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Insurers' investment strategies: pro- or countercyclical?

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Abstract

Traditionally, insurers are seen as stabilisers of financial markets that act countercyclically by buying assets whose price falls. Recent studies challenge this view by providing empirical evidence of procyclicality. This paper sheds new light on the underlying reasons for these opposing views. Our model predicts procyclicality when prices fall due to increasing risk premia, and countercyclicality in response to rises in the risk-free rate. Using granular data on insurers' government bond holdings, we validate these predictions empirically. Our findings contribute to the current policy discussion on macroprudential measures beyond banking.

JEL classification: G01, G11, G12, G22, G23

***Keywords*:** insurance companies, cyclicality, portfolio allocation, financial stability, sovereign debt crisis.

Non-technical summary

Insurance companies are large institutional investors. They provide the bulk of long-term funding to the economy. The sector has been growing in recent years and has become more interconnected with banks and other financial intermediaries. Therefore, insurers' response to changes in asset prices could have a significant direct impact on the availability of funding sources to the economy. Moreover, in crisis periods, large asset sales could amplify price falls and negatively affect other investors holding the same assets, potentially threatening the stability of the financial system. In boom periods, on the other hand, if insurers buy assets whose value is rising, they may contribute to the development of asset price bubbles.

Traditionally, insurers have been considered stabilisers of financial markets. As long-term investors, they typically hold assets until maturity and are indifferent to short-term price movements. Therefore, they are expected to respond countercyclically to changes in asset prices, i.e. to buy assets whose value declines (and vice-versa). Recent studies, however, challenge this view by providing empirical evidence of the procyclical investment behaviour of insurance firms, especially during crises.

In this paper, we provide a theoretical framework that helps explain some of the mixed results in the literature. We argue that it is the underlying driver of a price change, rather than just the direction, that matters. In particular, we develop a theoretical model to distinguish between the effects of changes in the risk-free interest rate and risk premia on insurers' equity valuations and thus on their investment behaviour. When prices fall due to increasing risk premia, our model predicts procyclical investment behaviour. By contrast, it suggests that countercyclicality occurs in response to price drops driven by a rising risk-free interest rate.

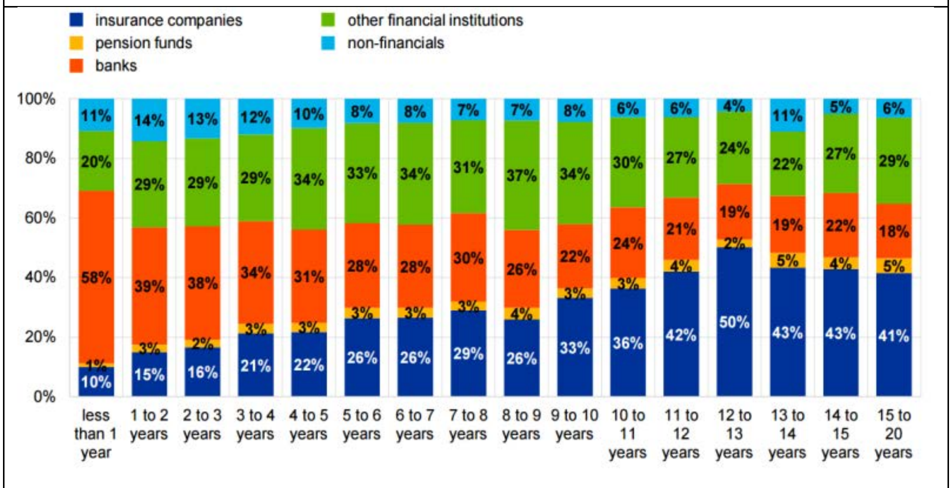
We test these predictions empirically by using security-by-security data on government bond holdings of euro area insurance companies from 2009 to 2016. In line with the predictions, we estimate that higher risk premia have a negative and significant effect on insurers' holdings of government bonds (procyclicality) whereas a higher risk-free interest rate has a positive and significant effect of on those holdings (countercyclicality). Moreover, we show that during the euro area sovereign debt crisis the procyclical effect of risk premia tended to outweigh the countercyclical effect of the risk-free rate. Interestingly, these results only hold for insurers' holdings of foreign government bonds, while domestic bonds appear to receive preferential treatment: insurers tend to respond countercyclically (rather than procyclically) to changes in the risk premia of their own sovereign.

Our findings are not without policy implications. By providing evidence of insurers' procyclical behaviour during the euro area sovereign debt crisis, our results contribute to the current policy discussion on macroprudential measures beyond banking by underlining the need for such measures. Moreover, since our paper sheds light on the underlying mechanism of such behaviour, it can be instrumental for the development of an effective policy instrument that helps address such behaviour. However, one shortcoming of our analysis is that it is too early for us to empirically assess insurers' investment behaviour under the current regulatory regime, Solvency II, as it only entered into force in January 2016. In particular, this regime already includes measures of a macroprudential nature, but their effectiveness during a crisis is yet to be tested in practice.

1. INTRODUCTION

Traditionally, insurers have been viewed as stabilisers of financial markets that respond countercyclically to changes in asset prices. Owing to the long duration of their liabilities, they are expected to hold assets until maturity and buy assets whose value declines. Such investment behaviour is particularly relevant from a financial stability perspective since insurers are strongly interconnected with other financial intermediaries and play a key role in the long-term financing of the economy. For instance, more than 40% of euro area investment in bonds with maturity over 10 years is provided by the insurance sector (Figure 1).

Figure 1: Euro area holdings of debt securities, broken down by residual maturity and holder sector (end-2016) Q4
(percentage of total securities holdings)



Source: ECB Securities Holdings Statistics and authors' calculations.

Our paper challenges this traditional view by unearthing the reasons why insurance investment behaviour can turn procyclical in distress periods. The framework we develop hinges on the theoretical insight that it is the underlying driver of a price change (rather than just the direction) that matters for insurers' investment behaviour.

More specifically, we present a stylised model, in which we separate the effects of the risk-free interest rate from those of the risk premia on insurers' equity valuations under a market-consistent regulatory regime. A rise in the risk-free rate pushes up the value of insurers' equity, whereas an increase in risk premia lowers it. Through their different effects on equity, we argue that the two factors can also imply different investment behaviours in response to a price change. When prices fall due to increasing risk premia, our model predicts procyclical investment behaviour as insurers attempt to restore their financial position. On the other hand, it predicts countercyclicality in response to price drops driven by a rising risk-free rate. These theoretical insights help explain some arguments put forward in the existing literature such as that of Cochrane (2017), who suggests that financial institutions may decide to sell assets for two reasons: either they think that the price drop is related to a real increase in the long-term default probability of the counterparty, or their risk-bearing capacity is declining due to increasing risk aversion.

We validate our predictions empirically using security-by-security data on government bond holdings of euro area insurers from 2009 to 2016. We estimate that higher risk premia have a negative and significant effect on euro area insurers' holdings of government bonds (procyclical behaviour) and that a higher risk-free interest rate has a positive and significant effect on those holdings (countercyclical behaviour). Moreover, we show that during the outbreak of the euro area sovereign debt crisis the procyclical effect of risk premia tended to outweigh the countercyclical effect of the risk-free rate. At the same time, these results hold only for insurers' holdings of foreign government bonds, while domestic bonds appear to receive preferential treatment. In particular, we find that insurers tend to respond countercyclically (rather than procyclically) to changes in the risk premia of their own sovereign.

We confirm that our empirical results are robust to different model specifications and estimation approaches. Specifically, we pay particular attention to the standard problem of empirical studies that estimate the impact of price changes on investment behaviour, which is the potential endogeneity of price changes. One concern is that our estimates are biased due to the possible omission of variables that affect both the two explanatory variables of interest and insurers' holdings. To address this concern, we include a number of control variables, such as measures of credit quality and economic fundamentals, the volumes of the ECB's recent purchases of government bonds as well as very granular fixed effects.

Another concern is that our estimates could be biased due to reverse causality, i.e. a causal effect of insurers' holdings on bond prices. To tackle this problem, we use the instrumental variable (IV) approach. We instrument the euro risk-free interest rate curve with the corresponding US curve, and the risk premia with inflation rates in the issuer country. These instruments are likely to be exogenous to euro area insurers' holdings of government bonds but at the same time they affect the risk-free rate and risk premia. In addition to tackling the potential endogeneity problem, we conduct a wide range of further robustness checks.

Our paper contributes to the existing literature on insurers' investment behaviour, which is scarce and often limited to country-specific studies. Moreover, the evidence on buy/sell decisions of insurance companies in response to price changes is mixed and the papers often fail to recognise that the investment pattern may vary with market conditions and/or type of assets. For instance, Timmer (2018) suggests that German insurance companies and pension funds (ICPFs) act countercyclically in the sovereign bond market, including during times of crisis such as the European sovereign debt crisis. These findings are supported by earlier studies such as Grinblatt and Keloharju (2000) on Finnish financial and insurance institutions, and De Haan and Kakes (2011) on Dutch institutional investors. By contrast, Bijlsma and Vermeulen (2016) find that Dutch insurers sold distressed euro area sovereign bonds during the European sovereign debt crisis, thus acting procyclically. Their results are supported by earlier findings by Impavido and Tower (2009) on life insurance companies, Ellul, Jotikasthira and Lundblad (2011) and Merrill et al. (2012) on insurers subject to high regulatory constraints, a Bank of England (2014) study on life insurance companies and pension funds, and Duijm and Bisschop (2018) on Dutch ICPFs.

Since our paper focuses on insurers' holdings of government bonds during the euro area sovereign debt crisis, it is closely linked to the work of Timmer (2018) and Bijlsma and Vermeulen (2016). Compared to these country-specific studies, our results can be considered more robust as they are based on new granular data from the ECB's Securities Holdings Statistics (SHS), which cover all 19 euro area countries. Moreover, our paper not only highlights the changing nature of insurers' investment behaviour in relation to market conditions and type of assets (domestic/foreign), but also underlines the importance of the regulatory regimes in place. In particular, our results also suggest that insurers' investment behaviour is more sensitive to price changes when insurers operate under a more market-based regime, such as the one in the Netherlands prior to the introduction of Solvency II. This helps explain the mixed results found in the two studies.

In line with our paper, two recent studies highlight that the investment behaviour of insurance companies and other institutional investors may turn from countercyclical to procyclical in periods of market distress. Using transaction-level data on the UK corporate bond market, Czech and Roberts-Sklar (2017) find that insurance companies, hedge funds and asset managers are typically acting countercyclically, but that the behaviour of asset managers turned procyclical during the 2013 ‘taper tantrum’. However, they fail to provide a theoretical motivation for such a reversal. This is different in Ellul et al. (2018), which provides evidence of the procyclical investment behaviour of US life insurers with a large variable annuity business. This paper argues that due to the high minimum return that insurers offer to policyholders and the related hedging activity, these insurance companies may stop acting as stabilisers in periods of market distress and may themselves become a source of significant selling activity. Even if the mechanism is different from ours, as US and euro area insurers have different business models and operate under different regulatory regimes, our paper is in the spirit of Ellul et al. (2018) since it provides both theoretical and empirical insights about the investment behaviour of insurance companies and its changing nature.

Finally, Domanski et al. (2017) show that insurers’ investment strategy can change over time in response to changes in asset-liability duration mismatch rather than acute market distress. Specifically, they provide evidence that when long-term rates fell in the period between 2009 and 2014, German insurance companies purchased more bonds with a higher duration. This ‘hunt for duration’ works as follows: when (long-term) interest rates fall, the duration gap between assets and liabilities becomes increasingly negative and insurers tend to extend the maturity of bond portfolios in order to contain it. Our paper cannot empirically investigate the relationship between insurers’ duration gap and their investment behaviour, due to the lack of time series data on the duration of insurers’ liabilities. However, even if not tested empirically, our theoretical framework suggests that the (negative) duration gap and the duration of assets increase insurers’ sensitivity to asset price changes.

