Investment strategies of euro area insurers and pension funds: Pro- or counter-cyclical?

Linda Fache Rousová, Margherita Giuzio
European Central Bank[1]

Preliminary, do not cite or circulate without permission

Abstract:
Traditionally, insurers and pension funds (ICPFs) are considered stabilisers of financial markets that act counter-cyclically by buying assets whose price falls. Recent studies challenge this view by providing empirical evidence of pro-cyclicality. This paper is the first to shed light on the underlying reason for these opposite views. Our model predicts pro-cyclicality when prices fall due to increasing risk-premia and counter-cyclicality in response to rises in risk-free rate. Using granular data on government bond holdings of ICPFs, we validate these predictions empirically. Our findings have significant policy implications and contribute to the current policy discussion on macro-prudential measures beyond banking.

***Keywords*:** insurance companies, pension funds, cyclicality, portfolio allocation, financial stability, credit quality, sovereign debt crisis.

Acknowledgements:
The authors would like to thank Lorenzo Cappiello, Casper Christophersen, Dieter Hendrickx, Spyros Palligkinis, Daniel Perez and Alexander Popov for helpful comments and suggestions. The paper also benefited from useful feedback from the participants of the 2nd Workshop on Systemic Stress, Investor Behaviour and Market Liquidity of the Financial Stability Board (FSB) in Amsterdam and the participants of internal seminars at the ECB. We remain responsible for any errors or omissions.

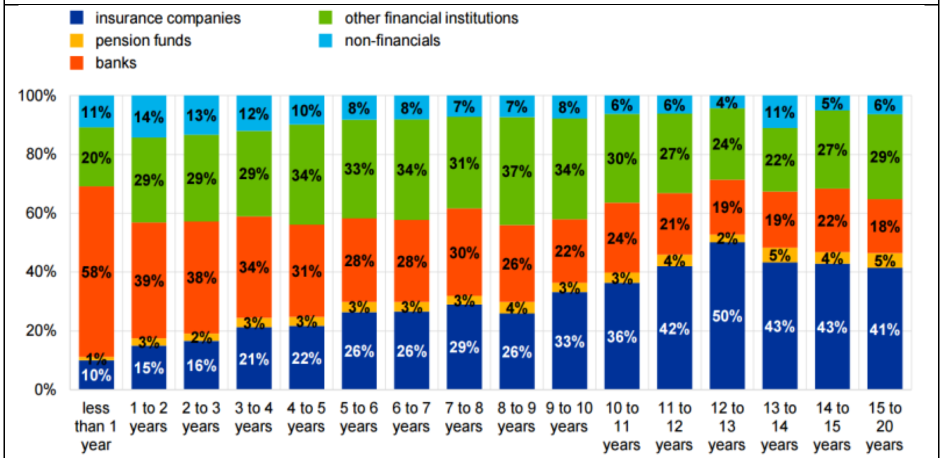
---

[1] Disclaimer: This paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

1. INTRODUCTION

Insurance companies and pension funds (ICPFs) are important institutional investors that play a key role in long-term financing of the economy. For instance, they are the most important euro area sector investing in bonds with maturity longer than 10 years (Figure 1). In addition to their role as a source of finance, they are strongly interconnected with banks and other financial intermediaries through direct and indirect links. Therefore, ICPFs' investment choices can have important implications for the stability of the financial system and for long-term economic growth.

Figure 1: Euro area holdings of debt securities, broken down by residual maturity and holder sector, 2016 Q3
(in percent of total securities holdings)



Source: ECB Securities Holdings Statistics and authors' calculations.

A potential pro-cyclicality in ICPFs investment behaviour, whereby ICPFs sell assets whose value declined and vice-versa, is particularly relevant from a financial stability perspective. On the one hand, large ICPF asset sales could amplify price falls, which could negatively affect other investors holding the same assets, potentially inducing another wave of fire sales and threatening the stability of the financial system as a whole. On the other hand, if ICPFs increase exposures to assets whose values are rising, they may contribute to the development of asset price bubbles. Therefore, we want to assess in this paper whether ICPF investment behaviour can be pro-cyclical and if so, what are the underlying driving forces of such behaviour.

Traditionally, ICPFs have been considered stabilisers of financial markets that act counter-cyclically by buying assets whose price falls. As they aim at matching their long-term liabilities with long-term assets, they are natural long-term investors and as such, they typically hold assets until maturity and are indifferent to short-term price movements. However, Cochrane (2017) suggests that financial institutions may decide to sell assets for two reasons: they think that the price drop is related to a real increase in the long-term default probability of the issuer or their risk-bearing capacity declines due to increasing risk aversion.

Despite the high relevance of the topic, the existing literature on investment behaviour of ICPFs is scarce and limited mainly to country-specific studies. Moreover, the evidence on buy/sell decisions in response to price changes is mixed. For instance, Timmer (2016) suggests that the German ICPF sector acts counter-cyclically in the sovereign bond market and his findings are supported by earlier studies such as Grinblatt and Keloharju (2000) and De Haan and Kakes (2010), that all provide evidence of counter-cyclical ICPF investment behaviour. On the other hand, Bijlsma and Vermeulen (2015) find that Dutch insurers sold distressed euro area sovereign bonds during the European sovereign debt crisis, thus acting pro-cyclically, and their results are supported by earlier findings by Impavido and Tower (2009), Merrill et al. (2012), Bank of England (2014), Duijm and Bisschop (2015). It is particularly striking that the German and Dutch studies reach opposite conclusions, even though they use a similar time span and similar type of data. Timmer uses data from 2005 to 2014, while Bijlsma and Vermeulen cover 2006 to 2013, and both studies use data on security-by-security holdings in the respective countries.[2]

Our paper sheds new light on this discussion by arguing that it is the underlying driver of a price change (rather than just the direction) that matters. We first develop a theoretical model, in which we separate the effects of the risk-free rate and risk premia on ICPFs equity valuations.[3] Through their different effects on equity, the two factors also imply different investment behaviours in response to a price change. In particular, when prices fall due to increasing risk premia, our model predicts pro-cyclical investment behaviour as ICPFs attempt to restore their financial position. On the contrary, it suggests counter-cyclicality in response to price drops driven by a rising risk-free rate of return.

We also validate the predictions of our model empirically. In line with our theoretical model, we estimate a negative and significant effect of risk premia on euro area ICPF holdings of government bonds, while we find a positive and significant effect of the risk-free rate of return on those holdings. We confirm that the empirical results are robust to different model specifications and estimation approaches.

Specifically, we pay a 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 estimated coefficients for the risk-free rate and risk premia are biased due to the possible omission of variables that affects both the two explanatory variables of interest and ICPF holdings. To address this concern, we include a number of control variables such as very granular fixed effects and measures of market volatility, credit quality, and volumes of recent ECB's purchases of government bonds. Another concern is that our estimates could be biased due to reverse causality, i.e. a causality running from ICPF holdings to bond prices. To tackle this problem, we do not limit ourselves only to the use of lagged explanatory variables as other studies do (e.g. Duijm and Bisschop, 2015; Becker and Ivashina (2015); Timmer, 2016; Bijlsma and Vermeulen, 2016) but we also use the instrumental variable (IV) approach. In addition to the potential endogeneity problem, we conduct further robustness checks. We test, for instance, whether our results hinge on the choice of the proxy for the risk-free rate of return.

Compared to the results of Timmer (2016) and Bijlsma and Vermeulen (2015) that are country-specific, our results can also be considered more robust as they are based on new granular data from ECB's Securities Holdings Statistics (SHS) that cover all 19 euro area countries. Such a wide cross-country variation allows us to investigate differences in ICPFs investment behaviour across countries, e.g. by distinguishing between ICPFs behaviour in "core" and "periphery" countries. Similarly, we can focus on the distinction between domestic and cross-border holdings using a large sample of countries.

The remainder of the paper is organized as follows. Section 2 discusses the main characteristics of the euro area ICPF sector and develops the notion of a stylised euro area ICPF firm. 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] For an overview of the studies on ICPF investment behaviour, see Annex A.
[3] As a risk-free rate, we consider the risk-free interest rate term structures such as the one published monthly by EIOPA, which insurance companies under Solvency II are required to use to discount their liabilities (see Annex B).

2. The euro area ICPF sector

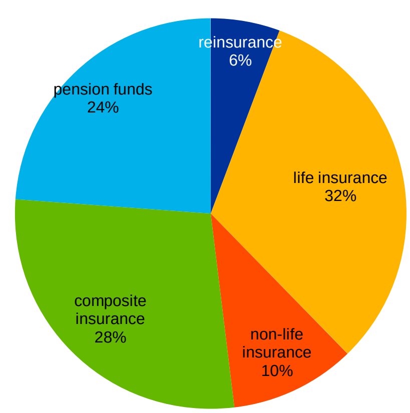
The investment behaviour of an ICPF firm is influenced by various factors. These include – but are not limited to – the type of firm and its business model, the structure of the balance sheet, the investment preferences of its management and stakeholders, market developments and the regulatory framework, under which an ICPF firm operates. A recent study by 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 the asset allocation behaviour of ICPFs.

Starting with the type of firm, the euro area ICPF sector comprises five broad categories: life and non-life insurers, composite insurers[4] and reinsurers, and pension funds. In terms of total assets, life insurers represent the largest category (32%), closely followed by composites (28%), whereas the size of non-life insurers (11%) and reinsurers (5%) is relatively limited. Pension funds account for the remaining quarter of the euro area ICPF assets and thus their size is around three times smaller than the size of insurance companies (Figure 2).[5]

The importance of life insurance business in the euro area is, however, much larger than these figures suggest. One reason is that the technical reserves of composite insurers are dominated by life insurance products (Figure 3). In addition to this, more than a 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 business.

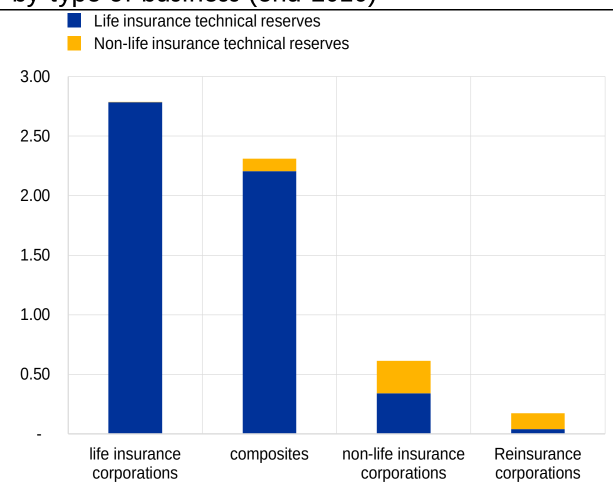
Moreover, the business model of a pension fund is similar to that of a life insurer because both offer saving products of a long-term horizon. This is particularly the case for the euro area, in which the dominant type of life insurance policy (non-unit linked products) is of the same nature as the dominant type of pension fund scheme (defined-benefit pensions). As both products provide a guaranteed rate of return to the policyholder, it is the ICPF firm (rather than the policyholder) who bears investment risk (see ECB, 2016, for more details).

