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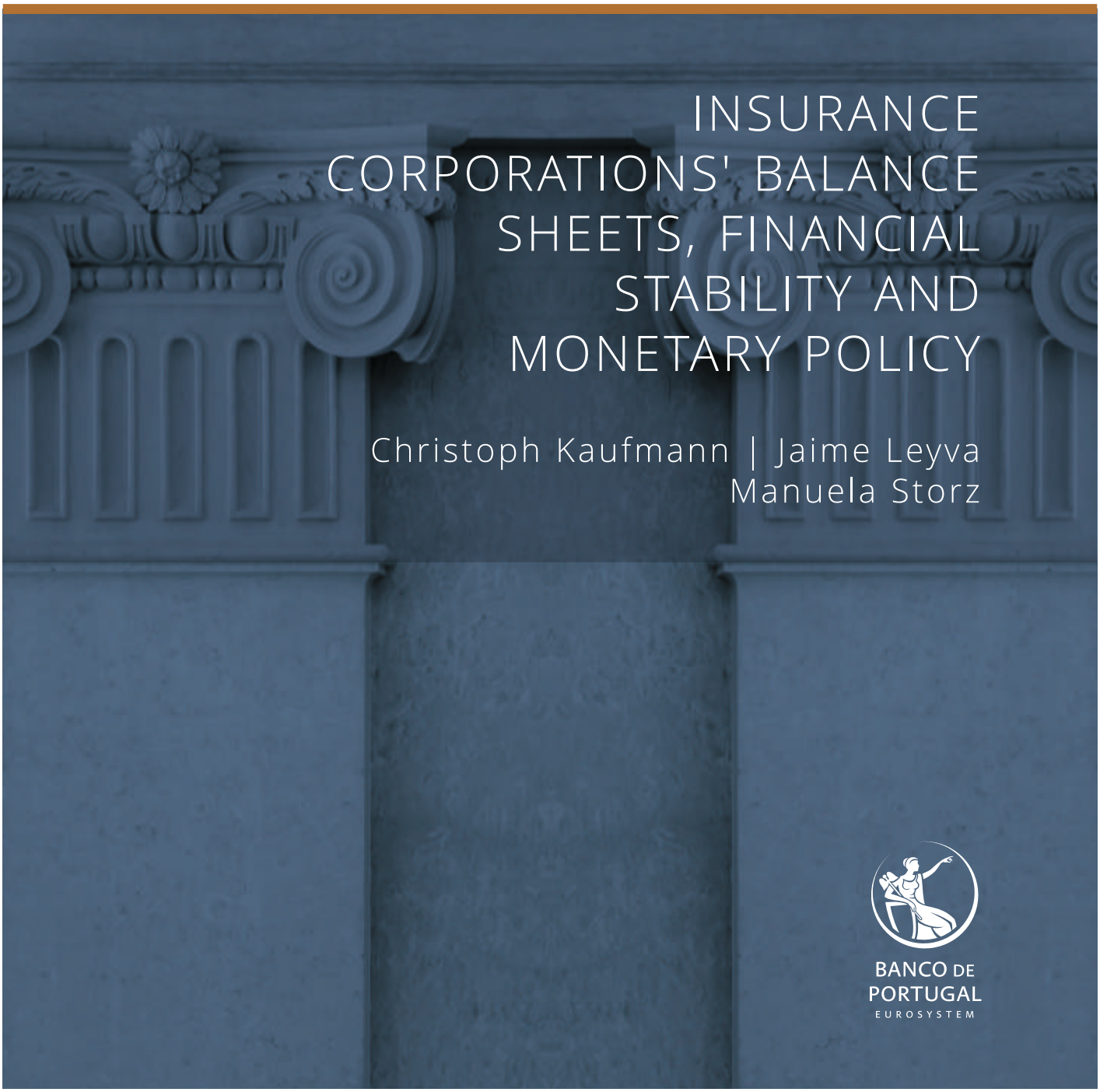

INSURANCE CORPORATIONS' BALANCE SHEETS, FINANCIAL STABILITY AND MONETARY POLICY

Christoph Kaufmann | Jaime Leyva
Manuela Storz

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This paper contains research conducted within the network "Challenges for Monetary Policy Transmission in a Changing World Network" (ChaMP). It consists of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the European System of Central Banks (ESCB).

ChaMP is coordinated by a team chaired by Philipp Hartmann (ECB), and consisting of Diana Bonfim (Banco de Portugal), Margherita Bottero (Banca d'Italia), Emmanuel Dhyne (Nationale Bank van België/Banque Nationale de Belgique) and Maria T. Valderrama (Oesterreichische Nationalbank), who are supported by Melina Papoutsi and Gonzalo Paz-Pardo (both ECB), seven central bank advisers and eight academic consultants.

ChaMP seeks to revisit our knowledge of monetary transmission channels in the euro area in the context of unprecedented shocks, multiple ongoing structural changes and the extension of the monetary policy toolkit over the last decade and a half as well as the recent steep inflation wave and its reversal. More information about it is provided on its website.

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Insurance corporations' balance sheets, financial stability and monetary policy

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Abstract
The insurance sector and its relevance for real economy financing have grown significantly over the last two decades. This paper analyses the effects of monetary policy on the size and composition of insurers' balance sheets, as well as the implications of these effects for financial stability. We find that changes in monetary policy have a significant impact on both sector size and risk-taking. Insurers' balance sheets grow materially after a monetary loosening, implying an increase of the sector's financial intermediation capacity and an active transmission of monetary policy through the insurance sector. We also find evidence of portfolio re-balancing consistent with the risk-taking channel of monetary policy. After a monetary loosening, insurers increase credit, liquidity and duration risk-taking in their asset portfolios. Our results suggest that extended periods of low interest rates lead to rising financial stability risks among non-bank financial intermediaries.

JEL: E52, G11, G22, G2

Keywords: Non-bank financial intermediation; monetary policy transmission; risk-taking; portfolio re-balancing.

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1. Introduction

Insurance corporations (ICs) play an important role in the economy by managing risks for households and firms. The premiums that ICs collect from their policyholders predominantly stem from life insurance and annuity policies and are invested in global capital markets. The size of the IC sector and, thus, its relevance for the financing of economic activity of firms and governments have grown significantly over the last two decades. In the euro area (EA), the sector's total assets nearly doubled from 5 to around EUR 9 trillion between 2008 and 2021, equivalent to more than a quarter of the euro area banking sector's assets (Figure 1, Panel A). This makes the insurance sector the second largest component of the rapidly growing non-bank financial intermediation (NBFI) sector after investment funds.[1]

Due to its massive asset holdings, the insurance sector is a major investor in several financial market segments and especially so in bond markets. Figure 1 (Panel B) depicts the investor base of different euro area bond markets. Barring official sector holdings, insurers are the single largest domestic investor in EA sovereign and non-financial corporate (NFC) bonds with holding shares of 25% and 29%, respectively. ICs also hold a sizeable share of financial corporate (FC) bonds, indicating significant interconnections in the financial system and suggesting that ICs are a relevant source of funding for banks. Due to the long maturity of their policy-linked liabilities, insurers tend to act as long-term and hold-to-maturity investors, and provide a relatively stable source of funding compared to other market participants.

Given their business model and sizeable asset holdings, monetary policy – by setting the interest rate environment – is a key factor for the insurance sector.

In this paper, we examine empirically the effect of monetary policy on the size and composition of insurers' balance sheets, as well as the implications of these effects for financial stability. To the best of our knowledge, the response of the insurance sector to monetary policy has not been studied systematically yet. Monetary policy can affect insurers in several ways. When a monetary loosening stimulates real economic activity and households' disposable income, this can translate into higher demand for insurance services, an increase in premiums collected and ultimately higher demand for assets from insurers. At the same time, lower yield levels dampen investment income and impede insurers' ability to provide minimum guaranteed returns to their policyholders. This can increase incentives for insurers to search for yield in riskier assets. Finally, as many insurers' balance sheets feature a negative duration gap, lower yields may deteriorate the capital position of insurers, providing incentives to extend the duration of their portfolios.

1. Similar trends in the growth of the non-bank financial system are observable globally, formerly also known as the "shadow banking system". FSB (2022) estimates the global size of the insurance sector to around USD 40 trillion at the end of 2021.

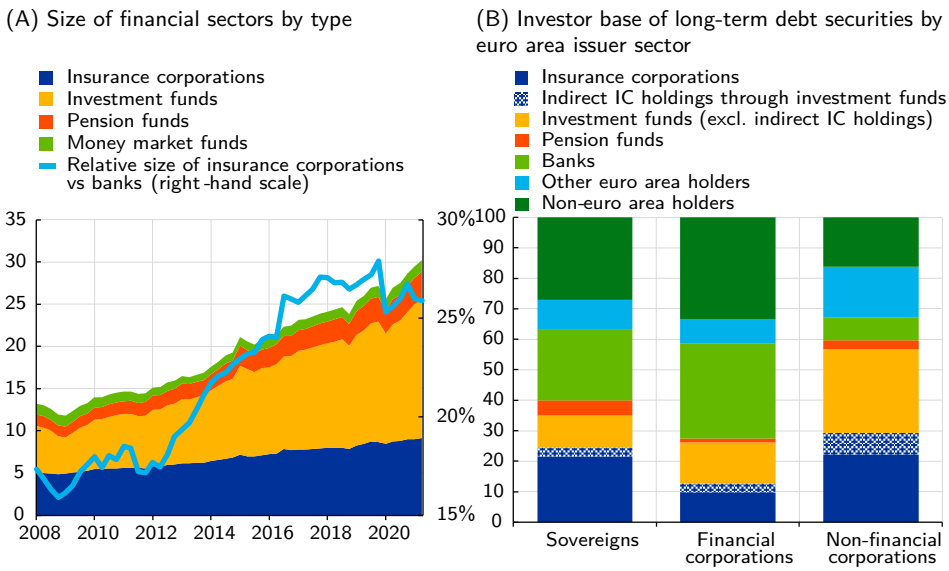

Figure 1: Size and relevance of insurance corporations in the euro area

Notes: Panel (A): Areas show the balance sheet size of non-bank financial institutions in EUR trillion. The line shows the size of insurance corporations relative to the banking sector in % (right-hand scale). Panel (B): In percent of total amounts outstanding as of 2021 Q4, excluding holdings of the Eurosystem.

In our analysis, we study the dynamic responses of all main asset and liability side balance sheet items as well as of several metrics for credit, liquidity and duration risk-taking after changes in monetary policy. We run local projections (Jordà, 2005) on country-sector level data for all 19 EA countries with quarterly observations between 2008 and 2021. The analysis of the main balance sheet items is based on administrative data from the ECB's Insurance Corporation Statistics (ICB), which have not been used in research before. In a further step, we analyse the bond portfolio, the largest component of ICs' asset holdings, in greater detail. This analysis is based on highly granular security-level information from the ECB's Security Holding Statistics by Sector (SHSS), which covers the whole universe of securities held by investors in the euro area. To identify exogenous changes in the interest rate environment, we employ high-frequency monetary policy shocks based on intra-day data around all ECB Governing Council meetings during our sample period, as provided by Altavilla *et al.* (2019). We construct a term structure surprise factor that covers different maturity segments of the yield curve to take into account changes both by conventional and unconventional monetary policy that was prevalent during our sample period. Given the relatively high average maturity of insurer's assets, changes in the longer end of the yield curve are particularly relevant to the sector. To separate genuine monetary policy yield

surprises from other information provided by the central bank, we follow the methodology suggested by Jarociński and Karadi (2020) that is based on the co-movement between stock market and yield surprises around monetary policy events.

Our results suggest that changes in monetary policy have a significant impact on both sector size and risk-taking. After a monetary loosening implying a 50 basis point reduction in yields on impact, total assets of the insurance sector increase by 4.5% over the course of one year. Abstracting from valuation effects, the cumulative rise of the sector's assets amounts to almost EUR 200 billion one year after the shock, a sizeable active expansion in their investments equivalent to 1.6% of euro area GDP in 2021. The financial intermediation capacity of the insurance sector thus increases after a monetary loosening. We document that these additional funds are used for purchases of stocks, investment fund shares and debt securities – the latter notably also issued by non-financial corporations. Our results imply that insurers actively transmit monetary policy to the wider economy on a macroeconomically relevant scale. To the best of our knowledge, this role of the insurance sector in monetary policy transmission has not been documented before in the literature. On the liability side, we find that the technical reserves, i.e. the funds set aside by ICs for their underwriting liabilities, and capital rise, while leverage falls.

We furthermore find that monetary loosening induces shifts in the composition of insurers' asset holdings, leading to a rise in credit, liquidity and duration risk-taking. At the level of main balance sheet aggregates, insurers re-balance their assets away from debt securities towards a higher proportion of investment fund shares and comparatively riskier stocks. Insurers also tend to decrease their cash holdings, pointing towards higher liquidity risk-taking amidst lower interest rates. Credit risk-taking within the bond portfolio is rising, as the share of lower-rated bonds increases after a monetary loosening consistent with a search for yield. We also find evidence of an international searching-for-yield channel with a rising share of bond holdings from issuers outside the euro area. In contrast, we find that insurers counter-cyclically reduce their exposures to euro area sovereign and financial corporate bonds. Finally, looking at the maturity structure of bond holdings, insurers tend to increase their duration risk-taking in response to a monetary loosening by investing more in bonds with longer maturities. This duration risk-taking is most pronounced for bonds with better credit ratings.

Our results point towards portfolio re-balancing in line with the risk-taking channel of monetary policy (Borio and Zhu, 2012, Choi and Kronlund, 2017, Koijen *et al.*, 2017, 2021). During the episode of low interest rate levels, various policy institutions have warned repeatedly that this can lead to more risks within non-bank financial intermediaries (see, e.g., BIS, 2018, ESRB, 2021, Adrian, 2020, ECB, 2021). Our paper is the first to confirm these observations for the insurance sector

using the latest methodological advancements for the identification of the effects of monetary policy.[2]

Our results have several important implications for monetary policy and financial stability. We show that accommodative monetary policy over an extended period indeed can contribute to the build-up of financial stability risks in the non-bank financial system. As such, the low-yield environment has increased the vulnerability of the insurance sector to macroeconomic shocks, such as an increase in corporate defaults. The higher demand from insurers for riskier assets after a monetary loosening can, however, also contribute to an intended improvement of financial conditions for firms and the wider economy. The decline in insurers' cash holdings makes the sector more vulnerable towards larger liquidity shocks. Such shocks could occur, for example, due to policy lapses or due to margin calls on insurers' derivative portfolios that may become more frequent when interest rate levels start rising again from low levels. Finally, insurers' counter-cyclical demand for lower-rated sovereign debt could partially alleviate concerns about "fragmentation" in euro area sovereign bond markets.

The rest of the paper is structured as follows. Section 2 reviews the related literature. In Section 3, we provide some stylised facts about the euro area insurance sector and we discuss the channels through which monetary policy can affect ICs' balance sheets. Section 4 describes the empirical setup, including an overview of the data sets used, the monetary policy shock identification, as well as our model specification. All results including several robustness checks are presented and discussed in Section 5. Section 6 concludes the paper.

2. Related literature

Our paper adds to the literature on the effects of monetary policy on non-bank financial intermediaries. To date, the literature focuses in particular on the investment fund sector and the risk-taking channel of monetary policy. Hau and Lai (2016), Choi and Kronlund (2017), Giuzio *et al.* (2021) and Kaufmann (2023) all find that monetary policy loosening implies higher inflows to the investment fund sector and that these inflows are stronger for riskier fund types. Analysing investment funds' asset portfolios, Choi and Kronlund (2017) and Daniel *et al.* (2021) document that asset managers tilt their portfolios also to riskier, higher yielding assets.

For other segments within the wider NBFI sector, some papers find that monetary loosening can have contractionary effects on size and credit provisioning of certain NBFI types. Xiao (2019) shows that monetary tightening leads to deposit inflows to money market funds because of competition about deposits with

2. In this way, our paper documents one mechanism how loose monetary policy increases the likelihood of financial stress (see Grimm *et al.*, 2023 and Jiménez *et al.*, 2022).

the banking system. Nelson *et al.* (2018) find that non-banks involved in asset securitisation activities grow larger when monetary policy rates rise. Elliott *et al.* (2022) show for certain NBFIs, including fintech lenders and finance companies, that credit supply and risk-taking increase after monetary tightening, as opposed to the traditional banking sector.

None of these papers analyses the reaction of the insurance sector to monetary policy. Our paper shows that the IC sector grows significantly after a monetary loosening. Our results, thus, suggest the presence of an insurance sector transmission channel of monetary policy that has previously not been documented in the literature.

Another strand of literature that we relate to studies the investment behaviour of insurance corporations. In their seminal work, Becker and Ivashina (2015) show that insurers usually hold higher-rated bonds due to the regulatory framework under which they operate, which notably includes non-linearly increasing capital requirements for riskier assets. Conditional on credit ratings, however, ICs prefer higher yielding bonds. Relatedly, Fringuellotti and Santos (2021) document risk-taking of insurers in collateralized loan obligations, also driven by capital regulation. Kirti and Sarin (2023) find that also the ownership structure of an IC can affect their investment behaviour, with private-equity owned insurers investing substantially stronger into poorly-rated securities. Domanski *et al.* (2017) argue that liability-driven investment strategies of ICs and negative duration gaps between assets and liabilities in ICs' balance sheets can create an upward sloping demand curve of the sector for longer-term bonds. Accordingly, lower interest rates negatively affect the capitalisation of insurers, as the valuations of their assets tend to rise by less than those of their liabilities. The authors then show empirically that this induces the sector to re-balance towards longer-term bonds, thus, exerting further downward pressure on long-term interest rates.[3] At the same time, Chodorow-Reich *et al.* (2020) show that the value of insurers' equity is usually well insulated from movements in their assets' valuations, except for in crisis times. Ozdagli and Wang (2019) study how changes in interest rates affect investment and risk-taking behaviour of US life insurers. They show that ICs re-balance their portfolios towards bonds with a higher return when interest rate levels fall. They find this shift to be primarily driven by duration rather than credit risk-taking.

Our results confirm risk-taking behaviour also for euro area insurers after monetary loosening using the latest advances in the identification of exogenous variations in yields using high-frequency monetary policy shocks. Consistent with Domanski *et al.* (2017) and Ozdagli and Wang (2019), we find more duration risk-taking for euro area ICs, which is strongest among higher-rated bonds. However, as opposed to the US case covered in the latter paper, we find that euro area

3. Carboni and Ellison (2022) implement this mechanism into a New-Keynesian dynamic stochastic general equilibrium framework and show that it can indeed amplify the transmission of monetary policy shocks along the yield curve. Their results suggest a potentially significant role of the IC sector for monetary policy transmission.

ICs also increase credit risk-taking in their bond portfolio, especially within the investment grade segment. Additionally, we also document re-balancing between different asset classes beyond bonds, such as equity and investment fund shares. Notably, this also includes pervasive liquidity risk-taking after monetary loosening, which has not been shown before in the related literature. This is relevant, as liquidity risks can materialise rapidly – for example, in case of derivative margin calls, which occurred at the onset of the Covid-19 pandemic in March 2020 or during the gilt market turmoil in autumn 2022. Moreover, policy surrender rates and thus cash needs can rise strongly when interest rates rise (Koijen *et al.*, 2024; Kubitza *et al.*, 2022).

