Theoria cum praxi – Essays in Times of Crisis on Solvency II, Yield Forecasts and Alternatives for Asset Managers in the Low Interest Environment

Von der Wirtschaftswissenschaftlichen Fakultät der
Gottfried Wilhelm Leibniz Universität Hannover
zur Erlangung des akademischen Grades

Doktor der Wirtschaftswissenschaften
- Doctor rerum politicarum -

genehmigte Dissertation

von

Dipl.-Ök. Norman Rudschuck
geboren am 29.03.1982 in Lüneburg

2018

Referent: Prof. Dr. J.-Matthias Graf von der Schulenburg

Korreferent: Prof. Dr. Kay Blaufus

Tag der Promotion: 15. Februar 2018

Meiner Frau Jasmin

Meinen Eltern

Meinen Schwiegereltern

Meinen Co-Autoren

Dr. Ute Lohse

DANKE

Zusammenfassung

Das Ziel dieser kumulativen Dissertation – insbesondere zu den Themen Solvency II, der Güte von Zinsprognosen und dem historischen Niedrigzinsumfeld gepaart mit unkonventioneller Geldpolitik – ist es, bestehende Theorien auf ihre Qualität und Zuverlässigkeit zu überprüfen. Der wissenschaftliche Beitrag basierend auf den empirischen Forschungsleistungen soll aufgrund der erzielten Ergebnisse zusätzlich einen praktischen Nutzen für Assetmanager in der Versicherungsindustrie leisten – kurz: Eine Brücke zwischen Theorie und Praxis zu schlagen. Insbesondere in Zeiten der historischen Niedrigzinsphase stellt(e) sich revolvierend die Frage: Warum und wofür werden Zinsprognosen erstellt? Dabei zeigte sich, dass gerade in volatilen Marktsituationen die Genauigkeit dieser Vorhersagen abnahm, wobei Orientierung in diesen Phasen von außerordentlicher Bedeutung gewesen wäre. Die Verschärfung des Anlagenotstands ergab sich zudem nicht nur durch sinkende Renditen, sondern auch durch den Regimewechsel mit Blick auf die Regulatorik. Solvency II kann als ein Paradigmenwechsel betrachtet werden und unterstreicht nicht erst seit der Einführung die Notwendigkeit einer angemessenen Kapitalausstattung von Versicherungsunternehmen.

Diese Rahmenbedingungen verschärften die kurz- bzw. langfristige Arbeit der Assetmanager im Bereich der Kapitalanlage, weshalb zu konstatieren war, dass konventionelle Lebensversicherungsprodukte aufgrund der sinkenden Garantieverzinsung mehr denn je erklärungsbedürftig geworden sind. Zudem resultieren hieraus für die Branche neue Herausforderungen und zusätzliches Umdenken mit Blick auf Vermarktung und Renditeerzielung, um das Produkt ‚Lebensversicherung' für Kunden attraktiv zu gestalten. Des Weiteren haben sich die Policen in der Gestalt weiterentwickelt, als dass teilweise nur noch eine Beitragsgarantie gewährt wird und der Garantiezins bei einzelnen Gesellschaften bzw. Produktangeboten keine Rolle mehr spielt. Diese beobachteten Zusammenhänge schlagen sich in praktischen und theoretischen Überlegungen nieder. Dies gilt insbesondere für das Ausweichen in Anlagetitel mit höherem Risiko-Ertrags-Profil, welche jedoch im Standardmodell unter Solvency II mit mehr Solvenzkapital zu hinterlegen sind – SCR und MCR (Minimum Capital Requirement). Die Wichtigkeit des Asset-Liability-Managements hat somit im Zeitablauf noch einmal an Relevanz gewonnen. Bisher werden Staatsanleihen, deren Emittenten Mitglieder des Europäischen Wirtschaftsraums oder der OECD sind, grundsätzlich als risikolos eingestuft. Eine Anpassung der aufsichtsrechtlichen Vorschriften wäre aus dem Blickwinkel der Staatsschuldenkrise durchaus überlegenswert. Versicherer müssen sich jedoch ohnehin im Rahmen der Säule II, also der Anforderungen an das Governance-System (Own Risk and Solvency Assessment – ORSA), intensiv mit den Staatenrisiken auseinandersetzen.

Weitere Module dieser wissenschaftlichen Arbeit beschäftigen sich mit der Güte von Zinsprognosen, die in dieser Form so noch nicht wissenschaftlich untersucht wurden. Grundlage dafür war stets die Verfügbarkeit einer geeigneten historischen Datenbasis. Am kurzen Ende der Zinsstrukturkurve spielte dabei insbesondere die aktuelle Geldpolitik der Europäischen Zentralbank – unkonventionell und streitbar zugleich – eine maßgebliche Rolle, welche direkte Impulse sowohl auf den Drei-Monats-Satz als auch die Prognosen hatte. Dabei ergab sich aus den Forschungsergebnissen, dass die Richtung der Zinsänderung – steigende oder weiter sinkende Sätze – aufgrund der zunehmenden Volatilität in Zeiten historisch ungewohnt niedriger Zinsen nicht immer zweifelsfrei vorhergesagt werden konnte. Eine naive Prognose als Alternative gereichte somit keineswegs zum Nachteil. Noch wichtiger für die Versicherungsindustrie war jedoch der untersuchte längerfristige Zins – mit oder ohne Einfluss von makroökonomischer Variablen. Dabei zeigte sich vor allem die Verschärfung der Lage im Zeitablauf für deutsche Assetmanager, da neben der Zunahme der Sicherheitsbedürfnisse vieler Investoren („flight to safety“) auch die Flucht in Qualitätswerte („flight to quality“) und das Zurückziehen in höchstliquide Titel („flight to liquidity“) vor allem deutsche Bundesanleihen mit einer Laufzeit von zehn Jahren und länger trotz der historisch niedrigen Renditen im sich verschärfenden Krisenfall sehr attraktiv erscheinen ließen.

Zusammenfassend münden die einzelnen Module dieser Arbeit in folgende Forschungsfragen:

- Wie verlässlich sind Zinsprognosen insbesondere in Zeiten von Unsicherheit, wo diesen gerade dann eine zunehmende Bedeutung zukommt?
- Verbessern makroökonomische Modellvariablen die Qualität der Zinsprognosen oder dominieren bei Vorhersagen in Krisenzeiten naive Prognosen?
- Inwiefern steigt die Erklärungsbedürftigkeit von Lebensversicherungspolicen mit Blick auf Marketingaspekte aufgrund von sinkenden Garantiezinsen?
- Sind Dividendenpapiere ein Lösungsansatz in der Niedrigzinsphase oder verhindert Solvency II das Partizipieren an neuen Höchstständen?
- Welche Opportunitäten haben Assetmanager bei der Anlage in Zinstitel, wenn Staatsanleihen eine negative Rendite abwerfen, zugleich aber die Sicherheit des Anlageportfolios gewahrt werden muss?

Schlagworte:

Asset-Liability-Management, Risikowahrnehmung, Solvency II, Zinsprognose, Staatsschuldenkrise, Geldpolitik, Kreditrisiko, Modellierung

Abstract

The aim of this cumulative dissertation is to examine the quality and reliability of existing theories bearing particular focus on the subject matters of Solvency II, the accuracy of interest rate forecasts and the historically low interest environment paired with unconventional monetary policy. This empirically-based scientific contribution should hold practical use to asset managers working in the insurance industry due to the results that it provides: put briefly, to act as build a bridge between theory and practice. In times of historically low interest rate phases, one question is often repeated, namely the whys and the wherefores regarding interest rate forecasts. Here, it has been shown that particularly in times of market volatility the precision of these forecasts decreased. Even though it would have held significant importance during such a phase to concentrate on it. The worsening of the asset crisis was not only a result of decreasing yields but also due to a regime change regarding regulatory requirements. Solvency II can be seen as a paradigm change and its introduction underlines the necessity of appropriate capital reserves of insurance companies that already existed.

The regulatory framework increased the short- and long-term work of asset managers in the field of capital investment, which resulted in the postulation that conventional life insurance products are – now more than ever – in need of explanation due to their declining guaranteed interest rates. In addition, this has also brought new challenges and a need for rethinking when considering the marketing and realization of (interest) earnings to the industry for the product “life insurance” to be attractive to the customer. Furthermore, the policies have continued to develop in structure, whereby in some cases only contribution guarantees are offered where the guaranteed interest rate does not play a role for individual companies or product offers. These observed correlations can be found in both theoretical and practical considerations. This can especially be said for the evasion of assets with higher risk return profiles as they require a higher amount of capital adequacy obligations under the standard model of Solvency II – Solvency Capital Requirement (SCR) and Minimum Capital Requirement (MCR). During the course of time, the importance of asset liability management has once again gained relevance. At present, sovereign bonds issued by members of the European Economic Area or the OECD are to be classified as risk-free. In light of the sovereign debt crisis, an adjustment of the supervisory regulations is worth considering. Insurers already have to intensively address sovereign risks pursuant to Pillar II, i.e. the governance system requirements (Own Risk and Solvency Assessment – ORSA).

Additional modules of this thesis are concerned with the accuracy of interest rate forecasts that have yet to be scientifically investigated in this form. The availability of appropriate historical databases served as the basis of the modules. The short end of the interest rate structure curve is especially affected by the current monetary policy of the European Central Bank – both unconventional and disputable – whose impulses are felt in the three-month rate and the forecasts. The research results here found that the direction of the interest rate change – increasing or further declining rates – cannot be unequivocally forecasted due to the increasing volatility during times of historically-unusual low interest rates. Thus, a naïve prognosis delivered as an alternative is not necessarily a disadvantage. However, more important for the insurance industry was the investigation of long-term interest rates, with or without the influence of macro-economic variables. Here, above all an escalation of the situation for German asset managers has developed over time as – in addition to the increase of "flight to safety" for many investors the need of "flight to quality" and the "flight to liquidity" – it has also made German sovereign bonds with a period of ten years and more appear especially attractive despite the historically low yields in an intensifying crisis situation.

In summary, the individual segments of this work gave rise to the following research questions:

- How reliable are interest rate forecasts especially during times of insecurity, when they hold increasing importance?
- Do macro-economic variables improve the quality of the interest rate forecasts or do naïve prognoses dominate during times of crisis?
- How much does the explanation necessity of life insurance policies increase with respect to the marketing aspects due to declining guaranteed interest rates?
- Are dividend-paying stocks a part of the solution approach during a low interest rate phase or does Solvency II hinder the participation in new peaks?
- What opportunities do interest-bearing securities offer asset managers when sovereign bonds yield a negative return, while at the same time the security of the investment portfolio has to be preserved?

Keywords:

Asset liability management, risk perception, Solvency II, sovereign debt crisis, interest rate forecasts, monetary policy, credit risk, modeling

Table of Content

Theoria cum praxi – Essays in Times of Crisis on Solvency II, Yield Forecasts and Alternatives for Asset Managers in the Low Interest Environment

1 Introduction

1.1 Motivation and Objectives

The last German polymath – Gottfried Wilhelm Leibniz[1] – still holds incomparable significance for the history of mathematics and philosophy in the Western world. His influence for sciences as well as during the Age of Enlightenment can be summed up in just three words:

Theoria cum praxi.[2]

This is the so-called *maxim* of Leibniz. Within this motivation, it is possible to combine theoretical models from economics and econometrics with the daily work of analysts elaborating forecasts as well as asset managers regarding the low interest environment. This combination of theoretical approaches and practical implementation was one of the main drivers for the work presented here during recent years.

Independently from Sir Isaac Newton, Gottfried Wilhelm Leibniz developed the differential calculus as well as the integral calculus in the field of mathematics more than 300 years ago.[3] In other words, he formulated the law of continuity[4] and the transcendental law of homogeneity.[5] He developed a binary system called "dyadics", which made it possible to represent any number with zeroes and ones: the concept that was later to become the basis of computer language.[6] Furthermore, he earned merits by expressing thoughts in the fields of insurance and financial mathematics as well as investment theory.[7] These letters already included pensions, (life) annuities and life expectancies.

---

[1] (*1646 – †1716)

[2] Foundation motto of the Royal Prussian Academy of Sciences, 1700.

[3] See Flanders (1973).

[4] See Katz and Katz (2012).

[5] See Bos (1974) as well as Katz and Sherry (2013).

[6] See Leibniz Association (2017).

[7] See Knobloch and Graf von der Schulenburg (2000), pp. 301-529.

Even though John Maynard Keynes said:

> *In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean is flat again.*[8]

The longer life is still pleasing, although it also has its price and thus the need for capital in a higher age holds strong importance. Therefore, it is unsurprising that pensions are counted among the urgent problems of our present times in developed industrial countries.

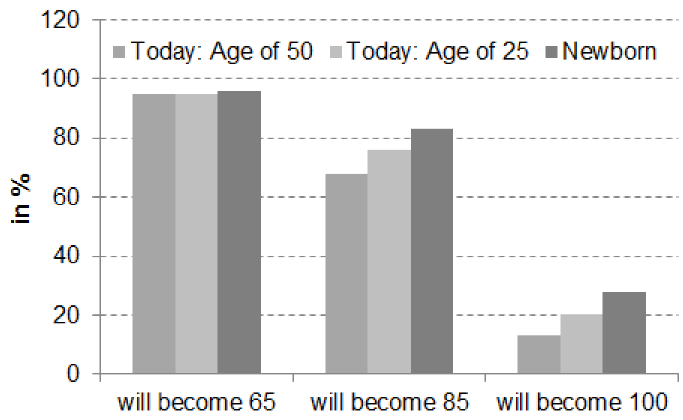


Figure 1: Share of women who will live to 65, 85 or 100 years of age[9]

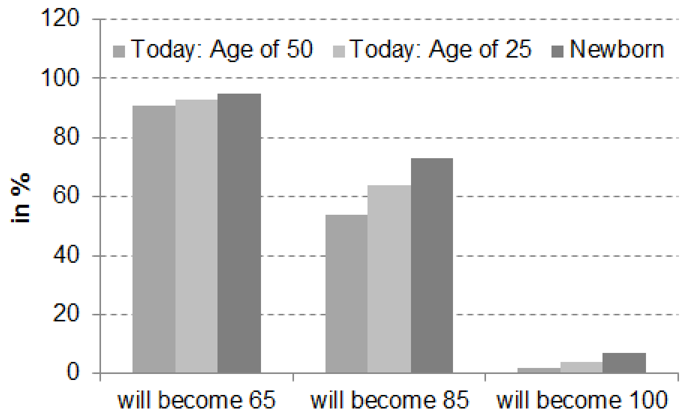


Figure 2: Share of men who will live to 65, 85 or 100 years of age[10]

[8] See Keynes (1923), p. 80.

[9] Own illustration following Max Planck Institute for Demographic Research and GDV (2017).

[10] Own illustration following Max Planck Institute for Demographic Research and GDV (2017).

The most common form of private pension insurance is the lifelong pension, which is paid until the death of the beneficiary. The management of life expectancy becomes one of the key concepts of our times.[11] However, how should those obligations be met?

In October 2016, the Austrian Treasury (OeBFA) first issued a bond with a maturity of 70 years[12] (RAGB 1.5% 2016-2086/4). The Austrian Treasury highlighted in their report that it received bids for around EUR 8bn, whereas the outstanding amount is just EUR 2.0bn. This results in a so-called bid-to-cover ratio of almost 4.0. Already in 2012, Austria issued the then longest-ever issued government within the Eurozone: A maturity of 50 years was new to investors and other issuers. In the same year, the OeBFA asked to change the legal framework to issue longer-dated bonds of up to 70 years, due to reasons of diversity and flexibility.[13] This was underlined with the argument of an increase in life expectancy.

Just recently, in September 2017, Austria wrote a new chapter of the historically low interest environment: the Republic of Austria – being founded only 99 years ago – placed a Methuselah bond via the OeBFA maturing on September 20, 2117 and attracted EUR 3.5bn from institutional investors.[14]

	2Y	**5Y**	**10Y**	**30Y**
Germany	-0.75%	-0.36%	0.34%	1.14%
France	-0.55%	-0.24%	0.64%	1.77%
Italy	-0.12%	0.65%	1.98%	3.18%
UK	0.22%	0.48%	1.06%	1.71%
Switzerland	-0.83%	-0.59%	-0.15%	0.28%
USA	1.33%	1.72%	2.14%	2.75%
Canada	1.55%	1.74%	2.02%	2.16%
Japan	-0.14%	-0.12%	0.02%	0.82%

Table 1: Yields of selected benchmark bonds on the government bond market [15]

[11] Further details regarding the calculation of the *probability of dying* can be found in Graf von der Schulenburg and Lohse (2014).

[12] See OeBFA (2017a).

[13] See OeBFA (2013).

[14] See OeBFA (2017b).

[15] Own illustration according to market data from September 12th, 2017; Bloomberg (2017).

France was already active in 2005 with an ultra-long maturity of 50 years and did so again in 2016, locking in a yield of just 1.923%.[16] Spain[17], Belgium[18] and Italy[19] followed during 2016, collecting altogether more than EUR 14bn.

Obviously, this is all about the economic fundamentals of *demand and supply*: Ireland was even able to arrange a private placement in 2016 for a maturity of 100 years, albeit only with an issue size of EUR 100m to a prior-named circle of customers, a so-called *private placement*.[20] The yield was fixed at low 2.35% p.a. according to the Irish NTMA (National Treasury Management Agency).

A year earlier, within its program of Euro Medium Term Notes (EMTN) the Kingdom of Belgium first used its highest maturity, which was also 100 years at that time.[21] The amount was EUR 75m in two tranches. Investors accepted a coupon of just 2.3% p.a. for the new Belgian “centennial bond”.

The bond holders of such papers are obvious, namely life insurance companies. Already in 2008, it was foreseeable that Solvency II would tie capital requirements to a very comprehensive risk definition including underwriting and market risks.[22] The implemented regulatory framework demands more sophisticated tools to detect interest rate risks on both sides of the balance sheet in an integrated approach.[23] Risk-taking is the core business concerning insurance companies.[24] As expected, efforts by life insurers to level these risks have led to an increased demand for long-term fixed income securities.[25]

Not only the underlying regulatory framework has changed during recent years, but also the interest rate environment has become a historically unique one.[26] This not only poses

[16] See Agence France Trésor (2016).

[17] See Tesoro Público (2016).

[18] See Agence Fédérale de la Dette (2017).

[19] See Borsa Italiana (2017).

[20] See National Treasury Management Agency (2017).

[21] See Belgian Debt Agency (2016).

[22] See Basse and Friedrich (2008).

[23] See Basse et al. (2007).

[24] See Romeike (2007).

[25] See Basse and Friedrich (2008).

[26] See Table 1.

challenges for the asset managers in the (German) life insurance industry,[27] but also for the customers of life insurance companies[28] as well as policy-setting central bankers.[29]

> *Prediction is very difficult, especially if it's about the future.*[30]

The idiom not only holds true for interest rate forecasts or stock market prices, but also for the introduction of new supervisory regimes like Solvency II, which is more time-consuming than one might expect.

The European Commission made a first proposal for a directive concerning life assurance on the take-up and pursuit of the business of Insurance and Reinsurance in July 2007. The Solvency II Directive 2009/138/EC[31] was agreed on in the European parliament in April 2009 and approved by all EU finance ministers in November 2009. It introduces advanced solvency requirements for insurers based on a holistic risk assessment and imposes new assessment rules for assets and liabilities, which now must be assessed at market values. This aims to reduce an insurer's risk of insolvency. At the same time, the directive serves to harmonize supervisory law in the European Single Market. The "new" supervisory regime Solvency II came into force in full January 1, 2016.

According to the German Federal Financial Supervisory Authority (BaFin), the risk-based adequacy of own funds forms the core of Solvency II. This procedure follows a three-pillar approach, whereas in *Pillar I* the own funds requirements, the rules for calculating the technical provisions and the review of the calculation approaches are underlined. In terms of the capital requirements, a distinction is made between minimum capital (MC) and solvency capital (SC).

The MC represents the absolute floor: the MCR is the level of own funds below which the policyholders' interests are at serious risk if the undertaking were to continue its business activities. It represents the final supervisory intervention threshold before the undertaking's authorization is withdrawn.

[27] See Koijen and Yogo (2017).

[28] See Schreiber (2017).

[29] See Borio and Gambacorta (2017) as well as Kiley and Roberts (2017).

[30] This quote is attributed on a rotating basis to either Kurt Tucholsky, Mark Twain, Winston Churchill or the here-mentioned Nobel laureate in Physics, Niels Bohr.

[31] See European Parliament (2009).

The SC is calculated using either a standard formula with a modular structure or an internal model. The SCR has to be covered by eligible own funds of the same amount, which enable insurers to absorb high levels of unexpected losses and give reasonable assurance to policyholders and beneficiaries that payments will be made as they fall due.

The *second pillar* sets out the principles and methods of supervision on the one hand and the qualitative requirements for engaging in insurance activities on the other. In terms of the supervisory rules, special attention is paid to the Supervisory Review Process used by the supervisory authorities to review and assess compliance with the quantitative and qualitative requirements.

Furthermore, it deals with the individual aspects of governance, including in particular the fit and proper requirements, risk management, the ORSA, internal controls, the internal audit function, the actuarial function and the framework conditions for outsourcing.

Pillar III deals with market discipline, transparency and disclosure obligations along with reporting to the supervisory authorities.[32]

Finally, the BaFin clarifies that both primary insurers and reinsurers fall within the scope of the directive, irrespective of their legal form. Institutions for occupational retirement provision, death benefit funds and small insurers are excluded from its scope. An initial indication for classifying an insurer as 'smaller' is the business volume.[33,34]

The still-young millennium has already been characterized by numerous economically and financially severe events: the bust of the New Economy Bubble, the stock market crash after 9/11, the introduction of the Euro, the collapse of the US sub-prime market, the bankruptcy filing of Lehman Brothers, the sovereign debt crisis within the Eurozone, and the all-time highs of stock markets going along with historical lows regarding interest yields. After the stock market burst around the turn of the century, the levels of stock investments by German insurers significantly declined, thus also missing out on the rises leading up to the Lehman crash and not participating in recent developments.

---

[32] The essential technical information underlying these calculations is set out uniformly across the EU by the European Insurance and Occupational Pensions Authority (EIOPA).

[33] Annual gross written premium income posted of lower than 5 million euros or gross technical provisions lower than 25 million euros.

[34] Further information on the exceptions to the scope of Solvency II can be found in Articles 4 to 12 of the Solvency II Directive.

Studies have shown that for asset-only allocations, the return forecasts are more important than assumptions about the variance-covariance matrix of the returns.[35] The same holds true for the asset liability management (ALM) of insurance companies.[36] Given the high quotas of bonds in the real and optimized insurance portfolios, interest rate forecasts hold exceptional importance.

> *"Prophesy is a good line of business, but it is full of risks."*
> Mark Twain in *Following the Equator*

In summary, the individual segments of this work gave rise to the following research questions:

- How reliable are interest rate forecasts especially during times of insecurity, when they hold increasing importance?
- Do macro-economic variables improve the quality of the interest rate forecasts or do naïve prognoses dominate during times of crisis?
- How much does the explanation necessity of life insurance policies increase with respect to the marketing aspects due to declining guaranteed interest rates?
- Are dividend-paying stocks a part of the solution approach during a low interest rate phase or does Solvency II hinder the participation in new peaks?
- What opportunities do interest-bearing securities offer asset managers when sovereign bonds yield a negative return, while at the same time the security of the investment portfolio has to be preserved?

[35] See Chopra and Ziemba (1993).

[36] See Basse et al. (2007).

1.2 Scientific Contribution of This Cumulative Dissertation

The first module examines some basic principles of Solvency II and discusses asset pricing models focusing on stock markets. It shows that equity prices are closely related to economic fundamentals as well as identifying stock crashes as seldom events rather than normal phenomena. By applying a consumption-based capital asset pricing model (CCAPM), it can be shown that future return expectations of mainly equity investors (mutual funds) cannot be anticipated as being as low as historical records have shown within the last decade, biased by two major severe stock shocks. Consequently, insurers especially have to do some rethinking of marketing strategies trying to sell endowment policies in the changed regulatory environment, namely under Solvency II.

Module 2 looks at some interest rate estimates for the European market using techniques of time series analysis. A set of criteria for the evaluation of the forecasts are presented. While some results seem to be quite favorable for forecasters, others indicate that none of the analyzed forecasts seem to provide relevant information about the future development. There is strong evidence showing that interest rates are very difficult to predict.