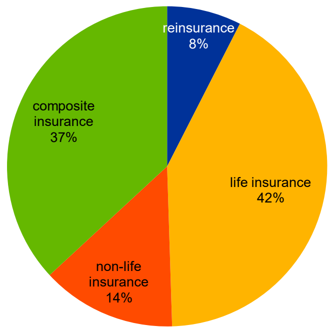
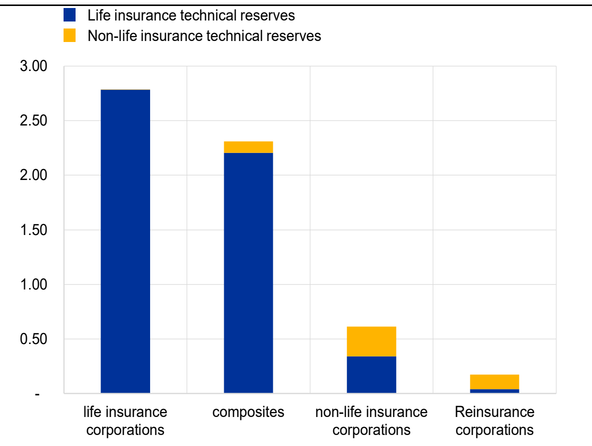
The remainder of the paper is organised as follows. Section 2 discusses the main characteristics of the euro area insurance sector and develops the notion of a stylised euro area insurer. Section 3 introduces the theoretical framework, while Section 4 outlines the empirical model and describes the data we use to estimate it. Section 5 presents the empirical results. Finally, Section 6 concludes.

2. The euro area insurance sector

The investment behaviour of an insurer can be influenced by various factors. These include – but are not limited to – the type of firm and its business model, the structure of the balance sheet, the investment preferences of its management and stakeholders, market developments and the regulatory framework under which an insurance firm operates. A recent study by the Bank of England and Procyclicality Working Group (2014) highlights, for instance, the importance of liability characteristics, regulation, accounting and valuation methods as well as industry practices for insurers' asset allocations.

Starting with the type of firm, the euro area insurance sector comprises four broad categories: life insurers, non-life insurers, composite insurers[4] and reinsurers. In terms of total assets, life insurers represent the largest category (42%), closely followed by composites (37%), whereas the size of non-life insurers (14%) and reinsurers (8%) is relatively limited (Figure 2). The importance of the life insurance business in the euro area is, however, much greater than these figures suggest. One reason is that the technical reserves of composite insurers are dominated by the life insurance products. In addition, more than half of non-life insurance products are considered to be technically "similar to life", thus those products are also recorded under life insurance technical reserves. As a result, around 91% of euro area insurers' technical reserves relate to life-type insurance businesses (Figure 3).

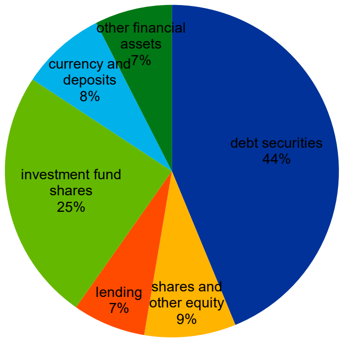
[4] Composite insurers offer both life and non-life insurance products.

Figure 2: Total assets of euro area insurers - by type of firm (end-2016)	Figure 3: Euro area insurance technical reserves - by type of business (end-2016)
	
Source: ECB's insurance balance sheet data and authors' calculations.	Source: ECB's insurance balance sheet data and authors' calculations.

Regarding investment preferences, the portfolios of euro area insurers are dominated by fixed income assets (Figure 4). Specifically, holdings of government and corporate bonds accounted for around 44% of euro area insurance financial assets at the end of 2016. Another important asset class is investment fund shares (25%), which also serve as an important channel for investment in fixed income instruments.[5] The remaining third of financial assets held by euro area insurers consists of shares and other equity (9%), currency and deposits (8%), lending (7%) and other financial assets (7%).

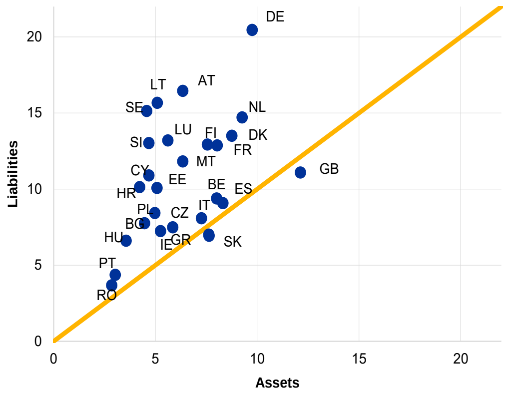
[5] According to the ECB's data on insurance corporations, bond fund shares and mixed fund shares are the two largest categories of investment fund shares held by euro area insurance corporations. Each category accounted for around a third of the insurers' holdings of investment fund shares at the end of 2016.

Figure 4: The composition of financial assets of euro area insurers (end-2016)



Source: ECB (euro area accounts) and authors' calculations.

Figure 5: Duration of assets and liabilities of European insurance companies (end-2013)



Source: EIOPA Insurance stress test (2014), Figure 78. Durations are based on Macaulay duration formula

Turning to other characteristics of the balance sheet, a typical life insurer operates with a negative duration gap, i.e. the duration of its liabilities exceeds that of its assets. According to EIOPA (2016a), the average modified duration of fixed income assets in the portfolio of a European life insurer is around 7.85 years. On the other hand, the average duration of liabilities is 13.97 years as measured by Macaulay duration, or 8.23 years as measured by approximate effective duration.[6] According to EIOPA (2014), the negative duration gap is a common characteristic of most insurers in EU/EEA counties (Figure 5).[7]

With respect to the regulatory framework, euro area insurers currently operate under the Solvency II regime, which entered into force in 2016. Solvency II introduced a single prudential rulebook for all insurance firms in the EU and thus limits prudential differences across individual EU countries. Prior to Solvency II, EU insurance firms operated under the Solvency I framework, which consisted of a set of *minimum* regulatory requirements at the EU

[6] Macaulay duration reflects the average maturity of liabilities, while effective duration aims at estimating the sensitivity of liabilities to interest rate changes and also takes into account optionalities of insurance contracts (e.g. options for lower guarantees). For more details, see EIOPA (2016a).

[7] Insurers can hedge some of the interest rate risk on their balance sheet arising from the negative duration gap through the use of interest rate derivatives, which is not reflected in these numbers. Fache Rousová and Letizia (2018), however, show that derivative usage by euro area insurers is relatively limited on aggregate, even if interest rate derivatives are the main derivative class used by the insurance sector.

level, and additional regulatory requirements at an individual country level. Hence, prior to 2016, insurers across the EU operated under a plethora of different regulatory requirements. However, the switch between the two regimes on 1 January 2016 cannot be considered as a one-off, short-term shock, as the insurance sector had been anticipating the new regime and gradually adjusting to it since at least 2009, when the Solvency II directive was published.[8] Moreover, given the long-term nature of the (life) insurance business, Solvency II allows for the use of transitional measures for up to 16 years after its introduction in 2016 in order to smooth the transition to the new rules (see robustness checks in Section 5 for more details).

Compared to Solvency I, Solvency II is a more fair value-based and more risk-sensitive supervisory regime as it captures a number of key risks, including market, credit and operational risks. Specifically, this regime requires insurers to value both assets and liabilities mark-to-market in order to provide a market-consistent view on insurers' solvency. The market-based valuation implies that an appropriate, market-consistent discount rate is to be used to discount the expected cash flows, and that insurers have to hold an amount of capital proportional to the risk on their balance sheet. In addition, Solvency II requires insurers to invest in accordance with the 'prudent person principle', which means that insurance companies have flexibility in their asset allocation decisions as long as they satisfy some high-level general principles related to proper risk identification and management. This regime is significantly different from the more simplistic and non-risk-sensitive Solvency I, under which insurers had to comply with certain quantitative limits and eligibility criteria on their asset holdings. Moreover, Solvency I did not provide any explicit capital requirement related to market risk, unless a more risk-sensitive requirement was embedded in the national law.

To sum up, although the euro area insurance sector comprises different types of firms, we focus in this paper on a stylised insurance firm. The firm in question is a life insurer whose balance sheet has a negative duration gap and whose portfolio is heavily invested in fixed income assets. It operates under Solvency II and has been transitioning to this regime since 2009.

[8] See Solvency II Directive.

3. Theoretical framework

3.1 Equity valuation of a stylised euro area insurer

The bulk of liabilities of a stylised euro area insurer are technical provisions, i.e. obligations to policyholders (see ECB, 2016). Under a market-consistent regulatory regime, the value of the technical provisions is to be discounted by a risk-free rate of return. In other words, the firm is required to value its liabilities as if its own default risk were zero and all obligations to policyholders were to be paid out. To reflect this requirement in a simple modelling framework, let us assume that the market value of liabilities (denoted as L) of a typical euro area insurer can be modelled as a zero coupon bond with face value B_L and maturity D_L:

$$L = \frac{B_L}{(1+r)^{D_L}}, \tag{1}$$

where r is the risk-free rate used to discount technical provisions. We assume $r > -1$ (thus $\frac{1}{1+r} > 0$).[9]

When valuing assets, the appropriate discount rate consists of both the risk-free rate of return and the risk premia. This is because a market-consistent regime would need to account for the riskiness of assets, as creditors may not deliver their payments (e.g. due to a default or liquidity squeeze). Since the portfolio of our stylised insurer is heavily invested in fixed income assets, let us assume that the market value of its assets (A) can be modelled as a zero coupon bond with face value B_A and maturity D_A:

$$A = \frac{B_A}{(1+r+p)^{D_A}}, \tag{2}$$

where $p > 0$ denotes the bond's risk premium.

Since the value of the firm's equity E can be expressed as a difference between the values of its assets and liabilities, it follows that:

[9] This assumption is also realistic for the current market environment, in which some interest rates have moved into a negative territory. The only situation in which the assumption would not hold is if the negative interest rates exceeded 100%.

$$E = A - L = \frac{B_A}{(1+r+p)^{D_A}} - \frac{B_L}{(1+r)^{D_L}} \;. \quad (3)$$

The simplifying assumption of zero coupon bonds to model insurers' assets and liabilities has the advantage that maturities D_A and D_L can be directly interpreted as the duration of assets and liabilities, respectively. Our model is, however, only a special case of the duration gap model and, together with the resulting predictions, it can be generalised to include all assets and liabilities on the balance sheet with their respective durations, as shown in Saunders and Cornett (1999). In addition to different durations, this framework also allows for a more general representation of insurer's asset and liability portfolios, composed by a mix of assets and liabilities (e.g. a mix of bonds with different levels of risk premia).

For simplicity, our model aims to capture only the basic mechanism of equity valuation under a market-consistent regime. However, the regulatory regimes in place are typically much more complex. In particular, Solvency II includes long-term guarantee (LTG) measures such as volatility and matching adjustments that are not considered in our model. These measures were designed to mitigate the impact of widening credit spreads and, more generally, of short-term price movements on insurers' assets, especially if those are unrelated to the default. This notwithstanding, the measures do not fully offset all short-term price movements and are applied only by some euro area insurers (e.g. insurers located in countries where the regulator allows for the use of LTG measures). Therefore, we believe that our framework, despite being simple, can provide realistic insights about the current dependencies between insurers' equity and the risk-free rate and risk premia.[10]

3.1.1 Insurers' sensitivity to risk-free rate changes

We compute the sensitivity of the market value of equity to a change in the risk-free interest rate by taking the first derivative of Equation (3) with respect to r. Re-arranging the equation, we obtain

$$\frac{\partial E}{\partial r} = \frac{1}{1+r}\left(LD_L - AD_A\frac{1+r}{1+r+p}\right) \quad (4)$$

[10] The results of the two scenarios considered in 2016 EIOPA stress test are in line with our framework (see EIOPA, 2016a).

Since $\frac{1}{1+r}$ > 0, the derivative is positive if and only if

$$\left(LD_L - AD_A\frac{1+r}{1+r+p}\right) > 0 \;\; <=> \;\; \frac{D_L}{D_A} > \frac{A}{L}\,\frac{1+r}{1+r+p} \qquad (5)$$

We further assume that this inequality is satisfied for our stylised firm because a typical euro area insurer has a negative duration gap (i.e. $D_L > D_A$) and operates with positive equity. Moreover, based on available evidence, it is plausible to assume that the negative duration gap (in its absolute value) is large enough compared to the (discounted) excess of assets over liabilities. Specifically, according to EIOPA's stress test in 2014 (EIOPA, 2014), for an average European insurer, D_L/D_A equals to 177% (as measured by Macaulay's duration) and A/L equals to 110%. Therefore, it also holds that $\frac{D_L}{D_A} > \frac{A}{L} > \frac{A}{L}\,\frac{1+r}{1+r+p}$ (considering that $\frac{1+r}{1+r+p} \leq 1$). Consequently, it is plausible to assume that $\frac{\partial E}{\partial r}$ > 0 for most euro area insurers. This in turn means that the value of equity of the stylised insurer increases with an increase in the risk-free rate.

