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Systemic Risk in the Insurance Sector under Solvency II: An Analysis of the Pro-Cyclicality Channel

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Abstract

This thesis studies the effect of a change in the regulatory environment on the cyclicality of insurers' investment behavior. Given their large amount of asset holdings, insurers have the potential to reinforce or dampen market and asset price movements. While their long-term investment horizon theoretically puts insurers in a position to act as stabilizers on financial markets, the regulatory framework could incentivize a pro-cyclical investment allocation. This in turn could lead to an enlarged contribution of insurers to systemic risk through the pro-cyclicality channel. The recently implemented Solvency II regulation, which introduced mark-to-market accounting standards and risk-based capital requirements for European insurance undertakings, provides an ideal setting to analyze the impact of a regulatory change on the cyclicality of an insurer's investment decisions. Using unique security level data, this thesis finds evidence that Solvency II incentivized German insurers to act slightly more pro-cyclical relative to pension funds, which are used as a control group. Being one of the first studies to compare the cyclicality of insurers' asset allocation under different regulatory frameworks, this thesis provides policymakers with first indicative insights on the effects of Solvency II on the pro-cyclicality channel of systemic risk.

Keywords: Cyclicality, Investment Behavior, Financial Stability, Insurance Regulation

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List of Abbreviations

BSCR . . . . Basic Solvency Capital Ratio

CTA . . . . . Common trend assumption

EIOPA . . . . European Insurance and Occupational Pensions Authority

ESCB . . . . European System of Central Banks

EU . . . . . . European Union

IC&PF . . . . Insurance companies and pension funds

IF&FVC . . . Investment funds and financial vehicle corporations

ITS . . . . . . Implementing Technical Standards

MCR . . . . . Minimum Capital Requirement

MFI . . . . . Monetary financial institutions

NCB . . . . . National Central Bank

OFI . . . . . . Other Financial Institutions

P&C . . . . . Property and causality

SCR . . . . . Solvency Capital Requirement

SHS . . . . . . Securities Holdings Statistic

1 Introduction: Motivation and Research Question

While the banking sector is still the major source for systemic risk in the financial system, the contribution of insurance companies to systemic risk increased steadily during the past years (International Monetary Fund [IMF], 2016b). Being among the biggest institutional investors, insurance companies have the potential to amplify market movements in asset prices, for instance by propagating a downward price-spiral when engaging in a simultaneous sell-off of certain assets (Duijm & Steins Bisschop, 2015; French, Vital, & Minot, 2015).

On January 1st, 2016, a new regulatory framework for European insurance companies - Solvency II – entered into force. Bringing about major changes by introducing e.g. market valuation and risk-based capital requirements, it provides an ideal case to study the impact of the new regulations on financial stability. Previously, regulatory standards for insurance undertakings in Germany and many other European countries were risk insensitive and available capital resources were determined following book valuation rules (Swain & Swallow, 2015). Using unique security level data from the German central bank's Security and Holdings Statistic (SHS), this thesis analyzes whether these major regulatory changes introduced by Solvency II incentivize pro-cyclical investment behavior in the German insurance sector. Thereby, it adds to two strings of literature: First, it provides empirical evidence on recent theoretical discussions of the effects of market vs. historical cost accounting in combination with risk-sensitive capital regulations. Second, it provides further insights to the literature that empirically studies the cyclicality of insurers' investment behavior. Specifically, it is one of the first studies to compare the cyclicality of insurers' investment allocation under different regulatory regimes. Moreover, this first indicative evidence provides regulators with insights on the effects of Solvency II on the pro-cyclicality channel of systemic risk in the German insurance sector. To the best of my knowledge, there is no other study analyzing the effect of Solvency II on the cyclicality of insurers' investment behavior using this unique micro data set.

For the empirical strategy, a difference-in-differences approach is chosen which exploits the fact that institutions for occupational retirement provision - a comparable type of institutional investors - are still regulated according to the previous Solvency I framework.

The remainder of this thesis is organized as follows: Section 2 gives an overview of the current state of knowledge in the literature. Section 3 introduces the (institutional) setting of this study. Section 4 briefly outlines the theoretical framework by elaborating on how different components of Solvency II might theoretically enhance or dampen pro-cyclical investment behavior, deriving the hypothesis for the empirical analysis. Section 5 describes the data and empirical strategy used to estimate the effects of Solvency II on the cyclicality of insurers' investment behavior and discusses the results. Section 6 concludes.

2 Literature Review

The academic literature in which context this thesis is based can be divided into (1) empirical studies analyzing the effect of market consistent accounting standards on the cyclicality of insurers' investment allocation, (2) theoretical papers discussing the incentives for pro-cyclical investment behavior following form mark-to-market accounting rules and risk-based capital requirements and (3) papers studying empirically the cyclicality of insurers' investment decisions.

Most closely related to the analysis conducted here, Ellul, Jotikasthira, Lundblad, and Wang (2015) exploit the difference in the regulation for American property and causality (P&C) insurers and life insurance companies. They find that P&C insurers facing mark-to-market valuation are more likely to exhibit a fire sale externality, i.e. to sell downgraded asset backed securities during the financial crisis, than insurers facing historical cost accounting. The propensity to sell a downgraded asset is about 2.8-3.3% higher for P&C than for life insurers according to their study.

Further, several theoretical papers have displayed that mark-to-market valuation in combination with risk sensitive capital requirements might incentivize pro-cyclical investment behavior: Allen and Carletti (2008) show that mark-to-market valuation can lead to distortions, contagion and unnecessary insolvencies, since asset prices in the need of attracting liquidity on rather illiquid markets tend to fall below their expected future payoffs. Using a model with simple capital requirements and price fluctuations stemming from variation in fundamentals, Heaton, Lucas, and McDonald (2010) find that market consistent valuation leads to inefficiencies, i.e. higher than optimal social costs[1] of regulating the banking system. The results obtained from a model of Plantin, Sapra, and Shin (2008) indicate that inefficiencies[2] are greater from mark-to-market accounting than from historical cost accounting if the liabilities of a financial institution are rather long-term, illiquid and senior – characteristics that apply to many of the insurers' liabilities.

Generally, given their rather long-term liabilities, insurers are often attributed the potential to act as contrarian traders when other financial market participants are under stress and in

[1] In their model, Heaton et al. (2010) define those social costs as deadweight costs associated with taxation, equity financing, excessive risk-taking and bank restructuring.

[2] According to Plantin et al. (2008), inefficiencies arising from historical cost accounting are rooted in sales decisions being based on historical, rather than (potentially appreciated) current prices. On the other hand, inefficiencies stemming from mark-to-market accounting arise in illiquid markets where market prices might not always reflect the fundamental value of illiquid assets.

need of liquidity (Duijm & Steins Bisschop, 2015). Yet, empirical evidence on the cyclicality of the investment behavior of insurance companies is mixed. For German insurance companies and pension funds (IC&PF) prior to the introduction of Solvency II, Baltzer, Jank, and Smajlbegovic (2014) find no evidence that IC&PF are momentum or contrarian traders[3] on the German stock market using data from the SHS, too. Timmer (2016), measuring cyclicality as a change in the volume of holdings of a certain security in response to a price change of this security, finds that IC&PF act as counter-cyclical investors in the debt security market. According to his analysis based also on the SHS, IC&PF increase their holdings of a security by 6.5% following a drop in the price of this security by 10%. Further, IC&PF tend to buy if securities trade at a discount (below their par value).

On the other hand, Bijlsma and Vermeulen (2016) find that Dutch insurers exhibited pro-cyclical investment behavior during the European sovereign debt crisis, selling assets (particularly government bonds) from affected southern European states and buying northern European ones instead. In particular, their results indicate that the difference between Dutch insurers' investments into Northern and Southern European assets equalled 18 percentage points. In connection to this, Duijm and Steins Bisschop (2015) provide descriptive evidence on IC&PF behaving pro-cyclically, selling their government bonds prior to a rating downgrade. This result is in line with Dutch insurance regulation already incorporating certain elements of the new Solvency II regulation, such as a similar liability valuation method and the prudent person principle[4]. Concerning equity portfolios, their analysis, covering the period from 2006 to 2015, shows that Dutch insurance companies invest pro-cyclically, while their analysis suggests that Dutch pension funds do not act pro- or counter-cyclically over a longer time horizon[5]. For

[3]Baltzer et al. (2014) refer to momentum traders as investors who keep on buying stocks with a high past return, while selling "loser" stocks with a poor past performance. Contrarian traders follow the opposite investment strategy.

[4]Anticipating already parts of the Solvency II regulation, a change in the valuation of liabilities was introduced in 2012 (De Nederlandsche Bank, 2012) and regular stress tests assessing the solvency of Dutch insurance companies were carried out since 2009 (IMF, 2011). Further, Dutch insurers were regulated based on the prudent person principle. Instead of rules-based quantitative limits on investment allocations, Dutch insurers were required to ensure sufficient diversification of risk and a prudent level of investments in risky assets (Bijlsma & Vermeulen, 2016).

[5]Dutch pension funds were subject to a regulatory regime that includes market valuation of their assets, a fixed actuarial discount rate for liabilities of 4% (until 2007, afterwards the discount rate was based on the euro swap curve defined by the Dutch Central Bank) and a funding ratio of minimum 100% (Boon, Brière, & Rigot, 2014). Since 2007, risk sensitive capital requirements are applied which require pension funds to hold enough capital to ensure at a 97.5% confidence level that its assets do not fall below the value of its liabilities within a year. If they fail to meet these requirements, pension funds are granted a recovery period of 10 years to restore their solvency position (prior to 2007, afterwards 3 years to restore the 100% funding ratio and 10 years to comply with required capital buffers). The respective regulatory frameworks are the Pensioen- en spaarfondsenwet (Pensions and Savings Fund Act) until 2007 and the Financieel Toetsingskader (Financial Assessment Framework) afterwards (Boon et al., 2014). The Financial Assessment Framework has been revised in 2015 (De Nederlandsche Bank, 2015).

insurance undertakings, they find that insurers buy (sell) between 0.172 % and 0.237 % of their equity portfolio if equities outperform (underperform) other asset classes with a 1% higher (lower) return. This behavior seems to be more pronounced during the global financial crisis. The statistically insignificant results indicate an acyclical investment behavior by pension funds. Yet, the authors recognize that the external validity of their results for pension funds is weakened due to the fact that they are not able to capture indirect investments. This is of particular relevance, since pension funds currently hold most of their equity investments in investment funds.

Further, Bank of England and the Procyclicality Working Group (BoE, 2014) provide tentative evidence on the pro-cyclical investment behavior of US, French and UK insurance companies: UK insurers seem to have shifted their asset allocation away from equity after the burst of the dotcom bubble in the early 2000s. US and French insurers' equity holdings seem to be correlated with the performance of the S&P 500 index.

This thesis adds to the literature by providing empirical evidence on the cyclicality of insurers' investment allocation in the context of a shift in the regulatory regime from book- to market value accounting rules and from risk-insensitive- to risk-based capital requirements.

3 Setting

3.1 Insurance companies and their role in the economy and on financial markets

Insurers perform an important economic function by allowing risk-averse agents to transfer their individual risks to a risk-neutral financial intermediary (Eeckhoudt, Gollier, & Schlesinger, 2005). This reduces uncertainty in investment decisions and promotes an efficient allocation of risks, thereby stimulating economic growth (Arena, 2008). A typical insurance contract specifies a risk transfer: The risk-averse agent is willing to pay a premium in exchange for the insurance company agreeing to compensate its client in case a pre-specified loss-generating event happens. Pooling the risks of many individuals, the insurer is able to diversify the individual risks as long as they are not highly correlated[6] (Eeckhoudt et al., 2005).

The business model of insurance companies is reflected in their balance sheet. Looking at

[6]Alternatively, the risk can be diversified as long as the insurance undertaking can find a suitable hedge for the aggregated risks.

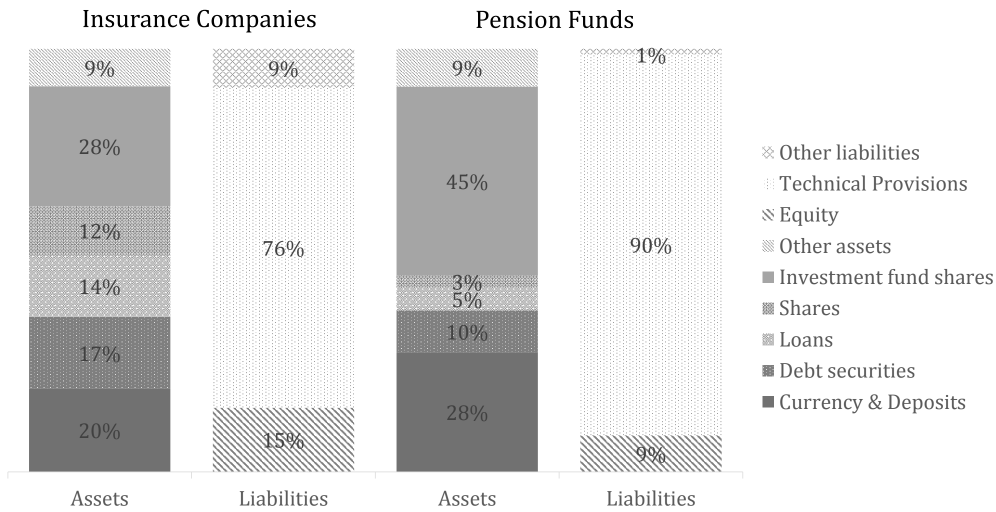


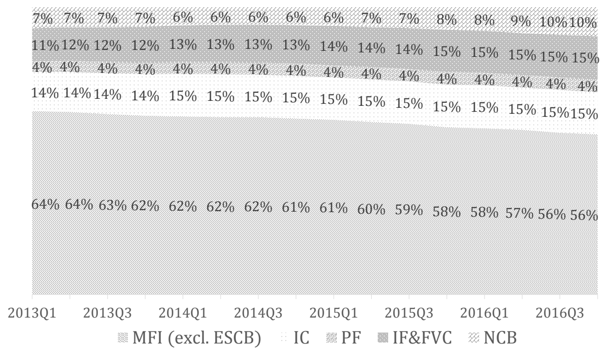
Figure 1: Balance Sheet Composition. *Source: Author rendering of data from Deutsche Bundesbank (2016a) and Deutsche Bundesbank (2016b)*

the average composition of an insurance undertaking's balance sheet[7], insurers' main source of funding are premium payments which enter the balance sheet's liability side as technical provisions, i.e. insurance technical reserves to cover future claims or benefit payments (see Figure 1). In contrast to the rather short-term liabilities of banks which are prone to withdraws and runs, an insurer's payment stream mainly depends on their clients suffering an insured loss[8] – which is usually relatively predictable on the aggregate level. This provides insurers with a rather stable, long-term source of financing (Deutsche Bundesbank, 2014). Furthermore, insurers are typically less leveraged than banks (Timmer, 2016). On the asset side, the premium payments received are primarily invested in debt securities or shares or are transferred into investment fund shares and loans. Thereby, the insurance industry serves as an important supplier of long-term financing to the economy (Duijm & Steins Bisschop, 2015).

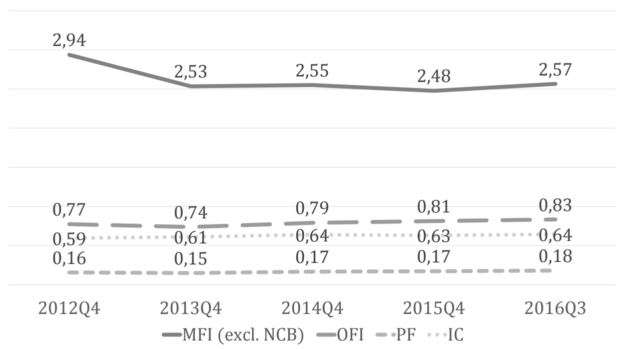
For pension funds, which are used as control group in the empirical analysis of this thesis, the asset side and especially the liability side of their balance sheets are composed of comparable positions (see Figure 1). At the first glance, the differences in the percentage share of e.g. investment fund shares and technical provisions might seem rather large, however contrasted to other financial market actors such as banks or investment funds, the balance sheet composition

[7]The average balance sheet composition is calculated from 2013 to 2015 which correspond to the pre-treatment period of this study. This allows a meaningful comparison to the balance sheet composition of the control group (pension funds). However, there were no major changes in the balance sheet composition of 2016.

