VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

VERSLO VADYBOS FAKULTETAS

FINANSŲ INŽINERIJOS KATEDRA

Monika Gudonytė

INFLIACIJOS RIZIKOS VALDYMAS NE GYVYBĖS DRAUDIMO ĮMONIŲ INVESTICINIO PORTFELIO KONTEKSTE

INFLATION RISK MANAGEMENT IN THE CONTEXT OF NON-LIFE INSURANCE COMPANIES INVESTMENT PORTFOLIO

Baigiamasis magistro darbas

Verslo vadybos studijų programa, valstybinis kodas 621N10004

Investicijų valdymo specializacija

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BAIGIAMOJO MAGISTRO DARBO
UŽDUOTIS

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BAIGIAMOJO DARBO UŽDUOTIS:

Atlikti mokslinės literatūros analizę, siekiant suprasti galimą infliacijos poveikį negyvybės draudimo įmonėms. Yra svarbu įvertinti, kaip negyvybės draudimo įmonių turto ir įsipareigojimų pusiausvyra gali būti paveikta infliacijos pokyčių. Praktinėje dalyje atlikti išvestinių investicinių produktų analizę, siekiant įtraukti juos į negyvybės draudimo įmonių investicinį portfelį sumažinant infliacijos galimą neigiamą poveikį. Taip pat įvertinti kokioms makroekonominėms sąlygoms esant infliacijos rizikos apsauga yra netikslinga. Tyrimas atliekamas Europos šalims.

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Pavadinimas **Infliacijos rizikos valdymas negyvybės draudimo įmonių investicinio portfelio kontekste**

Autorius: **Monika Gudonytė** Vadovas: **dr. Viktoras Filipavičius**

Kalba

	lietuvių
X	anglų

Anotacija

Baigiamajame magistro darbe tiriama infliacijos rizikos valdymas negyvybės draudimo įmonių investicinio portfelio kontekste. Pirmoje darbo dalyje nagrinėjama draudimo rizikų klasifikacija ir galimas infliacijos poveikis negyvybės įmonėms. Siekiama įvertinti, kaip negyvybės draudimo įmonių turto ir įsipareigojimų pusiausvyra gali būti paveikta infliacijos pokyčių. Antroje darbo dalyje pateikiama informacija apie draudėjų diversifikuotų investicijų portfelių kūrimą bei aptariama optimalaus investicijų portfelio samprata. Trečioje darbo dalyje yra pateikiama investicinių produktų susietų su infliacija analizės rezultatai, siekiant įtraukti juos į negyvybės draudimo įmonių investicinį portfelį, sumažinant infliacijos galimą neigiamą poveikį. Taip pat įvertinta kokiems rinkos pokyčiams esant infliacijos rizikos apsauga yra netikslinga. Gauti rezultatai yra aptariami ir pateikiamos išvados bei pasiūlymai.
Darbą sudaro 6 dalys: įvadas, trys pagrindinės dalys, išvados ir siūlymai, literatūros sąrašas.
Darbo apimtis – 61 p. Teksto be priedų, 15 iliustr., 10 lent., 58 bibliografiniai šaltiniai.
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Prasminiai žodžiai: Negyvybės draudimas, infliacijos rizika, infliacijos rizikos draudimas, investicinės priemonės susiję su infliacija, infliacijos apsikeitimo sandoriai.

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Business management study programme's master's final work

Title: **Inflation risk management in the context of non-life insurance companies investment portfolio**

Author: **Monika Gudonytė** Supervisor: **dr. Viktoras Filipavičius**

Language

☐ lithuanian

☒ english

Annotation

The master thesis analyses the inflation risk management in the context of the non life insurers' investment portfolio. The first part deals with the classification of the insurance business risks and the possible impact of inflation on non-life companies. The aim is to assess how the balance of the non-life insurance companies' assets and liabilities can be affected by changes in inflation. The second part contains information about the insurers diversified investment portfolio design and discusses about the optimal portfolio concept. The third part represents the result of the inflation linked securities analysis, in order to include them into the non-life insurance company's investment portfolio as purpose to reduce the potential negative effects of inflation. Also this part estimates the possible changes of portfolio value in different market scenarios in order to understand or this inflation hedging strategy is reasonable. The conclusions and the suggestions of this paper are based on results of analysis of theoretical and practical aspects

The structure of the thesis: introduction, three main parts, conclusions and suggestions, references.

The size of the thesis – 61 pg. excluding appendixes, 15 figures, 10 tables, 58 source of literature.

Appendixes are presented separately.

Keywords: Non-life insurance, Inflation risk, Inflation hedging, Inflation linkers, Inflation swap

(the document of Declaration of Authorship in the Final Degree Project)

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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Business Management

(Faculty)

Business Management, IVfmu-11

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DECLARATION OF AUTHORSHIP
IN THE FINAL DEGREE PROJECT

2013-01-04

(Date)

I declare that my Final Degree Project entitled ___inflation risk management in the context of non-life insurance companies investment portfolio ___ __ is entirely my own work. The title was confirmed on _2011-11-21 d.__ by Faculty Dean's order
(Date)
No. __460vv__. I have clearly signalled the presence of quoted or paraphrased material and referenced all sources.

I have acknowledged appropriately any assistance I have received by the following professionals/advisers:

___

___

___

The academic supervisor of my Final Degree Project is ___dr. Viktoras Filipavičius___ .

No contribution of any other person was obtained, nor did I buy my Final Degree Project.

___	MONIKA GUDONYTĖ
(Signature)	(Given name, family name)

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ABBREVIATIONS AND DICTIONARY

HICP Harmonized Index of Consumer Prices

ESG Economic Scenarios' Generator

BP Basic Point (1 BP is equal for 0.01 %)

P&C Property and Casualty Insurer

CAPM Capital Asset Pricing Model

CPI Consumer Price Index

GDP Gross domestic product

CEIOPS Committee of European Insurance and Occupational Pension Supervisors

ILB Inflation Linked Bond

ECB European Central Bank

RPI Retail Price Index (UK market)

IIS Inflation Indexed Swap

ZCIIS Zero Coupon Inflation Indexed Swap

YYIIS Year on Year Inflation Indexed

YOY Year-On-Year

BEIR Break-Even Inflation Rate (**BEI** Break-Even Inflation)

TIPS Treasury Inflation-Protected Securities (US market)

EMU Economic and Monetary Union

SSM Structural Simulation Model

Asset-liability management. The management of an insurer's assets with specific reference to the characteristics of its liabilities so as to optimise the balance between risk and return.

Asset-liability mismatch risk. Risk of a change in value from a deviation between asset and liability cash flows, prices, or carrying amounts, caused by a change in actual cash flows; the expectations on future cash flows; accounting inconsistencies.

Claims risk. A change in value caused by ultimate costs for full contractual obligations varying from those assumed when these obligations were estimated.

Disability risk. A change of value caused by a deviation of the actual randomness in the rate of insured persons that are incapable to perform one or more duties of their occupation due to physical or mental conditions.

Diversification. Reduction in risks among assets and/or obligations of an institution by accumulating risks that are not fully correlated in an aggregated risk position.

Equity risk. The risk of a change in value caused by deviations of the actual market values of equities and/or income from equities from their expected values.

Foreign exchange risk. The risk of a change in value caused by the fact that actual foreign currency exchange rates differ from those expected.

Hedgeable risk. A risk associated with an asset or an obligation that can be effectively neutralized by buying or selling a market instrument, whose value is expected to change.

Inflation risk. The risk of a change in value caused by a deviation of the actual market-consistent value of assets and/or liabilities from their expected value, due to inflation.

Interest rate risk. The risk of a change in value caused by a deviation of the actual interest rates from the expected interest rates.

Legal risk.. The possibility that lawsuits, adverse judgements from courts, or contracts that turn out to be unenforceable, disrupt or adversely affect the operations or condition of an insurer.

Liquidity risk. The risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimize a loss.

Longevity risk. A change in value caused by the actual mortality rate being lower than the one expected.

Market value margin. The measurement attribute for determining the risk margin in a market consistent measurement of an insurance obligation or asset reflecting the price charged by market participants for accepting the deviation risk inherent in a cash flow.

Migration risk. The risk of a change in value caused by a deviation of the actual probability of a future default by an obligor from the expected probability of future default.

Motor risk. A generic term referring to all types of insurance indemnifying for third party liability, legal liability for bodily injury, and damage to property of others.

Real-estate risk. The risk of a change in value caused by a deviation of the actual values of real-estate securities and/or income from real-estate securities, from their expected values.

Settlement risk. The risk of a change of value due to a deviation from the best estimate of the time-lag between the value and settlement dates of securities transactions.

Strategic risk. The risk of a change in value due to the inability to implement appropriate business plans and strategies, make decisions, allocate resources, or adapt to changes in the business environment.

Systematic risk. Any risk inherent to the entire market or entire market segment which cannot be mitigated through diversification.

Underwriting risk. The risk of a change in value due to a deviation of the actual claims payments from the expected amount of claims payments (including expenses).

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INTRODUCTION

Despite the relatively benign behaviour of the general inflation rate in many European countries for the past two decades, developments since the financial crisis of 2008 have created the potential for decreased price stability. Having weathered the worst crisis in terms of length and amplitude since the Second World War, insurers may have to cope with one of the potential outcomes of the subprime meltdown: the threat of a surge in the living and liabilities costs. In the current economic environmental with the accumulation of multiple factors raises the question as to whether a globally low and stable inflation environment can continue to exist (K. Kurt et al. 2010; M. Brière, O. Signori, 2010; N. Fulli-Lemaire, E. Palidda, 2012; A. A. T. Andersen 2011; K. C. Ahlgrim, S. P. D'Arcy, 2012). To support weak economies almost all developed countries applied unconventional monetary policies with significant stimulus packages and injections of liquidity into money markets. The resulting exceptional rise in government deficits and huge debt levels are a looming problem for the many European countries, while the recent Euro weakness and macroeconomic volatility are adding further pressures to the ongoing debate.

Conversely, in large part due to the expansionary fiscal policies adopted in response to the financial crisis, the risk of a significant increase in the inflation rate has grown. This renewed concern about inflation naturally raise the question of reconsidering how to build the portfolio of non-life insurance company that will shield investors effectively from inflation risk and, where possible, generate excess returns.

The aim of the final master thesis: This master research seeks to explain the insurer investment portfolio inflation risk management and to make analysis of possible inflation hedging with inflation linked securities.

Tasks of final master thesis:

To summarize the risk map of the insurance business;

To summarize the inflation risk influence for the non-life insurance business;

To summarize the possibilities of the inflation hedging;

To evaluate the possible consequences of inflation hedging with inflation linked bonds and explain advantage and disadvantage;

To evaluate possible consequences of inflation hedging with inflation swaps in the case of mix portfolio and inflation swap rates versus nominal rates.

The practical importance of the inflation hedging strategy: The volatile economic environmental that occurred in the last year and a half has caused some financial companies to go bankrupt and others, including insurance companies, to be aided with public money to prevent their bankruptcy, may give a different concern to the reading and interpretation of the risk factors obtained. In addition to the risk control which has traditionally been implemented by insurance companies so far, with higher or lower thoroughness in each case, of the more intuitive business risks (insurance risk and market risk), the introduction of other types of risk (in this case the inflation risk) could lead to a safer situation in terms of companies' viability, and also to the discovery of new improvement opportunities in production processes along the way. Nevertheless, inflation risk can be managed by insurers, but inflation risk management requires advanced planning.

The relevance of the inflation hedging topic in the Europe: With the increase in trading in inflation linked securities academic interest has spurred, but perhaps more interesting to financial institutions, central banks have started using the information content embedded in inflation linked products in relation to the economic analysis used to set policy rates (M. Bulletin, 2011; J. A. Garcia, T. Werner, 2010; J. A. Garcia, A. A. Van Rixtel, 2007).

The structure of the master thesis: This Master thesis consists of four sections. The first section provides some background on inflation risk, describes some problems in measuring claims by using general inflation index, and explains some of its effects on the insurance industry. The second section explaining the methods and investment instruments, those will be use for the design research and design solutions. The third section first of all reviews historical inflation rates; nominal and inflation swap rates. Later this section providing portfolio optimisation analysis based on Afterward it examines the effect of the inflation risk mitigation strategy (inflation hedging with inflation liked swap) on the property-liability insurance industry in the most probable inflation and break –even inflation scenarios. The final section provides conclusions.

The method used: analysis of scientific literature, collecting, grouping data and using comparison method, representing graphic data and its relations. Also it was made correlation, mean-variance and portfolio optimization analyses while using Excel program.

The master thesis research was prepared with the support of Ergo International AG in Düsseldorf. With half year internship in this company the author had possibility to get practical understand about insurance investment management in the department of strategic asset allocation for the international subsidiaries.

1. THE EFFECT OF INFLATION RISK ON THE INSURANCE INDUSTRY

The revolution (on in other words phenomenon) in the world economy that occurred in the last year and a half has caused some financial companies to go bankrupt and others, including insurance companies, to be aided with public money to prevent their bankruptcy, may give a different nuance to the reading and interpretation of the risk factors obtained. This discussion may reflect on how the insurance sector and the scientific community approached the different types of risks at the beginning of 2008 and how it would be approach now when it has been verified that the insurance sector, in spite of being traditionally conservative and used to fluctuating economic cycles, has not been immune to the crisis.

In addition to the risk control which has traditionally been implemented by insurance companies so far, with higher or lower thoroughness in each case, of the more intuitive business risks (insurance risk and market risk), the introduction of other types of risk (in this case the inflation risk) could lead to a safer situation in terms of companies' viability, and also to the discovery of new improvement opportunities in production processes along the way.

1.1. Insurance Risk Classification

Risk terminology varies from organization to organization, and actuaries working in different organizations may use different terms to refer to the same risk, or use the same nomenclature for completely different risks. Even at a high level, significant differences can exist between how different organizations classify rinks. P. O. J. Kelliher et al. (2011) was looking for a common risk classification in the context of insurance industry. In this Master thesis are sets out a risk classification system developed by the Solvency II (appendix A and B) that can be used as a common reference point for discussing risk in EU insurance business environmental.

The internal insurance business model is based on risk management system for the analysis of the overall risk situation of the insurance undertaking, to quantify risks and/or to determine the capital requirement on the basis of the company specific risk profile (European Insurance and Reinsurance Federation. 2007). Solvency II is the macro project started in the heart of the European Union; its implementation is scheduled for 2013 in this continent and it is based on three main pillars, namely: “Creating financial reserves according to the real level of risk undertaken by insurers, communicating information to the market and to the supervisor and the ability of both supervisors and insurers to foresee and evaluate crisis situations” (C. Fernández, 2009). The European Commission has, through the Solvency II Project, initiated a fundamental and wide-ranging review of the current EU solvency regime in the light of current developments in insurance, risk management, finance techniques, financial reporting, etc. (P. Hördahl, O. Tristani, 2007). Creation of a harmonized supervisory system throughout Europe based on an evaluation of the actual risk situation of each insurance company (P. Hördahl, O. Tristani, 2007; M. Dacorogna, 2010; C. Fernández, 2009). These three pillars can be summarized as follows:

- Pillar I: Measurement of own resources: assets, liabilities and capital;
- Pillar II: Supervision process;
- Pillar III: Transparency requirements through the disclosure of information to the market.

The Solvency II project pursues two main objectives:

First of all for the development and implementation of a new system to determine the minimum own resources required from each insurer according to the risks undertaken and their relevant management. Calculation methods should be adaptable to the evolution of the companies' risk profiles. The goal is to establish the mechanisms or procedures for the calculation of the companies' minimum own resources based on the final exposure to risks (European Insurance and Reinsurance Federation. 2007; P. Hördahl, O. Tristani, 2007).

Finally, it also aims at establishing the information that the companies should disclose, mainly with respect to their risk management policy: undertaken risks, mechanisms available for their management, follow-up and control and etc. In this way, all market players would have, for decision-making purposes, sufficient information on the existence and maintenance of the companies' solvency level (P. Hördahl, O. Tristani, 2007).

In the following discussion I will examined only the issues of the risk management, because Solvency II is really wade approach to insurance business. The concept of risk in relation to Solvency II can be defined as a change in value, either positive or negative, due to a deviation from the expected value (European Insurance and Reinsurance Federation. 2007). The Figure 1 is summarizing the classification of main types risk for insurers based on Solvency II view. The risk map should not be interpreted as a full overview of all risks for insurers that may have to be quantified under Solvency II, because this Solvency II is still ongoing process (European Insurance and Reinsurance Federation. 2007; P. O. J. Kelliher et al., 2011).

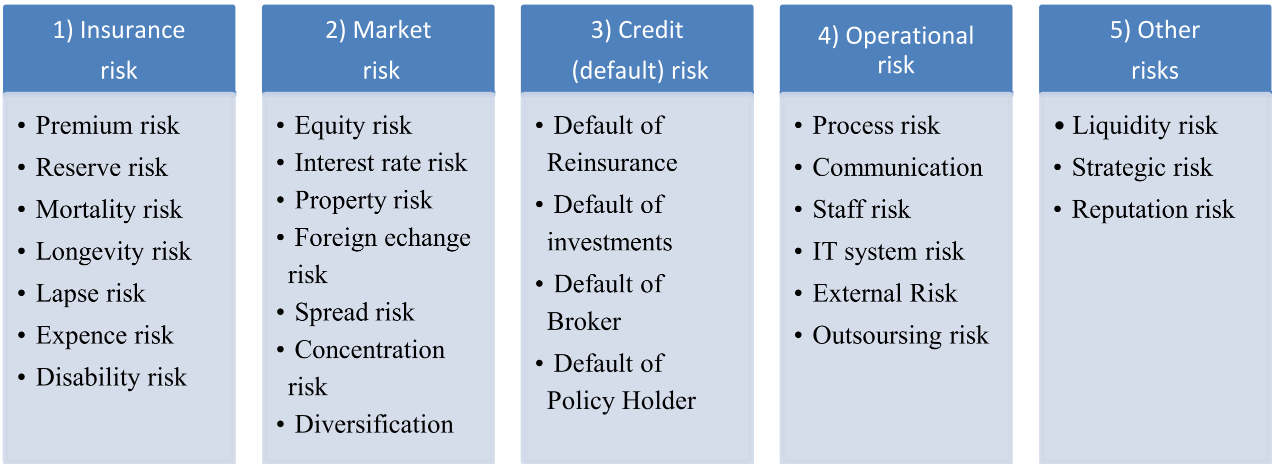


Figure 1. Insurance Risk Classification based on Solvency II. Source: European Insurance and Reinsurance Federation, 2007; P. O. J. Kelliher et al., 2011.