Prediction 1a: The value of insurers' equity increases with an increase in the risk-free rate (and vice-versa).

It is worth highlighting that this prediction holds in the presence of a negative duration gap and thus is characteristic only for certain financial institutions, notably (life) insurance firms.[11] In particular, it would not be verified for other financial institutions, such as banks and investment funds, which operate instead with a positive duration gap.

Moreover, since our model does not consider any changes to the structure and composition of insurers' liabilities in response to changes in the risk-free rate, the prediction only reflects an immediate (short-term) effect on insurers' equity valuation. In particular, in case of a large and persistent increase in the risk-free rate, an insurance firm could be faced with a significant risk of policy lapses, as policyholders could shift away from policies with low

[11] Kablau and Weiss (2014) point out that low interest rates are particularly important for life insurance companies, especially if the risk-free yield falls below the maximum technical interest rate, which is the maximum rate that they can typically use to calculate the premium reserves and the guaranteed return of new contracts.

guaranteed rates, underwritten by an insurer in the low-yield regime, to other types of financial products in view of higher returns. Such a scenario could then have a negative overall effect on the financial position of the firm. However, the size and nature of the overall effect is difficult to predict *ex ante* since insurers aim to mitigate policy lapses through increased profit sharing (i.e. redistribution of a part of the investment income to policyholders).

3.1.2 Insurers' sensitivity to risk premia changes

As with the risk-free rate, we compute the first derivative with respect to p in order to obtain the sensitivity of the market value of equity to a change in the risk premium as

$$\frac{\partial E}{\partial p} = -\frac{AD_A}{1+r+p}. \tag{6}$$

Since $1 + r + p \geq 0$, the change in equity corresponding to an increase in risk premium is always negative, i.e. the value of equity decreases with an increase in risk premia.

Prediction 2a: The value of insurers' equity decreases with an increase in risk premia (and vice-versa).

3.2 Insurers' response to changes in equity valuation

The predictions derived so far refer to the impact of interest rate changes on insurers' equity valuation, while we are interested in the effect of these changes on insurers' investment behaviour. Therefore, we turn in this section to a discussion of how shocks in equity propagate to the asset portfolio held by an insurance firm.

In case of a negative shock to equity, insurers have several ways of restoring their financial positions. In principle, they can act on all three parts of the balance sheet: equity, liabilities and assets. In the case of equity, firms can raise fresh capital in the market. However, this would dilute existing shareholdings and could be particularly difficult in periods of financial distress (Myers, 1977). They can also generate capital through retained earnings, yet such a process would improve capital levels only gradually (Cohen and Scatigna, 2016). With respect to liabilities, insurers can lower these by decreasing profit sharing, underwriting less business or shifting away from products with guaranteed rates of return towards capital-light, unit-linked policies. However, since most insurers' liabilities are of a long duration, and new policies and profit sharing represent only a small fraction of all outstanding liabilities, a significant reduction in liabilities is also not a viable option in the short-term.

Therefore, we can assume that an insurance firm would respond to a shock in equity by acting on the asset side. This assumption is also supported by the existing literature. Das (2017) shows empirically that non-deposit taking institutions, such as insurance firms with higher capital-to-asset ratio, are likely to purchase assets. The fewer the constraints in raising funding, the higher the likelihood that they buy assets.[12] Moreover, the theoretical model of Van Binsbergen and Brandt (2016) developed for asset-liability management investors such as insurance firms, predicts that they decrease the riskiness of their portfolio in response to a shock that reduces their assets-to-liabilities ratio (i.e. they shift away from riskier assets to safer assets).[13] The two studies thus suggest that the demand for risky assets can be modelled as a function of capital, whereby firms with higher capital (capital surplus) would have more cash to purchase assets and would be able to borrow more and on better terms. On the other hand, firms that experience a negative shock to equity (capital shortage) hold a higher level of risk on their balance sheet for a given level of capital, and would therefore need to de-risk their asset holdings.[14] Against this backdrop, we assume that **insurers sell/buy (risky) assets when they experience a negative/positive shock to their equity** in order to restore their financial position.

Our considerations are motivated by – but differ from – the deleveraging model for banks. According to Adrian and Shin (2010), banks target a specific leverage ratio (defined as a ratio of assets over equity) and thus sell off assets after a negative shock to equity in order to restore their target leverage.[15] The deleveraging mechanism assumes that banks use the

[12] Das (2017) focuses on purchases of risky assets such as real estate and loan portfolios, bank branches, equity investment portfolios and asset-backed securities.
[13] Douglas et al. (2017) has recently pointed out that the de-risking behaviour of UK insurers may be incentivised by the use of risk margins under Solvency II, which reduce the solvency position of the firm following a decrease in the risk-free rate and encourage the selling of risky assets to reduce the probability of insolvency.
[14] An alternative way for insurers to act on the asset side after a negative shock to their equity is to purchase (additional) reinsurance, but this is often a more costly solution.
[15] Adrian and Shin (2010, 2011) show that broker-dealers and commercial banks engage in leverage targeting, adjusting their balance sheets according to a fixed leverage ratio. Greenwood et al. (2015) and Eisenbach et al.

proceeds from asset sales to repay debt, thereby lowering their liabilities. This type of adjustment would, however, be rather limited for insurance firms because they are much less leveraged than banks, having only limited amounts of debt on their liability side.[16] Therefore, our predictions relate to balance sheet "de-risking" rather than "deleveraging". Recent evidence from the US shows that life insurers that were particularly affected by the global financial crisis de-risked their portfolio (Kirti, 2017). Rather than gambling for resurrection, US insurers characterised by lower equity-to-book ratios and dividend growth reduced credit and interest rate risks by buying bonds with low yield to maturity and long duration, and by entering fixed-interest rate swap positions.

Since we assume that assets of a typical insurance firm can be modelled as a zero coupon bond (or a mix of bonds in the generalised duration gap model), we use the inverse relation between bond prices and interest rates to rephrase our predictions in terms of price changes. Furthermore, considering the link between equity shock and investment behaviour, we formulate the predictions as follows:

Prediction 1b: Insurers buy (risky) bonds when their prices fall due to an increase in the risk-free rate of return (and vice-versa).

Prediction 2b: Insurers sell (risky) bonds when their prices fall due to an increase in risk premia (and vice-versa).

These two predictions imply that insurers' investment behaviour can be both procyclical and countercyclical, depending on the underlying driver of a price change. If the price change stems from a change in risk premia, then insurers are expected to behave procyclically. On the other hand, when the price change is due to a change in the risk-free rate, then insurers are expected to behave countercyclically. We believe that this new theoretical insight sheds light on the mixed results in the existing literature, which did not consider the distinction between the two types of price shocks. We test these predictions empirically in the following sections.

(2015) have recently used this evidence as the basis for constructing a systemic risk measure of fire sale in the banking system.

[16] According to the ECB's euro area accounts (EAA) data, loans represented around 5% of euro area insurers' liabilities at the end of 2016.

While we focus only on these two predictions in the rest of the paper, our theoretical framework allows us to make two further predictions. In particular, it follows from Equations (4) and (6) that the sensitivity of insurers' equity to changes in the risk-free rate increases with the size of the negative duration gap (Equation 4), while that to changes in the risk premia rises with the duration of assets (Equation 6). Hence, we could test empirically whether insurers' countercyclical investment behaviour diminishes with a shrinking duration gap and their procyclical behaviour attenuates with decreasing asset duration. Unfortunately, the lack of time-series data on insurers' asset and liability duration (and ultimately on the duration gap) does not allow us to do so.[17] If available, such data would enable us to significantly expand our research in the spirit of Domanski et al (2017).

4. Empirical model and data

4.1 Model set-up

We consider the following model specification to explain the amount of a security held by insurance sectors in the individual euro area countries:

$$\log(holdings_{i,j,t}) = \alpha r_{i,t-1} + \beta p_{i,t-1} + \gamma_i + y_{j,t} + \delta Z_{i,j,t} + \epsilon_{i,j,t} \quad (7)$$

where $\log(holdings_{i,j,t})$ denotes the natural logarithm of the nominal amount of security i held by the insurance sector in country j at quarter t and $\epsilon_{i,j,t}$ is the error term (see Section 4.2 for more details about the dependent variable).

Our two explanatory variables of interest are $r_{i,t-1}$ and $p_{i,t-1}$. They denote, respectively, the risk-free interest rate at maturity equal to security i's residual maturity and the corresponding risk premium of security i (see Section 4.3 for more details about these two explanatory variables of interest). In line with our theoretical predictions, we expect the estimate of α to be positive, indicating insurers' countercyclical behaviour in response to

[17] To our knowledge, the only available data on insurers' duration gap for all euro area countries can be found in EIOPA (2014) and these refer to a single point in time, the end of 2013, while our empirical analysis covers almost 10 years (see Figure 5).

rises in the risk-free rate of interest. On the other hand, we expect a negative estimate of β in order to confirm the prediction of procyclical behaviour in response to changes in risk premia. In all model specifications, we lag the two explanatory variables of interest by one-quarter to account for potential endogeneity due to reverse causality. A problem of reverse causality may in fact arise from the fact that insurers are important institutional investors in the (sovereign) bond market and thus a shift in their holdings of security i at time t may affect its price/yield in the same quarter (see Section 5 for a more in-depth discussion related to reverse causality).

Furthermore, we include several control variables in our model to address potential endogeneity arising from omitted variable bias. These controls include security fixed effects (γ_i), holder country-quarter fixed effects ($y_{j,t}$) and further time-varying factors (presented formally by vector $Z_{i,j,t}$) that potentially affect both insurers' holdings and the price of a security (see Annex B). More specifically, we include an indicator for a rating downgrade, the debt-to-GDP ratio of the issuer country and the volumes of the ECB's Public Purchase Programme (PPP). All control variables and their estimated effects are discussed in detail in Section 5. Finally, to correct for the possibility that error terms are correlated across individual securities, we cluster standard errors at the individual security level.

4.2 Dependent variable

We obtain our dependent variable from the new Securities Holdings Statistics (SHS) collected by the Eurosystem. To extend the time period and cover the euro area sovereign debt crisis, we combine both data from SHS collected under an ECB regulation since 2014[18] and those collected prior to 2014 under Securities Holdings Experimental Statistics (SHES).[19] As a result, our data span from the first quarter of 2009 to the last quarter of 2016.

This data source provides us with granular security-by-security information on holdings of the insurance sector in 19 euro area countries. These holdings are not available at the level of

[18] Regulation (EU) No 1011/2012 of the ECB of 17 October 2012 concerning statistics on holdings of securities ECB/2012/24.

[19] These data were collected on a voluntary and best-efforts basis from 2009 to 2013, i.e. in the period before the SHS collection on the basis of an ECB regulation began, and are thus subject to some quality limitations, such as lower coverage in some countries. We pay due attention to these limitations including via careful data cleaning and robustness checks (see Section 5).

individual insurance firms, but rather as an aggregate for the whole insurance sector in a given euro area country. We use nominal rather than market values of holdings to exclude valuation effects that do not reflect a buy/sell decision.

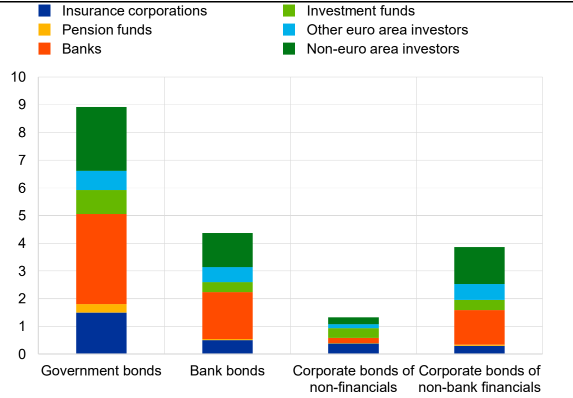
In the empirical analysis, we focus on holdings of government bonds in order to overcome certain data limitations. In particular, the information on the characteristics of individual securities such as prices and credit ratings, which we take from the Centralised Securities Database (CSDB), is more complete for government bonds than for other types of securities such as corporate bonds and equity. In the same vein, SHS holdings of government bonds tend to be of a relatively good quality and coverage, including for SHES data collected prior to 2014.[20]

Even if our empirical analysis is limited to government bonds, it is representative for a significant part of insurers' portfolios, since government bonds account for around 30% of insurers' securities portfolios (Figure 7). The holding amounts are also significant in absolute terms: at the end of 2016, the euro area insurance sector held around EUR 1.5 trillion in government bonds (according to the ECB's EAA). In addition, insurers hold roughly one-third of their securities portfolios in shares of investment funds, two-thirds of which are either bond or mixed funds that further increase the exposure of insurers to government bonds. At the same time, the euro area insurance sector is also one of the most important investor sectors in government bonds, as it directly holds around 15% of debt securities issued by euro area sovereigns (Figure 6) (i.e. excluding indirect holdings through funds). This figure increases to more than 40% for government bonds with a maturity of over 10 years.[21]

[20] In general, we carefully check the granular data used and clean them from outliers as well as making some further adjustments to address data quality limitations. For instance, the SHES data prior to 2014 includes an unclassified (residual) category within the ICPF sector, which we – after careful time-series and coverage checks – consider as belonging to the insurance sector. Moreover, we run robustness checks related to the use of SHES data in Section 5.