As a basic requirement to be a feasible predictor for the shape of the yield curve, survey forecasts should be cointegrated with the realized path of interest rates. The short end of the curve is determined to a large extent by the monetary policy of central banks. Especially in times of financial crisis, uncertainty about the coming policies rises and leads to higher dispersion within survey forecasts as well as structural breaks within the long-run relationship. Using an empirical model in module #3, it can be stated that emergence of uncertainty may be explained by worsening economic sentiment or liquidity constraints in the money market.

The purpose of the fourth module is to compare different econometric models regarding their power of forecasting government bond yields from the UK (GILTs). The paper distinguishes between two different basic approaches: the direct approach deals with VAR models, while the indirect approach deals with the Nelson-Siegel model and an extension – estimated by Differential Evolution – on the first stage and time series models on the second stage. The predictive accuracy is evaluated by Theil's U and the Diebold-Mariano Test. In the short run, it can be observed a better accuracy as a consequence of increasing central bank transparency. However, the efficient market hypothesis shows that it is not possible to outperform the market in the long run.

Module #5 is still as valid as in 2014: several stock market rallies and at the same time extremely low interest rates could be observed. This coincided with more volatile risk premiums for interest-bearing assets like government bonds. The mixture still makes life more difficult for investment managers of (especially life) insurances: they have to continuously find profitable investments with good returns for the customers' money – in case of the life insurers – to pay at least the promised returns of the contracts. With asset managers avoiding stocks in recent years, the question can be raised whether they are forfeiting a good opportunity for their portfolio and if there remains time to participate in possible future gains. On the other hand, the regulatory environment implemented in the meantime – namely Solvency II – will play an important role in the future and has likely already had an impact on the investment decisions of the companies. Higher capital requirements for stock investments make it even more difficult to earn the so-called "Garantiezins". Without ignoring the risks related to stock investments, effectively banning equities from asset managers' buy lists might lead to missing out on desperately-needed returns for the life insurance industry. Accordingly, policy-makers probably should reconsider their directives.

The sixth module investigates the possible influences of recent European Central Bank (ECB) monetary policy instruments on sovereign and sub-sovereign bond yields. It aims to shed light on the question of whether the Public Sector Purchase Program (PSPP) has distorted not only government bond yields but also the pricing of AAA sub-sovereigns within the Eurozone. For this purpose, the module elaborates tests for long-term relationships and investigates possible short-run dynamics between Economic and Monetary Union (EMU) sovereign bond yields as well as sub-sovereign bond yields. By adapting methodologies of time series analysis, we find clear evidence of changes in the converging behavior of EMU government bond yields. In addition, since the scarcity of bonds forced the ECB to extend the bond-buying even to supranationals, development agencies and sub-sovereigns like German Bundeslaender or French, Spanish and Belgian regions, the Expanded Asset Purchase Program (EAPP) can be seen as a reaction to the European debt crisis and the failure of the ECB's aim to fulfill the inflation target. However, it seems that the purchase program's recent acquisitions have not significantly influenced the pricing mechanism for sovereign and sub-sovereign yields in the EMU, at least econometrically for now.

1.3 Summary of Results

Solvency II has changed the paradigms of risk and asset management in the European insurance industry. The new set of regulations will still continue to force life insurers to reduce their exposure to equities. This was, is and will be definitely a problem for asset managers in insurance companies: in combination with the low level of interest rates observed for several years now and a permanent reduction to the equity quota, this will almost certainly result in rather unpleasant returns, especially in comparison to the performance of fund managers at mutual funds who face less constraints investing in equities.

The empirical and descriptive results in the six modules below indicate that stock prices are closely linked to the economic fundamentals, at least in the long run. Although portfolio management through the rear mirror of risk-adjusted returns are not favorable for stock investments, this does not necessarily have to rule them out completely. It somehow shows that timing plays a vital role. Furthermore, some empirical results show that speculative bubbles and their burst are rather an exception to the rule.

Focusing on relatively conservative measures, the dividend yield and the price-to-book ratio imply that even by reached levels in 2017 stocks are not to be considered unduly expensive. This is especially valid in comparison to government as well as corporate bonds, respectively. This leaves the prospect of positive future equity premiums and highlights the relevance of accurate stock price or dividend payment forecasts for asset managers in the life insurance industry.

Especially in the context of evaluating the attractiveness of stock investments for insurance companies, the always-inherent uncertainty (no matter what method was used) of future stock prices resulting from different earnings or dividends per share is important. Due to the long-term liabilities of life insurers, the underlying investment strategy also has to take into account long-term investments.

Unanticipated interest rate moves undertaken by the ECB (or any other central bank) not only demonstrate the relevance of accurate or at least unbiased stock market forecasts but also the predictions of interest rate moves of the monetary policy-makers. Hence, this underpins the relevance of interest forecasts for at least two reasons: first, the level of current interest rates influences the excess return of stock investments; and second, the return of the alternative investment in bonds may also change due to interest rate decisions.

As the interest decisions by central bankers not only influence the short-term interest rates but also the whole maturity spectrum, asset managers have to rely on interest rate forecasts for different maturities. Recent discussions about changes in the guarantees given with endowment policies originate from similar thoughts, albeit tackling the problem from the liability side: by looking at absolute guarantees, the basis of calculating the contracts has changed to limited guarantees or at least money-back guarantees only.

To earn those required yields, spreads of EMU countries as well as sub-sovereign spreads have been evaluated besides stocks. Asset managers do not simply want high returns, but also stable yields and assessable risks. Therefore, the investigation of trending behavior and checking for possible long-run relationships and Granger causal relationships was necessary in many of the presented papers. Furthermore, performing tests for statistical breakpoints within the data framework was inevitable.

Looking at the interference by the ECB's Public Sector Purchase Program (PSPP), sovereign bond yields have converged as they did before the crisis. Therefore, the spreads shrink or even disappear and risks are assumed to be mispriced. Furthermore, even yields of sub-sovereign bonds have decreased and the spread – e.g. to Bunds – has tightened. This is harmful for life insurers in general and German life insurance companies especially. The granted return cannot be earned by interest-bearing bonds from AAA-rated German sovereigns.

Even evading to sub-sovereigns like German Bundeslaender bonds is no longer an option, given that the ECB is carrying out their PSPP until at least the end of 2017. This evolution might push asset managers into riskier assets in the future. The investment process has changed and insurance companies must do some rethinking. For the time being, it remains unclear that an immediate end of the PSPP might be interpreted consecutively that the crisis is over. If the ECB's action gives rise to doubts that the council is not ready for battle, the yields might ultimately reverse dramatically to the upside. After months and years of injected money, this would mean that all effects might be gone asymmetrically at a moment's notice if the ECB announces any kind of tapering or so-called “fading out”.

1.4 Limitations and Scope for Further Research

Indubitably, stocks are a rather volatile and accordingly risky asset. Nevertheless, attractive and – in case of the German insurance industry – competitive required returns can be achieved. Stocks have reached all-time highs in 2017. However, when looking at indicators commonly used by practitioners, they possibly still offer some chances for additional returns. Stock prices are closely linked to the economic fundamentals, at least in the long run. This implies that although the backward-looking measures of risk-adjusted returns are not favorable for stock investments. Nevertheless, the measures used below are only part of a multitude of possible methods, thus requiring a cautious interpretation and leaving room for completion with other methods.

Nevertheless, the insurance asset managers have actively – and partially passively – reduced their stock exposure over the last decade. This could partly be an indication of the then-expected new regulatory environment, namely Solvency II. In its standard model, stocks require quite a large amount of solvency capital to cover the investment risks. This is a further restriction for insurance asset managers. In order for them to achieve competitive returns for their employer and thus also the clients – especially when compared to mutual funds – these rules might require some adaptation, which would result in rethinking to be done by the regulative authority.

Looking at the quality of data, stock market fixings and returns have the best availability. It is the nature of the beast that the Eurozone has only existed since 1999 and thus the history of yields within the EMU is restricted. The same holds true for recent crashes like Lehman's breakdown in September 2008 or the looming of the sovereign debt crisis. Examining the unconventional methods of the ECB since March 2015 on sovereign bonds also limits the research, having data for only two and a half years. Larger datasets accrue over time, whereby conducting similar analysis might underpin those findings presented here. Changing the set of examined countries or using different indices might be interesting to further specify the influence of certain factors.

Especially the usage of "alternative assets" rather than stock investments compared to government bonds or sub-sovereign bonds would greatly enhance the current risk return matrix as well as contemporary literature. Even the regulatory framework is developing gradually and should be examined permanently. A further risk to the future returns of insurance company is the increase of interest rates, whereby vice versa the market prices of bonds will fall, perhaps even sharply.

Other specific limitations are described directly in the individual modules below.

2 References

Agence Fédérale de la Dette (2017):
http://www.debtagency.be/en/productolostatistics
(last accessed on 02.09.2017)

Agence France Trésor (2016):
http://www.aft.gouv.fr/articles/launch-of-the-new-oat-1-25-25-may-2036-and-the-new-oat-1-75-25-may-2066_12640.html
(last accessed on 02.09.2017)

Basse, T. / Friedrich, M. (2008):
Solvency II, asset liability management, and the European bond market – theory and empirical evidence
in: Zeitschrift für die gesamte Versicherungswissenschaft; Volume 97, Supplement 1, pp 155–171

Basse, T. / Friedrich, M. / Krampen, B. / Krummaker, S. (2007):
Strategisches Asset-Liability Management in der Versicherungswirtschaft — Ein Ansatz zur integrierten Bilanzstrukturoptimierung
in: Zeitschrift für die gesamte Versicherungswissenschaft; Volume 96, Issue 4, pp 617–648

Belgian Debt Agency (2016):
http://www.debtagency.be/sites/default/files/content/download/files/rpt2015en.pdf
(last accessed on 02.09.2017)

Bloomberg (2017):
Market data from the terminal
(last accessed on 13.09.2017)

Borio, C. / Gambacorta, L. (2017):
Monetary policy and bank lending in a low interest rate environment: Diminishing effectiveness?
in: Journal of Macroeconomics, Available online 20 February 2017, In Press, Corrected Proof

Borsa Italiana (2017):
http://www.borsaitaliana.it/borsa/obbligazioni/mot/btp/scheda/IT0005217390.html?lang=it
(last accessed on 02.09.2017)

Bos, H.J.M. (1974):
Differentials, higher-order differentials and the derivative in the Leibnizian calculus
in: Archive for History of Exact Sciences; Volume 14, Issue 1, pp 1–90

Chopra, V.K. / Ziemba, W.T. (1993):
The effect of errors in means, variances, and covariances on optimal portfolio choice
in: Journal of Portfolio Management; 19, pp 6–11

European Parliament (2009):
DIRECTIVE 2009/138/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) (recast)
available online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:335:0001:0155:en:PDF
(last accessed on 15.08.2017)

Flanders, H. (1973):
Differentiation Under the Integral Sign
in: The American Mathematical Monthly, Vol. 80, No. 6, pp 615-627

GDV – Gesamtverband der Deutschen Versicherungswirtschaft e. V. (2017):
Neue Prognose zur Lebenserwartung – Eins von vier Mädchen wird wohl 100 Jahre alt
http://www.gdv.de/2017/05/eins-von-vier-maedchen-wird-wohl-100-jahre-alt/
(last accessed on 02.09.2017)

Graf von der Schulenburg, J.-M. / Lohse, U. (2014):
Versicherungsökonomik, 2. Auflage, Verlag Versicherungswirtschaft, Karlsruhe

Katz, K.U. / Katz, M.G. (2012):
A Burgessian Critique of Nominalistic Tendencies in Contemporary Mathematics and its Historiography
in: Foundations of Science; Volume 17, Issue 1, pp 51–89

Katz, M.G. / Sherry, D. (2012):
Leibniz's Infinitesimals: Their Fictionality, Their Modern Implementations, and Their Foes from Berkeley to Russell and Beyond
in: Erkenntnis; Volume 78, Issue 3, pp 571–625

Keynes, J.M. (1923):
A Tract on Monetary Reform
Macmillan and Co.

Kiley, M.T. / Roberts, J.M. (2017):
Monetary policy in a low interest rate world
In: Brookings Papers in Economic Activity; BPEA Conference Drafts, March 23–24

Knobloch, E. (1987):
Theoria cum praxi. Leibniz und die Folgen für Wissenschaft und Technik
in: Studia Leibnitiana; Bd. 19, H. 2 (1987), pp 129-147

Knobloch, E. / Graf von der Schulenburg, J.-M. (2000):
Gottfried Wilhelm Leibniz. Hauptschriften zur Versicherungs- und Finanzmathematik
Akademie Verlag

Koijen, R.S.J. / Yogo, M. (2017):
Risk of Life Insurers: Recent Trends and Transmission Mechanisms
NBER Working Paper No. 23365

Leibniz Association (2017):
https://www.leibniz-gemeinschaft.de/en/about-us/gottfried-wilhelm-leibniz/
(last accessed on 15.08.2017)

Max Planck Institute (2017):
Healthy life expectancy, mortality, and age prevalence of morbidity
MPIDR Working Paper
http://www.demogr.mpg.de/papers/working/wp-2017-015.pdf
(last accessed on 01.09.2017)

National Treasury Management Agency (2017):
http://www.ntma.ie/news/2017/07/10/ntma-publishes-2016-annual-report-and-2017-midyear-update/
(last accessed on 02.09.2017)

OeBFA (2013):
http://www.oebfa.at/de/osn/DownloadCenter/Investor%20Relations/annual_review12_de.pdf
(last accessed on 01.09.2017)

OeBFA (2017a):
http://www.oebfa.at/de/osn/DownloadCenter/Investor%20Relations/OeBFA%20Annual%20Review%202016%20de%20web.pdf
(last accessed on 01.09.2017)

OeBFA (2017b):
http://www.oebfa.at/de/InvestorRelations/Auktionskalender/Seiten/Auktionsdetails.aspx?id=f20823e5-fc21-4679-ab06-a74baf841b84
(last accessed on 18.09.2017)

Romeike, F. (2007):
Risikomanagement in Versicherungen – Ein Überblick
in: Wirtschaft und Management; Jahrgang 4, Nr. 6, pp. 7-22

Schreiber, F. (2017):
Identification of customer groups in the German term life market: a benefit segmentation
in: Annals of Operations Research; Volume 254, Issue 1–2, pp 365–399

Tesoro Público (2016):
http://www.tesoro.es/sites/default/files/deuda/boletin-mensual/2016may.pdf
(last accessed on 02.09.2017)

3 List of Modules

1	**Solvency II and the investment policy of life insures: Some homework to do for the sales and marketing departments** Rudschuck, N. / Basse, T. / Kapeller, A. / Windels, T. – Interdisciplinary Studies Journal 1.1:76–96 (2010)
2	**Asset management in the German insurance industry: the quality of interest rate forecasts** Schwarzbach, C. / Kunze, F. / Rudschuck, N. / Windels, T. – Zeitschrift für die gesamte Versicherungswissenschaft 101:693–703 (2012)
3	**Interest rate forecasts in times of financial crisis: What might be interesting to know?** Kunze, F. / Kramer, J. / Rudschuck, N. – European Journal of Political Economy 34:45–52 · online first (2013)
4	**Forecasting GILT Yields with Macro-Economic Variables: Empirical Evidence from the UK** Wegener, C. / Basse, T. / Rudschuck, N. – Working paper
5	**Stock investments for German life insurers in the current low interest environment: more homework to do** Schwarzbach, C. / Kunze, F. / Rudschuck, N. / Windels, T. – Zeitschrift für die gesamte Versicherungswissenschaft 103:45–63 (2014)
6	**EMU Sovereign and Sub-sovereign Bonds, the Euro Crisis and the ECB – New Insights for Asset Managers in the Life Insurance Industry** Rudschuck, N. / Kunze, F. / Windels, T. – Working paper

MODULE 1

Solvency II and the investment policy of life insures:
Some homework to do for the sales and marketing departments

Published:
Rudschuck, N. / Basse, T. / Kapeller, A. / Windels, T.
Interdisciplinary Studies Journal 1.1:76–96 (2010)
Contemporary Views on Business: Partnering for the Future

Norman Rudschuck, Tobias Basse, Alexander Kapeller & Torsten Windels

Solvency II and the Investment Policy of German Life Insures: Some Homework to Do for the Sales and Marketing Departments

Introduction

Solvency II is to be considered a paradigm shift for the European insurance industry and will lead to major changes in the process of asset and risk management. This new set of regulations is necessary. In fact, we believe that the current financial crisis has shown the importance of such advanced risk management processes in the financial services industry. The so-called subprime mortgage crisis obviously did have massive negative effects on capital markets and global economic growth. As a consequence, not only the stocks of banks and insurers dropped considerably; the equity market in general suffered huge losses. Finally, it was the unblamable general public to carry the burden. Stocks have recently been not the best investments compared to other asset classes, for example, German 10 year government bonds. Easily to understand, a reform of financial market regulation in general and insurance authority in special had to be undertaken. Taking into account Solvency II, which will require that equity investments have to be underlain with an extra amount of solvency capital, it seems to be very probable that insurers will permanently reduce their equity exposure. As a matter of fact, insurance companies, especially Germans, are lacking equity capital anyway and have problems to fulfill upcoming Solvency II capital requirements. However, having lately seen quite a recovery after the lows of March 2009, there may still be some potential for further gains in stocks. This could become a problem for asset managers in the insurance industry. Low interest rates even seem to increase these difficulties because life insurers will have a hard time trying to produce attractive returns in a post Solvency II world – especially compared to mutual funds. This is wanted by the regulators; Solvency

II is above all supposed to protect the customers. Therefore, our objective is to show that life insurer will face a disadvantage in terms of return in comparison to mutual funds caused by Solvency II. Consequently, insurers especially have to do some rethinking of marketing strategies trying to sell endowment policies in the new regulatory environment.

The organisation of the paper is as follows: Firstly we will examine some basic principles of Solvency II. Secondly we will briefly discuss asset pricing models focussing on stock markets and show that equity prices are closely related to economic fundamentals and identify stock crashes as rather seldom phenomena than normal events. This sheds light on future return expectations of mainly equity investors (mutual funds) and investors under the Solvency II regime (life insurers). This in mind we will suggest appropriate financial services marketing strategies from a Solvency II perspective before concluding.

Regulatory Way to Solvency II

Almost at the end of the actual Solvency II implementing process, the subprime mortgage crisis shook the financial system. It became obvious, that rules were misused or at least extended to their limits into certain grey areas, and rethinking of applicable regulations had to be done. The crisis has shown the importance of rethinking risk management highlighting the importance of Solvency II. Romeike et al. (2006) consider Solvency II to be a paradigm shift for the insurance industry including major upheavals for corporate-policy decision processes. Regarding Basse and Friedrich (2008) it is already foreseeable that capital requirements will be tightened according to Solvency II, especially due to a very comprehensive risk definition including underwriting and market risks. Even though a risk based approach was overdue and revised external or even internal models more state of the art, some experts doubt the necessity of Solvency II and call it a fatal error (see Huerta de Soto 2009). Basse et al. (2009) see it more differentiated. More refined tools will be needed in this new regulatory framework to face interest rate risks on both sides of the balance sheet in an integrated asset-liability-approach. As a matter of fact, any effort undertaken by life insurers to encounter these risks could easily lead to a stronger demand for long term fixed income securities. Insurance companies lack of equity capital, so Reddemann et al. (2010) have argued convincingly that besides different other measures, dividend cuts might increase their capital base. Unlike bank-related regulations, in particular Basel I and Basel II, Solvency II is a European objective. It is one of the major projects in the field of financial services regulation at the EU level. The ongoing process of implementing identical requirements for all European insurance companies is quite sophisticated and will be implemented 2012 – or 2013 the latest – into member state law. The goal is to introduce and establish for the first time economic risk-based solvency requirements across all 27 EU Member States. This new set of regulation will be more risk-sensitive and more accentuated than Solvency I, thus enabling a better coverage of the economic risks run by any particular insurer.

In contrast, the previous set of regulations is known as Solvency I, which has specified the solvency margin in the 1990s. Nevertheless, the focus thus far still lies on exactly this solvency margin, meaning the amount of regulatory capital an insurer is obligated to hold against unexpected events. These requirements have been in place since early 70s of the last century and were reviewed again during the 1990s. A limited reform was agreed by the EU-Parliament as well as the Council in 2002, leading to the well known reform, namely Solvency I. Nowadays, Solvency II is somewhat similar to the banking regulations of Basel II, this is why people tend to call it *"Basel for insurers"*. Others, like Schubert et al. (2004), enunciate it formula wise *Solvency II = Basel II + X*, meaning Solvency II will be based on Basel II – but further developed. For example, the proposed framework has in both cases three main pillars or fields, namely pillars 1 to 3. The first one consists of quantitative requirements (e.g., the amount of equity capital an insurance company should hold). The second pillar sets out the necessity for the risk management as well as governance of insurers combined with rules for the effective supervision of insurers. Pillar 3 focuses on requirements concerning disclosure issues and transparency.

As already mentioned, the first pillar outlines quantitative issues. Rules to evaluate the balance sheet are mainly in the focus, especially technical provisions and own funds actually held. The regulatory Solvency Capital Requirement (SCR) can be calculated either by applying a compulsory standard formula or an developed internal model, which has to be accepted by the regulators. Additionally, the Minimum Capital Requirement (MCR) refers to the last threshold for the solvency capital that has to be held. Falling below this lower limit would result in intervention of the authority and may lead to the withdrawal of the undertaking's authorisation. Pillar 2 deals with qualitative requirements for all undertakings and regulatory authorities. Insurers must be able to state their positions concerning risk strategy, an appropriate organisational and operational structure, an internal management and control system as well as their audit function. Regarding the differences between small insurers and global players, the principle of dual proportionality applies accordingly: even though there will not be a “one size fits all”-solution, same principles apply to all undertakings; but in each and every case the applying way must be tailored to the insurer's business model. Additionally, the Supervisory Review Process (SRP) must also be in line with the so-called principle of proportionality as well. The third pillar deals with public and the supervisory disclosure requirements. Gaining in importance are qualitative statements, especially regarding the insurer's strategy, risk management as well as usage of either the prescribed or internal model. Hard facts, like quantitative solvency capital requirements, must be published, too.

Examples to point out the changes of solvency capital requirements might help to understand the *new world order*. Solvency II is supposed to reduce the insurer's risk to be incapable when it comes to customer claims; to absorb costs by policyholders in the case an insurer is unable to meet all claims fully; to implement supervisors early warning so intervention can promptly be made if required equity capital falls below a certain level; and to restore confidence and financial stability of the insurance industry. Many European states (e.g., Germany, Switzerland, etc.) have declared the current minimum requirements for insufficient and have already implemented their own reforms (e.g., MaRisk VA, Swiss Solvency Test, etc.), accordingly leading to a dissatisfactory situation where there is a rag rug of regulatory requirements all across Europe. This definitely puts constraints on developing a standardized Europe-wide market. As a matter of fact, Solvency II is driven with the objective of developing and facilitating a European Single Market in insurance services the EU legislation but not with the price of losing sight regarding consumer protection. To develop new rules of regulation, four quantitative impact studies (QIS 1-4) have already been undertaken, the fifth study will be run between August and mid-November 2010. Participation was voluntarily at all stages, each undertaking business – life, non-life and reinsurance – had to report to their national supervisors before the results were consolidated and evaluated. Methodologies, simulation models and calculations were re-calibrated, developments were taken into account as well as solo results were considered differently as group results, etc.

Nonetheless, the exception proves the rule. France has drawn particular attention to the fact that their local insurance companies have a very different business model. Especially, the French government does not want to lose the insurance companies as investors at the Paris Stock Exchange (Euronext). The companies have the allowance to smoothen their stock investments over several years rather than evaluate them year by year with the implications of depreciations.

Notwithstanding all major upheavals as well as paradigm shift for the insurance industry, Solvency II is useful and necessary together. But which impacts do future regulations have for the customers? Will insurance clients have the same product? As briefly outlined, insurers have to underlay risky investments with equity capital. This has to be done for both interest mismatch and shares. The problem for insurers will be their lack of equity capital, especially for non-life insurers. Their actual option can only be, to reduce risky investments. Consequently, this implies that customers can only expect lower future returns, but with a higher security level. This fact necessitates an appropriate communication strategy to convince the customers to still sign insurance contracts with more safety but less expected return.

