Do Solvency II reports appropriately inform about European stock insurers' market risk exposures?

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1 Introduction

One of the major goals of Solvency II is to foster market discipline. To this end, insurance companies are obliged to create and publish the so-called "Solvency and Financial Condition Reports" (SFCRs). The SFCRs provide detailed information about the business and performance, the system of governance, the risk profile, the valuation for solvency purposes and capital management of insurance companies.[1] For instance, they inform about which risks the insurer considers as material, what portion of the Solvency Capital Requirement (SCR) results from market risks and whether the insurer employs a (partial) internal model.

The idea behind the SFCRs is that the insurers' stakeholders gain transparency about the companies' risk profiles and that their potential punishment provides the insurers with an incentive to seek a sound risk and solvency position. From a regulatory perspective it is important to have empirical evidence on whether this regulatory tool works. Gatzert and Heidinger (2018) demonstrate that the published quantitative data on risk characteristics in the SFCRs lead to a significant abnormal stock return indicating that shareholders react to "good news" or "bad news" provided by the SFCRs. Nevertheless, it remains an open question how much the reports are in line with the true risk profiles of insurers. Our idea is to measure (stock) insurance companies' true risk profiles based on the sensitivities of their market capitalization to movements in risk drivers and investigate which information in the SFCRs has explanatory power for those sensitivities.

Previous studies examining insurers' risk profiles find that market risks are typically the greatest threat to the solvency of life insurance companies[2] because of the long duration of their liabilities[3] and a high share of investments in government bonds[4]. Several empirical studies

[1] Cf. Articles 292 to 298 of the European Commission (2015).
[2] Cf. Duverne and Hele (2016).
[3] Cf. Frey (2012).
[4] Cf. EIOPA (2017).

have measured how insurance companies are exposed to changes in long-term interest rates.[5] For instance, Hartley et al. (2017) show that in the low interest rate environment following the recent financial crisis insurance companies benefit significantly from rising long-term interest rates. Moreover, Düll et al. (2017) reveal that insurers are significantly affected by changing credit default swap (CDS) spreads of government bonds. More recently, Schlütter et al. (2018) point out that sovereign credit risk is of relatively high importance for European insurance companies in comparison with US insurers, whose risk profile is dominated by interest rate risk. Berends et al. (2013) try to link the sensitivities of insurance companies to various balance sheet figures, such as the portion of liabilities with an interest rate guarantee. One would expect that the stock returns of insurers who have promised substantial interest rate guarantees would be more closely linked to long-term interest rates. However, Berends et al. (2013) do not find evidence for this expectation, probably because those insurers make use of additional risk instruments which (partly) immunize them against interest rate changes.

To study our research question, we proceed in three steps. Firstly, we analyze how the market capitalization of 69 listed insurance companies from 21 European countries react to long-term interest rate movements and CDS spread changes when controlling for an overall stock market index.[6] We perform firm-level multivariate regression analyses based on daily market data of the past few years. This step of analysis identifies insurance companies with a particularly high interest rate risk or investment credit risk (measured by the betas of the regression). The results of examining the risk profiles are largely consistent with other recent empirical studies. Our findings show that between 2012 and mid-2018 the impact of daily changes in long-term interest rates on stock returns is significant for 30.4% of all insurers. In addition, 34.8% of firms are significantly impacted by daily movements of CDS spreads of domestic sovereign debt. The estimated sensitivities also reveal a considerable heterogeneity in market risk exposures across European insurers which can be explained by the deviating width of duration gaps between the asset and liability sides of insurers' balance sheets,[7] the use of legally binding guarantees for policyholders in several countries[8] and the varying share of life insurance business[9].

[5] Cf., e.g., Brewer et al. (2007), Carson et al. (2008) and Möhlmann (2017).
[6] This procedure is in line with the empirical studies mentioned before. Controlling for an overall stock market index is necessary because insurers are strongly correlated with economic growth (Cf. Kessler et al. (2017)).
[7] Cf. EIOPA (2014).
[8] Cf. Eling and Holder (2013).
[9] Cf. Hartley et al. (2017).

In the second step, we systematically gather information about the insurers' risk profiles and risk management approaches from the SFCRs including data on the SCR, its calculation as well as qualitative descriptions of underlying market risks. Therefore, we examine all reports after the introduction of Solvency II in 2016 of the 69 companies in the sample. Thirdly, we investigate which specific aspects from the risk profiles according to the SFCRs is most helpful to explain the insurers' stock returns' sensitivities to market risk drivers.

Our results demonstrate that information in the SFCRs is consistent with the true risk profiles with respect to interest rates. We find that the market data based sensitivities for interest rate risk are significantly influenced by the SCR market risk module relative to the firms' own funds. Furthermore, the calculation of the SCR gives further insights into actual sensitivities. The use of the transitional on technical provisions significantly lowers market risks, whereas an increase in the impact of the volatility adjustment on an insurer's solvency ratio demonstrates higher interest rate risk and the matching adjustment reflects a higher sensitivity to credit risk. In contrast, insurers employing partial or full internal models do not have significantly lower sensitivities towards market risks than insurers applying the standard formula. Based on our findings to date, the company-specific calculation of the SCR is suitable for approximating insurers' true market risk exposures.

To the best of our knowledge, this is the first paper that systematically compares Solvency II reports with insurance companies' risk profiles according to financial market data. Given that market consistency is an important principle of Solvency II, the reports and market data based sensitivities should provide a consistent picture of the insurers' risk profiles. For the various addressees of Solvency II reports, it is important to understand how strong this consistency actually is, what type of information in the Solvency II reports is most relevant and what additional value they can create in the sense of market discipline. By shedding light into those questions, our analysis has important implications for insurance researchers as well as practitioners.

2 Market risks of European insurers

From a policyholder perspective, a life insurance contract is usually supposed to cover unforeseeable, biometric risks.[10] When trying to hedge against the financial consequences of longevity and mortality, some policyholders may not be aware of the risk of the insurer's insolvency which is related to the long duration of their policies. For insured individuals who often buy their products from a single company, it is difficult to protect themselves against insolvency risks with potentially severe consequences.[11] For the firms, biometric risks typically do not impose the largest threat for their financial solvency. Insurance companies can properly estimate the occurrences of mortality and longevity and offer long-term protection. Firms with numerous customers can thereby benefit from the law of large numbers.[12] Therefore, market risks usually have a significantly higher contribution to the insolvency risk of life insurers than biometric risks.[13]

In the European insurance industry, regulatory authorities seek to protect policyholders against insolvency risk.[14] Their regulations focus on the reduction of exposures relating to market movements; i.e., market risk. According to the European Commission (2009), market risk covers all risks related to the extent or the volatility of interest rates, equities, properties, credit spreads, currencies, and market concentrations.[15] For all these risks, insurance companies are supposed to estimate and quantify the potential influences on the value of their assets and liabilities.[16] Therefore, they calculate their legally prescribed Solvency Capital Requirements (SCR). These are capital buffers on top of regular technical provisions that must be covered by the firms' assets.[17] A lack of consideration for market risks in the form of capital reserves may lead to the withdrawal of an insurer's authorization[18] and potentially to the loss of insurance coverage for the policyholders. In this situation, it is possible that without an external intervention, the insured would have paid their life insurance premiums without receiving their promised benefits. To shield policyholders from this exposure, the European Commission introduced the market and counterparty default risk module for SCR.[19]

[10] Cf. Bratton and Puleo (2013), chapter 2.10.
[11] Cf. Froot et al. (2007), p. 274.
[12] Cf. Smith and Kane (1994), p. 1f.
[13] Cf. Duverne and Hele (2016), p. 59; Schlütter et al. (2018), p. 2.
[14] Cf. (14), L 335/3 of the European Commission (2009).
[15] Cf. Art. 105 (5) (a)-(f) of the European Commission (2009).
[16] Cf. Art. 105 (5) of the European Commission (2009).
[17] Cf. Art. 100 of the European Commission (2009).
[18] Cf. Art. 144 of the European Commission (2009).
[19] Cf. (106), L 335/10 of the European Commission (2009).