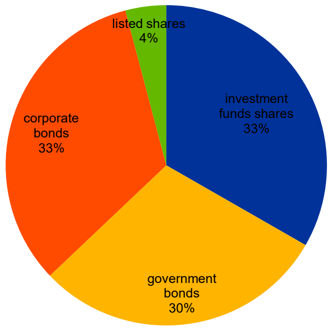
[21] There are various reasons why insurers hold such large amounts of government bonds in their portfolios. First of all, insurers use long-term government bonds, which ensure a fixed nominal return, to match the duration of their long-term nominal liabilities. Furthermore, government bonds can be used as collateral for hedging contracts, such as interest rate swaps. As in the case of banking regulation, government bonds also benefit from preferential treatment under Solvency II. Specifically, government bonds of countries in the European Economic Area (EEA) are exempted from the calculation of solvency capital requirements and from the large exposure regime in the standard formula. However, insurance firms using internal models should – at least in principle – account for the riskiness of their exposure to government bonds (ESRB, 2015).

Figure 6: Euro area holdings of euro area debt securities, broken down by holder sector (EUR trillion, end-2016)



Source: ECB Euro Area Accounts and authors' calculations.

Figure 7: Euro area insurers' securities holdings, broken down by main asset class (end-2016)



Source: ECB (SHS data).

4.2.1 Shifts in insurers' government bond holdings since 2009

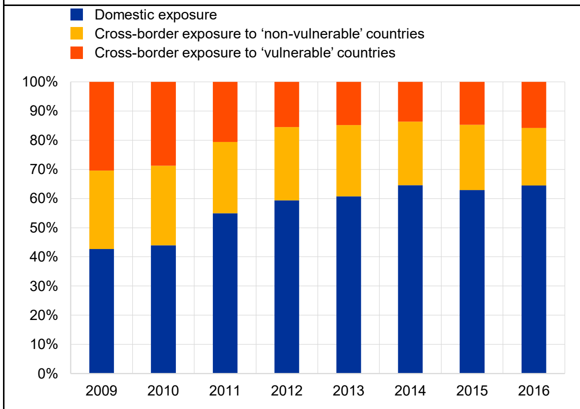
Government bonds also seem to be a good candidate for investigating the nature of changes in asset holdings and testing our predictions, when considering the period from 2009 to 2016, as we are doing. This is because, despite the preferential regulatory treatment of government bond holdings, the euro area sovereign debt crisis undermined the notion of government bonds as 'safe' assets and pointed out that exposure to sovereigns may represent an important element in determining market risk in insurers' and bank portfolios. Furthermore, Bijlsma and Vermeulen (2016), who investigate Dutch insurers' portfolio shifts within different asset classes, detect the largest changes in asset allocation to take place within a portfolio of government bonds.

Starting with descriptive evidence, Figure 8 reveals two significant changes in euro area insurers' asset allocations. First of all, euro area insurers significantly increased holdings of *domestic* government debt between 2010 and mid-2012, while they decreased cross-border exposure to government debt issued by 'vulnerable' euro area countries. At the same time, insurers' cross-border exposure to government debt issued by 'non-vulnerable' euro area countries remained broadly unchanged. This suggests – in line with the findings in Bijlsma and Vermeulen (2016) – that euro area insurers' asset allocations were strongly affected by the

European sovereign debt crisis, during which the credit quality of bonds issued by 'vulnerable' euro area countries (as measured by credit ratings) significantly deteriorated. Hence, in line with our predictions, credit risk (being a significant part of risk premia) is likely to be one of the main drivers of insurers' procyclical investment behaviour.

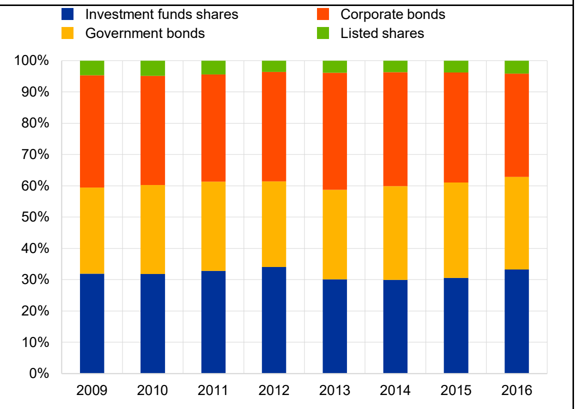
Even if euro area insurers reshuffled their portfolios of government bonds, this was not accompanied by substantial portfolio shifts between different types of assets. In particular, the share of government bonds in insurers' portfolios remained relatively stable throughout the full time span (Figure 9). Overall, Figures 8 and 9 indicate that, during the sovereign debt crisis, euro area insurers sold government bonds of (other) 'vulnerable' euro area countries and bought domestic government bonds instead (even if this might have been intermediated by bank dealers).[22]

Figure 8: Euro area insurers' holdings of government bonds, broken down by type of issuer.



Note: 'Domestic exposure' refers to all holdings where the issuer and holder are from the same country. Vulnerable countries include CY, ES, GR, IT, PT, SI and non-vulnerable countries include the remaining euro area countries.
Source: ECB (SHS data) and authors' calculations.

Figure 9: Euro area insurers' securities holdings, broken down by type of security.



Source: ECB (SHS data) and authors' calculations.

[22] Our data are not at transaction level and thus do not allow us to directly link the buyer and seller of a government bond.

4.3. Explanatory variables of interest

As a proxy for the risk-free rate r, we use the historical risk-free interest rate term structure for euro currency, published every month by EIOPA. Under Solvency II, this yield curve is used for the calculation of the value of technical provisions for insurance obligations in euro, which represent the bulk of technical provisions of euro area insurers.[23] For each month, the term structure includes the risk-free interest rate at different maturities, from one to 60 years, with time intervals of one year. We estimate a more granular term structure by using the Nelson-Siegel-Svensson method (see Nelson-Siegel, 1985 and Svensson, 1994) in such a way that the maturity brackets shrink from one year to 3.65 days. Given that the securities in our sample have different maturities, we assign to each security the value of the risk-free yield curve with the closest maturity. As a result, all securities with the same residual maturity m in our sample are assigned the same risk-free rate, i.e. $r_{i,t} = r_{m,t}$ for all securities i with maturity m.

Regarding the calculation of risk premia p, we first obtain the yield-to-maturity $YTM_{i,m,t}$ from the ECB's Centralised Securities Database (CSDB). The yield-to-maturity is assigned to each security i with residual maturity m at time t. We then construct risk premia p as the difference between the yield-to-maturity of such a security at time t and the risk-free rate r with the same maturity m:

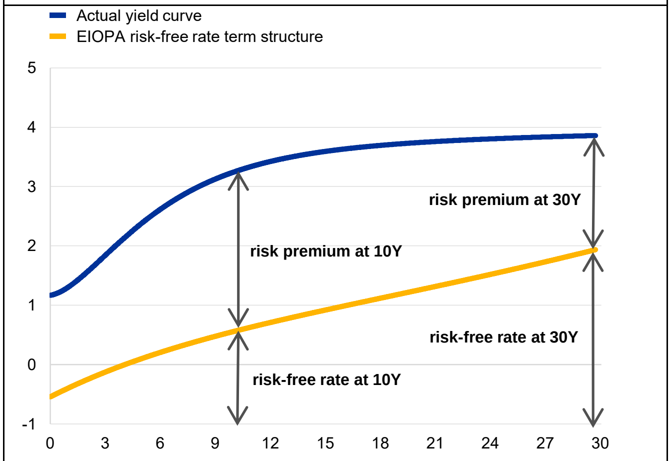
$$p_{i,t} = YTM_{i,m,t} - r_{m,t} \tag{8}$$

Figure 10 shows the risk-free rate curve at the end of 2016 and a hypothetical yield curve for sovereign bonds. For a bond with maturity m equal to 3 years, for example, the risk premium is calculated as the difference between the yield of the bond and the risk-free rate at 3 years. Therefore, the risk premia of sovereign bonds issued by the same country may differ in a given quarter, depending on the residual maturity of the securities. Since the risk-free rate varies only with maturity but not across countries, our risk premia captures various types of

[23] EIOPA risk-free yield curves are based on liquid swap and governments bond rates, and then adjusted to include the counterparty default risk. Further information is available at https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii-technical-information/risk-free-interest-rate-term-structures. To test the robustness of our results to the choice of the risk-free rate proxy, we also run robustness checks with alternative measures (see Section 5).

risks faced by the investor. Some risks such as credit and liquidity risks are specific to each individual security/issuer, while other types of risks such as those stemming from (expectations about) inflation and economic growth differentials reflect differences in macroeconomic fundamentals across countries.

Figure 10: EIOPA risk-free rate term structure (end of 2016) and a hypothetical sovereign bond yield curve to illustrate the construction of the risk premia variable



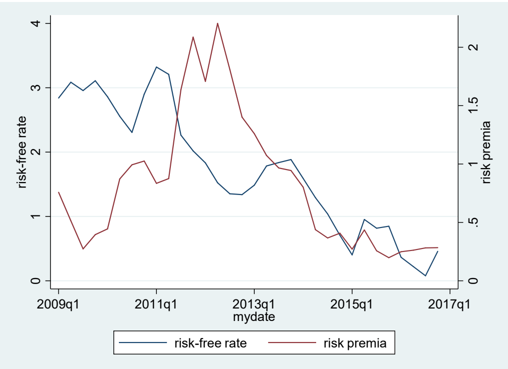
Source: EIOPA and authors' calculations.

4.3.1 Evolution of the risk-free rate and risk premia since 2009

Figure 11 shows the evolution of the average risk-free rate and risk premia over the time period we cover (weighted by insurers' government bond holdings in our sample). Following the financial crisis in 2007-2008, the risk-free yield has declined and, recently, reached historically low levels. The evolution of the sovereign risk premia was very different. Prior to the financial crisis, the levels were very low, as investors considered many sovereign bonds as risk-free investments. In November 2009, the Greek government announced a revised budget deficit, which significantly exceeded market expectations. This event led to a reassessment of the sovereign risk by investors and triggered the start of the European sovereign debt crisis. During the crisis, yield spreads across countries were mostly related to differences in their fiscal fundamentals, competitiveness and the need for foreign financing (De Santis, 2014). Specifically, the risk premia of euro area countries with weak fundamentals rose until mid-2012, when the ECB announced the Outright Monetary Transactions programme (OMT), which generated a decline in all euro area sovereign risk premia. Supported by further monetary policy accommodation and better macroeconomic prospects, the average risk premia in our sample decreased to pre-crisis levels at the end of 2016.

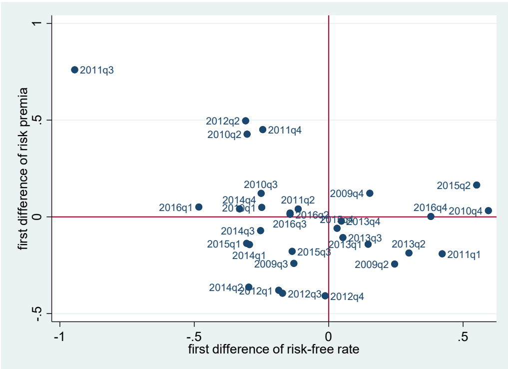
We plot the first differences of the average risk-free rate and risk premia in Figure 12 to check whether (and if so, in which periods) the two display a strong correlation. The variables show a slightly negative correlation, mostly due to the sovereign debt crisis period, in which the risk-free rate kept declining, while the risk premia were sharply increasing. Overall, however, our sample covers all four combinations of changes: increase and decrease in both the risk premia and risk-free rate as well as their movements in opposite directions.

