ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

O5 Case Study Reports

Intensive Programme "Advanced Topics"

O5/A3 Case Study Report

"Advanced Topics in Quantitative Methods in Finance"

Alma Mater Studiorum Università di Bologna

19 March – 1 April 2017

Rossella Agliardi

Umberto Cherubini

Erasmus+

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Change History

Version	Date	Author(s)	Changes
0.1	3rd June 2017	Rossella Agliardi Umberto Cherubini	Preliminary draft
0.2	13th June 2017	Rossella Agliardi Umberto Cherubini	First draft to be submitted to the partners
0.3	8th July 2017	Rossella Agliardi Umberto Cherubini	Final version (incorporating partners' and QCEB's feedback)

Disclaimer

This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Content

1. Case Structure

This report summarizes the results of the case study that has been worked out during the third intensive programme (IP) offered at the University of Bologna within the International Project **INTQUANT** (Creating an International Semester for Master Programmes in Quantitative Finance), Funding Scheme: Erasmus+ Strategic Partnerships (Key Action 2).
The intensive programme on 'Advanced Topics in Quantitative Methods in Finance' has been held in two weeks (19 March-1 April 2017).
This case study has been proposed in cooperation with the the local industry partner, Unipol Financial Group S.p.a. The assigned problem has been studied by four teams each consisting of four students. The formation of each team has tried to maintain a multinational environment due to the participation of students from several partner universities (University of Applied Sciences bfi Vienna, University of Bologna, University of Economics in Katowice and University of Iaşi).

1. Synopsis/Executive Summary

The proposed case study aims at gaining awareness of the efforts put by an insurance company in developing its risk management capabilities, in view of Solvency II. In particular, the focus is on the calculation of the market risk embedded in a portfolio of assets and liabilities provided by the local industry partner, as a component of the Solvency Capital Requirement (SCR) under the Standard Approach of the Solvency II framework[1].

[1]The general provisions for Solvency Capital Requirement (**SCR**) are given in Article 101 of the Solvency II Directive Framework. The SCR should correspond to the Value-at-Risk of the Basic Own Funds (BOF) of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period. The parameters and assumptions used for the calculation of the SCR reflect this calibration objective, in other words, they are set such that an insurance company would survive a shock at the one year horizon at the 99.5th percentile level.
For several sub-modules, the calculation of the capital requirement is scenario-based: the capital requirement is determined as the impact of a specified scenario on the level of *BOF*..

Solvency II provides a range of methods to calculate the SCR which allows undertakings to choose a method that is proportionate to the nature, scale and complexity of the risk that are measured. They include full internal models, standard formula and partial internal model, standard formula with undertaking-specific parameters, standard formula. Due to the constraints of the time available for the implementation of the team work, the teams have been asked to implement the standard formula, although the company has developed also its own internal methods, for some risk modules. As the portfolio under analysis embeds several forms of financial risk and exhibits some complex financial products, the prescribed task turns out to be non-trivial even to the students who have a good background in pricing and risk management.

The portfolio of assets consists of government and corporate bonds and structured products such as CLNs, Equity Linked Notes, etc (See Appendix, Table 1, for details), therefore the main task is to perform the calculation of the market risk module of the SCR framework, including several sub-modules (see Appendix, Table 2). The analysis should be performed on each individual sub-module and then the results need to be aggregated using the prescribed aggregation formula (see Appendix, Table 4).

In sum, the case study allows students to experiment the work within a control risk unit set up by an Insurance Company, whose task is to measure market and credit risk, satisfy regulatory compliance requirements, and provide suggestions for effective risk management solutions.
The case is designed to provide a context for an introduction to a typical problem in a risk management unit within an important multi-business insurance company, in this case, facing both a problem of ALM (assets and liabilities management) and risk management, that is evaluation of the impact of a change in market values in an assigned portfolio.
As a consequence of low interest rates in the market, generating very low returns to investors, even prudentially managed insurance companies are progressively modifying

their asset portfolio, traditionally mainly consisting of government bonds[2], and are taking exposure on corporate bonds as well. The disclosed portfolio under consideration reflects this change and poses the challenge of properly assessing the credit risk exposure. In the simplified setting of the Standard Approach, this additional risk is mainly addressed throughout the spread risk sub-module.