2.1 Interest rate risk

The most discussed market risk driver for life insurers in academic and regulatory papers are changes in the yield curve.[20] According to the European Insurance and Occupational Pensions Authority (EIOPA) (2013), "interest rate risk exists for all assets and liabilities for which the net asset value is sensitive to changes in the term structure of interest rates or interest rate volatility"[21]. This does not affect non-life insurers on a large scale.[22] Instead, Carson et al. (2008) observe that the type of insurers that are the most challenged by interest rate movements are life insurers.[23] This is mainly due to promised investment yields and the long duration of contracts because policy periods often run for centuries.[24] According to Holsboer (2000), the life insurance industry has been exposed to changes in the level of long-term interest rates since its origins.[25]

2.1.1 Impact of interest rate movements on life insurers

To understand the background of exposures to interest rates, the design of a typical life insurance contract and the impact of interest rate movements on the balance sheet of an insurer are explained in this section. In a typical agreement, policyholders pay premiums on a continual basis. In return, they receive benefits. These can be paid out in the form of a lump sum or as an annuity if a set amount of years passes or if a previously contracted case occurs.[26] In an endowment policy, these cases typically involve the death of the insured person or the beneficiary reaching a predefined age.[27] The benefit amount depends on the premiums paid in advance plus the investment income of the insurer. Companies typically invest the received premiums in financial markets until claims must be paid.[28]

The reason for the pronounced interest rate risk for life insurers lies in the duration gap between the asset and liability sides of their balance sheets. Because life insurance contracts often have a policy period of over 30 years, Frey (2012) argues that there is a lack of investment opportunities with a comparable maturity. Therefore, a fraction of interest rate risk cannot be hedged.[29] This results in a structural duration mismatch between life insurers' fixed-income

[20] Cf. Gründl (2015); Kablau and Weiß (2014); EIOPA (2014).
[21] EIOPA (2013), p. 134.
[22] Cf. Frey (2012), p. 38; Moody's (2015), p. 4f.
[23] Cf. Carson et al. (2008), p. 875.
[24] Cf. Moody's (2015), p. 4.
[25] Cf. Holsboer (2000), p. 38.
[26] Cf. Harrington and Niehaus (2003), p. 142; Berends et al. (2013), p. 51.
[27] Cf. Möhlmann (2017), p. 2.
[28] Cf. Harrington and Niehaus (2003), p. 142f.
[29] Cf. Frey (2012), p. 26.

securities, which compose the largest fraction of investments on the asset side[30] and of technical provisions on the liability side.

The existence of the duration gap poses a risk for life insurers' solvency situations when interest rates change. If the yield curve shifts downwards, the present value of the assets and the value of the liabilities increases.[31] This is because future cash flows must be discounted with lower rates. Because the technical provisions on the liability side have a longer duration compared with the fixed-income securities on the asset side, the liabilities are more sensitive to interest rate changes.[32] In the case of a downward shift of the yield curve for the entire term structure, the change in the market value of liabilities exceeds the change in the market value of assets.[33] In the long term, the insurer's investment income may fall below their expenses, which could lead to a debt overload and eventually to the life insurer's illiquidity.[34] For this reason, insurers rather benefit from an upward shift in the yield curve than from reductions in the interest rate level.[35] However, according to Förstemann and Feodoria (2015) even a positive interest rate shock can have severe negative effects for insurers in the form of policyholder runs.[36] In addition, the duration gap can be widened by changes in surrender rates.[37]

The duration gap is also considered in the SCR market risk module within Solvency II, which "shall properly reflect the structural mismatch between assets and liabilities, in particular with respect to the duration thereof"[38]. According to the regulatory framework, the interest rate risk must be measured based on a stress test with prescribed sudden upward and downward yield curve shifts.[39] Differing interest rate changes are provided for several maturities. The insurers must estimate the impact of the shock on the value of the assets and the liabilities by using the altered yields as discount rates. The SCR for the interest rate risk module is then defined as the maximum potential change in the net asset value.[40] This regulatory approach accounts for the duration mismatch because the change in the net asset value can only be positive if a duration gap exists. If it does, the sensitivities to interest rate changes differ for the asset and the liability side of a firm's balance sheet. Therefore, the regulator prescribes higher capital buffers for

[30] Cf. Love and Miller (2013), p. 44.
[31] Cf. Antolin et al. (2011), p. 238.
[32] Cf. Möhlmann (2017), p. 1.
[33] Cf. Gründl (2015), p. 192.
[34] Cf. Gründl (2015), p. 192.
[35] Cf. Möhlmann (2017), p. 1.
[36] Cf. Förstemann and Feodoria (2015), p. 18.
[37] Cf. Schlütter et al. (2018), p. 7.
[38] Art. 105 (5) of the European Commission (2009).
[39] Cf. Art. 166, 167 of the European Commission (2015).
[40] Cf. Art. 165 (1) of the European Commission (2015).

insurers with excessive interest rate risk exposures. The implemented rules seem to be reasonable because Moody's (2015) observe narrower duration gaps in countries with additionally prescribed capital reserves.[41]

Lowering the duration gap might even be necessary from a macroeconomic perspective. According to the International Monetary Fund (IMF) (2016), the duration mismatch can be a source of systemic risk due to the interconnectedness of insurers with other financial institutions.[42] If the firms' sensitivities are similar, an altered interest rate environment could affect the entire insurance industry in a comparable manner. Therefore, it is imaginable that the insurers' adapted investment strategies are quite homogeneous.[43] Due to the large size of the insurance sector, this might be a source of systemic risk. In addition, many insurers from Continental Europe are expanding as they sell insurance products abroad.[44] This increases the interconnectedness of industries and the impact of insurers' defaults as more markets are affected.

2.1.2 Sensitivities in European insurance markets

In the aftermath of the financial crisis that occurred between 2007 and 2009, the European Central Bank (ECB) lowered the key interest rate on a continual basis. It was set at 0% in March 2016. As analyzed in the previous section, interest rate reductions can have a severe negative effect on the solvency of life insurers. The impact is particularly considerable if a firm has a substantial duration mismatch between the asset and liability sides of its balance sheet. This is proven using a sample of European insurers by Hartley et al. (2017).[45] A distinctive heterogeneity exists among the magnitude of the average duration gap in European insurance markets. This is demonstrated in Table 1 for all countries where insurers in the empirical sample of the present study are headquartered. The life insurance markets with a wider average duration gap are expected to be more strongly affected by decreasing yields in the current low interest rate environment.

[41] Cf. Moody's (2015), p. 6.
[42] Cf. IMF (2016), p. 24.
[43] Cf. Möhlmann (2018), p. 4f.
[44] Cf. Hartley et al. (2017), p. 143.
[45] Cf. Hartley et al. (2017), p. 148.

Country	Average duration gap
Germany	10.7 years
Austria	10.09 years
Norway	> 10 years*
Slovenia	8.34 years
Malta	7.56 years
Cyprus	6.20 years
Croatia	5.89 years
Netherlands	5.43 years
Finland	5.36 years
France	4.82 years
Denmark	4.74 years
Poland	3.44 years
Hungary	3.03 years
Switzerland	< 2 years*
Greece	1.98 years
Belgium	1.37 years
Italy	0.81 years
Spain	0.75 years
Ireland	-0.63 years
United Kingdom	−1.05 years

Table 1: Average duration gaps in European life insurance markets[46]

Apart from the duration gap, the use of guaranteed life insurance products is another factor that considerably impacts interest rate risk. In many European countries, it is common to offer long-term guaranteed interest rate returns to customers.[47] If such a rate is implemented in a policy, the insurer is obliged to deliver at least the contractually promised yield. This applies even when the actual interest income is below the guarantee.[48] This procedure implies that the value of the policyholder's benefits equals at least the previously paid premiums plus a contractually agreed interest. Theoretically, life insurers should estimate this guaranteed rate conservatively to anticipate potential unfavorable economic conditions.[49] However, for the sake of competitiveness, many life insurers may choose a relatively high rate. This implies a higher interest rate risk due to the shorter duration of assets compared to liabilities. If the interest level decreases and the assets mature, insurers may struggle to find secure investment opportunities generating the promised yield for policyholders. This is called the reinvestment risk.

[46] Data sources: EIOPA (2014), p. 17 in case of no labeling and Moody's (2015), p. 8 for the data marked with *. The table is based on Table 1 of French et al. (2015), p. 249.
[47] Cf. Eling and Holder (2013a), p. 365.
[48] Cf. Möhlmann (2017), p. 1.
[49] Cf. Holsboer (2000), p. 42.

Guaranteed yields for policyholders are frequently used in the U.S.[50] According to the literature, in Europe this feature is often implemented in life insurance contracts offered in Italy,[51] Denmark,[52] Austria and Switzerland,[53] as well as in Spain, the Netherlands, and Norway.[54] A study from Moody's (2015) reveals that of these countries, the Netherlands and Norway are the most exposed to low interest rates.[55] In both countries, 60–80% of all products include fixed guaranteed returns[56] and on average firms have a distinctive duration mismatch.[57] Another European country, which might be very vulnerable to interest rate risk, is Austria. Most life insurers have a wide duration gap and offer guaranteed returns with a maximum that is based on the yields of bonds in the past 10 years.[58] The use of guaranteed minimum interest rates that cannot be adjusted retrospectively is also common in Germany.[59] In combination with the wide average duration gap of 10.7 years, Germany is the most prominent example of interest rate risk of life insurers in Europe.

Due to narrower duration gaps, the exposures are less severe for companies in Italy, Spain, and Switzerland. However, according to Moody's (2015), a risk to the life insurers' profitability due to the low interest rate environment still exists in these countries.[60] This is because they all offer a high proportion of products with implemented guarantees. In Italy, the yields are guaranteed in more than 60% of all policies; in Switzerland and Spain, they are guaranteed in more than 80% of contracts.[61] Nevertheless, insurers in Spain are the least sensitive to interest rate risk out of these three countries. This is because the promised yields are often directly linked to the investment income.[62] Technically, the investment risk is borne by policyholders.

