	NR	976229911

SD Group							
Highest Yield portfolio				**Highest Rating portfolio**			
ISIN	**Yield**	**Rating**	**Units**	**ISIN**	**Yield**	**Rating**	**Units**
PTBLMXOM0019	1,821	NR	1	XS0541454467	0,169	AA-	79
PTPTCYOM0008	3,696	NR	66	XS0844535442	0,084	AA	88
XS0215828913	2,636	BB	75	FR0011374198	0,151	AAA	1
XS0630463965	1,845	BB+	85	XS0986254455	0,313	AAA	104
XS1017435782	3,26	BBB-	91	DE000A1AKHB8	0,363	AA-	2
XS0970695572	2,062	BB+	108	FR0011431014	0,324	AAA	1
PTGALJOE0008	3,217	NR	1	XS0693812355	0,688	AA-	129
XS0486101024	3,012	BB+	3	XS0813400305	0,807	AA-	139
XS0835890350	6,092	BB+	146	FR0011470764	0,715	AAA	2
FI4000079041	0,65	AA+	146	FI4000079041	0,65	AA+	161
XS0982711714	6,15	BB+	179	IE00B4TV0D44	1,387	A-	17199933
XS1057659838	3,074	BBB+	182	XS1057659838	3,074	BBB+	199
FR0011225143	1,594	A+	2	FR0011225143	1,594	A+	2
ES0000095606	4,123	BB+	3455	FR0010970863	1,611	AAA	5
XS1120892507	2,264	BBB	2	XS1120892507	2,264	BBB	3
IE00BJ38CR43	1,809	A-	23846824	IE00BJ38CR43	1,809	A-	25474122
XS0137905153	4,745	BB	3	XS0129547948	2,225	AAA	5
XS0522079911	4,064	BB+	5	FR0011349109	1,86	AAA	3
FR0010014845	5,15	BB-	378	DE0003271482	1,741	AAA	30749755
BE0000333428	1,61	NR	31456617	BE0000333428	1,61	NR	30833051
XS0223484345	4,308	BBB-	325	BE0002436112	1,508	AAA	3
ES0001350125	3,823	BB+	3	BE0002440155	1,478	AAA	3
PTOTE5OE0007	3,678	NR	35446235	ES0000012932	2,651	BBB	341
XS1069178686	2,928	BBB	4	BE0002431063	1,594	AAA	4
XS0440592748	2,503	BBB+	9	XS1088825143	1,608	AAA	370
IT0004976764	3,687	NR	39485772	XS0884635524	1,503	AAA	365
XS0442127063	5,827	NR	569	XS0881486657	2,18	AA+	4
IT0004976806	3,741	NR	37956572	XS0752034206	1,521	AAA	370
XS0208362961	6,006	NR	551835	LU0962396452	1,616	AAA	4
IT0004976830	3,657	NR	37341738	FR0012039931	1,722	AA	4
AT0000A0CJE9	2,576	NR	53976439	XS1107247725	1,577	AAA	365
AT0000A0CJF6	2,578	NR	51446683	DE0001102341	1,384	AAA	35458810
XS0295018070	4,952	BB+	486	XS1061430051	2,045	AA	4
XS0181673798	4,193	NR	321	XS0352558422	0,365	AA	3
AT0000A0CJJ8	2,578	NR	47794523	DE0002942448	1,582	AAA	670
AT0000A0CJK6	2,578	NR	44635516	DE000NRW0DB8	1,538	AA	303
AT0000A0CJL4	2,578	NR	41378341	AT0000A0CJL4	2,578	NR	43776517
XS1055501974	5,619	NR	381	XS1055501974	5,619	NR	405
XS0970703772	3,605	NR	2	XS0877035765	1,743	AA+	3
AT0000A0CJP5	2,578	NR	33501187	AT0000A0CJP5	2,578	NR	34137368
XS0214965963	5,214	BB+	3	FR0010292169	2,002	AA+	216
AT0000A0CJR1	2,578	NR	29084250	AT0000A0CJR1	2,578	NR	29326694
XS0292467775	11,065	CCC	0	AT0000A0CJS9	2,578	NR	26504298
AT0000A0CJT7	2,578	NR	24109455	AT0000A0CJT7	2,578	NR	23834356
AT0000A0CJU5	2,578	NR	21545718	AT0000A0CJU5	2,578	NR	21270619
XS0515753183	3,347	NR	127	FR0010870956	2,005	AA+	125193
AT0000A0CJW1	2,578	NR	17796944	AT0000A0CJW1	2,578	NR	17348220
AT0000A0CJX9	2,578	NR	15777585	XS0757586267	2,256	AA	1
XS0936805612	3,649	NR	1	XS0939098363	2,089	AA	1
ES00000126D8	3,162	BBB	85	ES00000126D8	3,162	BBB	85
AT0000A0CK09	2,578	NR	11694064	AT0000A0CK09	2,578	NR	11694064
AT0000A0CK17	2,578	NR	10257225	AT0000A0CK17	2,578	NR	10257225
AT0000A0CK25	2,578	NR	8976319	AT0000A0CK25	2,578	NR	8976319
AT0000A0CK33	2,578	NR	7808380	AT0000A0CK33	2,578	NR	7808380
AT0000A0CK41	2,578	NR	6722068	AT0000A0CK41	2,578	NR	6722068
AT0000510102	2,578	NR	5730975	AT0000510102	2,578	NR	5730975
AT0000A0CK66	2,578	NR	4852405	AT0000A0CK66	2,578	NR	4852405
AT0000A04ER3	2,578	NR	4061048	AT0000A04ER3	2,578	NR	4061048
AT0000A0CK82	2,578	NR	3379811	AT0000A0CK82	2,578	NR	3379811
AT0000A0BNE3	2,578	NR	14478819	AT0000A0BNE3	2,578	NR	14478819