Students are invited to identify the risk factors to which the portfolio is exposed, to provide a Mark-to-Market (MtM) calculation, to estimate the total risk exposure with respect to the relevant risk measures and to perform a check of the financial "health" of the portfolio.
Students are also invited to make recommendations regarding portfolio adjustments and/or possible hedging strategies.
The case discussion can generate some tension with respect to the most appropriate method for pricing the structured financial securities and for identifying the risk factors to which each asset is exposed. A critical view regarding the simplified methodology for aggregating the individual risks under the standard approach is an interesting issue to be discussed, in order to gain awareness on the crucial challenge of risk aggregation.

The case materials introduce students to the problem of calculating the total risk exposure of a portfolio of assets and liabilities, with the Solvency Capital Requirement in view. In particular, students are expected to:

- become familiar with the methods for computing the Mark-to-Market value of fixed-income and floating-rate bonds, including credit-risky bonds, and some more complicated credit-sensitive financial products;

[2] According to the Solvency II Directive Framework, a number of bonds and loans are exempt from spread-risk SCR calculation, in particular, bonds and loans of:

- The European Central Bank
- The central government and banks of Member States, issued in their own currency
- Certain multilateral development banks and international organizations and certain local authorities

The entities that benefit from this exemption are listed in then document EIOPA-Bos-15/119 of June 30th 2015.

- become aware of the risk factors embedded in some structured securities;
- learn how to build a stress test scenario for the risk analysis of asset and liabilities of an insurance company with BSCR in view;
- critically assess their findings by comparing alternative methodologies and procedures of market and credit risk analysis.

2. Short history and company overview/ background

Unipol was born in 1963 when the insurance company began to operate in non-life business (car vehicles). In 1969 Unipol started operations in life business. In the 80' and 90' Unipol grew with M&A.

UnipolSai Assicurazioni S.p.A. is the multi-business insurance company of the Unipol Group, an Italian leader in non-life business, particularly in vehicle liability insurance. The company currently operates through five divisions (Unipol, La Fondiaria, Sai, Nuova MAA and La Previdente). UnipolSai is the second insurance company on the Italian market, classified among the top ten in Europe. Besides insurance sector, its core business is complemented by its presence in the banking sector, real estate sector and diversified activities that extend the scope of the Group to the hotel and agricultural industries.

At the end of 2015, Unipol Group reported direct insurance income of 16.9 bln (7.9 bln in non-life business and 8.6 bln in life business). The Group has approximately 14.000 employees, distributed in Bologna, Milan, Turin and Florence. It serves over 16 million customers thanks to a vast network of agencies.

The financial engineering team of UnipolSai is involved in a wide range of activities, among which the development of an in-house platform for the pricing and tracking of structured interest rate products and interest and equity derivative. This includes writing libraries for calibration to the market data, for pricing and sensitivity analysis of the portfolio. Among its tasks it has to develop an internal model to calculate the capital requirement in keeping with the Solvency II framework.

3. Body of the analysis

The case study aims at introducing the computational problems that are faced by a risk management unit of an insurance company, whose main task is to check the undertaking's risk exposure and to accomplish the international, regulation as set up by the European Commission. While the Solvency II paradigm allows for a choice among several methods, ranging from one's own internal method to a pre-specified set of computational rules (Standard Formula), the analysis of the case study will mainly adopt the latter method for the precise computation of SCR. The suggestion of alternative methods is left to the discussion, but will not be worked out in details, due to the time constraints. In the Standard Formula, the parameters to be used are provided by the regulator for each risk module and sub-module. The Standard Formula has a modular structure and is to be applied in a stepwise, bottom–up fashion. First, capital charges are derived for each risk (sub–)module and then they are aggregated to the overall SCR, with correlation parameters entering the calculations accounting for diversification effects among the risk components.

The Basic Solvency Capital Requirement is the Solvency Capital Requirement before any adjustments, and is obtained by combining capital requirements for six major risk categories. (See Appendix, Table 2). Due to the nature of the synthetic portfolio (actually, a sub-portfolio) provided by the Insurance Company for this case study, at the top level, the risk module to be considered is the market risk one. As the market risk module consists of several risk sub-modules, a preliminary careful analysis is needed to disentangle the risk factors affecting each individual financial security in the asset portfolio. For example, the exposure to Italian sovereign bonds should be considered as part of the interest rate risk sub-module, while bonds issued by banks or industrial corporations should be considered both in regards to the interest rate risk sub-module and the spread risk one. Some structured products (convertible bonds, equity linked note) are affected by equity risk as well, and a special care is to be taken when computing their MtM value. Furthermore, when computing the MtM value and duration of the bonds, a different method is to be used for fixed-income versus variable-income products. For example, BTPs pay

fixed rate coupon semiannually, while the exposure to bank bonds is taken both to fixed rate and floating rate notes.