Further papers estimate how the demand of financial sectors responds to yield changes. Timmer (2018) finds that ICs' demand for securities counter-cyclically rises with the asset return. Consistent with this result, O'Hara *et al.* (2024) show that ICs supported corporate bond markets during the Covid-19 crisis by absorbing bonds that were sold by investment funds. Koijen *et al.* (2021), focusing on euro area sovereign bond markets around the onset of the ECB's asset purchase programme (APP), document that ICs did not sell to but rather competed with the central bank for the same types of bonds despite falling yields. Giuzio and Fache Rousová (2019) disentangle pro- and counter-cyclical trading behaviour of insurers on sovereign bond markets by separating changes in risk-free rates from risk premia. They find that higher risk-free yields imply counter-cyclical purchases by ICs due to the positive effects on capital positions of ICs with negative duration gaps. Higher risk premia, instead, lead to less bond purchases by the sector.

We find that insurers' demand for debt securities in general rises after a monetary loosening that translates into lower interest rate levels, although by less than the demand for stocks and investment fund shares.

3. Insurers' balance sheet structure and monetary policy

3.1. Euro area insurance corporations: stylized facts

Before we delve into the analysis of how monetary policy affects the balance sheet composition and associated risk-taking of ICs, we provide some stylised facts on this growing financial sector in the euro area.

Figure 2 (Panel A) shows total assets and technical reserves of euro area insurers by the companies' country of domicile. In terms of their balance sheet size, ICs are concentrated in some of the larger EA economies, such as France, Germany and Italy. The harmonised statistical reporting takes place at the national subsidiary level, ensuring that local operations are reflected in the respective country aggregation. This reduces reporting biases towards countries in which large insurers set up their headquarters. Nevertheless, the figure illustrates significant variation regarding the size of national insurance sectors. Large differences in so-called "insurance penetration rates", i.e. the ratio of ICs' total assets to national GDP, are

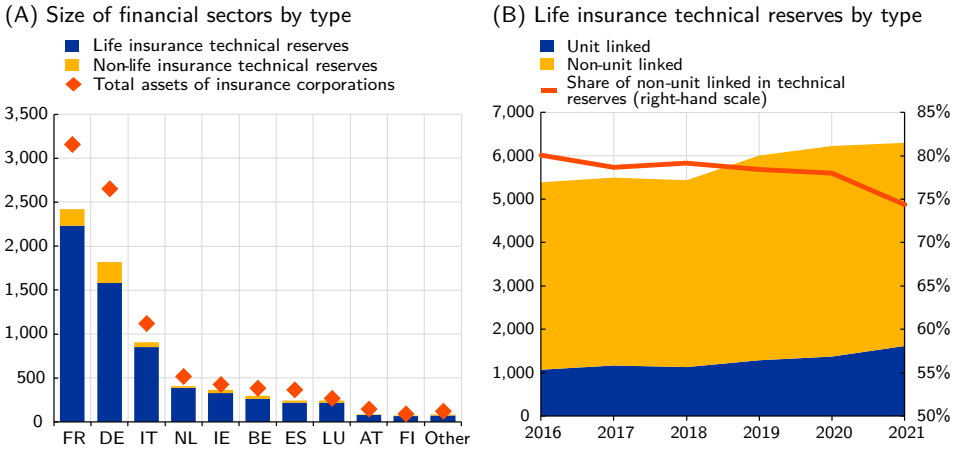

Figure 2: Size of insurance corporations by country and type of insurance activities

Notes: Panel (A): Data is shown in EUR billion in 2021 Q4. "Other" countries includes CY, EE, GR, LT, LV, MT, PT, SI and SK. Panel (B): Data is shown for the euro area aggregate in EUR billion and % of life insurance technical reserves (right-hand scale).

largely due to the different roles that insurers play compared to the public sector in offering various insurance services.

Irrespective of the concentration in domicile, insurers' assets under management are invested internationally. In some countries and asset classes (in particular government bonds), ICs tend to have a pronounced degree of "home bias", though.[4] Likewise, policyholders and thus insurers' liabilities may not only stem from the resident jurisdiction of the IC. Instead, technical reserves can also come from households and firms in other countries as well, as, for example, Italian insures also offer their services to, say, German clients, and vice-versa. Insurers in the euro area do, however, tend to offer their services to clients through local subsidiaries, so cross-border technical reserves reported in the aggregate data are in practice very limited (ECB, 2022b).

The bars in Panel A of Figure 2 show the size and breakdown of ICs' technical reserves by business line. The vast majority of the technical reserves (91% of the euro area total as of 2021) is linked to life insurance policies. This business line subsumes not only insurance contracts that pay out upon the death of the insured person. It also includes all types of private pension insurance contracts, i.e. annuities. As such, ICs provide an important function for the channelling of private savings to capital markets and for pension funding in many European countries.

4. We provide further information on the geographical split of insurer' investments in Section 4.1. For a discussion of the home bias in insurers' investments, see also EIOPA (2021). Instead, for an analysis of insurer's international portfolios, see Du *et al.* (2023).

The non-life insurance business lines are significantly less "asset-intensive" and are very diverse. For example, it includes lines such as general liability, medical, trade credit, motor vehicle, fire and property insurances. Most ICs are active in both the life and non-life business lines. Given the relative size of the two segments, developments in ICs' aggregate balance sheet size and composition can, however, be mainly attributed to the life insurance segment.

Figure 2 (Panel B) delves deeper into the technical reserves of life insurers by showing the split of unit-linked versus non-unit-linked policies. In the former type the investment risk is entirely borne by the policy holders. Instead, the latter type offers minimum guaranteed returns that expose life insurers to interest rate risk, as the duration of life insurance and annuity policies usually is longer than the duration of ICs' asset portfolios. The Figure shows that the share of technical reserves related to non-unit-linked policies fell continuously since 2016 (which is the time this series becomes available to us) in tandem with long-term interest rates. Nevertheless, such policies with minimum guaranteed returns still made up about 75% of all technical reserves of EA insurers at the end of our sample period in 2021.

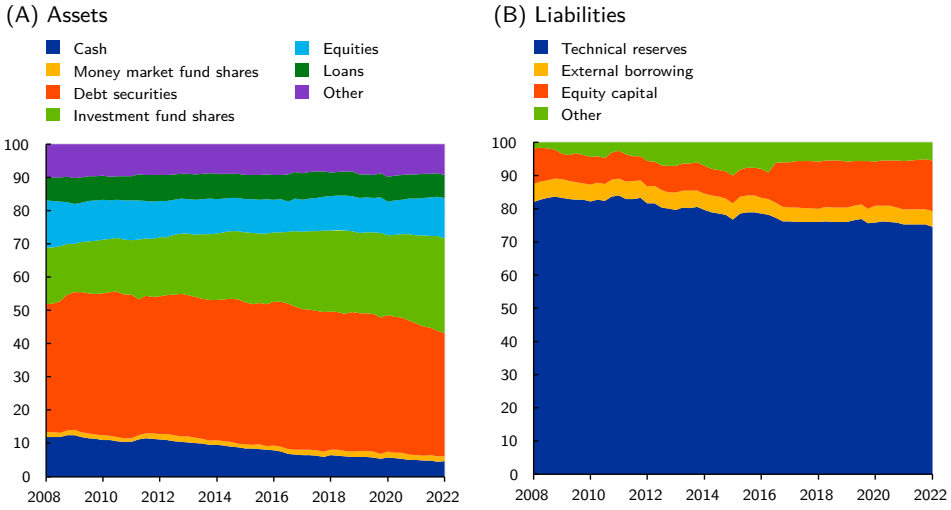

Figure 3: Aggregate balance sheet of euro area insurance corporations

Notes: Composition of the aggregate euro area insurance sector balance sheet in % of total assets (Panel A) and liabilities (Panel B).

Figure 3 shows the composition of ICs' balance sheets over time. Given the overall growth of the sector shown in Figure 1 Panel (A), all balance sheet items have increased in absolute amounts. In relative terms, however, Figure 3 reveals that the investment behaviour of ICs has changed over the past two decades.

Looking at the development of the aggregate balance sheet, we observe a modest decline in the relative share of debt securities held. Debt securities still

remain the largest type of assets held at the end of 2021, comprising 38% of total assets. Thus, ICs continue to play a significant role in the bond markets, as also shown in Figure 1. In contrast, holdings of investment fund shares have increased from 17% in 2008 to almost 30% in 2021. As our analysis will show, this change is at least partially driven by the low interest rate environment, in which ICs have operated in the last years. Indeed, the low yield levels have put pressure on the sector's profitability and ability to generate investment returns that are sufficiently high to cover obligations from long-maturity contracts with high guaranteed minimum returns. Increasing the exposures to investment fund shares could be one way to reach for additional yield. Also consistent with this argument, the lowest-yielding assets, cash holdings, have declined from 12% of the total assets in 2008 to 4.5% in 2021, thus making the sector vulnerable to sudden liquidity needs.

Figure 3 Panel (B) depicts the composition of ICs' liabilities over time. Insurers obtain the vast majority of their funding from collected policy premiums that accumulate on the liability side of the balance sheet as technical reserves. While rising in absolute amounts, the share of technical reserves in total liabilities has fallen from 82% in 2008 to around 75% in 2021. The importance of external borrowing, in form of bond issuance or bank loans, has remained broadly stable over this time period, while the capitalisation of the sector has increased from around 11% to 15%.

3.2. Monetary policy effects and transmission

In this section, we discuss the mechanisms through which monetary policy can affect the size and investment behaviour of the insurance sector. We also explain how these mechanisms affect the transmission of monetary policy to the wider economy. In the following, we will argue from the perspective of a monetary policy loosening.

We begin with considering how monetary policy may affect the total size of the IC sector. Monetary policy loosening will ease financing conditions and, thereby, stimulate real economic activity. To the extent that this leads to higher wages and a reduction in unemployment, households' disposable income will rise. Firm profits could also increase. As a result, households and firms can increase their demand for insurance products. For example, households may want to purchase additional life and pension insurance policies to prepare for their retirement. Demand by households and firms can also rise in the non-life insurance segments, such as motor vehicle insurance as well as various other property and liability lines. Written premiums and, thus, technical reserves will then rise. The total assets that the ICs will need to invest on financial markets will increase as well. These additional investments, e.g., in corporate bonds can further ease financing conditions and

transmit to the real economy by allowing for higher corporate investment activity.[5] Vice-versa, the demand for IC products may fall when monetary policy tightens, also driven by increasing surrenders of households on their life insurance policies (Koijen *et al.*, 2024; Kubitza *et al.*, 2022). In the remainder of the paper, we will refer to this first nexus as the *insurance demand channel* of monetary policy. The mechanism of this channel is directly linked to the macroeconomic effects after monetary policy changes, which typically occur with considerable time lags. We therefore expect that the full effect on IC's balance sheets will also only be felt over time.

Monetary loosening may, by reducing interest rates levels, also affect households' consumption-saving decisions. Specifically, the textbook New Keynesian macroeconomic model would imply that lower real interest rates reduce the growth rate of consumption, as dictated by the Euler equation. Ceteris paribus, current consumption may rise, while savings fall. Consequently, the demand for ICs' life and pension products could fall. As a result, premiums written, technical reserves and total assets of the sector would decline as well. We will refer to this mechanism as the *Euler equation channel*.

The two "real" economic channels discussed so far provide predictions for the development of the IC sector's total size after monetary policy changes. As the signs of the two channels point in opposite directions, it remains an empirical question which of the channels will dominate. The following "financial" channels, instead give guidance on the composition of assets and liabilities as well as on related financial stability risks.

Under full mark-to-market accounting, as it is for example the case under the European Solvency II framework that came into force in 2016, a monetary loosening will induce positive valuation effects on both assets and liabilities. However, as in particular life insurance companies' balance sheets usually feature sizeable negative duration gaps, the valuation increase of the assets will be smaller than the valuation increases on the liability side. ICs' capital positions would, thus, experience adverse pressure when yields fall, while leverage would rise. To dampen these negative effects on their capital, insurers may want to decrease the duration mismatch in their balance sheets. Their demand for assets with longer duration may, therefore, rise (Domanski *et al.*, 2017). This additional demand for especially long-term bonds can induce further downward pressure on the longer end of the yield curve, hence, easing financing conditions for sovereigns and firms (Carboni and Ellison, 2022). This mechanism is coined as the *negative duration gap channel*.

The effects of this channel on ICs' capital positions can be dampened in practice, though. First, in actual accounting practice, there are long running transitional periods until full mark-to-market accounting needs to be applied. Moreover, oftentimes mark-to-market is only applied on the asset valuations so

5. See Kubitza (2022) for causal empirical evidence on the link between higher insurance premiums collected and more real corporate investment.

far in many European jurisdictions. Hence, when only asset valuations increase after a monetary loosening, capital positions could even improve and there will be less pressure to adjust portfolio duration. Second, even when the negative duration gap effects occur, insurers may simultaneously increase their demand for riskier assets and would, thus, be required to also hold more capital for regulatory reasons (see Becker and Ivashina, 2015).

Finally, monetary policy can affect ICs' portfolio composition and risk-taking behaviour due to the liability-driven investment strategies they follow. In the largest share of the long-term life and pension insurance policies ICs offer their policy holders a guaranteed (minimum) return (See Figure 2, Panel B and Koijen and Yogo, 2022b). Falling yields on fixed-income securities after a monetary policy loosening may, therefore, pose a challenge for the IC sector and incentivise investments in higher yielding but riskier assets.[6]

This could materialise in form of re-balancing away from bonds towards stocks, riskier investment fund types or more alternative asset classes. Insurers may also reduce their liquid asset holdings and cash reserves, as these usually provide lower returns due to their inherent safety and liquidity premia. Within their bond holdings, insurers may increase credit and duration risk-taking to "reach for yield". While such portfolio re-balancing could increase financial stability risks in insurers' balance sheets, it may also provide additional intended monetary easing of financing conditions, including for riskier borrowers. This constitutes the *risk-taking channel* of monetary policy.

4. Empirical setup

4.1. Data sources and description of variables

The first part of our analysis is based on quarterly aggregate insurance sector data for the 19 euro area countries from 2008 Q1 to 2021 Q4, for which we have already provided some stylised facts in the previous section. To avoid potentially distorting effects from outliers during the global financial crisis of 2007/2008 and the onset of the Covid-19 pandemic in 2020, the main data set that we use runs from 2010 Q1 until 2019 Q4, giving us up to 760 usable observations.[7] We source this data from the ECB's Insurance Corporation Statistics (ICB) and until 2016 the Insurance Corporations and Pension Funds Statistics (ICPF),[8] which have not been used for

6. Notably, Koijen and Yogo (2022a) document that stock valuations of insurers with a higher share of liabilities with minimum return guarantees were more sensitive to stress during a low yield environment.

7. In robustness checks, we will show that all main results continue to hold when these two crisis episodes are included as well.

8. The previously collected data set for both insurers and pension funds was discontinued in Q3 2016 and replaced by the more granular Insurance Corporation Statistics.

research purposes and, hence, not been introduced to the literature before. This data set allows us to study the evolution of the balance sheet size as well as its composition in terms of broad asset and liability breakdowns. Besides the suitably long time series dimension, a key advantage of the data set is the harmonised statistical approach across the different euro area countries. Although the more recently collected sector data also reports additional information on insurance subsectors, such as life and non-life ICs, we cannot make use of these breakdowns given the limited number of data points available until now.

	Mean	St. Dev.	Median	Min	Max	Obs.
(A) Log-levels market value						
Total Assets	24.59	2.45	24.94	20.39	28.67	760
Cash Holdings	21.86	2.27	22.14	17.23	26.81	760
Loans	20.57	3.34	21.12	13.12	26.36	735
Debt Securities	23.64	2.42	24.36	19.40	28.09	739
Equity	21.70	2.97	22.40	14.51	26.60	739
Money market fund shares	19.27	2.82	19.35	12.21	25.41	632
Investment fund shares	22.99	2.41	23.41	17.96	27.38	656
(B) Log-levels nominal value						
Total Assets	24.54	2.37	24.84	20.40	28.51	678
Cash Holdings	21.93	2.16	22.01	17.36	26.84	678
Loans	20.84	3.16	21.11	13.82	26.46	661
Debt Securities	23.67	2.40	24.31	18.82	27.96	678
Equity	21.82	2.70	22.19	14.51	26.45	653
Money market fund shares	19.47	3.07	19.53	7.94	25.41	585
Investment fund shares	22.95	2.49	23.69	17.91	27.27	631
(C) Share of total assets in market value						
Cash Holdings	8.77	6.56	7.40	0.79	30.15	760
Loans	4.80	7.78	1.58	0.05	45.27	735
Debt Securities	45.14	15.88	44.25	10.52	73.84	739
Equity	7.55	4.63	6.83	0.17	22.47	739
Money market fund shares	1.14	1.29	0.51	0.00	5.37	632
Investment fund shares	20.55	11.38	18.02	3.26	51.28	656
(D) Share of total assets in nominal value						
Cash Holdings	9.76	6.86	8.72	0.80	33.33	678
Loans	5.75	9.13	1.81	0.07	47.09	661
Debt Securities	45.12	16.03	42.94	10.20	74.70	678
Equity	9.00	4.72	8.16	0.19	22.38	653
Money market fund shares	1.38	1.51	0.57	0.00	6.35	585
Investment fund shares	20.13	12.10	17.07	2.06	60.02	631

Table 1. Descriptive Statistics: Asset side

Notes: Observations at country-sector level for all 19 euro area countries between 2010 Q1 and 2019 Q4. Data in Panels (A) and (B) in log of EUR, Panels (C) and (D) in % of total assets.

While a relatively long time series is available for aggregate country-level insurance sectors, we face a structural break in the data for several, especially liability side, balance sheet items for several countries due to changes in the reporting related to the introduction of the Solvency II regulation in 2016. To ensure consistency across time, we subtract any significant level shifts that occur in individual country time series between 2016 Q2 and 2016 Q3. More specifically, we compare the growth rate between the two quarters in question and in case of deviations exceeding one standard deviation of the average growth rate, we rebase

Variables	Mean	St. Dev.	Median	Min	Max	Obs.
(A) Log-levels in market value						
Debt Securities	19.77	2.94	20.26	11.44	23.84	492
Loans	20.38	3.21	20.74	11.62	25.41	714
Capital	22.35	2.29	22.45	17.64	26.50	739
Technical reserves	24.25	2.48	24.66	20.01	28.43	739
(B) Log-levels nominal value						
Debt Securities	19.69	2.85	20.04	10.74	23.84	492
Loans	20.30	3.21	19.94	11.54	25.41	673
Capital	22.25	2.17	22.14	17.99	25.99	628
Technical reserves	24.26	2.42	24.57	20.05	28.37	683
(C) Share of total liabilities in market value						
Debt Securities	0.75	0.85	0.38	0.00	4.93	492
Loans	2.50	2.51	1.70	0.00	23.45	714
Capital	13.03	6.86	11.11	2.38	42.51	739
Technical reserves	76.84	6.69	77.22	55.40	95.14	739
(D) Share of total liabilities in nominal value						
Debt Securities	0.76	0.98	0.39	0.00	4.44	492
Loans	2.71	2.92	1.69	0.00	26.31	673
Capital	13.65	6.91	11.43	4.13	38.90	628
Technical reserves	78.66	11.12	79.62	47.18	107.37	678

Table 2. Descriptive Statistics: Liability side

Notes: Observations at country-sector level for all 19 euro area countries between 2010 Q1 and 2019 Q4. Data in Panels (A) and (B) in log of EUR, Panels (C) and (D) in % of total liabilities.

the following quarters to the level of 2016 Q2. We apply a rescaling factor in rare cases that would otherwise lead to negative values.[9] As an example, Figure A.1 in Appendix A shows the time series of capital for selected countries in the sample before and after the cleaning of the structural break.