Figure 2: Total assets of euro area ICPFs – by type of firm (end-2016)



Source: ECB (IC and PF balance sheet data) and authors' calculations.

Figure 3: Euro area insurance technical reserves – by type of business (end-2016)

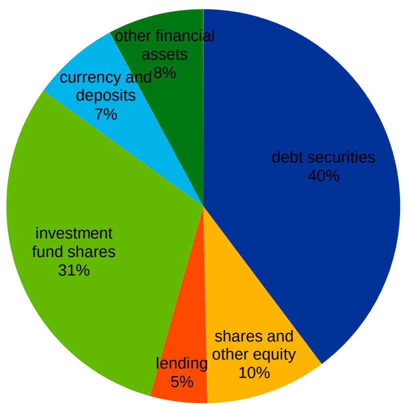


Source: ECB (IC balance sheet data) and authors' calculations.

[4] Composite insurers offer both life and non-life insurance products.
[5] Our analysis only focusses on occupational pension funds and excludes public pension funds.

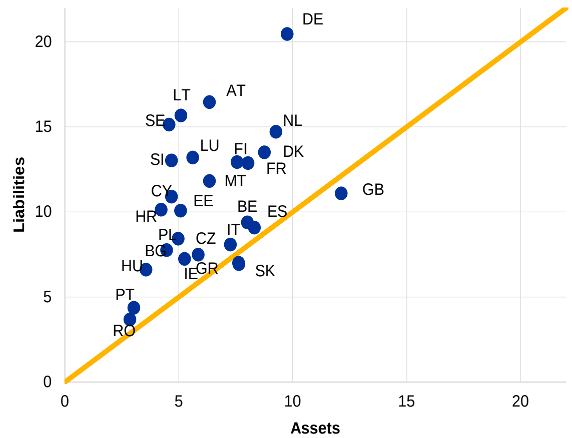
Regarding investment preferences, the portfolios of euro area ICPFs are dominated by fixed income assets (Figure 4). Specifically, holdings of government and corporate bonds accounted for around 40% of euro area ICPF financial assets at the end of 2016. Another important asset class is investment fund shares (30%), which also serve as an important channel for investment in fixed income instruments.[6] The remaining third of financial assets held by euro area ICPF consists of shares and other equity (10%), currency and deposits (7%), lending (5%) and other financial assets (8%).

Figure 4: The composition of ICPF financial assets in euro area countries in Q4 2016



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

Figure 5: Duration of assets and liabilities of euro area insurance companies in Q4 2014



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 the assets. According to EIOPA (2016), 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.[7] EIOPA (2014) also shows that the negative duration gap is characteristic for insurers in the majority of EU/EEA counties (Figure 5). Also occupational pension funds typically show a negative duration gap: for Dutch IORPs, which represent 57% of euro area pension funds (Figure 6), the average duration of liabilities is 17 years, while the corresponding duration of assets is only 7 years (see Annex C of ESRB, 2016).

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 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.

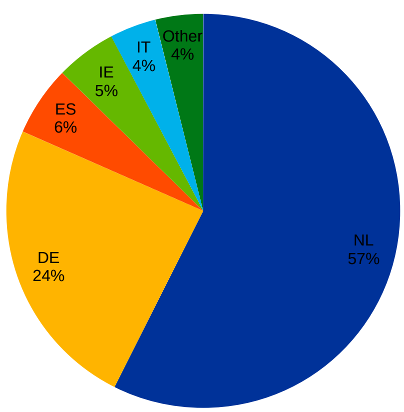
[6] According to the ECB's data on insurance corporations, bond fund shares and mixed fund shares are the two largest categories of investment fund shares held by euro area insurance corporations. Each category accounted for around a third of the ICs holdings in investment fund shares at the end of 2016. Similar data for euro area pension funds are not available to us.

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

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 of their balance sheet. Regarding investment rules, 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, such as principles related to proper risk identification and management. This is a significant difference compared to the simplistic and non-risk-sensitive requirements in 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.

In the case of pension funds, there are currently no harmonized prudential rules across EU countries. Nonetheless, euro area occupational pension funds are highly concentrated in a small number of euro area countries, with Dutch pension funds playing by far the most important role (Figure 6). Several features of the Dutch regulatory regime for pension funds resemble the Solvency II framework. In particular, the market-consistent regime and the prudent person principle for asset allocations apply (see Duijm and Steins Bisschop, 2015). Therefore, a significant part of the euro area pension funds sector can be considered as operating under a similar regulatory regime as Solvency II.

Figure 6: The distribution of pension funds' financial assets across euro area countries



Note: Financial assets of euro area pension funds amount to EUR 2.4 trillion.
Source: ECB (euro area accounts) and authors' calculations.

To sum up, although the euro area ICPF sector comprises different types of companies that operate under various regulatory regimes, we focus in this paper on a stylised euro area ICPF firm. The business model of such firm closely resembles that of a life insurer, its balance sheet has a negative duration gap and the firm is heavily invested in fixed-income assets. In addition, it operates under a market-consistent regulatory regime.

3. Theoretical framework

3.1 Equity Valuation of a stylised ICPF firm in the euro area

The bulk of liabilities of a stylised ICPF firm are technical provisions, i.e. obligations to policyholders (see ECB, 2016), whose value has to be discounted by a risk-free rate of return, under a market-consistent regime. In other words, the firm is required to value its liabilities as if its own default risk was zero and all obligations to policyholders are 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 ICPF firm 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 $\frac{1}{1+r} > 0$).[8]

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 regulatory regime requires 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 ICPF firm 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. We distinguish between the market value of safe assets (SA), whose risk premium is equal to zero, and the market value of risky assets (RA):

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

where $p > 0$ denotes the bond's risk premium. Without loss of generality, we assume the safe and risky assets have equal maturity D_A.
Since the value of firm's equity E can be expressed as a difference between the values of its assets and liabilities, it follows that:

$$E = A - L = \frac{B_{SA}}{(1+r)^{D_A}} + \frac{B_{RA}}{(1+r+p)^{D_A}} - \frac{B_L}{(1+r)^{D_L}} . \tag{3}$$

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 generalized to include all assets and liabilities on 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 an ICPF's asset portfolio, composed by a mix of assets with different risks (e.g. bonds with different levels of risk-premia).

Furthermore, our model aims at capturing only the basic mechanism of equity valuation under a market-consistent regulatory regime, while the regulatory regimes in place are usually much more complex. For instance, the Solvency II regulatory framework includes long-term guarantee (LTG) measures such as the 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 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

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

LTG measures). Therefore, we believe that our framework, despite being simple, can provide realistic insights about the dependencies between ICPFs' equity and the risk free rate and risk premia.

3.1.1 ICPFs sensitivity to risk-free rate changes

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

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

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

$$\left(LD_L - \left(SA + RA\frac{1+r}{1+r+p}\right)D_A\right) > 0 \quad <=> \quad \frac{D_L}{D_A} > \frac{SA+RA\frac{1+r}{1+r+p}}{L} \quad (5)$$

We further assume that this inequality is satisfied for our stylised ICPF firm. This assumption is plausible because a typical euro area ICPF firm has a negative duration gap (i.e., $D_L > D_A$) and operates with positive equity. Moreover, the negative duration gap (in its absolute value) is enough large 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%, while A/L equals to 110%. Therefore, it also holds that $\frac{D_L}{D_A} > \frac{A}{L} > \frac{SA+RA\frac{1+r}{1+r+p}}{L}$. Furthermore, considering that $\frac{1+r}{1+r+p} \leq 1$, it is plausible to assume that $\frac{\partial E}{\partial r} > 0$ for most euro area ICPF firms. This in turn means that the value of equity of the stylised ICPF firm increases with an increase in the risk-free rate.

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

It is worth-noting that this prediction is derived specifically for an ICPF firm and holds in the presence of a negative duration gap.[9] Therefore, it would not be verified for the majority of 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 in the structure and composition of ICPF liabilities, the prediction reflects only an immediate effect of changes in the risk-free rate on ICPF's equity valuation. In particular, in case of a large and persistent increase in the risk-free rate, an ICPF firm could face a significant risk of policy lapses, as policyholders could shift away from policies with low guaranteed rates underwritten by an ICPF firm 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 an ICPF firm. However, the size and nature of the overall effect is difficult to predict a-priori since ICPFs also aim at mitigating policy lapses through increased profit sharing (i.e. redistribution of a part of investment income to policyholders).

3.1.2 ICPFs sensitivity to risk premia changes

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

[9] 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.

$$\frac{\partial E}{\partial p} = -\frac{RA*D_{RA}}{1+r+p}. \quad (6)$$

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 ICPF equity decreases with an increase in risk premia (and vice-versa).

3.2 ICPFs response to changes in equity

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

In case of a negative shock to equity, ICPF firms have several ways how to restore their financial positions. In principle, they can act on all three parts of the balance sheet - equity, liabilities and assets. Regarding equity, ICPF firms can raise fresh capital in the market, but 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, but such process would improve capital levels only gradually (Cohen and Scatigna, 2016). With respect to liabilities, ICPF firms can lower them 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 ICPFs' liabilities are of a long duration, and new policies and profit sharing represent only a small fraction of all outstanding liabilities, significant reduction of liabilities is also not a viable option in the short-term.

Therefore, we can assume that one of the first reactions of an ICPF firm would be to act on the asset side. Recently, Das (2017) shows empirically that non-deposit taking institutions such as ICPF 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. Das (2017) focuses on purchases of risky assets such as real estate and loan portfolios, bank branches, equity investment portfolios and asset-backed securities. Moreover, the theoretical model of Van Binsbergen and Brandt (2016) developed for asset-liability management investors such as ICPF firms predicts that asset-liability management investors decrease the riskiness of their portfolio in response to a shock that reduces their assets-to-liabilities ratio (i.e. they would shift away from riskier assets to safer assets).[10] 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 contrary, 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.[11] Against this backdrop, we assume that **ICPFs 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)

[10] Douglas et al. (2017) has recently pointed out that the de-risking behaviour of UK insurers may be incentivized by the use of risk margins under Solvency II, which reduce the solvency position of the firm following a decrease in risk-free rate and encourage selling risky assets to reduce the probability of insolvency.