The insurance risk is associated both with the peril covered by the specific line of insurance business (fire, motor, liability, death, etc.) and with the specific processes associated with the conduct of the insurance business. Default (credit) risk is the risk of loss a firm is exposed to if a counterparty fails to perform its contractual obligations (including failure to perform them in a timely manner) including losses from downgrades and other adverse changes to the likelihood of counterparty failure (P. O. J. Kelliher et al., 2011). Market risks come from the level of volatility of market prices of assets. They involve the exposure to movements in the level of financial variables (e.g. stock prices, interest rates, exchange rates, etc.), but also the mismatch between assets and liabilities. Operational risks can be defined as the risks of loss resulting from inadequate or failed internal processes, people, and systems or from external events (P. O. J. Kelliher et al., 2011). Liquidity risk is the exposure to loss due to insufficient liquid assets being available.

If a risk category is not possible to model and treated as a Pillar I risk, it should be treated as a Pillar II assessment, i.e. under the supervisory reviews process (European Insurance and Reinsurance Federation. 2007). These five risks are used both for solo entities also for insurance groups or financial conglomerates. There is also a sixth main risk category that can be introduced for groups or conglomerates: group risk or participating risk.

1.2. Inflation Risk in the Context of Insurance Business

1.2.1. Inflation Risk

Inflation is defined as the change in price level. Most commonly inflation is represented in a form that references a defined basked of goods, such as food prices or wages. The constituents of these baskets are weighted in order to represent the purchases of consumers of the chosen parent population. The CPI is a current social and economic indicator that is constructed to measure changes over time in the general level of prices of consumer goods and services that householders acquires, use or pay for consumption. This may be done by measuring the cost of purchasing fixed basked of consumer goods and services of constant quality and similar characteristics, with the products in the basket being selected to be representative of households' expenditure during a year other specific period. Also the rate of inflation typically refers to changes in the overall level of prices within an economy, which consequently leads to the erosion of the domestic currency (K. C. Ahlgrim, S. P. D'Arcy, 2012).

The inflation risk definition based on Solvency II (European Insurance and Reinsurance Federation. 2007), it is the risk of a change in value caused by a deviation of the actual market - consistent value of assets and/or liabilities from their expected value, due to inflation, e.g. price inflation, wage inflation, etc., leading to an unanticipated change in insurance cost and/or impact of an insurance contract, e.g. with respect to contract limits.

During the financial crisis, inflation risk is a real concern for many financial institutions. Having weathered the worst crisis in term of length and amplitude since the Second World War, insurers and other investors may have to cope with one of the potential outcomes of the subprime meltdown: the treat of surge in the living costs (O. Signori, M. Brière, 2010).

Nevertheless, to support weak economies almost all developed countries applied unconventional monetary policies with significant stimulus packaged and injections of liquidity into money market. The resulting expectation rise in the government deficits and huge debt levels are a looming problem for the US and many European countries, while the recent oil price are rising, Euro weak and macroeconomic volatility are adding future pressures to the ongoing debate (O. Signori, M. Brière, 2010).

Insurers in particular identified inflation as one of their top risk management concern because it affects investments return, asset valuation and futures insurance liabilities. In the follow text I will be presented one of research in the context of inflation expectation according the financial institutions. Professional Risk managers' International Association and Capital Risk Advisors (2009) surveyed the top risk management concerns for US financial institutions and inflation was one of the biggest concern for these institutions (Figure 2.).

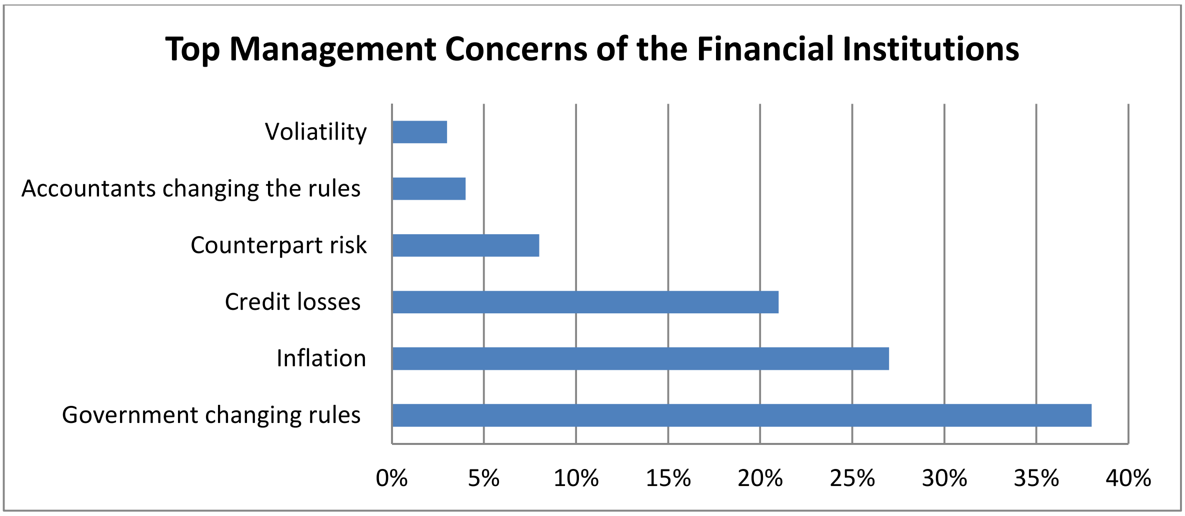


Figure 2. Top Management Concerns of the Financial Institutions. Source: Risk Governance. A Benchmarking Survey. Professional Risk managers' International Association and Capital Risk Advisors, July 2009

At same time Swiss Re research summarized the survey of the inflation expectations for the 2011-2014 of more than 1800 investors in US and Euro area (K. Kurt et al., 2010). According this research insurers are more worried about inflation than other institutional investors. In the Euro area, insurers, along with corporate and fund investors, also had the highest expected inflation rate for research period (target Euro area inflation was defined as 2,0 %).

Table 1. Results of the Investor's Survey about the Inflation Expectations and Impacts

Percentages based on investors expectation of the inflation rate					
Type of investors	Below target	Close to target	Above to target	2,5 % above target	Mean expected inflation %
	Total 100 %				
Fund managers	16	48	26	9	2,5
Hedge funds	21	42	25	12	2,6
Banks	19	50	27	4	2,4
Pension funds	15	41	35	9	2,7
Insurance companies	13	43	33	11	2,7
Corporate	12	45	33	10	2,7
Private banks	11	51	32	6	2,6
Total	17	46	28	9	2,6

Source: K. Kurt et al., 2010.

Inflation continues to be a significant emerging risk for the insurance industry. Concerned about inflation are well placed for two reasons. First, the economic arguments in favor of an eventual surge in inflation are quite compelling. Second if past experience is an indicator, inflation can significantly damage insurers' balance sheets and profitability. Incorporating inflation risk into insurance business model facilitates an understanding of how inflation might to produce economic losses (Figure 3.).

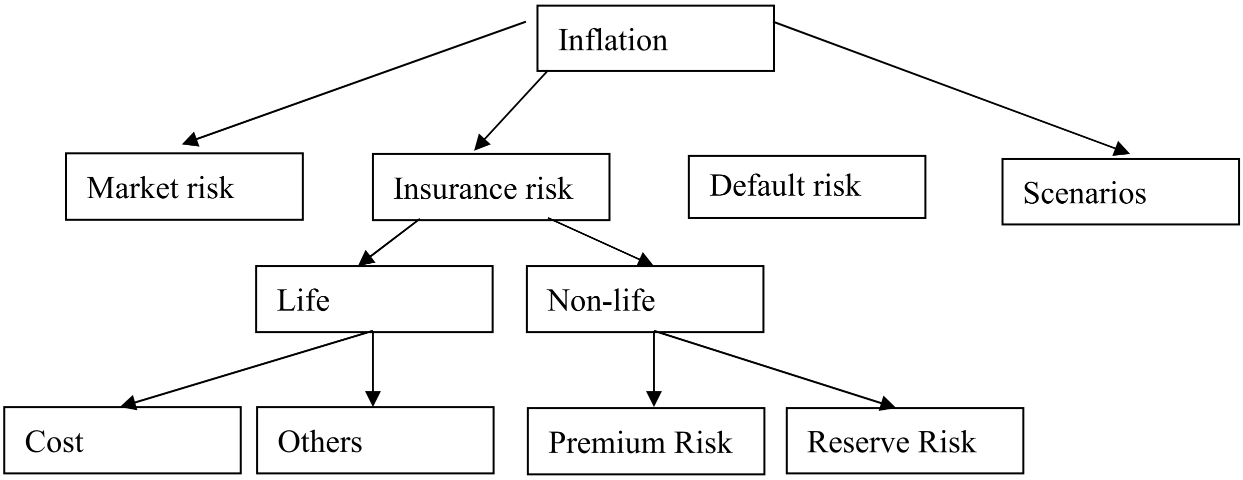


Figure 3. Inflation Influence in the Context of Solvency Model. Sources: European Insurance and Reinsurance Federation, 2007; P. O. J. Kelliher et al., 2011; Deloitte Consulting, 2011.

Life insurers are more likely to be indirectly affected by the impact of inflation (S. Lowe, R. Watson, 2010). Most life insurance products have benefits that are fixed in nominal terms: hence, changes in inflation do not create large movements in life insurers' liabilities (in the case of for most mortality, wealth accumulation and longevity protection policies) (K. Kurt and etc., 2010). They are more affected by inflation influence based on market risk.

Insurance risk for non-life insurers is typically divided into reserve risk and premium risk. Reserve risk considers known and unknown claims that have already occurred in the past, it thus focuses on uncertainty about future payments due to a claims settlement process. In contrast, premium risk (also called pricing risk or underwriting risk) deals with the uncertainty that payments for future claims are higher than their expected value, so it deals with future accident years. Therefore, quantifying the reserve risk and the premium risk by means of stochastic claims reserving methods plays an essential role in risk measuring for non-life insurers.

The Reserve Risk of claims inflation is different in short and long tail business. Short tail business is less exposure to inflation risk; inflation effects can be mitigated through appropriate pricing; some dependency on the level of regularization of the market (Deloitte Consulting, 2011). And the long tail business due to longer duration cash-flows, higher exposure towards inflation risks; inflation effects cannot be mitigated through appropriate pricing, only anticipated; it dependence on legislation; additional uncertainty through potential underestimation of late claim reinsurance. And the premium risk will be considered in the 1.5. section. According S. Lowe, R. Watson (2010) results inflation have a negative impact of inflation on P&C insurer's claims costs, loss reserves and asset portfolio.

Inflation risk in the market value margin consideration of the future cost of capital (Deloitte Consulting, 2011), it can be influence by: insurance risk (Claims, Costs, Salary, etc.); credit risk, effect of scenarios; non-hedgeable market risk (& hedging costs) calculation of the present value; it is based on the risk-free rate cost-of-capital rate; indirect protection against inflation through real estate, commodities, dividends.

K. C. Ahlgrim and S. P. D’Arcy (2012) express concerns about the moist of current insurers (in the developed countries like US and Euro area), underwriters and claim staff have never experienced about of severe inflation, so could be slow to adapt to any change in the economic environmental.

To conclude this part is need to point that inflation affects insurers though three basic channels: it impacts claims and general expenses, the value of liabilities and less directly, the value of assets. The next parts are examining the inflation influences on the asset and liabilities side, especially with respect to non-life insurance business.

1.2.2. How Inflation Risk affect the future Insurance Liabilities

In economics, inflation is a rise in the general level of prices of goods and services in an economy over a period of time. Each institution has liabilities with different linkage to inflation. As the non life insurance companies generally have liabilities denominated in their domestic currency it could be one of the argument that domestic inflation is the only important measure of inflation for them, but in Europe case it is different situation because Euro zone and common currency. Harmonized Index of Consumer Prices (HICP)(appendix C) - is an indicator of inflation and price stability for the European Central Bank Claims (P. O. J. Kelliher et al., 2011). When modelling the claims inflation peak risk to determine economic capital, a key assumption is whether central banks will maintain their long term inflation targets. Alternatively, the insurer may need to form a view as to the central bank's commitment to rein in any unanticipated spike in inflation (K. Kurt et al., 2010).

Insurance company profits are the sum of underwriting profit (premium less incurred loss) and investment income on the premium prior to paying incurred loss amounts as well as the capital necessary to support the operation (R. Krivo, 2009). This company receives a fixed premium at early durations (payments for insurance) but pays an uncertain, inflation impacted, claim payments at later durations. This mean that higher inflation could lead to higher claim costs for the non-life insurers and it would to erode of company profitability (D. Jones, T. Ryan, 2010; K. Kurt et al., 2010). This inflation risk is a challenge for insurance companies to manage it. Shortly claim inflation can be explained by it equality:

Claims Inflation = „CPI Inflation“ + „Superimposed“ Inflation

Superimposed Inflation:

- Costs that exceed „Basis Inflation“ (medical expenses, construction cost etc.);

- Measured by the change in the (annual) average claim cost;
- Cost/Salary.

It is hard to accurately gauge the level claims inflation has been running at each past year. This is because "the truth is hidden in the claims data with is distorted by lots of other factors such as changes in the mix of business, changes in limits, deductible and policy terms" (B. Brickman et al., 2005).

Different insurance business lines have different liabilities sensitivity to changes inflation. For example motor insurance line (the largest line of non-life insurance) can have duration between 6 to 7 years (D. Diers et al., 2012) other authors have different opinion that personal auto lag is only six months behind the closing data of claims so any inflationary spikes should be recognizable by insurers (R. Krivo, 2009). Same author workers compensation is particularly troubling an inflationary perspective due the absence of a limit on medical coverage. The additional danger for workers compensation is the effect of compounding inflationary increases due to amount of time it takes to settle claims. Clam distribution is much more volatile in line that is exposed to catastrophes. Casualty lines of insurance such as professional and general liability along with umbrella are long-tailed about two years (D. Diers et al., 2012). The danger in assuming risk in these lines is that any trend shortfall in the pricing won't be discovered or factored into policies until multiple renewals have ensured (R. Krivo, 2009).

According to F. Ranut (2006) inflation influences the average insurance cost of claims, because it makes the cost of repairs higher, and so its correlation coefficient (about 92 %) has a positive sign. And also F. Ranut (2006) and K. Karl et al. (2010) pointed that the empirical evidence shows that the insurance inflation is much higher than the general inflation. According K. Karl et al. (2010) research, which was based on US, Canada, UK, Germany, France Italy and Japan markets, the ratio of liability claims growth to CPI inflation ranges from 1,8 % to 2,6 %. In the US and Germany, for example, for every 1% increase in CPI, general liability claims have rise by 2,2 %. It is difficult to hedge general inflation satisfactorily, and even more difficult to manage the "basis risk" between general inflation and insurance claims inflation. Furthermore, in Europe area inflation tends to be more systemic across lines of business and geographical boundaries, and hence difficult to diversify away. That lead to discussion or all items CPI is the best measure for the claims cost.

This disparity between claim inflation and general rate of inflation is coming from few issues (K. C. Ahlgrim, S. P. D'Arcy, 2012):

- Insurers are likely to be exposed to specific components of the CPI rather than the overall level of prices changes;
- Based on the CPI approach the costs of residents reflect only house renting costs (consumption part) but do not include the selling price (investment part). As the cost of claims for

the home owner's losses covers the full costs of the home. Thus, the CPI did not incorporate the rapid increase in housing price during the 2000 – 2006 or the drop in prices that occurred subsequently (K. C. Ahlgrim, S. P. D'Arcy, 2012):

- New products, especially new technology, get include in CPI only when they reach mass appears. It is also time lag between general inflation rate and the claim inflation.

Finally, inflation does not have an isolated impact on insurer performance. While high inflation by itself may increase claims of insurers, the interaction with other economic and financial variables may lead to a more complex assessment.

With propose to add inflation risk as factor of insurance business model, it is need to be constructed inflation stress scenarios, and interdependencies with other risk factors need to be considered. Many insurance companies already use economic scenarios' generator (ESG) to simulate thousands of potential futures economic conditions, including future inflation. The advantage of an economic scenarios' generator approach is that inflation is modelled in a coherent way in conjunction with other risk factors, such as interest rates and foreign currency exchange. High-quality ESG reflects considerable research, including analysis of all available historical data supporting macroeconomic theory (S. Lowe, R. Watson, 2010).

Insurance business model typically is broken down into a series of investment and insurance (liability) portfolios. The insurance portfolio is divided by the product, each sub-portfolio is defined how the value of that portfolio will change in response to each risk factor (asset side will be considered in the follow section 1.2.3)

S. Lowe, R. Watson (2010) explaining the claims simulation model based on measure of inflation risk (based on the economic scenarios' generator model).

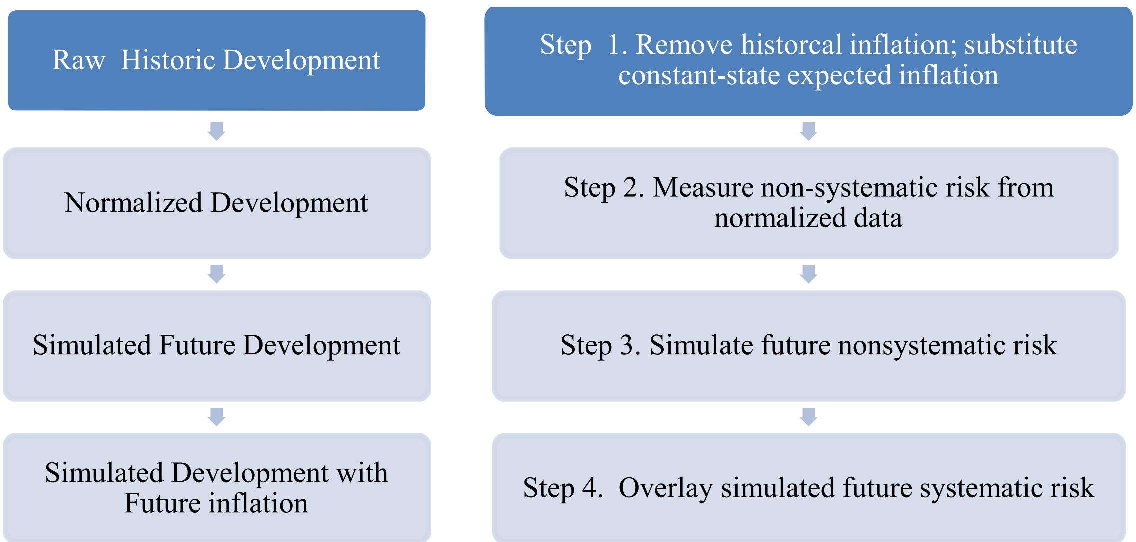


Figure 4. Overview of Structural Simulation Model (SSM) for P&C Claim Liabilities. Sources: B. Brickman et al., 2005; S. Lowe, R. Watson, 2010.