[8]Certain life insurance policies offer the possibility to withdraw funds prematurely, yet relatively high early-exit fees serve as a disincentive (Baluch, Mutenga, & Parsons, 2011). Feodoria and Förstemann (2015) present critical interest rates for the largest German life insurance companies at which a "policyholder run" could happen.



(a) Share of Total Financial Sector Assets. *Source: Author rendering of data from BSI statistics (ECB, 2017)*



(b) Ratio of Financial Assets to GDP. *Source: Author rendering of data from QSA and GDP statistics (ECB, 2017)*

Figure 2: Relative Size Insurance Sector

of IC&PF is relatively similar[9]. In particular, pension funds share the rather unique feature of insurers' liability side consisting mainly of long-term technical provisions.

To continue, looking at the insurers' share of total financial sector assets (see Figure 2a), they have - apart from credit institutions[10] – the largest quantity of assets under management in the German financial sector. Moreover, their assets account for around 60% of GDP (Figure 2b)[11]. These numbers underline the importance of insurance undertakings as source of funding for financial and non-financial corporations. Further, depending on the investment strategy applied, the large amount of assets held gives the insurance sector collectively the potential to dampen or accelerate market movements (Duijm & Steins Bisschop, 2015).

3.2 Insurance companies and Systemic Risk

Concerning the insurance industry's contribution to systemic risk, it is generally acknowledged that insurers are less of a concern for financial stability than banks – especially with regard to their traditional business activities (Eling & Pankoke, 2014b). Yet, recent assessments found an increased contribution of insurance companies to risk in the financial sector (Baluch et al., 2011; IMF, 2016b). The factors contributing to this increase include a rising connectedness with other financial market participants, or a higher engagement into non-traditional, non-insurance

[9] For instance, the asset side of German banks is mainly composed of loans to banks and non-banks, while their liability side consists primarily of retail deposits, interbank borrowing and debt securities issued. For investment funds, debt securities and shares form the major positions of their asset side and investment fund shares account for most of their liabilities (Timmer, 2016).

[10] Credit institutions make up for almost 100% of monetary financial institutions (MFI, excl. ESCB)'s assets.

[11] An additional figure (5) showing insurers' share of total financial assets in the financial sector can be found in the Appendix A.2

activities (Baluch et al., 2011; Billio, Getmansky, Lo, & Pelizzon, 2012)[12], as well as larger common exposures and vulnerability to market risks (IMF, 2016b). While risks arising from the failure of an individual insurance undertaking are considered to be less of a concern (domino view), risks that can be attributed to insurance companies reacting simultaneously to market shocks in a propagating manner are found to be of increasing importance (tsunami view) (IMF, 2016b). The latter include for instance the contagion of systemically important counterparties by a simultaneous stop in funding or the contagion of the rest of the financial system through pro-cyclical investment behavior that exacerbates price movements (French et al., 2015).

Specifically, risk transmission trough the pro-cyclicality channel describes a situation in which insurers react to a market shock such as a rating downgrade or a sudden drop in asset prices by selling off parts of their assets[13]. This might lead to a continued price decline, especially if a significant part of the insurance sector is affected by the shock. The further deterioration in asset values might induce serious liquidity constraints in the whole financial market, triggering forced asset sales at prices far below their normal level, given the lack of counter-parties able and willing to pay a higher price. This in turn could set off a downward price-spiral for similar asset classes, ultimately causing heavy distortions on financial markets that could harm the real economy (Shleifer & Vishny, 2011).

Summing up, insurance companies perform an important economic function by reducing individual financial risks and by providing a long-term financing option for the real economy. Given the long-term investment horizon following from their liability structure, insurance companies theoretically have the potential to act as a stabilizing force on financial markets (Duijm & Steins Bisschop, 2015). That is, they could calm down market movements by acting as a contrarian trader that buys assets when prices drop and sells assets when prices increase. However, depending inter alia on the regulatory environment in which insurers are operating, they might in practice also be incentivized to follow a rather pro-cyclical investment strategy that could lead to an increased contribution of insurance companies to systemic risk (Papaioannou et al., 2013). This thesis provides insights on whether a major regulatory change influences the cyclicality of insurers' investment behavior and thus their contribution to systemic risk.

[12]Specifically for Germany, the IMF (2016a) finds that the level of interconnectedness is very high between the largest German banks and insurance undertakings.

[13]Of course, risk transmission through pro-cyclical investment can also be caused by other financial market participants. Yet, in the case of insurance undertakings it might be less expected by other financial market actors and thus cause more severe disruptions (Papaioannou, Park, Pihlman, & Van der Hoorn, 2013).

3.3 Institutional Framework: Insurance Regulation

Given that insurance companies enhance the welfare of an economy by transferring and pooling individual risks, it is deemed desirable to safeguard an undisrupted provision of these important services (Hufeld, Koijen, & Thimann, 2017). Since a system relying purely on market forces is unlikely to meet this desire, regulatory agencies are entrusted with the task to ensure the well-functioning of the insurance sector. Different set of rules that insurance companies have to comply with have been set up in the past.

With the introduction of Solvency II on January 1, 2016, insurance regulation in Europe has undergone a major change. The new regulation replaces a framework of 14 European Union (EU) Directives commonly referred to as "Solvency I" which defined the regulatory standards for the previous 40 years (European Commission, 2015). Several weaknesses of the Solvency I Directives lead to a revision of the regulatory framework. Among others, defining minimum rather than specific requirements, Solvency I allowed for divergence between national insurance regulations, thus creating the possibility for regulatory arbitrage in the single European market (Swain & Swallow, 2015). Further, considering primarily the liability side of an insurer's balance sheet when defining (risk-insensitive) capital requirements, Solvency I was lacking the possibility to display an accurate picture of the risk position of an insurance undertaking (Swain & Swallow, 2015).

Being modelled to overcome those weaknesses, Solvency II aims at harmonizing the insurance regulation in the European Union, thus fostering competition in the European market. Solvency II builds on a three pillar approach. The first pillar ("quantitative") determines how capital requirements are calculated and specifies valuation rules for asset and liabilities using a "total balance sheet approach" (Swain & Swallow, 2015). The second pillar ("qualitative") describes the process of supervision and defines risk management and governance guidelines that insurance undertakings have to abide by. The third pillar ("transparency") lays out reporting and disclosure standards (Bundesanstalt für Finanzdienstleistungsaufsicht [BaFin], 2016b).

Technically, the new framework consists of the Solvency II Directive 2009/138/EC (amended by the Omnibus II Directive 2014/51/EC), the EU Delegated Regulation (EU) 2015/35 and its amendment (EU) 2016/467, as well as several Implementing Technical Standards (ITS) and accompanying guidelines[14]. In the following, the implementation time line of Solvency II is

[14]In line with the Lamfalussy architecture, EU regulation for financial services follows a revised process since the financial crisis with the goal to make the regulatory process more effective and flexible. The general process prescribes that a new regulation is based on a basic act (e.g. an EU directive) which is adopted by the European Parliament and the Council following a proposal of the European Commission. The basic act then entitles the European Commission to adopt Delegated Acts or Implementing Acts which specify technical details of the new regulation in accordance with the principle framework defined by the basic act. Delegated Acts are used for

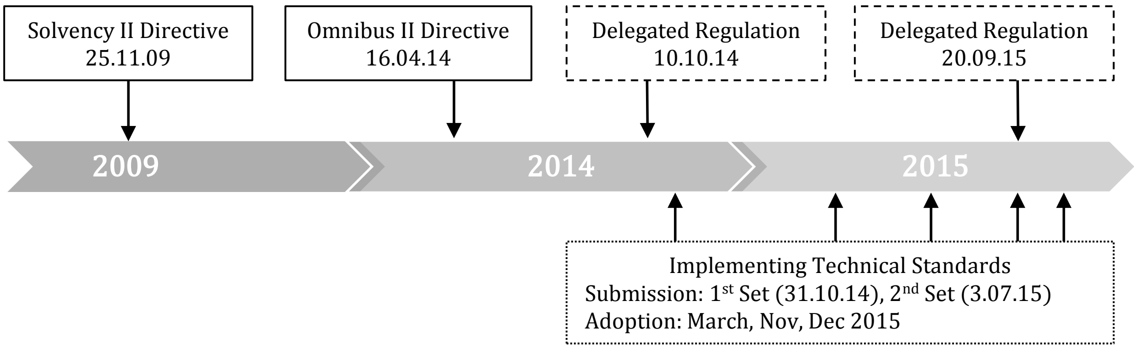


Figure 3: Solvency II Implementation Time Line. *Source: Author*

presented[15].

The Solvency II Directive was adopted by the European Parliament and the Council on November 25th, 2009. It defines the basic principles of the new regulatory framework and states the primary goal of Solvency II to be "the adequate protection of policy holders and beneficiaries" (Dir 2009/138/EC, 2009, Recital 16). This supposes, according to Dir 2009/138/EC (2009, Recital 14), that insurers "are subject to effective solvency requirements". "Financial stability and fair and stable markets" (Dir 2009/138/EC, 2009, Recital 16) are included as further objectives.

Yet, recognizing that "[t]he financial crisis [...] exposed important shortcoming in financial supervision" (Dir 2014/51/EC, 2014, Recital 1), failing for instance "to prevent the accumulation of excessive risk within the financial system" (Dir 2014/51/EC, 2014, Recital 4), the original directive was amended substantially by the Omnibus II Directive on April 16th, 2014. Inter alia, the amendment defines a set of measures aimed at reducing artificial volatility in an insurer's balance sheet, thereby promoting a continued offering of long-term products. Further, it gives powers to EIOPA to draft for instance the technical standards of the regulation that insurance undertakings have to comply with (European Commission, 2014).

The Delegated Regulation adopted by the Commission on October 10th, 2014[16] forms the core of the single prudential rule book transforming the general ideas and political objectives of the directives into detailed rules (European Commission, 2017c). Together with the amendment of September 20th, 2015[17], the Delegated Regulation - for the first time - lays down the

legislation which supplements or amends "non-essential" points of the underlying directive. Implementing Acts are used to specify rules aiming to ensure a uniform implementation. Further, the basic act can entitle European supervision authorities, such as the European Insurance and Occupational Pensions Authority (EIOPA) with the right to draft ITS which are put into force by an Implementing Act (European Commission, 2017b).

[15]Major mile stones are used in the empirical analysis later to test for the robustness of the result towards the exclusion of different transitory periods.

[16]It became official by means of the publication in the official journal on January 17th, 2015.

[17]The Delegated Regulation (EU) 2016/467 added information on the calculation of capital requirements for various types of assets (DA (EU) 2016/467, 2016).

specific requirements that insurers have to comply with from January 1st, 2016 onwards. Those requirements include the procedure to value assets and liabilities, methods to calculate required capital levels, management and governance guidelines and rules on the eligibility of an insurer's own funds (European Commission, 2017c).

Over the course of the year 2015 EIOPA drafted two sets of ITS which were submitted to the Commission in October 2014 and July 2015 (European Insurance and Occupational Pensions Authority [EIOPA], 2014, 2015) and adopted by the Commission in March, November and December 2015 (European Commission, 2017a). These ITS provide insurers e.g. with updated information on supervisory approval procedures and certain add-ons to the standard capital requirements. Hence, only throughout 2015 had European insurers been provided with all details concerning the new regulatory framework. Since the entry into force of Solvency II in January 2016, EIOPA publishes relevant parameters for the calculation of technical provisions and own funds on a quarterly basis (Dir 2009/138/EC, 2009, Article 77e).

Having described the reasons for the revision of the previous European regulatory framework, the legislation and guidelines that the new regulation is based on, the timing of its implementation, as well as the general approach of Solvency II, the next section focuses specifically on the theoretical effects of Solvency II on the cyclicality of insurer's investment behavior.

4 Theoretical framework: Cyclicality under Solvency II

To begin with a general definition, following BoE (2014) and EIOPA (2016a), pro-cyclicality describes an investment behavior of insurance companies that follows market or asset price movements. Pro-cyclical investment behavior can also be referred to as "institutional herding" or momentum trading, i.e. buying securities seeing a price increase and divesting from assets experiencing a drop in their price (Papaioannou et al., 2013; French et al., 2015). In a short term perspective, this tends to increase market volatility, potentially reducing financial market resilience (BoE, 2014). In the medium term, this exacerbates asset price and economic cycles which could harm financial stability and the economy through the pro-cyclicality channel of systemic risk as described in subsection 3.2.

Insurance regulation potentially impacts the cyclicality of an insurer's investment allocation which could - given their long-term investment horizon - be rather countercyclical (Papaioannou et al., 2013). Generally, the design of the regulation can influence an insurer's investment behaviour as it determines its free capital resources through the accounting and capital regulation rules applied. Depending on the regulatory environment, a financial shock (i.e. a change in the value of an asset, a downgrade of a security's rating or a change in the risk-free rate) changes the amount of available and required capital for an insurer in a specific way. Aiming at maximizing its (long-run) profits or its shareholder value, an insurer reacts to a change in the difference of available and required capital with a certain investment decision. Whether this investment allocation decision potentially exhibits pro-cyclicality depends on the regulatory framework. While Solvency II made both available and required capital more sensitive to market and credit risks, it includes in theory both pro-cyclicality incentivizing and dampening elements which are discussed in the following.

4.1 Pro-cyclicality incentivizing components of Solvency II

4.1.1 Determination of available capital resources: Accounting rules for the valuation of assets and liabilities under Solvency II

While available own funds were determined according to book values under Solvency I, Solvency II uses a market consistent approach to value assets and liabilities (Swain & Swallow, 2015; Heukamp, 2016). Assets and liabilities are valued according to the value they could currently be traded at between two financial market participants. If no market value exists, intangible assets receive a valuation of zero. As a market value often fails to exist for "non-hedgeable" technical provisions on the liability side of an insurer's balance sheet, insurers are instructed to calculate a "best-estimate"[18] of their value. On top of this estimate, a risk margin is added to account for the "cost of capital", i.e. the cost of holding the capital required to cover those liabilities. The available capital resources equal the difference of assets and liabilities, less own shares and plus subordinated debt. While providing the supervisor with a more accurate picture of the current solvency position of an insurer, the amount of available capital is prone to large fluctuations due to the market consistent valuation. Shocks to asset prices or changes in the relevant risk-free rate are immediately reflected in the balance sheet (Swain & Swallow, 2015; Heukamp, 2016).

[18]The „best-estimate" equals the expected future cash-flow of those liabilities, discounted with the relevant risk-free interest rate.

4.1.2 Determination of required capital: Capital requirements under Solvency II

While capital requirements were risk-insensitive under Solvency I and mainly dependent on the business volume of an insurer[19], the capital regulation under Solvency II aims at capturing the risks arising from all business activities of an insurer. Two levels of capital requirements are calculated: The Solvency Capital Requirement (SCR) and the Minimum Capital Requirement (MCR), whereby falling below the latter one induces regulatory action leading to a withdrawal of the insurance companies' authorization (BaFin, 2016b).