[11] An alternative way how ICPFs can 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.

and thus sell off assets after a negative shock to equity to restore their target leverage.[12] The deleveraging mechanism assumes that banks use the proceeds from asset sales to repay debt, thereby lowering their liabilities. This type of adjustment would however be rather limited for ICPF firms because they are much less leveraged than banks, having only limited amounts of debt on their liability side.[13] Therefore, our predictions relate to balance sheet "de-risking" rather than "deleveraging".

Since we assume that assets of a typical ICPF 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 are falling due to an increase in the risk-free rate of return (and vice-versa).

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

These two predictions imply that insurers' investment behaviour can be both pro-cyclical and counter-cyclical, depending on the underlying driver of price change. If the price change stems from change in risk premia, then insurers are expected to behave pro-cyclically. On the other hand, when the price change is due to a change in the risk free rate, then insurers are expected to behave counter-cyclically. This new theoretical insight helps to shed light on the mixed results in the existing literature that did not consider the distinction between the two types of interest rate shocks. We turn to test the predictions empirically in the following sections.

3.2.1 Examples of balance sheet rebalancing

Let us consider the behaviour of an ICPF firm that actively rebalances its balance sheet according to a target level of capital to risky assets ratio, to control the amount of risky assets to be funded by equity. The initial mark-to-market balance sheet at time t = 0 is shown in Table 1.1. Without loss of generality, we assume that the ICPF firm holds 100 worth of assets, equally spread between one risky and one safe security, and is funded 10% by equity[14]. The equity to risky assets ratio equals 20%, which is set to be the target level for the ICPF firm in this example. Therefore, 20% of the capital is to be used to fund the risky asset, which represents half of the ICPF firm' total assets in the baseline scenario. The initial values of risk-free interest rate, *r* and risk premia, *p* are both set to 0.02.

Table 1.1

Assets	Liabilities
RA, 50	L, 90
SA, 50	E, 10

Baseline scenario – initial balance sheet of an ICPF firm at time t = 0.

[12] 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. (2015) have recently used this evidence as an assumption to construct a systemic risk measure of fire-sale in the banking system.

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

[14] The nominal value of safe assets and liabilities is discounted by the risk-free interest rate only, while the nominal value of risky assets is discounted by both the risk-free interest rate and the risk premium, as described in Section 3.1.

Risk premium scenarios Assume that at time t = 1 the risk premia decreases to 0.01. Then, while the market values of safe assets and liabilities are not affected by changes in risk premia, the amount of risky assets and equity increases by 4. The value of total assets increases to 104 and the equity to risky assets ratio equals 26%, which means that the ICPF firm has a surplus of capital that can be used to buy more risky assets (see Table 1.2). To restore the target level of equity to risky assets ratio, the firm will buy risky assets and sell safe assets (see Table 1.3).

Table 1.2

Assets	Liabilities
RA, 54	L, 90
SA, 50	E, 14

Favourable risk premia scenario: balance sheet of an ICPF firm at time t = 1 when the risk premium decreases.

Table 1.3

Assets	Liabilities
RA, 69	L, 90
SA, 35	E, 14

Favourable risk premia scenario: rebalanced balance sheet of an ICPF firm at time t = 1 when the risk premium decreases.

On the contrary, if the risk premia increases to 0.03 at time t = 1, the values of risky assets and equity decrease by 4. The amount of total assets decreases to 96 and the equity to risky assets ratio equals 13%, which means that the ICPF firm suffers from a capital shortage (see Table 1.4). To restore the target level of equity to risky assets ratio, the firm will sell risky assets and buy safe assets, i.e. *derisking* the asset side of the balance sheet (see Table 1.5). Therefore, targeting the equity to risky assets ratio will lead ICPFs to sell assets whose risk premia increases (pro-cyclical behaviour), ceteris paribus.

Table 1.4

Assets	Liabilities
RA, 46	L, 90
SA, 50	E, 6

Adverse risk premia scenario: balance sheet of an ICPF firm at time t = 1 when the risk premium increases.

Table 1.5

Assets	Liabilities
RA, 31	L, 90
SA, 65	E, 6

Adverse risk premia scenario: rebalanced balance sheet of an ICPF firm at time t = 1 when the risk premium increases.

Risk-free rate scenarios Let us now consider an increase in risk-free interest rate by 0.01 at time t = 1. This time, the market value of safe and risky assets as well as liabilities is affected. The amount of total assets decreases to 93 and the equity to risky assets ratio increases to 30%, which means that the ICPF firm has a surplus of capital that can be used to buy more risky assets (see Table 1.6). To restore the target level of equity to risky assets ratio, the firm will buy risky assets and sell safe assets (see Table 1.7).

Table 1.6

Assets	Liabilities
RA, 46	L, 79
SA, 47	E, 14

Favourable risk-free rate scenario: balance sheet of an ICPF firm at time t = 1 when the risk-free rate increases.

Table 1.7

Assets	Liabilities
RA, 70	L, 79
SA, 23	E, 14

Favourable risk-free rate scenario: rebalanced balance sheet of an ICPF firm at time t = 1 when the risk-free rate increases.

On the other hand, if the risk-free interest rate decreases to 0.01 at time t = 1, the market values of assets and liabilities increase. The total assets equal 108 and the equity to risky assets ratio is 9%, which means that the ICPF firm suffers from a capital shortage (see Table 1.8). To restore the target level of equity to risky assets ratio, i.e. to limit the proportion of risky assets funded by capital, the firm will *derisk* its balance sheet, by selling risky assets and buying safe assets (see Table 1.9). Therefore, targeting the equity to risky assets ratio will lead ICPFs to sell securities, when their price is falling in response to an increase in risk-free rate and vice-versa (counter-cyclical behaviour), ceteris paribus.

Table 1.8

Assets	Liabilities
RA, 54	L, 104
SA, 54	E, 5

Adverse risk premia scenario: balance sheet of an ICPF firm at time t = 1 when the risk-free rate decreases.

Table 1.9

Assets	Liabilities
RA, 23	L, 104
SA, 85	E, 5

Adverse risk premia scenario: rebalanced balance sheet of an ICPF firm at time t = 1 when the risk-free rate decreases.

The pro- or counter-cyclical response of ICPF firms to changes in risk-free rate and risk premia can be weaker or stronger than the one described above, when the two variables are changing at the same time. For example, if the risk free rate increases to 0.03 and the risk premium decreases to 0.01 at time t = 1, the equity of the ICPF firm will increase by 8. Due to the large capital surplus, the firm will be able to buy 76% more risky assets (sell 83% of its safe assets) and restore the target level of equity to risky assets ratio of 20%. Here, however, we quantify the individual effects of risk-free rate and risk premia on ICPFs holdings ceteris paribus, without considering the potential dependence between them (e.g. changes in risk-free rate could in fact influence securities' risk premia).

4. Empirical model and data

4.1. Model set-up

We consider the following model specification to explain the level of a security holding by ICPF sectors in the individual euro area countries:

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

where $\log(holdings_{i,j,t})$ denotes the natural logarithm of the amount of security *i* held by ICPFs in country *j* at quarter *t* and $\epsilon_{i,j,t}$ is the error term.

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*. In line with our theoretical predictions, we expect the estimate of α to be positive, indicating a counter-cyclical behaviour of ICPFs in response to rises in the risk-free rate of interest. On the other hand, we expect to obtain a negative estimate for β in order to confirm the prediction of pro-cyclical 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 ICPFs are important institutional investors in the (sovereign) bond market and thus a shift in their holdings of security *j* 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-holder country fixed effects ($\gamma_{i,j}$), year fixed effects (y_t) and further time-varying factors (presented formally by vector $Z_{j,t}$) that potentially affect both ICPF holdings and price of a security. The effect of these control variables is discussed in Section 5. Finally, to correct for the possibility that error terms are correlated across individual securities and holder countries, we also use clustered standard errors, where the clusters correspond to the security-holder country fixed effects.

We describe the dependent variable and the two explanatory variables in more detail below. In addition, an overview of all variables and their respective data sources are provided in Annex B.

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[15] and those collected prior to 2014 under Securities Holdings Experimental Statistics (SHES).[16] 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 ICPF sector in 19 euro area countries. To be more precise, we have data on holdings of each individual security but such information is not accessible on the level of an individual ICPF firm. Rather, it is available as an aggregate for the whole ICPF sector in a given euro area country. The data are available in both market and nominal values but we use only nominal values. The reason is that a change in the market value of holdings may reflect a price change rather than a buy/sell decision.

In our empirical analysis, we focus on holdings of government bonds. One reason is that the euro area ICPF sector is one of the most important investor sectors in this type of securities. Specifically, euro area ICPFs hold around 24% of debt securities issued by euro area sovereigns, either directly (21%) or through investment funds shares (3%) (Figure 7). Considering only government bonds of long-term maturity, the importance of ICPFs holdings raises to nearly 50%, even when holdings through investment funds are excluded (see Figure 1 in Section 1). Hence, the euro area ICFP sector is of key importance for long-term financing of sovereigns.

Figure 7: Euro area holdings of euro area debt securities, broken down by holder sector, 2016 Q3 (as % of total securities holdings)

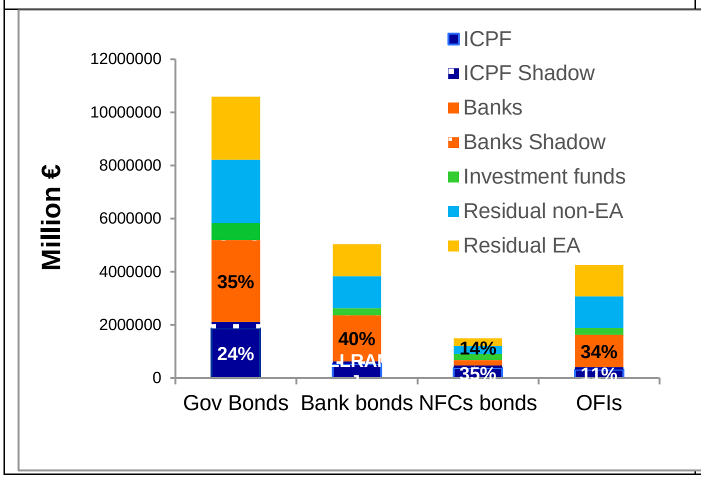
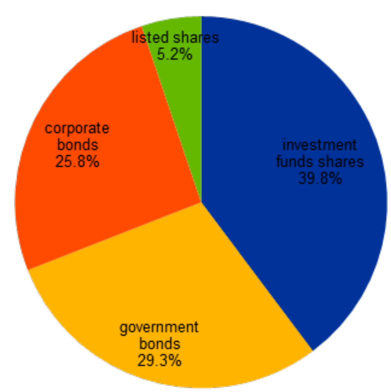


Figure 8: Euro area ICPF's securities holdings, broken down by main asset class, 2016 Q2



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

[16] 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 started, and are thus subject to some quality limitations (e.g. lower coverage in some countries).