Insurers are also less vulnerable to interest rate movements in Europe's two largest insurance markets in terms of gross written premiums (GWPs). These are France with 205.7 billion € of premiums and the United Kingdom (U.K.) with 254.4 billion € of GWPs in 2015. This further depicts the share of life and health insurance products (i.e., the portion of all premiums excluding those for non-life business). Insurers in France usually have the possibility to reduce

[50] Cf. Holsboer (2000), p. 46; Hartley et al. (2017), p. 136.
[51] Cf. Eling and Holder (2013b), p. 492.
[52] Cf. Jörgensen and Linnemann (2012), p. 138f.
[53] Cf. Eling and Holder (2013a), p. 365.
[54] Cf. Moody's (2015), p. 2, 6f.
[55] Cf. Moody's (2015), p. 2.
[56] Cf. Moody's (2015), p. 8.
[57] Cf. Table 1.
[58] Cf. Eling and Holder (2013a), p. 365.
[59] Cf. Berdin and Gründl, p. 386.
[60] Cf. Moody's (2015), p. 6f.
[61] Cf. Moody's (2015), p. 6f.
[62] Cf. Moody's (2015), p. 7.

credited yields to lower values.[63] The firms are thereby protected from reinvestment risk as the average duration gap in France is non-negligible. By contrast, insurance companies in the U.K. typically offer no or low guaranteed minimum rates.[64] Because they usually do not have a duration mismatch, U.K. insurers have almost no sensitivities towards interest rate changes.[65] These observations reflect the considerable heterogeneity in the interest rate risk among European insurance markets.

Apart from Germany, the other insurance markets with a high vulnerability to changes in the interest rate level are comparatively small. The total amount of GWPs from life insurance products from the most vulnerable European countries of Germany, the Netherlands, Norway, and Austria in 2015 lies approximately between 116.5 and 131.3 billion € based on the given data. Apart from the Netherlands, the most exposed countries have a comparatively smaller focus on life and health insurance business because the share of the premiums ranges between 60% and 70%. The Netherlands has the largest share of all countries in the sample, even though almost 60% of the total premiums relate to health and not to life insurance business according to Insurance Europe (2016).[66] The explanations clarify that the actual exposure of an industry to interest rate risk depends on several factors, such as the width of the duration gap, the use of guarantees, and the share of life insurance business.[67]

2.1.3 Empirical research on the influence on financial performances of insurers

To evaluate the impact of interest rate risks, empirically analyzing how insurance companies react economically to interest rates changes is necessary. This research question is examined by Browne et al. (1999) who, in contrast to expectations in the current environment, identify a positive relationship between rising interest rates and the insolvency risk of life insurers between 1972 and 1994.[68] Moreover, Brewer et al. (2007) empirically analyze the sensitivities of U.S. life insurers' stock returns towards interest rates in the years 1975 to 2000. They recognize that equity prices are particularly impacted by interest rates with long maturities and that sensitivities change over time.[69] These are crucial observations that could potentially be associated with the current low interest rate environment. This is because, in contrast to the conclusion of Browne et al. (1999), a positive relationship between interest rate increases and

[63] Cf. Moody's (2015), p. 7.
[64] Cf. Hartley et al. (2017), p. 136, Moody's (2015), p. 7.
[65] Cf. Hartley et al. (2017), p. 149, Moody's (2015), p. 8.
[66] Cf. Insurance Europe (2016), p. 11.
[67] Cf. Hartley et al. (2017), p. 143f, 148.
[68] Cf. Browne et al. (1999), p. 654.
[69] Cf. Brewer et al. (2007), p. 417.

the financial performances of life insurers seems to be more reasonable. As explained in the previous chapters, decreases of long-term interest rates in particular can have severe negative effects on the net asset value of an insurer. In fact, Hartley et al. (2017) detect that after the year 2010, U.S. life insurers' stock prices profit from rising interest rates, unlike previous time periods including the financial crisis.[70] This highlights the regular changes in the sensitivities of stock returns to interest rate movements over time.

The literature detects heterogeneity in the vulnerability to interest rate risk across firms. The deviating exposures are based on certain characteristics. Brewer et al. (2007) find evidence that interest rate risk has a higher impact on the equity returns of insurers with a low correlation to stock market movements.[71] Similarly, Carson et al. (2008) observe lower sensitivities for insurance companies who are more diversified in terms of their product portfolio and the countries in which they conduct business.[72] Berends et al. (2013) analyze sensitivities on a firm level and identify differences between life insurance companies based on their size. Thus, firms holding more total assets react more sensitively to interest rate changes.[73] These findings emphasize that it may not be sufficient to analyze sensitivities based on aggregate numbers for insurance markets. Instead, empirical analyses on a firm level are required to fully understand the sources of interest rate risk.

In this manner, Möhlmann (2017) reveals using a German sample that beyond size, the insurer's growth (measured by increases in annual premiums) and solvency ratios (measured by Solvency II capital ratios) have a strong negative correlation with interest rate sensitivities.[74] In terms of solvency, this suggests that the SCR in fact lowers the duration gap for firms with higher ratios. The observation also suggests that due to the heterogeneity in interest rate risks, insurers in financial distress could adjust their investment portfolio differently.[75] According to Möhlmann (2018), other factors that have an effect on interest rate risk are asset turnover and the share of government bonds held by the insurer. Therefore, firms with a higher frequency in trading assets and those investing a larger fraction in sovereign debt are less vulnerable to interest rate reductions.[76]

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[70] Cf. Hartley et al. (2017), p. 149.
[71] Cf. Brewer et al. (2007), p. 413.
[72] Cf. Carson et al. (2008), p. 889.
[73] Cf. Berends et al. (2013), p. 72.
[74] Cf. Möhlmann (2017), p. 3.
[75] Cf. Möhlmann (2017), p. 16.
[76] Cf. Möhlmann (2018), p. 3.

Thus far, most of the literature on the effects of interest rate risk on life insurers has focused on the U.S. market. Hartley et al. (2017) detect some difficulties when analyzing the sensitivities of European insurance companies. First, only a small number of insurers are listed on the stock market.[77] In addition, most of these companies are not pure life insurers, which complicates the creation of a broad meaningful sample. Second, many firms conduct business abroad and are therefore exposed to several markets with different regulation and product characteristics.[78] This refers particularly to the frequency of the use of implemented guarantees, which is handled differently in European countries.[79] In fact, some insurers might be better hedged to interest rate risk than others because their business is more diversified, or they focus on markets with lower implied interest rate risk. Third, as mentioned before, offering guaranteed minimum returns to policyholders is not prevalent in some countries.[80] Therefore, interest rate risk is almost nonexistent in the U.K.[81] These constraints complicate the empirical analysis of the effects of interest rate risk on the stock returns of European insurance companies.

2.2 Credit risk

A second considerable and due to the recent European sovereign debt crisis frequently discussed[82] market risk for insurance companies is credit risk. According to art. 13 (32) of the European Commission (2009), it covers all risks to an insurer's financial performance "resulting from fluctuations in the credit standing of issuers of securities, counterparties and any debtors to which insurance and reinsurance undertakings are exposed, in the form of counterparty default risk, or spread risk or, market risk concentrations"[83]. Credit risk is usually measured by default risk and is therefore reflected by CDS spreads.[84]

According to the EIOPA (2017), 83.5% of all assets in the European insurance sector in 2016 were allocated to bonds.[85] Because sovereign debt composes a large fraction of the aggregate investments of insurers,[86] it can be expected that a change in the creditworthiness of these bonds could affect an insurer's equity value. Düll et al. (2017) confirm this assumption by discovering a negative relationship between life insurers' stock returns and CDS spreads for government

[77] Cf. Hartley et al. (2017), p. 143.
[78] Cf. Hartley et al. (2017), p. 143.
[79] Cf. chapter 2.1.2.
[80] Cf. Hartley et al. (2017), p. 143.
[81] Cf. Hartley et al. (2017), p. 149; Moody's (2015), p. 8.
[82] Cf. Acharya et al. (2014); Düll et al. (2017).
[83] Art. 13 (32) of the European Commission (2009).
[84] Cf. Acharya et al. (2014), p. 2694; Düll et al. (2017), p. 97.
[85] Cf. EIOPA (2017), p. 8.
[86] Cf. J.P.Morgan Cazenove (2013), p. 1f; EIOPA (2016), p. 16f.

debt.[87] Since 2010, these dependencies have been particularly strong towards domestic sovereign bonds, which suggests that insurers mostly invest in domestic government debt securities.[88] Notably, the home bias is substantially larger for systemically relevant insurers.[89] These are also more exposed to credit risk in total.[90]

Insurance companies in Europe increase their share of investments in sovereign bonds.[91] This might be a result of regulatory actions. After the introduction of Solvency II, insurers do not need to set aside any capital in the form of SCR for investments in government bonds of countries within the European Economic Area (EEA) according to art. 180 (2) of the European Commission (2015). Although this measure increases the incentive for investments and thereby enhances the liquidity of the states in the EEA, it neglects the countries' probability of default. Thus, it omits a potential risk according to some EU member states.[92] In this manner, the specification of Solvency II imposes a potential risk for policyholders. This is because it gives insurers an opportunity to increase the riskiness of their asset portfolio and evade additional SCR,[93] although the promised yields may differ and impose deviating risks. Wilson (2013) notices that the regulatory framework does not discourage life insurers to invest more in sovereign debt.[94] This is similar to the situation in the U.S., where Becker and Ivashina (2015) detect that, with current regulation standards, insurers have an incentive to invest in riskier assets.[95] In fact, in the asset allocation of European insurers, the share of bonds with a rating of AAA has been continually decreasing since 2011.[96]

Ever since, the long-term interest rates and therefore also the CDS spreads of some European countries rose sharply in the aftermath of the financial crisis. The development of the CDS spreads with a maturity of 5 years of selected countries can be observed in Figure 2. In the graph, the y-axis reflects the yields (in percentage). Notably, in late 2008, all default probabilities were on the same considerably low level. The increased spreads in the sovereign debt crisis between 2010 and 2013 implied higher credit risk for insurance companies.