To incorporate inflation risk in to the first step is to evaluate each of the sub-portfolios to determine whether it is materially affected by inflation. Claim liabilities (cost of claim reserves associated with the current underwriting years) will almost certainly be affected to some degree by inflation, with the impact varying by products. Second step is to develop the loss functions, which measure the impact of changing inflation on each sub-portfolio. The first two steps develop the needed parameters of the approach and last two run the simulation. This model simulates scenarios of futures clam development also measuring inflation risk in the context of insurance company liabilities. To summaries insurance companies need to be proactive in analyzing and selecting trend factors in order to keep price and reserves adequate.

The analysis of claim cost development should allow understanding of claims inflation at the expected, anticipated level. Investors are often seeking to match assets against similar liabilities, and so a good choice of index would be one that meets the hedging requirements (M. Deacon et al., 2004).

General insurers (also known as Property and Casualty or P&C insurers) provide insurance cover against property and liability risks, sub-divided into categories such as property, motor, aviation, marine, fire, personal accident and legal liability (D. Rule, 2001). In most cases, policies are renewed annually with the insured bearing an initial share (the deductible or retention).

1.2.3. How Inflation Risk affect Insurer's Asset

Another question of strategic importance to insurers is: what impact does inflation have in asset return? On the asset side, all investors are affected by inflation since it tends to change the relative return of the various asset classes. Some asset classes perform better during periods of inflation than corporate bonds or long term government bonds. Insurers need to adjust their investment portfolios as inflation risks rise and fall.

As reported Insurance Europe (the European Insurance and Reinsurance Federation, 2012) non-life insurers in Europe is concerning that the wave of regulatory initiatives adopted in Europe as a response to the financial crisis could have an impact on insurers' investment activities, potentially making it more difficult for them to play that role in the economy.

The impact of inflation an asset prices and returns much depends on time horizon. An asset that keeps pace with inflation over a long time horizon might nonetheless react negatively to high inflation in the short term. It is therefore necessary to consider long and short-term effects on inflation separately. In the research of K. Kurt et al. (2010) pointed four main asset classes, which are positive correlated with inflation in short run: nominal (government) bonds, inflation linked bonds, commodities and real estate. Also this research shows that long term bonds exhibit strong, negative correlation with inflation.

A review of the literature shows different relationship between various asset classes and inflation strongly depends on the economic conditions. O. Signori, M. Brière (2010) research pointed that in the period of high economic volatility, an investors having pure target inflation should be mainly invested in cash when her investment is short and increase allocation to inflation linked bonds, equities, commodities and real estate when horizon increased. Also in the contrast case, in a more stable economy environmental, cash plays an essential role in hedging a portfolio against inflation in the short run, but in the long run it should be replaced by the nominal bonds and to a lesser extent by commodities and equities.

A. P. Attié and S. K. Roache (2009) were investigating differed US asset classes with purpose to hedge unexpected inflation and they come up with the Table 2.

Table 2.Summary of A. P. Attié and S. K. Roache (2009) Research for the effect of unexpected Inflation on the Asset Class Returns (data based on Jan-1927 to Nov-2008)

Asset class	Short term (1-18 months)	Intermediate term (18 months to 5 years)	Long term (5 years+)	Historical long run performance
Cash	Interest rates respond gradually, leading to real losses	Interest rates begin to climb, recovering some of the early losses	Partial inflation hedge, elasticity of 0.8	Modestly positive real returns
Nominal bonds	Bond yields rise, causing price declining and real return losses	Higher current yields begin to offset price declining, leading to some recovery	Real losses with elasticity of 0.1	Real returns in excess of cash, but lower than equities
Equities	Real return losses, but less than for bonds	Stabilizing real returns, but no meaningful recovery	Real losses with elasticity of -0.2	Real returns in excess of bonds
Commodities	Spot price increase, almost matching inflation	Spot price begin to gradually decline	Real spot price losses with elasticity of -0.2	Insufficient total return data for commodity futures

Source: A. P. Attié and S. K. Roache (2009)

How we can see traditional asset classes are imperfect at best and unlikely to work at worst. Authors noting that it is important to look for better inflation hedging possibility with the respect to inflation derivatives, which can be combined with the diversified investment portfolio strategy.

To conclude, all asset classes have outpaced inflation over time. But some of them are better in case of the additional economic conditions. Of course the portfolios' of the non-life insurance company most are structured with nominal bond, but in this volatile economic environmental it would be reasonable to cover inflation exposure with the inflation correlated asset classes, like inflation linked bonds, equities and commodities. It means that insurers could practically protect themselves against inflation surprise.

2. INFLATION RISK HEDGING

Insurance companies as investors face a common problem – how to maintain the purchasing power of their assets over the time and achieve a level of real returns consistent with their investment objectives. In this section I will investigate different scientific literature with the intention to understand how insurance companies are hedging inflation.

2.1. Markowitz Model in the Context of Insurance Investment Asset-Liability Management

In 1952, Harry Markowitz wrote a paper call "Portfolio Selection" which was published by the Journal of Finance. In this paper, he described how investors can maximize their expected returns while minimizing risks. Together with William Sharpe who formalized the concept of Capital Asset Pricing Model (CAPM) they brought about what was known as the Modern Portfolio Theory. The main rationale behind the theory is if investors were given a choice of investing in two (or more) different assets which provides the same returns but have different risks, the investors would likely choose the asset with a lesser risk.

This section of Master thesis discusses investment and inflation risk management strategies for non-life insurance companies. Using a simple mean-variance framework for understanding the risks and returns of alternative investment strategies, it is argued that the optimal strategy involves a full hedge of liability risks (inflation exposure in liabilities structure) combined with a mix of optimal nominal and inflation swap portfolios.

In finance, risk of security is defined as the volatility of the returns of this security over a period of time. Similarly, for a portfolio, it is the volatility of the returns of the portfolio over a period of time. The Standard Deviation is one way for tracking this volatility of the returns. A portfolio is simply a combination of assets or securities. The Modern Portfolio Theory describes how investors can combine different assets to create a portfolio that reduces risk but not the expected returns.

Investors interested in inflation-hedged strategies have often turned to Inflation linked bonds, inflation linked derivatives, equities or gold, oil and other types of commodities. Each of these inflation investment protections presents challenges of choosing hedging strategy.

Gold has remained largely synonymous with inflation protection for the centuries if not millennia, this trend also was observed after 2008 financial crisis. But gold itself is not immune to financial boom and bust phenomena (Fulli-Lemaire, N. 2012 a.; Fulli-Lemaire, N. 2012 b). N. Fulli-Lemaire and E. Palidda (2012) pointed that even though gold's very long- term inflation hedging properties are undeniable, its propensity to attract feverish investor confidence, makes it a highly unsuitable asset to hedge inflation when it comes to accounting or as a guarantee of purchasing power. D. Ghosh et al. (2004) investigated that gold price changes are consisted with the short-run movements of the general inflation.

In the years of 2009 A. P. Attié and S. K. Roache (2009) pointed that the supply and liquidity of the inflation linked bonds and derivatives are still limited and investors to continue to rely on the indirect hedging properties of traditional asset classes. In the section 2.3. I will discuss about inflation linked bond and derivatives separately with the purpose to understand advantages and disadvantages of them.

In related research, O. Signori, M. Brière (2010) focused measuring of relationships between asset classes and inflation in different regimes and they conclude "that inflation and inflation linked bonds positively correlated for an obvious reason - the impact of depends on the macroeconomics scenario.

G. Bhardwaj et al. (2011) investigated how different asset classes correlate with expected and unexpected inflation. They summarized positive relationships between: expected inflation and cash and gold; unexpected inflation and inflation linked securities' and commodities (futures); and negative relationship between unexpected inflation and nominal bonds. Also they pointed relatively high relationship between actual inflation and commodities futures and inflation linked securities in context of one year horizon. It's mean that these asset classes are more effective in short term period and non-life insurance companies usually have larges inflation exposure in 1-2 years duration.

M. Deacon et al. (2004) pointed that two of the main factors that can deter investors from purchasing inflation-indexed bonds are their tax treatment and their lack of liquidity compared with other investments.

In the follow research author will investigating inflation hedging strategies with inflation linked securities (ILBs and inflation swaps) in the case of Europe. Risk-averse insurers should hold same maturity inflation linkers as their liabilities duration with purpose to hedge possible inflation effect in claim costs. In addition, because inflation swaps offer a wide range of maturities, from one to thirty years, they can easily fit into a broad range of inflation views to complement a variety of investment strategies.

More concretely, I will show that the presence of the liability means that, in the absence of constraints, and with transaction costs ignored, the optimal strategy (in a mean-variance sense) consists of (S. Jarvis, 2007):

−The liability hedge;

−An allocation to an optimally diversified portfolio (with the allocation determined by the plan's return target or risk tolerance);

−The balance (positive or negative) in cash.

The situation becomes more complex in the consideration, where the market risk and the insurance risk are not independent. If paid claims depend on interest rates, then interest rates must be projected stochastically, and the discount factors cannot be considered as fixed (P. Foulquier and S. Sender, 2007). Sensitivity analysis may be used to assess how much the insurance risk adds to the volatility of the present value of the claims (inflation risk).

2.2. Introduction of the Mean-Variance Analysis Framework

Markowitz identified the trade-off faced by an investor. Investment decisions are made to achieve an optimal risk/return trade-off from the available opportunities. In order to meet this objective, the portfolio manager must first evaluate capital market information and quantify ex-ante measures of both risk and expected return for the appropriate set of assets. Thus, he has to isolate those combinations of assets that are the most efficient, in order to provide the lowest level of risk for a desired level of expected return. While the principle of identifying portfolios with the required risk and return characteristics is certainly clear, the appropriate definition of risk is more ambiguous. Risk may be defined differently according to the sensibility and the objectives of the portfolio manager. One manager might view risk as the probability of shortfall below some benchmark level of return, while another may be more sensitive to the overall magnitude of a loss.

Mean-variance analysis has been increasingly applied to asset allocation and it is now the traditional formulation of the investment decision problem. In order to achieve the most efficient portfolio, assets are combined so as to minimize the variance for a given level of return. Here, risk is defined as the variance or standard deviation of the portfolio. It corresponds to the dispersion of the returns around the mean return. The main justification for using the mean-variance formulation is its tractability, as it requires relatively limited data. Instead of using the full assets returns' distribution, we summarize it by its two first moments that is the mean and the variance of the returns (S. P. Kothari et al., 2000):

$$Mean = \bar{\mu}(R) = E(R) = \frac{1}{n}(\sum_{i=1}^{N} R_i) \quad (1)$$

$$Variance = \sigma_i^2 = \sigma_{ij} = Var(R) = E\lfloor(R - E(R))^2\rfloor \quad (2)$$

$$Standard\ Deviation = \sigma = \sqrt{Var(R)} \quad (3)$$

$$Sharpe\ ratio = E(R)/\sigma \quad (4)$$

where R is the expected return of the asset.

The Sharpe ratio is the ratio of mean excess return to standard deviation and is a commonly used portfolio reward-to-risk measure S. P. Kothari and J. Shanken (2004).

In the multi-asset investment portfolio it is n risky assets. Let R_i denote the return on each assets $_i$, with assumption that portfolio total wealth, which is invested equal to 1, in some units. With the allocations w_i to each assets $_i$. Assuming that the investment is linear, the total return will be:

$$R = \sum_{i=1}^{n} w_i * R_i \quad (5)$$

Then total portfolio expected return is

$$\bar{\mu}_R = E(R) = \sum_{i=1}^{n} w_i E(R) = \sum_{i=1}^{n} w_i \mu_i \quad (6)$$

Where $\mu_i = E(R_i)$ is the expected is return from asset i.

Since the w_i sum to unity, they often are called weights in the portfolio allocation problem. However, w_i do not always constrained to be positive, so some of the asset weights can be negative (if investor want to see short position), but I will consider only positive values of allocation.

The most naive possible portfolio allocation problem would be to choose the w_i subject to the constrain in a way that maximizes the expected return in this case I will used duration and allocation constraints with respect to cover insurer liabilities.

Portfolio covariance based on the formula:

$$\sigma_{ij} = cov(R_i R_j) = E[(R_i - \mu_i)(R_j - \mu_j)] \quad (7)$$

The variance of the total return in (formula 2) is

$$\sigma_R^2 = var(R) = \sum_{i=1}^{n} \sum_{i=1}^{n} w_i w_j \sigma_{ij} = w^t \sum w \quad (8)$$

This formula summarize the matrix notation where w is a column vector whose components are the w_i, w^t is the row vector that is the transpose of w, and $\sum$ is the covariance matrix whose entries are the variances (8) and covariances (7).

The risk averse investor or insurance company will chooses the weights w_i to make the expected return (6) large and the risk, as measured by the variance (8) small. There is no universal risk/return trade off that holds for all investors. Some will tolerate more risk for the sake of higher expected return, while others will tolerate lower expected return for the sake of less risk.

The individual's optimal choice of portfolio mean and variance is determined by the point where one of these indifference curves is tangent to the set of mean and standard deviations for all feasible portfolios, what we might describe as the risk versus expected return investment opportunity set. This set represents all possible ways of combining various individual assets to generate alternative combinations of portfolio mean and variance (or standard deviation). This set includes inefficient portfolios (those in the interior of the opportunity set) as well as efficient portfolios (those on the "frontier" of the set). Efficient portfolios are those that make best use of the benefits of diversification.

To use Solver to solve the quadratic program associated with tracing out the efficient frontier in Markowitz portfolio optimisation it is much more convenient to make use of the covariance in Excel. In the Excel sheet I will use of an array formula using MMULT. To see the logic behind this I need to look at the Markowitz objective function in terms of matrix arithmetic.

For simplicity suppose so I will w_i row matrix of weights multiplied by the square covariance matrix multiplied by the column matrix of weights. The MMULT term in the Excel sheet performs the first multiplication, of the row matrix (array) of weights by the square covariance matrix.

In simply Markowitz portfolio optimisation problem (using Solver) are that it have no constraint on the proportion of the total investment made in each asset (i.e. each w_i can take any value between zero and hundred percent). In practice a large w_i may (even though the portfolio is on the efficient frontier) expose insurers to an unacceptable degree of risk via putting too much of our total investment into a single asset.

To extend this Markowitz portfolio optimisation problem I will add that insurers have a required liability duration limits (those need to be cover) on the proportion of the total investment that can be made in each asset. The sum of the same maturity nominal and inflation swap part in the portfolio need to equal to same duration of liabilities (these constrains are add in the solver function to find right allocation).

The reason why insurers add constraints is that there are considerations outside the Markowitz objectives, they are shaping insurers portfolio through coverage and other legitimate considerations by adding constraints to the Markowitz model.

2.3. Inflation Hedging with Inflation Linked Securities

Many academic papers have been writing over last few years covering the topic of inflation/deflation, but only a few researches cover the concerns regarded to insurance industry (S. Lowe, R. Watson, 2010; K. Kurt et al., 2010; K. C. Ahlgrim, S. P. D'Arcy, 2012). All these research are based on the inflation risk concerns in term of consequence of the financial crisis and current volatile economical environmental. The insurers can limit the impact of inflation on investment returns, asset valuations and future insurance liabilities by using inflation hedges, adding index clauses to contracts and buying reinsurance.

A security is called indexed security, if its cash flows are linked to movements in a specific index. In this case of relationship with inflation index it is called inflation-linked security. An inflation index is typically a domestic Consumer Price Index (CPI), but other inflation indices such us wholesale prices, average earnings and GDP Deflators have been used as an inflation index.

In 2009, the Committee of European Insurance and Occupational Pension Supervisors (CEIOPS) published the Insurance Linked Securities Report, which clearly outlined the importance of Solvency II for the inflation linked securities market. According to the report: "The new principles – based on Solvency II framework is very likely to be a major development for the Inflation linked securities market". Solvency II will recognize securitization and derivatives as effective risk mitigation techniques.

However, the inflation linked bonds and derivatives may be undermined two risks (Norges Bank. 2012 a). First, the reference index may not accurately reflect the true liabilities cost and second, changes to the way the reference index is computed may put investors at a disadvantage. It means that before to choosing this asset classes it is need be properly considered.

2.3.1. Inflation Linked Bonds

Historically the first inflation-linked products were inflation-linked bonds (ILBs) issued by some governments. Inflation-linked bonds are fixed-income whose are designed to eliminate the risk of unexpected inflation to the holders of bonds (J. A. Garcia, A. A.Van Rixtel, 2007). The market for inflation –indexed or inflation-linked derivatives has grown considerably since its beginning in the early 1990s, in countries like UK and Euro-zone (A. Malvaez, 2005). But inflation linked products can by no means be considered a new investment instrument: a bond whose principal and interest were linked to the CPI (the price level of basked of goods) was first time issued by the US State of Massachusetts in 1790 (M. Deacon et al., 2004).

In the nineteenth century the interest payments on debt contract in real against nominal terms was already well developed, by for example John M. Keynes advocated the use of inflation linked bonds by the British Treasury in 1924 (J. A. Garcia, A. A.Van Rixtel, 2007). On the recommendation of Irving Fisher in 1925, the Rand Kardex Co. issued 30-years purchasing power bonds with interest and principal linked to the wholesale price index (J. A. Garcia, A. A.Van Rixtel, 2007). They and some others authors like Joseph Lowe in 1822, William S. Jevons in 1875 thought that issuance of inflation-linked debt could solve the difficulties to protect investors from potentially high and volatile inflation over long periods of times what could lead to an inefficient allocation of resources (M. Deacon et al., 2004).