Notes: ICPF Shadow and Banks Shadow are the estimated indirect exposures of ICPFs and banks, respectively, through their holdings of investment funds shares. Source: ECB Euro Area Accounts and authors' calculations.	Source: ECB (SHS data).

At the same time, government bonds are one of the most important asset classes in ICPFs portfolios, accounting for nearly 30% of ICPFs securities portfolios (Figure 8). The holding amounts are also significant in absolute terms: at the end of 2016, the euro area ICPF sector held around 1.9 EUR bn government bonds. In addition, ICPFs hold roughly 40% of their securities portfolios in shares of investment funds, which in turn invest more than 40% of their holdings in European government bonds (see Exhibit 56 in EFAMA, 2015). In fact, there are various reasons why ICPFs hold such large amounts of government bonds in their portfolios. First of all, ICPFs 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. Government bonds also often benefit from a preferential treatment under certain regulatory frameworks. For instance, under Solvency II, euro area (EAA) government bonds are exempted from the calculation of solvency capital requirements and from the large exposure regime in the standard formula, though insurance firms using internal models should - at least in principle - account for the riskiness of their exposures to government bonds (ESRB, 2015b).

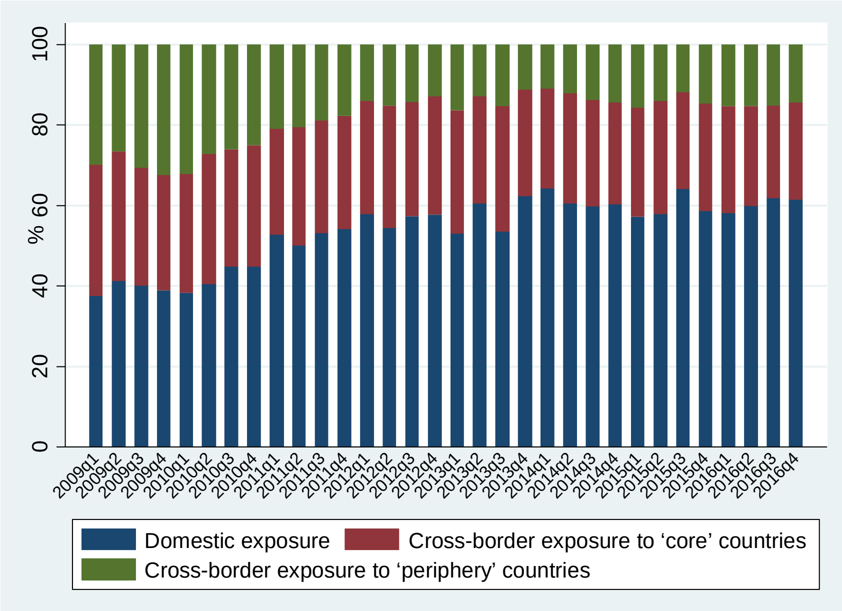
Furthermore, Bijlsma and Vermeulen (2015), which investigate Dutch ICPFs' portfolio shifts within different asset classes, detect the largest changes in asset allocation to take place within the portfolio of government bonds. Moreover, the euro area sovereign debt crisis has also undermined the notion of government bonds as "safe" assets and pointed out that exposures to sovereigns may represent an important element in determining market risk in ICPF and bank portfolios. Therefore, government bonds seem to be a good candidate to investigate the nature of changes in holdings and to test our predictions, at least when considering the period from 2009 to 2016, as we do.

Finally, from a practical point of view, focusing on government bonds helps us limit the scope of our paper and overcome certain data limitations. In particular, the information on the characteristics of individual bonds such as prices and credit ratings, which we take from Centralised Securities Database (CSDB), is more complete for government bonds than for other types of securities. In the same vein, SHS holdings of government bonds tend to be of relatively good quality and coverage, including for SHES data collected prior to 2014.[17]

Starting with descriptive evidence, Figure 9 reveals two significant changes in euro area ICPFs' asset allocations. On the one hand, euro area ICPFs significantly increased domestic holdings of government debt between 2010 and mid-2012, while on the other hand they decreased cross-border exposure to government debt issued by 'periphery' euro area countries. At the same time, ICPFs' cross-border exposure to government debt issued by 'core' euro area countries remained broadly unchanged. This suggests - in line with the findings in Bijlsma and Vermeulen (2016) - that euro area ICPFs' asset allocations were strongly affected by the European sovereign debt crisis, during which the credit quality of bonds issued by 'periphery' euro area countries significantly deteriorated. Hence, in line with our predictions, credit risk (being a part of risk-premia) appears to be a good candidate for one of the pro-cyclical drivers of ICPFs' investment behaviour.

[17] In general, we carefully check the granular data used and clean them from outliers as well as do some further adjustments to address certain quality limitations.

Figure 9: Euro area ICPF's 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. Periphery countries include CY, ES, GR, IT, PT, SI and core countries include the remaining euro area countries.
Source: ECB (SHS data) and authors' calculations.

4.3. Explanatory variables of interest

As a proxy for the risk-free rate r, we use the risk-free interest rate term structures, published every month by EIOPA. This yield curve is used by European insurers for the calculation of the value of technical provisions for insurance obligations, according to Solvency II.[18] Given that the securities in our sample have different maturities, we assign to each security that value of the risk-free yield curve that corresponds to the maturity of a given security. 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*.

Alternatives proxies for the risk-free rate, previously used in the literature are the yield curve of 10-year government bonds issued by Germany, the yield curve of 10-year government bonds issued by euro area countries whose credit rating is triple A, or the overnight index swap yield curve. We believe that our proxy fits best the scope of the paper as we are specifically studying the investment behaviour of the ICPF sector.

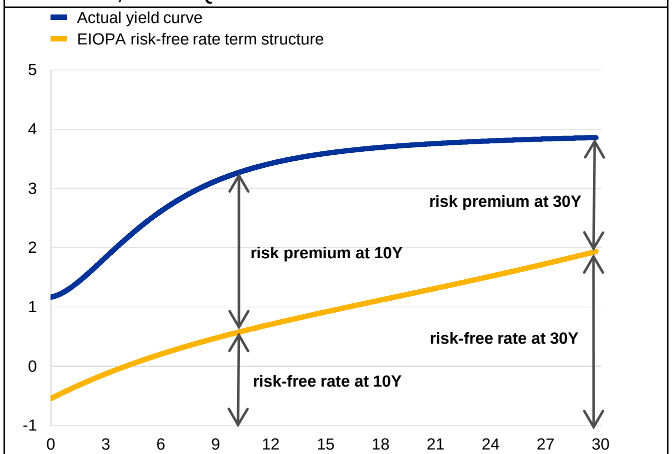
Regarding the calculation of risk premia *p,* we first obtain the yield-to-maturity $YTM_{i,m,t}$ from the ECB's Centralised Securities Database (CSDB). The yield-to-maturity is assigned to each security *i* with residual maturity *m* at time *t*. We construct then risk premia *p* as the difference between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

[18] 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 are available at https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii-technical-information/risk-free-interest-rate-term-structures.

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

Figure 10 shows the risk-free rate curve in the last quarter of 2016 and a hypothetical yield curve for sovereign bonds in the same quarter. 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 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 inflation and economic growth differentials reflect differences in macro-economic fundamentals across countries.

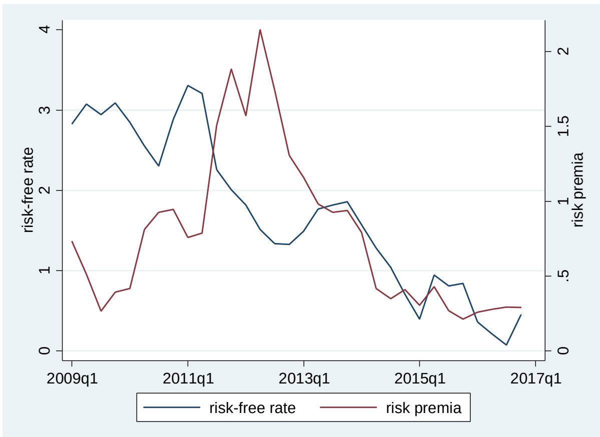
Figure 10: EIOPA risk-free rate term structure and actual yield curve used to construct the risk premia variable, 2016 Q4



Source: EIOPA and authors' calculations.

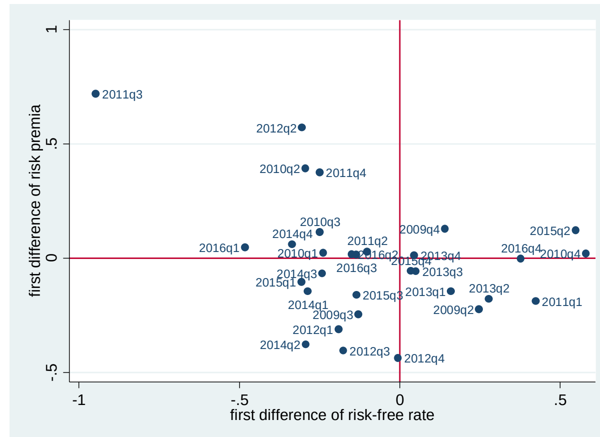
Figure 11 shows the evolution of the average risk-free rate and risk premia over the time period we cover (weighted by ICPF holdings in our sample). Since the financial crisis in 2007-2008, risk-free yield has declined and, recently, reached historically low levels. The evolution of the sovereign risk-premia 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 was much higher than expected. This event led to a reassessment of the sovereign risk by investors and triggered the start of the European sovereign debt crisis. Afterwards, yield spreads across countries were mostly related to differences in their fiscal fundamentals, competitiveness and 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 program (OMT), which generated a decline in all euro area sovereign risk premia. Supported by further monetary policy accommodation and better macro-economic prospects, the average risk-premia in our sample decreased to pre-crisis levels at the end of 2016.

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 holdings)



Source: ECB SHS data and authors' calculations.

We plot the first differences of the average risk-free rate and risk premia in Figure 12 to check if (and 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, our sample however covers all four combinations of changes: increase and decrease in both risk-premia and risk-free rate as well as their movements in opposite directions.