[87] Cf. Düll et al. (2017), p. 105.
[88] Cf. Düll et al. (2017), p. 101.
[89] Cf. Düll et al. (2017), p. 103.
[90] Cf. Düll et al. (2017), p. 103.
[91] Cf. EIOPA (2014), p. 88; EIOPA (2017), p. 12.
[92] Cf. EIOPA (2011), p. 75.
[93] Cf. Düll et al. (2017), p. 105.
[94] Cf. Wilson (2013) p. 132.
[95] Cf. Becker and Ivashina (2015), p. 1899.
[96] Cf. EIOPA (2014), p. 88; EIOPA (2017), p. 12.

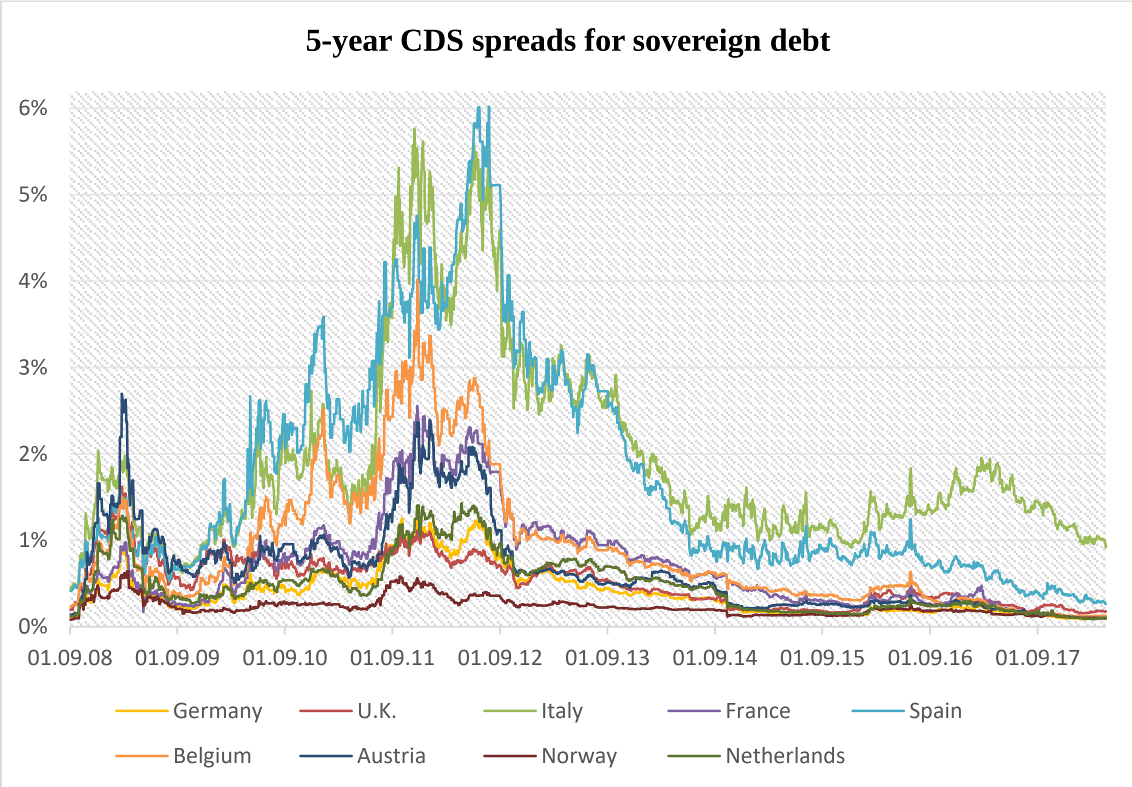

Figure 1: CDS spreads with 5-year maturities for European government bonds[97]

2.3 Equity risk

A third relevant market risk is equity (or stock market) risk. This deals with fluctuations of asset and liability values which, according to art. 105 (5) b) of the European Commission (2009), are related to "changes in the level or in the volatility of market prices of equities"[98]; i.e., sensitivities to stock market movements. For a procyclical industry, equity risk implies that if an entire economy is in a recession, it is more probable that a firm's financial performance will also be less prosperous. For the insurance sector, Kessler et al. (2017) demonstrate that companies' financial performances are traditionally strongly correlated with economic growth.[99] In contrast to interest rate and credit risk, equity risk should affect life and non-life insurers to a similar extent because both types of firms should experience lower investment incomes and delays or shortfalls in premium payments in a recession. Therefore, the condition and activity in an economy affects insurers' financial performances.[100] Regarding life insurers,

[97] X-axis: date. Y-axis: rate (in percentage).
[98] Art. 105 (5) b) of the European Commission (2009).
[99] Cf. Kessler et al. (2017), p. 24-27.
[100] Cf. Düll et al. (2017), p. 97.

Brewer et al. (2007) find that companies with a larger asset size experience equity risk that is lower than their interest rate risk.[101]

3 Estimation of market risk sensitivities based on market data

3.1 Sample of stock-listed insurance companies

For the selection of companies in our sample, we proceed according to the following approach. At first, we use a record from the company database Orbis. It contains financial information on firms that engage in insurance business according to the database supplier. The data are provided for insurers from 144 countries for the time period between 2007 to 2016. In total, the broad record contains financial information on 14,352 entities including subsidiaries and separated lines of business. From this dataset, we limit this list to companies that have an International Securities Identification Number (ISIN) according to Orbis. The existence of an ISIN is thereby used an indicator that a firm is listed on a stock exchange.

Furthermore, we exclude some firms to create an unbiased and relevant sample to tackle the research question. This mainly concerns companies that do not operate insurance as their main business; for example, investment banks with an insurance business line. Including these firms would cause a bias in the regression analysis because the sensitivities of stock returns to market risks could be influenced through other branches of business such as banking. In fact, the aim of this paper is to analyze the effects of market risks exclusively on insurers, so that the inclusion of sensitivities resulting from other business lines should be minimized. In the case that a parent company mainly focuses on other businesses than insurance, we add the insurance subsidiary as long as it is also listed on the stock market. However, if the parent enterprise mainly operates an insurance business, we only include the parent. The sample consists of all remaining firms from the Orbis dataset for which daily stock data can be gathered from Thomson Reuters Eikon. These are 69 joint-stock insurance companies. The sample contains all six European insurers that have ever been marked as global systemically important insurers (G-SIIs) by the Financial Stability Board (FSB).[102]

[101] Cf. Brewer et al. (2007), p. 417.
[102] Cf. FSB (2014), p. 2; FSB (2015), p. 3.

3.2 Dependent variable

For the empirical analysis of the market risk sensitivities, we collect daily stock prices of 69 European insurance companies for the time period between 1st January 2012 and 30th June 2018 from Thomson Reuters Eikon. The period starting from 2012 reflects the low interest rate environment in line with the current literature.[103] We choose this time frame because we want to focus on a current and relatively homogenous market phase. It corresponds to the time span of the regression analyses and covers a total amount of 1,657 trading days. Because we use daily returns in our empirical analysis, the maximum amount of observations for a firm is 1,656. The stock prices are all collected in national currencies. Converting them to EUR based on daily conversion rates could cause distortions in the empirical analysis that would be directly related to currency risk. As the dependent variable in our regression analysis, we use the daily change in the total return index which accounts for stock price changes due to dividend payments and fluctuations in the number of outstanding shares of a firm. We use this as a measure for the stock return. It is given for each firm i on each day t:

$$r(TRI_{i,t}) = \frac{TRI_{i,t}}{TRI_{i,t-1}} - 1 \quad (1)$$

Some insurers have no data on stock prices for certain trading days, for example, due to a public holiday in the country where they are listed. To avoid distortions and to ensure the comparability of the firms' sensitivities to our market risk estimates, we only include observations where the stock returns are given for two subsequent trading days. Consequently, if the stock price of an insurer i is missing for a particular day t, then we exclude the data on the relative change of the total return index $r(TRI_{i,t})$ for the days t and $t+1$ for firm i. A few insurers have provided stock data for days that are holidays in most other countries.[104] Since the independent variables are not available for these days, they are excluded in the regressions.