Inflation Linked Bonds are not Inflation Bonds, but real (Return) Bonds. Therefore it can be viewed as a classical bond investment without inflation risk (Waldenberger, S. 2011). Inflation Linked Bonds offer a "certain" real yield to maturity and they are most attractive asset class for inflation protection, because they can provide a complete inflation hedge. It is reasonable, because inflation linked bond are exposed to the basis risk characterized by the difference between the measure used to index the bond's cash flows and that most closely associated with liabilities (M. Deacon et al., 2004). Clearly, the larger basis risk the smaller the risk reduction benefits from holding inflation-indexed bonds.

Inflation linked bonds are all designed to protect investors against the erosion of principal and interest payments due to inflation, but they can take a variety of forms despite all being constructed to serve the same propose. Inflation-indexed bonds can give many different choices: of index, the cash flow structure of the bond, the application of the index to the cash flows and the impact of tax regulations. Cash flow structure is often determined by demand from end investors and driven by the nature of their liabilities. The inflation linked bonds pricing:

$$p_{IP}(T, t_0) = \frac{(T)}{(T_0)} \tag{9}$$

Where I(T) is the value of the CPI at time T. The denominator I (t_0) normalizes the dependence of the CPI, such that the inflation indexation is initiated at the issuance of the bond. The price of an inflation protected bond will be given by the expectation.

$$p_{IP}(t, t_0, T) = E_t^Q \left\lfloor exp\left(-\int_t^T n(s)\,ds\right)\frac{I(T)}{I(t_0)}\right\rfloor = p_n(t, T)E_t^T \left\lfloor\frac{I(T)}{I(t_0)}\right\rfloor \tag{10}$$

Where n(t) is the nominal spot rate and p_n (t,T) is the nominal zero coupon bond with maturity T, observed market price of an inflation protected ZCB, it will be defined as the real ZCB:

$$p_r(t,T) = \frac{p_{IP}(t,t_0,T)*I(t_0)}{I(t)} \quad (11)$$

Such that p_r (T,T)=1. Note that the relation above tells that p_r (t,T) is measured in units of the CPI-basket the real bond will give the investor one CPI-basket, and the real bonds are derived quantities and trust not directly traded. Finally differences between yields from nominal and real ZCBs are termed Break-even Inflation Rates, as it reflects the inflation compensation required by investors.

The uneven use of inflation-linked bonds among the largest bond issuers also leads to less market breadth by some measures (Norges Bank. 2012 b.). While 35 countries appear in the nominal government bonds market, only 20 countries are represented in the inflation-linked bonds market (Fig. 5.). M. Deacon et al. (2004) and (Barclays Capital, 2005; Barclays Capital, 2004) provided a comprehensive description of the world's indexed bond markets.

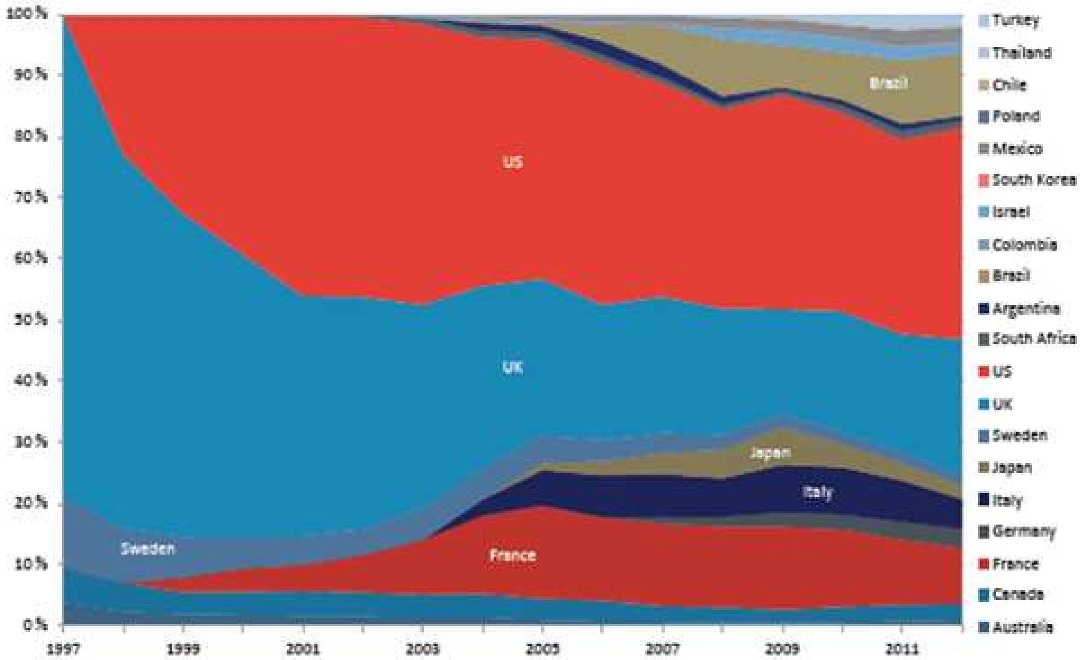


Figure 5. Share of Countries Issuers in the Global Inflation Linked Bond Market. Source: Norges Bank. 2012 b.

Until 2003 the UK and US was the main player in global inflation-linked market, together these countries made up at least three-quarters of the market value. This issuer concentration was subsequently decreased by the entry of new countries (mostly of the developing countries) and their faster growth in market value outstanding. The largest four country issuers as the US, the UK, Brazil and France represent 79 % of the market capitalization.

In consideration of the situation in the Euro-zone where – as of mid-2003 – liquid inflation-linked bond markets was limited to those based on one of just two inflation indices: a domestic French inflation index or a pan-European index (M. Deacon et al., 2004). In appendix D summarize possible structure of the European inflation linked bond index.

If it would be considered only developed issuers market then US, UK and Euro zone represent about 84 % of the market in 2010 and about 91 % in 2012, it showing that inflation linked bonds market is increasing in these developed countries also. Despite the increased relatively market share only US, UK and Germany increased government debt based on inflation linked bonds.

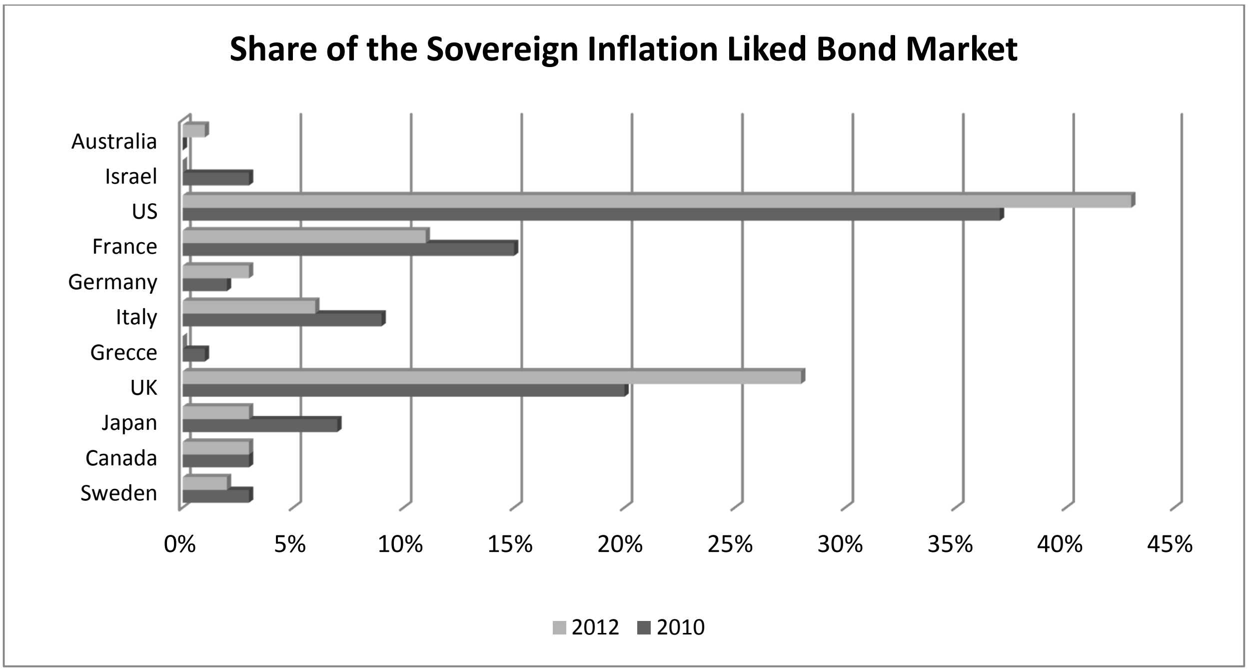


Figure 6. Inflation Linked Bond Market Structure in the 2010 and 2012. Sources: A. Giampaolo, E. Haines, 2010; Norges Bank. 2012 b.

2.3.2. Inflation Linked Swaps

In the 1990s markets trading inflation linked derivatives began to develop. Today, investment banks offer inflation linked derivatives linked to consumer price indices in the United Kingdom, the United States, the Euro area and Japan. The inflation-indexed swap market is a second big market for inflation-linked derivatives. For example, quotes on Euro Area and US CPI linked zero-coupon inflation swaps have been available from Bloomberg since 2004 (A. A. T. Andersen, 2011).

A swap is an agreement between two counter parties to exchange cash flows. An inflation swap involves transfer inflation risk from one party to another. An inflation swap is a derivative transaction in which one party agrees to swap fixed payments for floating payments tied to the inflation rate or inflation protected security, for a given notional amount and period of time

(M. Hinnerich, 2008; M. J. Fleming et al., 2012). For example buyer might therefore agree to pay a per annum rate of 1,9 % (as average forecast of the ECB for four years horizon) on a €18 million notional amount for 4 years in order to receive the rate of inflation for that same time period and amount, because buyer have higher expectations for inflation.

Inflation swaps have become increasingly popular since the turn of the century as financial institutions recognized the need for inflation-linked assets that match future liabilities (K. Kurt, 2011). Inflation linked swaps provide a cost-effective strategy to transform short-term nominal debt into synthetically long-term inflation indexed debt and match the duration of the financial investor's portfolio (A. Malvaez, 2005). Inflation linked products may also be used for risk diversification. Entities with obligations exposed to inflation, such as insurance companies, can hedge that risk by agreeing to receive inflation (M. J. Fleming et al., 2012). Also several researches (J. G. Haubrich et al., 2011; M. Bulletin, 2011) pointed that derivative security known as inflation swaps is the most liquid inflation derivative contracts that trade in the over-the-counter market. (Andersen A. A. T. 2011) pointed that typically inflation swaps require less capital to hold, than inflation linked bonds, making these contracts less prone to marked distortions. And the fourth advantage of the inflation linked swaps is that they are less influenced by the HICP seasonality than break-even inflation rates derived by inflation linked bonds, and are therefore more suitable for monitoring inflation expectation at short and medium horizon (M. Bulletin, 2011).

Several recent studies (M. J. Fleming et al., 2012; M. Bulletin, 2011) have noted that the inflation rate inferred from inflation swaps tends to be higher than that inferred from inflation linked bond; some of these summarized that inflation swap was undervalued during the financial crisis.

The main disadvantage of participating in an inflation swap is the risk that inflation rates may change drastically as a result of unexpected shifts in the global economy. Such changes can expose parties to loss of profit or negative equity. Also its need to be considered that the inflation linked bonds are have only recently been developed, there is little empirical evidence on the factors influencing inflation-linked swaps (M. Bulletin, M. 2011).

M. Deacon et al. (2004) pointed four categories for the inflation-indexed swap markets according to financial market development:

Category I: In this market there is no tradable market instruments linked to the index of interest. For example in the Spain inflation swap market. Swap prices are made on the basis of matched trades, supply and demand and/or taking of basis risk by using instruments from other markets as hedges (category II or III).

Category II: These markets are those with one or more tradable market instruments, typically sovereign inflation linked bonds, for example the Euro zone or the domestic French inflation swaps market. However, due to scarcity of maturities of interest, supply and demand on ILBs still drives investors to swap markets (A. Malvaez, 2005).

Category III: These markets have many tradable market instruments and so a near complete and near arbitrage free inflation or real swap curve can be constructed. In such cases swap reset risks, repo costs and convexity issues are the dominant factors that determine the swap rates relative to the more liquid securities along the yield curve. The UK Retail Price Index (RPI) swap market falls into in his category fall UK (RPI) and US (CPI) swap markets.

Category IV: This level is currently future approach because all the markets mentioned before would fall into one the category. This market would reach a level of maturity, liquidity and stability analogous to the major nominal interest rate swaps markets, such that inflation-indexed swaps trade into their own right but side-by-side with the inflation-indexed bonds.

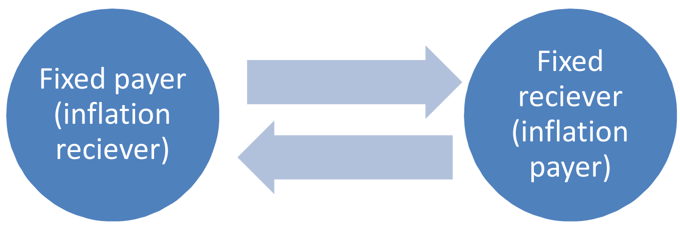
Indeed, the Euro area is currently likely to be the most developed market for inflation-linked swaps in the world, which makes its information particularly suitable for monitoring developments in inflation expectations, most notably for short and medium-term horizons (M. Bulletin, 2011).

The fast growing derivatives marked has broadened the range of different kind of products and opportunities. In this master thesis it will be considered two main types of inflation linked swaps, the zero coupon IIS (ZCIIS) and the year-on-year IIS (YYIIS) (S. Waldenberger, 2011), they will be explained in the follow text.

Zero Coupon Inflation Indexed Swap

In a ZCIIS one party pays a fixed interest rate and receives the inflation rate over the specified time period. The inflation rate is calculated as the percentage return of the consumer price index. The other party of the swap receives the same flows but of opposite signs.

$$Notional \times \left[(1 + swap\ rate)^{tenor} - 1\right]$$



$$Notional \times \left(\frac{Inflation\ index\ at\ maturity}{inflation\ index\ at\ start} - 1\right)$$

Figure 7. Zero-Coupon Inflation Swaps Cash Flows (the figure shows the cash flows exchanged at maturity by the swap counterparties). Source: M. J. Fleming et al., 2012.

As the name indicates, a ZCIIS has only one time interval [t, T] with payments at time T and no intermediary payments [K]. That is, cash flows are exchanged only once. ZCIIS quotes offer a term structure of the expected (risk adjusted) future inflation, also known as swap break-even inflation rates. (M. Hinnerich, 2008).

Reducing the mismatch to the profile of the swap and the uplifted bond cash flows may be desirable to reduce the distortion to spreads (Barclays Capital, 2005). The issuers see a potential advantage in moving towards structures that involve accreting notional on the swap side. Clearly the accretion cannot be variable, with inflation for instance. A potential solution is to price the asset swap given a fixed accretion of the notional of the swap at a rate in line with a market implied breakeven inflation rate, the best-guess rate of inflation.

A swap of any given tenor traded at the start of a month is a subtly different commodity from a swap of the same tenor towards the end of the month, and with the frequency of trading still relatively low and largely on full year tenors only, this can add unwanted complication to risk management by dealers. With a monthly fixed value the risk of a trade done early in the month can be exactly offset by an opposite trade later in the month, with no residual risk. If the need to hedge across month end arises, quotes on the previous month's basis are usually readily available. As trade frequency grows this advantage of the fixed monthly value will decline.

ZCIIS pricing formula (Waldenberger, S. 2011; A. A. T. Andersen, 2011):

$$ZCIIS_T(t,T,K) = \left(\frac{I(T)}{I(T)} - 1\right) - \left((1+K)^{T-t} - 1\right) = \frac{I(T)}{I(t)} - (1+K)^{T-t}$$

They are quoted with maturities ranging from 1 to 30 years. In addition, inflation swaps serve as the basic building blocks for the pricing of the majority of other inflation-related derivatives (J. Haubrich et al., 2008).

Considering only interest and inflation risk this is a clear arbitrage-opportunity. There exist several reasons causing those differences between ILBS and ZCIIS. Some of them are (S. Waldenberger, 2011):

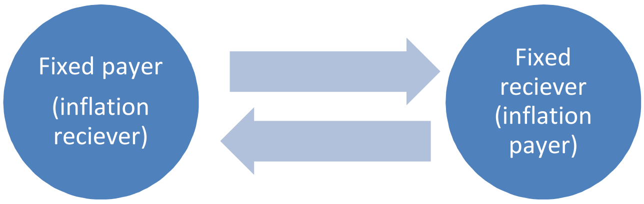
- Differences in liquidity for the underlying financial instruments,
- ILBs contain higher credit risk,
- Systemic risk,
- Asset purchases by central banks.

The swap itself consists of a series of zero-coupon swaps, because the most regularly traded structure in the inflation-linked swaps market, and particularly in the interdealer market, is the zero coupon inflation swap (Barclays Capital, 2005). Other traded inflation derivatives include caps, floors, and straddles, which are usually priced against year-on- year swaps.

Year-on-Year Inflation Indexed Swaps

In a year-on-year (yoy) inflation-linked swap, inflation is used on an annual basis rather than a cumulative one. This structure is suitable for investors seeking to protect cash flow. In an inflation-linked income swap two cash flows are exchanged, each of which follows the inflation index. One party pays a fixed inflation increase annually over the period of the contract. The other party pays the actual inflation over the period of the contract (M. Hinnerich, 2008):

$$Notional \times Fixed\ rate$$



$$Notional \times \left(\frac{Inflation\ index\ at\ maturity}{inflation\ index\ at\ start} - 1\right)$$

Figure 8. Year on Year Inflation Swaps Cash Flows. Source: Barclays Capital. 2005

In Europe (Barclays Capital, 2005), for example, the year-on-year (yoy) structure has traded frequently, and was more prevalent than the zero structure in the early days of the euro market. The year-on-year structure involves one counterparty agreeing to receive an annual coupon determined by the yoy rate of inflation in return for paying a fixed rate. The fixed rate is the quoted rate, and is analogous to a breakeven inflation, although not in as pure a sense as the zero swap's breakeven. The yearly inflation period lags the payment dates in a similar way to the zero structure. Sometimes the non-inflation leg of the swap will be a floating Libor with a spread rather than a fixed rate, in which case the spread is quoted.