Tables 1 and 2 report summary statistics for all main balance sheet item variables on both asset and liability side that we use in our analysis. On the asset side, these items consist of total assets and its following sub-items: debt securities, loans, equity, investment fund shares, money market fund (MMF) shares and cash holdings. On the liability side, these variables are the technical reserves, capital as well as debt securities and loan funding. Despite overall good data coverage, availability for some of these variables slightly varies for some countries over the whole sample period.

To cover both the absolute and relative changes in the balance sheet composition of ICs, we use the variables both in log-levels and as ratios capturing their share in terms of total assets.

We additionally distinguish between two valuation perspectives for the balance sheet variables: market and nominal values. The stock value of a given balance sheet item in market valuation of country i and quarter t is given as

$$S_{i,t}^{MV} = S_{i,t-1}^{MV} + Flow_{i,t} + \Delta Val_{i,t} + \Delta FX_{i,t} + \varrho_{i,t} \ , \tag{1}$$

9. Notably, our main results continue to hold also without this transformation and in case the break is defined by exceeding two standard deviations of the average growth rate.

where $Flow_{i,t}$ are financial transactions, $\Delta Val_{i,t}$ are price revaluation adjustments, $\Delta FX_{i,t}$ are exchange rate adjustments and $\varrho_{i,t}$ are statistical reclassification adjustments. A change in the market value from one quarter to the next can accordingly reflect both changes in the amounts of assets held, due to financial transactions and maturing assets, and valuation changes due to asset price and exchange rate movements in financial markets. An analysis of developments in balance sheet items at market value can already give valuable insights. They do not allow, though, to separate active financial transaction decisions by the ICs' asset managers from passive changes in the stock value of the balance sheet item due to valuation changes. After changes in monetary policy – the focus of our paper – we expect both active and passive adjustments to occur. We therefore construct nominal stock values S^{NV} that capture only active balance sheet changes in the following way:

$$S_{i,t}^{NV} = S_{i,0}^{MV} + \sum_{\tau=1}^{t} Flow_{i,\tau} \ , \tag{2}$$

where $S_{i,0}^{MV}$ denotes the size of the balance sheet item as reported in the data set at the beginning of the sample period. We illustrate these two different valuation concepts in Figure A.2 in Appendix A, using total assets of French insurers as an example. Overall and important for our analysis, changes are to the largest part driven by nominal values, while revaluation effects in the aggregate tend to play a smaller role. On average, 88% of the change in total assets in market value in 2021 relative to the sample start in 2008 can be attributed to nominal value increases, i.e. due to active financial transaction decisions, and only 12% can be attributed to revaluation effects.

In the second part of our analysis, we complement the aggregate country-sector data for balance sheet items with information on insurers' bond holdings from the ECB Security Holdings Statistics by Sector (SHSS). This quarterly security-level data set allows for additional analyses regarding different types of asset characteristics (ECB, 2015). It reports for each country and financial sector the amounts held of each security, thus allowing us to look at further breakdowns of investments, e.g., by type of security issuer, rating or maturity. The data from SHSS is available to us as of 2009 Q1.[10] Due to the granular security-level perspective in the data set, SHSS data can be merged via security identifiers with additional information from a wide range of sources. We obtain information on issuer sectors and countries, credit ratings and residual maturity for each security from the Centralised Securities Database (CSDB). The latter collects consistent and up-to-date information on all relevant securities for the statistical purposes of the European System of Central Banks. While the SHSS also features data on equity

10. The official start of the data set is in 2013 Q4, but we can make use of the so-called experimental data of SHSS that was collected as of 2009 Q1. While the data on bond holdings prior to 2013 Q4 is already comprehensive for most euro area countries, data for other securities types like equity and investment fund shares is less advanced in this earlier period.

and investment fund share holdings, we focus our security holdings analysis on bonds for two reasons. First, bond holdings constitute the single largest share of insurers' asset holdings. Second, usable data on other asset classes is only available to us after 2013 Q4 at the earliest, leaving the time dimension too short for the purpose of our analysis.

We combine information from SHSS and CSDB to calculate risk indicators for ICs' bond portfolio holdings, such as the share of lower-rated securities held or the average duration in the bond portfolio. For consistency with the analysis of the main balance sheet items, we aggregate the SHSS data to the country-sector level. SHSS has holding information both in market and nominal values. For our analysis, we focus on the nominal holdings that allow us to abstract from valuation effects.

The main breakdowns for our bond portfolio analysis are by issuer region (euro area and rest of the world), by issuer sector (government, non-financial and financial corporate) and by rating (higher- and lower-rated). We classify ratings of AAA, AA, and A as higher rated, while we define lower-rated bonds with a rating of BBB or below. The reason for this split is that insurers only hold very limited amounts of high-yield (rated below BBB) bonds, given non-linear regulatory capital requirements (see also Becker and Ivashina, 2015). Instead, credit risk-taking of insurers in search for higher yields often takes place in the BBB segment at the threshold between investment grade and high-yield (see Panel A of Figure A.3 in Appendix A). Table A.2 in Appendix A provides summary statistics for the bond portfolio holdings.

To assess duration risk in the bond portfolio we calculate the following two metrics. First, we approximate the bond portfolio duration by computing the weighted average residual maturity ($WARM$) of the IC sector in country i as

$$WARM_{i,j,r,t} = \sum_{s=1}^{S} \frac{HN_{s,i,j,r,t}}{HN_{i,j,r,t}} \cdot ResMat_{s,i,j,r,t}\,, \tag{3}$$

where we can differentiate by issuer sector j and bond rating r in quarter t. $ResMat_{s,i,j,r,t}$ is the residual maturity for security s expressed in years. HN denotes the nominal holdings in these holder country - issuer sector - rating - time combinations, either at the security level (numerator) or in total (denominator). Our measure for the duration is similar both in magnitude and dynamics compared with the classical Macauley duration, which due to data limitations is only available to us from 2017 onwards.

The second measure directly considers the portfolio share of longer-term bonds, hn, defined as

$$hn^{M}_{i,j,r,t} = \sum_{s=1}^{S} \frac{HN^{M}_{s,i,j,r,t}}{HN_{i,j,r,t}} \tag{4}$$

for bonds with a residual maturity equal to or longer than M years. To avoid distortions from money market instruments that are not necessarily held only for investment purposes, we restrict the analysis of duration risk metrics to securities

with a residual maturity of at least one year, i.e. bonds. Table A.3 in Appendix A shows summary statistics for the constructed bond portfolio duration measures.

Finally, we use the following variables in changing compositions as control variables in our analysis. As macroeconomic controls we use country-specific year-on-year GDP growth and inflation rates. As financial controls, we use German Bund yields and overnight index swap rates (OIS) at various maturities, euro area BBB-rated corporate bond yields from iBoxx, and the VSTOXX volatility index. We use corporate bond and Bund yields of the same maturity to construct bond spread measures. We source these variables from the ECB Statistical Data Warehouse (SDW). In some specifications, we also use country-specific demographic variables, such as life expectancy and the old age dependency ratio, which is defined as population aged 65 years and older over the population aged between 15 and 64. The demographic variables are taken from Eurostat.

Table A.1 in Appendix A provides a list of all variables used including their data sources.

4.2. Identification of monetary policy shocks

We identify monetary policy shocks using high-frequency data. To this end, we employ the Euro Area Monetary Policy Event-Study Database by Altavilla *et al.* (2019). This data set collects the intra-day changes of several financial variables during a narrow time window around the ECB's Governing Council meetings. We use the whole monetary event window, which includes the press release and the subsequent press conference. Specially, the surprises are calculated as changes between the median quote of a financial variable from the time window 13:25 to 13:35 before the press release and the median quote from the time window 15:40 to 15:50 after the end of the press conference. This tight time window allows to attribute the observed changes in yields and asset prices only to the announcement of monetary policy. Moreover, only effects that were not expected before by financial markets are captured, thus yielding a clean exogenous policy-induced variation in yields and asset prices. For the shock identification, we use OIS and Bund yield changes at various maturities as well as the change of the EuroStoxx 50.

Using this high-frequency data, we follow the approach introduced by Jarociński and Karadi (2020), who show that such intra-day surprise changes of monetary policy related interest rates do not necessarily coincide with stock market movements in the opposite direction. Such a negative co-movement between a monetary policy indicator and stock markets is, however, the expected result of a monetary policy shock in conventional economic theory. The approach by Jarociński and Karadi (2020) allows for disentangling these pure negative co-movement monetary policy shocks from positive co-movement shocks that the authors interpreted as central bank information shocks, in which the central bank conveys additional information to market participants. For example, an increase in equity markets after a monetary policy tightening could be the result when the central bank reveals information that tightening of monetary conditions was

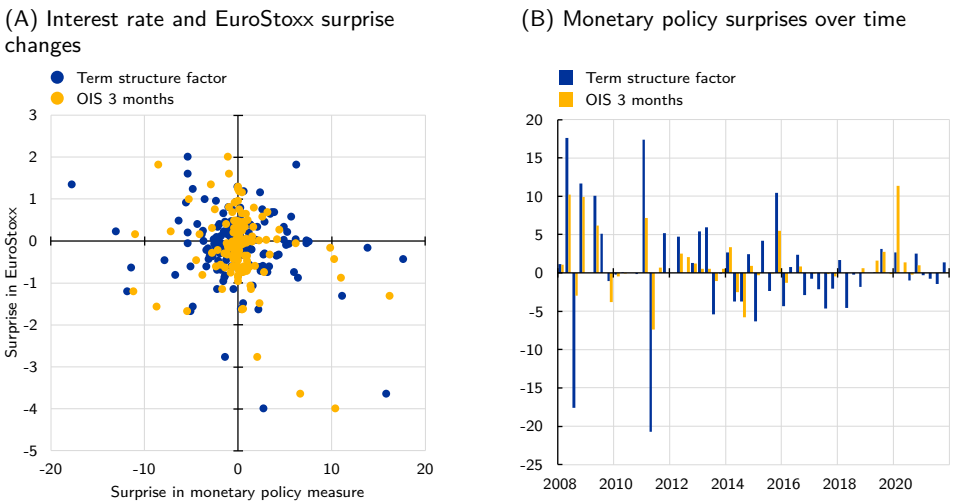

Figure 4: High-frequency monetary policy surprise measures

Notes: Panel (A): High-frequency interest rate changes (in basis points) and corresponding EuroStoxx changes (in percentage points) on all ECB Governing Council meeting days between 2008 and 2021 based on Altavilla *et al.* (2019). Panel (B): Cumulative quarterly monetary policy surprises between 2008 and 2021 in basis points.

required to prevent the economy from overheating, which financial markets can interpret as positive economic news. The authors show that the responses from macroeconomic and financial market variables can differ decisively under these two types of shocks. Therefore, studies not properly differentiating between these two shock types may not be able to clearly identify the effects of a genuine monetary policy surprise.

For the monetary policy surprise measures, the related literature usually employs interest rates from the short end of the yield curve, such as the 3-month OIS rate, which are linked mainly to conventional monetary policy instruments. As the ECB's main interest rates were set close to their effective lower bound with little variation over time during our sample period, we construct surprise measures that also use longer-term interest rates. In order to capture surprise changes over the whole longer-end of the yield curve, instead of focusing on the potentially idiosyncratic changes of yields at a certain maturity, we apply the method by Gürkaynak *et al.* (2005) to separate a "target factor" of monetary policy from a "term structure factor". To perform the principal component analysis, we use the OIS with maturities of 1 week, 1, 3, 6 months, and 1 year, plus changes of the German Bund with maturities of 2, 5, and 10 years.[11] Following the procedure

11. We use Bund yields in the medium and longer segment of the yield curve, as OIS quotes at longer horizons only become available after August 2011.

by Gürkaynak *et al.* (2005), we calculate the first two principal components of this data. After applying the transformations described in Gürkaynak *et al.* (2005), these can be interpreted as a monetary policy target factor, capturing monetary policy induced changes in short-term interest rates, and as a term structure factor, which captures monetary policy induced movements throughout the yield curve. We normalise the term structure factor such that a one-unit change corresponds to one percent change of the 5-year Bund.

Figure 4 Panel (A) shows a scatter plot of the surprise changes in the 3-month OIS and the term structure factor against the EuroStoxx 50 on all Governing Council dates during our sample. Following Jarociński and Karadi (2020) we identify pure monetary policy surprises when the high-frequency monetary policy shocks are negatively related to high-frequency changes in the EuroStoxx 50, i.e. events in the upper-left and lower-right quadrant. The higher variation of the term structure factor compared to the 3-month OIS is visible, with standard deviations of 4.6 versus 3.2 basis points, respectively. Moreover, the series for the 3-month OIS features 16 observations out of 141 with a surprise change of zero, compared to three observations (close to) zero for the term structure factor.

In our application, the term structure factor has three advantages. First, as opposed to a short-end yield measure, it can also capture the effects of unconventional monetary policies such as forward guidance and asset purchases programmes, which arguably were the instruments with the greatest variation during our sample period when short-term interest rates were kept close to zero with little variation for an extended period. Second, insurers are mainly long-term investors. In 2021 Q4, at the end of our sample period, the average duration of ICs' bond portfolio stood at 7.9 years. Monetary-policy induced changes to longer-term interest rates will, therefore, be of greater relevance for the insurance sector than changes in short-term interest rates. Third, the relatively higher variation of the term structure factor over the sample period facilitates the identification of monetary policy effects statistically.

To combine the high-frequency surprise measures with our otherwise quarterly data, we sum up all daily surprises that occur within one quarter, following the literature after Gertler and Karadi (2015). We plot the quarterly series of the genuine monetary policy surprises that we will employ in the regressions in Panel (B) of Figure 4.

4.3. Local projection specification

In order to compute the impulse response functions of the different IC variables, we estimate local projections of the high-frequency monetary policy shocks described in the previous section. Local projections allow us to compute the dynamic effect of monetary policy, while keeping a very flexible framework and being more robust to mis-specification than, e.g., a vector auto-regression model, as shown by Jordà (2005). We estimate the following specification at different horizons h:

$$y_{i,t+h} = \alpha_i^h + \theta^h MP_t + \sum_{l=1}^{L} \beta_l^h y_{i,t-l} + \sum_{l=1}^{L} \gamma_l^h Controls_{i,t-l} + \varepsilon_{i,t+h} \ , \qquad (5)$$

where θ^h represents the causal effect of the monetary policy shock MP_t on the dependent variable $y_{i,t+h}$ at period $t+h$. The impulse response function h periods after the shock is represented by the vector $(\theta^0, .., \theta^h)$.

In addition to the monetary policy shocks and lags of the dependent variable, we add further controls to sharpen our estimates. In the baseline estimations, we control for macroeconomic and financial conditions, as in recent studies that assess the effects of monetary policy such as Gertler and Karadi (2015). The macroeconomic controls are country-specific year-on-year GDP growth and inflation rates. The financial variables are the observed Bund yield at maturity of 3 years, the VSTOXX volatility index, the 3-year euro area BBB-rated corporate spread and the log total assets of the ICs (unless the latter is the dependent variable). The VSTOXX is used to capture the overall risk sentiment in financial markets. The BBB-rated corporate spread captures the tightness of financial conditions and potential frictions (see, e.g., Caldara and Herbst, 2019 and Jarociński and Karadi, 2020). It also measures the excess return from buying financial assets by lower-rated (corporate) issuers, which is relevant for the return on the ICs' bond portfolio and the incentives to search for higher yielding assets (confer again also Figure A.3, Appendix A).

As shown in Miranda-Agrippino (2016) and Ramey (2016), even if the shocks are identified using high-frequency methods and they are supposed to be uncorrelated with previous values, there still can be some auto-correlation. Hence, we also control for lagged values of the shocks. We also add country-fixed effects α_i^h to capture permanent structural differences in the IC sector across euro area countries. Our setup does not allow for the inclusion of time-fixed effects because they would be perfectly collinear with our shocks. Some of our controls, such as the yield, bond spread and VSTOXX are aggregate variables and, thus, capture some time period specific effects.

In our baseline specification, we choose a lag length L of two. The results are robust to different lag lengths. The standard errors are clustered at the country level. Finally, $\varepsilon_{i,t+h}$ denotes the regression error term.

5. Results

We present all results of our analysis in this section. In Section 5.1 we analyse the reaction of ICs' total asset size and all main balance sheet items after a monetary loosening. Subsequently, Section 5.2 examines the reaction of the ICs' bond portfolio in greater detail. Lastly, Section 5.3 provides a broad range of sensitivity analyses.

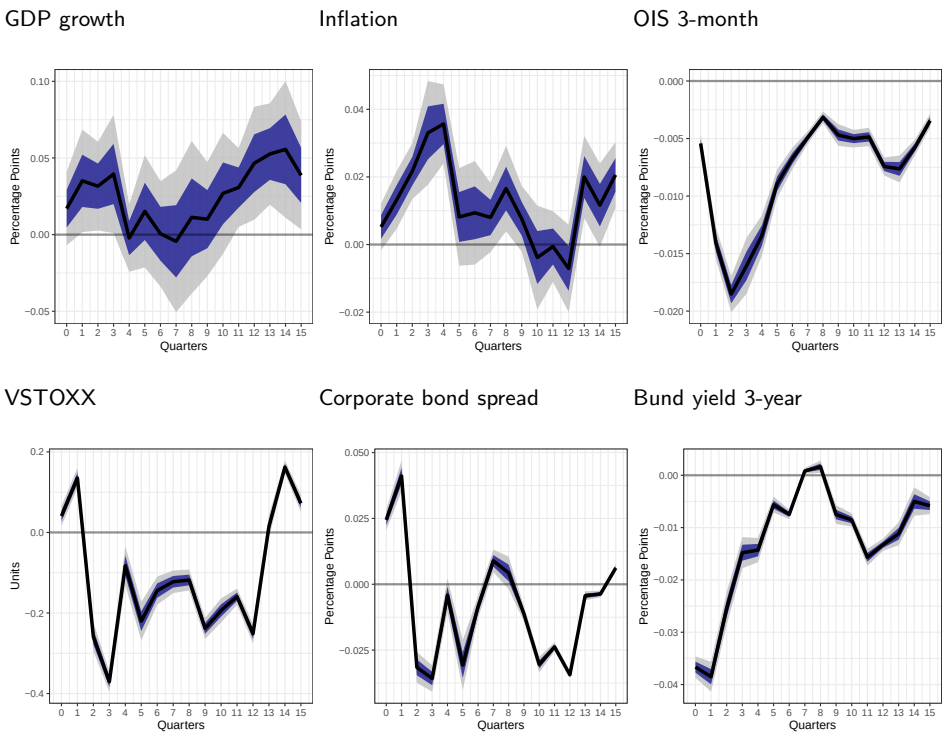

Figure 5: Impulse responses of macroeconomic and financial variables

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

Before we turn to the analysis of the insurance sector, we assess if our macro-financial control variables behave intuitively, in order to make sure that we properly identify monetary policy shocks. Figure 5 shows impulse response functions (IRFs) to an expansionary monetary policy shock that decreases the term structure factor by one basis point. The grey and blue-shaded areas display 95% and 68% confidence intervals. Consistent with the conventional wisdom and the related literature, we find that real economic activity increases and financial conditions loosen.