Stock Markets: Risk, Return and Economic Fundamentals

We will show by using different asset pricing models (e.g., CCAPM) that future return expectations for European equity markets are biased by two major shocks within the last decade. The low ex-post equity premium mainly seems to be a consequence of these shocks, which have been triggered by bursting asset bubbles.

As already noted, the so-called subprime mortgage crisis has had massive negative effects on global economic growth and has simultaneously pushed down stock prices and government bond yields. Focussing on data from the European Monetary Union (EMU) investors had to witness that the Euro Stoxx 50 – a very popular benchmark for asset managers – fell below the mark of 2.300 points in March 2009 while 10 year government bond yields in Germany dropped to about 3%. After the bursting of the dot-com bubble this was the second stock market crash whilst one decade. Consequently, equity investors hoping for high returns have in general been disappointed since 2001. As a matter of fact, examining the data sample January 1999 to December 2009 the mean stock market return in the EMU was lower than the mean return on German government bonds - still bonds obviously were less risky (figure 1). This period is very popular among financial econometricians in order to avoid possible structural breaks due to the introduction of the Euro in January 1999. The mean return of European stocks (month on month change, M/M) is calculated based on the performance of the Euro Stoxx 50 total return index. Our gauges of the performance of bond investments are the mean returns on the broad REXP and on the REXP 10 years (which only includes German government bonds with a maturity of 10 years). Risk is measured by the standard deviation of returns.

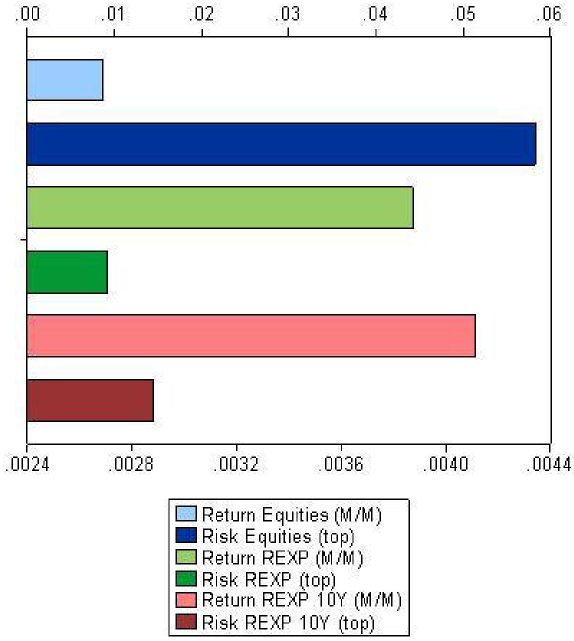


Figure 1: Risk and Return (M/M) – Equities versus Bonds 1999-2009

The results reported in figure 1 may be a major surprise at first sight. However, there is a simple explanation which already has been discussed: Two stock market crashes within the last decade (figure 2 and figure 3).

Figure 2: European Equity Markets

Especially figure 3 illustrates that the dismal performance of stocks has been a consequence of chrashes and bursted bubbles.

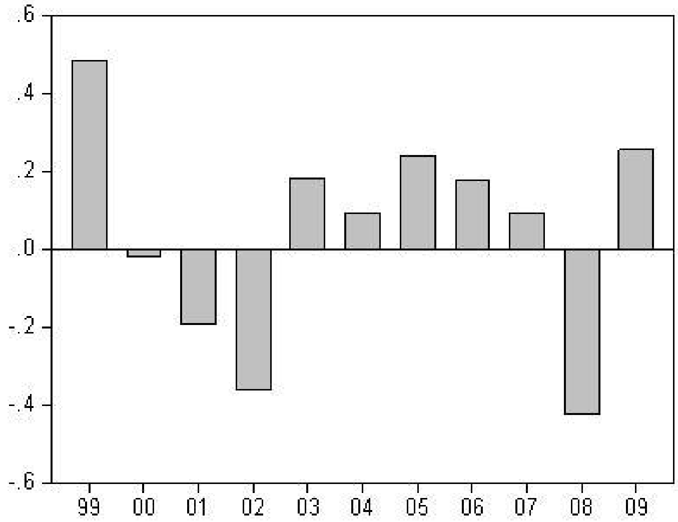


Figure 3: Crashes and Returns as measured by the Euro Stoxx 50

Economic theory does suggest that equity markets are highly volatile so that pronounced drops of share prices are always possible. Therefore, there should be a high risk premium. In fact, analysing long term trends does show that equity returns seem to be too high in order to be explained by some asset pricing models. This is especially true for the consumption based capital asset pricing model (CCAPM), which tries to explain stock returns by the consumption of economic agents. Assuming reasonable levels of risk aversion among economic agents consumption expenditures in the U.S. and other countries are simply not volatile enough to determine stock prices. This is the so-called equity premium puzzle (e.g., Mehra and Prescott 1985, Kocherlakota 1996). Stock market crashes have been suggested to solve this puzzle. However, dramatic events are needed to explain the high return on equities in the last 50 to 200 years (e.g., Rietz 1988, Mehra and Prescott 2003). The two crashes to be observed in the last decade are quite clearly no sufficient solution to the equity premium puzzle.

Taking an empirical perspective Campbell and Cochrane (2000) argued convincingly that the simple Capital Asset Pricing Model (CAPM) performs better than the more complex consumption based asset pricing model. According to the CAPM there is a strong relationship between risk and return. Therefore, investors ought to expect that the ex ante equity premium will be positive. Phrased somewhat differently, the negative ex post equity premium reported in figure 1 most probably is the result of bad luck! Similar discussions took place when the dot-com bubble was about to burst. Diamond (2000), for example, discussed stock market return projections evaluating proposals to reform the U.S. social security system that involved equity investments. He noted that stock prices were relatively high at that point of time and argued that – as a consequence – the assumption of a 7% p.a. real return and a 4% p.a. equity premium seemed to be ambitious. In this study he suggested a number of different possible scenarios favouring a correction that would subsequently allow a 7% real return thereafter.

While the recent historical experience quite clearly does suggest that stock market crashes are a phenomenon of economic relevance most financial economist seem to believe that stock prices in the long run are governed by economic fundamentals. This assumption has recently been challenged by Boldrin and Peralta-Alva (2009). At this point, a model is needed to explain the fundamental value of equities. It is quite usual to note that the level of stock prices today is determined by future expected dividend payouts (e.g., Diamond 2000, Boldrin and Peralta-Alva 2009). More precisely, the present value model predicts that stock prices in period t SPt are given by:

$$SP_t = \sum_{n=1}^{\infty} \frac{E\left(D_{t+n}\right)}{\left(1+R_t\right)^n}$$

where E(·) is the expectations operator, Dt are the dividend payouts in period t and Rt is the required return. In order to use this model to predict stock prices assumptions about future dividend payouts and the required rate of return on equities have to be made. Different assumptions do have major consequences for the resulting "fundamentally" justified stock prices. Most notably, Gordon (1959) suggested assuming that dividends grow at a constant rate g. Combined with the assumption that the required rate of return on equity is also time-invariant this leads to a very simple version of the model:

$$SP_t = \frac{D_t\left(1+g\right)}{R-g}$$

Based on this model Boldrin and Peralta-Alva (2009) have argued that there is no clear tendency of stock prices to revert to the well-established fundamentals in the long run. Analyzing data from the U.S. and using Gordon's version of the present value model they have assumed that R is 7% p.a. and that g is 3%. Their methodology of just comparing the results of the present value of dividend payouts with the market value of equities is simple but very plausible. Noting that the model may miss some short term fluctuations of the stock market they have focused on low frequency movements of stock prices using the Hodrick-Prescott filter. Their results seem to imply that dividends cannot explain the movements of stock prices. This is especially true after 1992. In fact, they have shown that dividend growth did not have a specific trend in the period 1992 to 2008 while stock prices have increased sharply. Following their methodology we examine the European stock market focusing on the post-1992 experience. Our measure of stock market activity is the FTSE Eurotop 100 index which is a modified capitalization weighted index of the 100 most actively traded and highly capitalized stocks in the European equity market. Stock prices and the data on dividends per index share are from Bloomberg. Our results (figure 4) are by far less discouraging. Contrary to the U.S. data set examined by Boldrin and Peralta-Alva (2009) the time series at least seem to follow similar trends.

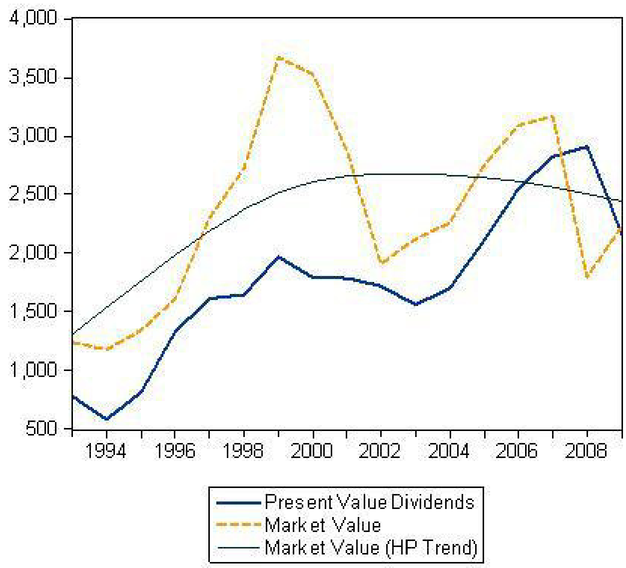


Figure 4: Present Value of Dividends versus Share Prices

At this point it may be helpful to use more sophisticated techniques of time series analysis. In order to do so we examine quarterly data on stock prices and dividends per index share (again focussing on the FTSE Eurotop 100) from 1993/I to 2009/IV. The dividend time series is seasonally adjusted. According to ADF-tests (not reported) both variables seem to be non-stationary and integrated of order one. Given this result, we test for cointegration among dividends and stock prices. By definition, two time series integrated of order one are cointegrated when there is a linear combination of these variables that is stationary. The existence of a cointegration relationship between two time series indicates that the variables share a common stochastic trend and – as a consequence - that there is a close equilibrium relationship between them. In other words, finding empirical evidence for the existence of a cointegration relationship among dividends and stock prices would imply that the market value of equities in the long run is closely linked to the economic fundamentals. The procedure suggested by Johansen (1991) is used to test for cointegration among the variables examined here. This test is based on the econometric technique of vector autoregressions (VAR). Here y is a vector of m possibly non-stationary variables and Ai is a m $\times$ m matrix (with i = 1, … , n):

$$y_t = A_1 y_t - 1 + A_2 y_t - 2 + \ldots + A_n y_t - n + u_t.$$

The error term u_t is assumed to be a serially uncorrelated random variable. Rearranging the equation yields:

$$\Delta y_t = (A_1 - I) y_{t-1} + A_2 y_{t-2} + \ldots + A_n y_{t-n} + u_t,$$

$$\Delta y_t = (A_1 - I)\Delta y_{t-1} + (A_1 + A_2 - I) y_{t-2} + \ldots + A_n y_{t-n} + u_t,$$

$$\Delta y_t = \prod_1 \Delta y_{t-1} + \prod_2 \Delta y_{t-2} + \ldots + \prod y_{t-n} + u_t =$$

$$\sum_{i=1}^{n-1} \prod_i \Delta y_{t-i} + \prod y_{t-n} + u_t,$$

where:

$$\prod_i = -\left(I - \sum_{h=1}^{i} A_h\right),$$

$$\prod = -\left(I - \sum_{i=1}^{n} A_i\right).$$

The rank of the so-called long run impact matrix Π is crucial. In fact, there are k cointegration relationships among the variables examined exist when the rank of the matrix Π is $k < m$. T is the number of observations. Johansen (1991) has suggested two tests to determine the rank of Π. While the trace statistic tests the null hypothesis that there are at most k cointegration relationships the max eigenvalue statistic tests the null hypothesis that the rank (Π) = k is against the alternative that the rank (Π) = k+1:

$$Trace\ Stat = -T \sum_{i=k+1}^{m} \ln(1-\lambda_i),$$

$$Max\ Eigen\ Stat = -T\ \ln(1-\lambda_{k+1}).$$

Including four lags and assuming that the data in levels and the cointegrating equations have linear deterministic trends there is clear evidence for cointegration between the two variables (table 1). We have used the critical values provided by MacKinnon et al. (1999).

Table 1: Testing for Cointegration among Dividends and Stock Prices

Sample (adjusted): 1994Q2 2009Q4

Trend assumption: Linear deterministic trend (restricted)

Lags interval (in first differences): 1 to 4

Trace Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Stat	0.05 Critical Value	Prob.
None *	0.272692	26.97485	25.87211	0.0364
At most 1	0.103957	6.915281	12.51798	0.3534

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Max Eigenvalue Test

Hypothesized No. of CE(s)	Eigenvalue	Max Eigen Stat	0.05 Critical Value	Prob.

None *	0.272692	20.05956	19.38704	0.0399
At most 1	0.103957	6.915281	12.51798	0.3534

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

After estimating the model we have analysed the residuals. A Portmanteau test is not able to reject the null hypothesis of no residual autocorrelation up to 16 lags (p-value 0.2864). This information – which is obviously interesting per se – does also have implications for the number of time lags considered in the model. While there may be some criteria suggesting a higher number of time lags the residuals already seem to be random variables considering only four time lags. This result and the now popular tendency to parsimonious econometric modelling quite clear speak for our model specification. In fact, given the rather limited number of data points available (1993/I to 2009/IV) parsimony is of special importance in order to preserve degrees of freedom. Hargreaves (1994), for example, performed Monte Carlo experiments indicating some difficulties with a small sample bias using the Johansen test procedure with less than 100 data points. However, he has also noted that it is a common practice in applied econometrics to work with sample sizes of about 50 observations.

Summing up, the empirical evidence reported in this section does indicate that stock prices, at least in the long run, are closely linked to the economic fundamentals. This finding does imply that speculative bubbles are the exception rather than the rule. Therefore, past equity returns – which have been depressed by two stock market crashes in the last decade – are not necessarily a good guide to forecast future returns. Phrased somewhat differently, economic agents ought to expect a positive ex ante equity premium for the next ten years. This prediction is also supported by the simple CAPM which postulates the existence of a close relationship between risk and return. In the current market environment – which is characterized by low interest rates – asset managers in the life insurance industry do face the problem that they will not be able to generate attractive returns. This will most probably especially be true in comparisons to fund managers at mutual funds because Solvency II will force life insurers to permanently reduce their exposure to equities. Mutual funds are less constrained. While low equity quotas recently have created no performance problems because of the negative ex post equity premium this will not necessarily be the case in the coming years. Quite to the contrary, there are good reasons to believe that the ex ante equity premium is going to be positive again. In this case asset managers at life insurance companies will most probably not be able to produce as attractive returns as mutual funds. In other words, the characteristics of endowment policies will change in the post Solvency II world. As prescribed by the regulators this financial product will quite clearly generate lower returns – but will also be less risky. Asset managers in the life insurance industry most probably will not be able to solve this problem – so there is some homework to do for the sales and marketing departments!

Marketing the “New” Financial Product

When talking about introducing new products, the academic literature offers theoretical well developed and sometimes also practical proven recommendations how product manager should structure the new product process (e.g., Meffert 2005, Cooper and Edgett 1996). This process involves more or less the following steps:

- idea generation,
- quick and dirty research, which leads to a first “kill or go” decision,
- in-depth market study, which covers both, customer and competitors, and yields in a detailed business case,
- the decision by senior manager to introduce the new product,
- development of prototypes,
- conducting first field trials and refinement of the product,
- validating the final product through preference tests or even test market simulations,
- the “go to launch” decision which leads to the
- final market rollout.

Solvency II will cause life insurers to change their investment policies. This will affect the product endowment life insurance. Considering the situation for endowment policies in the post Solvency II world the situation obviously differs from the new product process discussed above, because steps 1) through 3) are distinct. Phrased somewhat differently, there is no new product but just a significant change to the regulatory environment governing existing life insurance policies. Life insurers are in need to alter their asset allocation according to the new law. Given that interest rates are low this new investment strategy will certainly result in less attractive returns. Describing the situation from a change perspective, the customers in the pre Solvency II world can be classified as investors who want attractive returns at modest levels of risk. But this selection criteria cannot be offered sufficiently by the insurers in the post-Solvency II world By changing the product structure, customers will face a situation with lower returns and, of course, lower risk. Life insurers are consequently confronted with the situation that the product characteristics have changed but not the customer preferences. So the question, which is often day-to-day practice, is "How to sell the "new" product, which has already its main characteristics fixed?" Two strategies will be outlined: First, the shift of customer-preferences and second, targeting right customers.

The well known school of behaviourism (e.g., Watson 1919, Skinner 1971, Zimbardo et al. 2007) developed the basic explanation for most today's advertising campaigns through the stimuli response (SR) model. This SR-Model describes a clear causal structure between the stimuli perceived and the action resulting in open behaviour. Modifying this theory, Woodworth introduced the element of the organism, which describes internal states of the individual that influence the straight S→R connection (see Woodworth 1921). Following this, marketers make use of the so called S-O-R model to describe buying behaviour. The neo-behaviouristic S-O-R model is preferred to other buyer-behaviour models (e.g., Blackwell et al. 2001, Howard and Sheth 1969) because of its less complex but more flexible approach. Elements are the stimulus (S), the organism (O) and the response (R) of the buyer. The stimulus contains marketing (e.g., insurance advertising) and environmental factors (e.g, the breakdown of Lehman Brothers), which are directly observable. Organism describes the influence within the individual human, and helps to explain different outcomes of the same stimuli. The individual preferences

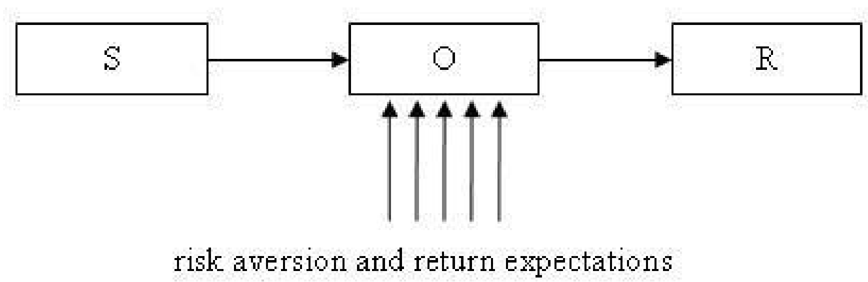


Figure 5: S-O-R Paradigm

which are influenced by, for example, culture, peer groups, education, or risk aversion and return expectations, act as intervening variables for the causal structure S → R. Intervening factors are not direct observable therefore often described as a “Black Box” and known as theoretical constructs. The response is again observable and describes, for example, buying a specific insurance, volume, or fee paid. Using only different advertising to make consumers buy the new insurance product will not be sufficient, because only those with suitable risk aversion and return expectations will match with the post Solvency II endowment policy. Not talking about ethics, a supplier wants to make consumers buy his product. Therefore a shift in consumer preferences, inherent in the organism, is necessary. The agenda for the product manager is not only advertising the endowment policies in the post Solvency II world, it includes also educating the crowd, that the new characteristics are superior which makes the buy a “good deal”. Figure 6 describes this task by showing the needed shift of preferences from a) (pre Solvency II world) to b) (post Solvency II world).

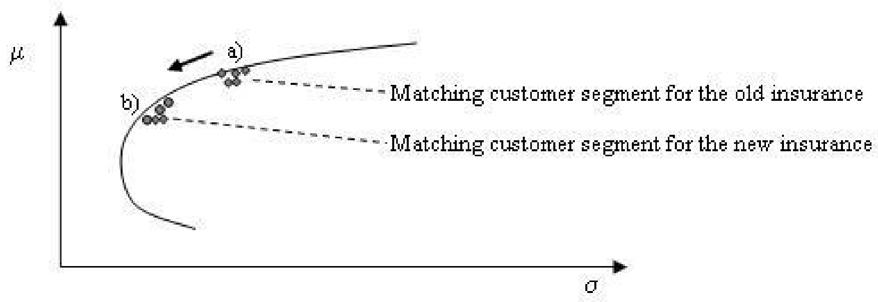


Figure 6: Shift of Preferences

Considering the atmosphere after the peak of the financial crisis, the image of speculative investments is badly damaged and trust seems to be lost (see Gounaris and Prout 2009). On this basis the insurance industry might find a way to change the preferences of the individual organism. Prospect theory shows that the human inherent risk adversity and the predominate insecure economic environment will also support the switch to a more security-wishing investor (e.g., Kahneman and Tversky 1979, Tversky and Kahneman 1992). Practically speaking, day-to-day marketing activities will address consumers’ prudence-oriented values. This will be done by using advisements which focus on investment risk vs. safe insurance opportunities, installing testimonials that recommend a safe investment strategy and at last but not least counselling the customers via well trained sales personnel showing that the new structure of insurance products is well suited for their needs.

But is this strategy made for long term success? First, is there no possibility that the customer’s mental state, reflecting the consequences of losses during the financial crisis, if not self-experienced, at least witnessed via the yellow-press, is only temporary? And after selling the low risk product, which of course are long term contracts including front-up costs for the investor caused by fees, would not there be complaints that the financial industry is still selling the “product of the week”. Finally the insurance industry could again damage its reputation, pushing the post Solvency II product whether it really fits the customer or not, by using manipulative advertising strategies. To avoid this, a second approach will be outlined now. As the first approach does not pay attention to customer heterogeneity, as all investors are receivers of the marketing campaign, the second approach focuses on targeting the right customers. It is characterized by paying attention to the individual preference orientation and works on the investment level of the individual subject, whereas the former approach deals on an aggregated crowd level. Market segmentation is seen as method for identifying different customers groups. Several methods have appeared to build these segments, which require to have intra-segment homogeneity and inter-segment heterogeneity, and will not further be discussed here (see Wedel and Kamakura 2003). The main task is to identify the individual preference structure, classify the customer and consequently find the right product that matches his preferences. But acting like this, only the customers with preferences b) in figure 6 will be addressee of the selling campaign, leaving out customer a). This can be a selling opportunity for other products. But there is already a way out of the dilemma, not having the right product for specific customers. Making use of the Markowitz Model on individual basis financial counsellors can identify the individual risk return preference (see Markowitz 1952). By doing so, the post Solvency II endowment policies can also be sold to customers with a differing risk return preference.

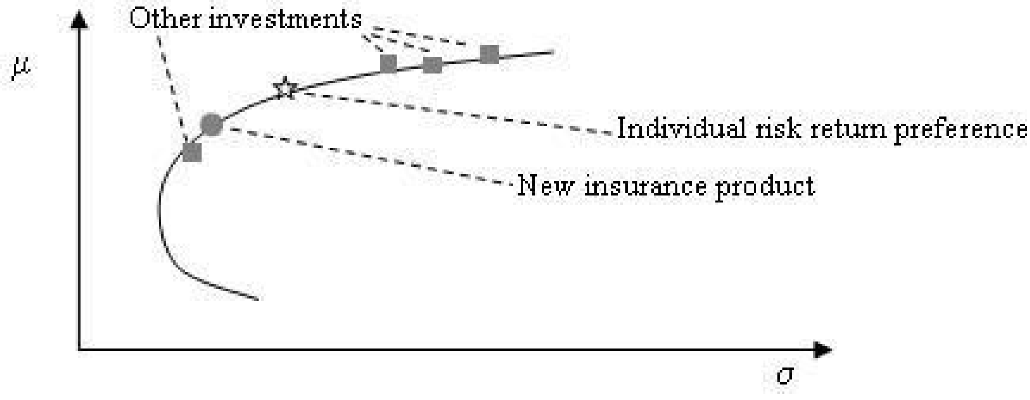


Figure 7: The Individual Investment Portfolio

This of course requires investment in the individual customer relationship, increases counselling effort and needs the generation and provision of individual customer data. The usage of data-mining tools for analysing customer investments can be seen as a good starting point. Integrated financial companies, which sell banking products as well as insurance products, have the advantage of utilizing the customer investment information they already have. Adaption of conjoint measurement methods during individual guidance can be used to identify customer preferences not only for developing new products, but also for segmentation purpose within a financial service setting (DeSarbo et al. 1997, Arias 1996, Teas and Dellva 1985). This preferences can then be utilized to cross check with the actual investment strategies followed by the customer thereby opening opportunities to sell post Solvency II world endowment policies even if they on there own do not fit the customer preferences. This approach is in comparison to the “shift of preferences” a by far more customer oriented approach and promises higher agreement of the investors also in the long run.