In the US (Barclays Capital, 2005), yoy inflation swaps tend to be quoted in the monthly cash flow format, whereas in Europe the cash flow frequency will tend to be annual. Although not quoted nearly as much on dealer screens as the zero coupon structure, indicative yoy rates are easily derivable from the zeros in the same way as is true for coupon interest rates from zero coupon interest rates.

Year on year elements regularly feature in structured inflation products, often in the inflation-plus-X format, and sometimes with a nominal first coupon. It is for the direct hedging of these structures that the yoy swap is most frequently employed. For those structures with a nominal first coupon the appropriate hedge is the forward starting swap. The floating leg of a yoy inflation swap is equivalent to a collection of consecutive forward inflation rates, and therefore the yoy structure can be useful for hedging inflation caps and floors, either standalone, or as features within structured products. The development of the swap markets and caps and floors markets will go hand in hand with each other and could be enhanced by the existence of a monthly yoy style inflation futures contract rather than the quarterly annualized Eurodollar style contracts as it was presented in the US.

2.4. Break-even Inflation Structure

The relationship between inflation and investment returns is of concern to investors and is the subject of a long line of research. The yield spread between nominal and inflation linked bonds, commonly referred to as the break-even inflation rate (BEIR) has become of the most important indicators of inflation expectations (J. A. Garcia, T. Werner, 2010; M. Bulletin, 2011). The concept of break-even inflation can be derived from the following variant of the Fisher equation for a nominal and an inflation linked security of the same maturity (A. Malvaez, 2005; J. A. Garcia, A. A. Van Rixtel, 2007; S. Waldenberger, 2011; Norges Bank. 2012 a.).

$$1 + i = (1 + r) \times (1 + \pi_{BEI}) \tag{12}$$

The nominal gross yield (1+i) of a conventional bond is the product of the real yields (1+π) (here could be on of inflation linked bond) and break-even inflation (I - r) (in the original equation this is expected inflation). This is not to be understood as an exact equation but as an economic principal and in reality this is a somewhat simplified description, since the break-even rate consists of more than just expected inflation (S. Waldenberger, 2011).

BEI reflect the overall inflation compensation requested to hold nominal bonds, comprising both the expected level of inflation and the premium to compensate for inflations risks (A. A. T. Andersen, 2011; J. A. Garcia, T. Werner, 2010).

The break-even rate and the inflation risk premium are two very important concepts in inflation markets (S. Waldenberger, 2011). The difference between nominal and real yields is influenced by (S. Waldenberger, 2011):

- Different liquidity premiums,
- Deflation protection premiums for ILBs,
- Different risk premiums for interest risk (since there are differences in duration for similar real and nominal bonds).

According to P. Hördahl and O. Tristani (2007) break-even inflation is decomposed into four main factors: expected inflation, inflation risk premium, liquidity premium and technical factors.

Removing all such influence it would be observed a quantity which is call the inflation premium. Still this cannot be interpreted as inflation risk premium since it still includes an expected inflation. Thus it will be summarized in a diagram as seen in figure 9.

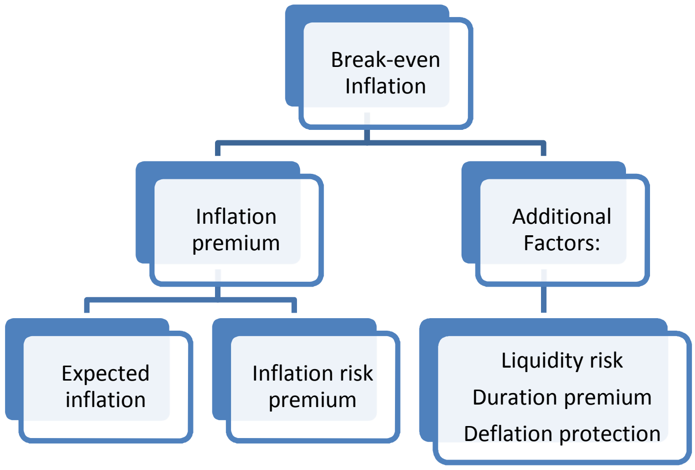


Figure 9. Break-even Inflation Structure. Sources: S. Waldenberger, 2011; J. Garayo, J. Falk, 2012.

The question of how to estimate the above quantities has also been extensively treated in financial research, especially by central banks. Recently a number of papers have tried to estimate inflation risk premium using various methodologies (J. Haubrich et al., 2008; P. Hördahl, O. Tristani, 2007; J. A. Garcia, T. Werner, 2010; G. And W. Bekaert, S. Xiaozheng, 2010; A. A. T. Andersen, 2011; Y. Thambiah, N. Foscari, 2011) overall only a few of them agree on the size of inflation risk premium.

In the context of inflation expectation and inflation risk premium most of research are based on inflation linked bonds and only a few authors (P. Hördahl, O. Tristani, 2007; J. Haubrich et al., 2008; A. A. T. Andersen, 2011) are estimating inflation swaps. A. A. T. Andersen (2011) is argue this choice with advantage of the inflation swap rates, that they can be included directly into estimation, making use of the data less prone to errors from interpretation. The research of UK (M. Bulletin, 2011) inflation-linked swaps, as with all market based indicators of inflation expectations, may include an inflation risk premium component to compensate investors for the risks surrounding inflation expectations over the forecast horizon.

Some of authors (G. And W. Bekaert, S. Xiaozheng, 2010) summarized that Inflation linked securities could rice the “utility” of the investors. For the financial investors (insurance companies, banks), who typically use mean variance optimization do determine strategic asset allocation, Inflation linked securities should increase Sharpe rate (typically referred to as risk rate).

J. Y. Campbell et al. (2009) examine that at the period of the collapse of Lehman Brothers (and 2008), the spread between inflation swaps and BEI from inflation linked bonds, widened due the financial crisis and liquidity effects.

Also it is important to indicate the difference between US area market and Euro area market. In the term of US market, TIPS (inflation linked bonds) are still by the far the most traded product (A. A. T. Andersen, 2011). In the term of swaps linked to the Euro area HICP have develop into a fairly liquid market.

To sum up theoretical part I could say that cash flows linked to a pan-European index should serve better, although in the long run, if inflation within each of the member states converges as economic theory might suggest, this might be less of an issue. But there is clearly a risk that the ”long run” may be beyond the investor's horizon and that realized cash flows linked to a pan-European CPI do not adequately match the inflation experienced by the investor in their home country.

Some of authors (G. And W. Bekaert, S. Xiaozheng, 2010) summarized that Inflation linked securities could rice the "utility" of the investors. For the financial investors (insurance companies, banks), who typically use mean variance optimization do determine strategic asset allocation, Inflation linked securities should increase Sharpe rate (typically referred to as risk rate).

The inflation swaps advantages versus ILBs: ISS require less capital to hold, making these contracts less prone to marked distortions; they are less influenced by the HICP seasonality, and are therefore more suitable for monitoring inflation; they offer a wider range of maturities.

Indeed, the Euro area is most developed market for IIS in the world, which makes its information particularly suitable for monitoring developments in inflation expectations.

In practice, the model (tool) developed in this work is going to be used for the inflation risk management and hedging analysis. The derivatives (swaps) are going to be valued individually as well as a part of the structured and trading portfolio of the insurance company.

3. ANALYSIS OF THE INFLATION HEDGING STRATEGY IN THE CASE OF EUROPE

The average of the annual rate of European HICP inflation computed over the period from January 2002 to each of the subsequent months has hovered within a rather narrow band around 2 % (Figure 10.). This measure reflects how closely inflation average was in the line with the price stability objective during Monetary Union.

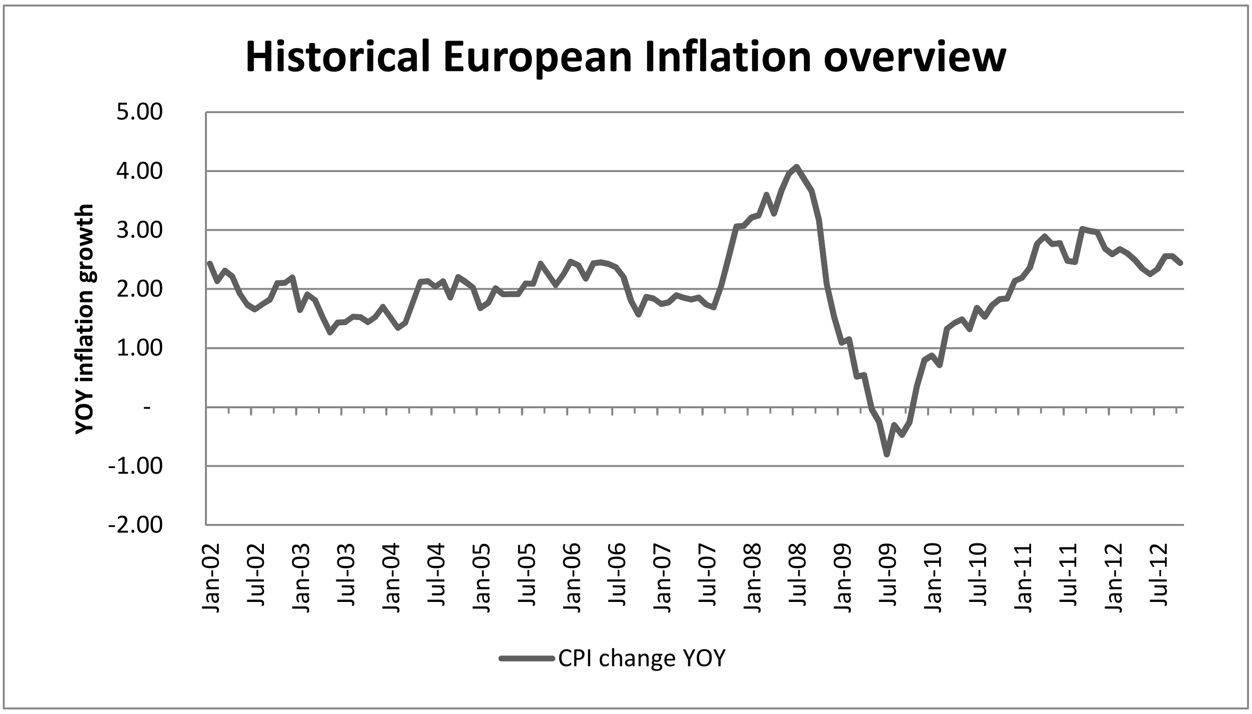


Figure 10. The Historical Inflation Review. Source: prepared by authors based on the Bloomberg data from January 2002 till October 2012.

But in the case of last two years (2010-2012) inflation average is about 2.5 %. How ECB (M. Bulletin, 2012) is investigating this situation they explaining this European inflation volatility (in the period 2007-2012) by strong movements, reflecting in particular the impact of commodity price on the energy and food components of CPI index. And in ECB forecast (ECB, 2012) for 2013 they give really wide range between 1.3 % and 2.5 % for projected annual European inflation rate.

This fact explaining investors concerns about possible inflation growth trend in future with rising question of inflation hedging demand. To support weak economies almost all developed countries applied unconventional monetary policies with significant stimulates packages and injections of liquidity into money markets. The resulting exceptional rise in government deficits and huge debt levels are a looming problem for the many European countries, while the recent oil price are back to high level and macroeconomic volatility are adding further pressure to the ongoing debate.

Consequently, there is increased attention from the insurance industry. Inflation affects investment returns, asset valuation and futures liabilities. These renewed concerns about inflation naturally suggest the question of inflation hedging, with demand to reconsider insurers' asset allocation. Insurers are looking for possibility how to built the portfolio that would shield them effectively from inflation risk and generate excess return.

3.1. Inflation Relationship between different Countries Inflation

Inflation derivatives market has evolved so rapidly that, by mid-2003, turnover in some markets has become a significant proportion of that in the underlying bond markets. As is the case with all derivatives, inflation derivatives are designed to help ‘‘plug the gaps’’ in the market for the underlying securities.

In general, derivative contracts are designed to meet more precisely a particular investor's or issuer's demands. For example, consider the situation in the Euro-zone where – as of mid-2003 – liquid inflation-linked bond markets are limited to those based on one of just two inflation indices: a domestic French inflation index or pan-European index (J. A. Garcia, T. Werner, 2010). This is all very well for French investors, for whom protection against unexpected changes in domestic French inflation would seem to be a valuable characteristic. For other EMU countries to receive cash flows linked to the price index of another country – albeit one with the same currency – would seem suboptimal to say the least. Cash flows linked to a pan-European index should serve better, although in the long run, if inflation within each of the member states converges as economic theory might suggest, this might be less of an issue. But there is clearly a risk that the ‘‘long run’’ may be beyond the investor's horizon and that realised cash flows linked to a pan-European CPI do not adequately match the inflation experienced by the investor in their home country. This is an example of where the derivatives market can play an important part, by developing contracts to meet the investor's precise need.

Table 3. could help to understand relationships between different countries CPI and deeper Europe countries CPI correlation analysis is in appendix E.

Table 3. The Correlation Coefficients between different Countries CPI Indices

Correlation	European HICP	Germany	France	UK	Poland	US
Austria	**0,86**	**0,89**	0,78	0,56	0,39	0,75
Belgium	**0,87**	**0,84**	**0,82**	0,58	0,32	0,71
Finland	0,50	0,49	0,37	0,59	0,49	0,24
France	**0,93**	0,79	**1,00**	0,28	0,10	0,78
Germany	**0,90**	**1,00**	0,79	0,40	0,32	**0,82**
Italy	**0,88**	0,69	**0,85**	0,28	0,09	0,64
Netherlands	0,45	0,28	0,25	-0,20	0,32	0,19
Spain	**0,87**	0,71	**0,82**	0,02	-0,10	**0,81**
Estonia	0,78	**0,83**	0,65	0,35	0,36	0,63
Denmark	0,71	0,58	0,62	0,52	0,20	0,50
Lithuania	0,35	0,54	0,27	0,55	0,33	0,27
Latvia	0,50	0,62	0,45	0,23	0,11	0,45
UK	0,28	0,40	0,28	**1,00**	0,19	0,24
Poland	0,18	0,32	0,10	0,19	**1,00**	0,10
Norway	0,19	0,09	0,15	0,17	0,21	0,21
Switzerland	0,63	0,56	0,63	0,06	0,10	0,71
Russia	0,18	0,03	0,05	-0,51	0,32	0,07
Turkey	0,16	-0,05	0,05	-0,50	0,11	-0,06

Source: prepared by authors based on the Bloomberg data from December 2000 till July 2012.

Insurer liabilities could be hedge by the European Inflation linked bonds in the case of countries inflation relationship with the European HICP as of Austria, Belgium France, Germany Italy and Spain. Insurer liabilities could be hedge by the France Inflation linked bonds only in the case that he has liabilities in the France, Belgium, Italy and Spain, because these country inflation have high correlation with France CPI. If insurer gave business in the countries as Germany, Austria, Belgium and Estonia he could add German Inflation linked bonds in them asset allocation.

Poland CPI inflation linked bonds could look as good solution for emerging market countries (as Lithuania and Latvia), but this analysis shows that Polish inflation are low correlated with other Europe countries. It is mean that Poland CPI inflation linked bonds could not be used as inflation hedge instrument in other countries.

This above table explains way it would be astray to buy other country inflation hedge, for example if investor (insurance company) would responsible for paying Netherlands inflation and receiving return of European inflation. Of course, the above example is oversimplified in order to give a flavor for how derivatives can be used to meet investor or issuer demands that cannot be perfectly accommodated by existing bond markets.

Inflation linked bonds do not represent optimal hedging instruments since:

- There are only a few issuers, most of which governments (largest issuers are UK, Germany, France and Italy) featuring either low yields or significant risk premiums due to credit risks;

- Most of these bonds are illiquid.

For these reasons, in the follow research it was selected to investigate inflation linked swap. Nonetheless their interaction with index-linked bond markets and the valuable information they provide should not be ignored. The two markets complement one another and both look set to grow rapidly together in the future.

3.2. Analysis of Nominal, Real and Inflation Swap Rates

In this section I will describe the data on inflation spar rates and its connection to the nominal swaps. How it was mentioned before a zero-coupon inflation linked swap is a swap agreement where the floating leg pays the percentage change on the reference consumer price index (for the Euro area it is HICP ex tobacco index).

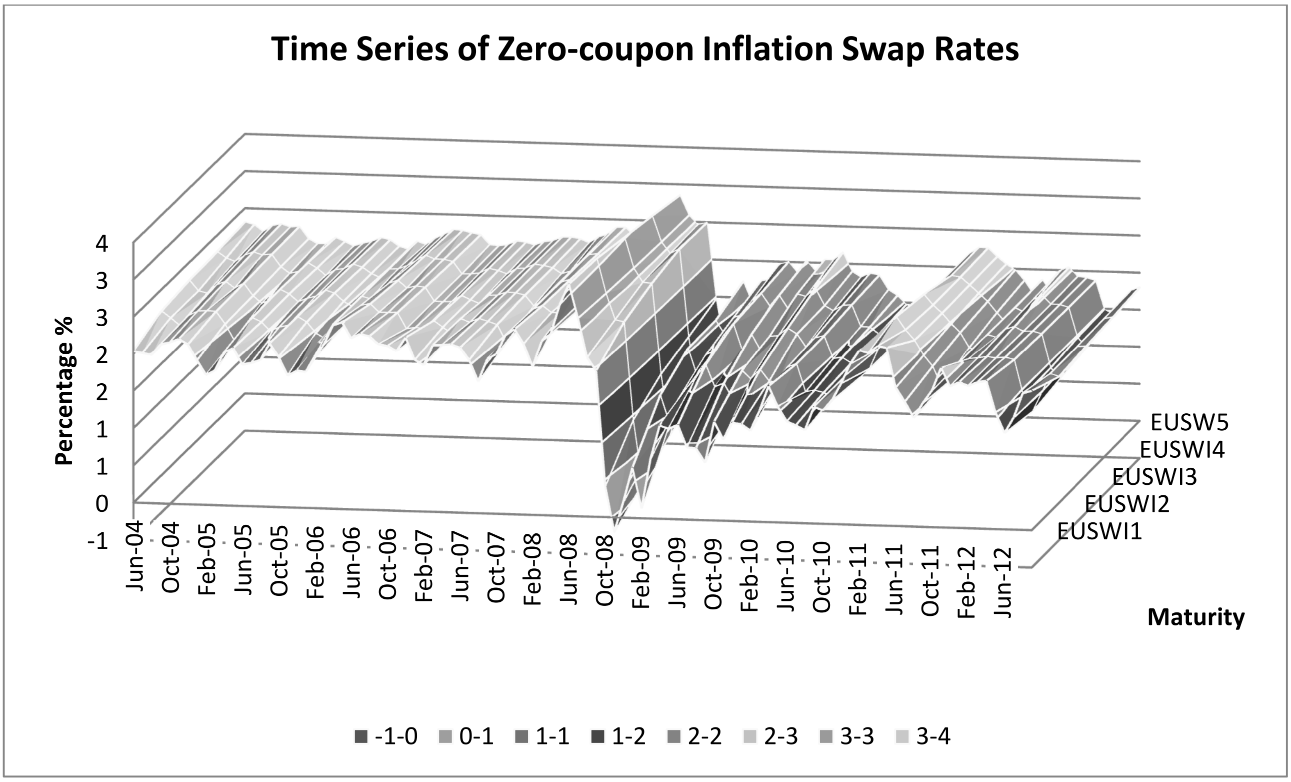


Figure 11. Time Series of the Europe Inflation Swap Rates. Source: prepared by authors based on the Bloomberg data from June 2004 till October 2012.