Figure 11: Average risk-free rate and risk premia over time (weighted by holdings in our sample)



Source: ECB SHS data and authors' calculations.

Figure 12: Scatter plot of the first differences of average risk-free rate and risk premia (weighted by insurers' holdings)



Source: ECB SHS data and authors' calculations.

5. EMPIRICAL RESULTS

5.1 Baseline model

To confirm our theoretical predictions empirically, we start estimating the effects of a drop in price due to a change in the risk-free rate and due to a change in risk premia on insurers' holdings. In line with our predictions, we find opposite effects for the two factors (see Table 1, column 1). On the one hand, the positive coefficient for the risk-free rate indicates that insurers buy (sell) securities whose prices have fallen (risen) due to an increase in the risk-free rate, showing a countercyclical behaviour (Prediction 2a). On the other hand, the negative coefficient for risk premia suggests that insurers sell (buy) securities whose prices have fallen (risen) due to an increase in risk premia, indicating a procyclical behaviour (Prediction 2b).

Our initial specification includes security fixed effects that control for any time-invariant characteristics of a security such as its type, original maturity, coupon payments frequency and face value. These fixed effects also capture any time-invariant issuer characteristics, notably the country of the issuer. Furthermore, the specification includes holder country-quarter fixed effects to account for any time-varying factors in individual holder countries and global trends. These fixed effects inter alia capture both cyclical and long-term structural changes in insurers' holdings such as a changing appetite to hold government bonds in view of (the price of) other products on the market and the increasing size of the insurance sector in a given holder country. They also control for changes in the macroeconomic environment and financial conditions of the holder country. Moreover, they capture any time-varying global factors such as market volatility and the overall level of yields (including any parallel shifts in the risk-free yield curve).

While the results in column 1 provide the first indicative confirmation of our predictions, a standard problem of empirical studies that estimate the impact of price changes on investment behaviour is the potential endogeneity of price changes, which may bias the estimates. The endogeneity problem can have two sources: omitted variable bias and reverse causality, which we discuss in turn below.

5.1.1 Addressing endogeneity due to omitted variable bias

The omission of variables that could simultaneously determine investment behaviour and price movements can be a potential source of endogeneity and thus could bias our estimated coefficients of risk-free rates and risk premia. The use of two types of fixed effects in our model already partially addresses this problem as they capture any unobserved security-specific and holder country-quarter specific factors. However, these fixed effects do not fully capture all time-varying co-determinants of insurers' investment behaviour and price/interest rate movements. Therefore, we turn to the inclusion of a number of security-specific or issuer-country specific time-varying variables. All these explanatory variables are lagged by one-quarter to specifically address the possibility that they are not only the determinants of insurers' asset holdings but also determinants of the lagged explanatory variables of interest.[24]

In column 2, we focus on the role of time-varying creditworthiness of an issuer as we predict that a deteriorating creditworthiness could trigger both asset sales and a price drop. We use two different measures. First, we include a dummy that indicates a (significant) rating downgrade. Given that sovereigns are rated by several credit rating agencies, we first map the available ratings into the four credit quality steps defined in the Eurosystem credit assessment framework (ECAI steps).[25] The dummy *ECAI downgrade* then equals one if the bond's credit quality changed from a lower to a higher ECAI step between two consecutive quarters. The negative and significant coefficient of 0.17 suggests that insurers decrease their bond holdings by around 17% after a (significant) rating downgrade. While a deteriorating credit quality *per se* can be a reason for a bond's sell off, insurance firms may also face regulatory limits linked to ratings and/or use ratings to define their internal investment strategies, which may contribute to the relatively large estimate of this effect.[26] As a complementary measure of creditworthiness, we use the issuer country's debt-to-GDP ratio, which is found to be insignificant in this specification. In line with our expectations, the inclusion of these two measures of creditworthiness lowers somewhat the size of the estimated coefficient of risk premia (from 0.30 to 0.20) but the estimate still remains highly significant.

In column 3, we account for the ECB's non-standard monetary policy measures by controlling for the volumes of Public Sector Programme Purchases (PSPP). Under PSPP, the ECB purchases bonds issued by euro area sovereigns with the objective of maintaining price stability in the euro area. Although PSPP only started in March 2015 and thus influences only the last two

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[24] Factors that are determinants of the dependent variable (holdings) but that do not affect the explanatory variables of interest (risk-free rate and risk premia) could have an explanatory power in our model. Their omission would, however, not lead to biased estimates of the coefficients for our explanatory variables of interest.
[25] For more details regarding the construction of the four ECAI steps, see Annex B.
[26] Recently, Becker and Ivashina (2015) observed a search for yield behaviour in the corporate bond holdings of insurance companies. As risky assets are assigned a capital requirement according to their rating, insurance firms prefer to hold higher rated bonds. However, within each rating class, they tend to buy higher yield assets to achieve higher returns. Therefore, insurance companies can be vulnerable to rating migrations.

years of our data, it is a potentially important confounding factor in our model. On the one hand, PSPP can influence the level of insurers' holdings, as some of the securities may be directly purchased from them.[27] On the other hand, the aim of PSPP is to ease monetary and financial conditions by lowering the level of interest rates along the yield curve. We use the publicly available aggregates of PSPP volumes on the level of individual issuer countries of the euro area to estimate this effect. Since PSPP is limited to the universe of securities eligible for Eurosystem operations, we associate (the log of) PSPP volumes only with insurers' holdings of securities from this universe, while we assign zero PSPP volumes to insurers' holdings of remaining securities. By the same token, we assign zero PSPP volumes to all insurers' holdings prior to the start of the purchase programme.[28] The estimated coefficient is found to be insignificant and the estimates of our explanatory variables of interest barely change.[29]

While the size of the estimated coefficient of risk premia decreases from 0.30 to 0.18 by the inclusion of these control variables, the estimate remains highly significant. Moreover, the estimated coefficient of the risk-free rate remains very stable and significant throughout these alternative specifications. Hence, the results provide a further empirical support of our model.

[27] As we are primarily interested in including factors that could lead to endogeneity, we lag the volumes of PSPP purchases by one quarter to explicitly control for the possibility that they influence our lagged explanatory variables of interest. However, the PSPP volumes are highly auto-correlated as the programme targets a fixed amount of monthly purchases (EUR 60 billion in the first year and EUR 80 billion in the second year of the programme) and, therefore, they also affect the level of insurers' holdings in the subsequent quarter. As an alternative, we also experimented with the inclusion of contemporary PSPP volumes in the model but our estimates remained broadly unchanged.

[28] PSPP is not the first ECB purchasing programme of securities issued by euro area sovereigns. From May 2010 to September 2012, the Eurosystem also enacted the Securities Market Purchase (SMP) programme. However, the volumes of the purchases were much smaller than those under PSPP and thus their effect is expected to be rather limited. Specifically, the SMP holdings amount to EUR 98 443 million and the last operation was allotted on 10 June 2014. The PSPP holdings amounted to EUR 1 568 013 million in June 2017 and include nominal and inflation-linked central government bonds, and bonds issued by recognised agencies, regional and local governments, international organizations and multilateral development banks located in the euro area. Moreover, we do not have quarterly information on the amount of the SMP purchases by country to properly control for the potential confounding effect.

[29] An alternative approach to controlling for PSPP purchases is to shorten the sample by excluding the quarters since the start of the purchase programme. Also in this case, the estimated coefficients of our explanatory variables of interest remain by and large unchanged (see column 6 in Table 6).

5.1.2 Do insurers treat domestic government bonds differently?

As outlined in Section 4, one of the main developments observed during the euro area sovereign debt crisis was an increase in insurers' holdings of domestic securities. In fact, insurers' holdings of domestic government bonds are substantial, representing around two-thirds of the holding amounts at the end of 2016 (i.e. EUR 1 trillion out of EUR 1.5 trillion). Therefore, in columns 4 and 5 of Table 1, we study the effects of the risk-free rate and risk premia on non-domestic and domestic holdings separately and compare them to our previous estimates.

The results for non-domestic exposures (column 4) further confirm our theoretical predictions of insurers' procyclicality with respect to risk premia, and countercyclicality with respect to the risk-free rate. Moreover, the coefficient of debt-to-GDP ratio becomes negative and significant. As higher debt levels may signal the unsustainability of public finances and a fundamental credit risk, this is a plausible finding.[30]

The results for domestic holdings, however, show the opposite picture. We estimate that a rise in the risk-free rate is associated with a decrease in insurers' holdings of its own sovereign bonds (procyclical behaviour) and that insurers tend to respond countercyclically to changes in the risk premia of their own sovereign. In particular, if the risk premia of a domestic sovereign rises (e.g. due to the deterioration in credit quality), we estimate that the insurance sector in that country will buy its bonds, which is the opposite result compared with non-domestic holdings. By further splitting the sample into 'vulnerable' and 'non-vulnerable' countries, we find that this type of behaviour is mainly driven by insurers' behaviour in 'vulnerable' euro area countries (CY, ES, GR, IE, IT, PT, SI).[31]

These empirical findings indicate that there are different incentives for insurers to hold domestic bonds. In the financial literature, it is well-known that the so-called home bias is present across different investment classes (not only in the sovereign bond market); it is widespread in both developed and emerging markets (French and Poterba, 1991) and is not necessarily an inefficiency to correct. There are manifold reasons for an investor to prefer

[30] The coefficient of PSPP volumes also becomes significant. The positive estimates suggest that PSPP purchases tend to be associated with larger volumes of insurers' government bond holdings.
[31] Results are available upon request.

domestic securities, particularly during a financial crisis (Gennaioli et al. 2014). Among others, the reasons include political pressure and moral suasion (Erce 2015, Acharya and Steffen 2015), redenomination and exchange rate risks (Fabozzi et al. 2015), transaction costs, information advantage and geographical hedging of assets and liabilities (Coeurdacier and Rey 2013, Choi et al., 2017).

The results for the risk premia based on domestic exposures seemingly contradict our theoretical predictions. However, this is not necessarily the case, provided that insurers (and regulators) view – for some of the reasons listed above – domestic sovereign bonds as if they were safe assets. For safe assets, the theoretical predictions of our model are the opposite to those for risky assets.

Going forward, we focus on the sample of non-domestic exposures and choose the (richest) specification in column 4 as our baseline regression.

5.1.3 Addressing endogeneity due to reverse causality

Reverse causality may bias our estimates if the risk-free rate and risk premia (explanatory variables of interest) depended on insurers' holdings (dependent variable). In particular, insurers' purchases of bonds could increase the overall demand for sovereign bonds in the market, which could suppress yields. For instance, if a large insurers' sell-off of a particular bond increased its risk premia, the coefficients obtained by OLS estimations in Table 1 would be biased downwards (taking into account their negative sign). To avoid such contemporary feedback, we lag our explanatory variables of interest by one-quarter in all model specifications. Nevertheless, as both insurers' holdings and yields are auto-correlated, this may not fully address our concern. Therefore, we aim to tackle this problem using instrumental variables and report the results in Table 2. For a better comparability of the coefficients, we include in column 1 of Table 2 the results of our baseline regression presented in column 4 of Table 1.

In column 2 of Table 2, we address the reverse causality of the (lagged) risk-free rate of return. We instrument the risk-free interest rate (at all maturities) with the US risk-free interest rate (at the corresponding maturity). The results of the first stage regression confirm that this variable is highly correlated with the risk-free interest rate, while being (likely) exogenous to euro area insurers' holdings of government bonds, because it is a result of the policy decisions of a foreign country, combined with the underlying economic conditions and expectations in that country. While the policy decision takes into account various factors, holdings of euro area insurers would only be a fraction of the overall information feeding into such a decision-making process. Therefore, the reverse causality problem is minimised by the use of this instrument. The fact that the coefficient of the risk-free rate remains significant (and even increases) confirms the robustness of our results.