In order to compute the SCR for the portfolio under consideration the following input information is required:

Mkt_{intUp} = Capital requirement for interest rate risk for the “up” shock

$Mkt_{intDown}$ = Capital requirement for interest rate risk for the “down” shock

Mkt_{int} = Capital requirement for interest rate risk

Mkt_{eq} = Capital requirement for equity risk

Mkt_{sp} = Capital requirement for spread risk

Mkt_{conc} = Capital requirement for risk concentrations

The Standard Formula Principle is as follows; apply a set of instantaneous shocks and calculate net impact on balance sheet. The prescribed rules for the computation for each risk sub-module are reported in the Appendix, Table 3. For more details, refer to the Solvency II Directive and related documents.

Finally, the market sub-risks should be combined to an overall capital requirement SCR_{mkt} for market risk using a correlation matrix (see Appendix, Table 4).

The selection committee in charge of selecting the RMU unit will evaluate the accuracy of the analysis proposed by four teams, where each team will work on the proposed case by choosing its own methodologies and offering its own set of solutions.

4. Questions for discussion

1) Describe the risk factors to which each asset in the portfolio is exposed, and design a reporting (cash flow mapping) of the exposures to each risk factor.

2) Bootstrap unshocked yield curve. Calculate discount factors for maturities of up to 1 year directly from money market spot rates using simple compounding; convert 1Y spot rate to swap rate and compute 1Y discount factor; iterate discount factors from swap rate formula for other maturities. For other maturities, use constant forward rate assumption or interpolation.
This step is preliminary to obtaining the shocked yield curves and discount factors that are used for calculating SCRint.

3) Calculate the implied hazard rates for each issuer.
Calculate Mid of quoted CDS spreads and set up theoretic pricing of CDS using a simple theoretical model (for example, assuming constant hazard rate across all maturities).
Calibrate your model to quoted CDS.
This step is preliminary to obtaining the shocked prices for corporate bonds and credit-linked notes.

4) Compute the present value for each financial product. This includes considering accrued interests, the present value of expected forward rate coupons for the floating rate notes, implied options for convertible bonds and ELNs.

5) Compute the modified duration for each product in the portfolio.

6) Provide a portfolio overview throughout the calculation of its market value and weighted average duration of portfolio. This general description should be displayed to represent the ALM stance of the portfolio.

7) Calculate concentration risk. (This task has not been assigned as mandatory).

8) Calculate shocked prices and aggregate SCR of the portfolio.

9) Comment on the contribution by the individual components to the total risk exposure, in particular, in terms of risk factors.

10) Propose your recommendations: portfolio adjustment, hedge design, etc.

5. Conclusion / recommendations

The analysis has been carried on by four international teams, each team working on the main questions of the above-described problem. Although all the teams had to follow a common protocol prescribing the rules and formulas of the standard approach, each team was free to select its own methodology, for example, in the construction of the term structure of interest rates or hazard rates, the computation of the MtM value of some structured financial securities, the accuracy in the computation of the shocked values, etc, and has therefore provided its own set of solutions. The main conclusions can be summarized as follows.

The MtM value of the portfolio obtained throughout different methods (depending on the chosen market quotes, approach for constructing the yield curve and the credit spread term structure, numerical code for implementation, pricing method for the structured products) does not vary significantly across the working teams. A similar conclusion applies to the computation of the duration of the portfolio. Some differences appear whenever approximation methodologies based on the duration are used, instead of straight re-pricing.

A common conclusion regarding risk factors is that most impact on the total value is caused by the equity and spread risk, while interest rate risk is a minor contributor due to the medium term duration of the assets. Equity risk exposure is taken mainly throughout the Adidas convertible bond. Concentration risk is quite stable. The largest impact on spread risk comes from INTESA SANPAOLO SPA floater, in view of the longer duration and the BBB rating.

Similar results across the working teams have been obtained regarding the diversification benefit, because pre-defined correlation matrices are used.

Overall, despite some minor differences due to the computational methodologies employed by the individual teams, the results were pretty unanimous.

6. References

EIOPA website : https://eiopa.europa.eu/

EIOPA – 14/209, Technical Specification for the Preparatory Phase (Part 1) , 30 April 2014

Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II): CELEX:32009L0138 (http://eur-lex.europa.eu/legal-content/FR-EN/TXT/?uri=CELEX:02009L0138-20150331)

7. Appendices

Here below the original data that relates to the study are reported.