Table 2 presents the results of the descriptive analysis of the daily stock returns $r(SHV_{i,t})$ of the 69 insurance companies from 20 European countries in the final sample. It includes the availability of stock prices, the standard deviation (SD), as well as the minimum (Min.) and maximum (Max.) observations of stock returns over all days in the time period of the sample. For nine firms, the data are available only from a later date because they were not listed on a

[103] Cf. Hartley et al. (2017).
[104] This refers particularly to insurers from Switzerland and the U.K.

stock exchange before.[105] By contrast, only two firms ceased to exist by the end of the sample period. For the 69 insurers in the final sample, the standard deviations of the returns range between 0.98% and 5.43% from 2012 to mid-2018. The actual daily observations of the stock returns of all firms are between −58.82% and 119.81%.

Name	Country	First day in sample	Last day in sample	SD of stock returns	Min. stock return	Max. stock return
UNIQA Insurance Group AG	Austria	02.01.12	29.06.18	1.56%	-10.10%	9.84%
Vienna Insurance Group AG Wiener V	Austria	02.01.12	29.06.18	1.55%	-17.93%	7.15%
Ageas SA	Belgium	02.01.12	29.06.18	1.53%	-9.75%	10.65%
KBC Groep NV	Belgium	02.01.12	29.06.18	2.20%	-13.88%	10.71%
Jadransko Osiguranje dd	Croatia	02.01.12	29.06.18	2.31%	-29.83%	47.19%
Atlantic Insurance Company	Cyprus	02.01.12	29.06.18	2.17%	-10.00%	11.61%
Cosmos Insurance PCL	Cyprus	02.01.12	29.06.18	1.86%	-20.08%	10.04%
Alm Brand A/S	Denmark	02.01.12	29.06.18	1.64%	-7.17%	14.08%
Topdanmark A/S	Denmark	02.01.12	29.06.18	1.17%	-7.03%	8.92%
Tryg A/S	Denmark	02.01.12	29.06.18	1.21%	-6.63%	7.75%
Sampo Plc	Finland	02.01.12	29.06.18	1.16%	-9.40%	4.86%
April SA	France	02.01.12	29.06.18	1.55%	-6.38%	10.03%
Axa SA	France	02.01.12	29.06.18	1.75%	-15.48%	7.55%
CNP Assurances SA	France	02.01.12	29.06.18	1.57%	-8.49%	11.73%
Coface SA	France	26.06.14	29.06.18	2.05%	-29.73%	8.87%
Scor SE	France	02.01.12	29.06.18	1.24%	-6.93%	5.61%
Allianz SE	Germany	02.01.12	29.06.18	1.28%	-10.17%	6.04%
Muenchener Rueckversicherungs Gesel	Germany	02.01.12	29.06.18	1.15%	-7.05%	4.94%
Nürnberger Beteiligungs AG	Germany	02.01.12	29.06.18	1.17%	-6.17%	7.31%
Rheinland Holding AG	Germany	02.01.12	29.06.18	2.76%	-12.34%	16.36%
Talanx AG	Germany	01.10.12	29.06.18	1.37%	-5.59%	5.23%
Wuestenrot & Wuerttembergische AG	Germany	02.01.12	29.06.18	1.61%	-7.87%	7.48%
European Reliance General Insurance C	Greece	02.01.12	29.06.18	2.95%	-16.43%	19.90%
CIG Pannonia EletBiztosito Nyrt	Hungary	02.01.12	29.06.18	2.32%	-12.83%	14.99%
Vatryggingafelag Islands hf	Iceland	24.04.13	29.06.18	1.13%	-5.49%	9.22%
FBD Holdings Plc	Ireland	02.01.12	29.06.18	2.01%	-20.54%	14.84%
Permanent TSB Group Holdings plc	Ireland	02.01.12	29.06.18	5.43%	-25.70%	39.16%
Assicurazioni Generali SpA	Italy	02.01.12	29.06.18	1.78%	-16.77%	9.35%
Societa Cattolica di Assicurazione Sc	Italy	02.01.12	29.06.18	1.93%	-17.43%	17.30%
UnipolSai Assicurazioni SpA	Italy	02.01.12	29.06.18	5.18%	-58.82%	119.81%
Vaudoise Assurances Holding SA	Italy	02.01.12	29.06.18	1.24%	-5.05%	8.52%
Vittoria Assicurazioni SpA	Italy	02.01.12	29.06.18	1.51%	-8.14%	19.73%
Mapfre Middlesea Plc	Malta	02.01.12	17.02.16	1.76%	-11.10%	14.93%
Aegon NV	Netherlands	02.01.12	29.06.18	1.98%	-11.37%	13.32%
ASR Nederland NV	Netherlands	09.06.16	29.06.18	1.37%	-7.43%	6.76%
Delta Lloyd	Netherlands	02.01.12	14.06.17	2.77%	-32.72%	47.89%
NN Group NV	Netherlands	01.07.14	29.06.18	1.39%	-8.03%	8.77%
Gjensidige Forsikring ASA	Norway	02.01.12	29.06.18	1.21%	-8.15%	12.28%
Insr Insurance Group ASA	Norway	08.04.14	29.06.18	3.75%	-54.56%	22.42%
Protector Forsikring ASA	Norway	02.01.12	29.06.18	1.91%	-9.91%	15.61%
Storebrand	Norway	02.01.12	29.06.18	2.13%	-14.25%	12.36%
Powszechny Zaklad Ubezpieczen SA	Poland	02.01.12	29.06.18	1.49%	-6.59%	7.13%

105 Talanx, for example, had its initial public offering on 2nd October 2012 which is its first day in the sample. Consequently, the daily stock return is measured starting with the following trading day.

Pozavarovalnica Sava dd	Slovenia	02.01.12	29.06.18	1.91%	-10.47%	12.39%
Zavarovalnica Triglav dd	Slovenia	02.01.12	29.06.18	1.56%	-7.94%	8.91%
Grupo Catalana Occidente SA	Spain	02.01.12	29.06.18	1.70%	-7.94%	13.26%
Mapfre SA	Spain	02.01.12	29.06.18	1.88%	-9.30%	14.14%
Baloise Holding Ltd	Switzerland	02.01.12	29.06.18	1.11%	-7.41%	4.57%
Chubb Ltd	Switzerland	02.01.12	29.06.18	0.98%	-4.83%	4.54%
Helvetia Holding AG	Switzerland	02.01.12	29.06.18	1.15%	-6.96%	5.65%
Swiss Life Holding AG	Switzerland	02.01.12	29.06.18	1.36%	-8.10%	8.73%
Swiss Re AG	Switzerland	02.01.12	29.06.18	1.09%	-5.63%	4.26%
Zurich Insurance Group AG	Switzerland	02.01.12	29.06.18	1.12%	-10.82%	6.57%
Admiral	UK	02.01.12	29.06.18	1.42%	-7.68%	10.00%
Aon PLC	UK	02.01.12	29.06.18	1.06%	-5.76%	6.11%
Aviva PLC	UK	02.01.12	29.06.18	1.62%	-15.68%	8.13%
Beazley PLC	UK	02.01.12	29.06.18	1.38%	-8.96%	6.85%
Chesnara PLC	UK	02.01.12	29.06.18	1.75%	-14.51%	8.85%
Direct Line Insurance Group PLC	UK	10.10.12	29.06.18	1.22%	-7.16%	12.62%
Hansard Global PLC	UK	02.01.12	29.06.18	2.35%	-14.36%	13.67%
Hastings Group Holdings PLC	UK	09.10.15	29.06.18	1.52%	-12.03%	6.82%
Legal & General Group PLC	UK	02.01.12	29.06.18	1.47%	-20.26%	7.88%
Old Mutual PLC	UK	02.01.12	29.06.18	1.64%	-10.83%	6.92%
Personal Group Holdings PLC	UK	02.01.12	29.06.18	1.17%	-6.98%	11.56%
Phoenix Group Holdings	UK	02.01.12	29.06.18	1.41%	-11.54%	11.17%
Prudential PLC	UK	02.01.12	29.06.18	1.59%	-10.53%	9.33%
RSA Insurance Group PLC	UK	02.01.12	29.06.18	1.48%	-20.84%	18.43%
Saga PLC	UK	22.05.14	29.06.18	1.58%	-21.41%	10.78%
St. James's Place PLC	UK	02.01.12	29.06.18	1.61%	-16.18%	7.24%
Standard Life Aberdeen PLC	UK	02.01.12	29.06.18	1.58%	-17.30%	8.07%

Table 2: Descriptive analysis of the stock returns of the 69 insurance companies in the final sample

3.3 Independent variables

For the regression analyses, we use interest rates with maturities of 1 and 10 years to measure interest rate risk. The data are taken from the ECB, which publishes daily estimates of the euro yield curve. The term structure is estimated by applying the Svensson model to government bonds in the Eurozone with a rating of AAA. The resulting annual interest rates equal those for a zero-coupon bond with a maturity of 1 or 10 years. Because the ratings alter over time, the data are based on a changing composition of sovereign debt. However, this does not cause any distortions because the quality of the bonds remains unchanged and the estimates reflect secure investments. Therefore, these independent variables can be interpreted as the risk-free interest rates for different maturities.