Conclusion

Solvency II will change the paradigms of risk and asset management in the European insurance industry. We believe that the new set of regulations will force life insurers to reduce their exposure to equities. This will definitely be a problem for asset managers in insurance companies; in combination with the low level of interest rates to be observed at the moment a permanent reduction to the equity quota will almost certainly result in rather unpleasant returns – especially in comparison to the performance of fund managers at mutual funds who face less constraints investing in equities. Given today's market environment asset mangers in the life insurance most probably will not be able to solve this problem. We think that the life insurance industry will be forced to reposition the product endowment life insurance. This will mainly be the task of the sales and marketing departments. Quite clearly, the European life insurance industry will have to explain to customers that the characteristics of one of its most important products is about to change by deemphasising the factor attractive return and focusing more strongly on the factor low risk. In this paper we have discussed two possible strategies – namely "shifting customer preferences" and "targeting the right customers" – to sell endowment policies in the post Solvency II world. Future studies might have a closer look into customer preferences considering the attributes of post Solvency II products. Further on the comparison between low risk Solvency II insurance products and alternative investment products like investment funds or other capital market oriented offers from a customer viewpoint might give valuable insights to market the new insurance products.

References

Arias, J.: Conjoint-based preferential segmentation in the design of a new financial service *International Journal of Bank Marketing*, 14 (1996), 3, pp. 30–32.

Basse, T. / Friedrich, M.: Solvency II, Asset Liability Management, and the European Bond Market – Theory and Empirical Evidence, *Zeitschrift für die gesamte Versicherungswissenschaft*, 97, (2008), pp. 653-661.

Basse, T. / Friedrich, M. / Schulenburg, J.-M. von der: Solvency II – wirklich ein fataler Irrtum?, *Versicherungswirtschaft*, 63, (2008), pp. 1798-1800.

Blackwell, R. / Miniard, P./ Engel, J.: *Consumer behaviour*, Fort Worth (2001).

Boldrin, M. / Peralta-Alva, A.: What Happened to the U.S. Stock Market? Accounting for the Past 50 Years, *Federal Reserve Bank of St. Louis Review*, 91, (2009), pp. 627-646.

Campbell, J. Y. / Cochrane, J.: Explaining the Poor Performance of Consumption-Based Asset Pricing Models, *Journal of Finance*, 55, (2000), pp. 2863-2878.

Cooper, R. G./ Edgett, S. J.: Critical Success Factors for New Financial Services, *Marketing Management*, 5 (1996), 3, pp. 26-37.

DeSarbo, W. / Ansari, A. / Chintagunta, P. / Himmelberg, C. / Jedidi, K. / Johnson, R.: Representing heterogeneity in consumer response models, *Marketing Letters*, 8 (1997), pp. 335-348.

Diamond, P. A.: What Stock Market Returns to Expect for the Future?, *Social Security Bulletin*, 63, (2000), pp. 38-51.

Gordon, M. J.: Dividends, Earnings and Stock Prices, *Review of Economics and Statistics*, 41, (1959), pp. 99-105.

Gounaris, K. / Prout, M.: Repairing Relationships and Restoring Trust, Behavioral Finance and the Economic Crisis, *Journal of Financial Service Professionals*, 63 (2009), 4, pp. 75-84.

Hargreaves, C.: A Review of Methods of Estimating Cointegration Relationships, *Nonstationary Time Series Analysis and Cointegration*, ed. by C. Hargreaves, Oxford, Oxford University Press, (1994), pp. 87-131.

Howard, J. A./ Sheth, J. N.: *The theory of buyer behaviour*, New York (1969).

Huerta de Soto, J.: The fatal error of Solvency II, *Economic Affairs*, 29 (2), (2009), pp. 74-77.

Johansen, S.: Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, (1991), 59, pp. 1551-1580.

Kahneman, D. / Tversky, A.: Prospect Theory: An Analysis of Decision under Risk, *Econometrica*, 47 (1979), pp. 263-292.

Kocherlakota, N. R.: The equity premium: it's still a puzzle, *Journal of Economic Literature* 34, (1996), pp. 42-71.

Mackinnon, J. / Haug, A. / Michelis, L.: Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration, *Journal of Applied Econometrics*, 14, (1999), pp. 563-577.

Markotwitz, H.: Portfolio Selection, *The Journal of Finance,* 7, (1952), pp. 77-91.

Meffert, H.: Marketing. *Grundlagen marktorientierter Unternehmensführung / Konzepte, Instrumente*, Wiesbaden (2005).

Mehra, R. / Prescott, E. C.: The Equity Premium: A Puzzle, *Journal of Monetary Economics*, 15, (1985), pp. 145-161.

Mehra, R. / Prescott, E. C.: The Equity Premium Puzzle in Retrospect, *Handbook of the Economics of Finance*, ed. by G.M Constantinides, M. Harris and R. Stulz, North Holland, Amsterdam, (2003), pp. 887-936.

Reddemann, S. / Basse, T. / Schulenburg, J.-M. von der: On the Impact of the Financial Crisis on the Dividend Policy of the European Insurance Industry, *The Geneva Papers*, 35, (2010), 53-62.

Rietz, T.A.: The equity risk premium: a solution, *Journal of Monetary Economy*, 22, (1988), pp. 117-131.

Romeike, F. / Erben, R. F. / Müller-Reichart, M.: Management Summary, *Solvency II – Status Quo und Erwartungen,* (2006), 1-8.

Schubert, T. / Grießmann, G.: Solvency II = Basel II + X, *Versicherungswirtschaft,* 59, 18, (2004), 1399-1402.

Skinner, B. F.: Beyond freedom and dignity, New York (1971).

Teas, K. / Dellva, W. L.: Conjoint measurement of consumer's preferences for multiattribute financial services, *Journal of Bank Research,* (1985), 15, pp. 99-112.

Tversky, A. / Kahneman, D.: Advances in prospect theory: cumulative representation of uncertainty, *Journal of Risk and Uncertainty,* (1992), 5, pp. 297-323.

Watson, J. B.: Psychology from the standpoint of a behaviourist, Philadelphia (1919).

Wedel, M. / Kamakura, W. A.: Market segmentation. Conceptual and methodological foundations, Boston (2003).

Woodworth, R. S.: Psychology. A study of mental life, New York (1921).

Zimbardo, P. G. / Gerrig, R. J. / Graf, R.: Psychologie, München (2007).

MODULE 2

Asset management in the German insurance industry: the quality of interest rate forecasts

Published:

Schwarzbach, C. / Kunze, F. / Rudschuck, N. / Windels, T.

Zeitschrift für die gesamte Versicherungswissenschaft 101: 693–703 (2012)

DOI:

https://doi.org/10.1007/s12297-012-0218-y

MODULE 3

Interest rate forecasts in times of financial crisis:
What might be interesting to know?

Published:

Kunze, F. / Kramer, J. / Rudschuck, N.

European Journal of Political Economy 34:45–52 · online first (2013)

DOI:

https://doi.org/10.1016/j.ejpoleco.2013.04.007

MODULE 4

Forecasting GILT Yields with Macro-Economic Variables: Empirical Evidence from the UK

Working paper:

Wegener, C. / Basse, T. / Rudschuck, N.

Touro College Berlin (Department of Management)
Working Paper Series
Working Paper No. 2

Forecasting GILT Yields with Macro-Economic Variables: Empirical Evidence from the UK

Christoph Wegener, Tobias Basse, Norman Rudschuck

Touro College Berlin
Department of Management
Am Rupenhorn 5
14 055 Berlin
Germany

Forecasting GILT Yields with Macro-Economic Variables: Empirical Evidence from the UK

Christoph Wegener[*,†], Tobias Basse[*,‡] and Norman Rudschuck[*,§]

January 31, 2013

Abstract The purpose of this paper is to compare different econometric models regarding their power of forecasting government bond yields from the UK (GILTs). In this context we distinguish between two different basic approaches: The direct approach deals with VAR models while the indirect approach deals with the Nelson-Siegel model and an extension, estimated by Differential Evolution (DE), on the first stage and time series models on the second stage. The predictive accuracy is evaluated by Theil's U and the Diebold-Mariano Test. Firstly, we show that the direct approach is superior to the indirect procedure. Secondly, we show that the predictive accuracy at the short end of the term structure is much better than at the long end within the direct approach. This might be a consequence from the increasing central bank transparency. Thirdly, we show that the predictive accuracy of the direct VAR model relative to the random walk gets poorer with the increasing forecasting horizon. This might be a consequence from the efficient market hypothesis. Thus it is not possible to outperform the market in the long run.

Corresponding Author: Christoph Wegener (christoph.wegener@nordlb.de)

Keywords: Interest Rate Forecasts, Central Bank Transparency, Taylor Rule and VAR

JEL Classification Numbers: E27, E43, E44, G17

[*] Norddeutsche Landesbank Girozentrale, Friedrichswall 10, 30159 Hannover

[†] Institute of Statistics, Leibniz Universität Hannover, Königsworther Platz 1, 30167 Hannover, Germany

[‡] Touro College Berlin, Am Rupenhorn 5, 14055 Berlin, Germany

[§] Institute for Risk and Insurance, Leibniz Universität Hannover, Königsworther Platz 1, 30167 Hannover, Germany

1 Introduction

Academics tended to discuss quite a variety of methods in the past decades regarding their suitability to predict interest rates. This is certainly an effort since capital markets may comply with the conditions of the efficient-market hypothesis in its semi-strong form (see Fama (1998)). This requires that all publicly available information have already factored into prices. In other words, it is not possible to outperform the market in a long period of time without using non-publicly available information.

Nevertheless, the purpose of this paper is to compare different econometric approaches concerning their power of predicting interest rates. The approaches are subdivided into two classes. The direct approach deals with some VAR models while the idea of this approach is to model the interest rates as time series without considering the term structure explicitly. Fauvel et al. (1999) prepared a survey of various time series models in the sense of the direct approach.

The models by Nelson and Siegel (1987) and Svensson (1994) are in the focus of the indirect approach. Quite a number of academic literature referring to this approach exists. For instance Diebold and Li (2006), Diebold, Rudebusch and Arouba (2006), Diebold, Li and Yue (2008), Mönch (2006), de Pooter (2007) and many others considered this approach. The original Nelson-Siegel approach specifies the yield curve for a given time as a non-linear function of the maturities. This function is known to fit poorly for extreme non-linear term structures. Therefore Svensson (1994) extended the Nelson-Siegel model by including an additional term. The approach by Gilli, Grosse and Schumann (2010) is used to calibrate the model parameters using differential evolution (DE). We use multivariate models including macroeconomic variables within both approaches to examine the capability of outperforming the univariate random walk and ARIMA$(p, 1, q)$ models.

The article is structured as follows: Chapter two defines the methodology, the following section describes the data used, the fourth chapter presents the results and the final section concludes.

2 Methodology

2.1 Direct approach

Regardless of whether a direct or an indirect approach is chosen to forecast interest rates, it is essential to investigate some properties of the underlying processes in order to avoid huge and systematic forecast errors. In this context it is very important to distinguish between stationary, trend stationary and difference stationary variables. If stationarity can be attained by differencing d times, the variable is integrated of order d − $I(d)$ − and contains d unit roots. We consider the time series behaviour by the tests proposed by Dickey and Fuller (1979) and Kwiatkowski, Phillips, Schmidt, and Shin (1992).

This section provides two multivariate models to predict interest rates in the context of the direct approach using several macro-economic variables will be used to forecast interest rates. After the seminal paper of Sims (1980), the VAR model became a very popular instrument to analyse the interdependencies between macro-economic variables. Prior to this, mainly large simultaneous equation models were used to investigate economic interrelations. One essential shortcoming of these model is the assumption that certain variables are exogenous in an equation which is often not substantiated by economic theory. In a VAR a classification concerning the exogeneity and endogeneity of the variables is not necessary due to the fact that each variable is regressed on a constant term and on its own p lags and on p lags of any other variable which is included in the model and therefore all variables are a priori endogenous.

Given a vector of K observable variables $y = (y_1, y_2, ..., y_K)'$, equation (1) denotes the corresponding VAR(p) model

$$y_t = \nu + \sum_{j=1}^{p} A_j y_{t-j} + \varepsilon_t \tag{1}$$

with $\nu = (\varphi_1, \varphi_2, ..., \varphi_K)'$ as a $(K \times 1)$ vector of constants or setting $\nu = CD_t$ with $D_t = [1, t]'$

and $C = \begin{pmatrix} \varphi_1, \varphi_2, ..., \varphi_K \\ \delta_1, \delta_2, ..., \delta_K \end{pmatrix}$ one can also deal with deterministic trends. A_j denotes a $(K \times K)$ matrix of coefficients with regard to the lag order p and ε_t is assumed as a vector of white noise innovations with $E[\varepsilon_t] = 0$, $E[\varepsilon_t \varepsilon_t'] = \Sigma_\varepsilon$ and $E[\varepsilon_t \varepsilon_s'] = 0$ for $s \neq t$. Σ_ε is a symmetric positive definite matrix (cf. Hamilton (1994)).

In the case of regressing two independent random walks onto each other, a phenomenon can occur, which is called 'spurious regression'. For $T \to \infty$ the probability of observing a significant relation between these variables converges to one (cf. Granger and Newbold (1974)). However, there might exist cointegration relations between the non-stationary time series. Since the seminal papers of Granger (1981, 1986), Engle and Granger (1987), Stock (1987) and Johansen (1988) the concept of cointegration became an indispensable part in the analysis of time series. A cointegration relation describes a long-term equilibrium $\beta' y_t = z_t$ between K variables which are individually $I(1)$. In this case, the variables share common stochastic trends and there exists a linear combination $\beta' y_t$ of these variables, which is stationary. To associate this with economic theory, one can e.g. think of the Solow growth model (1956), which implies that variables like income and investment grow by the same rate in the long-run steady-state and thus they share a common stochastic trend. The long-run relationship between these variables is stable and deviations from the equilibrium are temporary. To generate a stationary process it would be possible to estimate a VAR in differences (VARD) but this would neglect the long-term relationships. This shortcoming leads to the VECM formulation in equation (2). The VECM can be seen as a VAR model, which includes a variable, the error-correction term, representing the deviations from the long-run equilibrium (see Johansen (1988) and for a discussion of some practical problems working with VECMs see Basse and Reddemann (2010)):

$$\Delta y_t = \Pi y_{t-1} + \nu + \sum_{j=1}^{p-1} \Gamma_i \Delta y_{t-j} + \varepsilon_t \tag{2}$$

with Δy_t as the variables in first differences. $\Pi = \alpha\beta'$ contains the long-run steady-state relation with β denoting the cointegration relation, i.e., the relation between the variables in the long-run equilibrium and the loading matrix α describing the adjustments to this equilibrium and Γ_i captures dynamic adjustment effects of the variables.

To summarise the procedure in the case of the direct approach: First we investigate the trending behaviour of the variables. In the case of $I(1)$-variables we test for cointegration using the procedure by Johansen (1988, 1991). Thereafter we estimate a VARD model respectively a VECM for a rolling window of 100 observations and forecast $h = 1, 2, 4, 8$ steps afterwards. To evaluate the predictive accuracy we use the Theil's U and the Diebold-Mariano Test.

Theil (1966) proposed

$$TU = \sqrt{\frac{\frac{1}{H}\sum_{h=1}^{H}\left(y_{t+h} - \hat{y}_{t+h|t}\right)^2}{\frac{1}{H}\sum_{h=1}^{H}\left(y_{t+h} - \hat{y}^*_{t+h|t}\right)^2}} = \sqrt{\frac{MSE}{MSE^*}} \tag{3}$$

with $\hat{y}^*_{t+h|t}$ as the forecast and MSE^* as the Mean Squared Error of the Random Walk as the benchmark model. However this measures can only give an initial indication of the predictive accuracy since they do not consider their sampling uncertainty. Therefore it is advisable to use tests for further investigations. An often used test of the null hypothesis

$$H_0 : E\left[L\left(\epsilon_{t+h|t}\right)\right] = E\left[L\left(\epsilon^*_{t+h|t}\right)\right] \text{ vs. } H_1 : E\left[L\left(\epsilon_{t+h|t}\right)\right] \neq E\left[L\left(\epsilon^*_{t+h|t}\right)\right]$$

of no difference in prediction accuracy of two forecasts is the test by Diebold and Mariano (1995). $\epsilon^*_{t+h|t}$ and $L(\epsilon_{t+h|t})$ denote the prediction error of the benchmark model and loss function respectively. For instance, popular loss functions are the squared error loss $L\left(\epsilon_{t+h|t}\right) = \left(\epsilon_{t+h|t}\right)^2$ and the absolute error loss $L\left(\epsilon_{t+h|t}\right) = |\epsilon_{t+h|t}|$. The null hypothesis of equal predictive accuracy can also be formulated as $H_0 : E\left(d_h\right) = 0$ with

$d_h = L\left(\epsilon_{t+h|t}\right) - L\left(\epsilon^*_{t+h|t}\right)$ as the loss differential. Therefore the test statistic is given by

$$DM = \frac{\bar{d}_h}{\hat{V}\left(\bar{d}_h\right)} \tag{4}$$

the ratio of the sample mean of d_h and its estimated standard error. It can be shown that $\hat{V}\left(\bar{d}_h\right)$ asymptotically reads

$$\hat{V}\left(\bar{d}_h\right) \approx \frac{1}{H}\left(\hat{\gamma}_0 + 2\sum_{k=1}^{\infty}\hat{\gamma}_k\right) \tag{5}$$

with $\hat{\gamma}_k$ as the autocovariances of d_h. Diebold and Mariano (1995) showed that under the null hypothesis the test statistic is asymptotically standard normal distributed.

2.2 Indirect approach

The focus of this section is the theory of forecasting the term structure of interest rates in the context of the indirect approach. In a first step two procedures are presented to model the term structure. The resulting parameters can be interpreted as level, slope and curvature (see Diebold and Li (2006)). Thereafter, the parameters are understood as time series and hence univariate and multivariate time series models including macro-economic variables are used to forecast them. De Pooter (2007) examined the most popular types of the Nelson-Siegel class of term structure models in the context of their forecasting performance.

Nelson and Siegel (1987) suggested to fit the term structure by a parametric function. Thenceforth quite a number of authors extended the proposal of Nelson and Siegel (1987). Following De Pooter (2007), all different models of this class can in general be captured by the equation

$$Y_t = X_t\beta_t + \varepsilon_t. \tag{6}$$

Y is a vector of yields with respect to time t, $Y_t = [y_t(\tau_1), ..., y_t(\tau_n)]$, which contains N

different maturities. β_t denotes a vector of K factors, X_t a $(N \times K)$ matrix of factor loadings and ε_t a vector of N errors. The following models differ from each other in the number and the composition of the factor loadings.

The idea of Nelson and Siegel (1987) is to approximate the forward curve as

$$f_t(\tau) = \beta_{1,t} + \beta_{2,t} \exp\left(-\frac{\tau}{\lambda_t}\right) + \beta_{3,t}\left(\frac{\tau}{\lambda_t}\right)\exp\left(-\frac{\tau}{\lambda_t}\right) \tag{7}$$

since this equation generates typical tranjectories. To obtain the yield (or spot rate) curve $y_t(\tau)$ from equation (7) it is necessary to take the equally weighted average of the forward rates

$$y_t(\tau) = \frac{1}{\tau}\int_0^\tau f_t(m)dm. \tag{8}$$

In the case of Nelson-Siegel (1987) this leads to

$$y_t(\tau) = \beta_{1,t} + \beta_{2,t}\left[\frac{1-\exp\left(-\frac{\tau}{\lambda_t}\right)}{\frac{\tau}{\lambda_t}}\right] + \beta_{3,t}\left[\frac{1-\exp\left(-\frac{\tau}{\lambda_t}\right)}{\frac{\tau}{\lambda_t}} - \exp\left(-\frac{\tau}{\lambda_t}\right)\right]. \tag{9}$$

The parameters $\beta_{1,t}$, $\beta_{2,t}$, $\beta_{3,t}$ and λ_t have to be estimated. $\beta_{1,t}$ is independent of time to maturity and for that reason it is often interpreted as the long-run yield level. $\beta_{2,t}$ is weighted by a function which depends on the time to maturity τ. This function starts at one and decays exponentially to zero if τ grows. Therefore this part is often denoted as the short-term component. $\beta_{3,t}$ is also weighted by a function depending on τ. This function starts at zero and when τ grows it initially increases and then decreases back to zero. Hence this component creates a hump and so it is often denoted as the medium-term component. Diebold and Li (2006) interpreted $\beta_{1,t}$ as the level, $\beta_{2,t}$ as the slope and $\beta_{3,t}$ as the curvature of the yield curve. λ_t determines the maturity for which the components reach their maxima (see De Pooter (2007)). As mentioned above there exist many of extensions of the Nelson-

Siegel model. The most popular one is the Svensson model (1994). Svensson modeled the forward curve as

$$
\begin{aligned}
f_t(\tau) = {} & \beta_{1,t} + \beta_{2,t} \exp\left(-\frac{\tau}{\lambda_{1,t}}\right) + \beta_{3,t}\left(\frac{\tau}{\lambda_{1,t}}\right)\exp\left(-\frac{\tau}{\lambda_{1,t}}\right) \\
& + \beta_{4,t}\left(\frac{\tau}{\lambda_{2,t}}\right)\exp\left(-\frac{\tau}{\lambda_{2,t}}\right).
\end{aligned} \tag{10}
$$

This leads to the equation

$$
\begin{aligned}
y_t(\tau) = {} & \beta_{1,t} + \beta_{2,t}\left[\frac{1-\exp\left(-\frac{\tau}{\lambda_{1,t}}\right)}{\frac{\tau}{\lambda_{1,t}}}\right] \\
& + \beta_{3,t}\left[\frac{1-\exp\left(-\frac{\tau}{\lambda_{1,t}}\right)}{\frac{\tau}{\lambda_{1,t}}} - \exp\left(-\frac{\tau}{\lambda_{1,t}}\right)\right] \\
& + \beta_{4,t}\left[\frac{1-\exp\left(-\frac{\tau}{\lambda_{2,t}}\right)}{\frac{\tau}{\lambda_{2,t}}} - \exp\left(-\frac{\tau}{\lambda_{2,t}}\right)\right]
\end{aligned} \tag{11}
$$

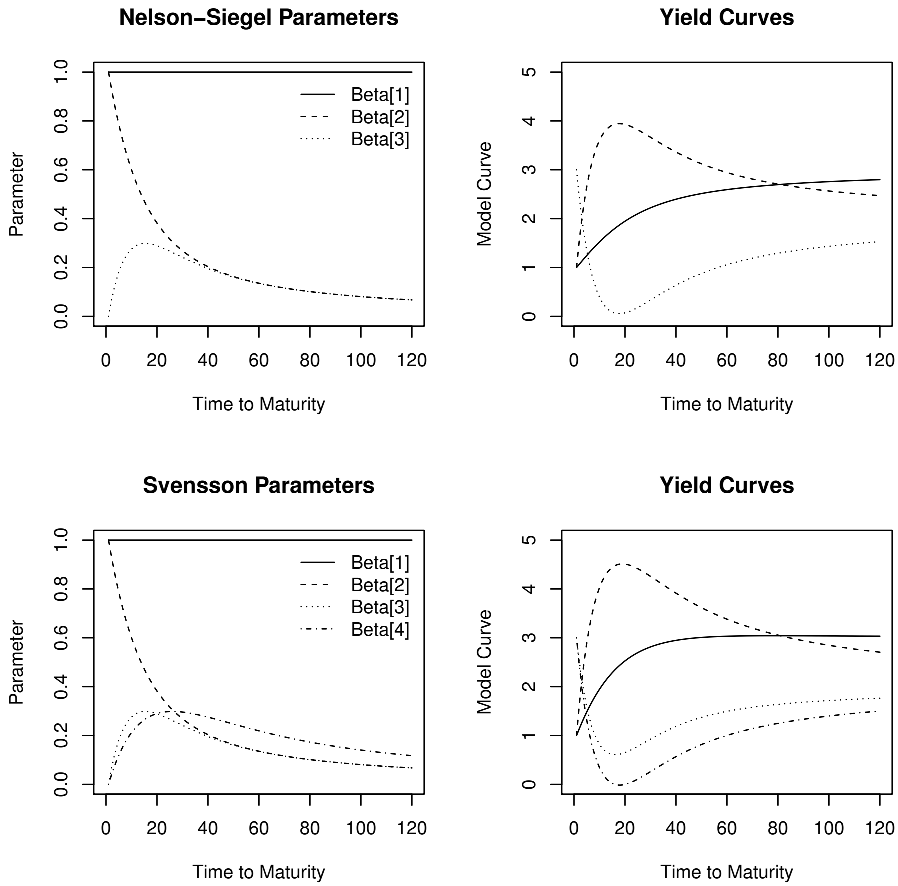
for the yield curve.