The SCR corresponds to the amount of capital needed for a firm to cover unexpected losses potentially arising over the next year in 99.5% of the cases. It can either be calculated using a standard formula or a (partially) internal model, whereby using an internal model requires prior approval by the supervisor (Swain & Swallow, 2015; Heukamp, 2016). The standard formula consists of the Basis Solvency Capital Requirement (BSCR) and the operational risk capital requirement minus adjustments for the loss-absorbing capacity of technical provisions. The BSCR is divided into different risk-(sub-)modules, with the risk-modules being underwriting risk, market risk and counter-party risk. The market risk module addresses for example risks arising from the sensitivity of an insurer's balance sheet items to changes in the valuation or volatility of interest rates, equity, exchange rates, property, concentration or credit spread. To determine the total BSCR, the square root formula is applied, which adds up the capital requirements calculated in the individual risk modules while adjusting for their correlation (DA (EU) 2015/35, 2015). At the beginning of 2016, the market risk module contributed to 59% (72%, 78% and 84%) of the capital requirements for P&C-, re-, life- and health insurance companies, respectively (BaFin, 2016a).

Being a framework that is risk sensitive, changes in all kind of market conditions that have an effect on the risk profile of an insurance company lead to a change in an insurer's SCR. With some changes in market conditions entering the calculations in many risk modules simultaneously, it is difficult to precisely predict the change in the SCR. However, given for instance the high importance of the market risk module, one can expect that shocks leading to changes in the market risk modules' capital requirement heavily affect the total SCR.

[19] Under Solvency I, for all insurers except life insurers, the Solvency Capital Requirement (SCR) equaled the higher amount of annual premiums and average yearly expenses for insurance claims from the past three years. For life insurers, the SCR was equal to the weighted sum of 4% of provisions and 0.3% of risk capital (the difference of sum insured and provisions) (KapAusstV, 2016).

4.1.3 How do mark-to-market valuation and risk-based capital requirements incentivize pro-cyclicality and what are the implications for financial stability?

Taken together, mark-to-market valuation and risk-based capital requirements are likely to lead to an insurers' SCR coverage ratios (available capital resources divided by solvency capital required) becoming much more volatile, since for instance a revaluation of assets and liabilities will promptly be reflected in the balance sheet. The theory is supported by the German Federal Financial Supervisory Authority observing changes in the SCR coverage ratio of up to 350 percentage points during the first quarter of 2016 (BaFin, 2016a).

Over the whole business cycle, with the accounting and capital regulation applied under Solvency II, an insurance undertaking is likely to feel rather capital rich during market upturns and rather capital poor in times of market stress (BoE, 2014; European Systemic Risk Board [ESRB], 2015). In theory, with market consistent valuation, there are two mechanisms leading to an insurer having increased available capital resources in boom periods and reduced available resources in a downturn. First, bond spreads tend to be lower during boom periods and higher during periods of financial distress or an economic downturn (Borio, Furfine, & Lowe, 2001). Therefore, for every insurer that does not exclusively hold risk-free assets, the value of assets is likely to increase relative to the value of liabilities during boom periods, since the riskier bond yields are falling (higher asset prices = higher value of assets) and the risk-free rate is likely to increase (liabilities are discounted at a larger rate = lower value of liabilities). The opposite holds true in periods of market stress: Yields on riskier bonds are likely to jump up, while the risk-free rate might fall and the value of assets therefore decreases relative to the value of liabilities. Second, many insurers (especially life insurers) have a duration mismatch with their assets being of shorter maturity than their liabilities. Thus, a change in the risk-free rate leads to a relatively larger change in the value of liabilities than in the value of assets. If the risk-free rate is rising in an upturn, the drop in the value tends to be larger for liabilities than for assets, everything else equal. The difference between the value of assets and liabilities widens. Vice versa, the value of assets decreases relative to liabilities if the risk-free rate drops[20] (ESRB, 2015). For both mechanisms, given that capital resources equal the difference of assets and liabilities[21], the amount of capital available to an insurer to meet its requirements changes pro-cyclically.

If capital requirements would follow the development of capital resources one to one, there wouldn't be any changes in the SCR coverage ratio of an insurer and one shouldn't expect to see

[20]For duration-matched insurers only the first mechanism prevails. In case the duration of liabilities is shorter-dated than the one of assets, the effect of the first mechanism would be weakened

[21]Ignoring subordinated debt and own shares.

the regulation incentivizing pro-cyclical investment behavior. However, the capital requirements are unlikely to perfectly match the change in capital resources, since most risks entering the SCR capital calculations are less than a 100% of an asset's value (ESRB, 2015). Furthermore, the risk assessment underlying the calculation of the SCR might not be "cycle-neutral" as risks tend to be underestimated during market upturns and overvalued in periods of stress (Borio et al., 2001) [22].

During market upturns, this leads to insurance companies having free capital available which they can use to buy e.g. further (risky) assets yielding additional return (BoE, 2014). Thereby, they contribute to prices of these assets further rising, providing them with additional free capital that they can invest. Yet, when the market turns to become distressed, insurers are likely to be capital constrained, since their capital resources are shrinking, while capital requirements are again unlikely to completely track the downwards movement[23]. This might require them to sell off assets - especially riskier assets which have high capital requirements attached and are declining in value (ESRB, 2015). Given the commonalities in their risk exposures (IMF, 2016b) and the application of homogeneous models to calculate the capital requirements following from these exposures[24], many insurers are likely to face similar problems and thus to react simultaneously with a sell-off of certain assets. Such a collective sell-off might propagate a downward price spiral, potentially leading to fire sales and contagion of the rest of the financial system, thereby negatively affecting other financial market participants.

To sum up, the fluctuation in the SCR coverage ratio following from the valuation standards and capital rules applied could incentivize insurers to act pro-cyclically. In times of the prices of riskier asset increasing relative to risk-free assets, insurers have free capital resources available and there are incentives for them to increase investments in riskier assets (which see their prices rising) (ESRB, 2015). On the other hand, when the price of riskier assets falls relative to risk-free assets, insurers are capital constrained and they are incentivized (or even forced) to sell-off riskier assets (for which the price is decreasing) and shift their portfolio allocation towards

[22]Related, Borio et al. (2001) provides evidence on credit rating agencies adjusting their ratings only *after* the outbreak of a crisis, thereby failing to take into account an increasing building up of risks when determining their ratings. This is of particular relevance, since capital requirements under Solvency II are partly rating-dependent (Duijm & Steins Bisschop, 2015)

[23]Of course, insurers could instead use the free capital resources to build up a buffer in boom periods. For the case of Basel II, Repullo and Suarez (2008) find that moving from a risk-insensitive to a risk-based capital regime leads to banks optimally building up some capital reserves to buffer shocks to their lending capacity in a downturn. Yet, their analysis shows that these buffers are not sufficient to offset swings in required and available capital, leading to capital shortages in periods of distress.

[24]Approximately 90% of German insurance undertakings are using the standard model to calculate their capital requirements (BaFin, 2016a).

lower risk assets (with an increasing price)[25]. Exercising pro-cyclical investment behaviour by buying assets that see a price increase and selling assets for which the price is falling, insurers could intensify asset price volatility and feedback loops in the short term(BoE, 2014). Thereby, the balance sheet and thus the available capital resources of other financial market actors marking-to market are affected which could induce a feedback reaction. Moreover, a higher volatility of asset prices could cause a decline in market liquidity through an increase in margins[26] (Brunnermeier & Pedersen, 2009).

In the medium term, pro-cyclical investment behaviour could lead to insurers exacerbating asset price and economic cycles. This could increase insurers' contribution to systemic risk through the pro-cyclicality channel (as described in subsection 3.2) with potentially negative consequences for financial stability and ultimately the real economy.

4.2 Pro-cyclicality dampening mechanisms of Solvency II

In light of the potentially negative side-effects of market consistent valuation and risk-based capital requirements on financial stability, Solvency II includes several measures to counteract these effects (European Commission, 2015):

Subject to approval by the supervisor, the *matching adjustment* allows insurance companies to adjust the relevant risk-free rate term structure[27]. If an insurer matches its claims with an asset portfolio with similar cash flow characteristics and holds the portfolio over the life time of its obligations, he is not exposed to changes in the spread of these assets. Thus, the matching adjustment seeks to artificially reduce the impact of short-term price fluctuations of those assets, thereby reducing the volatility in own funds available and limiting the incentives for pro-cyclical investment behavior (EIOPA, 2016a). This measure (and generally the total balance sheet approach taken by Solvency II) puts into practise certain recommendation on optimal insurance regulation design following from the theoretical work of Van Hulle, Degryse, and Smedts (2017). They argue that an insurer's probability to fail might actually be reduced by the insurer investing in riskier assets as long as these assets match the risk profile of its liabilities. In contrast to banks whose riskiness tends to increase with a riskier asset portfolio[28], insurer's risk position might be improved by holding also riskier assets if these assets are positi-

[25] Shifting their investments towards lower risk (or risk-free) assets not only reduces capital requirements, but also serves as a hedge against further declines in the risk-free rate (ESRB, 2015).

[26] A margin refers to the amount of equity that is required for a trade where the purchaser of a security borrows the money to finance its purchase using the security as a collateral (Brunnermeier & Pedersen, 2009).

[27] The interest rate used to calculate the "best estimate" of the value of an insurer's non-hedgeable liabilities.

[28] Van Hulle et al. (2017) refer to DeAngelo and Stulz (2015).

vely correlated with potentially occurring policy claims. According to Van Hulle et al. (2017), regulators should take these considerations into account and impose capital requirements that consider the correlation between the assets and liabilities. The matching adjustment might promote such an asset structure that serves as a natural hedge, thus reducing the potential of severe capital shortages and – in a worst case scenario – the need to fire sale assets.

In addition, the *volatility adjustment* aims at mitigating the effect of short-term exaggerations of asset spreads and is explicitly introduced with the goal to counteract pro-cyclicality (Dir 2014/51/EC, 2014, Recital 32). Again, insurers are allowed to adjust the relevant risk-free rate for their calculations of the "best estimate"[29]. Since the volatility adjustment is introduced as a permanent measure, there is criticism that it might incentivize risk-taking above the level intended in a framework without the adjustment mechanism, as insurers might anticipate the reduction in capital requirements during periods of market stress and use the available capital resources to invest in risky assets (ESRB, 2015)[30].

In theory, both the matching adjustment and the volatility adjustment work symmetrically, i.e. they could adjust capital requirements up- and downwards. However, in practice, they are more likely to be applied in times of crisis when spreads are increasing and thus are more likely to reduce capital requirements. Calculations of EIOPA of a hypothetical volatility adjustment show that the volatility adjustment would have been slightly negative only in 2000 and 2007 (ESRB, 2015). In practice, many insurers are taking advantage of the downward adjustment of capital requirements: In Germany, 65% of life insurers were applying the volatility adjustment while it is less or not used by other insurers in the first quarter of 2016[31] (BaFin, 2016a).

Further, Solvency II includes a symmetric adjustment (or "*equity dampener*") within the equity risk sub-module used in the standard formula for the calculation of the SCR: When equity prices exceed their medium-term average, insurers have to hold more capital to cover their exposures. On the other hand, capital charges are adjusted downwards if equity prices are below their medium-term average. Applying the SCR standard formula for the equity risk

[29] Sweden applied a similar mechanism, announcing an optional discount rate floor which allowed insurers to discount their liabilities at historical market quotas instead of a maximum of 60% of the long-term Swedish government bond yield. Yet, the discount rate floor was introduced as a discretionary rather than permanent measure.

[30] Since the volatility adjustment is calculated based on an annually updated reference portfolio of insurers' aggregate asset holdings, an increase in the insurers' investment allocation towards riskier assets might lead to an increase in the volatility adjustment. This second round effect which would soften capital requirements even more during periods of stress might further incentivize "anticipatory" risk taking during market upturns, turning the volatility adjustment potentially into a pro-cyclicality amplifying instrument or weakening at least its potential to counteract pro-cyclicality (ESRB, 2015).

[31] Within the EU, 852 insurance undertakings with a market share equal to 61% of the European market used the volatility adjustment, while 38 insurers accounting for a market share of 16% used the matching adjustment in 2016 (EIOPA, 2016b).

module on historic data for stylised insurer portfolios representative for 16 different European countries, Eling and Pankoke (2014a) show that the equity dampener leads to considerable deviations from the 99.5% confidence level foreseen in the standard capital stress calculation. They argue that this deviation helps to reduce the pro-cyclicality of capital charges, thereby decreasing the probability of fire sales to occur. Calculating two different measures[32] of systemic risk, they further show that capital requirements are lower during periods of increased system-wide risk and higher in low-risk periods. This result indicates that the symmetric risk adjustment seems to contribute to financial stability by reducing pro-cyclicality[33].

In addition, Solvency II allows for the application of transitional measures for the calculation of technical provisions (European Commission, 2015). Insurers can apply for the permission to calculate technical provisions either completely according to the previous Solvency I framework or partly by applying the Solvency I discount rates to the current framework. Yet, the application is limited to insurance contracts closed prior to the introduction of Solvency II and is phased out linearly until 2032. In Germany, mainly life insurance companies were using these transitional measures: 63% of life insurers where either using the first or second transitional measure during the first quarter of 2016 (BaFin, 2016a).

Having discussed the theoretical pro-cyclicality incentivizing and dampening components of Solvency II, the remainder of this thesis empirically studies whether the asset allocation of German insurance companies has become more pro-cyclical following the introduction of Solvency II. Following the theoretical discussion, the subsequent hypothesis is tested:

Hypothesis: *After Solvency II entered into force, the investment behavior of German insurers became more pro-cyclical compared to pension funds.*

Put differently, it is analyzed whether insurance undertakings - relative to pension funds - are trading more on momentum. That is, they invest into securities seeing a price increase and divest in case of a price decrease. While mark-to-market accounting rules and risk-based capital requirements are theoretically likely to contribute to such a behavior, measures such as the volatility or matching adjustment, which were widely applied during the first months of Solvency II, are likely to weaken a potential momentum trading incentivizing effect of Solvency II.

[32]The measures calculated are CoVar and MES.

[33]Since historical data is used, the analysis can however not capture the possibility that insurers might react to a change in the regulatory environment with a change in their investment behavior.

5 Empirical Analysis: Data and Methodology

5.1 Data

To study the effects of Solvency II on the cyclicality of insurers' investment behavior, this thesis uses data covering the period from January 2013 until December 2016 from the Deutsche Bundesbank SHS (Amann, Baltzer, & Schrape, 2012). The SHS is a centralized register of security holdings compiled from the mandatory reports of all German deposit taking institutions[34]. The unique micro data set provides monthly information on the aggregate holdings of German IC&PF on security level which is matched with information on various security attributes, such as price quotes. It is structured as a three-dimensional panel data set with a time, security and depositor sector dimension. Hence, for every month observed, the holdings of each sector of a specific security are known, allowing to study the investment behaviour of insurance companies on security level. To account for minor reporting inconsistencies in the original data set, a small number of observations are dropped as described in more detail in subsection A.1.

5.1.1 Data coverage

The data extract captures all holdings of debt securities and shares issued by domestic and foreign entities for German IC&PF that are deposited at the reporting institutions. For domestic issuers, the statistic covers 85.5% of debt securities currently in circulation, whereby 1.2% are held by IC&PF as of December 2016[35]. 60.3% of the shares currently in circulation are covered (whereof 1.4% are held by IC&PF) (Deutsche Bundesbank, 2017).

Comparing the total holdings of debt securities and shares of IC&PF obtained by the balance sheet statistics from the Bundesbank[36] to the SHS, between 74.9% (2015) and 77.5% (2013) of the debt securities hold by IC&PF are captured in the SHS[37]. Further, between 8.4% (2016) and 10.6% (2013) of shares are captured. This relatively low coverage ratio is caused by the SHS including only marketable shares (the shares must only be marketable, not actually quoted). However, the lion share of IC&PF's shareholdings consists of non-quoted shares (Deutsche

[34]The financial institutions that have to report to the SHS include German monetary financial institutions, capital management companies and other credit institutions providing safe custody services. For a detailed documentation of the database see Amann et al. (2012, note: Since 2013 monthly instead of quarterly data) and Bade, Flory, and Schönberg (2016, (note: Describes the SHS-base, some more variables included in the SHS))

[35]Calculations are based on nominal values. Unfortunately, reliable data on the coverage of foreign securities in circulation was not at hand.