Table A1. Synthetic portfolio for the case study.

Straight Bonds

ISIN	Name	Maturity	Coupon	Issuer	Nationality Issuer	Notional	Rating
XS1169707087	UCGIM 0 02/19/20	19/02/2020	3m Euribor + 100bps	UNICREDIT SPA	ITALY	20 000 000	BBB+
XS0357578722	ISPIM 0 02/01/33	01/02/2033	3m Euribor + 90bps	INTESA SANPAOLO SPA	ITALY	30 000 000	BBB+
FR0012432904	BNFP 0 01/14/20	14/01/2020	3m Euribor + 33bps	DANONE SA	FRANCE	30 000 000	BBB+
XS1403015156	UNANA 1 1/8 04/29/28	29/04/2028	1.125	UNILEVER NV	NETHERLANDS	40 000 000	A+
ES0413900392	SANTAN 1 1/2 01/25/26	25/01/2026	1.5	BANCO SANTANDER SA	SPAIN	10 000 000	AA
XS0420558248	BNP 4.62 03/04/22	04/03/2022	4.62	BNP PARIBAS	FRANCE	35 000 000	A+
IT0000366721	BTPS 8 1/2 12/22/23	22/12/2023	8.5	BUONI POLIENNALI DEL TES	ITALY	80 000 000	BBB+
IT0003934657	BTPS 4 02/01/37	01/02/2037	4	BUONI POLIENNALI DEL TES	ITALY	50 000 000	BBB+

Convertible bonds

ISIN	Name	Maturity	Coupon	Issuer	Nationality Issuer	Notional	Rating
XS1327914062	TOTAL 0 1/2 12/02/22	02/12/2022	0.5	TOTAL SA	FRANCE	15 000 000	A+
XS1394957309	ENIIM 0 04/13/22	13/04/2022	0	ENI SPA	ITALY	15 000 000	A-
DE000A1ML0D9	ADSGR 0 1/4 06/14/19	14/06/2019	0.25	ADIDAS AG	GERMANY	20 000 000	A

CLNs

ISIN	Name	Maturity	Coupon	Issuer	Nationality Iusser	Notional	Rating
XXY	UBS 01/12/2021 CNL Italy	01/12/2021	4	UBS	SWITZERLAND	5 000 000	UBS: A-
XXZ	SOC GEN 01/03/2019 CNL Intesa San Paolo	01/03/2024	2.4	SOCIETE GENERALE	FRANCE	12 000 000	SOC GEN: A-

Equity-linked notes

ISIN	Name	Maturity	Coupon	Issuer	Nationality Issuer	Notional	Rating
aaa	Highlands	01/05/2021	every year annual performance Eurostoxx 50/strike -1; redemtion at maturity	Deutsche Bank AG	GERMANY	20 000 000	BD: BBB+

Table 2. Risk modules and sub-modules in the Standard Formula (Source:EIOPA)