Specifically, the one basis point drop of the high-frequency surprise measure translates into a reduction of the quarterly 3-year Bund yield of almost three basis points on impact. The shorter end of the yield curve reacts less, as measured by the 3-month OIS rate, and falls by only 0.5 basis points.[12]

12. Figure B.1 in Annex B shows the response of some further quarterly yields over the whole yield curve. Figure B.2 replicates Figure 5 using euro area time series instead of panel data. While confidence bands naturally become wider, the patterns and magnitudes of most IRFs remain very similar.

GDP growth and inflation increase statistically significant on impact and remain positive during the 16 quarters for which we calculate the local projections. The VSTOXX volatility index briefly rises before falling significantly and persistently after two quarters. This indicates increasing risk appetite among financial investors (Bekaert *et al.*, 2013). Likewise, the BBB-rated corporate bond spread also falls significantly after a short-lived initial rise, suggesting a reduction of financial frictions (Gertler and Karadi, 2015).

Overall, all macroeconomic and financial variables behave intuitively and we conclude that our approach allows us to properly identify surprise changes in monetary policy.

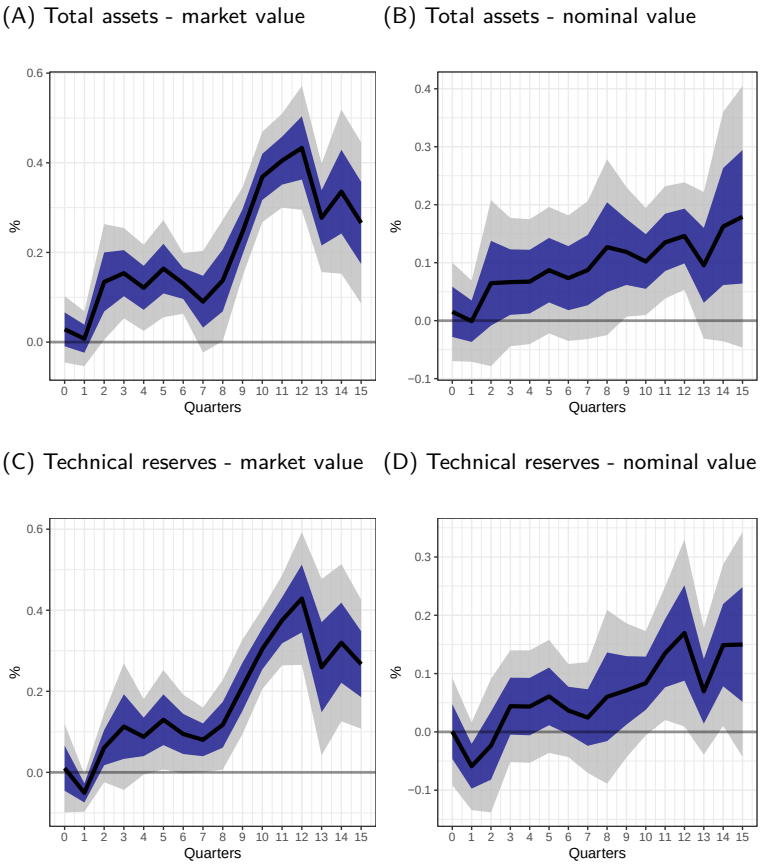

Figure 6: Impulse responses of insurance corporations' total assets and technical reserves

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects.

5.1. Main balance sheet items

We begin our analysis by investigating the reaction of the insurance sector's total size to monetary policy. Panel (A) of Figure 6 shows the impulse response function of total assets in market value. After a one basis point monetary loosening shock, total assets start increasing significantly after two quarters with a quarterly marginal effect of around 0.15%. The marginal effects continue to rise with a peak of more than 0.4% three years after the initial shock.

To assess to what extent this surge is not only driven by valuation effects but also by an actual increase in assets, Panel (B) shows the response of total assets in nominal terms, i.e. free of valuation effects as derived in (2). We find that this measure increases significantly and continuously to a quarterly marginal effect of more than 0.1% two years after the shock. Accordingly, the size of the IC sector is highly responsive to monetary policy induced yield changes.

We gauge the economic significance of this result next. To this end, we consider a high-frequency monetary policy shock that translates into a 50 basis point drop in the (quarterly) 3-year Bund yield on impact. The IRF from Figure 5 implies that the *cumulative* drop of this yield reaches around 150 basis points over the course of one year after the shock. ICs' total assets in market (nominal) value cumulatively increase by 4.5% (2.0%) over the same time.[13] This cumulative rise of the sector's total assets in nominal terms amounts to almost EUR 200 billion one year after the shock and, as we show below, implies an active expansion in ICs' investments. This compares to the euro area GDP in 2021 of around EUR 12.4 trillion. The rise in assets, accordingly, is equivalent to 1.6% of GDP. The financial intermediation capacity of the sector, thus, increases significantly after a monetary loosening. Accordingly, insurers transmit monetary policy changes to the wider economy on a macroeconomically relevant scale.

Panels (C) and (D) of Figure 6 display the response of insurers' technical reserves, the largest item on their balance sheets' liability side, in market and nominal value. After a small and short-lived drop, the responses resemble those of the total assets quite closely. In market value, technical reserves start rising by about 0.1% each quarter half a year after the shock. The response peaks three years after the shock at more than 0.4%. In nominal value, technical reserves increase continuously to a peak response of 0.16% three years after the shock.

This result implies that the premiums the IC sector collects from existing and new policy holders increase significantly, indicating that households and firms increase their demand for insurance products after a monetary loosening. The collected funds in turn need to be invested on capital markets by the ICs (see Kubitza, 2022). The increase in total assets and technical reserves is, therefore, consistent with the insurance demand channel of monetary policy, described in Section 3.2. As such, the built-up of the effects over time in Figure 6 is consistent

13. The necessary high-frequency shock amounts to 13.6 basis points on impact.

with the well-established finding that it can take several quarters until the full effect of a monetary policy change is fully transmitted to the macroeconomy. The short-lived drop in technical reserves after impact would be consistent with the Euler equation channel, before being dominated by a stronger insurance demand channel.

We examine the response of the main asset and liability balance sheet items next. Figure 7 provides results in levels of nominal value, again in order to abstract from valuation effects.[14] Based on these IRFs, Figure 8 provides a model-implied projection of the whole balance sheet composition. This graphical representation takes into account the relative size of every component on the balance sheet, while a conventional IRF would only show the impact of the shock at different horizons. This "balance sheet IRF" shows the projected evolution of the total asset composition after a 10 basis point high-frequency monetary policy loosening shock. In the following, we first discuss results regarding the asset side and then regarding the liability side.

As shown in the six upper panels of Figure 7, we find that a monetary loosening leads to an increase in the holding amounts of the largest and most important asset classes: debt securities, investment fund shares, and equity. Consistent with our previous finding of rising total assets, this implies more financial intermediation of ICs via capital markets and an active monetary policy transmission to the wider economy.

The response of debt securities starts rising statistically significantly only after about eight quarters. Instead, investment fund shares and equity rise significantly already after two quarters. The percentage increase of these categories is also larger than the one of debt securities. The response of direct loans granted by ICs remains mostly insignificant. Notably, we observe however that the amounts of cash holdings and money market fund shares fall significantly.

Panel (A) of Figure 8 presents these changes relative to total assets. Consistent with the findings in levels, the portfolio share of debt securities falls relatively strongly from the sample average of 45.1% to 39.4% three years later for the 10 basis point shock. The share of the most liquid asset category, cash, falls sizeably from about 9% to 1.9%. The relative portfolio share of investment funds, equity and loans increase strongly instead from about one third to 46%.

Overall, we hence document a sizeable portfolio re-balancing to a higher proportion of riskier stocks, investment funds and loans, while the shares of assets considered more safe, including debt securities, cash and money market funds declines sharply. As lower interest rate levels after a monetary loosening also reduce yields of newly issued bonds and MMF shares, while reducing the remunerations of ICs' cash deposit holdings, this finding is a first indication for a search for yield

14. Figures B.3, B.4 and B.5 in Appendix B.1 show the responses in levels of market value, and as a share of total assets in market and in nominal value.

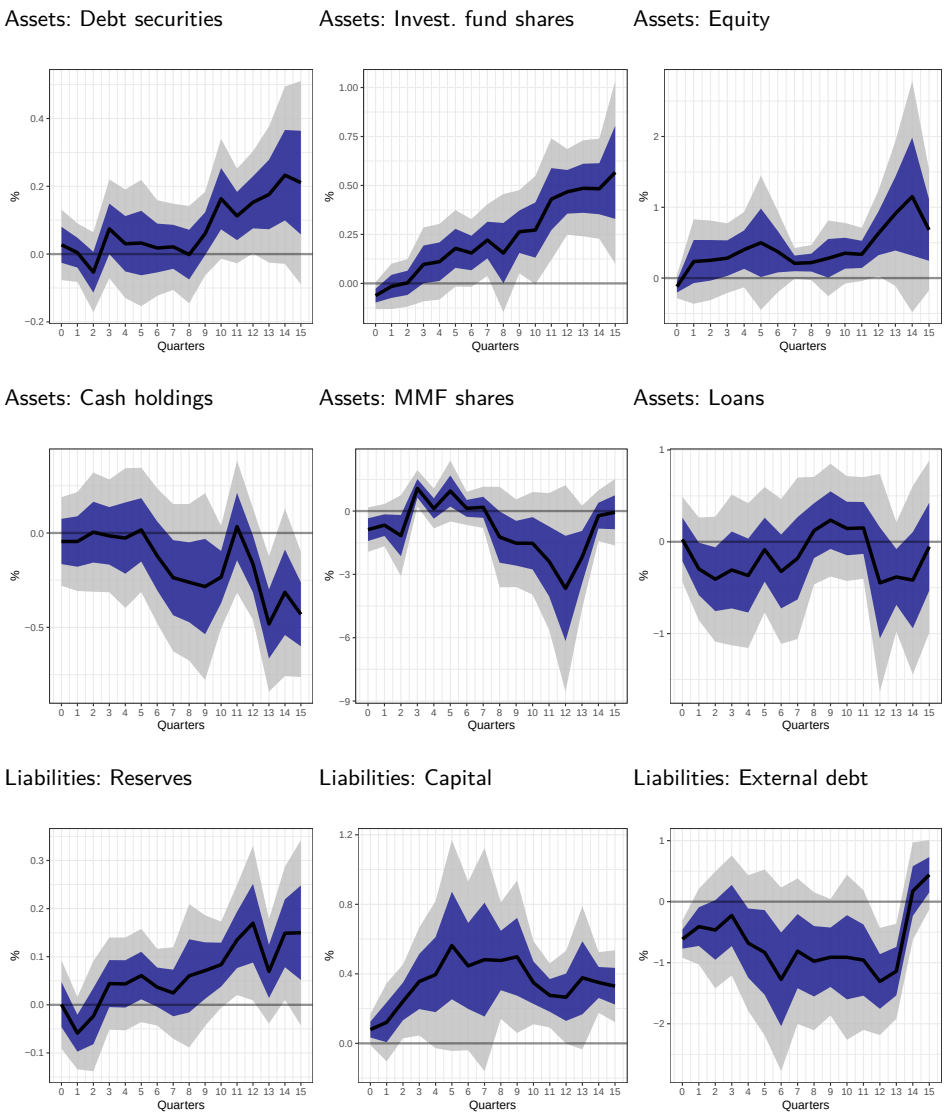

Figure 7: Impulse responses of main asset and liability components: Log-levels of nominal value

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects.

of insurers, consistent with the risk-taking channel of monetary policy (see Section 3.2).

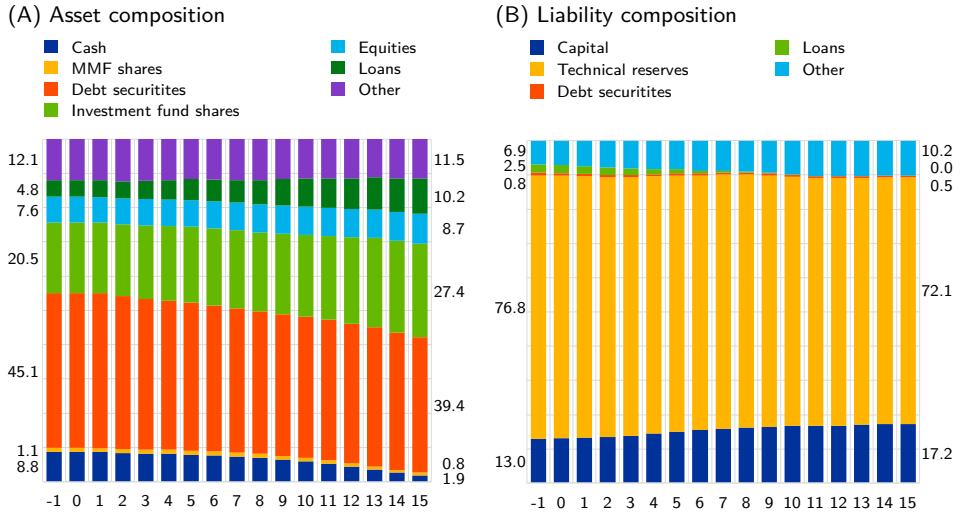

Figure 8: Balance sheet projection

Notes: The charts are a graphical representation of the projected evolution of insurance corporations' balance sheet composition in % of total assets, following an expansionary high-frequency monetary policy shock inducing a 10 basis point decrease of the term structure factor. The x-axis shows quarters after the shock. The bar denoted "-1" represents the sample average for each item. The balance sheet projections are based on the IRFs shown in Figure B.4 (Appendix B.1).

At the same time, the fact that holdings in the most liquid asset categories are reduced the most also implies a considerable increase in liquidity risk-taking of the insurance sector. This makes ICs more vulnerable to sudden liquidity needs during market turmoils, as for example experienced during March 2020 related to margin calls (see also Ghio *et al.*, 2023). This shift of insurers towards these different less liquid asset classes after a monetary loosening has not been documented so far using causal identification methods.

We now turn to the liability side of ICs' balance sheets. We find in Figure 7 that the amounts of the technical reserves (discussed above) and ICs' capital increase after the expansionary monetary policy shock. The size of ICs' external debt financing by issuing debt securities and taking loans falls, though. One reason for this could be that there is less need for external funding when there are sufficiently high inflows from written premiums. Generally, such external financing only plays a minor role for insurers with 3.23% of total liabilities. In relative terms (see Figure 8, Panel B), we find that the capital ratio rises and, thus, leverage falls, while the liability shares of the technical reserves and external debt fall.

It is interesting that we do not find a decrease in capital on impact – notably, also not when measured at market value in Figure B.3. This would have been in line with the valuation effects related to the negative duration gap channel (see Section 3.2) that is present in the balance sheet of many insurers (Domanski *et al.*, 2017).

The rise in insurers' capitalisation can be due to the regulatory framework under which the IC sector operates. For instance, the insurance regulation demands the calculation of risk-sensitive capital requirements. As our analysis shows, monetary policy loosening leads to increased risk-taking by ICs in terms of their investment profile. As a result their capital requirement will mechanically rise as well. Moreover, while the Solvency II regulation requires full mark-to-market accounting on the asset and liquidity side, there are significant implementation lags and transitional periods. During the sample period of our study, oftentimes mark-to-market is only applied on the asset valuations in many European jurisdictions. Hence, when only asset valuations increase after a monetary loosening, the market valuation of ICs' capital positions could even improve. Another reason that may explain the increase in capital is the symmetric adjustment of the equity capital charge. This measure implies that during periods of equity price booms, the capital requirement for equity investment increases. By construction, the monetary policy we identify is related to an increase in capital markets, and we also observe that investment in equity increases after the monetary policy shock.

5.2. Bond portfolio responses

Re-balancing and additional risk-taking does not only occur between asset classes, but also within the bond portfolio, which comprises the largest asset class within insurers' balance sheets. This section, therefore, studies the reaction of the bond portfolio after a monetary policy loosening in greater detail. Using the granular Security Holdings Statistics, we analyse shifts in the bond portfolio in terms of their geographical and sectoral allocation, as well as in terms of credit and duration risk-taking.

5.2.1. Geographical and sectoral allocation. The first dimension we look at is the split between domestic bonds, issued in the euro area, and bonds issued in the rest of the world (RoW). The insurance sector, like other investor groups (Coeurdacier and Rey, 2013; Florez-Orrego *et al.*, 2023), tends to have a preference for domestically-issued bonds. On average, ICs' bond portfolios in our sample consist of around 74% of euro area issued bonds, while only the remaining quarter is issued abroad. These portfolio shares, however, may vary with monetary policy, e.g., when foreign assets become relatively more attractive after a domestic monetary loosening (Ammer *et al.*, 2019). Investing in foreign assets can carry higher levels of risk compared with investing in euro area assets with similar characteristics. These risks can stem from foreign exchange fluctuations or a relatively lower expertise in foreign financial markets.

Figure 9 shows IRFs of EA and RoW bond holdings both in levels and as share of ICs' total bond portfolio after a 1 basis point monetary loosening. We find that bond holdings of euro area issued assets fall both in absolute and relative terms, while foreign bond holdings increase. This finding is consistent with searching-for-yield behaviour and it is evidence of an international risk-taking channel (see,

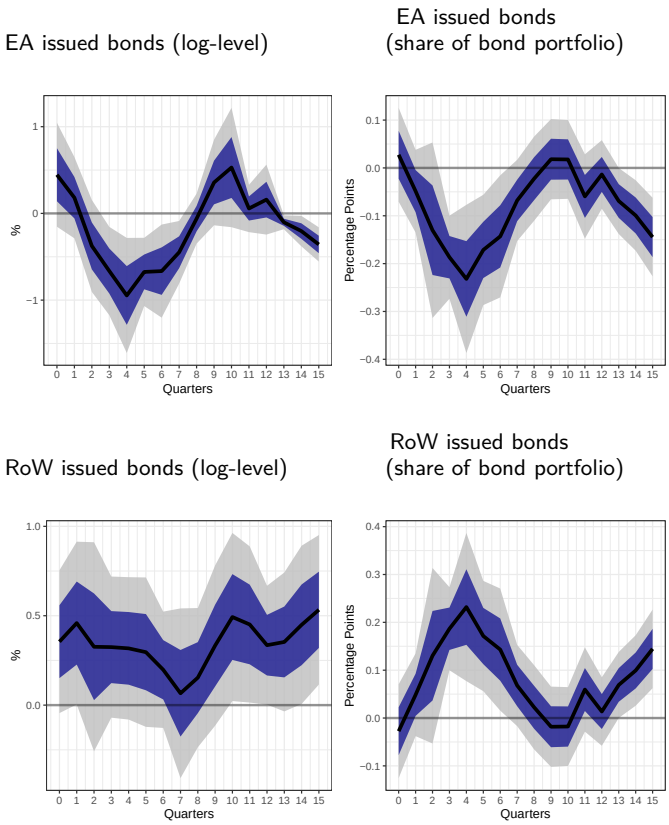

Figure 9: Impulse responses of insurers' bond portfolio by geographical focus

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column). Upper and lower panels show results for bonds issued by euro area (EA) and rest of the world (RoW) entities, respectively.

among others, Bruno and Shin, 2015 and Kaufmann, 2023) for the insurance sector. Indeed, the average return of ICs EA bond holdings decreased from 3.3% to 0.55% between 2010 and 2019, while the return on RoW bonds fell from 3.2% to 0.9%, implying a growing yield differential over our sample period (see Panel B of Figure A.3 in Appendix A).