In column 3, we turn to the potential reverse causality of the (lagged) risk premia. We first recall that we construct risk premia as a difference between the yield-to-maturity and the risk-free rate at the same maturity. While the long-term risk-free interest rate should in principle reflect inflation and growth expectations (Taylor, 1993), the fact that we use only a *single* risk-free rate for all bonds in our sample means that the (expectations about) country inflation and growth differentials are captured by the risk premia (in addition to credit and liquidity premia). Therefore, we instrument the risk premia by inflation rates in the country of issuer. The first stage results confirm that inflation is a significant determinant of risk premia. On the other hand, there is no particular reason why insurers' holdings of government bonds issued by a (different) country would significantly influence inflation in that country. While overall capital flows may do so, especially for small open economies, foreign insurers' holdings of government bonds are only a small part of the overall capital flows and other type of flows such as foreign direct investment may play a much larger role. This notwithstanding, to further limit the possibility of such a feedback loop, we lag the instrument by two-quarters (as compared to the dependent variable).[32] The estimated coefficient for the risk premia remains negative and significant, which further confirms our baseline results.

Finally, we use the two instruments jointly in the last column of Table 2 to instrument for both the risk premia and the risk-free rate. The results also remain robust in this case.

Overall, the results of the IV estimations provide further support for the significant and positive (negative) effect of the risk-free rate (risk premia) on insurers' holdings. The results are also robust to the selection of the IV method used. In particular, the estimates obtained

[32] The results are broadly unchanged, when the first (instead of a second lag) is used.

by the two-stage least square (2SLS), which are reported in Table 2, are very similar to those obtained by the General Method of Moments (GMM) estimator.

5.1.4 Model implications for insurers' investment behaviour

When considering the estimates obtained in our baseline specification (column 4 of Table 1), the estimated effects of the risk-free rate and risk premia are not only statistically but also economically important. For instance, if the risk-free rate increased by 100bp (i.e. 1 percentage point), we estimate that insurers would increase their nominal holdings by 11% in the following quarter *ceteris paribus*. Given that the non-domestic holdings of government bonds by euro area insurers at the end of 2016 totalled around EUR 0.5 trillion, an increase of 11% would translate into purchases of around EUR 55 billion. On the other hand, we estimate that if the risk premia increased by the same amount, insurers would decrease their nominal holdings by 2.2% *ceteris paribus*, i.e. by around EUR 11 billion.

Although the size of the estimated effect is smaller for risk premia than for the risk-free rate of return, the overall effect of an interest rate change (or price change) on insurers' holdings depends on the relative size of the change in the risk-free rate as compared with the change in risk premia. Particularly in crisis periods, the changes in risk premia can exceed those in the risk-free rate. If the excess is sufficiently large, our model implies that the risk premia become the main driver of the overall interest rate effect on holdings. As a result, insurers' investment behaviour in our model turns procyclical under such a scenario. On the other hand, in calm periods, when the changes in risk premia are relatively muted, our model predicts countercyclical behaviour because the risk-free rate effect dominates.

Figures 13 and 14 show those periods in which our model predicts pro- and countercyclical behaviour when using changes in the *average* risk-free rate and risk premia in our sample as examples.[33] The results suggests that insurers' investment behaviour tends to be countercyclical during calm periods, while turning procyclical in crisis periods with high risk-premia volatility such as during the euro area sovereign debt crisis. The results in Figures 13 and 14, however, only serve an illustrative purpose to the extent that individual bonds have

[33] In more detail, when using the estimated coefficients in column 5 of Table 1, insurers' investment behaviour is estimated to be countercyclical, if sign(-0.022*change in risk premia + 0.11*change in risk-free rate) = sign(change in risk premia + change in risk-free rate).

individual risk premia. For instance, in the middle of the euro area sovereign debt crises, the risk premia of a ten-year Italian government bond increased by around 145bps between the third and fourth quarters of 2011, while that of a ten-year German government bond declined by around 9bps. Hence, although the insurers' investment behaviour implied by our model was procyclical with respect to Italian government bonds in that period, it remained countercyclical with respect to German government bonds.

Figure 13: Insurers' pro-/countercyclicality over time (as estimated by our model for the average risk-free rate and risk premia)

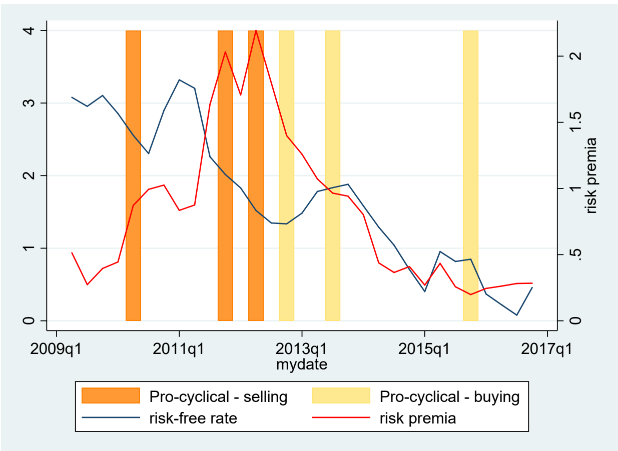
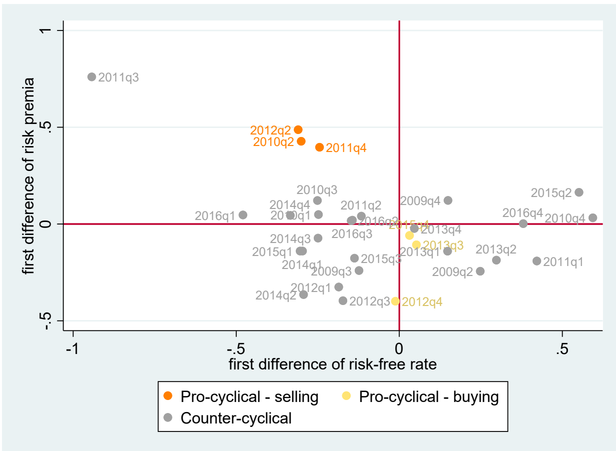


Figure 14: Insurers' pro-/countercyclicality in a scatter plot (as estimated by our model for the average risk-free rate and risk premia)



Source: ECB SHS data and authors' calculations.
Notes: The averages refer to averages of the risk-free rate and risk premia in a given period weighted by the holdings in our sample.

5.2 Robustness checks

One drawback of our empirical results is that they are largely based on the period prior to the start of Solvency II, when euro area insurers did not necessarily operate under a market-based regulatory regime. The regulatory regime, however, plays an important role in our theoretical considerations, which are derived assuming a market-consistent valuation of assets and liabilities. The following two robustness checks aim at addressing this shortcoming. In addition, we also test the robustness of the results with respect to different empirical specifications and (sub-)samples.

A. Do our empirical results hinge on the regulatory regime in place?

The Solvency II regime entered into force in January 2016. The basic principle of this regime requires all euro area insurers to provide a market-consistent view on their balance sheet, which is the starting point for our theoretical considerations. Therefore, in columns 2 and 3 of Table 3 we test whether our empirical results substantially change when we split the time span into periods (i) prior to 2016 (column 2) and (ii) during 2016 (column 3). Interestingly, the results hold for the period prior to the start of the Solvency II regime. [34] The second sample period is, however, very short (effectively only three quarters as we use lagged explanatory variables) and the estimated coefficient of risk premia becomes insignificant. Overall, we believe that it is too early for our study to empirically assess insurers' investment behaviour under the Solvency II regime given the short time period since its introduction.

Focusing on the period prior to the Solvency II introduction, our theoretical model suggests that insurers' investment behaviour was sensitive to price changes mainly in cases where insurers operated under a market-based regime, as also suggested by Lepore et al. (2018). To test this, we aim at singling out these countries, for which the introduction of Solvency II represented a notable change compared to the non-risk-sensitive requirements in Solvency I. Although our approach is far from perfect, it is based on the use of transitional measures under Solvency II as no detailed and comprehensive information on the nature of the regulatory regimes in place in individual euro area countries prior to 2016 is available to us. Since the transitional measures were designed to smooth the transition between the Solvency I and Solvency II regimes,[35] we assume that insurers in countries that had a more market-based regulatory regime prior to Solvency II do not (need to) use transitional measures. By contrast, we assume that insurers in countries with less market-based regimes prior to Solvency II are more likely to apply these measures.

[34] It is not necessarily the case that the regimes in place prior to 2016 were fully non-risk sensitive. First of all, euro area insurers were anticipating the introduction of Solvency II for several years before 2016 (see Section 2). Moreover, the national laws in some countries included more risk-sensitive requirements.

[35] The transitional measures under Solvency II are twofold and allow firms to use Solvency I valuation for some of their technical provisions (transitional measure on technical provisions) and apply a transitional adjustment to the risk-free rate (transitional measure on the risk-free rate) for up to 16 years after Solvency II entered into force (EIOPA 2016b).

In line with our expectations, we find that insurers' investment behaviour is sensitive to changes in the risk-free rate and risk premia when insurers operate under a more market-based regime since the corresponding coefficients are estimated to be highly significant (Column 5 of Table 3). By contrast, the size of both coefficients of interest decrease and the coefficient of the risk-free rate becomes insignificant for countries with less market-based regimes (column 4 of Table 3).

B. What is the role of different risk-free measures?

The choice of our proxy for the risk-free rate in the baseline model is motivated by the current Solvency II framework, which requires all euro area insurers to discount their technical provisions in euro using a single yield curve for euro currency published by EIOPA. However, this was not necessarily the case under Solvency I. Therefore, we test the robustness of our results to the use of different measures of the risk-free rate. The risk premia also change with the measures of the risk-free rates, as the former is calculated from the latter.

We report the results in Table 4. As a starting point, we use the baseline estimates from column 4 of Table 1. In Columns 2 and 3 of Table 4, we then proxy the risk-free rate with the yield curve of 10-year government bonds issued by Germany and the overnight index swap (OIS) yield curve. In both specifications, our baseline estimates are highly robust to the different choices of risk-free rate proxy.

C. Are our results driven by the empirical specification?

To assess the robustness of our results to changes in the empirical specification, we first include different types of fixed effects. Column 1 of Table 5 presents the baseline results obtained with security-specific fixed effects and with holder country-quarter fixed effects. Instead of the latter type of fixed effects, column 2 includes holder country fixed effects (which are less granular than holder country-quarter fixed effects) but also quarterly fixed effects. Our predictions are also verified in this empirical specification.

Furthermore, we estimate the overall effect of an interest rate shock on insurers' holdings by means of the yield-to-maturity variable. By doing this, we follow the spirit of previous studies (e.g. Timmer, 2018; Bijlsma and Vermeulen, 2016), which do not distinguish between the different drivers of an interest rate/price change. This overall effect is found to be negative and significant (see Table 5, column 3), which suggests that euro area insurers sell bonds, whose yield-to-maturity rises, i.e. whose price falls (and vice-versa). Hence, if we did not distinguish between the effect of the risk-free rate and risk premia, we could conclude that the euro area insurance sector (always) reacts procyclically to a bond price change.

It could also be that our results are only driven by positive or negative changes in the explanatory variables of interest. To test whether this is the case, we include in our model explanatory variables, which separately capture positive and negative changes in the risk-free rate and risk premia. The estimated coefficients suggest that our results hold for both positive and negative changes in the variables of interest (see Table 5, column 4), which seem to have a symmetric effect on insurers' holdings.

We also test our results with different specifications of the dependent variable. First, we difference the dependent variable and present the results with both holder country-quarter and holder country-year effects (columns 5 and 6). Second, we also difference all the explanatory variables and run regressions in changes, again including holder country-quarter and holder country-year effects (columns 7 and 8).[36] The coefficient of the risk-free rate is found to be insignificant in both specifications with holder country-quarter fixed effects (columns 5 and 7) but becomes significant with holder country-year fixed effects (columns 6 and 7). The insignificant result for the risk-free rate coefficient obtained with the very granular holder country-quarter fixed effects is not surprising given that these fixed effects fully account for any parallel shifts in the risk-free rate curve. At the same time, the effect of risk premia remains significant in all these regressions, which further supports the robustness of our finding of insurers' procyclical behaviour.

Finally, in the last column of Table 5, we construct a buy/sell indicator equal to 1 if the first difference of holdings is greater than 0 (insurers buy a security), to -1 if the first difference is

[36] The security fixed effects are dropped in these two specifications as they do not change over time and are thus differenced out.

negative (insurers sell a security), and 0 otherwise. We run ordered logit regressions with this dependent variable and the results further support our theoretical predictions.