5. EMPIRICAL RESULTS

5.1 Baseline Model

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

Our initial empirical specification also includes ICPF holdings lagged by one quarter, i.e. the autoregressive component of the dependent variable. This variable reflects the long-term investment horizon, typical of ICPFs, which hold a security until maturity. With respect to its potential effect on price changes, it could be expected that the higher the ICPF holdings of a security (in period t-1), the higher the demand for it and thus the higher the price (in period t-1). The significant coefficient of the autoregressive term confirms that there is a positive relationship between the two consecutive amounts of a security holding.[19]

[19] While positive and highly significant, the coefficient does not indicate the presence of a unit root in our model. This indicates that the choice of our dependent variable – which captures the *level* of holdings rather than the *difference* in holdings – is reasonable.

Furthermore, the specification includes security-holder country fixed effects that control for any time-invariant characteristics of a security held by the ICPF sector in a specific holder country. Hence, these fixed effects reflect holder country's preference to hold a security. More specifically, they control for any time-invariant characteristics of a security (e.g. security type, original maturity, coupon payments frequency, face value) including issuer-specific characteristics (e.g. issuer country, issuer sector). They also capture any time-invariant characteristics of a holder country such as the structure and size of the ICPF sector (averaged over the time-span covered). Finally, they also account for any security-holder country specific characteristics including the initial level of holdings of each security by the ICPF sector in a given country.

To partially account for time-varying factors in our model, our initial specification also includes year fixed effects, which capture long-term structural changes in ICPF holdings such as a changing ICPF appetite to hold a security in view of other products on the market or the increasing size of the euro area ICPF sector. Although our data are of quarterly frequency, we opt only for year fixed effects in this initial specification for the reasons discussed later in this section (see point D related to the discussion of the results in Table 7).

While these results 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 rate and risk premia. The use of the fixed effects in our model already partially addresses this problem as they capture any unobserved holder country-security specific factors and long-term structural changes in euro area ICPF holdings. However, these fixed-effects do not fully capture all time-varying co-determinants of both the ICPF investment behaviour and price/interest rate movements and, therefore, we turn to the inclusion of a number of time-varying variables. Most of these explanatory variables are lagged by one quarter to specifically address the possibility that they are not only determinants of ICPF asset holdings but also determinants of the lagged explanatory variables of interest.[20]

Column 2 includes the logarithm of the residual maturity of government bonds and the estimated coefficient is positive. This result is in line with our expectations because ICPF typically prefer to hold long-term securities in order to limit the duration mismatch between their assets and liabilities.

In columns 3 and 4, we focus on the role of credit-worthiness of an issuer as we expect that a deteriorating credit-worthiness could trigger both asset sales and a price drop. We use two different measures. In column 3, 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).[21] 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 0.07 suggests that ICPFs decrease their bond holdings by around 7% after a (significant) rating downgrade. While a deteriorating credit quality *per se* can be a reason for a bond's sell off, some ICPF firms also face regulatory limits linked to ratings and/or use ratings to define their internal investment strategies,

[20] 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.

[21] For more details regarding the construction of the four ECAI steps, see Annex B.

which may contribute to the relatively large estimate of this effect.[22] As a complementary measure of credit-worthiness, we use the country's debt to GDP ratio. The negative and significant coefficient indicates that ICPFs lower their holdings of securities, when those are issued by sovereigns whose debt-to-GDP ratio increased. As higher debt levels may signal unsustainability of public finances and a fundamental credit risk, this is a plausible finding.

In column 5, 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 started only in March 2015 and thus influences only the last two years of our data, the PSPP is a potentially important confounding factor in our model. On the one hand, PSPP can significantly influence the level of ICPF holdings, as some of the securities may be directly purchased from ICPFs.[23] 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. The exact PSPP volumes on the level of an individual security are not available to us and, therefore, we use the publicly available aggregates of PSPP volumes on the level of individual euro area countries. Since PSPP is only limited to the universe of securities eligible for Eurosystem operations, we associate (the log of) PSPP volumes only with ICPF holdings of securities from this universe, while we assign zero PSPP volumes to the ICPF holdings of remaining securities. In the same token, we assign zero PSPP volumes to all ICPF holdings prior to the start of the purchase program.[24] As expected, the estimated coefficient is negative and significant, indicating a lower level of ICPF holdings for higher PSPP volumes.[25]

Finally, in column 6, we further control for the possibility that market volatility could influence both price movements and ICPF investment behaviour. As a proxy for market volatility, we use the *log of VSTOXX* lagged by one quarter. VSTOXX captures the implied volatility for EURO STOXX 50 stock options, which varies over time but not by security. The variable is, however, not found significant at any of the conventional significance levels (1, 5 or 10%).

The estimated coefficients of our explanatory variables increase and remain significant after the inclusion of all these variables. These results provide a further empirical support of our model.

[22] Recently, Becker and Ivashina (2015) observed a search for yield behavior 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.

[23] 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 program targets a fixed amount of monthly purchases (EUR 60 billion in the first year and EUR 80 billion in the second year of the program) and, therefore, they also affect the level of ICPF holdings in the subsequent quarter. As an alternative, we also experimented with an inclusion of contemporary PSPP volumes in the model but our estimates remained broadly unchanged.

[24] PSPP is not the first ECB's purchasing program of securities issued by euro area sovereigns. From May 2010 to September 2012, the Eurosystem also enacted the Securities Market Purchase (SMP) program. 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 recognized 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.

[25] An alternative approach to control for PSPP purchases is to shorten the sample by excluding the quarters since the start of the purchase program. The estimated coefficients of our explanatory variables of interest, however, remain by and large unchanged.

5.1.2 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 ICPF holdings (dependent variable). In particular, ICPF purchases of bonds could increase the overall demand for sovereign bonds in the market, which could suppress yields. For instance, if a large sell-off by ICPFs of a particular bond increased its risk-premia, the coefficients obtained by OLS estimations in Table 3 would be biased downwards (considering 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 ICPF holdings and yields are auto-correlated, this may not fully address our concern. Therefore, we aim at tackling this problem using instrumental variables and report the results in Table 3. For a better comparability of the coefficients, we include in column 1 of Table 3 the results of our last regression presented in Table 2.

In column 2 of Table 3, we start with addressing the reverse causality of the (lagged) risk-free rate of return. We instrument the risk-free rate (at all maturities) with the US risk-free interest rate curve (at the corresponding maturity). The results of the first stage regression confirm that this variable is highly correlated with the risk-free rate at all maturities (i.e. of the full risk-free term structure). At the same time, the US risk-free curve is likely to be exogenous to euro area ICPF holdings of government bonds because it is a result of 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 institutions would be only a fraction of the overall information feeding into such decision-making process. Therefore, the reverse causality problem is minimized 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 rate of return 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 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 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 ICPF holdings of government bonds issued by a country would significantly influence inflation in that country. While overall capital flows may do so, especially for small open economies, ICPF holdings of government bonds are only a small part of the overall capital flows and other type of flows such as foreign direct investment (FDI) 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).[26] The estimated coefficient for the risk-premia remains negative and significant, which further confirms our initial results.

Finally, we use the two instruments jointly in the last column of Table 3 to instrument for both the risk premia and the risk-free rate. Also in this specification, the estimated coefficients of both variables of interest remain significant and with the expected signs.

Overall, the results of the IV estimations confirm the significant and positive (negative) effect of the risk-free rate (risk premia) on ICPF holdings. These results are also robust to the selection of the IV method used. In particular, the estimates obtained by the two-stage least square (2SLS), which are reported in Table 3, are very similar to those obtained by the General Method of Moments (GMM) estimator.

5.1.3 Model implications for ICPF investment behaviour

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

Even when considering the conservative estimates obtained in column 6 of Table 2, the estimated effects of 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 ICPFs would increase their nominal holdings by 2.5% in the following quarter *ceteris paribus*. Given that the holdings of government bonds by euro area ICPFs at the end of 2016 totalled around EUR 1.9 trillion, an increase by 2.5% would translate into purchases of around EUR 47 billion. On the other hand, we estimate that if the risk premia increased by the same amount, ICPFs would decrease their nominal holdings by 1.3% *ceteris paribus*, i.e. by around EUR 25 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 ICPF holdings depends on the relative size of the change in the risk-free rate as compared with the change in risk premia. Especially in crisis periods, the changes in risk-premia can exceed those in the risk-free rate and if the excess is sufficiently large, our model implies that the risk-premia effect becomes the main driver of the overall interest rate effect on holdings. As a result, the ICPF investment behaviour in our model turns pro-cyclical under such a scenario. On the other hand, in calm periods, when the changes in risk premia are relatively muted, our model predicts counter-cyclical behaviour because the risk-free rate effect dominates.

Figures 13 and 14 show those periods for which our model predicts pro- and counter-cyclical ICPF behaviour when using changes in the *average* risk-free rate and risk-premia as examples.[27] The results suggests that ICPF investment behaviour tends to be counter-cyclical during calm periods, while turning pro-cyclical in crisis periods with high risk-premia volatility such during the euro area sovereign debt crisis. The results in Figures 13 and 14 however serve only illustrative purposes to the extent that individual bonds have 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 quarter of 2011, while that of a ten-year German government bond declined by around 9bps (at the same time, the risk-free rate decreased by around 25bps). Hence, although ICPFs investment behaviour implied by our model was pro-cyclical with respect to Italian government bonds in that period, it remained counter-cyclical with respect to German government bonds.

Figure 13: ICPF pro-/counter-cyclicality over time (as estimated by our model for the average risk-free rate and risk premia)

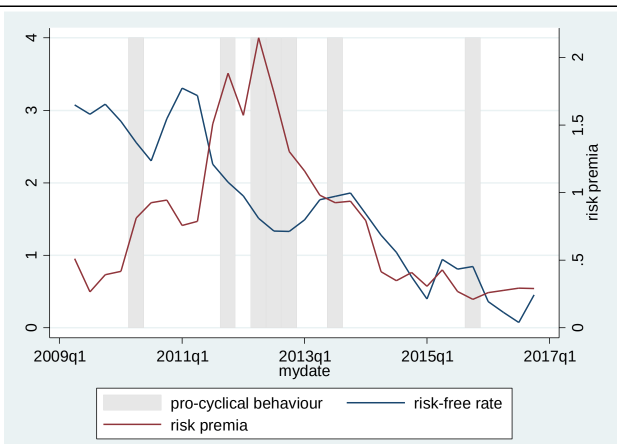
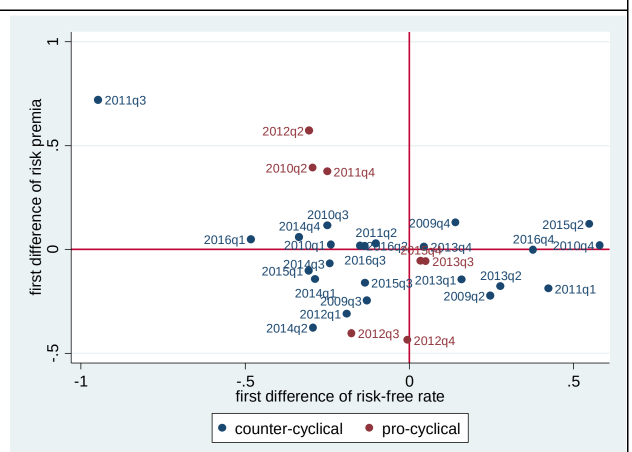


Figure 14: ICPF pro-/counter-cyclicality in a scatter plot (as estimated by our model for the average risk-free rate and risk premia)



[27] In more detail, when using the estimated coefficients in column 7 of Table 1, the ICPF investment behavior is estimated to be countercyclical, if sign(-0.012*change in risk premia + 0.022*change in risk free rate) = sign(change in risk premia + change in risk-free rate).