First I collected monthly data (last price) on zero-coupon inflation swaps on Euro area HICP ex tobacco from June 2004 to October 2012 (it was used Bloomberg source). Figure 10. shows time series of inflation swap rates.

As seen from Figure 11. inflation swap rates saw large drop through 2008, it was consequence of financial crisis (after bankruptcy of Lehman Brothers) and also some of pointed that at mid of 2008 inflation swaps was unevaluated. For same period A. A. T. Andersen (2011) pointed that inflation linked swap rates was suffering less than inflation linked bonds as consequence of swap structure. After 2009 inflation swap rates started to be more volatile than before as reason of volatile economic, floating market expectations.

M. Althof, J. Banet, (2012) in them research pointed difference between Euro area (current negative yields) and US (high positive yields) inflation linked securities in context of difficult economic situation (and possible inflation rising scenarios). Authors summarized the widening credit spreads in Italian inflation linked securities as reason for the negative trend in the European inflation linked securities.

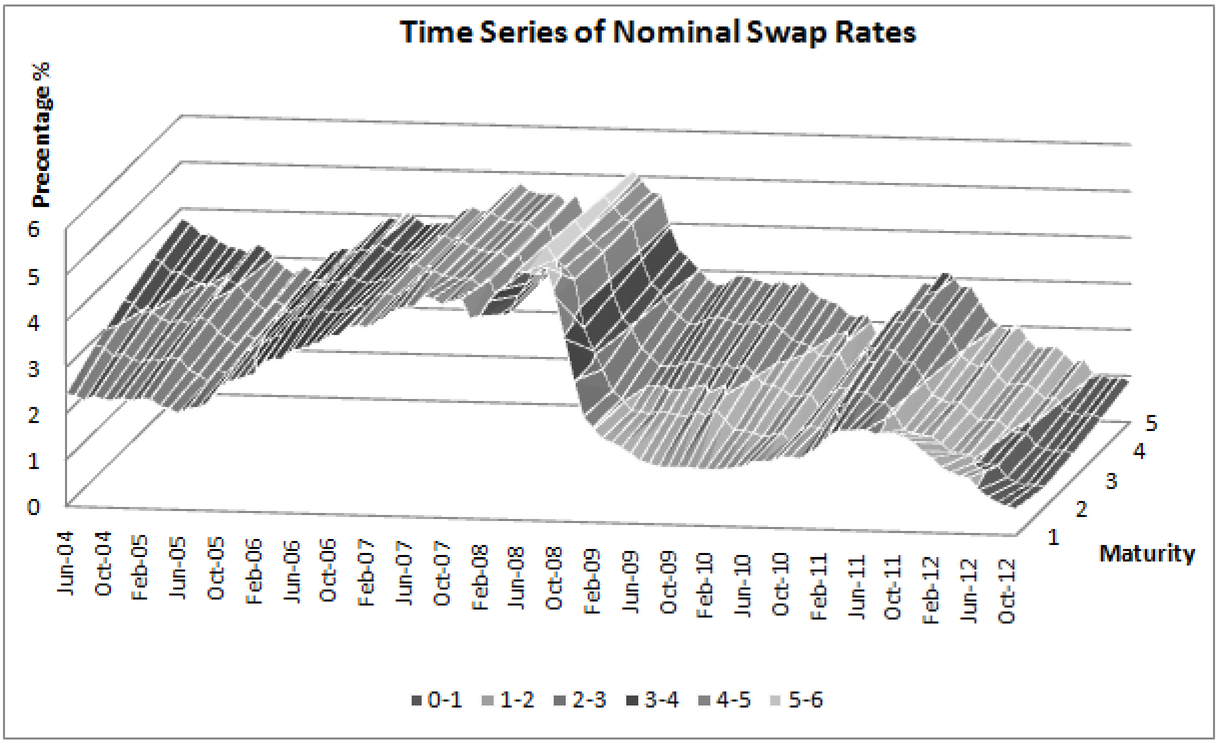


Figure 12. Time Series of the Europe Nominal Swap Rates. Source: prepared by authors based on the Bloomberg data from June 2004 till October 2012.

Second I collected monthly data (last price) on zero-coupon Euro area nominal swap from June 2004 to October 2012 for maturity 1 to 5 years (it was used Bloomberg source). Figure 11. shows time series of nominal swap rates. As seen from Figure 11. nominal swap rates had increasing trend till mid of 2008 and after they show large drop through 2008 as consequence of financial crisis. After 2009 inflation swap rates started to be more stable in range between 1 % and 3%, higher yield period was mid 2011. After mid of 2012 it started low nominal yield period, it would be explained as consequence of the Euro debt crisis.

3.3. Analysis of Nominal and Inflation Swap Returns

My empirical technique imposes model restrictions on both the cross-sectional and time-series properties of nominal swap yields, inflation and inflation swap rates. Given that our data is observed at a monthly frequency, the model's period is taken to be Δt = 1/12th of a year. Similarly, π_t is the rate of inflation expected over the next month, and r_t is the one-month real interest rate.

The inflation swap rates can be derived through nominal and real interest rates. On the other hand this relationship can help to derived real interest rate, as the ex-ante real interest rates, from nominal swap interest rates and inflation swap rates. Also it need to be considered the fact of the inflation swap indexation lag, i.e. that the swap fix to the CPI released 3 month prior to the maturity of the swaps (For Europe and US inflation indices indexation lag is 3 months and for UK 2 months) (M. Hurd, J. Relleen, 2006).

$$\frac{(1+nominal\ ZC\ swap\ yield)}{(1+real\ ZC\ swap\ yield)} = (1 + Inflation\ ZC\ Swap\ yield) \tag{13}$$

With available this data it is possible to calculate inflation swaps returns. With assumption that nominal and real swaps are hold to maturity (maturity = duration), the change in swap price over the considered period would be equal to change in yield over the considered period multiplied by duration.

$$Price = \Delta yield * duration \tag{14}$$

With available nominal (R_N) and real (R_R) swap returns data it was possible derive the inflation swap returns (hold to maturity), it would be calculated based on formula (π is equal to change in CPI index):

$$R_S = (1 + R_n) - (1 + R_R) * (1 + \pi) \tag{15}$$

Note that while these rates correspond to a one-month horizon, I express them in annualized terms (Table 4.) (for calculation in the 2012 it was used only ten months).

Table 4. Annual Historical Inflation Swap Returns

	Euro Inflation Zero Coupon Swap Returns				
	1 year swap	2 year swap	3 year swap	4 year swap	5 year swap
2005	0.21	0.53	0.68	0.96	1.18
2006	- 0.58	- 0.68	- 0.70	- 0.81	- 0.92
2007	- 0.28	- 0.61	- 0.89	- 1.09	- 1.25
2008	2.23	3.76	4.63	4.69	4.67
2009	- 1.09	- 2.18	- 2.86	- 3.07	- 3.30
2010	- 0.64	- 0.17	0.38	1.14	1.88
2011	- 0.12	- 0.47	- 0.74	- 0.99	- 1.21
2012*	0.01	0.37	0.79	1.00	0.92

Source: prepared by author based on Bloomberg data from January 2005 till October 2012.

How we can see from annualized returns this investment asset is profitable only in inflationary period, in case of Euro area it was recognize in these years: 2005, 2008, 2010, 2012. After the 2008 crisis losses in the short maturity swap returns are declining and in the 2012 returns are again positive (also it shows growth in inflation expectation). In the case of 3-5 year swaps market had higher expectations at the 2010 and 2012 and it lead to earn higher returns. While the highly customized and tailored solutions that inflation derivatives provide might be of interest to some, inflation linkers as swap have historically been a relatively expensive hedge with many practical issues that limit their effectiveness (D. Lomelino et al., 2011). Related to this argument is the portfolio diversification view, which studies the mean-variance efficiency of portfolios with and without inflation linked swaps.

Using historical covariance of US inflation securities market, S. P. Kothari and J. Shanken (2004) argued that a substantial weight should be given to inflation linked securities in the efficient portfolios because that inflation linked bonds and derivatives can enhance the return trade-off risk within a diversified. In the follow research I will used portfolio mean-variance analysis based on 2.2.1 section and I will examine asset allocation based on estimates of return variances and correlations.

First I will evaluate the separate possible investments in nominal and Euro inflation Zero Coupon swap to maturity from 1 to 5 years (Table 5.).

Table 5. Historical Analysis of Nominal and Inflation Swap Returns

	1 Y Nom.	2 Y Nom.	3 Y Nom.	4 Y Nom.	5 Y Nom.	1 Y swap	2 Y swap	3 Y swap	4 Y swap	5 Y swap
Average of returns	0.018	0.048	0.079	0.111	0.140	- 0.004	0.005	0.014	0.019	0.022
Standard deviation of returns	0.206	0.433	0.641	0.826	1.001	0.293	0.503	0.685	0.816	0.952
Sharpe ratio	0.088	0.111	0.124	0.134	0.140	- 0.013	0.010	0.020	0.023	0.023

Source: prepared by author based on Bloomberg data from June 2004 till October 2012.

The average on inflation swap returns is slightly lower than that for the corresponding nominal swap returns, 1 year inflation swap returns are even negative. The same maturity nominal and inflation swaps have similar standard deviation.

Table 6. The Covariance Table of Nominal and Inflation Swaps

Maturity	1 Y Nom.	2 Y Nom.	3 Y Nom.	4 Y Nom.	5 Y Nom.	1 Y swap	2 Y swap	3 Y swap	4 Y swap	5 Y swap	CPI
1 Y N.	0.042	0.089	0.132	0.170	0.206	0.060	0.104	0.141	0.168	0.196	0.195
2 Y N.	0.089	0.187	0.278	0.358	0.434	0.127	0.218	0.296	0.353	0.412	0.409
3 Y N.	0.132	0.278	0.411	0.530	0.642	0.188	0.322	0.439	0.523	0.611	0.606
4 Y N.	0.170	0.358	0.530	0.683	0.827	0.242	0.416	0.566	0.674	0.787	0.781
5Y N.	0.206	0.434	0.642	0.827	1.002	0.293	0.504	0.685	0.817	0.953	0.946
1 Y S.	0.060	0.127	0.188	0.242	0.293	0.086	0.147	0.201	0.239	0.279	0.277
2 Y S.	0.104	0.218	0.322	0.416	0.504	0.147	0.253	0.344	0.410	0.479	0.475
3 Y S.	0.141	0.296	0.439	0.566	0.685	0.201	0.344	0.469	0.559	0.652	0.647
4 Y S.	0.168	0.353	0.523	0.674	0.817	0.239	0.410	0.559	0.666	0.777	0.771
5 Y S.	0.196	0.412	0.611	0.787	0.953	0.279	0.479	0.652	0.777	0.907	0.900
CPI	0.195	0.409	0.606	0.781	0.946	0.277	0.475	0.647	0.771	0.900	0.893

Source: prepared by authors based on the separate return results.

Finally, I work with the unconditional covariance matrix of returns here. It is likely that the covariance matrix (Table 6.) changes over time, however, and it may be possible to predict some of these changes in terms of observable variables that can be incorporated into the asset allocation decision.

Table 7. The Correlation Table of Nominal and Inflation Swaps

Maturity	1 Y Nom.	2 Y Nom.	3 Y Nom.	4 Y Nom.	5 Y Nom.	1 Y swap	2 Y swap	3 Y swap	4 Y swap	5 Y swap	CPI
1 Y N.	1										
2 Y N.	0.76	1									
3 Y N.	0.70	0.98	1								
4 Y N.	0.66	0.94	0.99	1							
5 Y N.	0.63	0.90	0.96	0.99	1						
1 Y S.	**0.20**	0.46	0.47	0.47	0.45	1					
2 Y S.	0.19	**0.47**	0.49	0.49	0.49	0.88	1				
3 Y S.	0.19	0.46	**0.48**	0.48	0.48	0.84	0.97	1			
4 Y S.	0.21	0.47	0.49	**0.49**	0.48	0.81	0.94	0.96	1		
5 Y S.	0.20	0.45	0.47	0.47	**0.47**	0.76	0.89	0.94	0.98	1	
CPI	- 0.04	0.10	0.09	0.09	0.09	0.21	0.21	0.19	0.18	0.17	1

Source: prepared by authors.

Table 7. reveals one attractive property of the Euro inflation zero coupon swap returns that they have lower correlation with nominal returns: especially for same maturity it is only 0.20 between 1 year swaps and about 0.48 for maturity from 2 till 5 years.

The relatively low correlation between the two different type investments reflects the differential impact of unanticipated inflation on the nominal and inflation swap returns. Nominal swap prices are, naturally, negatively impacted by unanticipated inflation. Inflation swap prices are only affected insofar as the unanticipated inflation is correlated with changes in real riskless rates, however, since the swap cash flows are hedged against inflation. In this analysis we see low correlation between asset investments and inflation because it was used the monthly changes.

In the research of A. P. Attié and S. K. Roache (2009) the higher correlation between nominal securities and inflation linked securities was explained by the higher volatility of these factors comparing them with the lower inflation volatility in the case of proactive monetary policy, which keens to hold stable inflation.

O. Signori, M. Brière (2010) were investigating inflation hedging portfolios in different regimes and in them research they summarized that correlation level between inflation and inflation linked securities was lower in the stable economical conditions (in the period 1991-2009) than in the volatile economic (1973-1990). Based on this research and obvious evidence of growing instability of Europe area economy I could make assumption that in further inflation correlation relationship will increase with inflation linked securities interest rates and decrease with nominal interest rates.

Using this nominal and inflation swap variance matrix and separated asset average returns and standard deviations (Table 5.) I computed the nominal and inflation swap allocation for the mean-variance optimal portfolio. The efficient frontier of the insurer portfolio without constrain based on insurer liabilities are represent in appendix F. But in this case insurer will suffer duration mismatch. And Markowitz portfolio optimisation expose insurers to an unacceptable degree of risk via putting too much of our total investment into a single asset. To extend this Markowitz portfolio optimisation problem I will add that insurers have a required liability duration limits. I will add assumption that the insurer inflation exposure are distributed like: 1 y. – 45%, 2 y. – 23%, 3 y. – 12%, 4 y. – 7% and 5+ (5 y and more) – 13% (based on practical experience of author in Ergo International). This new efficient frontier is districted in area of the first efficient frontier but with more narrow area, these results are representing appendix F.

Also I am looking for optimal solution portfolio with respect to liabilities structure. I'm reporting the Sharpe ratio value for the optimal portfolio and for portfolios with various nominal and inflation swap weights (appendix G) and to summarize these results I represent Figure 12 and Table 8.

Table 8. Optimal Portfolio Structure based on Appendix F

Investments	1 Y Nom.	2 Y Nom.	3 Y Nom.	4 Y Nom.	5 Y Nom.	1 Y swap	2 Y Swap	3 Y swap	4 Y swap	5 Y swap
Optimal portfolio allocation	45%	23%	12%	0%	0%	0%	0%	0%	7%	13%

Source: prepared by author.

The insurer could choose portfolio, which would be on the efficient frontier curve above the optimal portfolio (with minimized risk) (Figure 13).

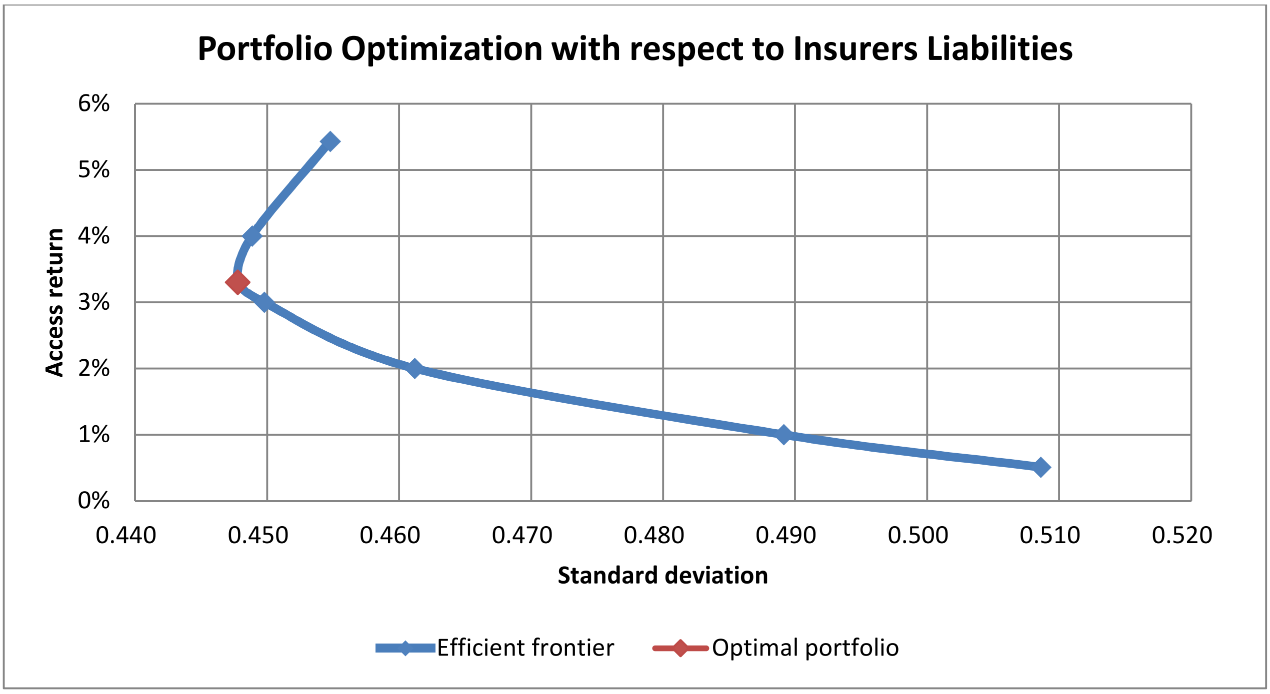


Figure 13. Portfolio Optimization with respect to Liability Distribution of the Insurer. Source: prepared by author based on appendix G.