The next dimension we analyse is the sectoral breakdown of the bond issuers within the EA and the RoW portfolios. Specifically, we split the portfolio into government, financial and non-financial corporate bonds. These categories may differ in terms of their average returns and riskiness. For example, government bonds usually feature relatively lower returns than similarly rated corporate

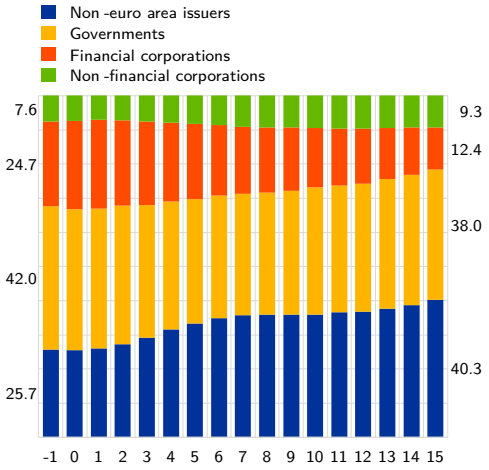

Figure 10: Bond portfolio projection: Geographical and sectoral allocation

Notes: The figure is a graphical representation of the projected evolution of insurance corporations' bond portfolio composition in percentages, following an expansionary high-frequency monetary policy shock inducing a 10 basis point decrease of the term structure factor. The x-axis shows quarters after the shock. The bar denoted "-1" represents the sample average for each item. The balance sheet projections are based on the IRFs shown in Figures B.6 and B.7 (Appendix B.2).

bonds, given their safety and liquidity benefits (Krishnamurthy and Vissing-Jorgensen, 2012; Nagel, 2016). We therefore expect that monetary policy can have heterogeneous effects on the holdings of different issuer sectors.

Figure 10 provides a projection of the bond portfolio composition along these dimensions, based on IRFs shown in Figures B.6 and B.7 (Appendix B.2), to a 10 basis points high-frequency loosening shock. Consistent with Figure 9, we find that the average portfolio share of RoW bond holdings increase from 25.7% before to more than 40% three years after the shock. Figure B.7 adds that within the RoW portfolio, all issuer sectors increase with relatively stronger effects for corporate bonds. Within the shrinking EA bond portfolio, we document a powerful re-balancing away from government and financial corporate bonds, while the the share of non-financial corporate bond holdings increases moderately from 7.6% to 9.3%. Figure B.6 shows that NFC bonds are the only sector, where ICs' holdings also increase significantly in absolute amounts (log-levels). This provides further evidence for a transmission of monetary policy to the real economy via the insurance sector.

The decline in holdings of EA financial corporations, consisting to the largest part of bank bonds, point to a reduction of interconnectedness through funding links in the financial system when interest rates fall. This is consistent with the observation that banks have tended to rely more on central bank and deposit funding compared to wholesale funding on bond markets while yields were low (ECB, 2022a). The decline in government bond holdings is in line with the

downward pressure on their yields when central banks reduce interest rate levels and increase government bond scarcity by quantitative easing programmes (Eser *et al.*, 2023), as was the case during our sample period, rendering these assets relatively less attractive.

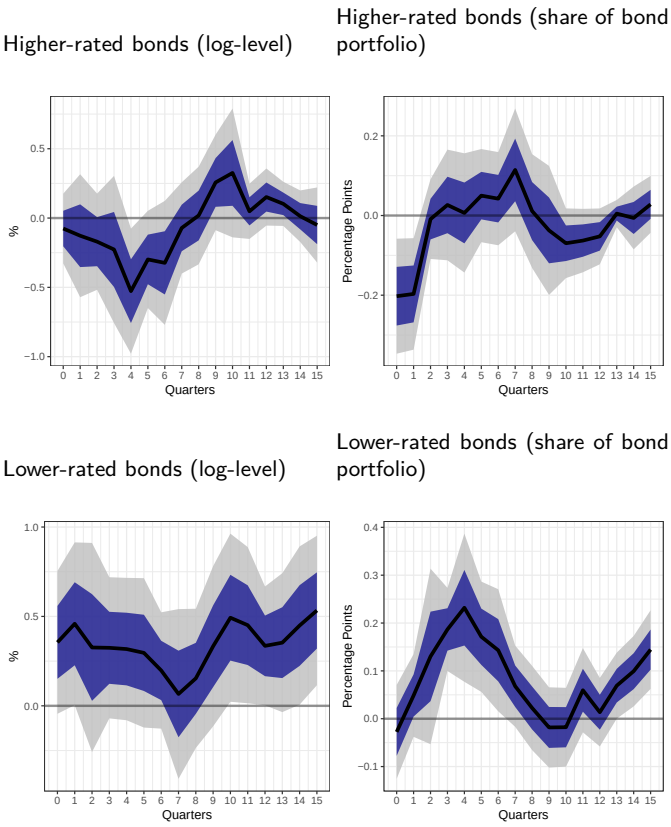

Figure 11: Impulse responses of insurers' bond portfolio by credit rating

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column). Higher-rated bonds include ratings above BBB. Lower-rated bonds are rated BBB or below.

5.2.2. Credit risk. Augmenting our data set with information on issuer ratings, we assess the effect of monetary policy on credit risk-taking within insurers' bond portfolios. We distinguish between two broad rating categories: Higher-rated bonds corresponding to debt securities with a rating of AAA, AA and A; and lower-rated bonds including debt securities with a rating below or equal to BBB. We choose

this split, as insurers credit risk-taking in search for yield usually takes place in the BBB segment given high regulatory capital requirements for bonds rated as high-yield (see Panel A of Figure A.3 in Appendix A).

Figure 11 reports IRFs for ICs' holdings of these rating categories in levels and as share of the total bond portfolio. We find that, both in absolute and in relative terms, the holdings of higher-rated bonds fall while lower-rated holdings increase. We illustrate the projected bond portfolio, again for a 10 basis point monetary loosening shock, in Figure 12. We observe that the share of higher-rated bonds declines from 53.2% of the total bond portfolio to 49.6%, while the share of lower-rated securities in the bond portfolio increases by 5 percentage points from 32% to 37%. Consistent with the risk-taking channel of monetary policy, this finding shows that the IC sector's risk appetite increases after a monetary policy loosening.

This shows that the IC sector's risk preferences change depending on monetary policy changes, leading to a higher concentration of risk in the IC sector bond portfolios after a monetary policy loosening. While this risk-taking in the bond portfolio helps to transmit monetary policy and ease financial conditions also for the riskier agents in the economy, it also implies an additional build-up of credit risk in insurers' balance sheets. To the best of our knowledge, this form of credit risk-taking after expansionary monetary policy has not been documented before for European insurers using a causal econometric approach.

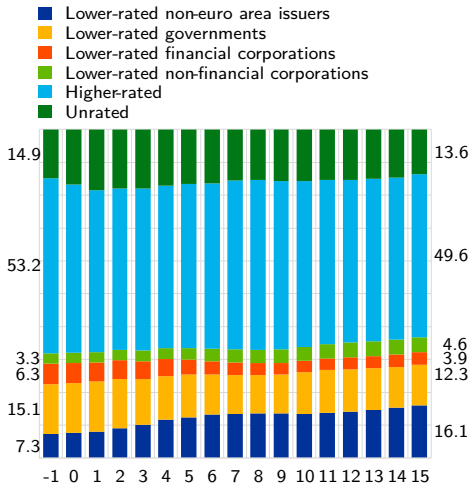

Figure 12: Bond portfolio projection by sectoral allocation and rating

Notes: The figure is a graphical representation of the projected evolution of insurance corporations' bond portfolio composition in percentages, following an expansionary high-frequency monetary policy shock inducing a 10 basis point decrease of the term structure factor. The x-axis shows quarters after the shock. The bar denoted "-1" represents the sample average for each item. The balance sheet projections are based on the IRFs shown in Figures B.8 and B.9 (Appendix B.2).

Looking more deeply into the composition of the lower-rated bond holdings by issuer sector and region (confer Figures B.8 and B.9 in Appendix B.2), we find

that the strongest increase can be found in the holdings of bonds issued outside the euro area. Consistent with the last section this points towards a searching for yield in foreign assets. In line with Figure 10, we find that also in the lower-rated segment, holdings of government and financial corporate bonds fall, while those of non-financial corporate bonds rise mildly.

The unrated segment, which makes up about 15% of the bond portfolio on average, is projected to remain of similar magnitude after the monetary policy shock. Darmouni and Papoutsi (2023) show that these bonds are often related to small new issuers and that their yields are comparable with those of the BBB segment.

5.2.3. Duration risk. We discuss two main channels in Section 3.2 why a drop in yield levels could induce insurers to buy more longer-term securities and, thus, lengthen the duration of their bond portfolio. First, purchasing more longer-term bonds could help insurers maintaining their capital positions when their balance sheets feature a negative duration gap (Domanski *et al.*, 2017). Second, investments in longer-maturity assets can offer a higher return and thus support the profitability of the sector in times of declining yields, in case yield curves are upward sloping (Ozdagli and Wang, 2019).

Figure 13 shows IRFs of the weighted average residual maturity of insurers' bond portfolio after a monetary loosening shock by issuer sector and by rating as defined in (3). We find that the average portfolio duration increases after the shock in line with the two channels. For the total bond portfolio (upper left panel) the effect becomes significant after around two years. The effect is considerably more pronounced within the government bond portfolio and for higher rated bonds. It is strongest for AAA-rated government bonds.[15] In this category a significant rise in WARM is visible already after three quarters.

These effects are also of a economically relevant magnitude. Considering again a shock that implies 50 basis points higher quarterly yields on impact, we find that the WARM of the whole bond portfolio rises by more than 7 months within three years after the shock, which compares to an average portfolio duration of around 9 years in our sample. In case of the AAA-rated segments, the WARM of government and corporate bond holdings each increase by about two years. The sample average for these categories read 11 and 8.4 years (Table A.3, Appendix A). Our findings imply that insurers engage into duration risk-taking especially in safe assets where credit losses are unlikely and in their government bond portfolios. The relatively stronger effects in the government debt portfolio are consistent with the fact that yield compression is arguably strongest in this segment, also in view of unconventional monetary policies that increase the scarcity of these assets.

15. Focusing on AAA-rated bonds allows us to separate duration from credit risk-taking to the extent possible. Moreover, for the duration analysis we only consider bonds issued in the euro area to avoid potentially conflating effects from exchange rate risks.

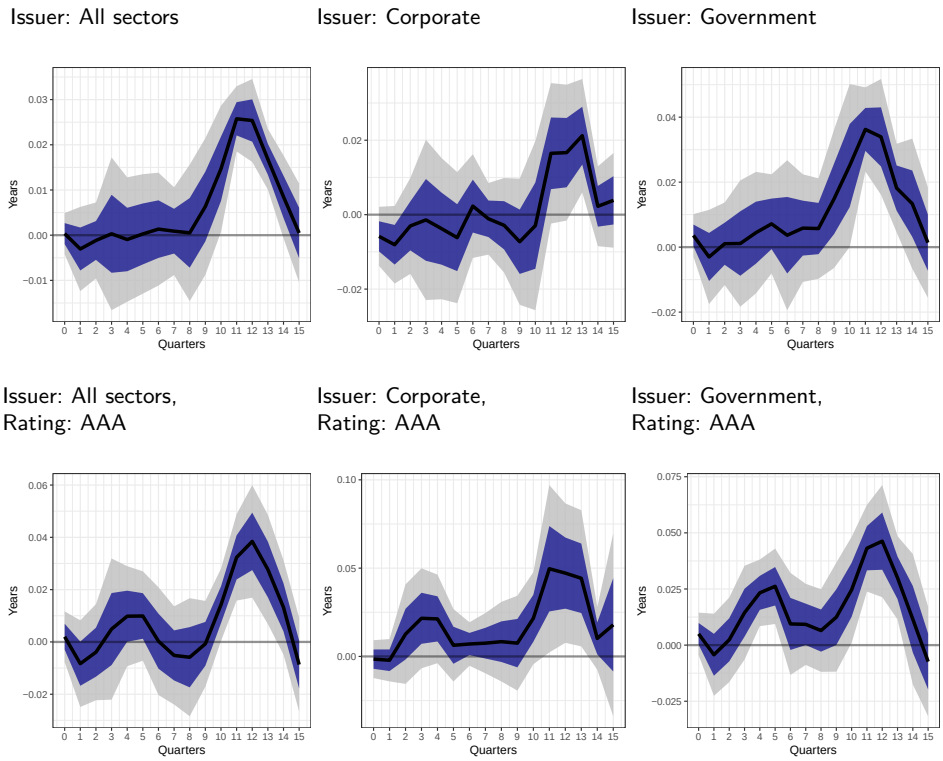

Figure 13: Impulse responses of weighted average residual maturity of insurers' bond portfolio

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Weighted average residual maturity is calculated as described in (3).

The higher demand by insurers for longer-term bonds is also mirrored by changes on the supply side of bond markets. For government bonds, Plessen-Mátyás *et al.* (2023) show that EA governments significantly increase the maturity of newly issued debt when yields are low and in presence of active quantitative easing programmes. Likewise, there is evidence that also firms extend the maturity of their bond issuance when long-term assets become scarce due to monetary policy operations (Greenwood *et al.*, 2010; Badoer and James, 2016; Foley-Fisher *et al.*, 2016).

Duration risk-taking is also visible when analysing changes in bond holdings by maturity segments. Figure B.10 (Appendix B.2) shows that ICs increase the absolute amounts of holdings of long-term bonds, defined by a WARM of 10 years and above. Moreover, the holding ratios of long-term bond relative to similar assets, as defined by (4), increase significantly as well. For example, three years after

the shock that translates into 50 basis points higher quarterly yields, the ratio of long-term bonds increases from, on average, 34 percentage points by another 9.5 percentage points in ICs' government AAA bond portfolios.

5.3. Sensitivity analysis

In this section, we examine a series of robustness checks for our main results. Specifically, we assess the sensitivity of the results to changes in the shock definition, the used control variables, and the sample length. All Figures pertaining to this section are shown in Appendix B.2. In all exercises, we show the response of total assets and technical reserves (as in Figure 6) and the response of all main balance sheet items as a share of total assets (as in the IRFs underlying Figure 8).

We begin with alternative definitions of the monetary policy shocks. In Figures B.11 and B.12 we show IRFs in which we replace our term structure surprise factor with surprises in the 10-year German Bund around all ECB Governing Council meetings during our sample. The responses of total assets and technical reserves are very similar to the baseline, especially when measured in nominal values. Likewise, the responses of the main balance sheet items are also very close to the baseline results, confirming the re-balancing away from safer assets like cash holdings and debt securities to assets like equity and investment fund shares.

Further, we consider responses to a shock to the short-end of the yield curve, proxied by the 3-month OIS rate. This shock can be considered as a measure that mainly captures the effect of conventional monetary policy to control short-term interest rates. Total assets and technical reserves also rise significantly after this shock (Figure B.13). The increase only commences with a lag of around two years, though. In terms of portfolio re-balancing and changes of the liability composition, the results are again very consistent with the baseline findings (Figure B.14).

Next, we examine variations in the control variables added to the local projections. Figures B.15 and B.16 show results for when we add country-specific old-age dependency ratios and life expectancy. The rationale for this is that demographic change is considered as one of the main driving factors for the high savings and wealth increases observed in many advanced economies in the last decades (see, e.g., Krueger and Ludwig, 2007 and Auclert *et al.*, 2021). As such, it can also be an important determinant of the growth of the financial – and especially the life and pension insurance – sector. We find that the results regarding sector growth as well as balance sheet composition are virtually unchanged when these variables are added.

Our estimation model does not allow for the inclusion of time-fixed effects due to their collinearity with the monetary policy shocks. Common time effects stemming from financial markets are already captured in our setting by the aggregate variables for the interest rate level, bond spreads and the VSTOXX. In a further exercise we now add aggregate euro area GDP to the control variables as a proxy for common time effects related to macroeconomic developments. Our main results (see Figures B.17 and B.18) are again very robust to this extension of

the model. The rise in total assets and technical reserves only starts a few quarters later than in the baseline.

These last two extensions of the control variable set add further confidence that our monetary policy shocks are indeed exogenous and do not pick up effects of other macro-financial developments.

Lastly, we extend the estimation sample of our analysis. We now begin our analysis in 2008 Q1 instead of 2010 Q1 and we end it in 2021 Q4 instead of 2019 Q4. In this way, we include both the global financial crisis and the Covid-19 episode. These two events are known to have potentially highly distorting effects on econometric estimates. Moreover, as shown in Figure 4, some of the largest monetary policy shocks in our sample are found in these times. Given the exceptional economic circumstances at the beginning of the coronavirus pandemic, we still exclude the first two quarters of 2020.[16] The results, presented in Figures B.19 and B.20, however, show that our main results are also robust in this longer sample period.

6. Conclusion

In this paper we analyse the effects of monetary policy on the size and composition of insurers' balance sheets, as well as the implications of these effects for financial stability. We find that changes in monetary policy have a significant impact on both sector size and risk-taking. Insurers' balance sheets grow materially after a monetary loosening, implying an increase of the sector's financial intermediation capacity and an active transmission of monetary policy through the insurance sector. Our results suggest the presence of an insurance sector transmission channel of monetary policy that has previously not been documented in the literature. We also find evidence of portfolio re-balancing consistent with the risk-taking channel of monetary policy. After a monetary loosening, insurers increase credit, liquidity and duration risk-taking in their asset portfolios. Our results suggest that extended periods of low interest rates lead to rising financial stability risks among non-bank financial intermediaries.

In the context of rising interest rate levels, our results suggest that medium-term financial stability risks could decline, though, when insurers reduce the riskiness of their assets symmetrically to the risk increases undertaken when yields declined. This would strengthen the sector's resilience to adverse macroeconomic shocks, such as an increase in corporate defaults. Lower demand from insurers for riskier assets may, however, also contribute to deteriorating financing conditions for firms and the wider economy. Increases in insurers' cash holdings could allow the sector to

16. This approach relates to Lenza and Primiceri (2022), who show that for the purpose of consistent parameter estimation it is appropriate to drop the observations at the onset of the pandemic.

withstand larger liquidity shocks, helping it to absorb policy lapses or large margin calls that may become more frequent as yields rise.