Analogous to Brewer et al. (2007), we use the holding period return within one trading day as the independent variable for interest rate risk. This equals the yield achieved by buying a zero-coupon bond with the given interest rate and then selling it the next day. If the interest rate y increased in the meantime, the market value of the bond would decrease. Therefore, the holding period return $r(y_{T,t})$ is only positive after a decline of the interest rate. With the time to maturity T, the 1-day holding period return on day t is calculated followingly:

$$r(y_{T,t}) = (\frac{1+y_{T,t-1}}{1+y_{T,t}})^T - 1 \text{ , with } T = \{1, 10\} \quad (2)$$

Because insurers invest the largest fraction of their assets in sovereign bonds,[106] we use CDS spreads of European government debt as a measure for credit risk. The data are collected from the supplier Markit. Analogous to Düll et al. (2017), we select CDS spreads with a maturity of 5 years that are denominated in USD. The quotas correspond to the probability that a country will not meet its payment obligations in the 5 years after the issue date. This would imply a default.

We collect sovereign CDS data for all countries where insurers in our sample are listed on the stock exchange. Consistent with Düll et al. (2017), each insurer is assigned to domestic CDS quotes depending on its country of origin c. Therefore, we use country-specific data as a measure for credit risk in contrast to the other independent variables. This approach is applied because insurers' sensitivities are particularly large towards domestic CDS spreads.[107] For each day t, we calculate the relative daily change of each government bond's CDS spread and use it as an independent variable in the regression analysis. It is denoted as $r(CDS_{t,c})$. Consequently, the following formula applies:

$$r(CDS_{c,t}) = \frac{CDS_{c,t}}{CDS_{c,t-1}} - 1 \quad (3)$$

To measure equity risk, we gather daily data on the index prices of Euro Stoxx 50 and Euro Stoxx 50 Volatility (VStoxx) from Thomson Reuters Eikon. The Euro Stoxx 50 index consists of the stock prices of 50 large corporations with liquid stocks from countries in the Eurozone. This is a well-established barometer stock and serves as an adequate indicator for the share price development in Europe and for the growth of the European economy.[108] In an empirical model, the market index controls for macroeconomic shocks, which affect all corporations simultaneously.[109] When analyzing the impact of market risks on insurer's shareholder values, Brewer et al. (2007), Hartley et al. (2017), and Düll et al. (2017) use returns in stock indices as a control variable.

[106] Cf. EIOPA (2016).
[107] Cf. Düll et al. (2017).
[108] Cf. Brechmann and Czado (2013), p. 308.
[109] Cf. Hartley et al. (2017), p. 131.

Furthermore, the VStoxx index measures the implied volatility of the Euro Stoxx 50 index and thereby reflects expectations regarding stock price fluctuations in the future. It is included in the empirical model because expected changes in volatility might impact the stock prices of individual firms, especially in times of stress. Volatility indices are also implemented in the panel regression models of Düll et al. (2017), who describe them as a measure for "market sentiment and risk aversion"[110]. Accounting for the volatilities of stock market prices is also necessary in terms of the calculation of the SCR.[111] We calculate the daily relative change in the indices and use it as a control variable in the regression model:

$$r(Euro\ Stoxx\ 50_t) = \frac{Euro\ Stoxx\ 50_t}{Euro\ Stoxx\ 50_{t-1}} - 1 \quad (4)$$

$$r(VStoxx_t) = \frac{VStoxx_t}{VStoxx_{t-1}} - 1 \quad (5)$$

Table below presents the results of the descriptive analysis of the independent variables measuring interest rate and equity risk. Statistics are given for the number of observations, the mean of the daily relative changes, their standard deviations as well as the minimum and the maximum values over the entire time period of the regressions.

Variable	**Observations**	**Mean**	**SD**	**Min.**	**Max.**
10-year yield	1656	0.01%	0.53%	-1.74%	1.94%
Euro Stoxx 50	1656	0.03%	1.15%	-8.62%	4.96%
VStoxx	1641	0.17%	6.86%	-35.26%	60.05%

Table 3: Statistics of the independent variables

Furthermore, Table 4 illustrates the descriptive statistics for the independent variables measuring credit risk; these are, the relative changes in CDS spreads. The statistics are presented for each country for which domestic CDS quotas are included in the sample. The large maximum percentage increase for default risk for sovereign debt in Switzerland is due to the fact that the domestic CDS spreads are usually considerably low. For this reason, an increase of the quotas can have a large relative impact.

[110] Düll et al. (2017), p. 97.
[111] Cf. Articles 105 (5) b) of the European Commission (2009).

Country	Observations	Mean	Std. Dev.	Min	Max
Austria	1656	-0.13%	2.80%	-13.30%	33.12%
Belgium	1656	-0.15%	2.44%	-11.59%	35.43%
Croatia	1656	-0.08%	1.78%	-19.65%	19.80%
Cyprus	1656	-0.10%	2.69%	-23.70%	30.05%
Denmark	1656	-0.13%	2.45%	-12.20%	14.78%
Finland	1656	-0.10%	2.08%	-11.09%	17.08%
France	1656	-0.11%	3.02%	-19.16%	44.72%
Germany	1656	-0.10%	2.95%	-24.57%	31.67%
Greece	1656	0.10%	4.89%	-43.68%	73.46%
Hungary	1656	-0.10%	1.88%	-10.37%	18.05%
Iceland	1656	-0.09%	1.44%	-14.65%	9.84%
Ireland	1656	-0.18%	2.49%	-16.19%	32.86%
Italy	1656	-0.01%	3.64%	-16.38%	53.96%
Malta	1052	0.22%	4.70%	-47.37%	65.22%
Netherlands	1656	-0.11%	3.25%	-16.28%	29.68%
Norway	1656	-0.07%	2.46%	-16.67%	30.85%
Poland	1656	-0.06%	2.05%	-12.51%	25.26%
Slovenia	1656	-0.08%	1.99%	-14.07%	23.14%
Spain	1656	-0.05%	4.02%	-24.76%	37.65%
Switzerland	1656	-0.10%	2.28%	-22.33%	27.69%
U.K.	1656	-0.06%	2.54%	-20.61%	41.99%

Table 4: Statistics of the variables for credit risk

3.4 Regression model

In our empirical model, we use regressions with several independent variables to account for the effects of interest rate, credit and equity risk on insurers between 2012 and mid-2018. This approach prevents the existence of an omitted variable bias which could occur when analyzing the impact of either interest rate or credit risks on insurers’ stock returns separately. Similarly, in terms of Solvency II, European insurers also need to consider all market risks and their interdependencies.[112] While most authors examine the effects of market risks either on a portfolio of life insurers[113] or for groups of firms by means of panel regressions,[114] we analyze market risk sensitivities on a firm level. This approach allows us to examine the heterogeneity in market risk exposures of insurers which has been detected by Berends et al. (2013) and

[112] Cf. Art. 164 of the European Commission (2015).
[113] Cf. Brewer et al. (2007), p. 404.
[114] Cf. Hartley et al. (2017), p. 131; Düll et al. (2017), p. 96.

Möhlmann (2017). We perform a linear regression for each firm in the sample based on the following model:

$$\log[r(TRI_{i,t}) + 1] = \alpha_i + \beta_{1,i} \cdot \log[r(Euro\ Stoxx\ 50_t) + 1] + \beta_{2,i} \cdot \log[r(y_{10,t}) + 1] + \beta_{3,i} \cdot \log[r(CDS_{c,t}) + 1] + \beta_{4,i} \cdot \log r[(VStoxx_t) + 1] + \varepsilon_{i,t}$$

In the empirical model, $r_{i,t}(TRI)$ marks the dependent variable; i.e., the daily return on the total return index. This is measured for each firm i for each day t. While α_i is the intercept of the linear regression, $\beta_{1,i}$ to $\beta_{5,i}$ are the coefficients for the independent variables for each firm. The first of these variables is $r(Euro\ Stoxx\ 50_t)$, which measures relative changes in the daily total return index value. The second independent variable is $r(y_{10,t})$; i.e., the 1-day holding period return of a bond with daily interest rate estimates for 10-year yields by the ECB. The additionally introduced variables are $r(y_{1,t})$, $r(CDS_{c,t})$ and $r(VStoxx_t)$. Lastly, $\varepsilon_{i,t}$ denotes the residual term in the regression.

From all regressions, we save the estimated $\beta_{k,i}$ for each independent variable k as well as the t-values for each coefficient. A t-value equals the coefficient β ("beta" in the further course) of a regression divided by its standard error.[115] The betas and the t-values indicate whether the relationship of each market risk to each insurer's stock price is positive or negative in a given time window. They further provide information on the magnitude of the risks' influences. In addition, high absolute t-values show that this relationship is statistically significant. Therefore, comparing the t-values of the beta coefficients for the variable $r(y_{10,t} + 1)$ in the regression results of a firm enables to detect differences in interest rate risk sensitivities.