If $\lambda_{1,t}$ and $\lambda_{2,t}$ take on similar values a multicolinearity problem arises. In this case only the sum of $\beta_{3,t}$ and $\beta_{4,t}$ can be estimated efficiently.

The trajectories of the factors for an increasing τ and several resulting yield curves are presented in figure 1. It is easy to see that some restrictions must be taken into account to come to a clear economic interpretation. For instance, in the case of Nelson and Siegel (1987) the parameters should be $\beta_{1,t} > 0$ and $\beta_{1,t} + \beta_{2,t} > 0$ to model positive interest rates. Furthermore λ is restricted to $\lambda_t > 0$. The restrictions are very similar in the Svensson model with $\lambda_{1,t} > 0$ and $\lambda_{2,t} > 0$.

De Pooter (2007) pointed out that another multicolinearity problem occurs for very small

Figure 1: Nelson-Siegel and Svensson factor loadings.



or very large values of λ_t. He stated that

$$\lim_{\lambda \downarrow 0} \left[\frac{1-\exp\left(-\frac{\tau}{\lambda_{1,t}}\right)}{\frac{\tau}{\lambda_{1,t}}} \right] = 0 \tag{12}$$

and

$$\lim_{\lambda \downarrow 0} \left[\frac{1-\exp\left(-\frac{\tau}{\lambda_{t}}\right)}{\frac{\tau}{\lambda_{t}}} - \exp\left(-\frac{\tau}{\lambda_t}\right) \right] = 0. \tag{13}$$

This means that in the case of very small λ_t, slope and curvature cannot be identified precisely and thus the estimates take on extreme values.

Beyond he avouched that

$$\lim_{\lambda \to \infty} \left[\frac{1 - \exp\left(-\frac{\tau}{\lambda_{1,t}}\right)}{\frac{\tau}{\lambda_{1,t}}} \right] = 1 \tag{14}$$

and

$$\lim_{\lambda \to \infty} \left[\frac{1 - \exp\left(-\frac{\tau}{\lambda_t}\right)}{\frac{\tau}{\lambda_t}} - \exp\left(-\frac{\tau}{\lambda_t}\right) \right] = 0. \tag{15}$$

So the problem of identification occurs for the curvature. This problem becomes very important if someone wants to forecast the parameters in a two-step approach using time series models due to outliers. Thus, some authors imposed several restrictions on λ_t (see for instance De Pooter (2007) and Gilli, Grosse and Schumann (2010)).

Other variants are for instance the two-factor model by Diebold, Piazzesi and Rudebusch (2005), the three-factor model by Bliss (1997) and the four-factor and five-factor model by Björk and Christensen (1999). The model by Bliss (1997) relaxed the restriction by Nelson and Siegel (1987) and allowed for two different decay parameters $\lambda_{1,t}$ and $\lambda_{2,t}$. However, this paper focuses on the Nelson-Siegel (1987) and the Svensson (1994) models since they are frequently used by academics and practitioners.

Furthermore, there are several ways to calibrate the model parameters. For instance, Nelson and Siegel (1987) fixed λ_t and estimated the $\beta_{i,t}$-values by linear least squares. In the context of this paper, the minimisation problem is given by

$$\min_{\beta,\lambda} \sum \left(y(\tau) - y^M(\tau)\right)^2 \tag{16}$$

subject to the constraints mentioned above to model positve interest rates. $y(\tau)$ describes the model rates and $y^M(\tau)$ the observed rates. This paper follows the approach by Gilli, Grosse and Schumann (2010). They used DE to solve the problem in equation (16). DE is a stochastic, population-based optimisation algorithm for continuous objective functions and was firstly presented by Storn and Price (1997). This procedure can be used to find approximate solutions for problems which cannot be solved analytically.

Gilli, Grosse and Schumann (2010) argued that the problem of term structure estimation is twofold. At first, as mentioned above, a multicollinearity problem occurs in the Svensson model (1994) for similar values of $\lambda_{1,t}$ and $\lambda_{2,t}$. They also pointed out that for several values of λ, the β-coefficients are highly correlated in both models. So they advised to restrict λ_t or $\lambda_{1,t}$ and $\lambda_{2,t}$ to

$$0 \leq \lambda^{NS} \leq 10$$

and to

$$0 \leq \lambda_1^S \leq 2.5 \text{ and } 2.5 \leq \lambda_2^S \leq 5.5$$

respectively.

Second, the authors argued that the problem in (16) is not convex, thus they applied DE. The parameters of the Nelson-Siegel (1987) model are restricted as

$$\begin{aligned} 0 &\leq \beta_1^{NS} \leq 15, \\ -15 &\leq \beta_2^{NS} \leq 30, \\ -30 &\leq \beta_3^{NS} \leq 30 \end{aligned}$$

and the Svensson (1994) coefficients are restricted as

$$0 \leq \beta_1^S \leq 15, -15 \leq \beta_2^S \leq 30,$$

$$-30 \leq \beta_3^S \leq 30, -30 \leq \beta_4^S \leq 30.$$

DE is parameterised as $F = 0.5$, $CR = 0.99$, $NP = 200$ and $G = 600$.

To summarise the procedure in the case of the indirect approach: First we estimate the Svensson parameters by DE (see Storn and Price (1997) for a detailed description of the optimisation algorithm). Thereafter we investigate the trending behaviour of the parameters. In the case of $I(1)$-variables we test for cointegration between the parameters and the macro-economic variables using the procedure by Johansen (1988, 1991). Then we estimate a VARD model respectively a VECM for a rolling window of 100 observations and forecast $h = 1, 2, 4, 8$ steps afterwards. To evaluate the predictive accuracy we use the Theil's U and the Diebold-Mariano Test.

Other authors also considered an one-step state-space procedure (see for instance Diebold, Rudebusch, and Aruoba (2006) and De Pooter (2007)). We focus on the two-step procedure since our preliminary assessments of the predictive accuracy of the one-step approach has been unsatisfactory. Results are not reported to conserve space.

3 Data

As input variables for our model, we have used seven interest rates from short- and middle-term up to long-term maturities as well as two macro-economic variables (Index of Production, the Consumer Prices Index). Our data analysis starts back in 01/1994 and actual data up to 04/2012 are used on monthly basis. The interest rates are as follows: Libor GBP 3 Month as well as 6 Month and Generic United Kingdom government bills and bonds with the duration of 2, 3, 5, 7 and 10 years. The time series are taken from Bloomberg.

As stated before, we included two macro-economic variables: The Consumer Prices Index and the seasonal-adjusted UK Industrial Production. This index provides a timely indicator at constant prices. The Consumer Prices Index (CPI) is the main measure of inflation. Since December 2003 it has been used as inflation target of the Bank of England (2%).

4 Results

First of all we investigate the trending behaviour of the government bond yields and the macro-economic variables.

Table 1: p-values of the unit root tests for the yields and the macrovariables.

	3M	6M	2Y	3Y	5Y	7Y	10Y	IP	CPI
ADF	0.2732	0.3136	0.4697	0.497	0.3854	0.3484	0.5213	0.743	0.99
KPSS short	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
KPSS long	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.013	0.01

Table 1 shows that all variables can be assumed to be $I(1)$. This result is also affirmed by the common literature (e.g., Swanson (1998) and Basse, Friedrich and Kleffner (2012)). Secondly, we investigate the cointegration relations. Table 2 summarises the results of the test procedure by Johansen (1988, 1991). Surprisingly, not more than one cointegration relation can be found. Thus, we assume that the bond yields and the macro-economic variables do not share a common stochastic trend since IP and CPI are cointegrated.

Table 2: Results of the Johansen-Test procedure for the bond yields.

	crit value 5%	3M	6M	2Y	3Y	5Y	7Y	10Y
$r \leq 2$	8.18	3.41	3.48	6.17	6.22	6.22	6.12	6.04
$r \leq 1$	14.90	8.39	7.81	8.69	7.94	7.88	7.82	7.00
$r = 0$	21.07	20.04	19.99	19.28	23.40	24.27	24.55	25.92

Thirdly, we use DE to estimate the yield curve parameters. The procedure leads to a root mean squared error of 0.1173936 for the Nelson-Siegel and of 0.1022366 for the Svensson model. The errors are also reported by figure 3 and figure 4. However, we use both models to predict the bond yields.

Table 3: p-values of the unit root tests for the yield curve parameters.

		β_1	β_2	β_3	β_4	λ_1	λ_2
ADF	Svensson	0.49	0.01	0.01	0.34	0.01	0.01
	Nelson-Siegel	0.56	0.02	0.32		0.15	
KPSS short	Svensson	0.01	0.1	0.1	0.01	0.01	0.1
	Nelson-Siegel	0.01	0.088	0.01		0.1	
KPSS long	Svensson	0.01	0.1	0.1	0.01	0.054	0.1
	Nelson-Siegel	0.01	0.1	0.075		0.1	

Now we investigate the trending behaviour of the model parameters. The lag-length of the unit root tests are determined by the integer of $(n-1)^{\frac{1}{3}}$ in the case of the ADF test, $\frac{3*\sqrt{n}}{13}$ for KPSS short and $\frac{10*\sqrt{n}}{14}$ for KPSS long. n is the number of observations. Table 3 shows that β_1 can be assumend to be $I(1)$. This test result also holds for β_3 in case of Nelson-Siegel respectively for β_4 in the case of the Svensson approach. However the findings of KPSS and ADF differ from each other for β_3 of the Nelson-Siegel model. It is quite clear that at least one term on the right handside of equation (9) is $I(1)$ since the left handside is also $I(1)$. Because the trending behaviour of β_1 is obvious and it is the long term component we concentrate on β_1. Table 4 shows the results and figure 2 shows the parameters as time series.

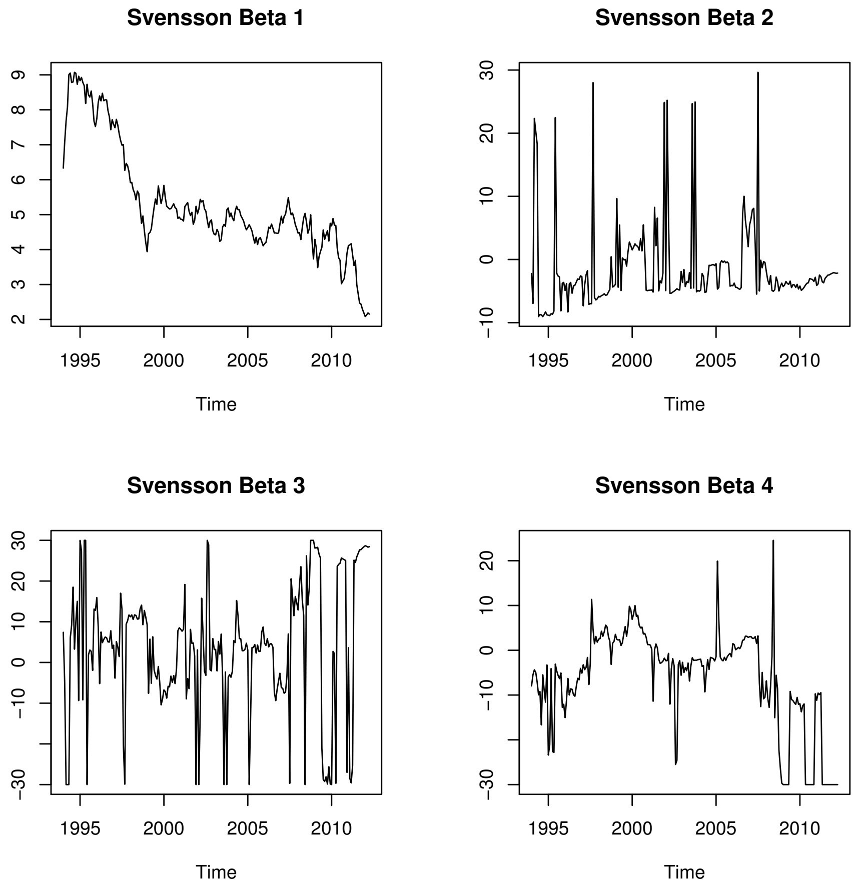
Table 4: Results of the Johansen-Test procedure for the β_1.

	crit value 5%	Nelson-Siegel	Svensson
$r \leq 2$	8.18	6.27	6.20
$r \leq 1$	14.90	6.96	6.73
$r = 0$	21.07	25.56	25.94

Unsurprisingly also β_1 is not cointegrated with the macro-economic variables. After investigating the properties of the data we forecast the bond yields. Within the direct framework we estimate and predict an ARIMA(1,1,0) model as an univariate benchmark beside the random walk. Table 5 shows the results for the best models we investigated. The first line shows the Theil's U and the second line contains the p-value of the Diebold-Mariano Test if Theil's U < 1. To determine the lag-length we also predicted further models with $p = 1, 2, 3, 4, 5$.

In the case of the direct approach we use a VARD(1) model using IP and CPI as macro-economic variables. Despite the fact that the results of the Johansen procedure preclude

Figure 2: The Svensson Betas as time series.



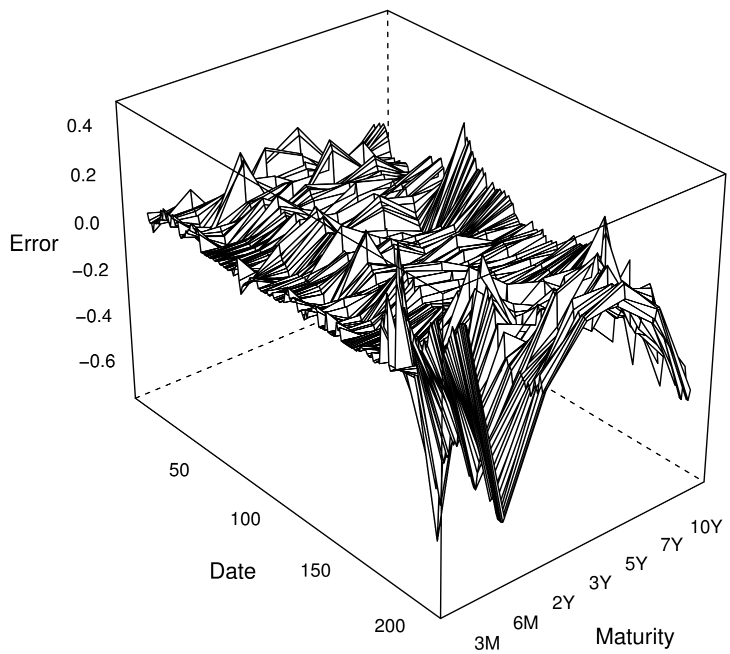
cointegration relation, we used a VECM(2) for completeness. Of course the results of this approach are strictly inferior to the results of the VARD(1). As a benchmark we used an ARIMA(1,1,0) model and also in this case the VARD(1) is superior.

It is equivalent to predict the rates directly using an ARIMA$(0,1,0)$ model or to forecast each Nelson-Siegel or Svensson parameter using ARIMA$(0,1,0)$ models on condition that the term structure model fit is perfect. Thus, on the one hand the indirect approach involves the possibility that one can improve or even deteriorate the predictive accuracy by predicting each parameter by another model. On the other hand the indirect approach involves an important error source on the first stage if the respective model fit is poor. This applies to both, the Nelson-Siegel and the Svensson method.

Table 5: The forecasting results.

h=1	3M	6M	2Y	3Y	5Y	7Y	10Y
ARIMA(1, 1, 0)	0.9829	0.9539	1.0365	1.0229	1.0368	1.0257	1.0310
	(0.8173)	(0.5493)	-	-	-	-	-
VARD(1)	0.6350	0.5568	0.7943	0.7854	0.8413	0.8927	0.9386
	(0.0464)	(0.0567)	(0.0085)	(0.0002)	(0.0002)	(0.0007)	(0.1038)
VARD(1)-RW-NS	1.3620	1.0268	1.1237	1.0705	1.1430	1.0138	1.1192
	-	-	-	-	-	-	-
VARD(1)-RW-S	1.0726	1.0265	1.0242	1.0912	1.2189	1.0033	1.1867
	-	-	-	-	-	-	-
VARD(1)-ARIMA-NS	1.8042	1.5147	1.7072	1.5414	1.3903	1.1492	1.1780
	-	-	-	-	-	-	-
VARD(1)-ARIMA-S	4.4368	6.0469	3.2007	2.3202	1.5666	1.3610	1.6562
	-	-	-	-	-	-	-
VECM(2)	0.9297	0.8915	0.9854	0.9769	0.9938	0.9920	1.0203
	(0.4819)	(0.3288)	(0.8597)	(0.7556)	(0.9274)	(0.8863)	-
h=2	3M	6M	2Y	3Y	5Y	7Y	10Y
ARIMA(1, 1, 0)	1.0499	1.0235	1.0701	1.0079	1.0426	1.0308	1.0392
	-	-	-	-	-	-	-
VARD(1)	0.6879	0.5956	0.8665	0.7854	0.8842	0.9185	0.9607
	(0.1821)	(0.1880)	(0.0343)	(0.0058)	(0.0104)	(0.0236)	(0.2504)
VARD(1)-RW-NS	1.2421	0.9038	1.0960	1.0451	1.0940	1.0178	1.0637
	-	(0.6453)	-	-	-	-	-
VARD(1)-ARIMA-NS	1.4447	1.1186	1.2034	1.1289	1.1451	1.0557	1.0825
	-	-	-	-	-	-	-
VARD(1)-ARIMA-S	3.9394	5.0553	2.9506	2.1531	1.4812	1.3248	1.4951
	-	-	-	-	-	-	-
VECM(2)	0.9470	0.9082	1.0218	1.0037	1.0176	0.9757	1.0181
	(0.5567)	(0.4145)	-	-	-	(0.6836)	-
h=4	3M	6M	2Y	3Y	5Y	7Y	10Y
ARIMA(1, 1, 0)	1.0838	1.0343	1.0252	1.0341	1.0187	1.0222	1.0424
	-	-	-	-	-	-	-
VARD(1)	0.8759	0.8914	0.9459	0.9403	0.9609	0.9892	1.0247
	(0.0596)	(0.1149)	(0.0342)	(0.0136)	(0.0294)	(0.3760)	-
VARD(1)-RW-NS	1.1178	1.0016	1.0641	1.0687	1.0905	1.0169	1.1047
	-	-	-	-	-	-	-
VARD(1)-RW-S	1.0249	0.9870	1.0151	1.0582	1.1155	1.0212	1.1295
	-	(0.7245)	-	-	-	-	-
VARD(1)-ARIMA-NS	1.3192	1.1600	1.0565	1.0625	1.0861	1.0169	1.1000
	-	-	-	-	-	-	-
VARD(1)-ARIMA-S	4.0699	5.3512	2.6060	2.0971	1.5762	1.4398	1.6212
	-	-	-	-	-	-	-
VECM(2)	1.0525	1.0210	1.1065	1.1072	1.0894	1.0591	1.1057
	-	-	-	-	-	-	-
h=8	3M	6M	2Y	3Y	5Y	7Y	10Y
ARIMA(1, 1, 0)	1.2820	1.1743	1.1292	1.0673	1.0359	1.0260	1.0382
	-	-	-	-	-	-	-
VARD(1)	0.7859	0.78095	1.01838	1.0268	1.0171	1.0228	1.0407
	(0.0610)	(0.0812)	-	-	-	-	-
VARD(1)-RW-NS	1.0910	0.9190	1.0793	1.0855	1.1315	1.0356	1.0072
	-	(0.5616)	-	-	-	-	-
VARD(1)-RW-S	1.0048	0.9758	1.0123	1.0758	1.1559	1.0427	1.0051
	-	(0.6023)	-	-	-	-	-
VARD(1)-ARIMA-NS	1.1449	0.9599	0.9836	1.0210	1.0944	1.0107	0.9868
	-	(0.7927)	(0.4562)	-	-	-	(0.6779)
VARD(1)-ARIMA-S	2.8314	3.733	2.2436	1.7669	1.3516	1.1745	1.2362
	-	-	-	-	-	-	-
VECM(2)	1.1420	1.0765	1.2338	1.1905	1.1708	1.1476	1.2175
	-	-	-	-	-	-	-

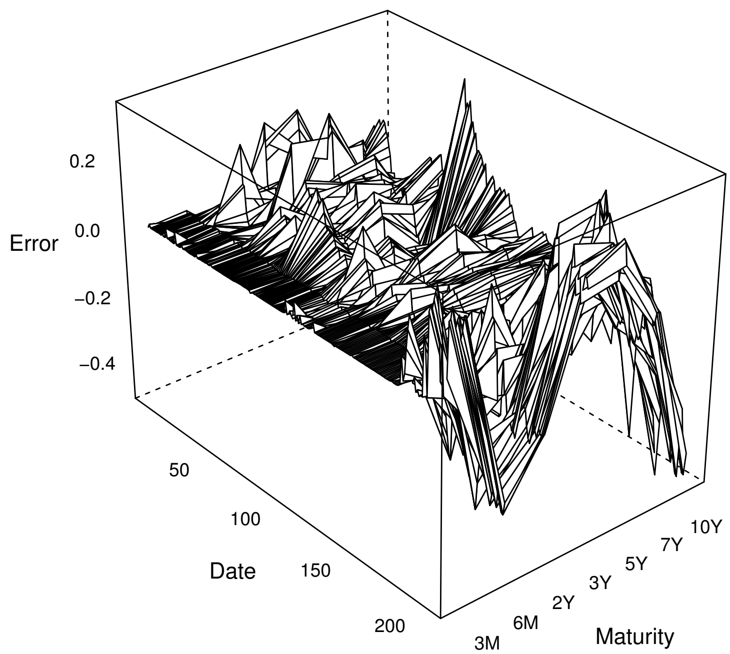
Figure 3: Errors from the Nelson-Siegel model.



However, evaluating the indirect approach leads to relatively huge forecasting errors. VARD(1)-RW-NS and VARD(1)-RW-S describe two models which use a VARD(1) to forecast β_1 in consideration of macro-economic variables and assumes the other parameters to be constant. VARD(1)-ARIMA-NS and VARD(1)-ARIMA-S model β_1 also within a multivariate approach but predict β_2 as an ARIMA(1,0,0) and β_3 as an ARIMA(1,1,0) model in the case of the Nelson-Siegel model. Considering the Svensson model: β_2 and β_3 are predicted by ARIMA(1,0,0) and β_4 is forecasted by ARIMA(1,1,0). The λ is assumed to be constant. None of the models is able to outperform the direct approach.

To summarise the results of the forecasting procedure, the VARD(1) is the best model. Especially for bonds at the short end the VARD(1) works well. Swanson (2004) showed that within the 1990s and early 2000s forecasters from the private sector were better able to predict

Figure 4: Errors from the Svensson model.



the federal funds rate as a consequence of increasing central bank transparency. Middeldorp (2011) confirmed this result. A paper by Neumann and von Hagen (2002) examined the central banks reactions concerning their interest rate policies to changes in inflation and output by estimating VARs and Taylor rules (see Taylor (1993) and Svensson (1999)). The authors showed that inflation targeting matters. With regard to the UK they found empirical evidence indicating that short term interest rate react significantly to shocks to output gaps and inflation. So, with increasing transparency forecasters look behind the scenes and thus they know on which way central banks react on the macro-economic environment. Additionally, given that a data driven forecasting approach is used here, transparency also forces central bankers to more strongly adhere to the prespecified principles of monetary policy. This might be one explanation for the great predictive accuracy at the short end of the term structure since we used IP and CPI as macro-economic variables. This feature seems to get lost in the indirect framework. Another interesting fact is that the predictive accuracy of the direct VAR model relative to the random walk gets poorer with the increasing forecasting horizon. This might be a consequence from the efficient market hypothesis that one cannot outperform the market in the long run.