3.4. Portfolio Inflation Hedging Sensitivity to the Market Trends

In this section I will measure the sensitivity of inflation hedging returns to changes in actual inflation (represented by CPI index) and break-even inflation (represented by inflation swap) over the one-year horizon. Non-life insurance investors tend to focus on return outcomes over the multi-years periods, but many also report their portfolio performance every 12 months. Also insurers yearly change their strategic asset allocation. In this case it would be useful to gain understanding of how actual or expected inflation might impact annual returns over a one-year horizon.

Assumptions and data for analysis of inflation hedging sensitivity to change in CPI and break-even inflation (Table 9.):

- The investment horizon is 1 year;
- The analysis includes nominal and inflation swaps with maturity 1 to 5 years;
- The inflation is represented by the CPTFEMU index, last value - 116.21 - was taken from Bloomberg as of 31.10.2012;
- The break-even inflation is represented by inflation swap rates, them levels were taken from Bloomberg as of 31.10.2012;
- The nominal zero-coupon yields are represented by nominal swap rates, them levels were taken from Bloomberg as of 31.10.2012;
- The analysis assumes that the nominal interest rate will not change;
- The analysis assumes that the insurer inflation exposure are distributed like: 1 y. – 45%, 2 y. – 23%, 3 y. – 12%, 4 y. – 7% and 5+ (5 y and more) – 13% (based on practical experience of author in Ergo International).

Table 9. Primary Nominal and Real yields and Break-even Inflation Rates

Maturity	Beginning Nominal Yields	Beginning Real Yields	Beginning break-even inflation rate (annual rate)	Expected inflation index growth though maturity period
1	0.57%	-1.12%	1.72%	1.72%
2	0.42%	-1.27%	1.72%	3.46%
3	0.53%	-1.18%	1.72%	5.26%
4	0.68%	-1.00%	1.70%	6.98%
5	0.87%	-0.87%	1.76%	9.10%

Source: prepared by authors based on Bloomberg data as of 31.10.2012.

Moreover, there is useful interpretation of break-even inflation in terms of the relative maturity return (and same liability duration structure) of Euro inflation swaps versus nominal swaps under different inflation scenarios, which is summarized in Table 10.

The CPI* is expressed the actual inflation growth comparing with one year before. And the break-even inflation* is expressed in the basic points by the change in swap rate over the one year. Negative values indicate that the hedge will lose money compared to a strategy of leaving inflation exposure unhedged. Positive values illustrate possible scenarios where inflation hedging could be profitable and effective.

If realized inflation turns out to be exactly the same as break-even inflation, swaps will have the same ex-post return as nominal swaps, i.e. they break even with nominal swaps. If realised inflation exceeds break-even inflation, inflation swaps generate a higher return. If realized inflation is lower than break-even inflation, inflation swaps underperform.

Table 10. The Net Gain of Inflation Hedge expressed in Basic Points of Inflation Linked Portfolio Exposure (in one year horizon)

	BEI* / CPI* (%)	Change in break-even inflation (bps)						
		-150	-100	-50	0	50	100	150
Change in CPI index	-1.00%	-439	-383	-326	-269	-210	-151	-90
	-0.75%	-415	-359	-302	-244	-185	-125	-65
	-0.50%	-391	-334	-277	-219	-160	-100	-40
	-0.25%	-367	-310	-253	-194	-135	-75	-15
	0.00%	-342	-286	-228	-170	-110	-50	10
	0.25%	-318	-261	-203	-145	-86	-25	36
	0.50%	-294	-237	-179	-120	-61	-0	61
	0.75%	-269	-212	-154	-96	-36	25	86
	1.00%	-245	-188	-130	-71	-11	50	111
	1.25%	-221	-163	-105	-46	14	75	136
	1.50%	-197	-139	-81	-21	39	100	161
	1.75%	-172	-115	-56	3	64	125	187
	2.00%	-148	-90	-31	28	88	150	212
	2.25%	-124	-66	-7	53	113	175	237
	2.50%	-99	-41	18	78	138	200	262
	2.75%	-75	-17	42	102	163	225	287
	3.00%	-51	8	67	127	188	250	313
	3.25%	-27	32	91	152	213	275	338
	3.50%	-2	56	116	176	238	300	363

Source: prepared by author.

In scenario of stable inflation year on year growth (contract rate 1.6 %) and inflation swap rates (with volatility 0) the inflation hedging would gain only 0.03 % of insurer portfolio value.

In the scenario of stable break-even inflation and lower inflation portfolio would suffer losses, with 1.5 % decrease in actual portfolio would lose 0.21 % of value; with 1% decrease it would lose 0.71 % value, with 0.5% decrease it would lose 1.2 % value. In the scenario of stable break-even inflation and higher inflation as 2 % portfolio would gain 0.28% of value; with 2.5 % increase it would gain 0.78 % value, with 3 % increase it would gain 1.27 % value. Norges Bank (2012 a.) research also argument that if held to maturity inflation linkers are perfect hedge against inflation the scenario that realized inflation exceeds the inflation compensation discounted at the time of purchase. Risk-averse insurers should by same maturity inflation linkers as their liabilities duration with purpose to hedge possible inflation effect in claim costs.

In the scenario with stable inflation but with negative volatile break-even inflation portfolio would suffer losses, with 0.5 % decrease in break-even inflation (inflation expectation) portfolio would lose 0.56 % of value; with 1% decrease it would lose 1.15 % value, with 1.5 % decrease it would lose 1.72 % value. In the scenario with stable inflation but with positive increase in expected inflation: with 0.5 % increase in break-even inflation portfolio would gain 0.63 % of value; with 1% increase it would gain 1.25 % value, with 1.5 % increase it would gain 1.87 % value.

Result of inflation hedging is influenced not only of changes in inflation but also by changes in inflation expectation. Investors are interested to follow spread between nominal and real value of interest rates.

It is difficult to evaluate these scenarios without knowing what the possibility that it can happen is. Figure 14. represents probability distribution of change in BEI based on last 8 years swap indices monthly (year on year change) data. This probability distribution is calculated based on standard deviation of these swap index with different maturity, with assumption that they are normal distributed.

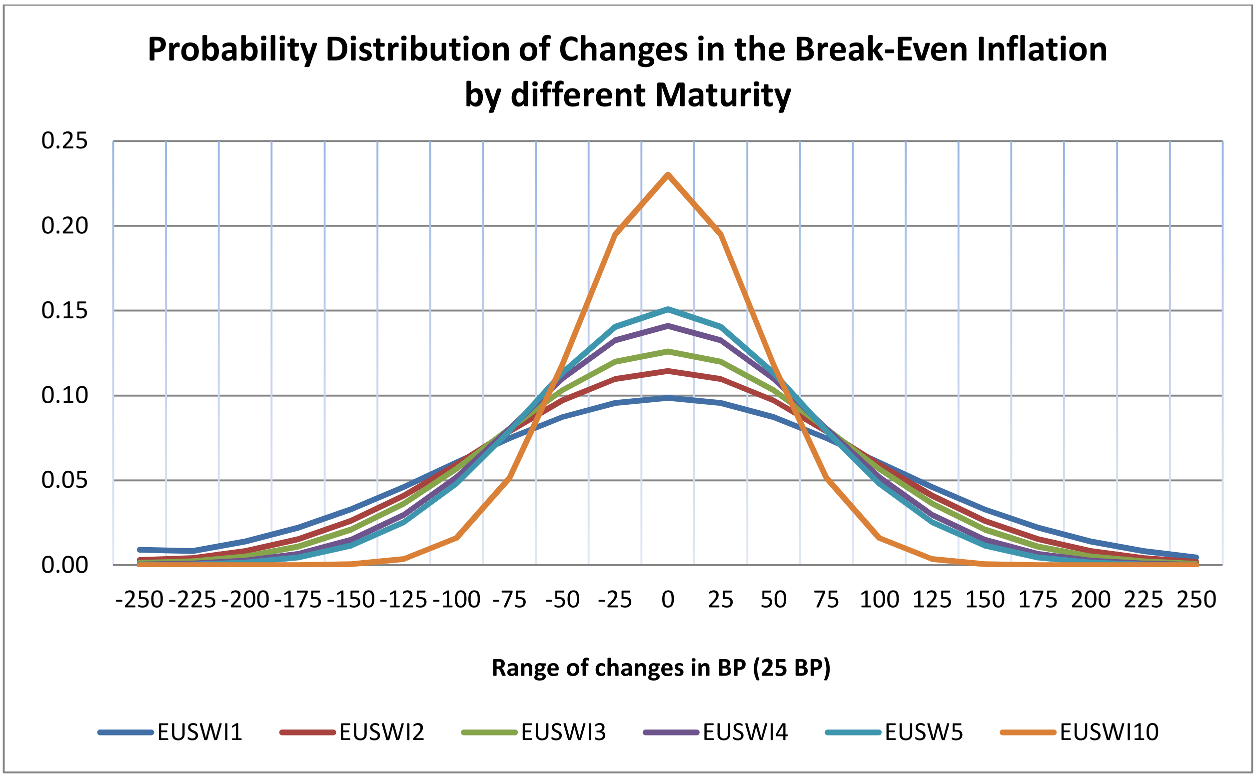


Figure 14. Probability Distribution of the Changes in Break-Even Inflation by different Maturity. Source: prepared by authors.

The shorter maturity swap yields are more volatile (with higher standard deviation) as consequence them probability distribution is more flat. And the 10 y swap yields are less volatile that way probability distribution are steeper.

Figure 15. represents probability distribution of actual inflation growth rate based on last 10 years CPTFEMU (European inflation index year on year change) index monthly data. This probability distribution is based on standard deviation of this index with assumption that they are normal distributed.

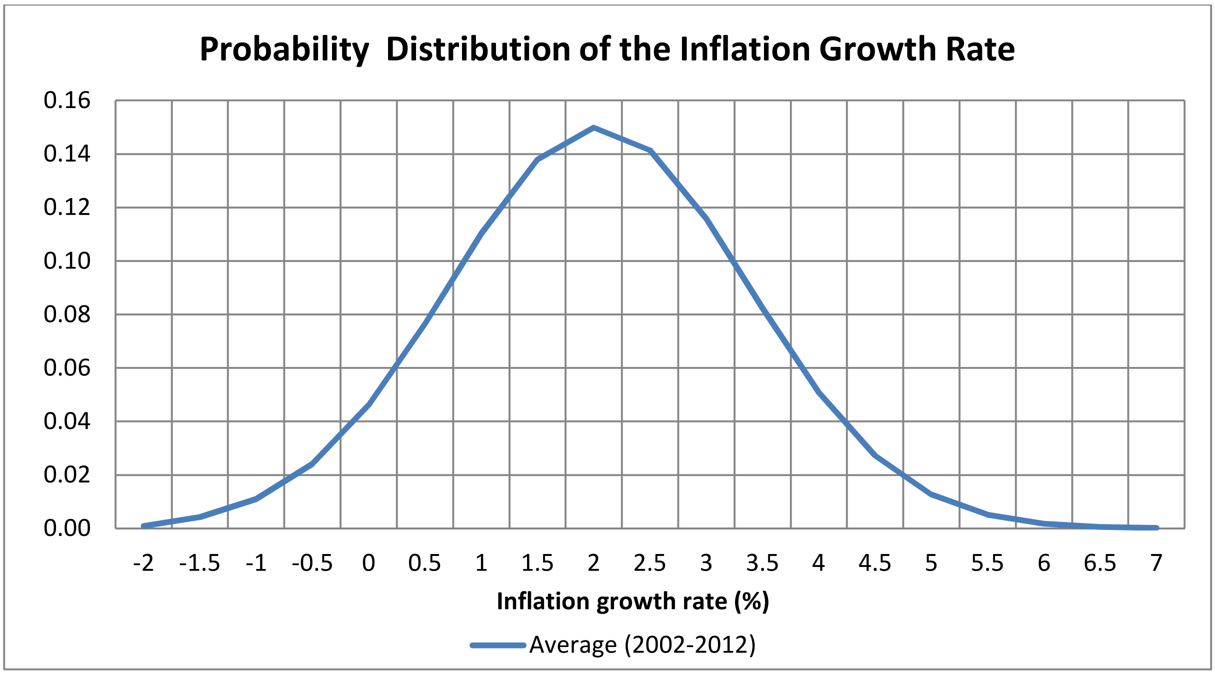


Figure 15. Probability Distribution of the Changes in the actual Inflation. Source: prepared by authors.

But even in ECB forecast (ECB, 2012) for 2013 they give really wide range for projected annual rate between 1.3 % and 2.5 %. And 1 y European inflation swap rates are about 1.7 % as 31.10.2012 and was about 1.87 % as 30.09.2012.

CONCLUSIONS

The risk control which has traditionally been implemented by insurance companies so far, with higher or lower thoroughness in each case, turning on the more specific risk management as example the inflation risk and it could lead to a safer situation in terms of companies' viability.

The inflation risk is a change in value caused by a deviation of the actual market - consistent value of assets and/or liabilities from their expected value, due to inflation, e.g. price inflation, wage inflation.

Insurers in particular identified inflation as one of their top risk management concern because it affects insurers though three basic channels: it impacts claims and general expenses, the value of liabilities and less directly, the value of assets.

Some of analysed authors as K. C. Ahlgrim and S. P. D'Arcy (2012) express concerns about the moist of current insurers (in the US and Euro area), claim staff have never experienced about of severe inflation, so could be slow to adapt to any change in the economic environmental.

Insurance business model typically is broken down into a series of investment and insurance (liability) portfolios. Insurers are seeking to match assets against similar liabilities.

The portfolios' of the non-life insurers are most structured with nominal bond, but in this volatile economic environmental it would be reasonable to cover inflation exposure with the inflation correlated asset classes, like inflation linked bonds, inflation linked derivatives (swaps), equities or commodities. But each of these inflation investment protections presents challenges of choosing hedging strategy.

In the follow research author was investigating inflation hedging strategies with inflation linked securities (inflation linked bonds and swaps) in the case of Europe countries.

The research of the different European countries CPI correlation shows that insurer liabilities could be hedge by the European inflation linked bonds (ILBs) in the case of Austria, Belgium France, Germany Italy and Spain; by the France ILBs in the case of France, Belgium, Italy and Spain; by the German ILBs in the case of Germany, Austria, Belgium and Estonia.

Polish CPI ILBs only look as good solution for emerging market countries (as Lithuania or Latvia), but analysis shows that Polish CPI are low correlated with the other Europe countries. It is mean that these ILBs could not be used as inflation hedge instrument in other countries.

Inflation linked bonds do not represent optimal hedging instruments since are only a few issuers featuring either low yields or significant risk premiums due to credit risks; most of these bonds are illiquid and reasonable allocation are only for the core Europe economies.

The inflation swaps advantages versus inflation liked bonds: IIS require less capital to hold, making these contracts less prone to marked distortions; they are less influenced by the HICP seasonality, and are therefore more suitable for monitoring inflation; they offer a wider range of maturities.

Indeed, the Euro area is most developed market for inflation swaps in the world, which makes its information particularly suitable for monitoring developments in inflation expectations.

The European inflation swap annualized returns were profitable only in inflationary periods as these years: 2005, 2008, 2010, 2012.

The research reveals one attractive property of the Euro inflation zero coupon swap returns that they have lower correlation with nominal returns: especially for the same maturity.

Using nominal and inflation swap returns variance matrix and separated asset average returns and standard deviations author computed the nominal and inflation swap allocation for the mean-variance optimal portfolio (appendix F). It was made analysis without and with constrains to insurer liabilities duration structure. Constrains to the liability duration structure would help avoided duration mismatch.

The insurer could choose portfolio, which would be on the efficient frontier curve above the optimal portfolio (with minimized risk).

In the research based on current market data (as 31.10.2012) and assumption (insurer's liability distribution) it was derived with measure of the portfolio value sensitivity to changes in actual inflation and break even inflation (represented inflation swaps) in them of full inflation hedging (inflation versus nominal swaps). This tool leads insurers to understand possible inflation hedging consequence in different market scenarios (with updating data it is possible to have straightforward estimation):

- with stable inflation growth (contract rate 1.6 %) and inflation swap rates (with volatility 0) the inflation hedging would gain only 0.03 % of insurer portfolio value;
- with stable break-even inflation and lower inflation, or stable inflation but negative volatile break-even inflation portfolio would suffer losses;
- with stable break-even inflation and higher inflation or stable inflation but positive volatile break even inflation portfolio would gain.

Result of inflation hedging is influenced not only of changes in inflation but also by changes in inflation expectation.

Author would propose to use the inflation liked bonds only after individual analysis of the insurer liabilities relationship with the selected market inflation (CPI).

Insurer must to be careful, because inflation linked securities may be undermined two risks: the reference index may not accurately reflect the true liabilities cost; changes to the way the reference index is computed may put investors at a disadvantage.