[36]See Deutsche Bundesbank (2016a) and Deutsche Bundesbank (2016b)

[37]Calculations are based on market values, since the balance sheet statistics provide only information on the amount of market valued holdings.

Bundesbank, 2016a, 2016b). If one compares the total value of IC&PF's shareholdings covered by the SHS to the value of quoted shares in IC&PF's aggregated balance sheet, the holdings captured by SHS amount to more than 1.5 times the value of the latter. Furthermore, it is not possible to capture insurers' indirect security holdings via their investment fund shares. Yet, along the two dimensions "coverage of securities in circulation" and "coverage of total direct securities' holdings of IC&PF", analyzing the investment behavior of IC&PF with the use of the SHS provides a good insight into insurers' asset allocation of tradable securities.

5.1.2 Descriptive Statistics

To continue, exploiting the fact that pension funds are still regulated according to the previous regulatory framework, Solvency I, they are used as a control group in this analysis. The descriptive statistics presented in the following indicate that pension funds represent a suitable control group, provide stylized facts about IC&PF's "investor type" and give an overview of the development of the dependent and independent variable later used in the empirical analysis. This adds to section 3.1 where the similarity of IC&PF's balance sheet composition is discussed.

Table 1: Summary statistics by Depositor Sector and Treatment Period

VARIABLES	N	Mean	sd	p1	p25	p50	p75	p99
PF, Pre-Solvency II								
Nominal Holdings in m €	133,599	6.63	18.02	0.0001	0.25	1.27	5.30	74.83
Log Change Nominal Holdings	126,491	0.003	0.235	-0.384	0	0	0	0.530
Log Change Price	126,464	0.00078	0.102	-0.116	-0.004	0	0.0073	0.108
PF, During Solvency II								
Nominal Holdings in m €	52,900	7.85	20.58	0.00004	0.36	2.00	7.17	83.72
Log Change Nominal Holdings	51,617	0.0068	0.199	-0.154	0	0	0	0.431
Log Change Price	51,594	0.00072	0.0916	-0.124	-0.0041	0	0.0074	0.118
IC, Pre-Solvency II								
Nominal Holdings in m €	338,849	22.83	68.35	0.0000007	0.20	4.18	19.85	300.0
Log Change Nominal Holdings	318,471	0.00358	0.273	-0.491	0	0	0	0.633
Log Change Price	318,349	-0.000903	0.116	-0.205	-0.00345	0	0.00527	0.162
IC, During Solvency II								
Nominal Holdings in m €	124,303	25.98	71.59	0.0000009	0.50	5.60	25.00	327.9
Log Change Nominal Holdings	120,724	0.000453	0.287	-0.438	0	0	0	0.502
Log Change Price	120,683	0.00153	0.123	-0.142	-0.00328	0	0.00503	0.134

Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)

Starting with some general summary statistics of the data set, Figure 6 in subsection A.2

depicts that insurers' and pension funds' aggregate *security holdings* measured by nominal or market value in billion € grew over the observation period. Table 1, presenting summary statistics of the holdings and price variables, shows that the median as well as the average nominal amount in € held per security increased for both IC&PF from its pre-Solvency II- to its during-Solvency II-Level. For the four subsamples, the mean seems to be driven by some large outliers, being around five times as large as the median.

Analyzing in more detail the composition of IC&PF's security holdings according to different security attributes during the period analyzed in this study, the weighted portfolio composition of IC&PF seems to be relatively similar (Figure 7, 8, 9 and 10 in subsection A.2). Especially when looking at the portfolio structure according to the currency of denomination and the broad category of the securities held, one can see that the aggregate portfolio of both insurers and pension funds mainly consists of Euro denominated and long-term debt securities. Looking at the portfolio composition according to the issuer country, IC&PF have exposures to similar countries, with exposures being concentrated towards European issuers. Likewise, the aggregated portfolio composition according to the issuer sector looks comparable, with the majority of holdings being allocated towards deposit-taking corporations, the central government and other financial institutions except IC&PF.

If one fully inflates the panel, i.e. constructs the panel data set to include all securities ever held by insurance undertakings or pension funds during the whole observations period[38], setting the holdings of previously non-registered observations equal to zero, one can see that there is quite some similarity in IC&PF's asset allocation even on the single security level (Figure 11 in subsection A.2). Taken together, insurers hold more different securities than pension funds which is likely due to the overall larger amount of securities held by insurance undertakings. Yet, during the period covered, roughly 28%[39] of the securities either hold by IC&PF in one reporting month are hold by both IC&PF. Thus, comparing their security portfolio composition according to broader security attributes - which reflects their general investment orientation - or on the individual security level, IC&PF seem to be rather similar financial market's participants.

Looking at their *trading behavior*, one can see that IC&PF tend to trade their securities rather infrequently. For both, IC&PF, the 25th and 75th percentile of the log change in nominal holdings - the dependent variable of the following empirical analysis – equals zero (Table 1).

[38]To avoid artificially including securities that are not yet or are not anymore alive, artificially created observations for securities are dropped prior to their date of issuance and past their date of maturity.

[39]On average, approximately 19% of all securities ever hold are hold by both insurance companies and pension funds in one reporting month. Dividing this number by the average percentage of securities hold either by insurance companies or pension funds (or both) in one reporting month returns 19%/68%≈28%.

This contrasts IC&PF to banks and investment funds who are more active traders (Timmer, 2016). However, at the tails of the distribution, once IC&PF shift their asset allocation, they trade relatively large amounts (an increase of roughly 43% to 63% relative to the previous period's holdings equals the 99th percentile and a decrease of approximately 15% to 49% equals the 1st percentile)[40]. Figure 12 (subsection A.2) depicts the development of the mean, the 1st and the 99th percentile of the log change in nominal holdings for the two depositor sectors over time. While they are in a similar range for insurance companies over the period studied, there is a larger volatility for pension funds. This could be caused by much fewer observations constituting the 1st and the 99th percentile of pension funds' log change in nominal holdings. Overall, these descriptive statistics indicate that one can characterize IC&PF rather as buy-and-hold investors, who thereby exercise a stabilizing influence on financial markets. However, the relatively large shifts of holdings once IC&PF decide to reallocate their assets could negatively impact financial stability if these shifts occur in a pro-cyclical manner. The empirical analysis in section 5 will shed light on whether this is increasingly the case for insurance companies following the introduction of Solvency II.

Continuing with the *log change in price*, which is used as an explanatory variable to proxy pro-cyclicality later, one can see overall more fluctuations in this variable (Table 1). The price changes seem to be rather moderate at the tails of the distribution (a decrease of approximately 11% to 21% represents the 1st and an increase of about 11% to 16% the 99th percentile). Looking at the development of the mean, the 1st and 99th percentile of the log change in prices for the securities that experienced a change in holdings in the respective reporting month, one can see a rather similar movement in the mean for the two depositor sectors (Figure 13 in subsection A.2). Apart from a few outliers (probably for similar reasons than mentioned already above), the portfolios of IC&PF seem to be exposed to price changes of their securities in a similar range, suggesting that pension funds are a suitable control group along this dimension.

Figure 14 (subsection A.2) shows the *average price* for percent quote-securities[41] – unweighted and weighted by nominal holdings in € - held by IC&PF. Overall, the percent-quoted securities held by IC&PF trade on average at a premium. Especially if weighted by nominal holdings, the average price saw a substantial increase from 2013 to 2015, followed by a rapid

[40] This is in line with Timmer (2016) who finds that IC&PF trade on average larger quantities than investment funds once they shift their assets.

[41] Since the price for unit quoted securities is stated as the price of one unit of a security in the currency of denomination, it is hard to compare and take the average for unit quoted securities. On the other hand, the price of a percent quote-security is stated as the price of the security relative to its face value and thus comparable between different securities. I.e. a percent quoted-security with a price of 105 trades at 105% percent of its par value.

drop that was reversed after the introduction of Solvency II. Further, the averages for IC&PF move very close to each other, indicating that IC&PF's portfolios have a similar price structure. While there is a small gap in the beginning, the averages tend to overlap from May 2015 onwards. Thus the average price for an insurer's portfolio of percent quoted securities increased relative to pension funds towards the introduction of Solvency II. The empirical analysis will provide insights whether this is partly caused by insurance companies increasingly buying securities that experience a price increase (or selling securities that see a price drop) after Solvency II entered into force.

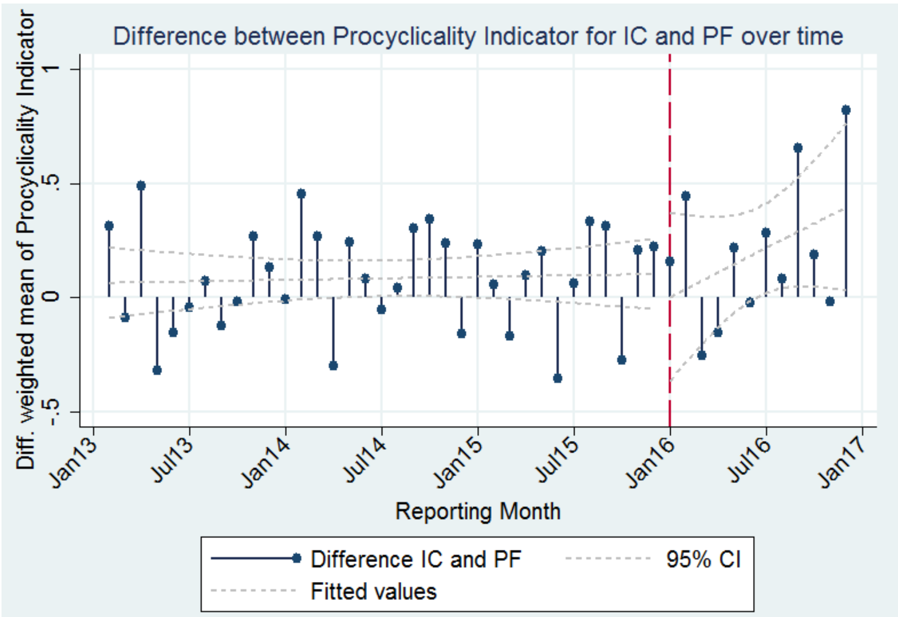


Figure 4: Difference between Pro-Cylcicality Indicator for IC&PF over time. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

Adding to this, Figure 4 provides descriptive evidence on the impact of Solvency II on the *pro-cyclicality* of insurers' investment behavior. It shows the differences between the weighted mean of a simple pro-cyclicality indicator for IC&PF over time. This simple indicator equals one if the log change in nominal holdings and the log change in price point into the same direction (i.e. both variables saw an increase, a decrease or remained unchanged in a given month) and zero otherwise. By depositor sector, for every month the mean of this dummy variable is calculated weighted by the absolute log change in nominal holdings, i.e. observations that experienced a larger change in holdings receive a higher weight. The mean can be seen as a simple indicator of the pro-cyclicality of a depositor sector's investment allocation in a given month: A value close to 1 suggests a rather pro-cyclical, a value of 0.5 a-cyclical and a value close to 0 counter-cyclical investment behavior. Taking the difference between insurance companies' and pension funds' weighted mean of the pro-cyclicality dummy for every reporting month observed, one can see that both depositor sectors had a relatively similar level of pro-cyclicality for most of the months observed. Only after the introduction of Solvency II are larger differences visible. A thorough empirical analysis is needed to obtain more meaningful results, but this simple descriptive approach already hints towards an increased pro-cyclicality in the insurance sector following the introduction of Solvency II.

Summing up, this section provided an overview of the development of IC&PF's holdings structure and investment behavior. Further, considering the characteristics discussed in this section, pension funds seem to be a suitable control group. Featuring a rather similar composition of their securities portfolio and their balance sheet (see section 3.1), insurers and pension funds are in general likely to be exposed to common shocks influencing their investment behavior.

5.2 Empirical identification strategy

Since German institutions for occupational retirement provision do not fall under Solvency II and are still regulated according to the Solvency I accounting and capital rules, this provides an ideal setting to empirically analyze the effect of market-based accounting standards and a risk-sensitive regulatory framework on the cyclicality of insurers' investment allocation decisions using a difference-in-differences approach. Therefore, to test for potentially pro-cyclical investment behavior of insurance companies after the introduction of Solvency II, a standard difference-in-differences approach with a continuous treatment variable is conducted. Applying the definition of momentum trading introduced in section 4 and following Timmer (2016), pro-cyclical investment behavior is measured as a change in the holdings of a certain security in comparison to the change in the price of the respective security. A pro-cyclical investor would increase its holdings of a certain security if this security is experiencing a price increase. Thus, the effect of Solvency II on the cyclicality of an insurer's investment behavior is identified by comparing the difference in the reaction of insurers' holdings to price changes before and after the introduction of Solvency II relative to the difference in the reaction of pension funds' holdings. This results in the following regression specification:

$$\begin{aligned}\Delta Holdings_{i,j,t} = \alpha_0 + \delta_0 IC + \gamma_0 Sol + \beta_0 IC * Sol + \alpha_1 \Delta P_{i,t} \\ + \delta_1 IC * \Delta P_{i,t} + \gamma_1 Sol * \Delta P_{i,t} + \beta_1 IC * Sol * \Delta P_{i,t} + \epsilon_{i,j,t}\end{aligned}$$

$\Delta Holdings_{i,j,t}$ is the log change in nominal holdings[42] of security i of depositor sector j from period $t-1$ to period t. Sol is a dummy variable equal to 1 after the introduction of Solvency II (treatment period dummy), IC is a dummy variable indicating the insurance sector (treatment group dummy) and $\Delta P_{i,t}$ is calculated as the log change of the price for security i from period $t-1$ to period t. The regression formulation above can be rewritten as the Average Treatment Effect of the Treated (ATET), thereby better visualizing the difference-in-differences set up:

$$
\begin{aligned}
&ATET(\Delta P_{i,t}) \\
&= \Big[E\left[\Delta Holdings_{i,j,t}|IC=1, Sol=1, \Delta P_{i,t}\right] - E\left[\Delta Holdings_{i,j,t}|IC=1, Sol=0, \Delta P_{i,t}\right]\Big] \\
&- \Big[E\left[\Delta Holdings_{i,j,t}|IC=0, Sol=1, \Delta P_{i,t}\right] - E\left[\Delta Holdings_{i,j,t}|IC=0, Sol=0, \Delta P_{i,t}\right]\Big]
\end{aligned}
$$

With

$$
\begin{aligned}
&E\left[\Delta Holdings_{i,j,t}|IC=1, Sol=1, \Delta P_{i,t}\right] = \alpha_0 + \delta_0 + \gamma_0 + \beta_0 + (\alpha_1 + \delta_1 + \gamma_1 + \beta_1)\,\Delta P_{i,t} \\
&E\left[\Delta Holdings_{i,j,t}|IC=1, Sol=0, \Delta P_{i,t}\right] = \alpha_0 + \delta_0 + (\alpha_1 + \delta_1)\,\Delta P_{i,t} \\
&E\left[\Delta Holdings_{i,j,t}|IC=0, Sol=1, \Delta P_{i,t}\right] = \alpha_0 + \gamma_0 + (\alpha_1 + \gamma_1)\,\Delta P_{i,t} \\
&E\left[\Delta Holdings_{i,j,t}|IC=0, Sol=0, \Delta P_{i,t}\right] = \alpha_0 + \alpha_1 \Delta P_{i,t}
\end{aligned}
$$

this yields

$$
\begin{aligned}
ATET(\Delta P_{i,t}) &= \Big[\gamma_0 + \beta_0 + (\gamma_1 + \beta_1)\,\Delta P_{i,t}\Big] - \Big[\gamma_0 + \gamma_1 \Delta P_{i,t}\Big] \\
&= \beta_0 + \beta_1 \Delta P_{i,t}
\end{aligned}
$$

Thus, the coefficient β_0 on the interaction term of treatment group and period dummy can be interpreted as the difference in the intercept following from the treatment, while the coefficient β_1 on the interaction term of the treatment period dummy, the treatment group dummy and the change in price indicates the difference in the slope of the relationship between price changes and holdings changes. A positive coefficient points to a relative increase in pro-cyclicality, i.e. an increase in the price leads to a relative larger increase in holding. Assuming that the main identifying assumption - the common trend assumption (CTA) - holds, i.e. assuming that IC&PF would have followed the same trend in the cyclicality of their investment if Solvency II would not have been introduced, the coefficient β_1 thus identifies the effect of Solvency II on

[42] The log change in nominal holdings is calculated as the log change of the raw holdings, i.e. the change in the nominal value of holdings as defined by the currency of denomination. Thus, price and exchange rate movements do not affect the nominal amount held and a change in nominal holdings can be attributed solely to an active decision to shift holdings.

the cyclicality of insurer's investment behavior.