D. Are our results driven by sample bias?

Our sample combines the holdings of euro area insurance companies from SHS collected since 2014 and those collected prior to 2014 under Securities Holdings Experimental Statistics (SHES). In Columns 2 and 3 of Table 6, we split our sample in these two periods to see whether SHES data, which were collected on a voluntary and best-efforts basis, could drive the results in the full sample. The results indicate that this is not the case because the coefficients of our variables of interest remain highly significant and the estimated effect of risk premia rises, when estimated on the sample that excludes SHES data (column 3). Moreover, the results based on SHES sample are also in line with our theoretical predictions, even if the significance of the risk-free rate coefficient is found to be only borderline (column 2).[37] In fact, the quality and coverage of SHES data on non-domestic holdings (i.e. data used in this regression) are fairly good since security-by-security data have been historically used in many euro area countries for the compilation of balance of payments statistics (see Fache Rousová and Rodríguez Caloca, 2018).

Our time series includes the European sovereign debt crisis and the following Outright Monetary Transactions programme of the ECB. Under this programme, the ECB is ready to purchase sovereign bonds of euro area Member States in the secondary market, under certain conditions. For this reason, we test the behaviour of insurance companies and the robustness of our results in the two sub-samples, before and after the OMT announcement in July 2012 (see columns 4 and 5 of Table 6). The estimates of our variables of interest show a slightly lower sensitivity to changes in risk premia before the OMT announcement and a slightly lower sensitivity to changes in the risk-free rate after the OMT announcement. However, signs do not vary and all the coefficients of interest remain significant. Similarly, in Column 6 of Table 6, we test whether our results are driven by the Public Sector Purchase Programme of the ECB and we find no major changes in the estimates of our variables of interest.

[37] The p-value of 0.14 indicates significance at 15% confidence level.

During the European sovereign debt crisis, some countries (i.e. Cyprus, Spain, Greece, Ireland and Portugal) entered the bailout programs provided jointly by the International Monetary Fund, the European Commission and the European Central Bank. In Column 7 of Table 6, we exclude the holdings of securities issued by such sovereigns with fundamental risk and test whether they drive our estimates. We find that the sensitivity of insurers' holdings to changes in risk premia increases, but signs and significance do not vary.

Finally, our sample includes some bonds, for which the risk premium is negative, given that we construct it as a difference between the yield-to-maturity and EIOPA risk-free yield curve. We exclude these bonds in Column 8 of Table 6. Our results also remain robust in this sub-sample.

To sum up, the different robustness checks provide a strong empirical support to our theoretical predictions. The procyclical effect of risk premia for non-domestic holdings is found to be particularly robust as the coefficient remains negative and highly significant in all types of robustness checks, except for one regression, in which we use only three quarters of the data (Table 3, column 3). The countercyclical effect of the risk-free rate is also fairly robust to the different empirical specifications, even if we estimate an insignificant coefficient in the regressions in changes (Table 5, columns 5 and 7). The likely reason for the insignificant coefficient is, however, the high collinearity of the risk-free rate with the very granular holder country-quarter fixed effects, since the coefficient becomes significant with fewer granular time-fixed effects.

6. CONCLUSIONS

In this paper, we develop a stylised model of insurers' investment behaviour, which predicts procyclicality when prices fall due to increasing risk premia, and countercyclicality when prices drop due to rises in the risk-free interest rate. Using security-by-security data on government bond holdings of euro area insurance companies from 2009 to 2016, we validate these predictions empirically. In line with the theoretical framework, we estimate a positive and significant effect of the rise in the risk-free interest rate on insurers' holdings (countercyclicality), while the effect of risk premia is found to be negative and significant (procyclicality). These results, however, only hold for insurers' holdings of foreign government bonds, while domestic bonds appear to receive preferential treatment. In particular, we find that insurers tend to respond countercyclically (rather than procyclically) to changes in the risk premia of their own sovereign.

The estimated effects for non-domestic government exposures are not only statistically but also economically important. While the size of the estimated effect is smaller for risk premia than for the risk-free rate, the overall effect of an interest rate change (or price change) on insurers' holdings also depends on the relative size of the changes in the risk-free rate and risk premia. Therefore, insurers' investment behaviour in our model turns procyclical in a crisis scenario, when changes in risk premia significantly exceed those in the risk-free rate, and we show that this was the case during the euro area sovereign debt crisis. Our paper thus helps explain *why* insurers' investment behaviour tends to turn procyclical in crisis periods, even if previous empirical literature already suggested that this may be the case.

Our theoretical framework and empirical results also suggest that insurers' investment behaviour is more sensitive to price changes, when insurers operate under a more market-consistent regulatory regime. This finding may help shed light on some of the mixed results in the existing literature such as the procyclical behaviour evidenced by Biljsma and Vermeulen (2017) for Dutch insurers (under a market-based regime) and the countercyclical behaviour found by Timmer (2018) for German insurers (under a non-market based regime) during the sovereign debt crisis.

One shortcoming of our analysis is, however, that it is too early for us to empirically assess insurers' investment behaviour under the current regulatory regime, Solvency II, as it entered into force only in January 2016. Another limitation of our paper is that our empirical results are estimated on a sample of government bonds only and thus cannot be generalised to other asset classes. By the same token, the findings are characteristic for a time period, in which the euro area sovereign debt crisis played a prominent role and the risk-free rate tended to gradually decline. Even if we do have observations of increases in the risk-free rate in our sample and specifically check for the robustness of our results to positive and negative changes in this rate, it is not clear to what extent our results would hold going forward if the risk-free rate were to rise over a long-term horizon and the negative duration mismatch of insurers were to fall.

Our findings are not without policy implications. By providing robust evidence of insurers' procyclicality during the euro area sovereign debt crisis, our paper contributes to the current policy discussion on macroprudential measures beyond banking. Since it highlights that insurers' procyclicality is linked to changes in risk premia, it can be instrumental for the development of an effective countercyclical policy instrument that targets risk-premia volatility. Some insights put forward by this paper can also be useful in a broader context such as in the development of system-wide stress tests that aim to model the investment behaviour of all sectors in the economy. One particular question in these models is who buys the assets whose prices have declined. Our finding that insurers bought domestic sovereign bonds during the sovereign debt crisis, even if their risk premia and credit quality deteriorated, can provide some indication as to where to look for the potential buyers in a crisis scenario.

Table 1: Baseline model and omitted variable bias

	(1)	(2)	(3)	(4)	(5)
				Baseline	
Sample	Full	Full	Full	Non-Domestic	Domestic
Dependent Variable			Log Holdings		
Risk premia *(lag)*	-0.030***	-0.020***	-0.018***	**-0.022*** **	0.014*
	(0.00)	(0.00)	(0.00)	**(0.00)**	(0.09)
Risk-free rate *(lag)*	0.074***	0.079***	0.081***	**0.11*** **	-0.084**
	(0.01)	(0.00)	(0.00)	**(0.00)**	(0.03)
ECAI downgrade *(lag)*		-0.17***	-0.17***	**-0.18*** **	-0.051
		(0.00)	(0.00)	**(0.00)**	(0.21)
Debt/GDP *(lag)*		0.00065	0.00053	**-0.0035** **	-0.020
		(0.71)	(0.76)	**(0.03)**	(0.62)
Log PSPP volume *(lag)*			0.010**	**0.016*** **	-0.0044
			(0.02)	**(0.00)**	(0.73)
Security FE	Y	Y		**Y**	Y
Holder country-quarter FE	Y	Y		**Y**	Y
Observations	190,469	168,643	168,643	**149,130**	19,513
R-squared	0.603	0.587	0.587	**0.603**	0.981

The dependent variable is the logarithm of a nominal amount of single government bonds held by insurance companies in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. The risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and the risk-free rate. The ECAI downgrade is a dummy equal to one if the credit quality of a security significantly deteriorates from one-quarter to another. Debt/GDP ratio is the amount of an issuer country's total gross government debt as a percentage of its GDP. Log PSPP volume is the log of the cumulative quarterly net purchases under the Public Sector Purchase Programme (aggregated by issuer country). In columns 4 and 5, the sample is limited to exposures of euro area insurers to non-domestic and domestic government bonds, respectively. 'Security FE' denotes security-specific fixed effects, 'Holder country-quarter FE' denotes fixed effects that are specific for quarterly developments in a holder country. Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 2: Reverse Causality

	(1)	(2)	(3)	(4)
	Baseline			
Second stage		Log Holdings		
Dependent Variable				
Risk premia *(lag)*	-0.022***	-0.022***	-0.16***	-0.16***
	(0.00)	(0.00)	(0.00)	(0.00)
Risk-free rate *(lag)*	0.11***	0.16***	0.087***	0.10*
	(0.00)	(0.00)	(0.01)	(0.07)
First stage				
Instrument for risk-free rate				
US risk-free interest rate *(lag)*		0.458***		0.458***
		(0.00)		(0.00)
Instrument for risk premia				
Issuer country inflation rate *(lag 2)*			0.255***	0.255***
			(0.00)	(0.00)
Security FE	Y	Y	Y	Y
Holder country-quarter FE	Y	Y	Y	Y
Other controls	Y	Y	Y	Y
Observations	149,130	148,703	142,341	142,341
R-squared	0.603	0.370	0.373	0.373

Estimates are obtained using two-stage least-squares (2sls). The first panel shows the results of the second stage. The dependent variable is the logarithm of a nominal amount of single government bonds held by insurance companies in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. The risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and the risk-free rate. The second panel shows the results of the first stage. US risk-free interest rate is the yield curve obtained from the US risk-free interest rate term structures. Inflation rate is the inflation rate of a country, measured by the Consumer Price Index. 'Security FE' denotes fixed effects that are specific for each security. 'Holder country-quarter FE' denotes fixed effects that are specific for quarterly developments in a holder country. 'Other controls' include all the control variables listed in the baseline specification (see column 4 of Table 1). The Generalised Method of Moments (GMM) returns very similar estimates. Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 3: Robustness checks – less and more market-based regimes prior to Solvency II

	(1) **Baseline**	(2)	(3)	(4)	(5)
Sample	Full	w/o 2016 (09q1-15q4)	only 2016 (16q1-16q4)	Countries with less market-based regime prior to SII (w/o 2016)	Countries with more market-based regime prior to SII (w/o 2016)
Dependent variable			Log Holdings		
Risk premia *(lag)*	-0.022***	-0.019***	-0.0030	-0.016*	-0.022***
	(0.00)	(0.00)	(0.90)	(0.07)	(0.00)
Risk-free rate *(lag)*	0.11***	0.087***	0.13**	0.0032	0.10***
	(0.00)	(0.00)	(0.01)	(0.95)	(0.00)
ECAI downgrade *(lag)*	-0.18***	-0.17***	-0.067	-0.16***	-0.19***
	(0.00)	(0.00)	(0.58)	(0.00)	(0.00)
Debt/GDP *(lag)*	-0.0035**	-0.0045***	0.0043	-0.0022	-0.0059***
	(0.03)	(0.01)	(0.31)	(0.40)	(0.00)
Log PSPP volume *(lag)*	0.016***	0.015***	-0.030	0.039***	0.014***
	(0.00)	(0.01)	(0.22)	(0.00)	(0.01)
Security FE	Y	Y	Y	Y	Y
Holder country-quarter FE	Y	Y	Y	Y	Y
Observations	149,130	121,507	27,623	34,985	86,522
R-squared	0.603	0.599	0.659	0.620	0.656

The dependent variable is the logarithm of a nominal amount of single non-domestic government bonds held by insurance companies in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. The risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and risk-free rate. The ECAI downgrade is a dummy equal to one if the credit quality of a security significantly deteriorates from one-quarter to another. The debt/GDP ratio is the amount of an issuer country's total gross government debt as a percentage of its GDP. Log PSPP volume is the log of the cumulative quarterly net purchases under the Public Sector Purchase Programme. In 2016 q1, the quality of the insurance data in SHS improved due to the new requirement of direct reporting by insurance corporations (and at the same time the Solvency II regulatory regime entered into force). 'Countries with less market-based regime' are the countries that use large transitional measures under the Solvency II regulatory regime: GR, ES, PT, DE and FI. 'Countries with more market-based regime' are countries using less/no transitional measures and are the remaining euro area countries. The transitional dummy is equal to 1 if a holder country belongs to those having large transitional measures. 'Security FE' denotes fixed effects that are specific for each security. 'Holder country-quarter FE' denotes fixed effects that are specific for quarterly developments in a holder country. Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 4: Robustness checks – measurement of risk-free rate