3.5 Resulting sensitivities

Figure 2 depicts the t-values of the betas for the impacts of long-term interest rates (x-axis) and CDS spreads of domestic sovereign bonds (y-axis) on the shareholder values of all insurance companies in the sample. Each dot reflects the estimates for interest rate and credit risk for one insurer. For all absolute t-values above 2.33, the impact of impact of daily changes in long-term interest rates and CDS spreads on stock returns can be considered as highly significant at a 1% significance level. This is the case for 30.4% of all insurers in terms of interest rate risk and for 34.8% of all insurers in terms of credit risk. In addition, 18.8% of insurers are highly significantly affected by both, interest rate and credit risk. The estimated sensitivities also reveal

[115] Cf. Schlütter et al. (2018), p. 12.

a considerable heterogeneity in market risk exposures across European insurers which can be explained by the deviating width of duration gaps between the asset and liability sides of insurers' balance sheets,[116] the use of legally binding guarantees for policyholders in several countries[117] and the varying share of life insurance business[118]. There are however, no significant differences in terms of the total asset size of insurance companies.

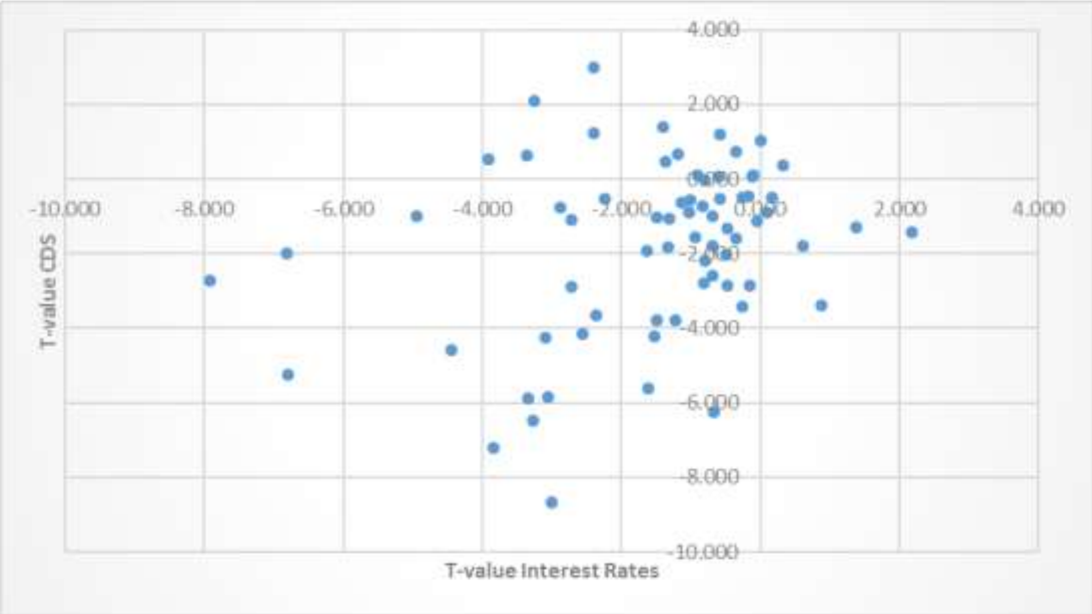

Figure 2: Sensitivities to interest rates and CDS

4 Estimation of market risk sensitivities based on SFCRs and comparison with market data

4.1 Empirical approach

We systematically gather data from the SFCRs published for the years 2016 and 2017 for all 69 companies in the sample. In order to examine whether Solvency II reports appropriately inform about European stock insurers' market risk exposures, we detect risk profiles based on SFCRs and compare them with the previously obtained risk sensitivities of European insurers based on market data. For the means of consistency, the reported risk profiles should be in line with empirical data and provide a consistent picture of the insurers' market risk profiles.

As explained in chapter 2, the European Commission (2015) prescribes capital buffers in form of SCR to cover for the potential negative consequences of interest rate and credit risk. The market risk module, which is an integral part of the SCR, can be used as an indicator for higher

[116] Cf. EIOPA (2014).
[117] Cf. Eling and Holder (2013).
[118] Cf. Hartley et al. (2017).

interest rate risk of European insurers. For each company i in the sample, we calculate the share s of the market risk module $SCR_{market\ risk}$ relative to the firm's own funds OF for each year t. The use of this value as a measure for interest rate risk is supported by the fact that Gatzert and Heidinger (2018), who analyze the effectiveness of market discipline, find a significant impact of the published solvency ratio and SCR on insurers' abnormal stock returns. On average the share of the market risk module accounts for 34.5% of an insurer's own funds.

$$s(SCR_{market\ risk,i,t}) = \frac{SCR_{market\ risk,i,t}}{OF_{i,t}}$$

As we systematically analyze SFCRs and the attached Quantitative Reporting Templates (QRTs), we also examine whether the extent of the use of transitionals for technical provisions (1) and interest rates (2) as well as the use of the volatility (3) and the matching adjustment (4) for the calculation of the SCR impacts market risk sensitivities. To this end, we calculate the absolute impacts Δ of each of the four applications on the solvency ratio.

$$\Delta(transitional_{j,i,t}) = solvency\ ratio\ with\ transitionals - solvency\ ratio\ without\ transitional\ j \qquad , with\ j = \{1,2,3,4\}$$

Lastly, we aim to test whether the use of internal models, which demonstrate advanced risk management approaches, significantly lowers market risk sensitivities. We use the binary variable $internal\ model$ indicating whether an insurer i applies an internal model (including both partial and full internal models) for the calculation of the SCR in year t. In total, 42% of all companies in the sample employ internal models in the year 2017.

To answer the research question on the transparency of risk profiles in SFCRs, we test whether the fluctuations of the market data sensitivities can be significantly explained by the collected information from Solvency II reports. Therefore, we estimate the following two linear regression models for interest rate and credit risk:

$$\beta_{interest\ rate\ risk,i} = \alpha + \beta_1 \cdot s(SCR_{market\ risk,i,t}) + \sum_{j=1}^{4} \beta_{1+j} \cdot \Delta(transitional_{j,i,t}) + + \beta_6 \cdot internal\ model_{i,t} + \varepsilon_{i,t}$$

$$\beta_{credit\ risk,i} = \alpha + \beta_1 \cdot s(SCR_{market\ risk,i,t}) + \sum_{j=1}^{4} \beta_{1+j} \cdot \Delta(transitional_{j,i,t}) + + \beta_6 \cdot internal\ model_{i,t} + \varepsilon_{i,t}$$

In terms of risk management quality, we further aim to test whether insurers accounting for sovereign credit risk in their internal models, which is not required according to art. 180 (2) of the European Commission (2015), have lower credit risk sensitivities. Moreover, the relationship between Solvency II reporting and risk will be examined by the use of textual analysis. Potentially, more qualitative information on market risks in SFCRs and more negative words relating to interest rate and credit risk indicate significantly higher market risk sensitivities.

4.2 Preview on results

The regression results in Table 5 reveal that that the market data based sensitivities (betas) for interest rate risk are significantly influenced by the SCR market risk module relative to the firms' eligible own funds $s\left(SCR_{market\ risk,i,t}\right)$. The negative sign shows that a firm bears higher interest rate risk, if the relative amount of the market risk module increases. This demonstrates that in terms of interest rate risk the regulatory reports include information which is in line with market data. In terms of credit risk, the market risk module does not significantly reflect insurers' market sensitivities (cf. Table 6).

Relating to the calculation of the SCR, we find that an increase in the transitional for technical provisions significantly lowers both interest rate and credit risk. This is probably because insurers using this transitional have lower fluctuations of technical provisions, a stabilized solvency ratio and are thus better immunized against changing market developments. Instead, firms' using the volatility adjustment have a higher degree of interest rate risk. We assume that insurers applying this measure invest more heavily in bonds and are thus more exposed to changing yield curves. Similarly, the use of the matching adjustment significantly shows that insurers have higher credit risk sensitivities. Notably, insurers using more advanced risk management schemes (i.e., internal models), do not have significantly lower sensitivities towards market risks than insurers applying the standard formula. Nevertheless, our results demonstrate that the company-specific calculation of the SCR is suitable for approximating insurers' true market risk exposures.

	Dependent variable: $\beta_{interest\ rate\ risk,i}$
$s(SCR_{market\ risk,i,t})$	-2.9152**
	(0.1315)
Technical provision transitional	0.1021**
	(0.045)
Interest rate transitional	36.3651
	(32.0588)
Volatility adjustment	-1.0183***
	(0.322)
Matching adjustment	-0.1461
	(0.1323)
Internal model (binary variable)	0.0662
	(0.0643)
R^2	0.3087
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 5: Regression results for interest rate risk

	Dependent variable: $\beta_{credit\ risk,i}$
$s(SCR_{market\ risk,i,t})$	-0.1782
	(0.0204)
Technical provision transitional	0.0148**
	(0.0070)
Interest rate transitional	3.7108
	(4.9811)
Volatility adjustment	-0.0306
	(0.0500)
Matching adjustment	-0.0679***
	(0.0206)
Internal model (binary variable)	0.0071
	(0.0100)
R^2	0.2785
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 6: Regression results for credit risk

Literature

Acharya, V., Drechsler, I., Schnabl, P. (2014), 'A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk', *Journal of Finance*, 69 (6): 2689-2739.

Antolin, P., Schich, S., Yermo, J. (2011), 'The Economic Impact of Protracted Low Interest Rates on Pension Funds and Insurance Companies', *OECD Journal: Financial Market Trends*, 2011 (1): 237-256.