5 Conclusion

Obviously, none of the methods examined here should be understood as a 'crystal ball' able to produce perfect forecasts. Whether one of the models is capable to outperform the market has to be determined using trading strategies based on the predictions. So the question whether the efficient-market hypothesis holds clearly remains open. The fact that multivariate models within the direct approach are superior to the univariate models suggests that considering fundamental data is important to predict interest rates. It is also obvious that important information get lost by predicting within the indirect approach. Furthermore the examinations of this paper can be extended in a number of ways. First of all the predictive accuracy was detected using Theil's U and the Diebold-Mariano test. It is appropriate to use additional methods to study the out-of-sample performance of the models in more detail. Further investigations should consider the relationship between the variables using impulse response functions or Granger-Causality tests. Particularly the relationship between predictive accuracy and increasing central bank transparency should by examined in more detail. The Bank of England is one of the pioneers concerning increasing transparence. Thus, structural break analysis using data from the UK is appropriate to examine the relationship between transparency and predictive accuracy.

References

T. Basse, M. Friedrich, and A. Kleffner. Italian government debt and sovereign credit risk: an empirical exploration and some thoughts about consequences for european insurers. *Zeitschrift für die gesamte Versicherungswissenschaft*, 101:1–9, 2012.

T. Basse and S. Reddemann. Variable-ordering induced problems of impulse-response analysis and other difficulties: the dividend policy of austrian firms. *International Journal of Computational Economics and Econometrics*, 1:278–293, 2010.

T. Björk and B. Christensen. Interest rate dynamics and consistent forward rate curves. *Mathematical Finance*, 9:323–348, 1999.

R.R. Bliss. Testing term structure estimation methods. *Advances in Futures and Options Research*, 9:197–231, 1997.

M. De Pooter. Examining the nelson-siegel class of term structure models: In-sample fit versus out-of-sample forecasting performance. Tinbergen Institute Discussion Paper 2007-043/4, 2007.

D.A. Dickey and W.A. Fuller. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74:427–431, 1979.

F.X. Diebold and C. Li. Forecasting the term structure of government bond yields. *Journal of Econometrics*, 130:337–364, 2006.

F.X. Diebold, C. Li, and V.Z. Yue. Global yield curve dynamics and interactions: A dynamic nelson-siegel approach. *Journal of Econometrics*, 146:351–363, 2008.

F.X. Diebold and R.S. Mariano. Comparing predictive accuracy. *Journal of Business and Economic Statistics*, 13:253–265, 1995.

F.X. Diebold, M. Piazzesi, and G.D. Rudebusch. Modeling bond yields in finance and macroeconomics. *American Economic Review*, 95:415–420, 2005.

F.X. Diebold, G.D. Rudebusch, and S.B. Aruoba. The macroeconomy and the yield curve: a dynamic latent factor approach. *Journal of econometrics*, 131(1):309–338, 2006.

R.F. Engle and C.W.J. Granger. Co-integration and error correction: representation, estimation, and testing. *Econometrica*, 55:251–276, 1987.

E.F. Fama. Market efficiency, long-term returns, and behavioral finance. *Journal of financial economics*, 49:283–306, 1998.

Y. Fauvel, A. Paquet, and C. Zimmermann. A survey on interest rate forecasting. Cahiers de recherche CREFE / CREFE Working Papers 87, CREFE, Universite du Quebec a Montreal, 1999.

M. Gilli, S. Grosse, and E. Schumann. Calibrating the nelson-siegel-svensson model. COMISEF Working Paper Series 31, 2010.

C.W.J. Granger. Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, 16:121–130, 1981.

C.W.J. Granger. Developments in the study of cointegrated economic variables. *Oxford Bulletin of Economics and Statistics*, 48:213–228, 1986.

C.W.J. Granger and P. Newbold. Spurious regressions in econometrics. *Journal of Econometrics*, 2:111–120, 1974.

J.D. Hamilton. *Time Series Analysis*. Princeton University Press, Princeton, 1994.

S. Johansen. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12:231–254, 1988.

S. Johansen. Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica*, 59:1551–1580, 1991.

D. Kwiatkowski, P.C.B. Phillips, P. Schmidt, and Y. Shin. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, 54:159–178, 1992.

M. Middeldorp. Central bank transparency, the accuracy of professional forecasts, and interest rate volatility. *FRB of New York Staff Report*, (496), 2011.

E. Mönch. Term structure surprises: The predictive content of curvature, level, and slope. *Journal of Applied Econometrics*, 2010.

C.R. Nelson and A.F. Siegel. Parsimonious modeling of yield curves. *Journal of Business*, 60:473–489, 1987.

M.J.M. Neumann and J. von Hagen. Does inflation targeting matter? *Federal Reserve Bank of St. Louis Review*, 84(4):127–148, 2002.

C.A. Sims. Macroeconomics and reality. *Econometrica*, 48:1–48, 1980.

R. Solow. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70:65–94, 1956.

J.H. Stock. Asymptotic properties of least squares estimators of cointegrating vectors. *Econometrica*, 55:1035–1056, 1987.

R. Storn and K. Price. Differential evolution - a simple and efficient heuristic for global optimization over continuous space. *Journal of Global Optimization*, 11:341–359, 1997.

L.E.O. Svensson. Estimating and interpreting forward interest rates: Sweden 1992-1994. NBER Working Paper 4871, 1994.

L.E.O. Svensson. Inflation targeting as a monetary policy rule. *Journal of Monetary Economics*, 43(3):607–654, 1999.

E. Swanson. Federal reserve transparency and financial market forecasts of short-term interest rates. *Finance and Economics Discussion Series*, (2004-6), 2004.

N.R. Swanson. Money and output viewed through a rolling window. *Journal of Monetary Economics*, 41:455–474, 1998.

J.B. Taylor. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39:195–214, 1993.

H. Theil. *Applied economic forecasting*. North-Holland Pub. Co., 1966.

MODULE 5

Stock investments for German life insurers in the current low interest environment: more homework to do

Published:

Schwarzbach, C. / Kunze, F. / Rudschuck, N. / Windels, T.

Zeitschrift für die gesamte Versicherungswissenschaft 103: 45–63 (2014)

DOI:

https://doi.org/10.1007/s12297-013-0258-y

MODULE 6

EMU Sovereign and Sub-sovereign Bonds, the Euro Crisis and the ECB – New Insights for Asset Managers in the Life Insurance Industry

Working Paper:

Rudschuck, N. / Kunze, F. / Windels, T.

EMU Sovereign and Sub-Sovereign Bonds, the Euro Crisis and the ECB – New Insights for Asset Managers in the Life Insurance Industry

Abstract

Given the requirements in the context of Solvency II, interest bearing bonds are important elements of the ALM process of life insurers. This article investigates the possible influences of recent ECB monetary policy instruments on sovereign and sub-sovereign bond yields. We aim to shed light on the question of whether the Public Sector Purchase Program (PSPP) has distorted not only government bond yields but also the pricing of AAA sub-sovereigns within the Eurozone. We find clear evidence of changes in the converging behavior of EMU government bond yields. In addition, since the scarcity of bonds forced the ECB to extend the bond-buying even to supranationals, development agencies and sub-sovereigns like German Bundeslaender or French, Spanish and Belgian regions, the Expanded Asset Purchase Program (EAPP) can be seen as a reaction to the European debt crisis and the failure of the ECB's aim to fulfill the inflation target.

JEL classification: C15, E52, E58, G12, H63.

Keywords: Sovereign Debt Crisis, Sovereign Credit Risk, Monetary Policy, Central Banking, Bond Interest Rates.

Corresponding author: Norman Rudschuck, NORD/LB Norddeutsche Landesbank Girozentrale and Leibniz University of Hanover
Mail: norman.rudschuck@nordlb.de Friedrichswall 10, 30159 Hannover, Germany; Phone: 0049 511 361 6627

Frederik Kunze, NORD/LB Norddeutsche Landesbank Girozentrale and Georg-August-University of Göttingen
Mail: frederik.kunze@nordlb.de Phone: 0049 511 361 5380

Torsten Windels, Chief Economist of NORD/LB Norddeutsche Landesbank Girozentrale
Mail: torsten.windels@nordlb.de Phone: 0049 511 361 2008

1. Introduction

The global financial crisis and the preceding Economic and Monetary Union (EMU) sovereign debt crisis had severe consequences for financial market participants. This is especially true for asset managers in the life insurance industry. In the early years of the common currency area, country-specific risk factors (e.g. sovereign credit risk and redenomination risk) were not major issues for portfolio managers. However, the global financial crisis and the preceding sovereign debt crisis led to a re-emergence of these risk factors. One major consequence of these developments was rising EMU government bond yields in the countries mostly affected by the crisis (see, for example, Gómez-Puig and Sosvilla-Rivero, 2013, Basse, 2014, as well as Sibbertsen et al., 2014).

At the peak of the EMU sovereign debt crisis, international rescue mechanisms were built up and coordinated by the International Monetary Fund (IMF) and newly-established supranational institutions like the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM). In addition, the ECB's monetary policy has significantly changed. On July 26 2012, European Central Bank (ECB) President Mario Draghi said the now-famous sentence "Whatever it takes to preserve the euro" (see ECB, 2012). About three years later, in 2015, a purchase program of EUR 60bn started to underpin the words with injected money (see ECB, 2015). It is now intended to be in place until at least the end of 2017 (see, for example, Eser and Schwab, 2016). One consequence of this coordinated adjustment of the ECB's monetary policy framework is the current low interest rate environment (see, for example, Gerlach and Lewis, 2014 as well as Fratzscher et al., 2016).

Hence, asset managers in the life insurance industry have to deal with the re-emergence of risks in the EMU sovereign bond market, a low interest rate environment and the uncertainty regarding the future outlook of interest rates (see, for example, Belongia, 1987 and more recently Kunze et al., 2013, Rodriguez et al., 2017, as well as Kunze et al. 2017). This environment is especially challenging for German life insurers, since German interest rates are extremely low as a consequence of both the ECB's monetary policy and flight-to-quality effects (see, for example, Brand et al., 2010 as well Ehrmann and Fratzscher, 2017). Furthermore, Solvency II influences the insuers' demand for long-term bonds (see Basse and Friedrich, 2008), because investments in alternative asset classes – for example, stock markets (see Schwarzbach et al., 2014) – are restricted by regulators, asset managers have been seeking substitutes in other segments of the government bond markets. In this context, sub-sovereign bonds with low credit risk but comparably high yields have to be seen as an attractive alternative (see, for example, Mitze and Matz, 2015 as well as Bellot et al., 2016). Addtionally, the reemergence of redenomination risk in the course of the EMU debt crisis (see, for example, Rodriguez et al., 2017) raises the relative attractivenesse of sub-sovereign bonds. However, EMU sub-sovereign bond markets do not seem to be independent from EMU government bond markets (see, for example, Beck et al., 2016).

As asset managers have to manage assets and liabilities in the long run, we are not looking at overnight rates – as did Beckmann et al. (2013) – to investigate the interest rate pass-through from money market rates to various loan rates in EMU countries. The purpose of this paper is to investigate long-term EMU government bond yields from the perspective of asset managers in the German life insurance industry, focusing on the ECB's monetary policy framework. For this purpose, we test for long-term relationships between 10Y government bond yields in Germany and Ireland, Germany and Portugal, Germany and Finland, as well as Germany and Belgium. Due to the relevance of the sub-sovereign bond market in the context of our paper, we will additionally investigate the relationship between 10Y government bond yields and 10Y bond yields of AAA rate EMU regions. Furthermore, by investigating the spreads between the relevant time series, we are able to assess the hypothesis that the most recent measures of the ECB have had a substantial impact on the EMU government and EMU sub-sovereign bond markets, respectively.

The remainder of the paper is structured as follows. After presenting the relevant literature in chapter 2, the third chapter describes the ECB's recent monetary policy. The following section describes the dimensions of the EMU sovereign bond market, before the fifth chapter highlights the scale of the German sub-sovereign bond market. Chapter 6 describes the data used, methodological issues and provides an initial empirical analysis. In chapter 7, we present the empirical evidences, before the final chapter concludes the elaboration.

2. Literature Overview

Several authors have already examined the movements of yields in the context of the EMU debt crisis. For example, Afonso and Rault (2015) examined the short- and long-run behavior of long-term sovereign bond yields in OECD countries, while Afonso and Leal (2017) analyzed the importance of political and economic determinants as explanatory factors in sovereign bond yield spreads. The methodological approaches to examining the characteristics of bond yields in recent literature are broad-ranging: from adapting panel cointegration approaches for incorporating structural breaks into the analysis (Constantinia et al., 2014) to using the Merton model for decomposing corporate bond spreads into different components (Dötz, 2014) and computing bivariate time-varying coefficient models for different determinants (Afonso and Jalles, 2015), the approaches widely vary.

Looking at Solvency II, European insurance and reinsurance undertakings are facing a new regulatory framework. Under the pillar 1 standard formula, sovereign debt of European Union (EU) member states is treated as risk-free. Ludwig (2014) examines the validity of this assumption for 26 EU member states. Besides evidences for the convergence of government bond yields of several countries – with the yields of a risk-free asset – he gives a detailed discussion of regime shifts in relation to European bond market integration. Eling et al. (2007) pointed out that as early as in the 1970s, EU member countries implemented rules to coordinate insurance markets and regulation. However, with a generalised single EU market, financial services regulation has taken on new meaning and priority. The creation of risk-based capital standards, the main focus of Solvency II, will determine the exact form of capital regulation. O'Brien (2010) has looked deeper into the problem of low probability events combining insurance regulation and the global financial crisis.

Höring (2013) has stated that the European insurance industry is among the largest institutional investors in Europe. Therefore, major reallocations in their investment portfolios due to the new risk-based economic capital requirements introduced by Solvency II would cause significant disruptions in European capital markets and corporate financing. By giving a counterpoint, Höring (2013) see in Solvency II no binding capital constraint for market risk and thus would not significantly influence the insurance companies' investment strategies.

As the euro was introduced as book money on January 1, 1999, all literature regarding EMU states and government bond yield spreads is somewhat recent. Klepsch and Wolmershäuser (2011) used a dynamic panel regression approach to show that before the outbreak of the financial crisis investors generally ignored fundamental sovereign bond risk factors. Dötz and Fischer (2010) presented an approach for analyzing the EMU sovereign bond spreads based on a GARCH-in-mean model originally used in the exchange rate target zone literature. Therefore, spreads are decomposed into a risk premium, an expected loss component and a liquidity premium. Time-varying default probabilities are derived. The results of the authors hold strong relevance in the context of our paper, because they suggest that the rise in sovereign spreads during the recent financial crisis mainly reflects an increased expected loss component.

In addition, Dötz and Fischer (2010) found that the rescue of Bear Stearns in March 2008 seemed to mark a change in the market perceptions of sovereign bond risk, whereby the government bonds of some countries lost their previous role as a safe haven. Since volatility reflects the extent to which the market evaluates the arrival of new information and provides useful insights into the dynamics of EMU sovereign debt markets, Fernandez-Rodriguez et al. (2015) analyzed their spillovers using a measure proposed by Diebold and Yilmaz (2012). For this purpose, it is determined whether core or non-core/peripheral markets present differences both before and during the crisis periods: these classifications are also relevant for our analysis presented below. More than half of the total variance of the forecast errors is explained by shocks across countries rather than by idiosyncratic shocks. Besides, they provide further support to the idea that during the pre-crisis period most of the triggers in the volatility spillovers were central countries – peripheral countries imported credibility from them – while during the crisis peripheral countries became the dominant transmitters. They offer a detailed empirical investigation of the EMU sovereign debt crisis.

Arghyrou and Kontonikas (2012) found a shift in market pricing behavior from a 'convergence-trade' model before August 2007 to one driven by macro-fundamentals and international risk thereafter. They also found evidence of contagion effects, particularly among EMU periphery countries. The EMU debt crisis is divided into an early and current crisis period. Leschinski and Bertram (2017) analyzed the time-varying behavior of pure contagion effects between EMU government bond spreads before and during the subprime mortgage crisis and the EMU debt crisis. First, the main sources of pure contagion in the later phase of the EMU debt crisis appear to be Italy and Spain. According to them, substantial contagion effects among EMU government bond spreads (caused by Ireland and Portugal) had already arisen during the subprime mortgage crisis and not only during the EMU debt crisis, as one might have had expected. This is even true for the evidence of our break point tests as well, which we will discuss later.

Singh et al. (2016) attempted to identify and trace inter-linkages between sovereign and banking risk for each main country in the euro area. They applied a dynamic approach to test for Granger causality between the two measures of risk in each country to check for episodes of significant and abrupt increases in short-run causal linkages. The empirical results indicate that episodes of causality intensification vary considerably in both directions over time and across the different EMU countries. The directionality suggests the presence of causality intensification, mainly from banks to sovereigns in crisis periods. Afonso and Jalles (2017) produced results that advanced economies become more fiscally sustainable if they contract a higher share of long-term public debt, if more debt is held by the central bank or if it is easily marketable in capital markets. Giordano and Pericoli (2013) examined investors' increased attention to the variables that ultimately determine the creditworthiness of a sovereign borrower (wake-up-call contagion) and behavior not linked to fundamentals (pure contagion).

This not only holds true for the very young common currency, but also for recent ECB measures undertaken. Indeed, launched in summer 2012, the ECB's Outright Monetary Transactions (OMT) program indirectly recapitalized European banks through its positive impact on periphery sovereign bonds (see Acharya et al., 2017). Ehrmann and Fratzscher (2017) saw that a flight to quality was present at the height of the crisis but largely dissipated after the ECB's OMT program was announced. At the same time, Italy and Spain became more interdependent. This suggests that countries have been effectively ring-fenced, and Italy and Spain benefited from the joint reduction in yields following the OMT announcement. Furthermore, they found that euro-area government bond markets were well integrated prior to the crisis but saw a substantial fragmentation from 2010 onwards.

Regarding the implications of the EMU sovereign debt crisis there, by comparison no much literature exists dealing with the market segment of sub-sovereign bonds. Bellot et al. (2016) have recently highlighted the importance of research in this field, owing to the relevance for the region's capital cost. Lemmen (1999), Heppke-Falk and Wolff (2008) as well as Jenkner and Lu (2014) drew attention to possible bail-outs in fiscal federations and the risk premia on sub-national credit risk.

In relation to the scope of this paper, the work by Beck et al. (2016) focuses on the drivers of sub-sovereign bond yield spreads. However, they mainly investigate the extent to which these spreads are influenced by bailout expectations and investors' risk-seeking behavior. Covering various economic areas being subject to a broad range of characteristics allows them to confirm the general relationship between sub-sovereign bond yield spreads and both sub-sovereign debt levels relative to GDP and global risk aversion. Moreover, they present evidence of a break-down of the positive relationship between debt levels and risk premia when certain thresholds of sub-sovereign government debt are passed. Using data samples for both EMU sovereign and EMU sub-sovereign bonds, we want to add to both strands of literature, focusing on the applied applications for portfolio managers with a long-term investment horizon.

3. The ECB and their Unconventional Purchase Programs

According to the ECB, its primary objective of the monetary policy is to maintain price stability. The ECB aims at inflation rates of below – but close to – 2% over the medium term (see ECB, 2003).

Inflation refers to a general increase in consumer prices and is measured by an index that has been matched across all EU Member States, the Harmonized Index of Consumer Prices (HICP). This is the measure of inflation that the ECB's Governing Council uses to define and assess price stability in the euro area as a whole in quantitative terms (see ECB, 1998).

The operational framework of the Eurosystem comprises several instruments, namely open market operations, standing facilities and minimum reserve requirements for credit institutions. In addition, since 2009 the ECB has implemented several non-standard monetary policy measures – i.e. asset purchase programs – to complement the regular operations of the Eurosystem (see ECB, 2017), which we call "unorthodox actions".

At almost at the same time when the Federal Reserve Bank in the United States started their unconventional measures (Quantitative Easing, QE1-3), the ECB started to buy Covered Bonds under their first Purchase Program (CBPP) in July 2009. It enfolded to EUR 60bn to recapitalize banks. A second program (CBPP2) started in November 2012 and was supposed to involve another EUR 40bn, although it never grew that strong. In October 2014, CBPP3 started more than a year earlier than our main focus in this paper, namely the buying of public local or regional debt, respectively.

On January 22, 2015, the ECB introduced the PSPP, under which the Eurosystem started to buy sovereign bonds from euro-area governments and securities from European institutions (like EFSF, ESM or EIB) and national agencies (like German KfW, French Unédic or Spanish ICO) in March 2015. The PSPP started with the amount of EUR 60bn per month (see ECB, 2015).

On December 3, 2015, ECB president Mario Draghi announced an extension of the program: while it was initially foreseen to last until at least September 2016, it was extended until at least March 2017 for the time being. Additionally, regional and local government bonds were added to the list of eligible assets for purchase. Especially the German sub-sovereign market exceeds EUR 330bn. Therefore, it is larger and more liquid than the market for some EMU countries, namely Finland, Ireland or Portugal.

For the sake of completeness, the Eurosystem started to buy corporate sector bonds under the Corporate Sector Purchase Program (CSPP) on June 8, 2016. The measure helps to further strengthen the pass-through of the Eurosystem's asset purchases to financing conditions of the real economy and – in conjunction with the other non-standard monetary policy measures in place – provides further monetary policy accommodation.

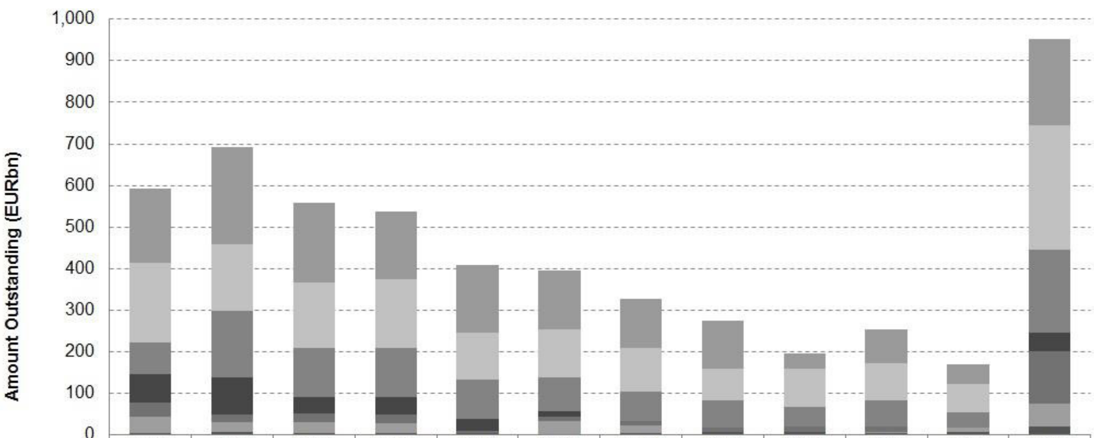
The Expanded Asset Purchase Program (EAPP) now included all purchase programs under which private sector securities and public sector securities are purchased to address the risks of an overly-prolonged period of low inflation. It comprises the third Covered Bond Purchase Program (CBPP3), Asset-Backed Securities Purchase Program (ABSPP), Corporate Sector Purchase Program (CSPP) and Public Sector Purchase Program (PSPP).

From March 2015 until March 2016, the average monthly pace was EUR 60bn, while from April 2016 until March 2017 the average monthly pace was EUR 80bn. Since April 2017, the monthly amount has been reduced to the original size of EUR 60bn and is expected to last until at least the end of 2017. Thereafter expectations suggest that a tapering or so-called "phasing out" will take place to reduce the monthly amount slowly to zero.

4. The Dimensions of the EMU Sovereign Bond Market

With a GDP of more than EUR 10,500bn, the Eurozone is the world's second largest currency area after the USA, closely followed by China. The euro was introduced as a book currency with eleven accession countries on January 1, 1999 in accordance with article 136 et seq. of the Treaty on the Functioning of the European Union. The euro has also been the official means of payment in cash transactions since January 1, 2002. The Eurozone has existed in its present total of nineteen countries since January 1, 2015.