Further, the coefficients α_0 and α_1 specify the intercept and the slope for the non-treated group prior to the introduction of Solvency II. δ_0 and δ_1 indicate the difference in the intercept and the slope of the treated group before Solvency II, thereby capturing any existing pre-treatment differences between the treated and control group. The difference in the intercept and the slope in the pre- and during-treatment period for the untreated group is given by γ_0 and γ_1. This accounts for any common time trends which are not caused by the treatment.

In addition, with unobserved security specific effects potentially influencing the investment decisions of insurance companies and pensions funds differently prior and after the introduction of Solvency II, a fixed effects panel estimation with standard errors being clustered on the security-depositor level is used[43].

5.3 Results

Having described the regression set-up, the results of the baseline specification as presented in Table 2 (Column 1) provide evidence for the investment behavior of insurance companies having become slightly more pro-cyclical after the introduction of Solvency II.

Table 2: Baseline Regression Results

VARIABLES	(1) $\Delta Holdings$	(2) $\lvert\Delta Holdings\rvert$
Sol	-0.008***	-0.019***
	(0.001)	(0.001)
IC*Sol	-0.005***	0.009***
	(0.002)	(0.002)
ΔP	0.015	
	(0.015)	
IC*ΔP	-0.057***	
	(0.021)	
Sol*ΔP	-0.029	
	(0.019)	
IC*Sol*ΔP	0.051**	
	(0.025)	
Constant	0.007***	0.040***
	(0.000)	(0.000)
Observations	615,782	616,215
R-squared	0.001	0.000
Security-Depositor FE	Yes	Yes

Robust standard errors in parentheses (clustered on Security-Depositor level):
*** p<0.01, ** p<0.05, * p<0.1. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16)

The coefficient of interest on the interaction term of treatment group, treatment period and price change is statistically significant different from zero at the 5% level, but only to a very small positive economic magnitude. It indicates that a price increase (or a price drop) in a certain security by 10% would increase (decrease) an insurer's holdings of this security by 0.51%

[43] In the baseline regression, security and depositor fixed effects are applied, i.e. instead of including a treatment group dummy potentially existing differences between insurers and pension funds are captured as depositor fixed effects.

compared to the counter factual scenario where Solvency II would not have been introduced. This corresponds to an increase (decrease) in holdings of 132.000 €[44] on average for an asset seeing a 10% price increase (decline). Thus, there is evidence that insurers' investment strategy became slightly more that of a momentum trader which buys if prices are increasing and sells if prices are falling. Yet, even if the price was to increase by 14% which equals approximately the 99% percentile of the log change in price observed in the whole data (a decrease of 17% corresponds to the 1% percentile), the increase in holdings that can be ascribed to Solvency II would only equal about 0.71% (0.87% for a decrease). On average, this reallocation of holdings would equal an investment of 185.000 € (or divestment of 226.000€). If one was to set the effect obtained in relation to the results found by Timmer (2016) who studies the cyclicality of German IC&PF's investment behavior from 2005 until 2014, the counter-cyclicality of insurers' investment allocation would be reduced by approximately 8%[45] under Solvency II. Hence, there is evidence in favor of the hypothesis stated in section 4, but the increase in pro-cyclicality is very small in economic terms. A possible explanation could by the widespread application of measures dampening the volatility of available capital resources. Another explanation could be that many insurers have been operating with a non-binding SCR coverage ratio during the first quarter of 2016[46] (BaFin, 2016a). Hence, changes in their SCR coverage ratio might not require them to react immediately with a change in asset allocation. However, as soon as insurers target their own non-regulatory SCR ratio above the mandatory level[47], there are again the same incentives to act pro-cyclically. Thus whether the official SCR coverage ratio is binding or not might not have full explanatory power about the strength of the pro-cyclicality incentivizing effects of mark-to-market accounting rules and risk-based capital requirements (ESRB, 2015).

Additionally to the baseline regression, it is also tested whether Solvency II leads to a larger fluctuation in insurance companies' holdings. This complements the findings of the baseline regressions, allowing a better assessment of the impact of Solvency II on financial stability. As discussed in section 5.1.2, IC&PF generally tend to be less active traders, shifting relatively large quantities at fewer points in time. Yet the increased volatility of insurers'

[44] Taking the average amount held by insurers after the introduction of Solvency II times 0.51%

[45] As described in section 2, Timmer (2016) finds that insurers react to a 10% price with a 6.5% decrease in holdings. Hence, the effect found in this thesis would reduce the counter-cyclicality by 0.51%/6.5% $\approx$ 8%. However, this comparison has to be interpreted with caution, since Timmer (2016)'s result does not distinguish between insurers and pension funds, but analysis their investment behavior jointly. Further, despite using the same database the study is based in a slightly different setting. Given that the regression design applied in this thesis is primarily designed to identify a causal effect of Solvency II on the cyclicality of insurers' investment behavior, causal statements about the overall cyclicality of insurers' investment allocation cannot be derived without additional assumptions being fulfilled.

[46] Data for the other quarters of 2016 is not available to the public, yet.

[47] Following for instance from their Own Risk and Solvency Assessment under Pillar II

capital coverage ratio that is likely to follow from Solvency II (see subsubsection 4.1.3), could incentivize insurance companies to trade more often or transact even larger quantities. In combination with a pro-cyclical investment behavior, this could increase asset price volatility with potentially destabilizing consequences for financial markets (see subsubsection 4.1.3). To analyze whether the introduction of Solvency II led to an increased fluctuation of insurer's holdings, the baseline regression above is slightly modified: The dependent variable is replaced to be the absolute log change in nominal holdings and the right-hand side of the regression equation consists now only of the interaction term of treatment group and treatment period and the corresponding dummies.

$$|\Delta Holdings_{i,j,t}| = \alpha_0 + \delta_0 IC + \gamma_0 Sol + \beta_0 IC * Sol + \epsilon_{i,j,t}$$

The coefficient of interest β_0 on the interaction term indicates that insurers' security holdings saw a slightly increased fluctuation after Solvency II compared to pension funds' holdings (Table 2, Column 2). On average, the absolute change in insurers' holdings increased by 0.009% after the introduction of Solvency II compared to pension funds.

Summing up, the main result provides evidence that insurance companies became a slightly less stabilizing actor in financial markets compared to a counter factual scenario where Solvency II would not have been introduced. In case insurers are acting overall pro-cyclically following the introduction of Solvency II, the complementing results reinforces this effect[48].

5.4 Discussion of the results: Robustness checks & potential biases

As described in section 5.2, the main identifying assumption which allows for a causal interpretation of the effect of Solvency II that has been found in the baseline specification is the CTA. Section 5.1.2, discussing the suitability of pension funds as a control group, provides arguments why the CTA is likely to hold. Yet, there are other potential sources of biases which are discusses below. Further, several robustness checks, whose results mainly support the outcome of the baseline regression, are described.

[48]As stated before, the design of the baseline regression does not allow to make causal statements about the overall cyclicality of insurers' investment behaviour without ensuring that additional assumptions are valid. Hence, the complementing result presented here has to be interpreted as having potentially adverse effects for financial stability in case insurers are acting overall rather pro-cyclical.

5.4.1 Reverse causality

An issue of concern is a potential bias that could arise from reverse causality: Prices could not only lead to a change in holdings, but a change in holdings could also induce a shift in prices. Hence, the baseline equation aiming at measuring the effect of a price change on holdings could be distorted by prices being simultaneously determined through a change in securities demanded or supplied. Yet, the difference-in-differences set up might weaken this argument: The coefficient of interest β_1 aims at measuring whether a change in the price leads to a different reaction of insurance companies' holdings following the introduction of Solvency II for insurance companies relative to pension funds' reaction prior and during Solvency II. Thus, assuming that the impact of insurers' changes in holdings on prices has not changed relative to the impact of pension funds' changes in holdings on prices after the introduction of Solvency II, the potential reverse causality bias could be mitigated.

The relatively constant share of insurers' and pension funds' share of total (financial) assets of the financial sector (see Figure 2a in section 3.1 and Figure 5 in subsection A.2) supports this argumentation. While the relative amount of an insurer's asset holdings generally bears the potential for insurance companies to influence asset prices, thereby making them a source of systemic risk, did their share not increase substantially during the observation period. For instance, relative to pension funds, which saw their share of financial sector's total financial assets increase by 1 percentage point, the share of insurers' financial assets increased only by 0.1 percentage points more (Figure 5). Looking at total assets instead of financial assets, insurers experienced an increase in their share by 1.1 percentage points – 0.5 percentage points more than pension funds (Figure 2a).

The argumentation is further supported when looking at the specific securities studied in this analysis. For the domestic debt securities and shares captured by the SHS, insurers' and pension funds' share of the total amount in circulation remained at their 2013-level of 1.2% in 2016 for debt securities and decreased for shares from 1.8% to 1.4% (Deutsche Bundesbank, 2017). For foreign debt securities insurers' and pension funds' share increased slightly by 2.3 percentage points, while it decreased for foreign shares by 0.3 percentage points from 2013 to 2016[49]. Moreover, looking at the portfolio composition of IC&PF as presented in Figure 7, 8, 9 and 10 in subsection A.2, one can see that the exposure to a certain security class didn't increase substantially after Solvency II was introduced. Thus, insurance undertakings are unlikely to

[49]For foreign debt securities and shares it is only possible to derive insurers' and pension funds share of the foreign securities deposited at German depositing institutions, not from the total amount in circulation. Further, the share of foreign shares hold is based on market values while all other shares are based on nominal values.

have seen an increased potential to impact prices with their investment allocation decision following the introduction of Solvency II in comparison with pension funds.

Another approach to reduce a potential simultaneity bias could be the use of the lagged change in prices rather than the contemporaneous price change, refraining however from the assumption that a forward-looking price curve perfectly anticipates and takes into account future holdings changes. Table 3 shows the results of the regression with lagged log changes in price. The coefficient of interest β_1 becomes negative, but statistically insignificant. This might be caused by the potentially too large time period in between the price change and the potential change in holdings observed: Insurers might react faster than a month after the price change occurred under Solvency II.

5.4.2 Regression specification

Another source of bias could be an incorrectly specified regression. Thus, it is tested whether alternative regression specifications such as pooled OLS, random effects and various models absorbing different types of fixed effects lead to different results (Table 4). Overall, the results of the baseline regression proof to be robust against potential issues of misspecification.

If one was to assume that the unobserved security specific characteristics are uncorrelated with the regressors[50] and thus applies a random effects or pooled OLS model, the coefficient of interest β_1 would be marginally smaller, but still positive and statistically significant. However, the outcome of the Hausmann Test suggests that the hypothesis of the assumptions underlying the Random Effects Model being valid can be rejected at a 1% significance level. This supports the usage of a model accommodating fixed rather than random effects in the baseline regression.

To continue, it is studied whether estimates of the standard errors vary substantially if other assumptions on the homoscedasticity and serial correlation of idiosyncratic errors are made. In the baseline regression, standard errors are clustered on the security-depositor level, i.e. it is allowed for heteroscedasticity and intragroup correlation of observations on the security-depositor level[51]. In the context of a difference-in-differences study and a security-depositor fixed effects regression, it is plausible to assume that a correlation of idiosyncratic errors within the security-depositor clusters prevails. Still, in case the stricter assumption of homoscedastic and serially uncorrelated idiosyncratic errors would be valid and conventional non-robust

[50] A fixed effects model assumes a correlation between the unobserved effects and the regressors.

[51] Using conventional standard errors as derived from asymptotic theory or standard errors that are more robust (relaxing certain assumptions from classic asymptotic theory) affects the estimation of the variance-covariance matrix corresponding to the estimated coefficients. However, it doesn't affect the estimated coefficients.

standard errors could be consistently estimated, their estimate would only be slightly smaller and the coefficient of interest would become statistically significant at the 1%[52]. If one was to assume in a second scenario that idiosyncratic errors are heteroscedastic, but only serially correlated on the security level, this would lead to a minimally reduced estimate of the standard error. Hence, using standard error estimates which would be valid under stricter assumptions about the idiosyncratic errors returns only slightly smaller estimates of the standard error than in the baseline regression[53].

In addition, the robustness of the baseline results towards the absorption of different types of fixed effects is tested. Using only security fixed effects, the coefficient indicating the effect of Solvency II on the cyclicality of insurers' investment behavior becomes marginally smaller, but points overall into the same direction. Demeaning along the time dimension, i.e. assuming that unobserved effects prevail and are correlated within one reporting month rather than for one security over time, the coefficient of interest would be in a similar economic range, but would no longer be statistically significant at a 10% level. This might be the case because one loses too much of the variation over time, estimating the equation mainly based on the variation within one time period. The same is likely to be the case when applying depositor-time fixed effects.

5.4.3 Outliers

In a second check, the robustness towards outliers is tested by winsorizing or trimming both the dependent and independent variables (Table 5). Winsorizing or trimming the log change in nominal holdings at the 0.01%/ 99.99% level leads to $\beta_1$being in a similar economic range and still being statistically significant at the 5% level. Winsorizing or trimming the dependent variable at the 1%/99% level returns a lower estimate of $\beta_1$which only remains statistically significant for the winsorized variable. This might due to the large mass of observations with a zero change in holdings – cutting off too much of the variation in the dependent variable at both ends of the distribution could thus lead to an insignificant estimate. Hence, one can conclude that winsorizing or cutting off the most extreme changes in holdings doesn't affect the result of the baseline regression. However, further trimming the distribution seems to minimize (or even vanish) the impact of Solvency II which appears to be driven by the variation at the

[52]This finding is in line with Bertrand, Duflo, and Mullainathan (2004) who find that using conventional standard errors in a difference-in-differences setting often understates the standard errors as usually existing serial correlation is ignored.

[53]Kézdi (2004) shows that clustered robust standard errors behave well for a medium-size number of clusters, however a substantial bias can arise in a setting with only 10 groups. Thus it is not tested for clustering standard errors only on the depositor level, i.e. only on two groups.

ends of the distribution of the change in holdings.

Winsorizing the log change in price at the 0.01%/99.99% level leads to a similar result as in the baseline regression, trimming the variable at this level turns the effect however statistically insignificant. Winsorizing the independent variable further to the 1%/99% level leads also to statistically insignificant results. Yet, trimming or winsorizing the price variable at the 5%/95% level returns again a statistically significant effect that is substantially larger than in the baseline regression, i.e. for the trimmed variable a price increase of 10% would lead on average to an increase in insurer's holdings of 3.5% compared to a scenario without Solvency II. Thus, the results do not seem to be driven completely by the tails of the distribution of the price variable, but they seem to be sensitive to arbitrarily replacing or cutting of certain parts in the end of the distribution.