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

A. Do ICPF firms treat domestic sovereign bonds differently?

More than half of the ICPF holding amounts (51%) are domestic, i.e., ICPFs hold a large chunk of government bonds issued by their own country. In column 2 and 3 of Table 4, we study the effects of risk-free rate and risk premia on non-domestic and domestic holdings separately and compare them to our baseline estimates. The results show that non-domestic exposures are more sensitive to changes in debt-to-GDP ratio, PSPP volume and market volatility than the aggregate holdings in the baseline regression. However, the significance and signs of the variables of interest do not change and thus the results confirm our theoretical predictions.

Instead, the results for domestic holdings show a different picture. We estimate that ICPFs domestic holdings are not significantly affected by changes in risk premia, while ICPFs react counter-cyclically to changes in debt-to-GDP ratio and risk-free rate. This means that if the credit quality of a domestic sovereign deteriorates, the ICPF sector in that country will buy its bonds (i.e. an opposite result than in case of non-domestic holdings). Comparing columns 4 and 5 of Table 4, we find that this type of behaviour is mainly driven by ICPFs of periphery euro area countries.

These empirical findings indicate that there are different incentives for ICPF 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 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 hedge of assets and liabilities (Coeurdacier and Rey 2013, Choi et al., 2017).

The results for the risk-free rate and risk premia based on domestic exposures seemingly contradict our theoretical predictions. However, this is not necessarily the case, provided that ICPFs 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 opposite than those for risky assets, i.e. ICPFs are expected to react counter-cyclically to a change in (average market) risk-premia and pro-cyclically to a change in risk-free rate.

B. What is the effect of Solvency II?

Since 2016, euro area insurers operate under the Solvency II regime, which requires them to provide a market-consistent view on their balance sheet and in particular mark-to-market valuation of assets. For some countries, the introduction of this new regulatory regime represented a notable change compared to the non-risk-sensitive requirements in Solvency I. For this reason, the introduction of the Solvency II Directive includes transitional measures, which allow firms to use Solvency I valuation rules for a part of their balance sheet and move to the full implementation of Solvency II over a long period of time (of up to 16 years). Within the euro area, countries that benefit from exceptionally large transitional measures are Germany, Spain, Greece, Finland and Portugal (see Figure 26 of EIOPA, 2016). Due to the different valuation method applied to a part of their balance sheet, we would expect the insurance companies from these countries to hold a portfolio that is less sensitive to market changes.

To test this hypothesis, we split the sample in columns 2 and 3 of Table 5 based on whether or not ICPFs in that country benefit from exceptionally large transitional measures. We study the effects of risk-free rate and risk premia on their holdings separately and compare them to our baseline estimates in column 1. Given the previous findings about ICPFs behaviour with respect to domestic sovereign debt holdings, we limit our analysis in Table 5 to non-domestic holdings only.

The results confirm our predictions and show that ICPFs that do not fully comply to the mark-to-market valuation are on average less sensitive to changes in risk-free rate and risk premia. Furthermore, they react less to changes in the credit quality of a sovereign and to market volatility. This behaviour is confirmed if we use slightly different specifications estimated on a full sample of holder countries, where we include interactions between the variables of interest and a 'transitional dummy', which equals to 1 if a holder country belongs to countries having exceptionally large transitional measures and 0 otherwise (see Columns 4-6 of Table 5).

C. 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 using a single yield curve published by EIOPA. However, this was not the case under Solvency I. In addition, pension funds are also not subject to Solvency II rules and thus may use different discount curves, depending on their national regulatory framework. 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 6. As a starting point, we use the baseline estimates from column 6 of Table 2, which provide one of the most conservative estimates for coefficients of both the risk-free rate and the risk premia. In Columns 2 and 3 of Table 6, 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 different choices of risk-free rate proxy.

D. Are our results driven by the empirical specification?

To assess the robustness of our results to changes in the empirical specification, we include different fixed effects. Columns 1-4 of Table 7 show the results obtained with (i) security-holder country FE, which denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country; (ii) security FE, which denote fixed effects that are specific for each security; (iii) issuer country FE, which denote fixed effects that are specific for each individual sovereign issuer; (iv) year and quarter FE, which capture any variation in holdings that happen over years and quarters, respectively.[28] Our predictions are verified in all these empirical specifications.

Furthermore, we estimate the overall effect of an interest rate shock on ICPFs holdings by means of the yield-to-maturity variable. By doing this, we follow the spirit of previous studies (e.g. Timmer, 2016; 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 7, Column 5), which suggests that euro area ICPFs 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 ICPF sector reacts pro-cyclically to interest rate changes.

[28] We do not include quarter FE in the baseline/initial regressions because they fully account for any parallel shifts in the risk-free curve from quarter to quarter. Therefore, they are highly correlated with the risk-free rate of return, which is our variable of interest.

Finally, we test our results with different specifications of the dependent variable by using the difference in log holdings (Column 6) and the Buy/sell indicator (Column 7). The latter equals 1 if the first difference of holdings is greater than 0 (ICPFs buy a security), it is -1 if the first difference is negative (ICPFs sell a security), and 0 otherwise. In both cases, the empirical results confirm our theoretical predictions.

E. Are our results driven by sample bias?

Our time series includes the European sovereign debt crisis and the following Outright Monetary Transactions program of the ECB. Under this program, the ECB purchases sovereign bonds of euro area member states in the secondary market, under certain conditions. For this reason, we test the behaviour of ICPFs and the robustness of our results in the two sub-samples, before and after the OMT announcement in July 2012 (see Columns 2 and 3 of Table 8). The estimates of our variables of interest show a slightly lower sensitivity to changes in risk-free rate and risk premia before the OMT announcement, but signs and significance do not vary. Similarly, in Column 5 of Table 8, we test whether our results are driven by the Public Sector Purchase Programme of the ECB and we find no significant changes in the estimates of our variables of interest.

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 4 of Table 8, 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 ICPFs holdings to changes in risk premia largely decreases, as expected, but signs and significance do not vary.

In Column 6 of Table 8 we exclude the so called “Experimental SHS” data, as holdings were collected on a voluntary and best-efforts basis from 2009 to 2013 and are thus subject to some quality limitations. Similarly, in Columns 7 and 8 of Table 8, we split our sample before and after 2016 Q1, as the quality of SHS data on holdings of ICPFs improved in 2016, owing to the new requirement of direct reporting by insurance corporations. The estimates of our variables of interest are very similar to the coefficients in the full sample and the relationship between ICPFs holdings and explanatory variables seems to be stronger when using higher quality data (see column 8).

Finally, our sample includes the exposures to all securities hold by euro area ICPFs. Since the structure of the sovereign bond market may have changed over time, it could be the case that our results are driven by the investment in newly issued bonds and/or by redemptions of bonds at maturity. For this reason, we test the robustness of our estimates by including in the sample only the holdings of securities that were already issued before 2009 Q1 and that were not yet expired in 2016 Q4. We report the results in column 9 of Table 8. The coefficients of our variables of interest are very similar to the baseline estimates, and the relationship between the level of holdings and the explanatory variables seems to be even stronger, when excluding newly issued bonds and bonds close to maturity.

6. CONCLUSIONS

ICPF firms are important institutional investors with a long-term investment horizon, which limits pressures and incentives to adjust to short-term market volatility. From this point of view, ICPFs have the potential to play a stabilising role in the financial system and the findings of several empirical studies support this line of reasoning. Other papers, however, challenge this view by providing empirical evidence of pro-cyclical investment behavior of ICPFs, especially in periods of severe market distress.

This paper is the first to shed new light on the underlying reason for these opposite views. Our theoretical model predicts pro-cyclicality of ICPF investment behavior when prices fall due to increasing risk-premia and counter-cyclicality when prices drop due to rises in risk-free rate of return.

Using security-by-security data on government bond holdings of euro area ICPFs 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 risk-free rate of return on ICPF holdings, while the effect of risk-premia is found to be negative and significant.

The estimated effects are not only statistically but also economically important. Specifically, the results suggest that, *ceteris paribus*, a rise in the risk-free rate by 100 basis points would increase euro area ICPF holdings by around 2.5% (i.e. by around 47 billion), while the same increase in the risk premia is estimated to reduce ICPF holdings by around 1.3% (i.e. by around EUR 25 billion). Since these predictions are based on rather conservative estimates, selected from a range of model specifications, they can be considered as lower bound estimates. In particular, the estimate of the effect of risk premia is obtained, when controlling for the (significant) role of country's fiscal fundamentals and credit rating. However, if risk premia were to rise on the back of concerns about the sustainability of public finances, then fiscal fundamentals and credit ratings would also deteriorate and the corresponding bond sell-off predicted by our empirical model would in fact be much larger. By the same token, although we interpret the estimates of the effects of risk premia and risk free rate *ceteris paribus*, it is not realistic to assume that the two factors would move independently.

Our findings have significant policy implications. To the extent that pro-cyclical ICPF investment behaviour has the potential to amplify asset price volatility and to decrease the resilience of the financial system, it is important that policy makers pay a due attention to this type of behaviour. In this respect, our results contribute to the current policy discussion on macro-prudential measures beyond banking by underlining the need for such measures. Moreover, our theoretical framework and empirical results suggest that those measures are especially relevant for ICPFs that operate under a market-consistent regulatory regime such as Solvency II. While Solvency II already includes measures of macro-prudential nature such as volatility and matching adjustments that were designed to mitigate the impact of widening credit spreads on insurers' balance sheets, their effectiveness under adverse market and economic shocks is yet to be tested in practice. It is also too early for our study to empirically assess insurers' investment behaviour under this new regime as it entered into force only in 2016.