The creation of a single euro bond market was only made possible through the introduction of the single currency. However, nation states still act as issuers because they have retained responsibility for fiscal policy. The current situation is that investors in European sovereign bonds – like German asset managers of insurance companies – resort to the respective bonds offered by national treasuries or financial agencies. Italy is the largest issuer, ahead of France, Germany and Spain.



	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	>2027
Italy	176.9	233.2	190.9	162.3	164.0	142.7	117.0	114.4	37.8	80.1	46.6	208.5
France	192.9	162.7	157.2	165.4	113.6	115.9	106.5	77.0	92.4	91.6	66.6	298.7
Germany	77.0	160.0	118.0	118.0	94.0	80.0	70.0	64.3	46.0	62.0	37.2	198.5
Spain	66.8	87.2	40.5	42.2	29.0	13.5	0.0	0.0	0.0	0.0	0.0	44.6
Periphery	35.7	19.3	21.8	21.2	4.2	11.3	9.5	12.3	14.4	14.2	1.6	126.9
Core	38.4	23.8	26.3	21.9	0.2	31.9	20.0	0.6	0.3	0.0	10.5	55.1
CEE	4.5	7.1	3.6	5.8	5.2	1.4	4.4	6.2	6.3	6.1	6.3	19.8

Own representation according to NORD/LB (2016a)

Figure 1: EUR bonds Eurozone (EURbn) – Maturity profile

Germany alone issues more than EUR 200bn of fixed coupon bonds per annum, whereby we are not focusing on Italy, France in Spain in this study. As a core country – and owing to its proximity to the sub-sovereign bond market – we decided to review Finland's yields. Its government bond market has the size of around 85bn. Ireland and Portugal are considered non-core EMU states due to their necessary financial aid by the IMF (for example, Afonso and Silva, 2017 have discussed this topic intensively). Their bond markets are as large as EUR 180bn and EUR 130bn, respectively. Whereas Artis and Zhang (2001) perceive Belgium as part of the EMU core group, we are defining the Kingdom of Belgium as an intermediate EMU country – between core and non-core – due to the interest movements during the crisis. We have looked at the yields of Belgium, which has outstanding sovereign bonds to the amount of EUR 350bn. For asset managers, it is not only important to earn a certain yield, but also to have a liquid market.

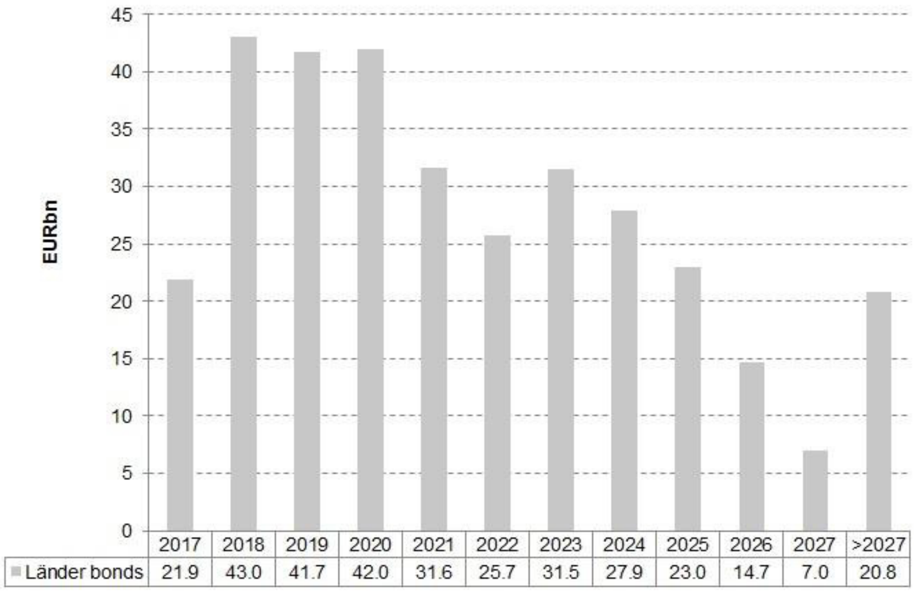
There has been a dramatic fall in yields on all major bond markets since 2014. This situation is exacerbated by the ECB's purchase program, which is also pushing prices to historically high levels, as a result of which yields have fallen into negative territory and were still stuck there in maturities of up to ten years (Germany) at the start of October 2016. If the current ultra-expansive monetary policy is prolonged beyond the end of 2017, inflation approaches a zero level again, the crisis mode might continue in some European countries and there might be ever-new speculation about current and future problem children in the Eurozone. This would mean that no appreciable increase in yields – especially in the AAA range – can be expected in the coming years. Not many scenarios could be worse for asset managers.

Having said this, the investigated countries follow some certain trends, but they either had to receive financial aid to avoid undergoing such a severe crisis as Greece has or were downgraded during or after the crisis. In order to have another huge bond market within the Eurozone with a high investment grade rating, we also investigate yields for AAA-rated EMU regions and have looked into the very liquid German sub-sovereign market in detail.

5. The Scale of the German Sub-sovereign Bond Market

The segment of German Laender is by far the largest sub-sovereign market in Europe, according to Bloomberg market data and the Markit iBoxx € Regions index. No other sub-national level within the EMU has a similarly high volume outstanding or annual issuance volume as the Bundeslaender segment (EUR 330bn). Therefore, it is considerably larger than the sovereign markets of Finland, Portugal and Ireland, as well as being better rated. Both factors – risk and liquidity – are important factors for assets managers (See Cornett et al., 2011). Traditionally characterized by a high degree of stability in terms of funding volume, especially German sub-sovereigns have always represented an attractive alternative to German sovereign debt, so-called Bunds (See Bellot et al., 2016).

The principle of federal loyalty and the federal financial equalization system result in a clear convergence of the credit profiles of the individual Bundeslaender, with respect to both each other and the federal government (see, for example, Lemmen, 1999 or more recently Heppke-Falk and Wolff, 2008). The ECB's purchase program has precipitated a significant increase in demand, as investors are being pushed into Laender bonds as alternative investment products, while the ECB and Bundesbank are major investors by purchasing Bundeslaender bonds. This leads to distortions, which we believe renders an accurate assessment solely in terms of the market price very difficult.



Own representation according to NORD/LB (2016b)

Figure 2: Outstanding bonds issued by the German Bundeslaender (EURbn)

In 2015, the spread performance – as a gage of risk – of SSAs (Supranationals, Sub-sovereigns and Agencies) was especially affected by the unorthodox actions undertaken by the ECB. The pushy proceedings by the ECB have strongly affected the spread development in the asset class of sub-sovereigns, even though at this stage only sovereign bonds were bought, as well as supranationals and agencies. Even after extending the PSPP from those aforementioned bonds to regional bonds – which was in a way foreseen due to liquidity shortages in the main markets – the undertaken actions affect the German Bundeslaender directly. Furthermore, the spreads were determined by an overall decreasing liquidity in the segment of SSAs. Hence, the rarity of opportunities from certain issuers and outstanding bonds dramatically increased.

Traditionally, in the German SSA segment, bonds issued by the German Bundeslaender enjoy a relatively high level of attractiveness versus Bunds (see, for example, Bellot et al., 2016). Even though the PSPP already had an indirect impact on the Bundeslaender segment before they extended the PSPP to regional bonds, the attractive premia still exist in our view due to the more or less same risk profile.

6. Data, Methodological Issues and Initial Empirical Analysis

In this paper, we want to investigate the EMU sovereign and AAA-rated sub-sovereign bond markets and test for possible influences of the recent ECB monetary policy instruments on long-term EMU interest rates focusing on 10Y sovereign and sub-sovereign bond yields. Our data sample contains 10Y sovereign bond yields for Germany and Finland (as core EMU countries, see, for example, Basse, 2014) as well as Portugal and Ireland as (non-core EMU countries). Following – for example – Costanini et al. (2014), Belgium may also be seen as a core EMU country. However, following the substantial spread widening in the course of the EMU debt crisis, we treat Belgium as a country being neither core nor non-core. The monthly data in this sample ranges from 1999/01 to 2017/01. The data are taken from the Federal Reserve Bank of St. Louis' FRED database.

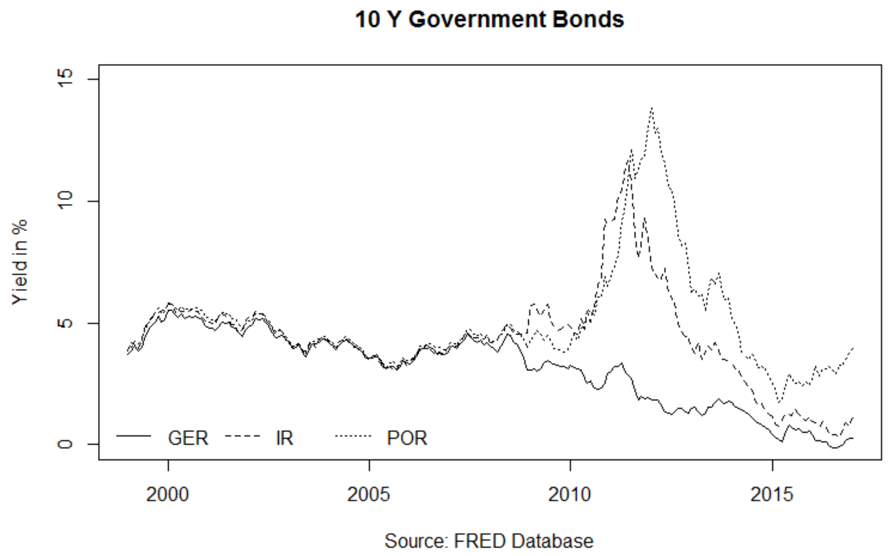


Figure 3: Government bond yields of Germany, Ireland and Portugal

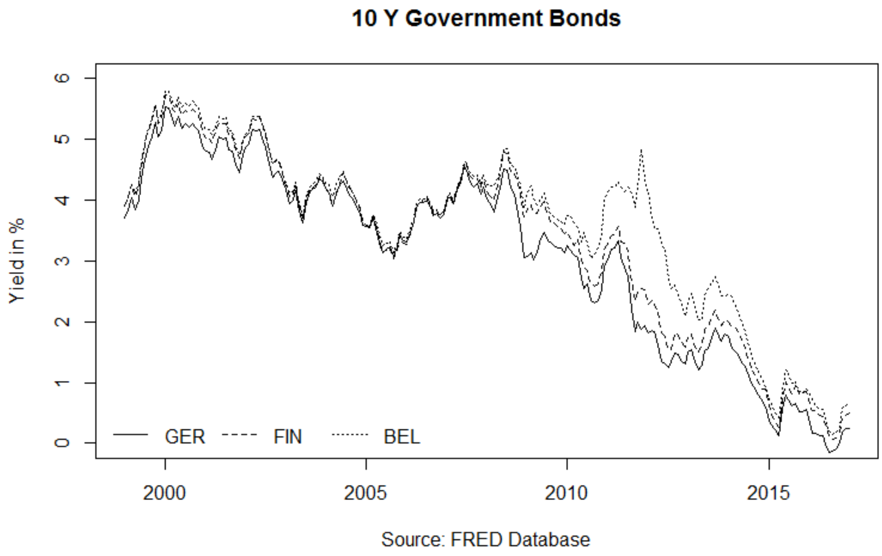


Figure 4: Government bond yields of Germany, Finland and Belgium

Our second data sample contains 10Y AAA-rated (EMU) sub-sovereign bond yields (SUB). The index is compiled by Bloomberg. The monthly data ranges from 2003/01 to 2017/01. We will start our empirical analysis by testing for possible long -term relationships before investigating short-run dynamics for the four pairs of 10Y sovereign bond yields; i.e. Germany (GER) and Ireland (IRE), Germany and Portugal (POR), Germany and Finland (FIN) as well as Germany and Belgium (BEL). The countries and the corresponding government bond yields of these countries have been differently affected by the global financial crisis and EMU sovereign debt crisis. Following previous studies, sovereign credit risk and redenomination risk have been major drivers of rising yields, especially in the non-core EMU countries (see for example Basse, 2014 as well as Klose and Weigert, 2014). However, the long-term interest rates of core EMU countries' bonds have been influenced to a much lesser extent. The spread of Finland's 10Y government bond yields versus 10Y German government bond yields peaked at moderate 80bp (see Figure 4 above) at the peak of the EMU sovereign debt crisis. In addition, we investigate the relationship between German 10Y government bond yields (GER) and 10Y yields for AAA-rated EMU regions

(SUB) and between Finish 10Y government bond yields and 10Y yields for AAA-rated EMU regions (SUB). These investigations hold strong relevance in the context of our research question, since we want to gain new insights into the characteristics of the important sub-sovereign market and the ECB's monetary policy impact on that segment. We chose Germany and Finland as EMU core countries due to the comparable risk, since we assume that our results will not be strongly distorted by risk premia.

Before checking for possible long-run relationships between the relevant pairs of time series, the trending behavior of the relevant time series has to be investigated. Hence, we start our empirical analysis by checking for unit roots. To empirically assess the order of integration of the time series, the semi-parametric testing procedure proposed by Phillips and Perron (1988) will be applied. The results for the PP test in levels and first differences for the sovereign as well as the sovereign/sub-sovereign sample can be found in Tables 1 and 2 below.

Time Series	p-value
pv_GER	0.1007
pv_dGER	0.0100
pv_IRE	0.8220
pv_dIRE	0.0100
pv_POR	0.8048
pv_dPOR	0.0100
pv_FIN	0.2413
pv_dFIN	0.0100
pv_BEL	0.4863
pv_dBEL	0.0100

Table 1: Results PP Test sovereign bond yields

Time Series	p-value
pv_sub	0.6642
pv_dsub	0.0100

Table 2: Results PP Test sub-sovereign bond yield

Since we found empirical evidence that all investigated time series are non-stationary,[1] in a second step we will test for possible cointegrating relationships between the pairs of time series. Two time series are said to be cointegrated if they share a common stochastic trend (see, for example, Stock and Watson, 1988). We will use the approaches proposed by Engle and Granger (1987) as well as Johansen (1991). The results for the cointegration tests for the sovereign as well as the sovereign/sub-sovereign pairs can be found in Tables 3 and 4 below.

	Test Statistic	Critical Value		
GER and IRE		10pct	5pct	1pct
r <= 1 |	1.80	6.50	8.18	11.65
r = 0 |	3.39	12.91	14.90	19.19
GER and POR		10pct	5pct	1pct
r <= 1 |	1.34	6.50	8.18	11.65
r = 0 |	2.67	12.91	14.90	19.19
GER and FIN		10pct	5pct	1pct
r <= 1 |	0.88	6.50	8.18	11.65
r = 0 |	8.24	12.91	14.90	19.19
GER and BEL		10pct	5pct	1pct
r <= 1 |	0.79	6.50	8.18	11.65
r = 0 |	4.68	12.91	14.90	19.19

Table 3: Cointegration Test Sovereigns

	Test Statistic	Critical Value		
GER and SUB		10pct	5pct	1pct
r <= 1 |	0.49	6.50	8.18	11.65
r = 0 |	5.52	12.91	14.90	19.19
FIN and SUB		10pct	5pct	1pct
r <= 1 |	0.18	6.50	8.18	11.65
r = 0 |	16.16	12.91	14.90	19.19

Table 4: Cointegration Test Sovereigns vs. Sub-Sovereigns

[1] GER and FIN are also non-stationary for the shorter data sample for 2003/01 to 2017/01.

Regarding the pairs of 10Y government bond yields, we found no empirical evidence for cointegrating relationships (see Table 3 above). As noted above, these results are corresponding to earlier findings. Furthermore, the cointegration test for GER and SUB leads to the empirical result that the null of no cointegrating relationships cannot be rejected. Interestingly, the test for FIN and SUB delivers contradicting results. We found empirical evidence of a long-term relationship between Finland's 10Y government bond yields and the 10Y AAA-rated sub-sovereign bond yields at the 5% significance level.

In order to check for causal relationships in a Granger sense and given the results of the cointegration tests above, we will proceed to estimate five vector autoregressive (VAR) models for the relevant pairs of time series (see, for example, Lütkepohl and Krätzig, 2004). To avoid spurious regression in the context of our analysis, we will use the model in first differences. For each model, the lag length has been derived using the AIC criterion (see, example Lütkepohl, 2006).[2] As a robustness check, we have tested for possible structural breaks in the VAR models using OLS-CUSUM tests (see, for example, Zeileis et al., 2002). The corresponding results are presented in the Appendix. Using this procedure, we do not find evidence of instabilities of the VAR models under investigation. To analyze the VAR models regarding possible Granger causal relationships, we use impulse response functions. For the FIN-SUB case, we estimate a vector error correction model (VECM) in levels (see, for example, Lütkepohl and Krätzig, 2004) and perform impulse response analysis to check for Granger causality.

We proceed by investigating the spread between the 10Y government bond yields (i.e. IRE-GER, POR-GER, FIN-GER as well as BEL-GER) and GER-SUB, respectively FIN-SUB. Given the above results from the cointegration tests, we know that the corresponding spreads (as linear combinations of the interest rates) are non-stationary (with FIN - SUB being the only exception). However, our data sample for the sovereign bond yields includes

[2] Lag length of corresponding VAR models: IRE-GER: l =7, POR-GER: l = 5, FIN-GER: l=2, BEL-GER: l =2, GER-SUB: l =1

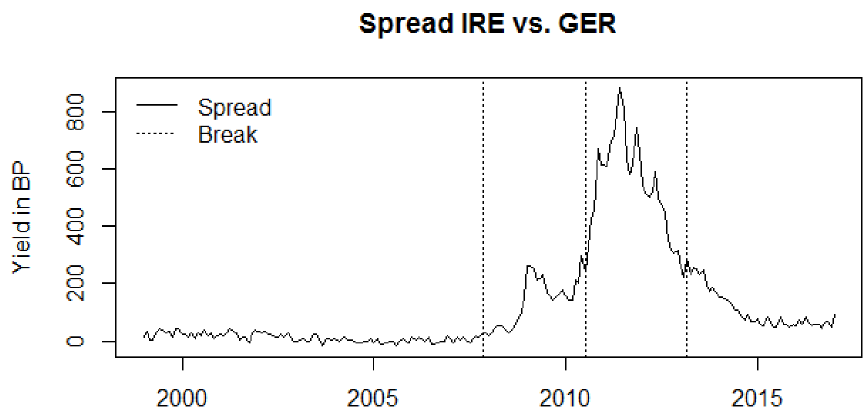
the calmer earlier years of the EMU, turbulent times of the global financial crisis and EMU sovereign debt crisis as well as the ECB's efforts to mitigate the risks of the break-up of the euro area. Furthermore, as discussed earlier, the measures undertaken by the monetary policy decision-makers of the ECB might also hold strong relevance for the sub-sovereign bond markets. We will test for more than one structural break with unknown timing in the five spread time series (see, for example Ploberger et al., 1989; Zeileis et al., 2003 respectively Bai and Perron, 2003).

7. Empirical Evidence

The empirical results for the impulse response analysis for the first differences of the sovereign spreads are presented in the Figures 13 to 20 in the Appendix. The empirical results of the VAR impulse response analysis deliver rather clear evidence of a unidirectional Granger causality running from the changes in the German government bond yields to the changes of the sovereign bond yields, with the only exception of Ireland.

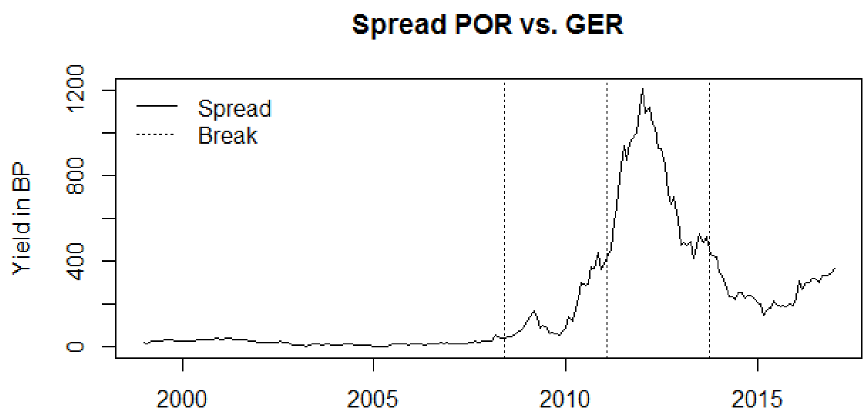
The results of the impulse response functions for the VAR model for dGER and dSUB are shown in Figures 21 and 22. Interestingly, the empirical evidence is quite similar to the results of the impulse response functions for the majority of the EMU countries analyzed above. Changes in the German 10Y government yields (dGER) seem to cause Granger changes in the sub-sovereign bond yields (dSUB), but not vice versa. Hence, following our empirical results, there only exists a unidirectional Granger causality. The impulse response functions for the FIN-SUB VECM Model can be found in Figures 23 and 24 in the Appendix. These results are even more interesting, whereby we found empirical evidence of bi-directional Granger causality. Following these findings, there not only exists a long-term relationship between 10Y sovereign bond yields of Finland and the 10Y AAA-rated EMU sub-sovereign bonds, but it can also be stated that in the short-run changes in one of the yields are followed by changes in the other. These findings are also useful in the context of forecasting and hence might prove helpful for asset managers in the life insurance industry.

Summing up the empirical results for the investigated VAR models, it can be stated that at least from a short-run perspective changes in the 10Y German government bond yields lead changes in most of the other interest rates, in a Granger sense at least. However, these findings do not prove very helpful in the context of investigating possible effects of the adjusted monetary policy framework of the ECB, because the timing of changes in the yields (or in the context of our research question yield spreads) holds vital importance. The results of the tests for structural shifts with unknown timing for the sovereign yield spreads are presented in Figures 5 to 8 below.



Source: Own calculations

Figure 5: Yield spread of Ireland and Germany 10Y



Source: Own calculations

Figure 6: Yield spread of Portugal and Germany 10Y

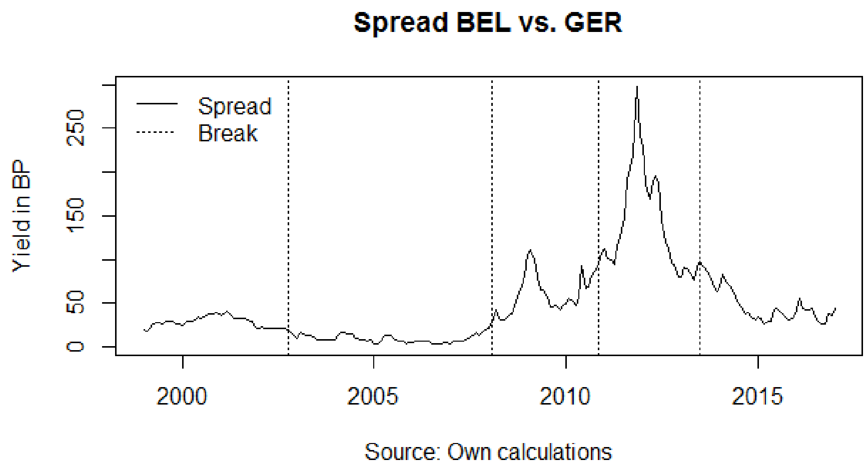


Figure 7: Yield spread of Belgium and Germany 10Y

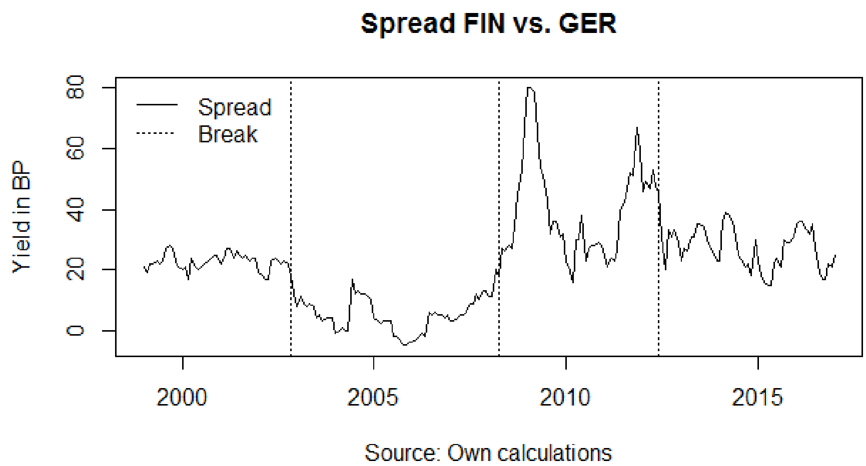


Figure 8: Yield spread of Finland and Germany 10Y

The timings of the breaks are presented in Table 5. Especially in the case of Ireland and Portugal, the timing of the first two structural shifts in the yield spread is unsurprising at all, given the outbreak of the global financial crisis 2007/08 and the preceding sovereign debt crisis 2011 and beyond. Due to flight-to-quality effects, the timing of the second and third breaks in the case of Belgium and Finland also correspond with economic theory. However, given the smaller scale of the spread, these results should be analyzed with caution and should not be seen as a shift in economic fundamentals. This also seems to be true for the first break for Belgium and Finland, which is economically not explainable. For all four spread time series, the timing of the last break also does not come as a surprise at all. Especially in the case of Portugal and Ireland, the ECB's confidence-building measures resulted in shrinking spreads. Interestingly – and probably most importantly in the context of our analysis – we did not find empirical evidence of structural shifts that are concurrent with the ECB's purchasing programs starting in 2015 (see ECB, 2015). One possible explanation for this may be the fact that the ECB's verbal commitment to preserve the euro (see ECB, 2012) led to some kind of premature praise.