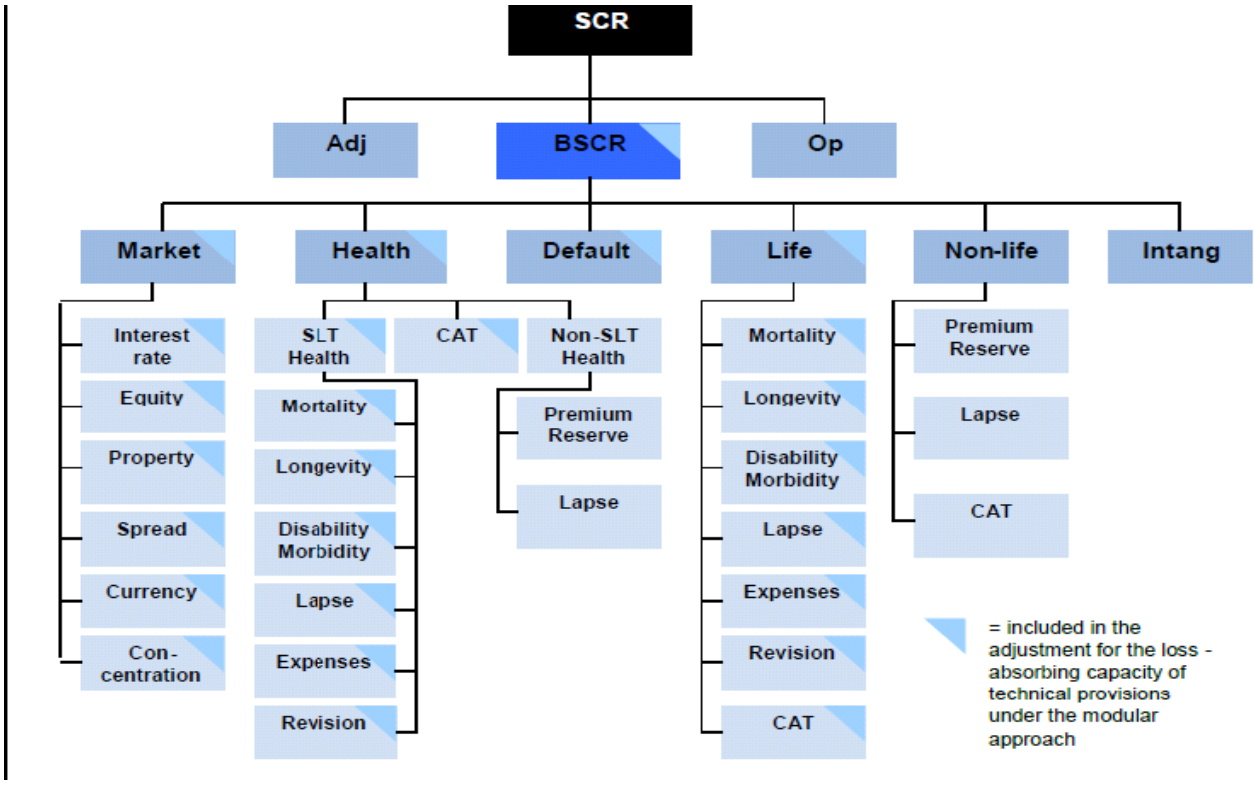

Table A3.

Up and down scenarios for interest rate risk (Source: EIOPA)

Tenor (year)	Upward	Downward	Tenor (year)	Upward	Downward
1	70.0%	-75.0%	18	29.0%	-29.0%
2	70.0%	-65.0%	19	27.0%	-29.0%
3	64.0%	-56.0%	20	26.0%	-29.0%
4	59.0%	-50.0%	25	25.6%	-28.4%
5	55.0%	-46.0%	30	25.1%	-27.7%
6	52.0%	-42.0%	35	24.7%	-27.1%
7	49.0%	-39.0%	40	24.3%	-26.4%
8	47.0%	-36.0%	45	23.9%	-25.8%
9	44.0%	-33.0%	50	23.4%	-25.1%
10	42.0%	-31.0%	55	23.0%	-24.5%
11	39.0%	-30.0%	60	22.6%	-23.9%
12	37.0%	-29.0%	65	22.1%	-23.2%
13	35.0%	-28.0%	70	21.7%	-22.6%
14	34.0%	-28.0%	75	21.3%	-21.9%
15	33.0%	-27.0%	80	20.9%	-21.3%
16	31.0%	-28.0%	85	20.4%	-20.6%
17	30.0%	-28.0%	90	20.0%	-20.0%

Upward and Downward Shocks applied to the zero-coupon RFR curve.

Formula for spread risk to be applied to bonds:

$$SCR_{bonds} = \sum_i MV_i \cdot F^{up}(rating_i, duration_i)$$

where the function ***F*** uses the CQS and modified duration of the exposure, is capped at 100% and is calibrated to deliver a shock consistent with the 99.5% VaR requirement.

Function F:

CQS / *Duration D (years)*	0	1	2	3	4	5	6
up to 5	0.9 %. *D*	1.1 %. *D*	1.4 %. *D*	2.5 %. D	4.5 %. D	7.5 %. D	7.5 %. D
more than 5 and up to 10	4.5% + 0.5 %.(D - 5)	5.5% + 0.6%.(D - 5)	7.0% + 0.7%.(D - 5)	12.5% + 1.5%.(D - 5)	22.5% + 2.5%.(D - 5)	37.5% + 4.2%.(D - 5)	37.5% + 4.2%.(D - 5)
more than 10 and up to 15	7.2% + 0.5 %(D -10)	8.4% + 0.5 %(D -10)	10.5% + 0.5 %(D -10)	20.0% + 1.0 %(D -10)	35.% + 1.8 %(D -10)	58.5% + 0.5 %(D -10)	58.5% + 0.5 %(D -10)
more than 15 and up to 20	9.7% + 0.5 %.(D -15)	10.9% + 0.5 %.(D-15)	13.0% + 0.5 %.(D-15)	25.0% + 1.0 %(D -15)	44.0% + 0.5 %(D -15)	61.0% + 0.5 %(D -15)	61.0% + 0.5 %(D -15)
more than 20	12.2% + 0.5 %(D -20)	13.4% + 0.5 %.(D-20)	15.5% + 0.5 %(D -20)	30.0% + 0.5 %(D -20)	46.6% + 0.5 %(D -20)	63.5% + 0.5 %(D -20)	63.5% + 0.5 %(D -20)