Appendix C

SCR Standard Formula



Appendix D

Excel and VBA sample functions

Example of VBA programmed code, used to compute the Matching Adjustment and the Matching portfolios

```
'###   Computes de MA using solver
Private Sub MAcompute()
    SolverReset
    SolverOk SetCell:="$E$5", MaxMinVal:=3, ValueOf:=0, ByChange:="$H$4", Engine:=1,
    EngineDesc:="GRG Nonlinear"
    SolverSolve True

    SolverReset
    SolverOk SetCell:="$F$5", MaxMinVal:=3, ValueOf:=0, ByChange:="$J$4", Engine:=1,
    EngineDesc:="GRG Nonlinear"
    SolverSolve True
End Sub

'###   Creates the highest yield portfolio
Sub HighestYield()
Worksheets("Data Bonds").Activate
For n = 2015 To 2074
    For i = 3 To 700
        If year(Worksheets("Data Bonds").Cells(i, 6).Value) = n Then
            Set Max = Worksheets("Data Bonds").Cells(i, 2)
            Exit For
        End If
```

```
    Next i

    For x = 3 To 700
        If year(Worksheets("Data Bonds").Cells(x, 6).Value) = n Then
            If Worksheets("Data Bonds").Cells(x, 5).Value > Max.Offset(, 3) Then
                Set Max = Worksheets("Data Bonds").Cells(x, 2)
            End If
        End If
    Next x

    For a = 2 To 16
    Worksheets("Portfolio").Cells(n - 2012, a).Value = Max.Offset(, a - 2).Value
    Next a
Next n
End Sub
```

Example of an Excel worksheet, used to compute the Matching Adjustment

Matching Portfolio

	Market value	Best estimate
	#VALOR!	0,00 €
Equation	#VALOR!	0,00 €

AAER	-	LAER	-	FS	=	MA
	-		-	#VALOR!	=	#VALOR!

Final MA =	######

t	Year	Liabilities cashflow	AAER Computation	LAER Computation
1	2016	0,00 €	0,00 €	0,00 €
2	2017	0,00 €	0,00 €	0,00 €
3	2018	0,00 €	0,00 €	0,00 €
4	2019	0,00 €	0,00 €	0,00 €
5	2020	0,00 €	0,00 €	0,00 €
6	2021	0,00 €	0,00 €	0,00 €
7	2022	0,00 €	0,00 €	0,00 €
8	2023	0,00 €	0,00 €	0,00 €
9	2024	0,00 €	0,00 €	0,00 €
10	2025	0,00 €	0,00 €	0,00 €
11	2026	0,00 €	0,00 €	0,00 €
12	2027	0,00 €	0,00 €	0,00 €
13	2028	0,00 €	0,00 €	0,00 €
14	2029	0,00 €	0,00 €	0,00 €
15	2030	0,00 €	0,00 €	0,00 €
16	2031	0,00 €	0,00 €	0,00 €
17	2032	0,00 €	0,00 €	0,00 €
18	2033	0,00 €	0,00 €	0,00 €
19	2034	0,00 €	0,00 €	0,00 €
20	2035	0,00 €	0,00 €	0,00 €
21	2036	0,00 €	0,00 €	0,00 €

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