	(1)	(2)	(3)
	Baseline		
Dependent Variable		Log Holdings	
Risk premia *(lag)*	-0.022***		
	(0.00)		
Risk-free rate *(lag)*	0.11***		
	(0.00)		
Risk premia OIS *(lag)*		-0.020***	
		(0.00)	
Risk-free rate OIS *(lag)*		0.094**	
		(0.01)	
Risk premia DE *(lag)*			-0.022***
			(0.00)
Risk-free rate DE *(lag)*			0.12***
			(0.00)
Security FE	Y	Y	Y
Holder country-quarter FE	Y	Y	Y
Other controls	Y	Y	Y
Observations	149,130	149,130	149,130
R-squared	0.603	0.603	0.603

The dependent variable is the logarithm of a nominal amount of single non-domestic government bonds held by insurance companies in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. The risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and risk-free rate. 'Risk-free rate DE' represents the yield curve of 10-year government bonds issued by Germany, which we use as a second proxy for risk-free rate, and 'risk premia DE' the spread between the yield-to-maturity of a security and the German yield at the same maturity. Similarly, 'risk-free rate OIS' denotes the overnight index swap yield curve, and 'risk premia OIS' is the spread between the yield-to-maturity of a security and the overnight index swap yield at the same maturity. 'Security FE' denotes fixed effects that are specific for each security. 'Holder country-quarter FE' denotes fixed effects that are specific for quarterly developments in a holder country. 'Other controls' include all the control variables listed in the baseline specification (see column 4 of Table 1). Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 5: Robustness checks – empirical specification

	(1) **Baseline**	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable			Log Holdings			Difference in Log Holdings			Buy/sell Indicator
Yield-to-maturity			-0.019***						
			(0.00)						
Risk premia *(lag)*	-0.022***	-0.025***			-0.0085***	-0.0094***			-0.010***
	(0.00)	(0.00)			(0.00)	(0.00)			(0.00)
Risk-free rate *(lag)*	0.11***	0.10***			0.0039	0.021***			0.083***
	(0.00)	(0.00)			(0.67)	(0.00)			(0.00)
Δ Risk premia *(lag)*							-0.0084***	-0.010***	
							(0.00)	(0.00)	
Δ Risk-free rate *(lag)*							-0.0075	0.014**	
							(0.47)	(0.01)	
Risk premia neg *(lag)*				-0.025***					
				(0.00)					
Risk premia pos *(lag)*				-0.021***					
				(0.00)					
Risk-free rate neg				0.11***					
				(0.00)					
Risk-free rate pos				0.11***					
				(0.00)					
Security FE	Y	Y	Y	Y	Y	Y			Y
Holder country-quarter FE	Y		Y	Y	Y		Y		
Holder country FE		Y							
Quarter FE		Y							Y
Holder country-year FE						Y		Y	
Other controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	149,130	149,130	149,130	149,130	147,117	147,117	145,456	145,884	147,557
R-squared	0.603	0.588	0.603	0.603	0.078	0.037	0.078	0.011	

The dependent variable in columns 1-4 is the logarithm of a nominal amount of single government bonds held by insurance companies in different euro area countries. In columns 5-8 is the first difference of this logarithm. In column 9 is a buy/sell indicator that equals 1 if the first difference of holdings is greater than 0 (insurers buy a security), -1 if the first difference is negative (insurers sell a security), and 0 otherwise. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. Yield-to-maturity is the interest rate of single government bonds in a given quarter. The risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and the risk-free rate. 'Security FE' denotes fixed effects that are specific for each security. 'Holder country FE' denotes fixed effects that are specific for the insurance sector in each euro area country. 'Holder country-quarter FE' and 'Holder country-year FE' denote fixed effects that are specific for quarterly and yearly developments in a holder country, respectively. 'Other controls' include all the control variables listed in the baseline specification (see column 4 of Table 1). In columns 7 and 8, these control variables are included in differences. Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 6: Robustness checks – sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	**Baseline** Full	Only SHES data (09q1-13q3)	w/o SHES data (13q4-16q4)	Pre-OMT announcement (09q1-12q2)	Post-OMT announcement (12q3-16q4)	w/o PSPP (09q1-14q4)	w/o countries with fundamental risk	Only securities with positive risk premia
Dependent variable					Log holdings			
Risk premia *(lag)*	-0.022***	-0.016**	-0.044***	-0.013*	-0.023***	-0.013**	-0.037***	-0.025***
	(0.00)	(0.02)	(0.00)	(0.08)	(0.00)	(0.01)	(0.00)	(0.00)
Risk-free rate *(lag)*	0.11***	0.058	0.10***	0.12***	0.092***	0.069**	0.075**	0.13***
	(0.00)	(0.14)	(0.00)	(0.00)	(0.01)	(0.04)	(0.01)	(0.00)
Security FE	Y	Y	Y	Y	Y	Y	Y	Y
Holder country-quarter FE	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y
Observations	149,130	70,818	78,312	46,406	102,724	97,594	126,326	106,308
R-squared	0.603	0.605	0.615	0.628	0.600	0.598	0.583	0.634

The dependent variable is the logarithm of a nominal amount of single government bonds held by insurance companies in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and 30 years. All independent variables are lagged by one-quarter. Risk-free rate is obtained from EIOPA's risk-free interest rate term structures (using the same maturity as that of a given security). The risk premia are calculated as being spread between yield-to-maturity and the risk-free rate. Columns 2 and 3 refer to the sub-samples before and after the Outright Monetary Transactions' announcement by the ECB, respectively. Countries with fundamental risk in column 7 are CY, ES, GR, IE, PT. SHES data are SHS data collected on a voluntary and best-efforts basis from 2009 to 2013 and are thus subject to some quality limitations. 'Security FE' denotes fixed effects that are specific for each security. 'Holder country-quarter FE' denotes fixed effects that are specific for quarterly developments in a holder country. 'Other controls' include all the control variables listed in the baseline specification (see column 4 of Table 1). Standard errors are clustered at holder country and individual security level and the corresponding p-values are reported in parenthesis. *** denotes significance at 1% level, ** significance at 5% level and * significance at 10% level.

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Annex A: Literature Review

Authors	Data	Findings	Behaviour
Grinblatt and Keloharju (2000)	Finland's stock market	Insurance companies and financial institutions are contrarian in the short run and neutral in the long run.	countercyclical / neutral
Impavido and Tower (2009)	OECD and Latin American countries, 2007 - 2009	During the financial crisis, life insurance companies were acting procyclically, as the sales of equity and other instruments were more widespread.	procyclical
De Haan and Kakes (2011)	Netherlands, 1999-2005	Pension funds, life insurers and non-life insurers tend to be contrarian traders, i.e. they buy past losers and sell past winners. Life insurers tend to be contrarian traders when they have a high proportion of unit-linked policies, while non-life insurers are contrarian when they have a more risky business model.	countercyclical
Ellul, Jotikasthira, Lundblad (2011)	Insurance data from the National Association of Insurance Commissioners (NAIC), 2001-2005	Insurance companies subject to tighter regulation are more likely to sell downgraded bonds. Bonds subject to a high probability of regulatory-induced selling exhibit price declines and subsequent reversals. These price effects appear larger in periods of distress.	procyclical
Merrill, Nadauld, Stulz and Sherlund (2012)	US Insurance sector	Between 2006 and 2009, capital-constrained US insurance companies sold more non-agency, residential mortgage-backed securities, and at lower prices, than their peers who were less capital constrained. Such behaviour might be consistent with insurers being incentivised to sell risky assets during periods of market stress to improve their capital positions.	procyclical
Papaioannou, Park, Pihlman and van der Hoorn (2013)	Different data sources, 2000-2012	There is evidence of the procyclical investment behaviour of major institutional investors during the global financial crisis. Many factors could account for such behaviour, which may be considered rational from an individual institution's perspective.	procyclical
Bank of England and Procyclicality Working Group (2014)	Bank of England aggregate asset allocation data, 2006-2012, OECD flow data	There is some evidence of procyclical shifts in asset allocation following the dotcom crash of the early 2000s, and to a lesser extent during the recent financial crisis. However, structural shifts in asset allocation occurred during the financial crisis, which make identifying procyclical behaviour more difficult (from equity to fixed income). Liability characteristics, accounting and valuation methods, regulation and industry practices influence asset allocation decisions. A risk-sensitive capital regime, when combined with mark-to-market valuation, can encourage insurers to act procyclically.	procyclical
Becker and Ivashina (2015)	Lipper eMAXX, 2004-2010Q	Insurance companies buy corporate bonds that are the highest yielding within each rating group, due to reluctance to hold capital against worse-rated bonds. Reaching for yield is driven by capital requirements and private contracting frictions: firms with aggressive capital management and with weak governance take on more risk in the corporate bond market.	countercyclical
Bijlsma and Vermeulen (2016)	60 insurance companies, Dutch data, 2006-2013Q	Insurance companies acted procyclically during the sovereign debt crisis by selling distressed countries' government bonds.	procyclical

Douglas, Noss, Vause (2017)	Based on simulated data. Stylised UK insurer	While Solvency II may partly protect insurers' solvency positions from falls in risky asset prices, it might encourage certain types of UK life insurers to de-risk, i.e. move to holding safe assets in place of risky ones, following falls in risk-free interest rates. Once Solvency II is fully implemented by 2032, UK life insurers may have markedly reduced their holdings of long-term, risky assets. This behaviour is driven by the so-called 'risk margin', which reduces insurers' solvency positions following falls in risk-free interest rates, thereby encouraging them to sell risky assets to reduce their probability of regulatory insolvency.	procyclical
Czech and Roberts-Sklar (2017)	Sterling corporate bond market, 2011-2016	Insurance companies, hedge funds and asset managers are typically net buyers when corporate bond yields rise. Dealer banks clear the market by being net sellers. However, this behaviour reverses in times of stress for some investors. During the 2013 'taper tantrum', asset managers were net sellers of corporate bonds in response to a sharp rise in yields, while dealer banks were net buyers.	countercyclical
Duijm and Bisschop (2018)	Netherlands SHS, 2006-2015Q	ICs sold equities during the crisis (procyclical behaviour), while PFs kept buying equities as markets tumbled (countercyclical behaviour). ICPFs sold their affected sovereign bonds prior to a rating downgrade (destabilising at a macro-level).	procyclical
Ellul, Jotikasthira, Kartasheva, Lundblad, Wagner (2018)	US Insurance sector	US life insurers with a significant variable annuity business may stop acting as stabilisers in periods of market distress, and may themselves become a source of significant selling activity.	procyclical
Timmer (2018)	German SHS, 2005-2014Q	ICPFs respond countercyclically to price changes, acting as market stabilisers by pushing prices to their face values, i.e. buying bonds that are trading at a discount and selling bonds that are trading at a premium.	countercyclical

Annex B: Variables description

Variable	Description
Log Holdings	Natural logarithm of the nominal amounts of government bond holdings of euro area insurers. Includes holdings of zero- and fixed-coupon bonds with residual maturity of between three months and 30 years (ECB's SHS Sector data)
Yield-to-maturity	Interest rate of single government bonds in a given quarter (ECB's CSDB)
Risk-free rate EIOPA	Risk-free interest rate term structures, published monthly by EIOPA. The risk-free yield curves are based on liquid swap and government bond rates, and then adjusted to include the counterparty default risk (https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii-technical-information/risk-free-interest-rate-term-structures)
Risk-free rate OIS	Overnight index swap yield curve (Bloomberg)
Risk-free rate DE	Yield curve of 10-year government bonds issued by Germany (ECB – Euro area government bond yield curves)
Risk premium	Difference between the yield-to-maturity of a security and the risk-free-rate at the same maturity
ECAI downgrade	A dummy that is equal to one if the bond's credit quality changed from a lower to a higher ECAI credit quality step between two consecutive quarters. ECAI credit quality steps are defined in accordance with the Eurosystem credit assessment framework (ECAF), which provides a harmonised rating scale classifying ratings into three credit quality steps. The first category includes securities rated from AAA to AA-, the second from A+ to A- and the third from BBB+ to BBB-. A fourth category is added which includes all rated securities with a rating below credit quality step three.
Debt/GDP	Amount of a country's total gross government debt as a percentage of its GDP (OECD https://data.oecd.org/gga/general-government-debt.htm#indicator-chart)
Log PSPP volume	Natural logarithm of the cumulative quarterly net purchases under the Public Sector Purchase Programme (ECB https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html)
Inflation rate	Quarterly inflation rate of a country, measured by the Consumer Price Index (OECD https://data.oecd.org/price/inflation-cpi.htm)

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