5.4.4 Anticipation of the regulation

Another concern about the robustness of the result could be seen in a potential anticipation of the new regulation: The transition towards the new regulatory regime might already have had an impact on the investment behavior of insurance companies prior to the actual enforcement of the new regulations with insurance companies preparing to comply with the new standards. Whilst insurance companies had all the information about the new regulatory regime only available by the end of 2015 (see subsection 3.3), they still might have been able to anticipate many of the major changes. If insurance companies already heavily adjusted their investment behavior in the months prior to the introduction of Solvency II, this would lead to distortions and the baseline regression would fail to properly identify the effect of Solvency II on the cyclicality of an insurer's investment behavior. This motivates an analysis of the robustness of the results towards the exclusion of different transitory periods. The results for the exclusion of four different periods are reported in Table 6. Different mile stones on the transition towards the new regulatory regime are chosen as starting points for the exclusion periods: The first one excludes all months past the submission of the second set of ITS of EIOPA to the European Commission at the beginning of July, 2015 (EIOPA, 2015). The second set of the guidelines which was officially approved by the Commission in the months following the submission forms one of the latest substantial parts of implementation details, providing insurers with the last information about Solvency II. The second exclusion period starts with the adoption of the first set of ITS after February 2015 (European Commission, 2017a). The third starting point is set to November 2014, the month following the submission of the first set of ITS on October 31st, 2014 (EIOPA, 2014) and the adoption of the Commission Delegated Regulation which constitutes the core of Solvency II's prudential rule book on October 10th, 2014 (DA (EU) 2015/35, 2015). The last starting point creates a pre-treatment and treatment period of equal length.

Overall, the results of the four regressions support the findings of the baseline setting. The coefficient on the interaction term of treatment group, treatment period and the log change in price is statistically significant at the 5% level for all four exclusion periods. Its economic margin ranges from a 0.53% increase in insurers' holdings following a 10% increase in the price (Transitory period November 2014 until December 2015) to a 1% increase (Transitory period January 2014 until December 2015) that can be ascribed to the introduction of Solvency II. Thus, excluding different time periods to avoid potential distortions following from the transition towards the new regulatory regime, indicates a similar or even stronger effect of Solvency II compared to the baseline regression. Since insurers might have shifted some of their holdings in preparation for Solvency II at least in the last months prior to the regulation entering into force, the effect of Solvency II on the cyclicality of insurers investment allocation might be slightly larger than indicated in the baseline regression.

5.4.5 Placebo effect

To provide evidence in favor of the CTA, a difference-in-differences study of a "placebo" law is performed. If such a "placebo " test was to find a significant effect, unobserved differences in the trends of the treatment and control group are likely to exist and the difference-in-differences study of the effect of Solvency II might simply be measuring some pre-existing trend differences.

To conduct the "placebo" test, different artificial treatment periods are defined and the effect of this "placebo" treatment on the pro-cyclicality of insurers' investment behavior is analyzed in the standard difference-in-differences setting (Table 7). More specifically, a random point in time prior to the introduction of Solvency II is chosen as the starting point of the artificial regulation, dividing the sample into an artificial pre-treatment period (from January 2013 until the random starting point) and an artificial treatment period (from the random starting point until a random ending point). Generally, it would be desirable to conduct a "placebo" treatment study long before the introduction of a new regulation to minimize the likelihood of the placebo study already being influenced by the introduction of the new regime. Unfortunately, the holdings of IC&PF are reported separately in the Security and Holdings Statistic only from 2013 onwards, making it possible to study a "placebo" treatment only already rather close to the actual introduction of Solvency II. Being aware of this limitation, the statistically insignificant results of the two placebo studies presented in Table 7 provide evidence that the results obtained in the actual study can be interpreted as causal effects of the change in the insurance regulation.

The first “placebo” study was chosen to be as early as possible before major details of the Solvency II regulation were announced during the observation period available. Therefore, the ending point of the “placebo” test was set to be the month of the adoption of the Omnibus II Directive in April 2014 (Dir 2014/51/EC, 2014). To create a pre-treatment and treatment period of equal length, September 2013 is selected as the starting point of the artificial treatment period. The second “placebo” study was set to be as late as possible before the last major implementation details of the Solvency II regulation were submitted, i.e. the second set of the ITS in the beginning of July 2015 (EIOPA, 2015). Creating again a pre-treatment and treatment period of equal length, the starting point of the “placebo” regulation is chosen to be April 2014. The hypothesis that the effect estimated in the baseline regression can be attributed to the Solvency II regulation is supported by the fact that both “placebo” studies do not find a statistically significant impact of the artificial regulation.

5.4.6 Confounders violating CTA

In a last set of checks, the robustness of the results towards including possible confounding variables that could violate the CTA is analyzed. The CTA described in subsection 5.2 can be relaxed to assuming a common trend conditional on certain confounding variables. For instance, some macroeconomic trends jointly influencing prices and investment decisions could have impacted insurance companies differently than pension funds after 2016 with the differential effect not being caused by the introduction of Solvency II. Capturing such macroeconomic trends, the exchange or inflation rate and the GDP growth in the country of the issuer could be such possible confounding variables.

Table 8 reports the results for the regressions controlling for the exchange rate, the inflation rate, GDP growth and both, the inflation rate and GDP growth. When including the exchange rate, the coefficient of interest turns to be statistically insignificant (column 1). However, this is likely to be due to the case that matching the exchange rate information to the individual securities reduces the sample size to only percent quoted securities (for unit quoted securities there is no information on the currency denomination available). Running a regression on only percent quoted securities leads to almost identical results. Controlling for the inflation rate only marginally changes the results of the baseline regression (column 2). Adding GDP growth as a control variable leads to the effect found in the baseline scenario to become more than twice as large (column 3). Compared to the counterfactual scenario where Solvency II would not have been introduced, a 10% price increase is associated with a 1.19% increase in insurers’ holdings.

A similar coefficient is obtained when controlling jointly for GDP and inflation growth (column 4). This supports the general direction of the effect found in the baseline regression and can be seen as evidence that the validity of the CTA is strengthened by the inclusion of possible confounders such as GDP growth. Controlling for these confounders, the effect of Solvency II on the cyclicality of insurance companies investment behavior might actually be twice as large than found in the baseline regression.

Despite security-level unobserved characteristics already having been taken into account by the application of security-level fixed effects, certain time varying security characteristics could still act as possible confounders violating the CTA. Thus, it is analyzed whether including controls for different security attributes such as issuer sector, security category, issuer country and nominal currency leads to substantially different results[54]. The results presented in Table 9 show almost identical results than in the baseline regression, providing evidence that these variables do not seem to confound the CTA.

6 Conclusion & Policy Recommendations

Being one of the largest institutional investors, insurance undertakings have the capability to reinforce or attenuate market and asset price movements. Given the long-term investment horizon following from their liability structure, insurers theoretically have the potential to override short-term fluctuations and act as a stabilizing force on financial markets. However, other factors such as the regulatory environment can incentivize pro-cyclical investment behavior, thereby increasing insurers' contribution to systemic risk through the pro-cyclicality channel (Papaioannou et al., 2013). The recent introduction of a market consistent and risk-based regulatory regime in Europe thus provides an interesting case to study the effect of a change in the regulatory framework on the investment behavior of a generally long-term investor.

Using a unique micro data set that allows to study insurers' investment behavior on the security level, this study provides evidence that pro-cyclicality in the insurance sector slightly increased after the introduction of Solvency II. When controlling for possible confounders to the CTA such as GDP growth or when excluding transitory periods during which insurers potentially already reacted to the upcoming regulatory change, the effect found in the baseline regression becomes more pronounced. The direction of the result obtained confirms theoretical studies that expect mark-to-market valuation and risk-based capital requirements to incentivize

[54] Generally, these attributes should not vary over the lifetime of a security (and should thus be demeaned in the fixed effects estimation), yet, the data collection process leads to some re-categorizations for a small number of securities during the observation period studied.

pro-cyclicality and is in line with the findings of Ellul et al. (2015). Yet, the economic magnitude is relatively small. This could be caused by the widely spread application of pro-cyclicality dampening measures included in Solvency II.

To continue, this thesis provides policymakers with first indicative evidence that the introduction of Solvency II is not likely to cause a major increase in insurers' contribution to systemic risk through the pro-cyclicality channel. However, to derive more conclusive results, it might be interesting to consider non-linearities in the effect of Solvency II and to simulate insurers' investment behavior over the whole business cycle, since the effect of mark-to-market accounting and risk-based capital requirements might be stronger in a severe downturn when there is a sharp decline of available relative to required capital. Furthermore, a relatively high share of insurance undertakings is still applying transitional measures. If these measures are phasing out during the following years, policymakers might be required to act in order to prevent the build up of increased systemic risk in the insurance sector.

For instance, Solvency II is lacking a purely macro-prudential tool that allows supervisory authorities to require e.g. the build up of buffers or to relax capital requirements in a discretionary manner during a severe downturn (ESRB, 2015). The inclusion of such an instrument could help to counteract negative consequences for financial stability potentially following from mark-to-market accounting and a risk-based capital regime. While allowing for the application of measures such as the volatility or matching adjustment also softens market swings, the permanent nature of these measures could lead to insurers anticipating their adjustment effects in a downturn and therefore increasing the risk taking in boom periods (ESRB, 2015).

Moreover, another focus could be to limit the cycle-dependency of risk assessments, working on the improvement of forward-looking risk measurement (Borio et al., 2001). As more "cycle-neutral" capital requirements might track available capital resources more closely, translating such an enhanced risk measurement into adequate capital requirements could reduce the pro-cyclicality of the SCR coverage ratio and thus the incentives to invest pro-cyclically.

In addition, promoting an increased usage of (partially) internal models to calculate capital requirements would increase model heterogeneity. While this comes together with the need of more extensive supervision by the regulatory agency, this could limit the probability of a shock affecting insurers' SCR coverage ratios likewise. Thereby, the probability of such a shock triggering a simultaneous reaction of multiple insurers that could propagate a price spiral could be reduced (Danielsson, 2013).

While this thesis has been - to the best of my knowledge - the first to study the effect of Solvency II using unique security-level data for the German insurance sector, future research could aim at mitigating the concerns about reverse causality in the current estimation strategy by applying an instrumental variable approach. Further, it might be interesting to use the variation of previously existing regulatory regimes in Europe prior to the introduction of Solvency II to disentangle the effects of the pro-cyclicality incentivizing and dampening components of Solvency II.

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A Appendix

A.1 Data cleansing

To account for minor reporting inconsistencies in the original data set, a small number of observations are dropped for securities that are already officially matured or that are reported as being part of a repurchase agreement. Further, a few observations for securities that change their currency of denomination relative to the previous month are dropped[55]. Including them would lead to there being a – sometimes very large[56] - price change for a security from one month to the other which actually didn't happen in reality. Excluding not only observations with a change in denomination relative to the previous month, but excluding all observations for one security that changes its currency of denomination at least once during the whole observation period doesn't change the main results.

A.2 Figures & Tables

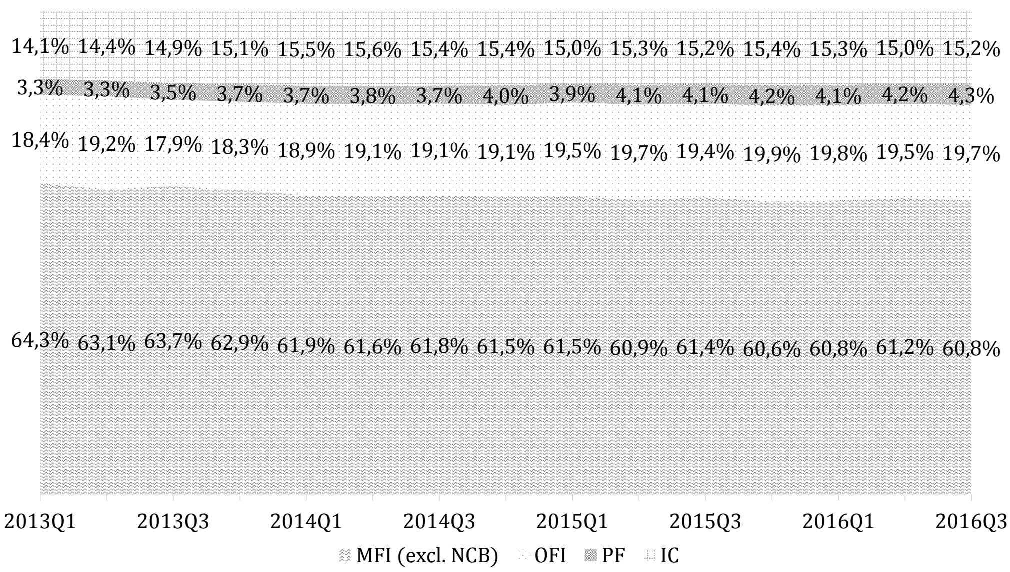

Figure 5: Share of Total Financial Sector Financial Assets. *Source: Author rendering of data from QSA statistics (ECB, 2017)*

[55]Given that information on security attributes such as currency denomination is obtained from various data sources, it is possible that inconsistencies occur due to a certain security being labeled as e.g. Euro-denominated by some sources and falsely labeled as Dollar-denominated by another source. The currency denomination found in the SHS generally takes on the value of the majority of the sources. If the currency reported by the majority switches from one reporting month to another, this leads to the inconsistency described. Much effort is put onto minimizing these irregularities, but a few cases remain.

[56]For instance, if the currency of denomination changes from Yen to Dollar or from a percent-quoted to a unit-quoted security.

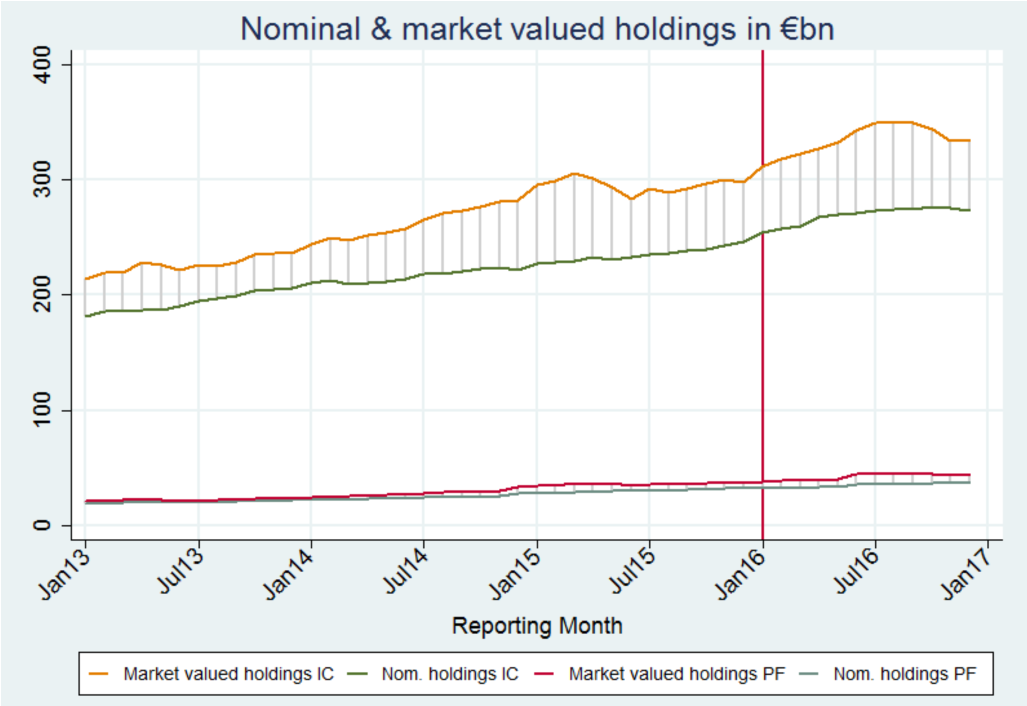

Figure 6: Development Holdings IC&PF. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