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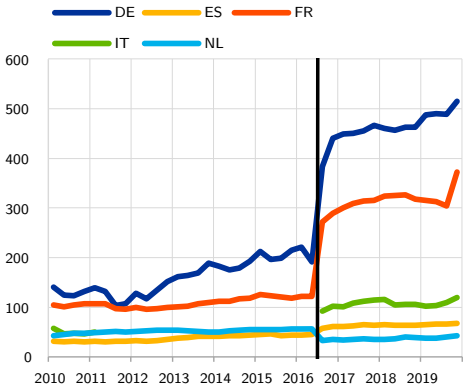
Appendix

Appendix A: Additional Information on the Data Set

(A) Original data series



(B) Modified data after cleaning the structural break

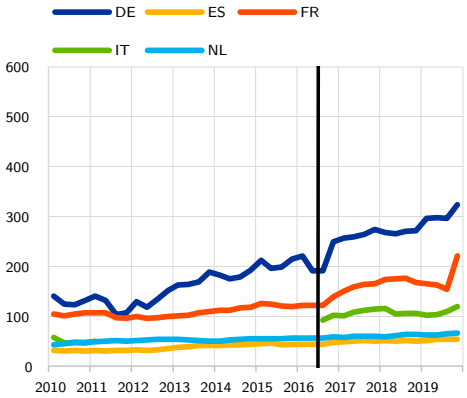
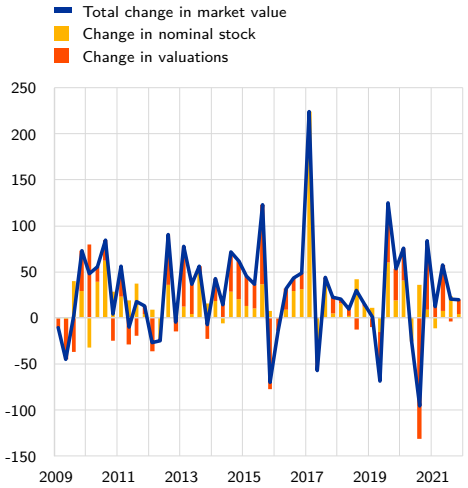


Figure A.1: Capital: Cleaning the structural break

Notes: Panel (A): Original data on insurance sector capital for selected countries in billion EUR. Panel (B): Modified data for selected countries after removing the structural data break in Q3 2016.

(A) Decomposition of quarterly changes in total assets



(B) Nominal and market value of total assets 2009–2021

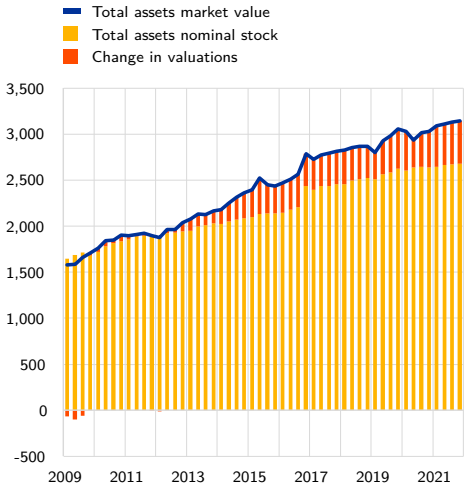
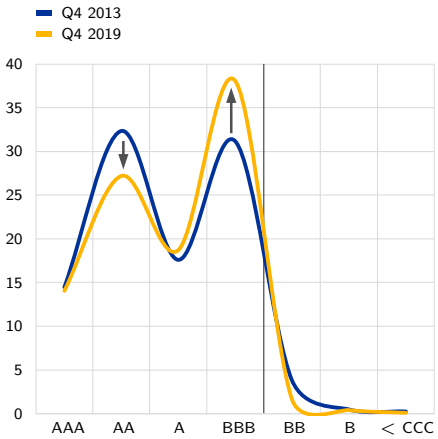


Figure A.2: Market and nominal value of total assets for French insurers over time

Notes: The charts illustrate the differences in total assets developments due to active (i.e. nominal) and passive (i.e. valuation) changes. Nominal assets are constructed as described in (2). Quarterly changes (Panel A) and stocks (Panel B) of total assets are shown for the French insurance sector, which is the largest euro area sector based on total assets. Numbers are in EUR billions.

(A) Bond holding distribution by credit rating



(B) Weighted average yield of bond holdings by issuer region

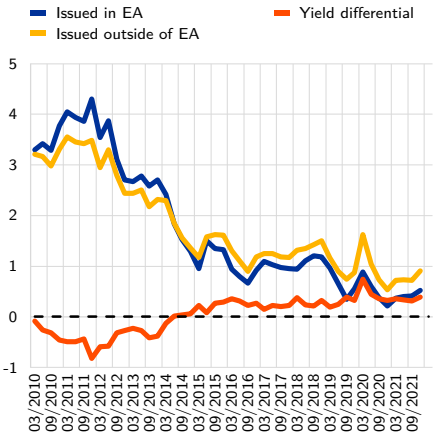


Figure A.3: Insurance corporations' bond portfolios

Notes: Panel (A): Numbers in percentage of total bond portfolio. Vertical line indicates threshold between investment grade and high-yield segment. Panel (B): Numbers are in percent. Yield differential defined as foreign minus euro area yields.

Insurance corporation main balance sheet items
Source: ECB Insurance Corporations and Pension Funds Statistics (ICPF, 2008 Q1 – 2016 Q2); ECB Insurance Corporations Balance Sheet Statistics (ICB; from 2016 Q3)
Variables: Total assets; Asset side: cash holdings, debt securities, equities, investment fund shares, loans; Liability side: capital, technical reserves, debt securities, loans
End-of-quarter country-level balance sheet stocks in market values or nominal values. Nominal values derived as market value at the beginning of the sample period plus sum of all subsequent cumulative flows; see (2). – in levels: log of market or nominal values – as shares: in percent of total assets
Insurance corporation bond portfolio measures
Source: Experimental ECB Securities Securities Holdings Statistics by Sector (SHES, 2009 Q1 – 2013 Q3), ECB Securities Holdings Statistics by Sector (SHSS, from 2013 Q4) and ECB Centralised Securities Database (CSDB)
While data in SHES is of high quality, it has lower coverage. Countries initially missing include: Germany, Ireland, Lithuania, Luxembourg, Latvia, Malta and Slovenia.
Variables with breakdowns by issuer region and issuer sector based on securities holdings in nominal value:
Higher-rated bonds: End-of-quarter country-level debt securities holdings rated A, AA or AAA in the respective issuer segment
Lower-rated bonds: End-of-quarter country-level debt securities holdings rated BBB or below in the respective issuer segment
WARM: End-of-quarter country-level weighted average residual maturity as defined in (3).
Portfolio share of longer-term bonds: End-of-quarter country-level observations as defined in (4).
Monetary policy surprise measures
Source: Euro Area Monetary Policy Event-Study Database by Altavilla *et al.* (2019)
Variables: Overnight index swap rates with maturities of 1 week, 1, 3, 6 months and 1 year; German Bund rates with maturities of 2, 5 and 10 years; EuroStoxx 50.
Changes of variables in basis points (percentage points for EuroStoxx) between the median quote from the time window 13:25 to 13:35 before the press release and the median quote from the time window 15:40 to 15:50 after the end of the press conference on ECB Governing Council meeting dates.
Additional control variables
GDP growth (country specific): Source: Eurostat Main Aggregates National Accounts (MNA). Year-on-year growth rate of gross domestic product at market prices, calendar and seasonally adjusted.
Inflation (Country specific): Source: Eurostat Indices of Consumer prices (ICP). Annual rate of change.
VSTOXX index. Source: ECB Financial Market Data (FM). No additional transformations.
Overnight index swap rates and German Bund yields at various maturities. Source: ECB Financial Market Data (FM). No additional transformations.
Euro BBB-rated corporate bond yield index with residual maturity 3-5 years. Source: ECB Financial Market Data (FM), iBoxx. No further transformations.

Table A.1. Data sources and description of variables

	Mean	St. Dev.	Median	Min	Max	Obs.
(A) Log-Levels in nominal value						
All issuers						
Debt securities	23.72	2.45	24.24	18.62	27.95	660
Higher-rated	22.99	2.44	23.07	17.94	27.50	660
Lower-rated	22.26	2.57	22.59	16.23	26.77	660
Euro Area issued bonds						
All issuers	23.41	2.51	23.94	18.47	27.74	660
Government	22.74	2.55	22.77	17.38	27.00	660
Financial corporate	22.17	2.73	23.06	14.63	26.74	660
NFC	20.99	2.65	21.77	15.61	26.00	660
Lower-rated bonds	21.85	2.75	22.18	15.12	26.69	660
Lower-rated Government	21.31	2.74	21.42	13.17	26.47	553
Lower-rated Financial corp.	20.75	2.84	21.69	13.96	25.28	644
Lower-rated NFC	20.31	2.47	20.85	14.79	25.11	622
Rest of the World issued bonds						
All RoW issuers	22.24	2.33	22.75	15.56	26.33	660
RoW Government	20.08	2.12	19.96	14.68	24.55	660
RoW Financial corp.	21.71	2.50	22.43	13.73	25.87	660
RoW NFC	20.20	2.73	20.75	14.18	25.12	660
Lower-rated RoW	20.85	2.29	21.41	14.41	25.09	660
Lower-rated RoW Government	18.57	2.08	18.73	12.19	22.86	609
Lower-rated RoW Financial corp.	20.32	2.44	20.96	12.64	24.34	633
Lower-rated RoW NFC	19.61	2.51	20.03	13.87	24.50	601
(B) Share of total bond portfolio in nominal value						
All issuers						
Higher-rated	53.15	19.27	59.84	12.26	84.70	660
Lower-rated	29.61	19.57	22.93	1.09	84.01	660
Euro Area issued bonds						
All EA bonds	74.32	12.19	77.51	46.81	95.30	660
Government	42.03	18.47	38.68	8.43	89.33	660
Financial corporate	24.66	12.29	22.75	1.02	75.24	660
NFC	7.63	4.18	6.91	0.87	29.10	660
Lower-rated EA bonds	22.31	19.36	14.88	0.08	77.54	660
Lower-rated Government	15.10	17.64	6.54	0.03	63.11	553
Lower-rated Financial corp.	6.27	4.33	5.22	0.08	25.94	644
Lower-rated NFC	3.26	1.79	2.84	0.22	10.58	622
Rest of the world issued bonds						
All RoW issuers	25.68	12.19	22.49	4.70	53.19	660
RoW Government	5.12	5.86	3.11	0.05	29.70	660
RoW Financial corp.	15.71	8.44	13.57	0.39	43.52	660
RoW NFC	4.12	3.24	3.46	0.32	17.31	660
Low-rated RoW	7.30	5.38	5.68	0.35	33.04	660
Low-rated RoW Government	1.66	3.04	0.57	0.00	23.35	610
Low-rated RoW Financial corp.	3.88	4.06	2.74	0.12	32.27	633
Low-rated RoW NFC	2.08	1.86	1.68	0.02	9.36	601

Table A.2. Descriptive statistics: Bond portfolio holdings

Notes: Observations at country-sector level for all 19 euro area countries between 2010 Q1 and 2019 Q4 (unbalanced panel). Data in Panel (A) in log of EUR, Panel (B) in % of total bond portfolio. Lower-rated bonds defined with a rating of BBB or below. NFC: non-financial corporate; RoW: rest of the world.

	Mean	St. Dev.	Median	Min	Max	Obs.
(A) Weighted average residual maturity (years)						
Issuer sector						
All sectors	9.15	2.88	8.75	3.49	18.31	660
Government	10.02	3.27	9.66	3.48	21.76	660
Corporate	7.87	2.59	7.65	3.25	17.21	660
(B) Weighted average residual maturity of AAA-rated debt (years)						
Issuer sector						
All sectors	9.94	3.34	9.39	3.75	18.94	660
Government	10.84	3.98	10.17	3.78	23.46	660
Corporate	8.36	3.62	7.72	1.21	30.69	651
(C) Bond holdings at different maturities						
Issuer sector, all AAA-rated						
All sectors, maturity over 5 years	21.52	2.82	21.45	15.26	26.81	660
All sectors, maturity over 10 years	20.82	2.95	20.49	13.12	26.08	652
Government, maturity over 5 years	21.07	2.87	21.02	15.26	26.40	660
Government, maturity over 10 years	20.40	3.01	20.25	12.32	25.82	651
Corporate, maturity over 5 years	20.30	2.75	20.30	12.65	25.74	649
Corporate, maturity over 10 years	19.41	2.89	19.06	12.65	24.70	639
(D) Portfolio share of long-term bonds						
All issuers and AAA-rated						
Maturity over 5 years	63.55	14.97	65.16	22.33	94.32	660
Maturity over 10 years	34.43	18.16	34.73	1.54	79.21	652
Government issued bonds and AAA-rated						
Maturity over 5 years	67.01	16.96	69.08	22.24	99.22	660
Maturity over 10 years	38.29	22.13	37.60	0.65	93.32	651
Corporate issued bonds and AAA-rated						
Maturity over 5 years	56.59	17.33	57.94	2.59	100.00	649
Maturity over 10 years	26.94	17.20	24.76	0.63	100.00	639

Table A.3. Descriptive statistics: Bond portfolio duration

Notes: Observations at country-sector level for all 19 euro area countries between 2010 Q1 and 2019 Q4 (unbalanced panel). Data in Panels (A) and (B) in years as defined in (3). Panel (C) in log-levels. Panel (D) shows portfolio share of long-term bonds in % as defined in (4).

Appendix B: Additional Results

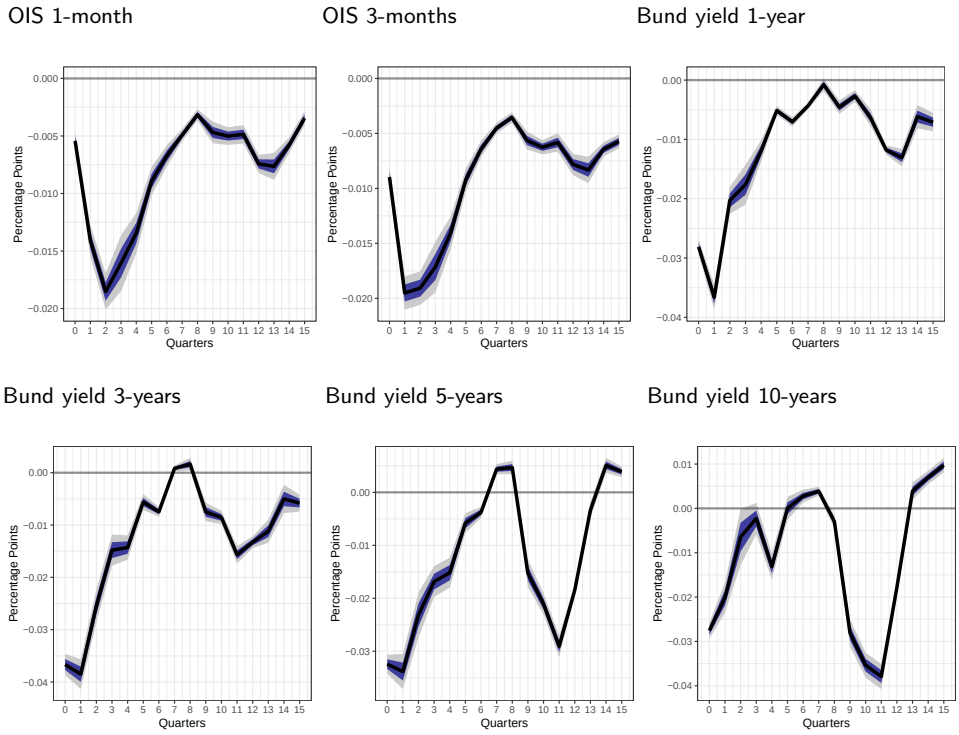


Figure B.1: Impulse responses of various interest rates

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

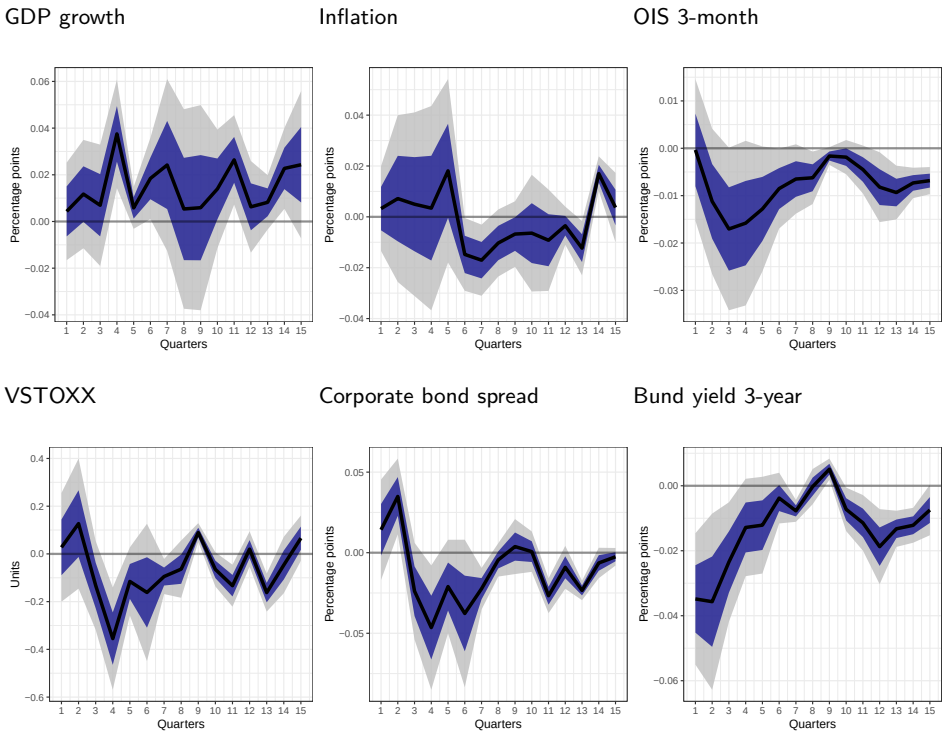


Figure B.2: Impulse responses of macroeconomic and financial variables - Time series model

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Results are based on aggregate time series data for the euro area instead of the panel data used in the main text.