Here:

MV_i is the credit risk exposure i as determined by reference to market values;

$rating_i$ is the external rating of credit risk exposure i ;

duration is the modified duration;

CQS is obtained from the following table:

ECAI	AAA	AA	A	BBB	BB	B	CCC
CQS	0	1	2	3	4	5	6

Formula for equity risk:

Instantaneous decrease of the value of the equity markets as follows.

	Type 1	*Type 2*
Equity shock	46.5%	56.5%

Afterwards, the SCR_E is calculated by combining the capital requirements of the individual categories using a 75% correlation coefficient.

Formula for concentration risk:

Mkt_{conc} (j) = E_j (= excess exposure) * g_j (= risk factor)

for each single name exposure j, where

$E_j = \max[0, A_j - \text{Assets} * CT(CQS_j)]$

Aj average exposure,

CT = relative threshold depending on credit quality of j.

The capital requirement for this sub-module is computed assuming no correlation among the requirements for each counterparty.

Table 4. ***Correlation matrix for SCRmkt sub-modules aggregation***

	SCR_{IR}	**SCR_{spread}**	**SCR_{conc}**	**SCR_{FX}**	**SCR_{EQ}**	**SCR_{PR}**
SCR_{IR}	1	↑0/↓0.5	0	0.25	↑0/↓0.5	↑0/↓0.5
SCR_{spread}	↑0/↓0.5	1	0	0.25	0.75	0.5
SCR_{CONC}	0	0	1	0	0	0
SCR_{FX}	0.25	0.25	0	1	0.25	0.25
SCR_{EQ}	↑0/↓0.5	0.75	0	0.25	1	0.75
SCR_{PR}	↑0/↓0.5	0.5	0	0.25	0.75	1

Source: Commission Delegated Regulation (EU) 2015/35 of 14 October 2014, Article 164.2

2. Teaching Note Structure

1. Synopsis

This case study aims at mimicking the work within a control risk unit of a big Insurance Company, whose assignment is to measure market risk in view of the international regulatory standards that have been recently introduced (Solvency II Directive).

The main task is to compute the Solvency Capital Requirements and to suggest some effective solutions for a best practice line in market risk management.

The study can be briefly described as follows. The Insurance Company discloses one of its portfolios. The analysis should consider the impact of the possible shocks on the portfolio value due to various risk factors on future net cash-flows and on present value of assets and liabilities. The shocks to be applied are prescribed by the standard formula of the Solvency II framework (see Appendix, Table 3). The disclosed portfolio consists of bonds, structured products embedding option-like features and liabilities, and the ISIN and main characteristics of each product is reported in the Appendix of Section 1 (see Table 3). A synthetic picture of the component of the portfolio is represented in the Figure 1 below.

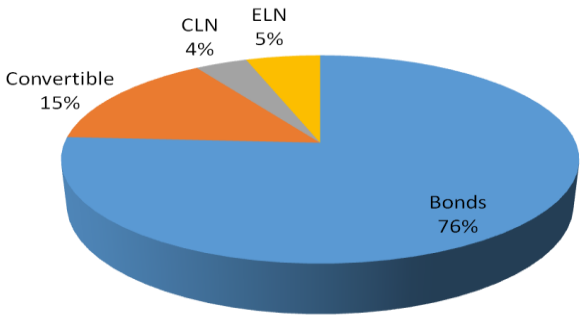

Figure 1. Components of the asset portfolio

The bond component represents the largest portion of the exposure. The presence of corporate bonds carries the credit-risk concern into the problem, besides the consideration of interest rate risk exposure. In the Standard Formula, this is addressed throughout the spread risk sub-module. Moreover, the portfolio has a component consisting of various

structured bonds, which poses the challenge of properly pricing some more complex products. As a consequence, the case combines a risk management assignment with a pricing problem and thus offers an ideal arena to practice with different fields and expertise of quantitative finance.

2. Topical Area

The area of research for the case study can be described, in a broad sense, as follows: advanced methods for modeling the exposure to interest rate risk, spread risk and equity risk in plain-vanilla and structured bonds: impact for stress testing in financial and insurance institutions.