The subsequently following steps may rather be seen as performance of the ECB's resulting duty. Germany has experienced the lowest ever measured within the PSPP in July 2016, because the largest share of the ECB capital key belongs to Germany and thus due to the setup of the PSPP the largest bought part are Bunds every month. This movement to historically lows has almost been copied by Finland with the rock bottom in September 2016. We experienced the same pattern in Belgium, but never negative yields for the 10y tenor. The spreads are not as low as they were before the crisis, although it seems to be a new equilibrium at present. This holds especially true for the low spreads of Finland and Belgium to German Bunds. The IRE-GER spread is a little higher, although the levels are stable due to the monthly buying of the central banks.

By contrast, the political situation in Portugal (change of government) has brought some uncertainty, resulting in increasing yields and thus lifting the POR-GER spread. After the haircut was performed on Greek debt, many asset managers kept the hands off periphery bonds due to their assumed mispricing. First the spreads escalated (Figure 6) after the second break, before the spreads came down too quickly.

	Timing of break(s)			
IRE-GER		2007(11)	2010(7)	2013(3)
POR-GER		2008(6)	2011(2)	2013(10)
BEL-GER	2002(10)	2008(2)	2010(11)	2013(7)
FIN-GER	2002(11)	2008(4)	2012(6)	
SUB-GER		2007(6)	2011(6)	2013(11)

Table 5: Summary breakpoints

The result of the structural shift regarding the GER-SUB spread is presented in Figure 9 below.[3] Unsurprisingly, the timing of the breaks does not deviate from the results for the sovereign spreads. Furthermore, the ECB's purchasing program has not led to changes in the spread to the 10Y German government bonds.

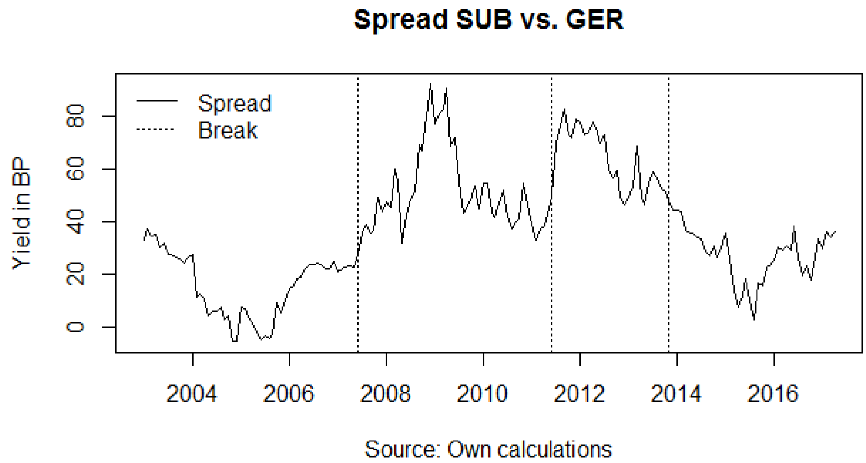


Figure 9: Yield spread of Sub-Sovereigns and Germany 10Y

[3] Given that we found empirical evidence of a cointegrating relationship between the FIN and SUB yields, the FIN-SUB-spread should be stationary. Hence, we will not perform.

8. Conclusions

In this paper, the yields and spreads of EMU countries as well as sub-sovereign spreads have been evaluated. Therefore, we investigated the trending behavior and checked for possible long-run relationships and Granger causal relationships. Subsequently, we tested for statistical breakpoints within the data framework. The dataset covers all 18 years of the existing European Monetary Union, which was shaken ten years ago due to financial turmoil. Asset managers do not simply want high returns, but also stable yields and assessable risks. As reckoned and expected due to interference by the ECB's PSPP, sovereign bond yields have converged as they did before the crisis. Therefore, the spreads shrink or even disappear and risks are assumed to be mispriced. Furthermore, even yields of sub-sovereign bonds have decreased and the spread – e.g. to Bunds – has tightened. This is harmful for life insurers in general and German life insurance companies especially. The granted return cannot be earned by interest bearing bonds from AAA-rated German sovereigns. Even evading to sub-sovereigns like German Bundeslaender bonds is no longer an option, given that the ECB is carrying out their PSPP until at least the end of 2017. This evolution might push asset managers into riskier assets in the future. The investment process has changed and insurance companies must do their homework. We have not found any straightforward effects on yields for now. For the time being, it remains unclear that an immediate end of the PSPP might be interpreted consecutively, that the crisis is over. The monthly data are limited since the start two years ago. If the ECB's action gives rise to doubts that the council is not ready for battle, the yields might ultimately reverse dramatically to the upside. After months and years of injected money, this would mean that all effects might be gone asymmetrically at a moment's notice if the ECB announces any kind of tapering or so-called "fading out." Certainly, further research is necessary in this field.

References

Acharya, V.V., Eisert, T., Eufinger, C., Hirsch, C. (2017) 'Whatever It Takes: The Real Effects of Unconventional Monetary Policy', SAFE Working Paper No. 152.

Afonso, A., Jalles, J.T. (2015) 'Economic Volatility and Sovereign Yields' Determinants: A Time-Varying Approach', ISEG Economics Department Working Paper No. WP 04/2016/DE/UECE.

Afonso, A., Jalles, J.T. (2017) 'Sovereign Debt Effects and Composition: Evidence from Time-Varying Estimates', ISEG Economics Department Working Paper No. WP 03/2017/DE/UECE.

Afonso, A., Rault, C. (2015), 'Short- and long-run behaviour of long-term sovereign bond yields', Applied Economics, Volume 47 – Issue 37, 3971-3993.

Afonso, A., Silva, J.D.F. (2017) 'Debt Crisis and 10-Year Sovereign Yields in Ireland and in Portugal', ISEG Economics Department Working Paper No. WP 06/2017/DE/UECE.

Afonso, A., Leal, F.S. (2017) 'Sovereign Yield Spreads in the EMU: Crisis and Structural Determinants', ISEG Economics Department Working Paper No. WP 09/2017/DE/UECE.

Arghyrou, M.G., Kontonikas, A. (2011) 'The EMU sovereign debt crisis: fundamentals, expectations and contagion', Economic Papers, vol. 436. European Commission.

Artis, M.J., Zhang, W. (2001) 'Core and Periphery EMU: A Cluster Analysis', Economic Issues, Vol.6, Part 2: 39-59.

Bai, J., Perron, P. (2003) 'Computation and analysis of multiple structural change models', Journal of applied econometrics 18.1: 1-22.

Basse, T. (2014) 'Searching for the EMU core member countries', European Journal of Political Economy 34: 32-39.

Beck, R., Ferrucci, G., Hantzsche, A., Rau-Goehring, M. (2016) 'Determinants of sub-sovereign bond yield spreads: the role of fiscal fundamentals and federal bailout expectations', ECB Working Paper, No. 1987.

Beckmann, J., Belke, A., Verheyen, F. (2013) 'Interest rate pass-through in the EMU – New evidence from nonlinear cointegration techniques for fully harmonized data', Journal of International Money and Finance, vol. 37, issue C, 1-24.

Bellot, N.J., Martí Selva, M.L., Menéndez, L.G. (2016) 'Bond spreads issued by sub-sovereign European governments', Journal of Innovation & Knowledge, In Press, Corrected Proof, Available online.

Belongia, M.T. (1987) 'Predicting interest rates: a comparison of professional and market-based forecasts', Federal Reserve Bank of St. Louis: 9-15.

Brand, C., Buncic, D., Turunen, J. (2010) 'The impact of ECB monetary policy decisions and communication on the yield curve', Journal of the European Economic Association 8 (6): 1266-1298.
Cornett, M.M., McNutt, J.J., Strahan, P.E. and Tehranian, H. (2011) 'Liquidity risk management and credit supply in the financial crisis', Journal of Financial Economics, Volume 101, Issue 2: 297-312.
Costantinia, M., Fragetta, M. and Melina, G. (2014) 'Determinants of sovereign bond yield spreads in the EMU: An optimal currency area perspective', European Economic Review, Volume 70, 337-349.
Diebold, F.X. and Yilmaz, K. (2012) 'Better to give than to receive: Predictive directional measurement of volatility spillovers', International Journal of Forecasting 28: 57-66.
Dötz, N. and Fischer, C.A. (2010) 'What Can Emu Countries' Sovereign Bond Spreads Tell Us About Market Perceptions of Default Probabilities During the Recent Financial Crisis?', Bundesbank Series 1 Discussion Paper No. 11.
Dötz, N. (2014) 'Decomposition of Country-Specific Corporate Bond Spreads', Bundesbank Discussion Paper No. 37.
ECB (1998) 'The definition of price stability – Quantitative definition', Available online at https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html
ECB (2003) 'The definition of price stability – Quantitative definition', Available online at https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html
ECB (2012) 'Verbatim of the remarks made by Mario Draghi', Speech by Mario Draghi, President of the European Central Bank at the Global Investment Conference in London, 26 July 2012.
ECB (2015) 'ECB announces expanded asset purchase programme',' Press release, 22 January 2015.
ECB (2017) 'Monetary policy decisions – Key interest rates and Non-standard measures', Available online at https://www.ecb.europa.eu/mopo/decisions/html/index.en.html
Ehrmann, M. and Fratzscher, M. (2017) 'Euro Area Government Bonds – Integration and Fragmentation During the Sovereign Debt Crisis', Journal of International Money and Finance vol. 70, issue C: 26-44.
Eling, M., Schmeiser, H. and Schmit, J. T. (2007) 'The Solvency II Process: Overview and Critical Analysis', Risk Management and Insurance Review, 10(1):69-85.
Engle, R.F. and Granger, C.W. (1987) 'Co-integration and error correction: representation, estimation, and testing', Econometrica: Journal of the Econometric Society, Vol. 44, No. 2, 251-276.

Eser, F. and Schwaab, B. (2016) 'Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB′ s Securities Markets Programme', Journal of Financial Economics 119.1: 147-167.
Fernández-Rodríguez, F., Gómez-Puig, M. and Sosvilla-Rivero, S. (2015) 'Volatility spillovers in EMU sovereign bond markets', International Review of Economics & Finance, vol. 39, issue C, 337-352.
Fratzscher, M., Lo Duca, M. and Straub, R. (2016) 'ECB unconventional monetary policy: Market impact and international spillovers', IMF Economic Review 64.1: 36-74.
Gerlach, S. and Lewis, J. (2014) 'Zero lower bound, ECB interest rate policy and the financial crisis', Empirical Economics 46.3: 865-886.
Giordano, R., Pericoli, M. and Tommasino, P. (2012) ''Pure' or 'Wake-Up-Call' Contagion? Another Look at the EMU Sovereign Debt Crisis', Midwest Finance Association 2013 Annual Meeting Paper.
Gómez-Puig, M. and Sosvilla-Rivero, S. (2013) 'Granger-causality in peripheral EMU public debt markets: A dynamic approach', Journal of Banking & Finance 37.11: 4627-4649.
Heppke-Falk, K. and Wolff, G.B. (2008) 'Moral hazard and bail-out in fiscal federations: Evidence for the German Länder', Kyklos, 61: 425-446.
Höring, D. (2013) 'Will Solvency II Market Risk Requirements Bite? The Impact of Solvency II on Insurers' Asset Allocation', The Geneva Papers on Risk and Insurance – Issues and Practice, 38(2), 250-273.
Jenkner, E. and Lu, Z. (2014) 'Sub-national credit risk and sovereign bailouts – Who pays the premium?', WP 14/20 IMF.
Johansen, S. (1991) 'Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models', Econometrica: Journal of the Econometric Society, Vol. 59 No. 6, pp. 1551-1580.
Klepsch, C. and Wollmershäuser, T. (2011) 'Yield Spreads on EMU Government Bonds - How the Financial Crisis Has Helped Investors to Rediscover Risk', Intereconomics, Volume 46, Issue 3, pp 169–176.
Klose, J. and Weigert, B. (2014) 'Sovereign yield spreads during the euro crisis: Fundamental factors versus redenomination risk', International Finance 17.1: 25-50.
Kunze, F., Kramer, J. and Rudschuck, N. (2013) 'Interest rate forecasts in times of financial crisis: What might be interesting to know?', European Journal of Political Economy, 34: 45-52.
Kunze, F., Wegener, C., Bizer, K. and Spiwoks, M. (2017) 'Forecasting European interest rates in times of financial crisis – What insights do we get from international survey forecasts?', Journal of International Financial Markets, Institutions and Money, 48: 192-205.

Lemmen, J. (1999) ‘Managing government default risk in federal states’, FMG special paper, Financial Markets Group, London School of Economics, No 116.
Leschinski, C. and Bertram, P. (2013) ‘Contagion dynamics in EMU government bond spreads’, Discussion Paper, Wirtschaftswissenschaftliche Fakultät, Leibniz Universität Hannover, No. 515.
Ludwig, A. (2014) ‘Credit risk-free sovereign bonds under Solvency II: a cointegration analysis with consistently estimated structural breaks’, Applied Financial Economics, 24(12), 811-823.
Lütkepohl, H. and Krätzig, M. (2004) ‘Applied time series econometrics’, Cambridge university press.
Lütkepohl, H. (2006) ‘New Introduction to Multiple Time Series Analysis’, Springer, New York.
Mitze, T. and Matz, F. (2015) ‘Public debt and growth in German federal states: What can Europe learn?’, Journal of Policy Modeling, Volume 37, Issue 2: 208-228.
NORD/LB (2016a) ‘Issuer Guide 2016 Eurozone – EU(19)’, available online at https://www.nordlb.com/fileadmin/redaktion_en/analysen_prognosen/public_issuers/issuer_guides/2016/20161220_IssuerGuide_2016_Eurozone_Sovereigns.pdf; downloaded on 04/02/2017
NORD/LB (2016b) ‘Issuer Guide German Bundesländer 2016’, available online at https://www.nordlb.com/fileadmin/redaktion_en/analysen_prognosen/public_issuers/specials/2016/MasterIssuerGuide2016_eng.pdf; downloaded on 04/09/2017
O'Brien, C. (2010) ‘Insurance Regulation and the Global Financial Crisis: A Problem of Low Probability Events’, The Geneva Papers on Risk and Insurance – Issues and Practice, 35(1), 35-52.
Phillips, P.C. and Perron, P. (1988) ‘Testing for a Unit Root in Time Series Regression’, Biometrika 75: 335–346.
Ploberger, W., Krämer, W. and Kontrus, K. (1989) ‘A new test for structural stability in the linear regression model’, J. Econometr. 40: 307–318.
Rodriguez Gonzalez, M., Kunze, F., Schwarzbach, C. and Dieng, C. (2017) ‘Asset liability management and the Euro crisis–sovereign credit risk as a challenge for the German life insurance industry’, The Journal of Risk Finance, (just-accepted), 00-00.
Schwarzbach, C., Kunze, F., Rudschuck, N. and Windels, T. (2014). ‘Stock investments for German life insurers in the current low interest environment: more homework to do’, Zeitschrift für die gesamte Versicherungswissenschaft, Vol. 103: 45-63.
Sibbertsen, P., Wegener, C. and Basse, T. (2014) ‘Testing for a break in the persistence in yield spreads of EMU government bonds’, Journal of Banking & Finance 41: 109-118.

Singh, M.K, Gómez-Puig, M. and Sosvilla-Rivero, S. (2016) ‘Sovereign-bank linkages: Quantifying directional intensity of risk transfers in EMU countries’, Journal of International Money and Finance, 63: 137-164.

Stock, J.H. and Watson, M.W. (1988) ‘Testing for common trends’, Journal of the American statistical Association 83.404: 1097-1107.

Zeileis, A., Leisch, F., Hornik, K. and Kleiber, C. (2002) ‘strucchange: An R Package for Testing for Structural Change in Linear Regression Models’, Journal of Statistical Software, 7(2): 1-38.

Zeileis, A., Kleiber, C., Krämer, W. and Hornik, K. (2003) ‘Testing and dating of structural changes in practice’, Comput. Stat. Data Anal. 44, 109–123.

Appendix

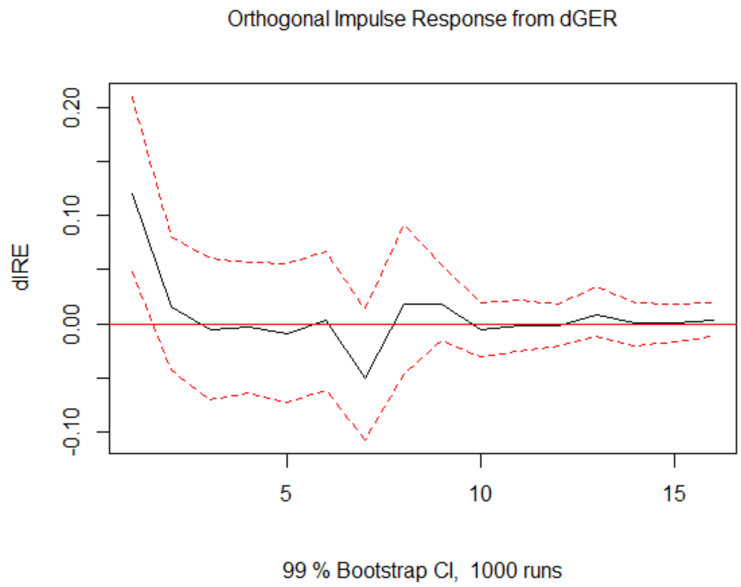


Figure 10: Impulse response function IRE-GER: impulse from dGER

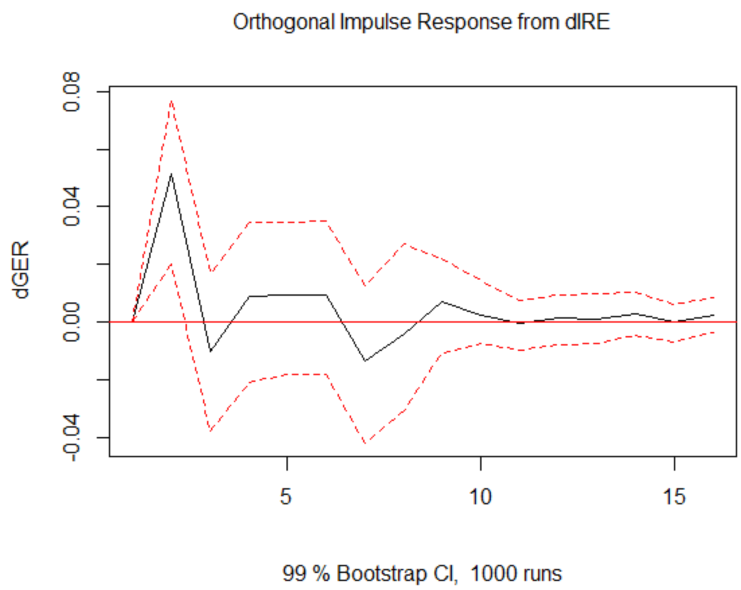


Figure 11: Impulse response function IRE-GER: impulse from dIRE

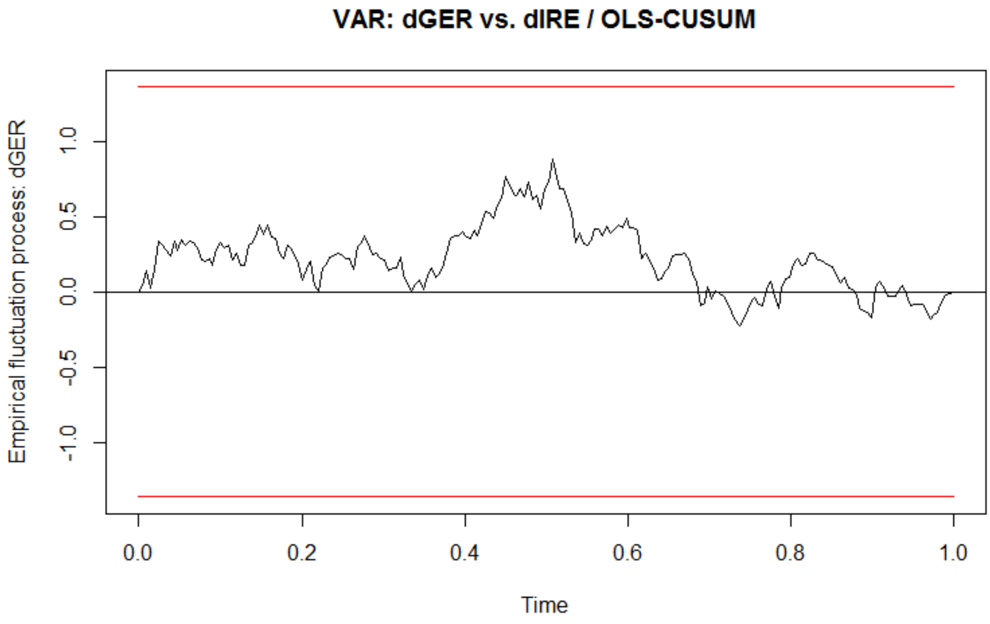


Figure 12: OLS-CUSUM stability test GER/IRE

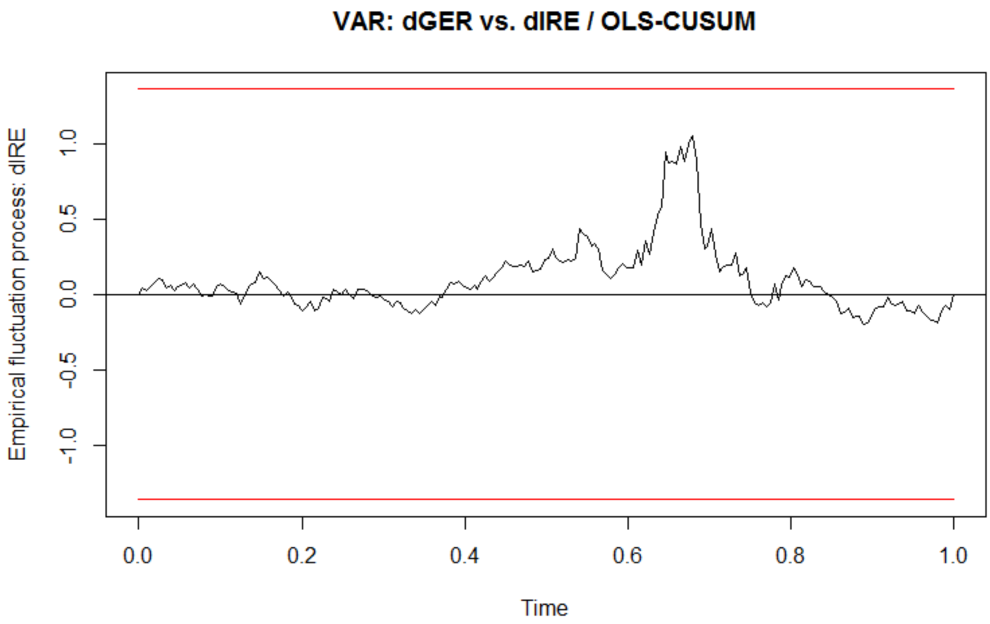


Figure 13: Stability test OLS-CUSUM: dIRE