B.1. Main balance sheet items

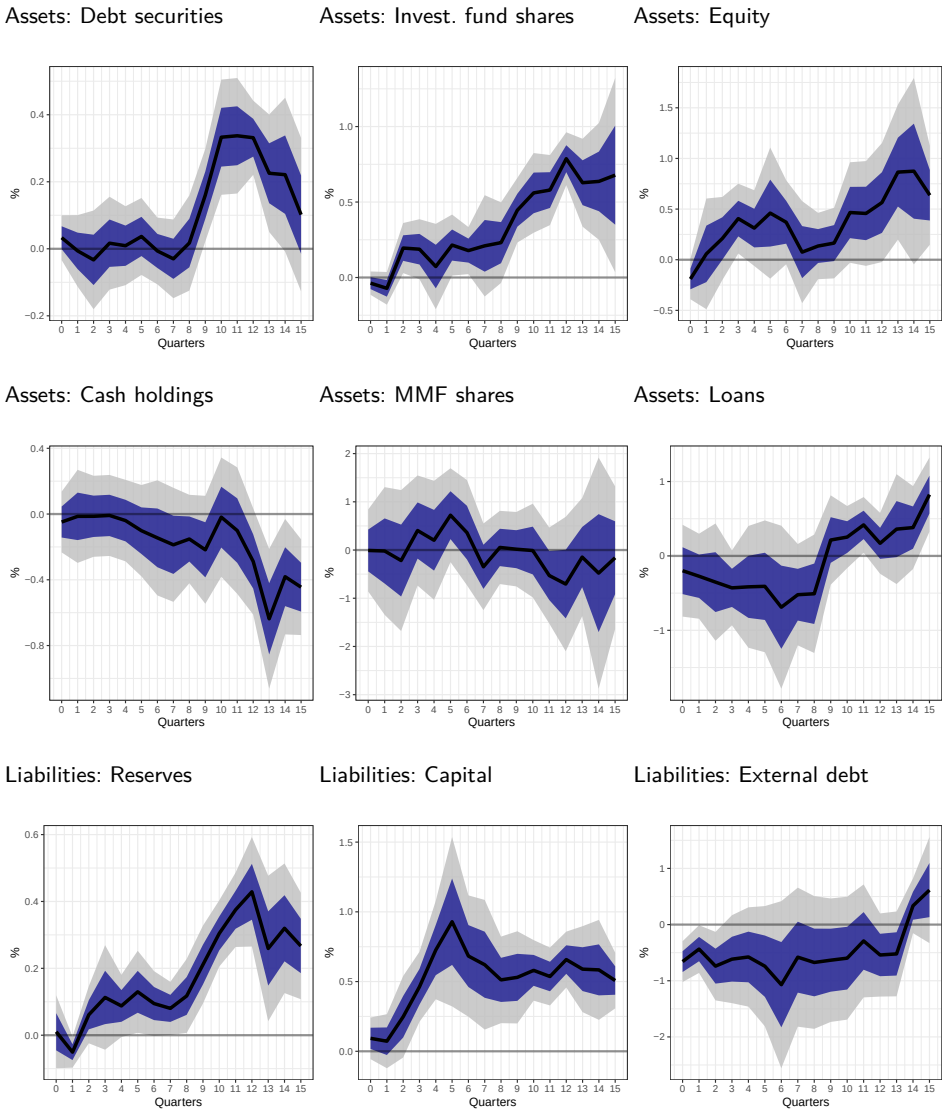


Figure B.3: Impulse responses of main asset and liability components: Log-levels of market value

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

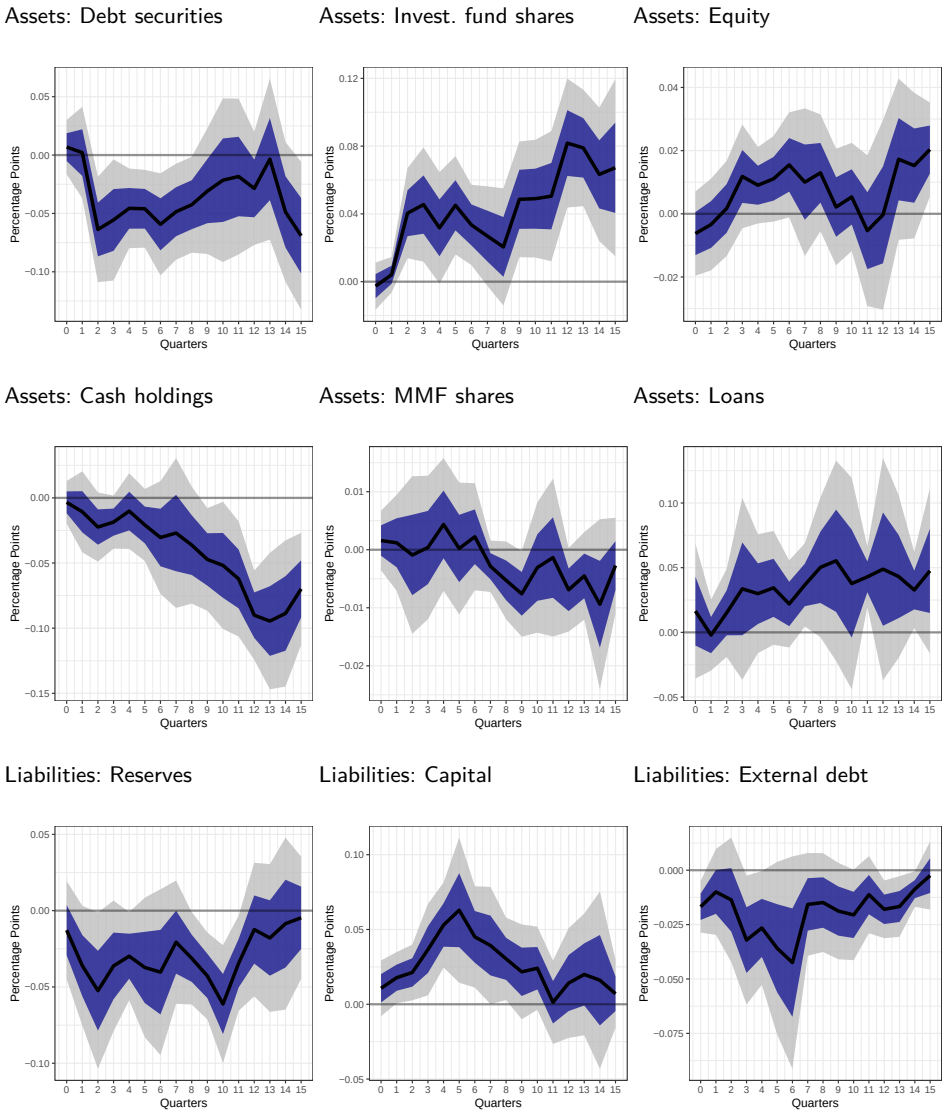


Figure B.4: Impulse responses of main asset and liability components as a share of total assets: Market value

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

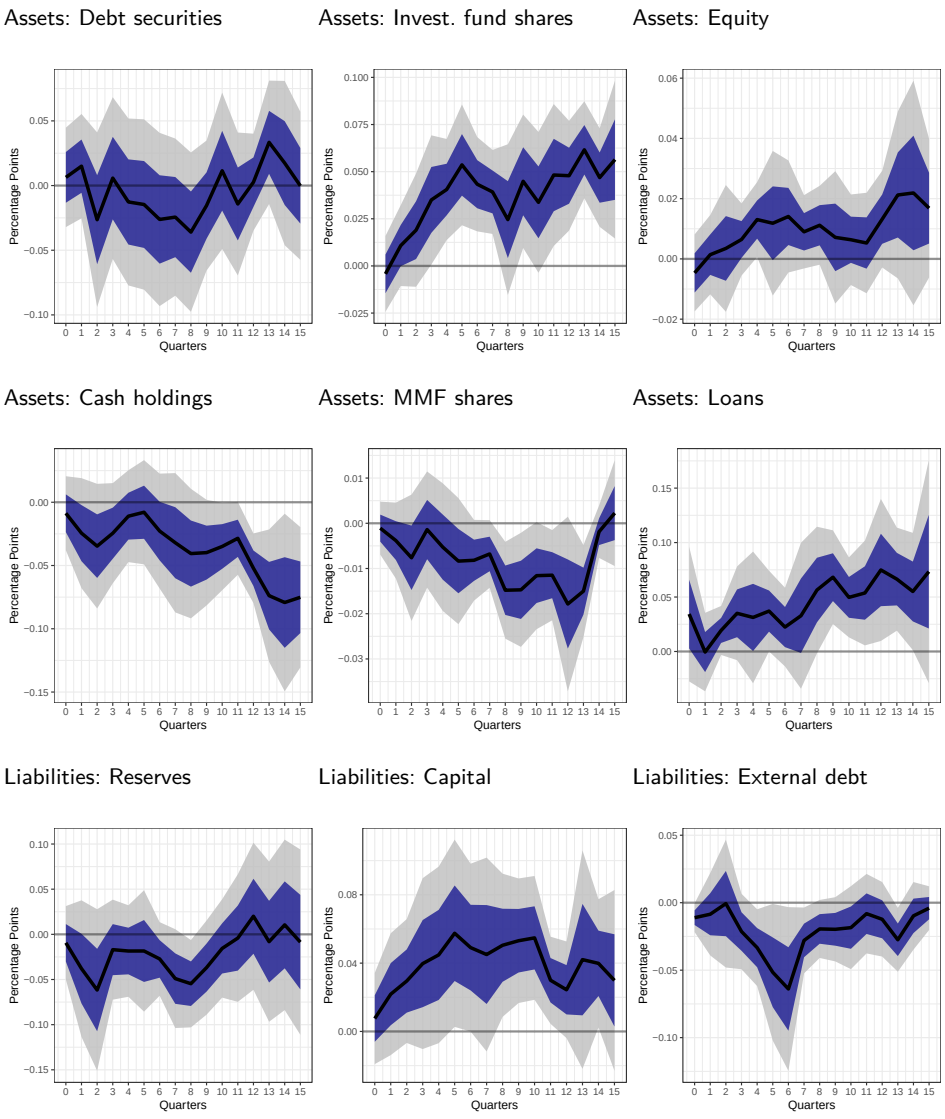


Figure B.5: Impulse responses of main asset and liability components as a share of total assets: Nominal value

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects.

B.2. Bond portfolio responses

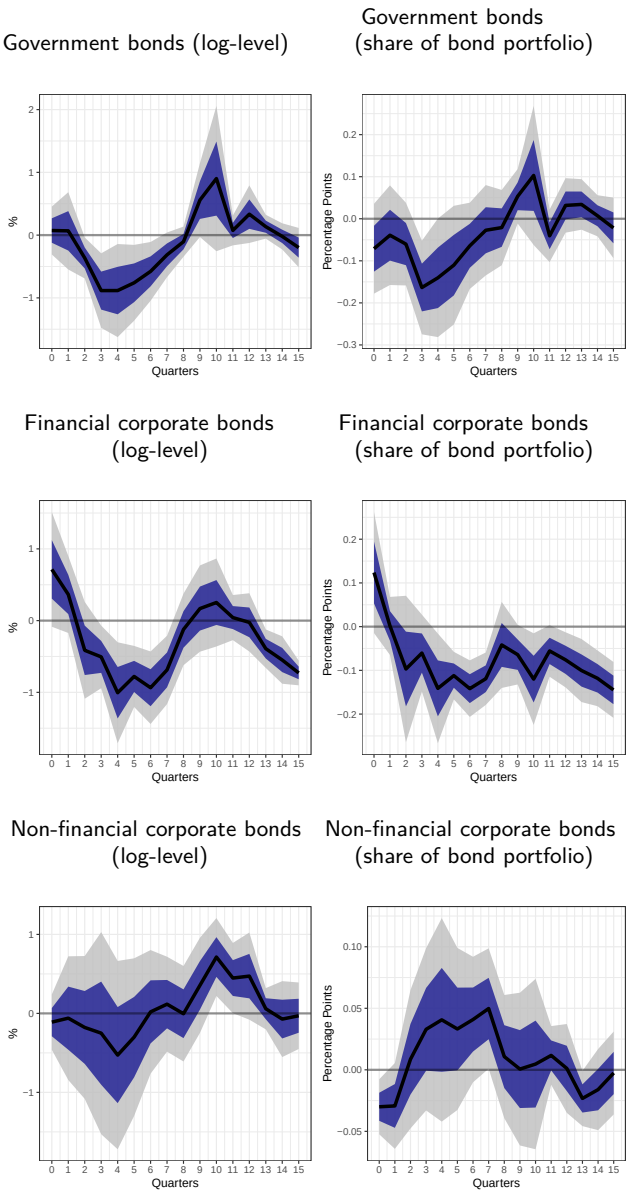


Figure B.6: Impulse responses of insurers' bond portfolio by euro area issuer sector

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column).

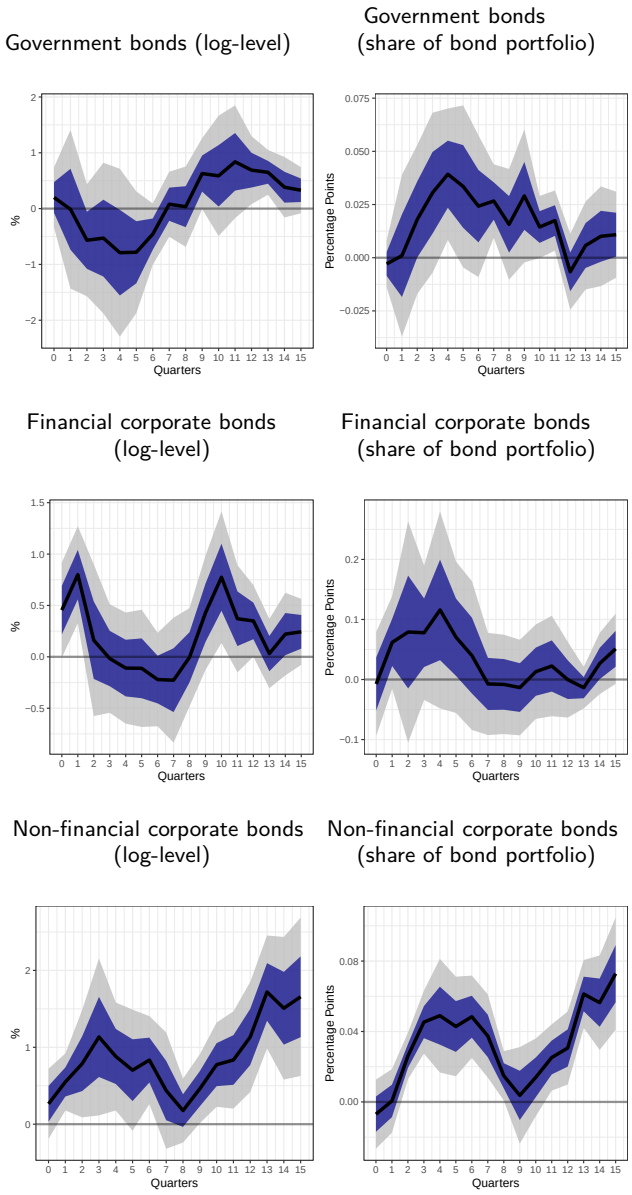


Figure B.7: Impulse responses of insurers' bond portfolio by issuer sector outside of euro area

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column).

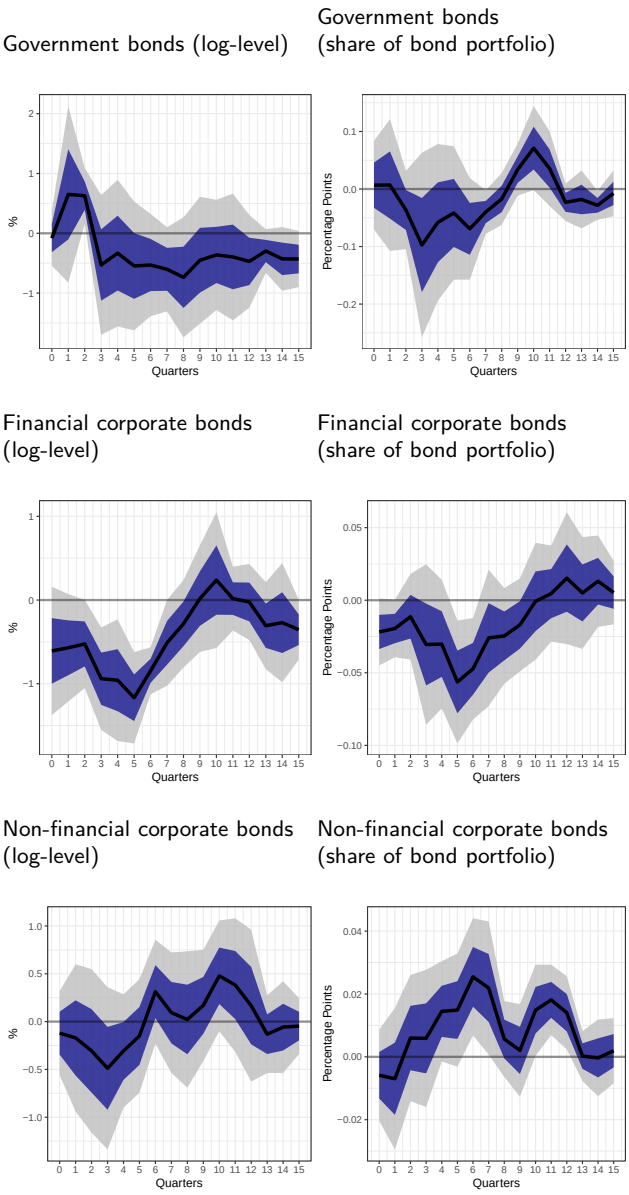


Figure B.8: Impulse responses of insurers' lower-rated bond holdings by issuer sector in the euro area

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column). Lower-rated bonds are rated BBB or below.

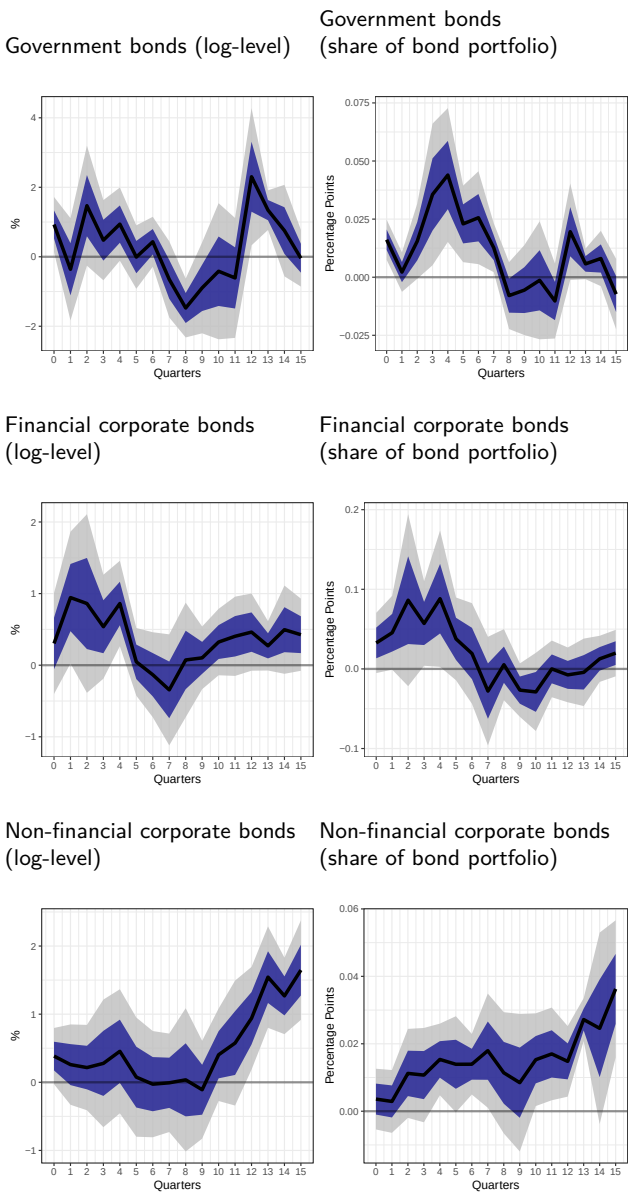


Figure B.9: Impulse responses of insurers' lower-rated bond holdings by issuer sector outside of the euro area

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value, i.e. without valuation effects, (left column) and as share of total bond portfolio (right column). Lower-rated bonds are rated BBB or below.