Table 2: Baseline model and omitted variable bias

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable			Log Holdings			
Risk premia *(lag)*	-0.011***	-0.012***	-0.011***	-0.012***	-0.013***	-0.013***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Risk-free rate *(lag)*	0.014***	0.015***	0.020***	0.025***	0.024***	0.025***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log Holdings *(lag)*	0.67***	0.67***	0.70***	0.69***	0.69***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log Residual maturity		0.085***	0.090***	0.091***	0.090***	0.090***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ECAI downgrade *(lag)*			-0.072***	-0.090***	-0.091***	-0.090***
			(0.00)	(0.00)	(0.00)	(0.00)
Debt/GDP *(lag)*				-0.0020***	-0.0020***	-0.0020***
				(0.00)	(0.00)	(0.00)
Log PSPP volume *(lag)*					-0.0028***	-0.0026***
					(0.00)	(0.00)
Log VSTOXX *(lag)*						-0.016
						(0.22)
Security-holder country FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	229,602	229,602	205,832	172,009	172,009	172,009
R-squared	0.960	0.960	0.964	0.965	0.965	0.965

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. 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 a 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. Log VSTOXX is the log of the implied volatility for EURO STOXX 50 stock options. Security-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Reverse Causality

	(1)	(2)	(3)	(4)
Second stage Dependent Variable	Log Holdings			
Risk premia *(lag)*	-0.013***	-0.012***	-0.045***	-0.046***
	(0.00)	(0.00)	(0.00)	(0.00)
Risk-free rate *(lag)*	0.025***	0.030***	0.019***	0.018***
	(0.00)	(0.00)	(0.00)	(0.01)
Log Holdings *(lag)*	0.69***	0.69***	0.69***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)
ECAI downgrade *(lag)*	-0.090***	-0.091***	-0.045***	-0.045***
	(0.00)	(0.00)	(0.01)	(0.01)
Debt/GDP *(lag)*	-0.0020***	-0.0020***	-0.0015***	-0.0015***
	(0.00)	(0.00)	(0.00)	(0.00)
Log PSPP Volume *(lag)*	-0.0026***	-0.0026***	-0.0044***	-0.0044***
	(0.00)	(0.00)	(0.00)	(0.00)
Log Residual maturity	0.090***	0.091***	0.094***	0.094***
	(0.00)	(0.00)	(0.00)	(0.00)
Log VSTOXX *(lag)*	-0.016	-0.018	0.0069	0.0073
	(0.22)	(0.16)	(0.63)	(0.61)
First stage				
Instrument for risk-free rate				
US risk-free interest rate *(lag)*		0.692***		0.705***
		(0.00)		(0.00)
Instrument for risk premia				
Issuer country inflation rate *(lag 2)*			0.232***	0.220***
			(0.00)	(0.00)
Security – holder country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	172,009	169,513	169,374	169,374
R-squared	0.965	0.963	0.963	0.963

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 nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. 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 a 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. Log VSTOXX is the log of the implied volatility for EURO STOXX 50 stock options. 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-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Using the Generalized Method of Moments (GMM) returns very similar estimates. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Robustness checks – domestic vs non-domestic holdings

Sample	(1) Full	(2) Non-domestic exposures	(3) Domestic exposures	(4) Domestic exp., core countries	(5) Domestic exp., periphery c.
Dependent variable			Log holdings		
Risk premia *(lag)*	-0.013***	-0.013***	0.0014	0.0022	0.0047
	(0.00)	(0.00)	(0.68)	(0.58)	(0.37)
Risk-free rate *(lag)*	0.025***	0.024***	0.026***	-0.0078	0.068***
	(0.00)	(0.00)	(0.01)	(0.39)	(0.00)
Log Holdings *(lag)*	0.69***	0.69***	0.70***	0.70***	0.66***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log Residual maturity	0.090***	0.091***	0.092***	0.055***	0.16***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ECAI downgrade *(lag)*	-0.090***	-0.090***	-0.090***	-0.018	-0.10***
	(0.00)	(0.00)	(0.00)	(0.52)	(0.00)
Debt/GDP *(lag)*	-0.0020***	-0.0030***	0.0083***	0.0011	0.0090***
	(0.00)	(0.00)	(0.00)	(0.54)	(0.00)
Log PSPP volume *(lag)*	-0.0026***	-0.0030***	-0.0052***	-0.0037**	-0.0041**
	(0.00)	(0.00)	(0.00)	(0.04)	(0.03)
Log VSTOXX *(lag)*	-0.016	-0.027*	0.10***	0.067*	0.12***
	(0.22)	(0.07)	(0.00)	(0.05)	(0.00)
Security – holder c. FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Observations	172,009	153,673	18,336	11,030	7,306
R-squared	0.965	0.955	0.989	0.992	0.975

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. 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 a 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. Log VSTOXX is the log of the implied volatility for EURO STOXX 50 stock options. In Column 2 and 3, the sample includes exposures of euro area ICPFs on non-domestic and domestic government bonds, respectively. In Column 3 and 4, the regressions are performed on domestic exposures of "core" (i.e., AT, BE, DE, EE, FI, FR, LT, LU, LV, MT, NL, SK) and "periphery" (i.e., CY, ES, GR, IE, IT, PT, SI) euro area countries, respectively. Security-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Robust p-values are in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Robustness checks – the effect of transitional measures under Solvency II

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Full	Countries with large transitionals	Countries with less/no transitionals	Full	Full	Full
Dependent variable			Log holdings			
Risk premia *(lag)*	-0.013***	-0.012***	-0.014***	-0.015***	-0.013***	-0.013***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Risk-free rate *(lag)*	0.024***	0.014	0.027***	0.024***	0.022***	0.024***
	(0.00)	(0.12)	(0.00)	(0.00)	(0.00)	(0.00)
Log Holdings *(lag)*	0.69***	0.68***	0.69***	0.69***	0.69***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log Residual maturity	0.091***	0.074***	0.099***	0.091***	0.092***	0.092***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ECAI downgrade *(lag)*	-0.090***	-0.053***	-0.11***	-0.091***	-0.090***	-0.11***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Debt/GDP *(lag)*	-0.0030***	-0.000080	-0.0041***	-0.0030***	-0.0029***	-0.0035***
	(0.00)	(0.92)	(0.00)	(0.00)	(0.00)	(0.00)
Log PSPP volume *(lag)*	-0.0030***	-0.0012	-0.0029***	-0.0030***	-0.0028***	-0.0032***
	(0.00)	(0.53)	(0.00)	(0.00)	(0.00)	(0.00)
Log VSTOXX *(lag)*	-0.027*	0.0084	-0.041**	-0.027*	-0.027*	-0.026*
	(0.07)	(0.78)	(0.01)	(0.07)	(0.06)	(0.07)
Risk-premia *(lag)* * Transitional dummy				0.0069**		
				(0.04)		
Risk-free rate *(lag)* * Transitional dummy					0.010*	
					(0.06)	
ECAI downgrade *(lag)* * Transitional dummy						0.052**
						(0.02)
Debt/GDP *(lag)* * Transitional dummy						0.0021***
						(0.01)
Security-holder c. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	153,673	38,745	114,928	153,673	153,673	153,673
R-squared	0.955	0.945	0.958	0.955	0.955	0.955

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. 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 a 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. Log VSTOXX is the log of the implied volatility for EURO STOXX 50 stock options. Countries with large transitional measures under Solvency II regulatory regime are GR, ES, PT, DE and FI. Countries with less/no transitional measures are the remaining euro area countries. Transitional dummy equals to 1 if a holder country belongs to those having large transitional measures. Security-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Robustness checks – measurement of risk-free rate

	(1)	(2)	(3)
Dependent variable		Log holdings	
Risk premia *(lag)*	-0.013***		
	(0.00)		
Risk-free rate *(lag)*	0.025***		
	(0.00)		
Risk premia DE *(lag)*		-0.012***	
		(0.00)	
Risk-free rate DE *(lag)*		0.022***	
		(0.00)	
Risk premia OIS *(lag)*			-0.010***
			(0.00)
Risk-free rate OIS *(lag)*			0.0071
			(0.16)
Security-holder country FE	Y	Y	Y
Year FE	Y	Y	Y
Other Controls	Y	Y	Y
Observations	172,009	172,009	172,009
R-squared	0.965	0.965	0.965

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as 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-free rate 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-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Robustness checks – empirical specification

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable			Log Holdings			Difference of log holdings	Buy/Sell indicator
Yield-to-maturity					-0.0093***		
					(0.00)		
Risk premia *(lag)*	-0.013***	-0.0096***	-0.0060**	-0.012***		-0.011***	-0.017***
	(0.00)	(0.00)	(0.04)	(0.00)		(0.00)	(0.00)
Risk-free rate *(lag)*	0.025***	0.027***	0.010**	0.019*		0.027***	0.027**
	(0.00)	(0.00)	(0.03)	(0.06)		(0.00)	(0.02)
Log Holdings *(lag)*	0.69***	0.97***	0.97***	0.69***	0.69***		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Cross-sectional FE							
Sec – Holder country FE	Y	N	N	Y	Y	Y	N
Security FE	N	Y	N	N	N	N	N
Issuer country FE	N	N	Y	N	N	N	N
Time FE							
Year FE	Y	Y	Y	N	Y	Y	Y
Quarter FE	N	N	N	Y	N	N	N
Other controls	Y	Y	Y	Y	Y	Y	Y
Observations	172,009	172,009	172,009	172,009	172,009	172,009	172,009
R-squared	0.965	0.954	0.953	0.965	0.965	0.124	

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty years. All independent variables are lagged by one quarter. Yield-to-Maturity is the interest rate of single government bonds in a given 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. Security-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Security FE denote fixed effects that are specific for each security, while issuer country FE denote fixed effects that are specific for each individual sovereign issuer. Year and quarter FE capture any variation in holdings that happen over years and quarters, respectively. Buy/sell indicator equals 1 if the first difference of holdings is greater than 0 (ICPFs buy a security), it is -1 if the first difference is negative (ICPFs sell a security), and 0 otherwise. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Robustness checks – sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	Full	Pre-OMT announcement (09q1-12q2)	Post-OMT announcement (12q3-16q4)	w/o issuer countries with fundamental risk	w/o PSPP (09q1-14q4)	w/o experimental SHS (13q4-16q4)	w/o 2016 (09q1-15q4)	only 2016 (16q1-16q4)	Only securities outstanding over the whole period
Dependent variable					Log holdings				
Risk premia *(lag)*	-0.013***	-0.0060*	-0.011***	-0.0055***	-0.011***	-0.018***	-0.013***	-0.025**	-0.0087***
	(0.00)	(0.07)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)
Risk-free rate *(lag)*	0.025***	0.020**	0.033***	0.019***	0.014***	0.028***	0.011***	0.042**	0.024***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
Security-holder c. FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	172,009	51,281	120,728	144,430	112,679	92,315	141,164	30,845	73,452
R-squared	0.965	0.966	0.967	0.962	0.967	0.968	0.967	0.979	0.969

The dependent variable is the logarithm of nominal amount of single government bonds held by insurance companies and pension funds (ICPF) in different euro area countries. The sample includes exposures on zero- and fixed-coupon bonds with residual maturity between three months and thirty 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). Risk premia is calculated as spread between yield to maturity and risk-free rate. Columns 2 and 3 refer to the sub-samples before and after the Outright Monetary Transactions' announcement by ECB, respectively. Countries with fundamental risk in column 4 are CY, ES, GR, IE, PT. "Experimental SHS" are SHS data collected on a voluntary and best-efforts basis from 2009 to 2013 and are thus subject to some quality limitations. In 2016 q1, the quality of the ICPF 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). Security-holder country FE denote fixed effects that are specific for each individual security held by ICPFs in a given euro area country. Robust p-values are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

REFERENCES

Acharya, V.V. and Steffen, S. (2015). The "Greatest" Carry Trade Ever? Understanding Eurozone Bank Risks. Journal of Financial Economics 115, 215 – 236.