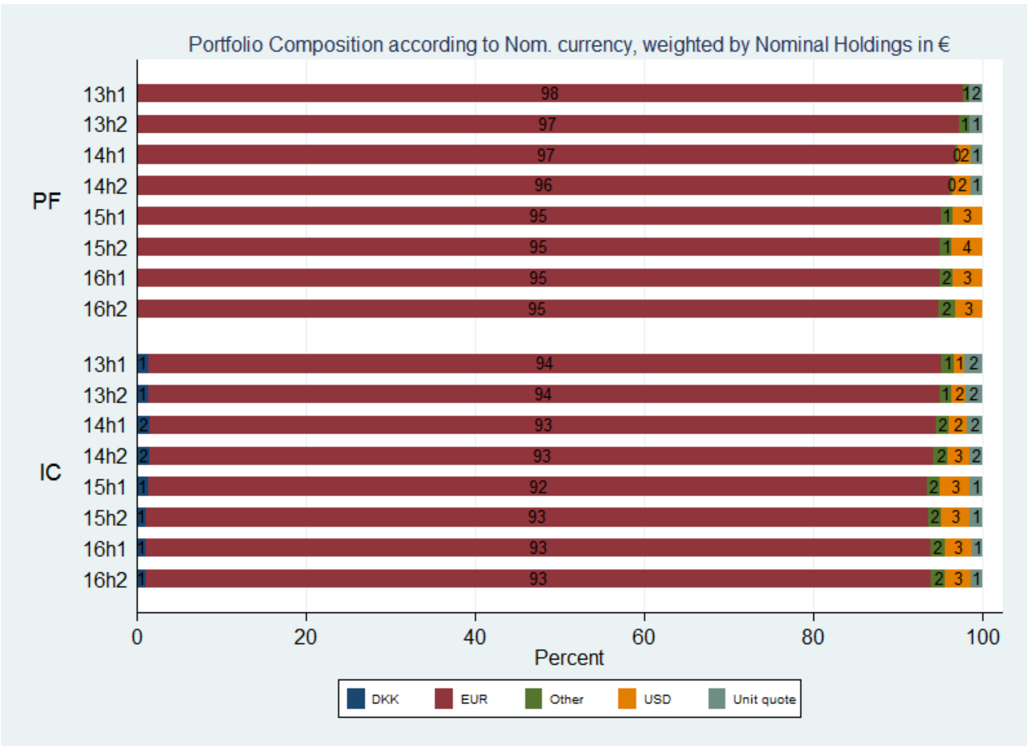

Figure 7: Weighted Portfolio Composition according to Nominal Currency. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

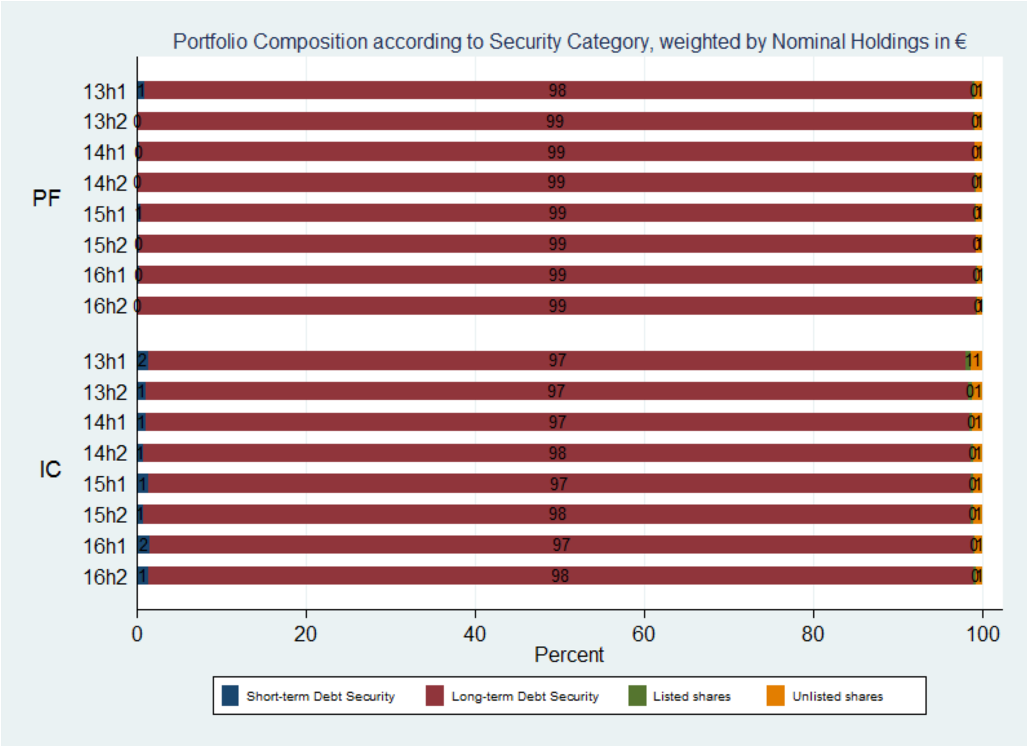

Figure 8: Weighted Portfolio Composition according to Security Category. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

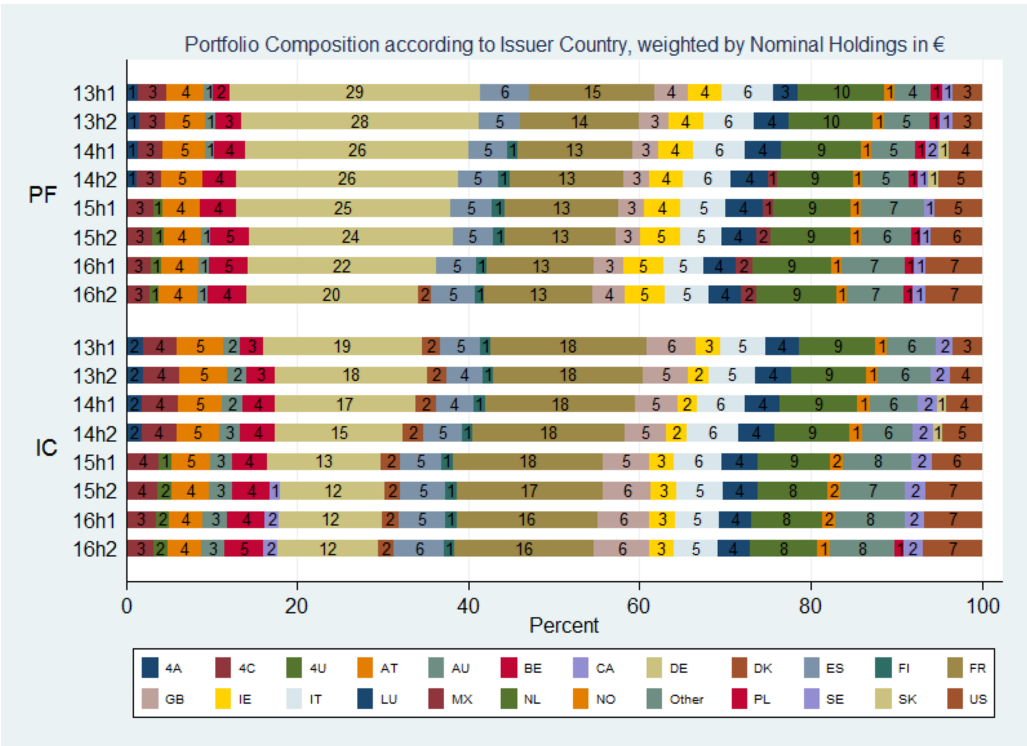

Figure 9: Weighted Portfolio Composition according to Issuer Country. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

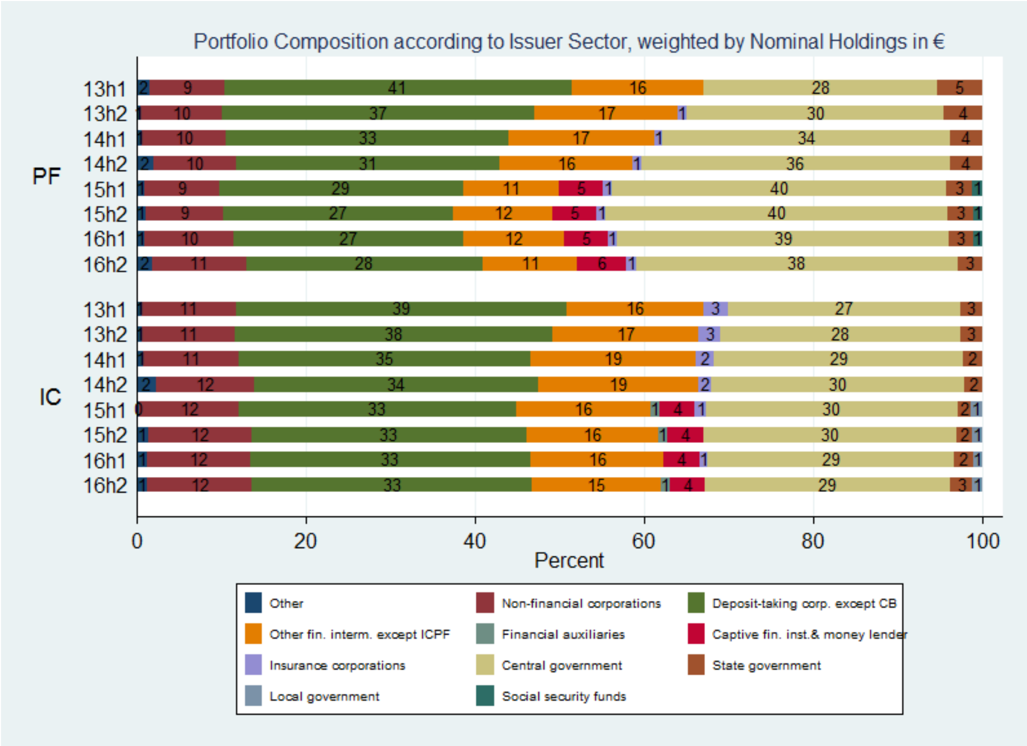

Figure 10: Weighted Portfolio Composition according to Issuer Sector. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

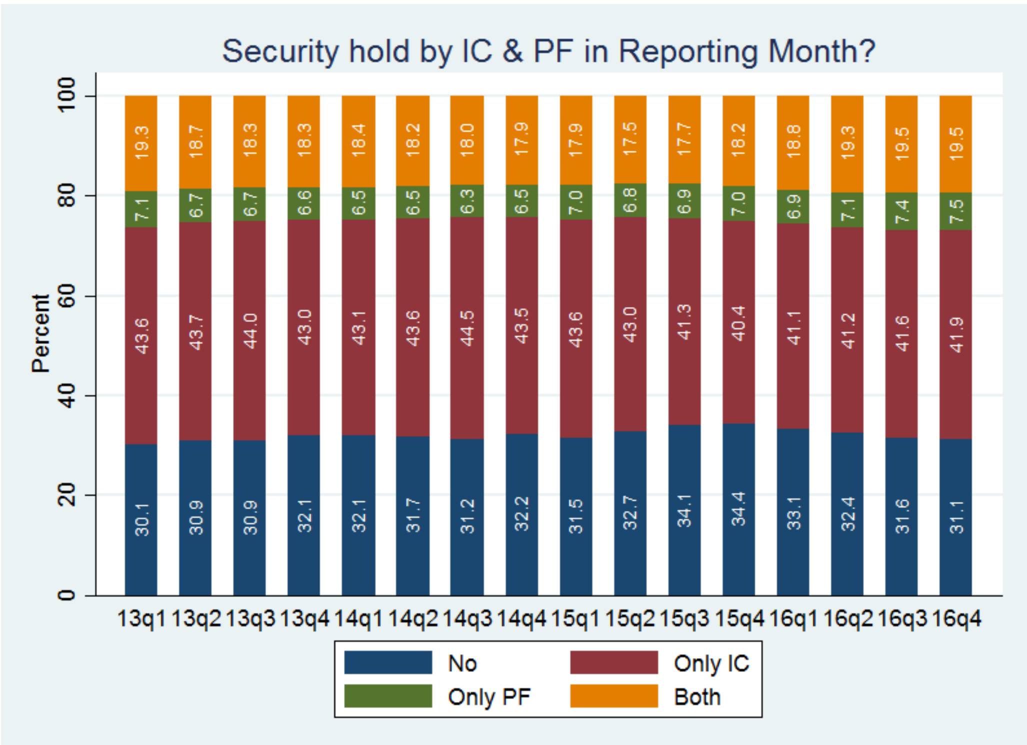

Figure 11: Portfolio Similarity IC&PF on Security Level. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

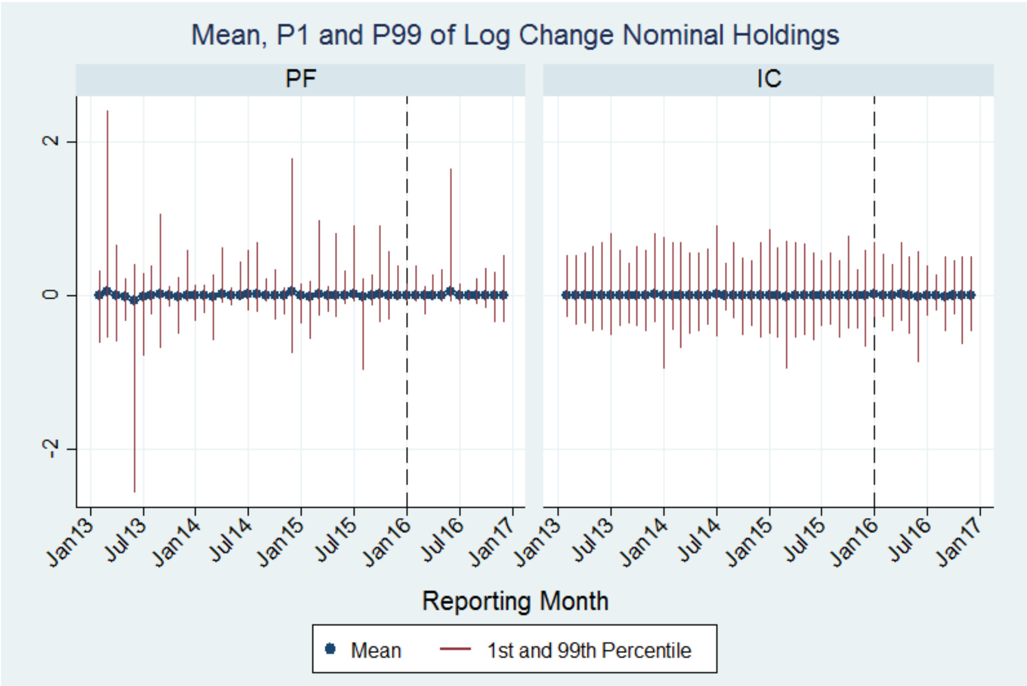

Figure 12: Mean, 1% & 99% of log change in nominal holdings. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

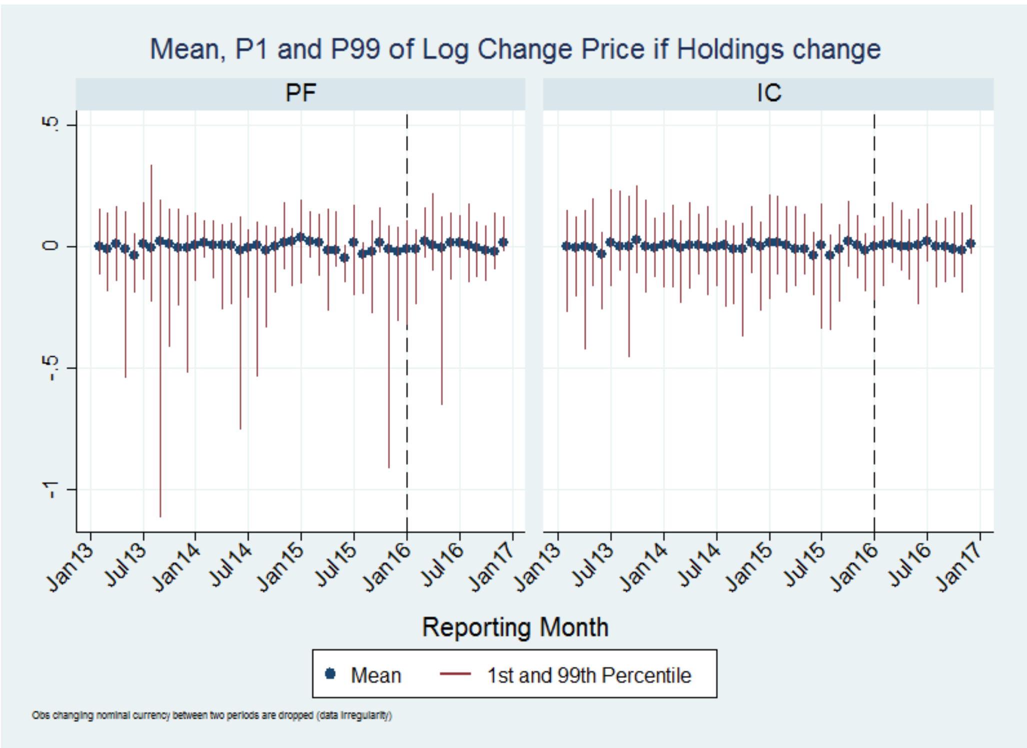

Figure 13: Mean, 1% & 99% of log price change if change in holdings occurs. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