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APPENDICES

Appendix A

Definitions of the insurance faced risks

CLASSIFICATION OF RISKS	SOLVENCY II CLASSIFICATION II				
	Insurance	Market	Credit	Liquidity	Operational
Deviation risk: It concerns statistical deviations of risks, such as changes in mortality rates, morbidity rates, improvements in life expectancy, crime, increase in prices and salaries, decrease of interest rates, etc.	X				
Insufficient premium risk: It represents the risk of the premiums collected turning out to be very low. This type of risk may present overlapping, since it may be classified as deviation risk when the premium is insufficient despite having performed a careful and responsible assessment with all the information available.	X				
Technical reserve assessment risk: It is used when there is an incorrect assessment of risks and, therefore, the technical reserves are insufficient to cover the obligations resulting from insurance contracts.	X				
Reinsurance risk: It is the bankruptcy or insolvency risk of reinsurers or of the bad quality thereof. It may also be classified with the non-technical ones.			X		
Operating expenses risk: It concerns the risk when the amount of operating expenses included in the premium is insufficient to cover them in the future.					X
Major losses risk (major risks): It appears only in nonlife insurance and it reflects the potential risk that an insurance company may be exposed to higher risks in number or size.	X				
Accumulation or catastrophic risk: It describes the risk of accumulation of losses caused by a single event (earthquake, storm, etc.).	X				
Growth risk: It is associated to the technical consequences derived from excessive or uncoordinated growth.	X				
Depreciation risk: It describes the risk of loss in value of an investment due to changes in the capital markets, in the exchange rate (for obligations in foreign currencies) and incompliance due to bankruptcy of creditors.		X			

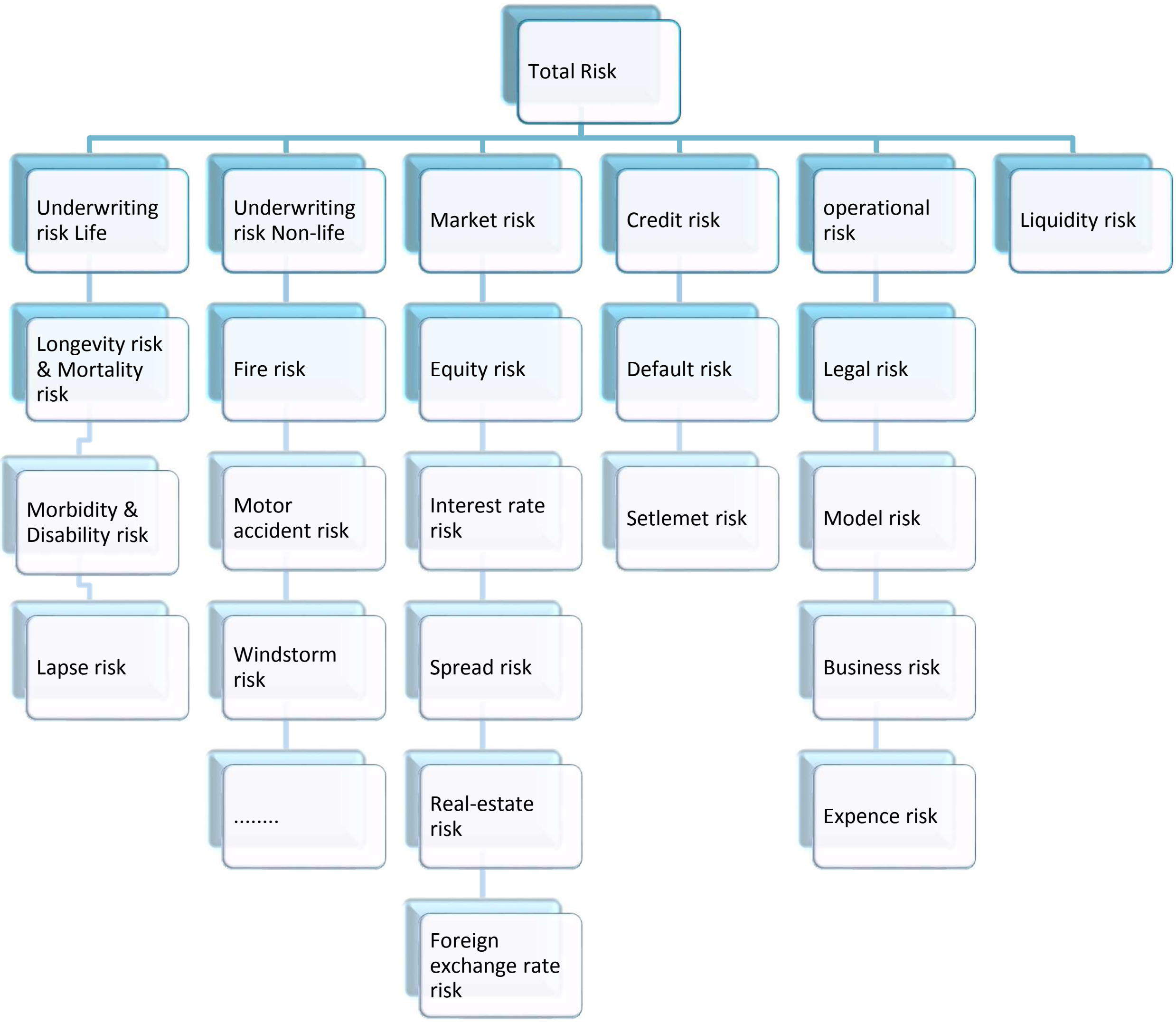
Sequel in the follow page

Sequel					
CLASSIFICATION OF RISKS	SOLVENCY II CLASSIFICATION II				
	Insurance	Market	Credit	Liquidity	Operational
Mismatching or reinvestment risk: It is used when the assets of an insurance company, in terms of maturity and interest rate, do not cover the technical reserves in the same terms. = ALM RISK				X	
Market risk: It is the risk run by the financial situation of an insurance company as a result of the adverse movements in the market prices of the value of the assets comprising the portfolio of an insurance company, regardless of the nature of its liabilities.		X			
Credit risk: It occurs when the counterpart of a financial transaction does not fulfill the obligation it has before the insurance company.			X		
Investment assessment risk: Related to investments, it describes the risk that an investment be incorrectly assessed.		X			
Third-party account risk: It describes the risk that third parties external to the insurance company may not fulfil their obligations, either under the reinsurance, coinsurance or intermediation contract schemes.			X		
General business risk: It concerns the consequences that the modifications of the general legal, economic and social conditions have over the general situation of the company.					X
Operational risk: It concerns the risk of generating losses derived from failures or lack of adequacy of internal processes, people, systems or external events.					X
Spread risk: A change in value due to a deviation of the actual market price of credit risk from the expected price of credit risk.		X			
Lapse risk: A change in value caused by deviations from the actual rate of policy lapses from their expected rates.	X				
Morbidity risk A change of value caused by the actual disability and illness rates of the persons insured deviating from the ones expected. **Mortality risk**. A change in value caused by the actual mortality rate being higher than the one expected.	X				

Source: P. Hördahl, O. Tristani, 2007

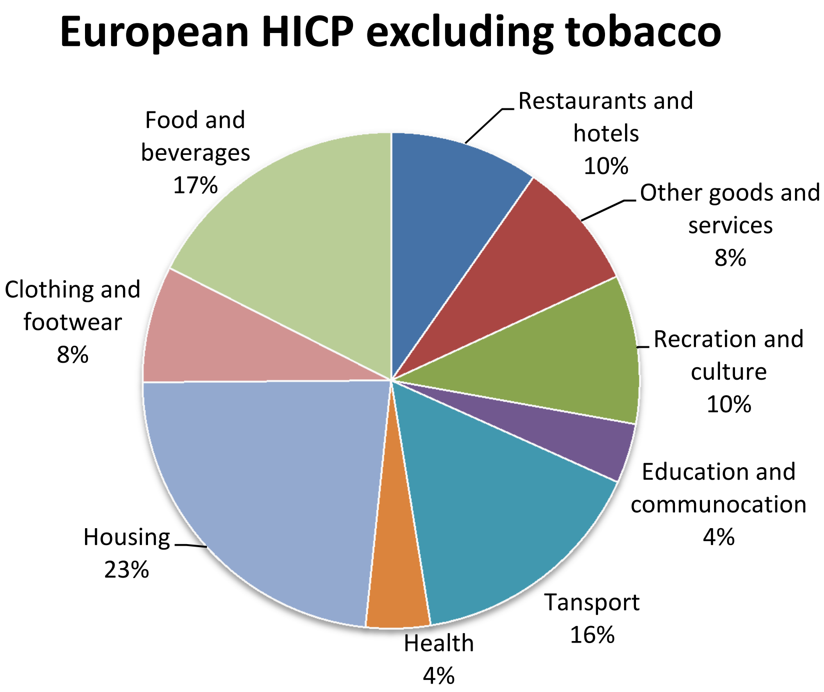
Appendix B

Risk mapping based on Solvency II approach



Source: European Insurance and Reinsurance Federation, 2007.

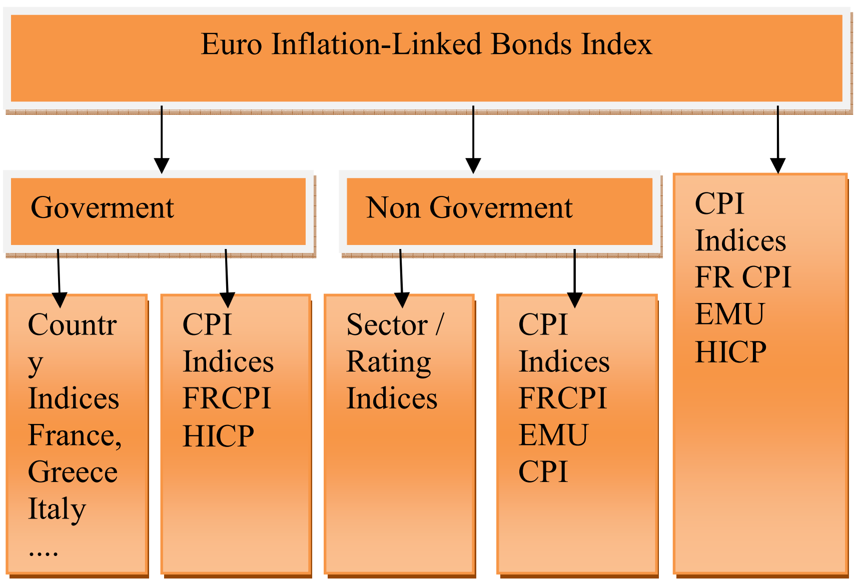
Appendix C



Source: prepared by authors based on Eurostat data

Appendix D

Euro Inflation linked Bonds index structure



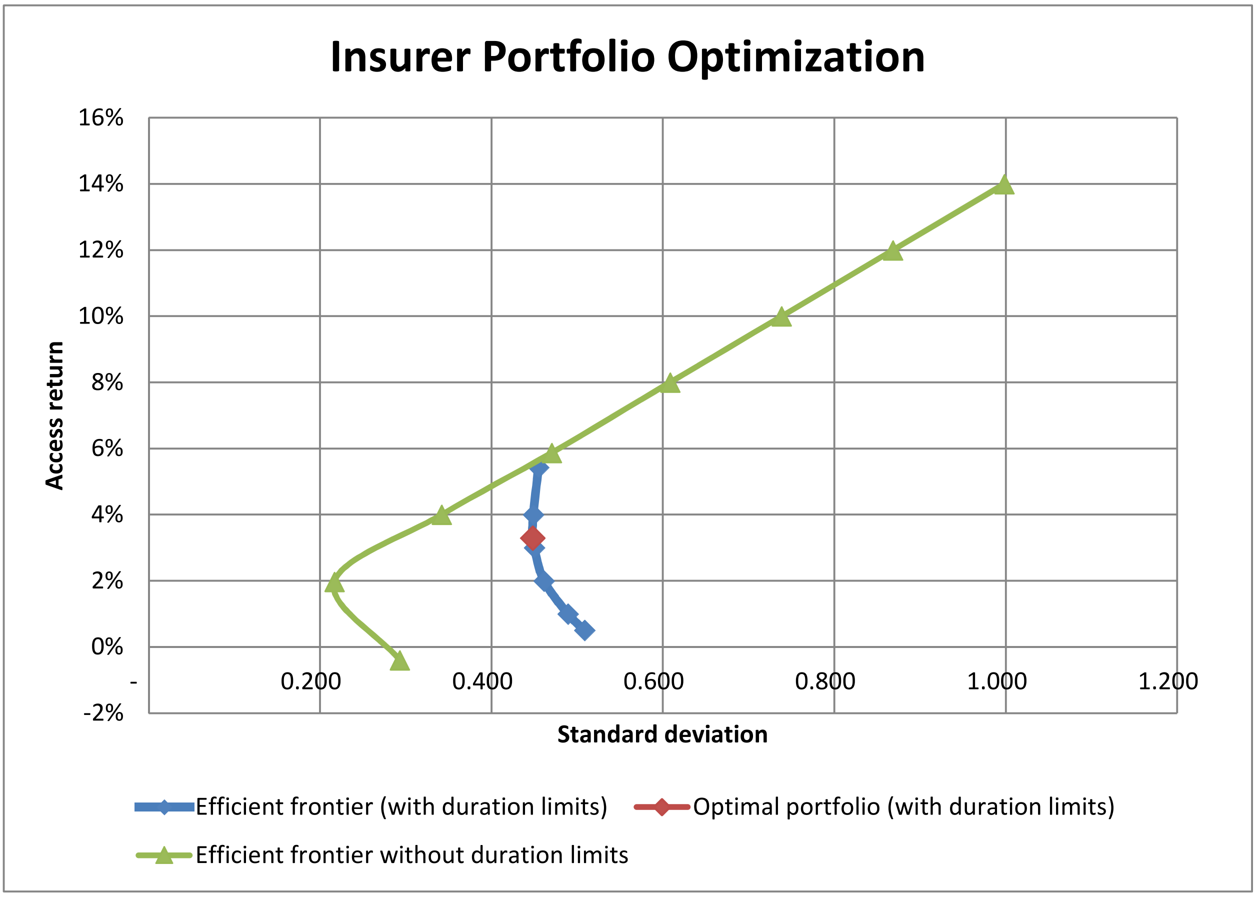
Source: Norges Bank, 2012 b.

Appendix E
Relationship between Europe Countries CPI

Correlations between different countries CPI	HICP	Germany	France	UK	Poland	US
Euro Area	**1,00**	**0,90**	**0,93**	0,28	0,18	**0,83**
Austria	**0,86**	**0,89**	0,78	0,56	0,39	0,75
Belgium	**0,87**	**0,84**	**0,82**	0,58	0,32	0,71
Finland	0,50	0,49	0,37	0,59	0,49	0,24
France	**0,93**	0,79	**1,00**	0,28	0,10	0,78
Germany	**0,90**	**1,00**	0,79	0,40	0,32	**0,82**
Greece	0,57	0,40	0,59	0,17	-0,08	0,47
Ireland	0,64	0,44	0,52	-0,38	-0,11	0,47
Italy	**0,88**	0,69	**0,85**	0,28	0,09	0,64
Luxemburg	**0,82**	0,80	**0,84**	0,33	0,11	**0,91**
Netherlands	0,45	0,28	0,25	-0,20	0,32	0,19
Portugal	0,77	0,57	0,63	-0,08	0,04	0,60
Spain	**0,87**	0,71	**0,82**	0,02	-0,10	**0,81**
Slovenia	0,51	0,27	0,41	-0,45	0,20	0,30
Slovakia	0,38	0,17	0,40	-0,38	0,09	0,27
Malta	0,37	0,41	0,32	0,17	0,29	0,14
Cyprus	0,73	0,54	0,76	0,25	-0,05	0,63
Estonia	0,78	**0,83**	0,65	0,35	0,36	0,63
Denmark	0,71	0,58	0,62	0,52	0,20	0,50
Lithuania	0,35	0,54	0,27	0,55	0,33	0,27
Latvia	0,50	0,62	0,45	0,23	0,11	0,45
Sweden	0,29	0,18	0,27	0,10	0,22	0,17
UK	0,28	0,40	0,28	**1,00**	0,19	0,24
Poland	0,18	0,32	0,10	0,19	**1,00**	0,10
Bulgaria	0,56	0,63	0,47	0,01	0,29	0,46
Hungary	0,19	0,22	0,11	-0,28	0,50	0,16
Czech republic	0,64	0,71	0,55	0,17	0,57	0,49
Romania	0,18	-0,02	0,05	-0,59	0,31	0,04
Albania	0,17	0,08	0,14	-0,04	0,00	-0,02
Armenia	0,20	0,19	0,33	0,47	0,28	0,14
Croatia	0,57	0,62	0,47	0,18	0,41	0,55
Iceland	-0,14	-0,04	-0,16	0,33	0,31	-0,22
Norway	0,19	0,09	0,15	0,17	0,21	0,21
Switzerland	0,63	0,56	0,63	0,06	0,10	0,71
Moldova	0,56	0,50	0,56	-0,10	-0,02	0,63
Russia	0,18	0,03	0,05	-0,51	0,32	0,07
Turkey	0,16	-0,05	0,05	-0,50	0,11	-0,06

Source: prepared by author.

Appendix F



Source: prepared by author.

Appendix G

Portfolio optimization II

Portfolio structure based on required return and minimum standard deviation with respect to Insurer liability distribution

Required return for portfolio optimization						
Portfolio return	0.00	0.01	0.02	0.03	0.04	0.05
	Portfolio structure based on required return and minimum standard deviation with respect to liability distribution					
Investment \ Portfolio nr.	1	2	3	4	5	6
1 Y Nom.	0%	22%	45%	45%	45%	45%
2 Y Nom.	0%	0%	12%	23%	23%	23%
3 Y Nom.	0%	0%	0%	8%	12%	12%
4 Y Nom.	0%	0%	0%	0%	7%	7%
5 Y Nom.	0%	0%	0%	0%	1%	13%
1 Y swap	45%	23%	0%	0%	0%	0%
2 Y swap	23%	23%	12%	0%	0%	0%
3 Y swap	12%	12%	12%	5%	0%	0%
4 Y swap	7%	7%	7%	7%	0%	0%
5 Y swap	13%	13%	13%	13%	12%	0%

Portfolio weight	100%	100%	100%	100%	100%	100%
Portfolio return	0.005	0.010	0.020	0.030	0.040	0.054
Portfolio SD	0.509	0.489	0.461	0.450	0.449	0.455
Sharpe rate	0.010	0.020	0.043	0.067	0.089	0.119

Duration	Insurer Liability Distribution					
1 Y	45%	45%	45%	45%	45%	45%
2 Y	23%	23%	23%	23%	23%	23%
3 Y	12%	12%	12%	12%	12%	12%
4 Y	7%	7%	7%	7%	7%	7%
5 Y	13%	13%	13%	13%	13%	13%

Source: prepared by author.