3. Teaching objectives

The case focuses on developing the following teaching objectives:

- to gain an in-depth understanding of the methodologies behind the Standard Formula of Solvency II;
- to build student judgment on how to appropriately perform specific calibrations for risk factors to be applied on different types of insurers' investments;
- to implement the standard pricing methodology for various structured financial products;
- to experiment how to build a stress test scenario for the risk analysis of asset and liabilities of an insurance company.

Additionally, the work on the case can contribute to achieve some general teaching objectives, such as the ability to:

- summarise case findings in a team report, present and defend these in a clear and effective way;
- critically asses both one’s own and other teams’ case reports during the presentation phase;

- work in an international team environment and use intercultural creativity to achieve an agreed outcome.

4. Student Reading Assignment

EIOPA Technical specifications (EIOPA website : https://eiopa.europa.eu/). See Section 1, for details.

5. Student Study Questions

1). What are the risk factors to which each asset in the portfolio is exposed?
2). What is the MtM value of the portfolio?
3). What is the shocked MtM value of the portfolio? (Perform the stress-test analysis on the MtM value of the portfolio following the rules included in the Standard Formula).
4). What is the aggregate SCR of the portfolio ?
5). Comment on the contribution by the individual components to the total risk exposure, in particular, in terms of risk factors.
6). Design a hedge against the relevant risk factor in one year.

6. Suggested Teaching Plan for *60*-Minutes Class

(10 min.) Why study this case?
(10 min.) What are the big issues Unipol is dealing with today?
(20 min.) What does the globalization of regulation mean for an Insurance Company?
(20 min.) Assume that you are a financial engineer working for this Insurance Company and your task is to report the financial «health» of the company. What does your CFO expect to find on his desk ?

- MtM value and duration of the assigned portfolio
- Stress-test analysis on the MtM value of A-L as a result of some pre-defined shocks of the market data (prescribed scenarios for the relevant risk factors).

- Overview of the portfolio stance and assessment of the major contributions to the overall risk.

7. Discussion Questions and Analysis / Student Response

This section gives details information to the instructor on how to address the main questions. This section can be seen as a roadmap to the instructor.

1. *What are the risk factors to which the portfolio is exposed?*

A preliminary discussion identifies all the risk factors to which each component of the portfolio is exposed. Then a parsimonious set of risk factors is selected. Students are invited to design a reporting (cash flow mapping) of the exposures to each risk factor.

While the analysis of the plain bonds is straightforward, the analysis of the structured product should be conducted with a special care, because of their complex nature and simultaneous exposure to different risk factors. For these products, the choice will be between a parsimonious modeling and a comprehensive treatment, the latter implying the use of a pricing model that could be hard to implement. The regulatory prescriptions leave room for interpretation. For example, for hybrid products the following is suggested. 'Where there are any assets which exhibit both fixed income and equity characteristics, both of these features should be taken into account when determining which of the standard formula's risk sub-modules should apply. The determination of which of the standard formula risk sub-modules apply should have regard to the economic form of the asset. Where the asset can be considered as the composite of discrete components, it may be appropriate to apply the relevant stresses to each of these components separately. Where it is not possible to consider the asset as the composite of separate components then the determination of which of the standard formula risk sub-modules apply should be based on whichever of the fixed income or equity characteristics is predominant in an economic sense'.

2. *What is the MtM value of the portfolio?*

Asking students to compute MtM value of the assigned portfolio is an excellent starting point to find out the varying levels of knowledge of interest rate models, credit risk models, derivative pricing and structure of the financial products. Students have to decide how to produce the implied spot rates and the corresponding discount factors to be employed. They might bootstrap the zero curve and the forward curve from the market data and use a parsimonious model or use a more advanced theoretical model and calibrate it to the market data. A similar decision is to be taken regarding the term structure of hazard rates. Each team will have to take advantage of its internal financial and numerical expertise and will have to discuss about the accuracy of its approach, on how to deal with the lack of liquidity of some bonds and how to model the embedded credit risk. The instructor might suggest a stylized way to model interest rate and credit risk, in order to reduce the difficulties of the implementation, in the presence of so many components in the portfolio.
For the structured bonds, the standard valuation methods used by practitioners can be suggested to make the numerical procedure more expedite.

We suggest that the students should be free to select the data sources for market quotes, the computational method to interpolate Euribor rates and the forward rates, how to bootstrap the credit risk curves, the method for valuing the financial products embedding derivatives, etc.