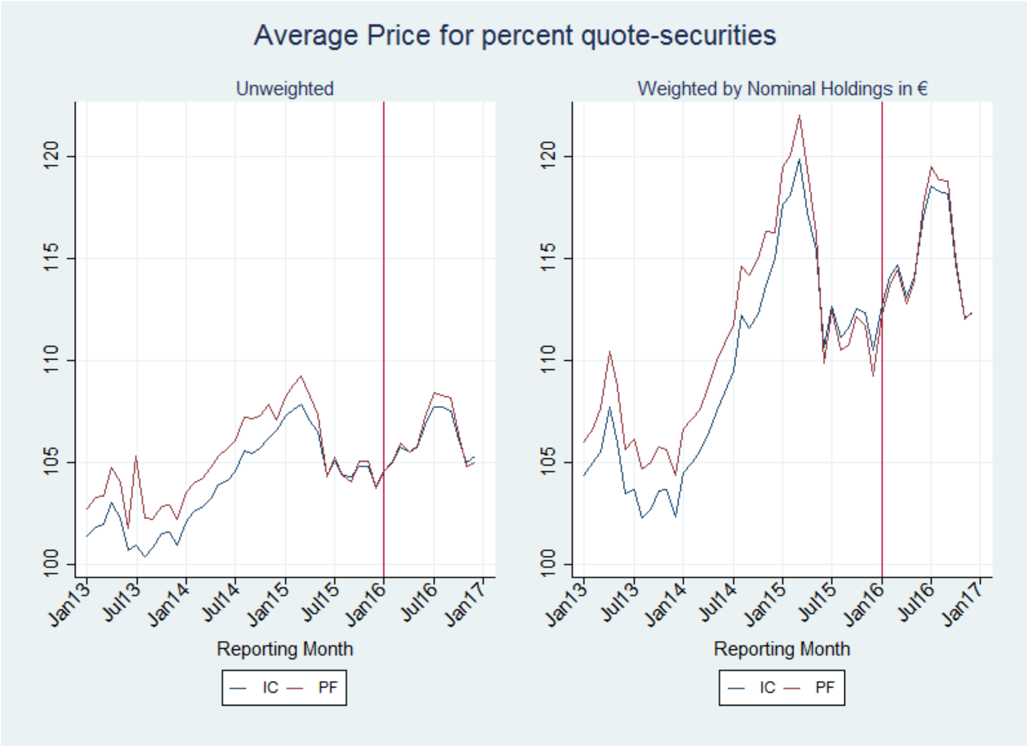

Figure 14: Average Price for percent-quoted securities. *Source: Author rendering of data from the Deutsche Bundesbank SHS (Jan 13 - Dec 16)*

Table 3: Lagged Price

VARIABLES	(1)	(2)
Sol	-0.006***	-0.003
	(0.001)	(0.006)
IC*Sol	-0.004**	-0.024***
	(0.002)	(0.007)
ΔP_{t-1}	-0.020**	-0.011
	(0.008)	(0.013)
IC*ΔP_{t-1}	0.022**	-0.006
	(0.010)	(0.017)
Sol*ΔP_{t-1}	0.005	-0.026
	(0.009)	(0.027)
IC*Sol*ΔP_{t-1}	-0.013	0.021
	(0.012)	(0.049)
Constant	0.005***	0.008***
	(0.000)	(0.001)
Observations	594,898	188,269
R-squared	0.000	0.001
Security-Depositor FE	Yes	Yes
Controls	No	Inflation
		GDP Growth

The dependent variable is the log change in nominal holdings. The independent variable log change price is lagged by one month. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16)

Table 4: Alternative Regression Specifications

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
IC	0.000	0.000			-0.001	0.000	
	(0.001)	(0.001)			(0.001)	(0.002)	
Sol	0.004***	-0.002**	-0.008***	-0.008***	-0.007***		
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)		
IC*Sol	-0.006***	-0.006***	-0.005***	-0.005***	-0.006***	-0.006	
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.005)	
ΔP	0.013	0.014	0.015**	0.015	0.012	0.011	0.009
	(0.016)	(0.015)	(0.007)	(0.015)	(0.015)	(0.019)	(0.019)
IC*ΔP	-0.058***	-0.056***	-0.057***	-0.057***	-0.053***	-0.057**	-0.054**
	(0.021)	(0.021)	(0.008)	(0.021)	(0.021)	(0.027)	(0.027)
Sol*ΔP	-0.024	-0.027	-0.029*	-0.029	-0.024	-0.022	-0.024
	(0.019)	(0.019)	(0.016)	(0.019)	(0.019)	(0.022)	(0.022)
IC*Sol*ΔP	0.046*	0.048**	0.051***	0.051**	0.044*	0.046	0.048
	(0.025)	(0.024)	(0.018)	(0.024)	(0.024)	(0.030)	(0.030)
Constant	0.003***	0.007***	0.007***	0.007***	0.007***	0.004**	0.004***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.002)	(0.000)
Observations	615,782	615,782	615,782	615,782	615,782	615,782	615,782
R-squared	0.000		0.001	0.001	0.037	0.001	0.002
FE	No - Pooled OLS	No - RE	Security-Depositor	Security-Depositor	Security	Time	Time-Depositor
Cluster	Security-Depositor	Security-Depositor	No	Security	Security	Time-Depositor	Time-Depositor

The dependent variable is the log change in nominal holdings. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16)

Table 5: Robustness towards outliers

VARIABLES	(1) Win 1%/99%	(2) Win 0.01%/99.99%	(3) Trim 1%/99%	(4) Trim 0.01%/99.99%	(5)	(6)	(7)	(8)	(9)	(10)
Sol	-0.005***	-0.008***	-0.002***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.007***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IC*Sol	-0.003***	-0.006***	-0.002***	-0.006***	-0.005***	-0.006***	-0.005***	-0.005***	-0.006***	-0.006***
	(0.001)	(0.002)	(0.000)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ΔP	0.001	0.015	-0.003	0.015						
	(0.006)	(0.015)	(0.002)	(0.015)						
IC*ΔP	-0.011*	-0.056***	-0.001	-0.049***						
	(0.006)	(0.021)	(0.002)	(0.019)						
Sol*ΔP	-0.012	-0.029	0.000	-0.028						
	(0.009)	(0.019)	(0.002)	(0.019)						
IC*Sol*ΔP	0.017*	0.052**	0.002	0.048**						
	(0.009)	(0.024)	(0.002)	(0.023)						
ΔP Win 1%/99%					0.086***					
					(0.030)					
IC*ΔP Win 1%/99%					-0.145***					
					(0.036)					
Sol*ΔP Win 1%/99%					-0.110**					
					(0.043)					
IC*Sol*ΔP Win 1%/99%					0.051					
					(0.057)					
ΔP Trim 1%/99%						0.156***				
						(0.036)				
IC*ΔP Trim 1%/99%						-0.197***				
						(0.044)				
Sol*ΔP Trim 1%/99%						-0.176***				
						(0.050)				
IC*Sol*ΔP Trim 1%/99%						0.095				
						(0.069)				
ΔP Win 0.01%/99.99%							0.007			
							(0.011)			
IC*ΔP Win 0.01%/99.99%							-0.052***			
							(0.018)			
Sol*ΔP Win 0.01%/99.99%							-0.021			
							(0.016)			
IC*Sol*ΔP Win 0.01%/99.99%							0.044**			
							(0.023)			
ΔP Trim 0.01%/99.99%								-0.001		
								(0.013)		
IC*ΔP Trim 0.01%/99.99%								-0.034**		
								(0.017)		
Sol*ΔP Trim 0.01%/99.99%								-0.015		
								(0.017)		
IC*Sol*ΔP Trim 0.01%/99.99%								0.020		
								(0.023)		
ΔP Win 5%/95%									0.263***	
									(0.052)	
IC*ΔP Win 5%/95%									-0.358***	
									(0.063)	
Sol*ΔP Win 5%/95%									-0.274***	
									(0.068)	
IC*Sol*ΔP Win 5%/95%									0.227**	
									(0.090)	
ΔP Trim 5%/95%										0.390***
										(0.070)
IC*ΔP Trim 5%/95%										-0.484***
										(0.084)
Sol*ΔP Trim 5%/95%										-0.234***
										(0.087)
IC*Sol*ΔP Trim 5%/95%										0.353***
										(0.112)
Constant	0.006***	0.007***	0.003***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	615,782	615,782	603,479	615,681	615,782	609,400	615,782	615,715	615,782	575,284
R-squared	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.001
Security-Depositor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the log change in nominal holdings (winsorized/ trimmed at indicated levels for column 1-4). Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16)

Table 6: Robustness towards exclusion of different transitory periods

VARIABLES	(1)	(2)	(3)	(4)
Sol	-0.009***	-0.010***	-0.008***	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
IC*Sol	-0.007***	-0.007***	-0.008***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.003)
ΔP	0.019	0.023	-0.000	0.016*
	(0.019)	(0.021)	(0.008)	(0.009)
IC*ΔP	-0.068***	-0.077***	-0.061**	-0.110***
	(0.026)	(0.029)	(0.024)	(0.038)
Sol*ΔP	-0.034	-0.037	-0.012	-0.025*
	(0.023)	(0.024)	(0.013)	(0.014)
IC*Sol*ΔP	0.065**	0.071**	0.053**	0.100**
	(0.029)	(0.032)	(0.027)	(0.039)
Constant	0.008***	0.009***	0.010***	0.011***
	(0.000)	(0.000)	(0.000)	(0.001)
Observations	521,943	468,175	428,949	302,019
R-squared	0.001	0.001	0.001	0.001
Security-Depositor FE	Yes	Yes	Yes	Yes
Transitory Period	Jun15-Dec15	Feb15-Dec15	Nov14-Dec15	Jan14-Dec15

The dependent variable is the log change in nominal holdings. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16, excl. transitory periods)

Table 7: Placebo Treatment Test

VARIABLES	(1)	(2)
Placebo	0.003	0.001
	(0.002)	(0.001)
IC*Placebo	-0.013***	-0.013***
	(0.003)	(0.002)
ΔP	0.033**	0.012
	(0.016)	(0.008)
IC*ΔP	-0.062***	-0.092***
	(0.020)	(0.029)
Placebo*ΔP	-0.040**	0.019
	(0.020)	(0.035)
IC*Placebo*ΔP	-0.040	0.052
	(0.052)	(0.047)
Constant	0.007***	0.008***
	(0.001)	(0.000)
Observations	179,425	363,489
R-squared	0.001	0.001
Security-Depositor FE	Yes	Yes
Art. Pre-Treatment	Jan13-Aug13	Jan13-Mar14
Art. Treatment	Sep13-Apr14	Apr14-Jun16

The dependent variable is the log change in nominal holdings. Placebo is a dummy indicating the placebo-treatment period. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Jun 16)

Table 8: Including Macro Controls

VARIABLES	(1)	(2)	(3)	(4)
Sol	-0.009***	-0.008***	-0.011**	-0.005
	(0.001)	(0.001)	(0.005)	(0.006)
IC*Sol	-0.005***	-0.005***	-0.018***	-0.025***
	(0.002)	(0.002)	(0.007)	(0.007)
ΔP	0.005	0.015	0.061**	0.061**
	(0.004)	(0.016)	(0.027)	(0.027)
IC*ΔP	-0.009**	-0.057***	-0.115***	-0.115***
	(0.005)	(0.021)	(0.038)	(0.038)
Sol*ΔP	-0.015	-0.031	-0.092**	-0.090**
	(0.011)	(0.020)	(0.038)	(0.038)
IC*Sol*ΔP	0.023	0.054**	0.119**	0.117**
	(0.017)	(0.026)	(0.051)	(0.051)
Log Change Exchange Rate	-0.306***			
	(0.118)			
IC*Log Change Exchange Rate	0.447***			
	(0.143)			
Sol*Log Change Exchange Rate	0.432***			
	(0.160)			
IC*Sol*Log Change Exchange Rate	-0.365*			
	(0.193)			
Inflation		0.405***		0.033
		(0.152)		(0.457)
IC*Inflation		-0.427**		-0.230
		(0.210)		(0.564)
Sol*Inflation		-0.556***		-1.608**
		(0.195)		(0.693)
IC*Sol*Inflation		-0.026		2.113**
		(0.296)		(0.882)
GDP Growth			-0.002***	-0.002***
			(0.001)	(0.001)
IC*GDP Growth			0.001	0.001*
			(0.001)	(0.001)
Sol*GDP Growth			0.004*	0.003
			(0.002)	(0.002)
IC*Sol*GDP Growth			-0.000	0.001
			(0.003)	(0.003)
Constant	0.008***	0.007***	0.010***	0.010***
	(0.000)	(0.000)	(0.001)	(0.001)
Observations	527,683	592,369	191,308	191,061
R-squared	0.001	0.001	0.001	0.001
Security-Depositor FE	Yes	Yes	Yes	Yes
Controls	Exchange Rate	Inflation	GDP Growth	Inflation GDP Growth

The dependent variable is the log change in nominal holdings. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16). Data on GDP growth (quarterly change in real GDP in percent, linearly interpolated to monthly changes) and the inflation rate (calculated by taking the log change of the monthly CPI index with base year 2010, quarterly data for Australia, New Zealand and Papua New Guinea linearly interpolated since no monthly data available) is obtained from the IMF International Financial Statistics Data Base (2017). Monthly exchange rate information vis-à-vis the Euro is derived from the Statistical Data Warehouse of the ECB (2017) (the change in the exchange rate is calculated as the log change of the exchange rate. Information on historical exchange rates of former national currencies of the Euro-Area is retrieved from the ECB's homepage (European Central Bank [ECB], 2017)).

Table 9: Including Security Controls

VARIABLES	(1)	(2)	(3)
Sol	-0.021	0.001*	0.056**
	(0.014)	(0.000)	(0.023)
IC*Sol	0.023	-0.003	-0.014**
	(0.017)	(0.005)	(0.006)
ΔP	0.015	0.015	0.015
	(0.015)	(0.016)	(0.016)
IC*ΔP	-0.056***	-0.057***	-0.057***
	(0.021)	(0.021)	(0.021)
Sol*ΔP	-0.027	-0.031	-0.028
	(0.019)	(0.019)	(0.019)
IC*Sol*ΔP	0.050**	0.054**	0.050**
	(0.024)	(0.025)	(0.025)
Constant	0.005	0.063	0.002
	(0.007)	(0.058)	(0.005)
Observations	615,782	615,782	615,782
R-squared	0.001	0.001	0.001
Security-Depositor FE	Yes	Yes	Yes
Controls	Issuer Sector	Security Category	Issuer Country Nominal Currency

The dependent variable is the log change in nominal holdings. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered on the Security-Depositor level. Data: Deutsche Bundesbank SHS (Jan 13 - Dec 16)