Adrian, T. and H. S. Shin (2010). Liquidity and leverage. Journal of Financial Intermediation 19 (3), 418–437.

Adrian, T. and H. S. Shin (2011a). Financial intermediary balance sheet management. Annual Review of Financial Economics 3 (1), 289–307.

Allen, F., and Gale, D. (2000): "Bubbles and Crises," Economic Journal, 110, 236–255.

Allen, F., and Gale, D. (2004): "Asset Price Bubbles and Monetary Policy," in Global Governance and Financial Crises, ed. by M. Desai and Y. Said. London: Routledge, 19–42.

Allen, F., and Rogoff, K. (2011): "Asset Prices, Financial Stability and Monetary Policy," in The Riksbank's Inquiry Into the Risks in the Swedish Housing Market, ed. by P. Jansson and M. Persson. Stockholm: Sveriges Riksbank, 189–218.

Bank of England and Procyclicality Working Group, 2014. Procyclicality and Structural Trends in Investment Allocation by Insurance Companies and Pension Funds. http://www.bankofengland.co.uk/publications/Documents/news/2014/dp310714.pdf.

Berdin, E., Kok, C., Mikkonen, K., Pancaro, C. and J. M. Vendrell Simon, 2015. Euro area insurers and the low interest rate environment. Special Feature B in ECB's Financial Stability Review, November 2015.

Becker, B., and Ivashina, V., 2015. Reaching for yield in the bond market. Journal of Finance, 70 (5), 1863–1901.

Bijlsma, M., and Vermeulen, R, 2015. Insurance companies' trading behaviour during the European sovereign debt crisis: flight home or flight to quality? De Nederlandsche Bank Working Paper No 468.

Borio, C., and Zhu, H. (2008). "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism,"Working Paper, Bank for International Settlements.

Choi, N., Fedenia, M., Skiba, H., and Sokolyk, T. (2017). Portfolio concentration and performance of institutional investors worldwide. Journal of Financial Economics 123, 189-208.

Cochrane, J., 2017. Macro-Finance. Review of Finance, 21 (3), 945-985.

Cohen, B.H., and Scatigna, M. (2016). Banks and capital requirements: Channels of adjustment. Journal of Banking & Finance 69, S56–S69.

Coeurdacier, N. and Rey, H. (2013). Home bias in open economy financial macroeconomics. Journal of Economic Literature, 51(1):63 – 115.

Das, S. 2017. The Effect of Leverage on Asset Sales Between Financial Institutions. IMF Working Paper No. 200.

De Haan, L., and Kakes, J., 2010. Are non-risk based capital requirements for insurance companies binding? Journal of Banking & Finance 34, 1618–1627.

De Santis, R.A., 2014. The euro area sovereign debt crisis: Identifying flight-to-liquidity and the spillover mechanisms. Journal of Empirical Finance 26, 150–170.

Douglas, G., Noss, J., and Vause N., 2017. The impact of Solvency II regulations on life insurers' investment behaviour. Bank of England Staff Working Paper No. 664.

Diamond, D. W., and Rajan, R. G. (2012): "Illiquid Banks, Financial Stability, and Interest Rate Policy," Journal of Political Economy, 120, 552–591.

Duijm, P., and Steins Bisschop, S., 2015. Short-termism of long-term investors? The investment behaviour of Dutch insurance companies and pension funds, DNB Working Paper No. 489, December 2015.

ECB, 2016. Report on financial structures, October 2016.

Eisenbach, T., and Duarte, F., 2015. Fire-Sale Spillovers and Systemic Risk. Federal Reserve Bank of New York Staff Report No 645.

EIOPA, 2014. 2014 EIOPA Insurance Stress Test Report.

EIOPA, 2016. 2016 EIOPA Insurance Stress Test Report.

EIOPA, 2017. Financial Stability Report, June 2017 (link).

EFAMA, 2015. Asset Management in Europe. 8th Annual Review, April 2015.

Erce, A. (2015) Bank and sovereign risk feedback loops. Working Paper Series European Stability Mechanism, 1.

ESRB, 2015a. Report on systemic risks in the EU insurance sector, December 2015.

ESRB 2015b. ESRB report on the regulatory treatment of sovereign exposures.

ESRB, 2016. Macroprudential policy issues arising from low interest rates and structural changes in the EU financial system, November 2016.

Fabozzi, F. J. and Giacometti, R. and Tsuchida,N. (2015) The ICA-based factor decomposition of the Eurozone sovereign CDS spreads. IMES Discussion Paper Series, 4.

French, K.R. and Poterba, J.M. (1991), Investor Diversification and International Equity Markets, American Economic Review, 81, 222-226.

Gennaioli, N. and Martin, A. and Rossi, S. (2014). Banks, government bonds, and default: What do the data say? Working Paper IMF, 120.

Greenwood, R., Landier, A. and Thesmar, D., 2015. Vulnerable Banks. Journal of Financial Economics 115 (3), 471-485.

Grinblatt, M., and Keloharju, M., 2000. The investment behaviour and performance of various investor types: a study of Finland's unique data set. Journal of Financial Economics 55(1), 43–67.

Impavido, G., and Tower, I., 2009. How the Financial Crisis Affects Pensions and Insurance and Why the Impacts Matter. IMF Working Paper No. 151.

Jimenez, G., Ongena, S., Peydró, J.L., and Saurina, J., 2014. Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?. Econometrica 82(2), 463-505.

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

Merrill, C.B., Nadauld, T.D., Stulz, R.M. and Sherlund, S. M. (2012): Did Capital Requirements and Fair Value Accounting Spark Fire Sales in Distressed Mortgage-BackedSecurities? NBER Working Paper No.18270.

Myers, S., 1977. Determinants of corporate borrowing. Journal of Financial Economics 5, 147-175.

Papaioannou, M.G., Park, J., Pihlman, J., and van der Hoorn, H., 2013. Procyclical Behavior of Institutional Investors During the Recent Financial Crisis: Causes, Impacts, and Challenges. IMF Working Paper 193-2013.

Rajan, R. G. (2006): "Has Finance Made the World Riskier?" European Financial Management, 12, 499–533.

Saunders, A., and Cornett, M.M., 1999. Financial Institutions Management: A Modern Perspective (6th edition). Irwin Series in Finance, Insurance, and Real Estate, McGraw-Hill, New York.

Taylor, J.B. (1993): “Discretion versus policy rules in practise” Carnegie-Rochester Conference Series on Public Policy, 39, 195–214.

Timmer, Y., 2016. Cyclical investment behaviour across financial institutions. Deutsche Bundesbank Discussion Paper No 08/2016.

Van Binsbergen, J., and Brandt, M.W., 2016. Optimal asset allocation in asset liability management. In: Veronesi, P. (Ed.), Handbook of Fixed Income Securities.Wiley, pp. 237–275.

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.	counter-cyclical / neutral
Impavido and Tower (2009)	OECD and Latin American countries, 2007 - 2009	During the financial crisis, life insurance companies were acting pro-cyclically, as the sales of equity and other instruments were more widespread.	pro-cyclical
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.	counter-cyclical
Merrill, Nadauld, Stulz and Sherlund (2012)	US Insurance sector	Between 2006 and 2009, capital-constrained US insurance companies sold more non-agency, residential mortgagebacked 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.	pro-cyclical
Papaioannou, Park, Pihlman and van der Hoorn (2013)	Different data sources, 2000-2012	There is evidence of the pro-cyclical investment behavior of major institutional investors during the global financial crisis. Many factors could account for such behavior, which may be considered rational from an individual institution's perspective.	pro-cyclical
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 pro-cyclical shifts in asset allocation following the dotcom crash of the early 2000s, and to a lesser extent during the recent financial crisis. There are though structural shifts in asset allocation occurring during the financial crisis, which make identifying pro-cyclical 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 pro-cyclically.	pro-cyclical
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	counter-cyclical
Duijm and Bisschop (2015)	Netherlands SHS, 2006-2015Q	ICs massively sold equities during the crisis, while PFs kept buying equities as markets tumbled. There is evidence of a pro-cyclical behaviour by ICs only. ICPFs sold their affected sovereign bonds prior to a rating downgrade (destabilising at a macro-level).	pro-cyclical
Bijlsma and Vermeulen (2016)	60 insurance companies, Dutch SHS, 2006-2013Q	Insurance companies acted pro-cyclically during the sovereign debt crisis through the sale of distressed countries' government bonds.	pro-cyclical
Timmer (2016)	German SHS, 2005-2014Q	ICPFs respond counter-cyclically to price changes, acting as market stabilizers 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.	counter-cyclical
Douglas, Noss, Vause (2017)	Based on simulated data. Stylized 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, 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 risk margin: The risk margin increases, as risk-free rate falls, as the net present value of future capital requirements increases, which worsen insurers' solvency positions.	pro-cyclical

Annex B: Variables description

Variable	Description
Log Holdings	Natural logarithm of the nominal amounts of government bond holdings of euro area ICPFs. Includes holdings of zero- and fixed-coupon bonds with residual maturity between three months and thirty 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 governments 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
Log VSTOXX	Natural logarithm of the implied volatility for EURO STOXX 50 stock options (Datastream)
ECAI downgrad e	A dummy that equals 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)
ECB policy rate	Level of ECB interest rate on the main refinancing operations with fixed rate tenders (ECB https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/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)
GDP growth rate	Quarterly GDP growth of a country (ECB - National accounts)