Becker, B., Ivashina, V. (2015), 'Reaching for Yield in the Bond Market', *Journal of Finance*, 70 (5): 1863-1902.

Berdin, E., Gründl, H. (2015), 'The Effects of a Low Interest Rate Environment on Life Insurers', *The Geneva Papers on Risk and Insurance – Issues and Practice*, 40 (3): 385-415.

Berends, K., McMenamin, R., Plestis, T., Rosen, R. (2013), 'The sensitivity of life insurance firms to interest rate changes', *Federal Reserve Bank of Chicago Economic Perspectives*, 37 (2): 47-78.

Brechmann, E. C., Czado, C. (2013), 'Risk management with high-dimensional vine copulas: An analysis of the Euro Stoxx 50', *Statistics & Risk Modeling*, 30 (4): 307-342.

Brewer, E., Carson, J. M., Elyasiani, E., Mansur, I., Scott, W. L. (2007), 'Interest rate risk and equity values of life insurance companies: A GARCH-M model', *Journal of Risk and Insurance*, 74 (2): 401-423.

Carson, J. M., Elyasiani, E., Mansur, I. (2008), 'Market risk, interest rate risk, and inter-dependencies in insurer stock returns: A System-GARCH model', Journal of Risk and Insurance, 75 (4): 873-891.

Düll, R., König, F., Ohls, J. (2017), 'On the exposure of insurance companies to sovereign risk portfolio investments and market forces', *Journal of Financial Stability*, 31: 93-106.

Duverne, D., Hele, J. (2017), 'How the Insurance Industry Manages Risk', in: Hufeld, F., Koijen, R. S. J., Thimann, C. (Eds.), The Economics, Regulation, and Systemic Risk of Insurance Markets, Oxford University Press, Oxford, Ch. 3: 55-75.

EIOPA (2011), 'EIOPA Report on the fifth Quantitative Impact Study (QIS5) for Solvency II', *EIOPA*, Frankfurt am Main, March 2011, https://eiopa.europa.eu/publications/reports/qis5_report_final.pdf, download on 13th July 2018.

EIOPA (2013), 'Technical Specification on the Long Term Guarantee Assessment (Part I)', EIOPA-DOC-13/061, January 2013, https://eiopa.europa.eu/Publications/QIS/A_-_Technical_Specification_on_the_Long_Term_Guarantee_Assessment__Part_I_.pdf, download on 06th July 2018.

EIOPA (2014), 'EIOPA Insurance stress test 2014', EIOPA-BOS-14-203, November 2014, https://eiopa.europa.eu/Publications/Surveys/Stress%20Test%20Report%202014. pdf, download on 16th July 2018.

EIOPA (2016), '2016 EIOPA Insurance Stress Test Report', EIOPA 16/302, December 2016, https://eiopa.europa.eu/publications/surveys/eiopa-bos-16-302%20insurance%20 stress%20test%202016%20report.pdf, download on 16th July 2018.

EIOPA (2017), 'Investment behavior report', EIOPA-BoS-17/230, November 2017, https://eiopa.europa.eu/publications/reports/investment_behaviour_report.pdf, download on 07th July 2018.

European Commission (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)', *Official Journal of the European Union*, December 2009.

European Commission (2015), 'Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II)', *Official Journal of the European Union*, January 2015.

Eling, M., Holder, S. (2013a), 'Maximum Technical Interest Rates in Life Insurance in Europe and the United States: An Overview and Comparison', *The Geneva Papers on Risk and Insurance - Issues and Practice*, 38 (2): 354-375.

Eling, M., Holder, S. (2013b), 'The value of interest rate guarantees in participating life insurance contracts: Status quo and alternative product design', *Insurance: Mathematics and Economics*, 53 (3): 491-503.

Förstemann, T., Feodoria, M. (2015), 'Lethal lapses — how a positive interest rate shock might stress German life insurers', Deutsche Bundesbank Discussion Paper, No. 12/2015.

French, A., Vital, M., Minot, D. (2015), 'Insurance and financial stability', *Bank of England Quarterly Bulletin*, 2015 Q3, 242-257.

Frey, A. (2012) 'Facing the interest rate challenge', *Sigma Study*, No. 4/2012, Swiss Re, cas.confex.com/cas/ica14/webprogram/Handout/Paper1898/sigma4_2012_en.pdf, download on 28th July 2018.

Froot, K. A. (2007), 'Risk management, capital budgeting, and capital structure policy for insurers and reinsurers', *Journal of Risk and Insurance*, 74 (2): 273-299.

FSB (2014), '2014 update of list of global systemically important insurers (G-SIIs)', November 2014, http://www.fsb.org/wp-content/uploads/r_141106a.pdf.

FSB (2015), '2015 update of list of global systemically important insurers (G-SIIs)', November 2015, http://www.fsb.org/wp-content/uploads/FSB-communication-G-SIIs-Final-version.pdf.

Gatzert, N., Hedinger, D. (2018), 'An Empirical Analysis of Market Reactions to the First Solvency and Financial Condition Reports in the European Insurance Industry', Working Paper.

Giot, P. (2005), 'Relationship Between Implied Volatility Indexes and Stock Index Returns', *The Journal of Portfolio Management*, 31 (3): 92-100.

Gründl, H. (2015), 'Auswirkungen der anhaltenden Niedrigzinsen auf das Versicherungswesen', *Zeitschrift für Wirtschaftspolitik*, 64 (2): 191-201.

Harrington, S. E., Niehaus, G. (2003), *Risk management and insurance*, 2nd edition, Boston, London, McGraw-Hill.

Hartley, D., Paulson, A., Rosen, R. J. (2017), 'Measuring Interest Rate Risk in the Life Insurance Sector: The U.S. and the U.K.', in: Hufeld, F., Koijen, R. S. J., Thimann, C. (Eds.), *The Economics, Regulation, and Systemic Risk of Insurance Markets*, Oxford University Press, Oxford, Ch. 6: 124-150.

Holsboer, J. H. (2000), 'The Impact of Low Interest Rates on Insurers', *The Geneva Papers on Risk and Insurance – Issues and Practice*, 25 (1): 38-58.

Insurance Europe (2016), 'European Insurance – Key facts', Brussels, August 2016, https://www.insuranceeurope.eu/sites/default/files/attachments/European%20Insurance%20-%20Key%20Facts%20-%20August%202016.pdf, download on 12th July 2018.

IMF (2016), 'Global Financial Stability Report – Fostering Stability in a Low-Growth, Low-Rate Era', World Economic and Financial Surveys, October 2016. International Monetary Fund, www.imf.org/en/Publications/GFSR/Issues/2016/12/31/Fostering-Stability-in-a-Low-Growth-Low-Rate-Era, download on 20th July 2018.

Jörgensen, P. L., Linnemann, P. (2012), 'A comparison of three different pension savings products with special emphasis on the payout phase', *Annals of Actuarial Science*, 6 (1): 137-152.

J.P.Morgan Cazenove (2013), 'Europe Insurance - FY12 Sovereign Exposures of Large Insurers', Europe Equity Research, March 2013, https://www.investireoggi.it/forums/attachments/jpm_europe_insurance_fy1_2013-03-28_1084619-pdf.233600/, download on 15th July 2018.

Kablau, A., Weiss, M. (2014), ‘How is the low-interest-rate environment affecting the solvency of German life insurers?’, Deutsche Bundesbank Discussion Paper, No. 27/2014.

Kessler, D., de Montchalin, A., Thimann, C. (2017), ‘The Macroeconomic Role of Insurance’, in: Hufeld, F., Koijen, R. S. J., Thimann, C. (Eds.), *The Economics, Regulation, and Systemic Risk of Insurance Markets*, Oxford University Press, Oxford, Ch. 2: 20-54.

Love, T., Miller, W. C. (2013), ‘Repercussions of a Sustained Low-Interest-Rate Environment on Life Insurance Products’, *Journal of Financial Service Professionals*, 67 (2): 44-52.

Möhlmann, A. (2017), ‘Interest rate risk of life insurers – evidence from accounting data’, Deutsche Bundesbank Discussion Paper, No. 10/2017.

Moody's (2015), ‘Low Interest Rates are Credit Negative for Insurers Globally, but Risks Vary by Country’, Global Insurance Themes, Moody’s Investors Service, March 2015, http://www.actuarialpost.co.uk/downloads/cat_1/Moodys%20Report%202015.pdf, download on 20th July 2018.

Schlütter, S., Browne, M. J., Gründl, H., (2018), ‘The Influence of Market Risks on the Stock Return of Life Insurance Companies’, Working Paper Goethe University Frankfurt.

Smith, M. L., Kane, S. A. (1994), ‘The Law of Large Numbers and the Strength of Insurance’, in: Gustavson, S. G., Harrington, S. E. (Eds.), *Insurance, Risk Management, and Public Policy*, Huebner International Series on Risk, Insurance and Economic Security, Springer, Dordrecht, (18): 1-27.

Wilson, T. C. (2013), ‘Risk Management in the Face of Risky Sovereign Debt: Four Observations’, *BIS Papers*, No. 72, 130-135.