3). *What is the shocked MtM value of the portfolio?*

After setting up the numerical procedure to compute the MtM value for each financial product, the calculation of the stressed values is quite straightforward. Students just need to re-price each security under the stressed scenario. However, we encourage to gain awareness of the philosophy behind the pre-defined rules and to keep an eye on the explanatory document produced by regulators. In particular, the Solvency II Framework Directive specifies that the SCR corresponds to the Value-at-Risk of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period. The parameters and assumptions used for the calculation of the SCR reflect this calibration objective and to ensure that the different modules of the standard

formula are calibrated in a consistent manner, this calibration objective applies to each individual risk module.

4). *What is the aggregate SCR of the portfolio ?*

Under the Standard Formula of the Solvency II framework, the computation of SCR_{mkt} is performed for each risk sub-module individually and then the results are combined to an overall capital requirement SCR_{mkt} using a prescribed correlation matrix. This matrix is meant to represent the benefit of diversification.

Thus this aggregation method is very easy to implement. However, a discussion may concern the issue of risk aggregation. Students should be made aware that the approach taken in the Standard Formula, i.e. linear correlation techniques, does not capture non-linear dependencies (for instance, tail dependencies). It is worth mentioning how the risk aggregation problem has evolved into a crucial matter in the theoretical and empirical financial literature, and alternative methodologies have been developed to reflect potential dependencies in the tail of the distributions. Another subject for discussion is the issue of the stability of any correlation assumption under stress conditions.

8. Conclusions

One major aim of this case study is to expose the students, like professionals are, to the dualism of duties of risk management and compliance. Measuring and managing risk is different and, in some cases, may also be in conflict with the duty of complying with the measures required by the regulation. Moreover, the students, divided in groups, can experiment, in a tangible way, how cross checking the risk measurement results achieved throughout different numerical algorithms by the different groups, may increase the awareness of the complexities behind an appropriate design of an assessment methodology for the risk embedded in a portfolio. At the same time, the benefits and limitations of a standard approach can be fully appreciated throughout this simple case study.

3. Case study materials

Suggested readings for the specialization track

EIOPA – 14/209, Technical Specification for the Preparatory Phase (Part 1) , 30 April 2014

Preliminary readings

Participating students will have to prepare themselves prior to work on the case. Students should have a notion of the credit risk concepts (probability of default, loss given default, ratings, transition matrices, credit spread) along with the basic concepts in finance referring coupon bonds, term structure, swaps, credit derivatives.
A good knowledge of some general concepts in finance, such as arbitrage pricing and martingale methods, is needed as well.

For an introduction the following texts are recommended:

A. Saunders, L. Allen, Credit Risk Measurement in and out the financial crisis: new approaches to Value at Risk and other paradigms, Wiley, 2011

D. Lando, Credit risk Modelling, Princeton University Press, 2004

D. Brigo, F. Mercurio, Interest Rate Models – Theory and Practice: with Smile, inflation and credit, Springer-Verlag, 2006

Case study method

Ellet, W. (2007). *The Case Study Handbook: How to Read, Discuss and Write Persuasively About Cases*. Boston: Harvard Business Review Press.

Shapiro, B. (2014). *Hints for Case Teaching.* Boston: Harvard Business Publishing. Retrieved from [http://hbsp.harvard.edu/he-main/resources/documents/web-files/M00016_Hints_for_Case_Teaching_Brochure.pdf]

Materials for the case study

Spreadsheet for the disclosed asset portfolio and liabilities under study.
Additional data on: the Euribor and Swap curve; CDS spreads; the up and down scenarios for interest rate risk, the stress scenarios for spread risk, equity risk and concentration risk under the Basic Solvency Capital Requirement.

Supplementary materials

Supplementary slides on Solvency II principles have been provided by prof. Nino Savelli, who gave a guest lecture during the IP.

APPENDIX

Presentation Evaluation Form

Criteria	Maximum Points
Accuracy of computation Did the team properly build the term structure of interest rate and credit spreads? Were the complex products properly valuated? Was the MtM value of the portfolio correctly computed?	35
Originality of the recommendations *Did the team propose sound and original suggestion to reduce or hedge the risk of the portfolio?*	15
Questions from the jury Did the team answer the questions from the Jury effectively?	20
Team Involvement Were all members of the team involved in the presentation and in answering the questions?	10
Poise Were the team-members confident and convincing in the presentation and when answering the questions?	10
Quality of slides Was the quality of the slides convincing for prospective investors?	10
Total	100