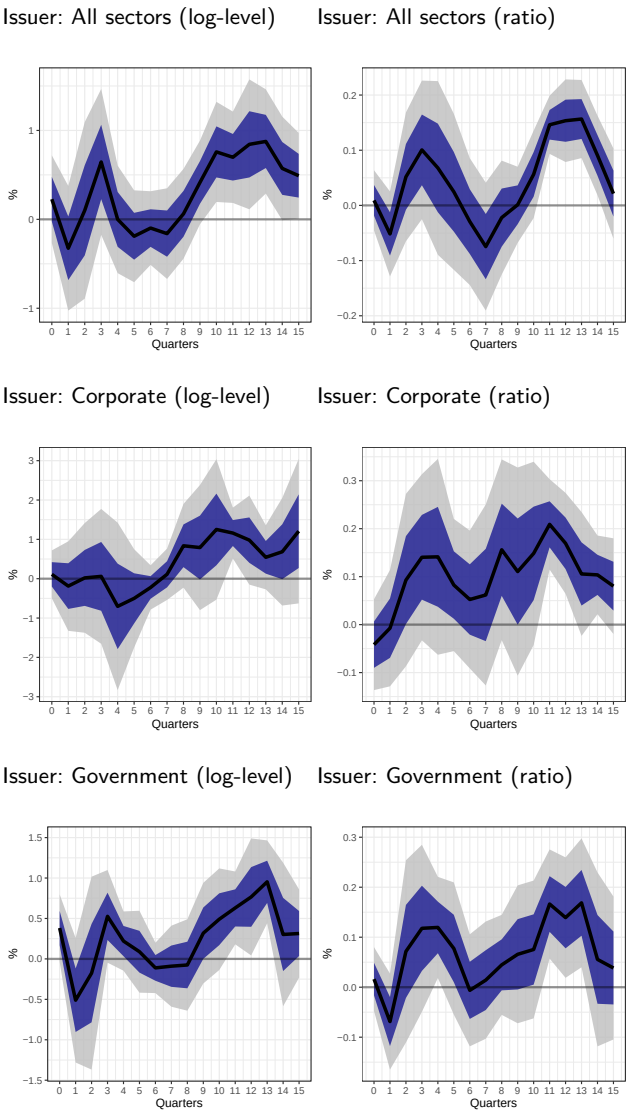


Figure B.10: Impulse responses of insurers' bond holdings with maturity over 10 years

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Variables in log-levels of nominal value (left column) and as portfolio share as defined in (4) with $M = 10$ (right column). Bonds are restricted to a rating of AAA to control for changes in credit risk.

B.3. Sensitivity analysis

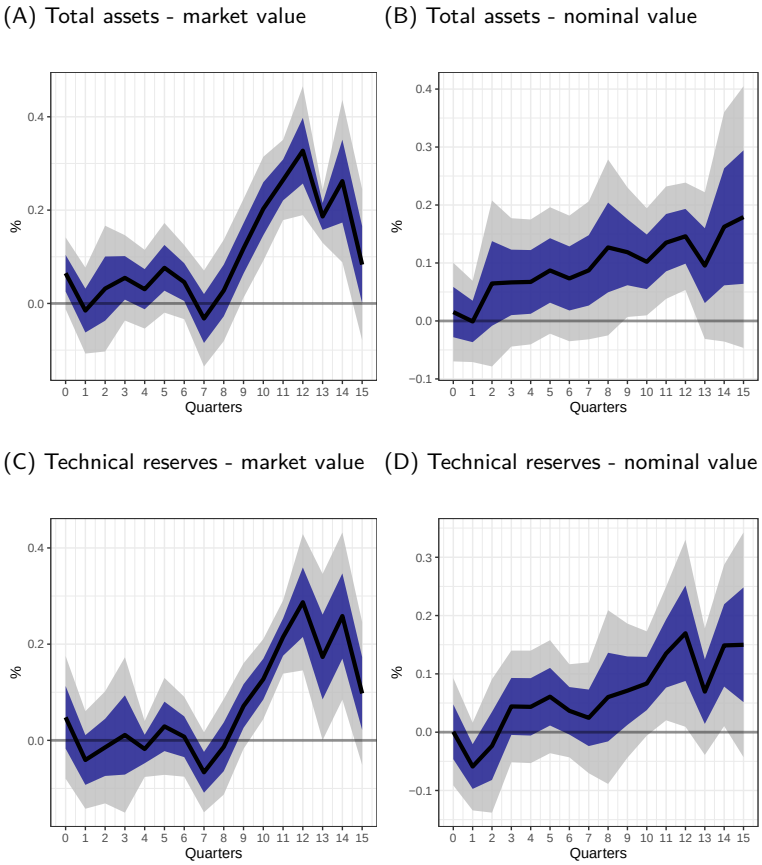


Figure B.11: Impulse responses of insurance corporations' total assets and technical reserves: shock to 10-year yield

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the 10-year Bund rate. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects.

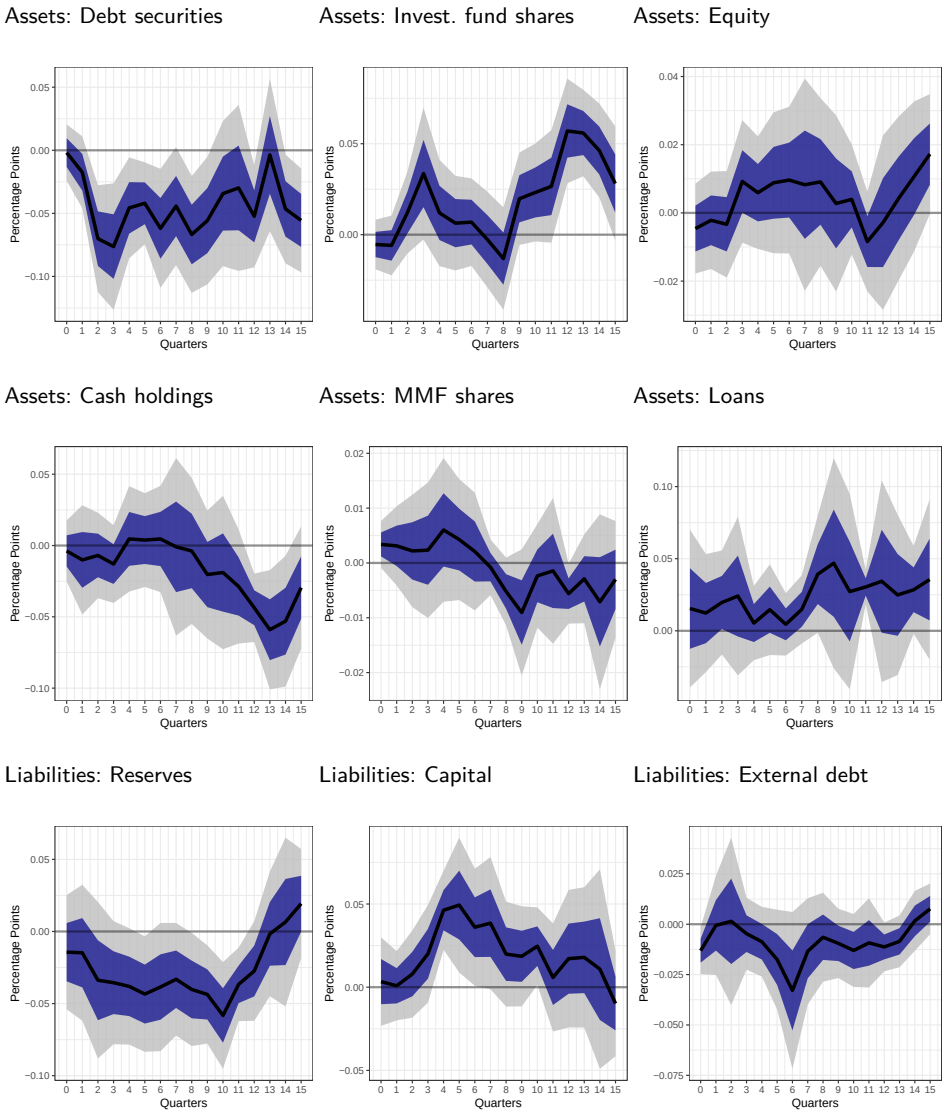


Figure B.12: Impulse responses of main asset and liability components as a share of total assets: shock to 10-year yield

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the 10-year Bund rate. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

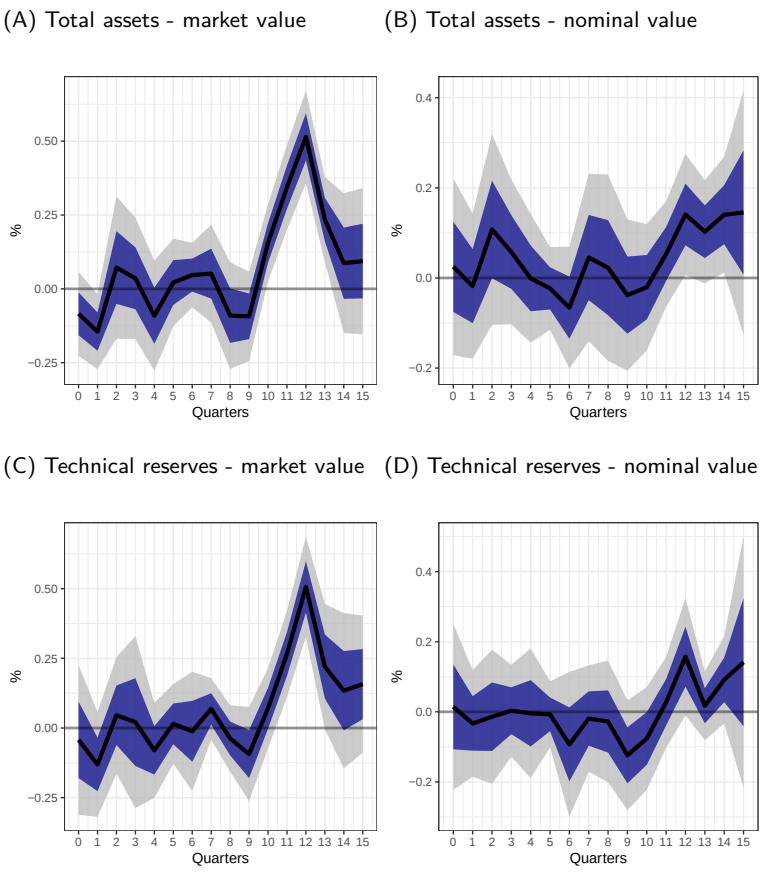


Figure B.13: Impulse responses of insurance corporations' total assets and technical reserves: shock to 3-month OIS

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the 3-month OIS rate. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects.

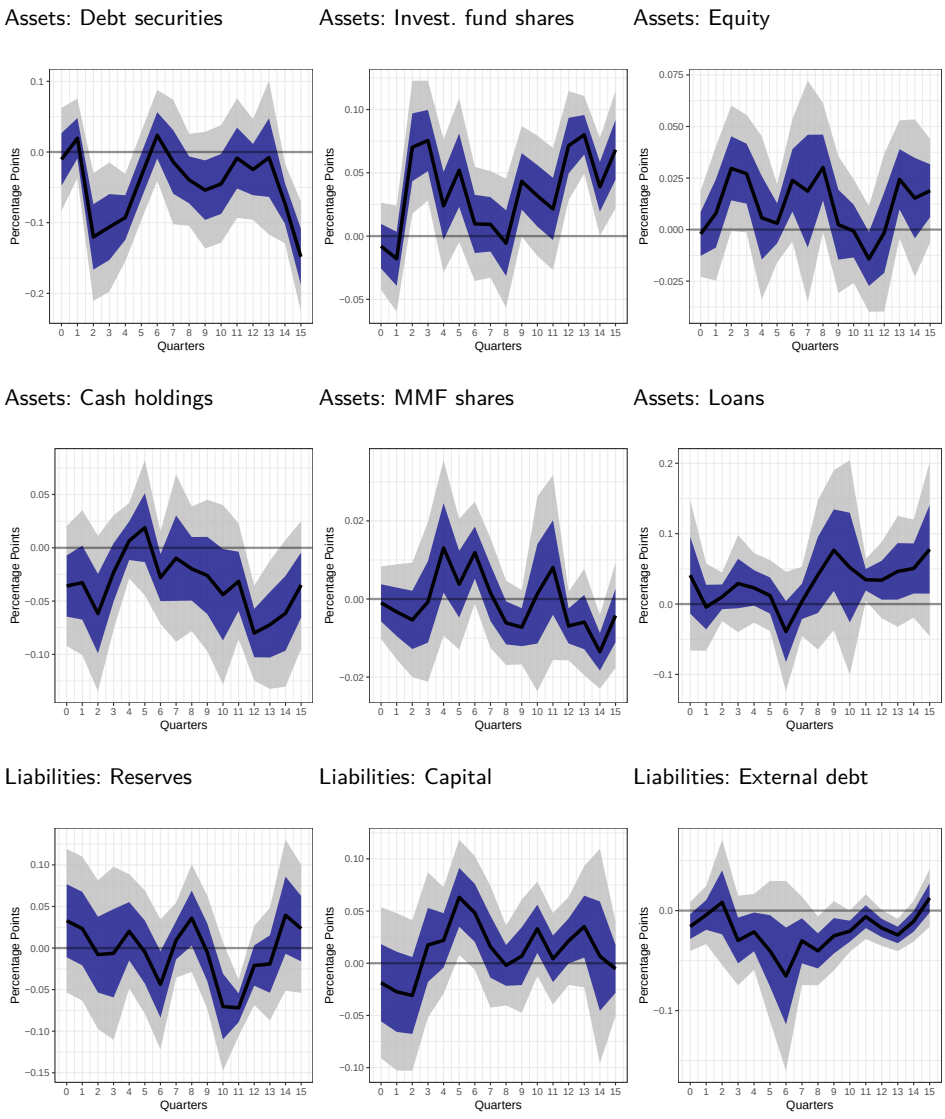
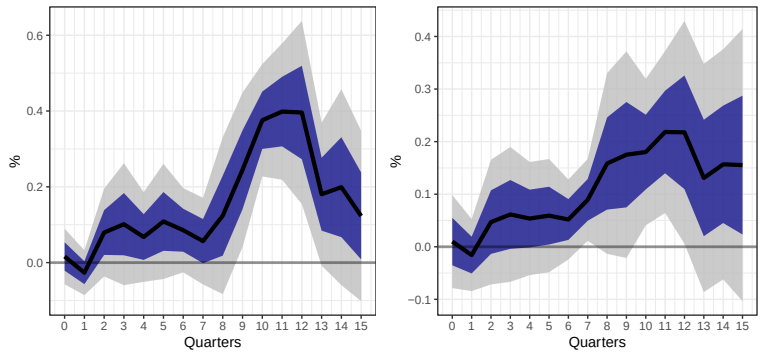


Figure B.14: Impulse responses of main asset and liability components as a share of total assets: shock to 3-month OIS

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the 3-month OIS rate. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals.

(A) Total assets - market value (B) Total assets - nominal value



(C) Technical reserves - market value (D) Technical reserves - nominal value

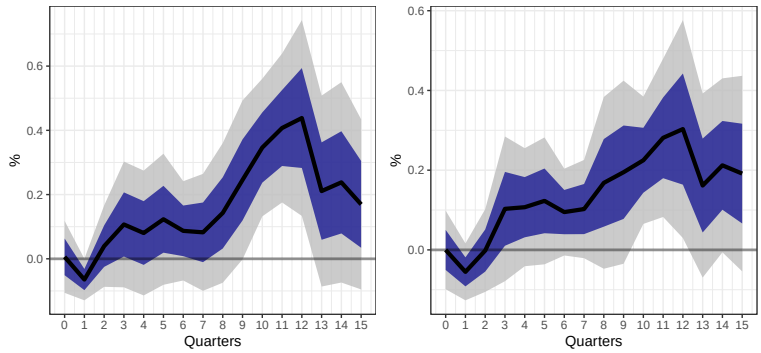


Figure B.15: Impulse responses of insurance corporations' total assets and technical reserves: with demographic controls

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects. Country-specific life expectancy and old age dependency ratio are added as additional control variables.

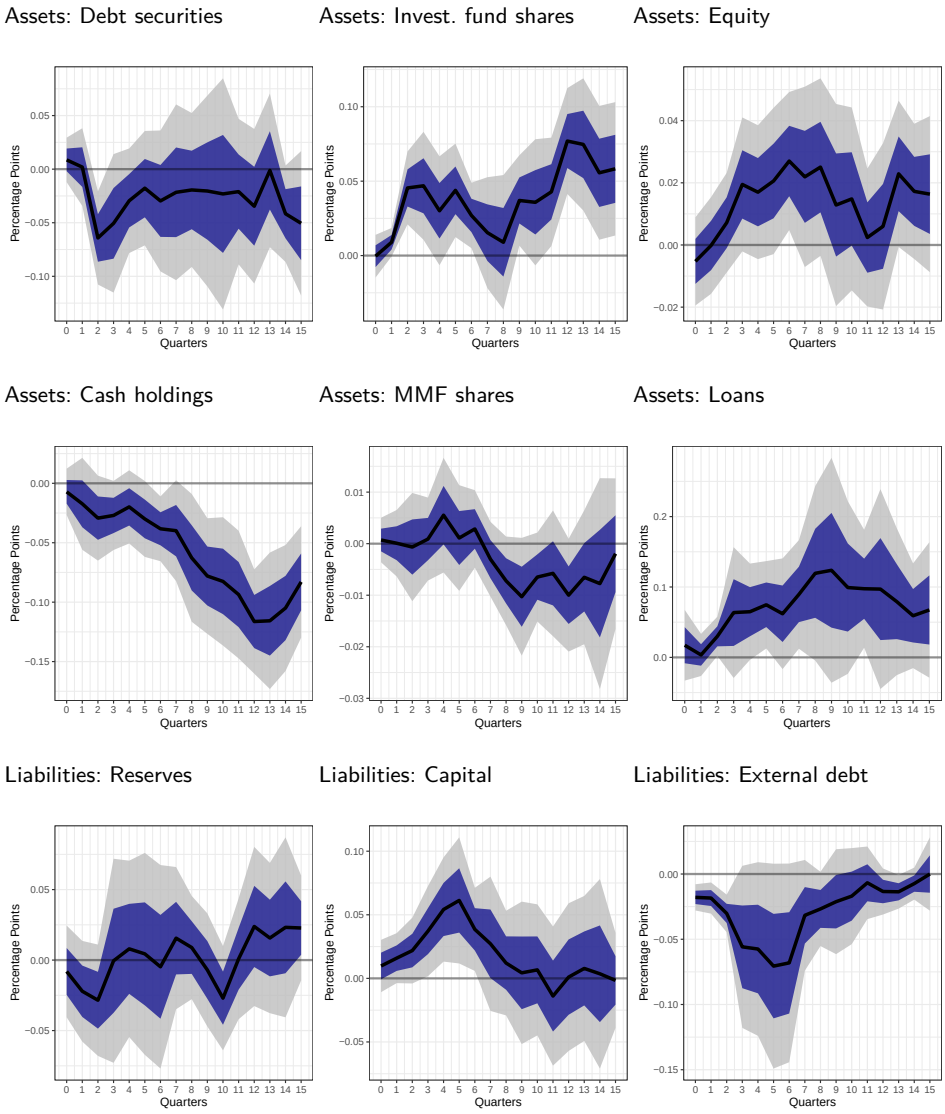


Figure B.16: Impulse responses of main asset and liability components as a share of total assets: with demographic controls

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Country-specific life expectancy and old age dependency ratio are added as additional control variables.

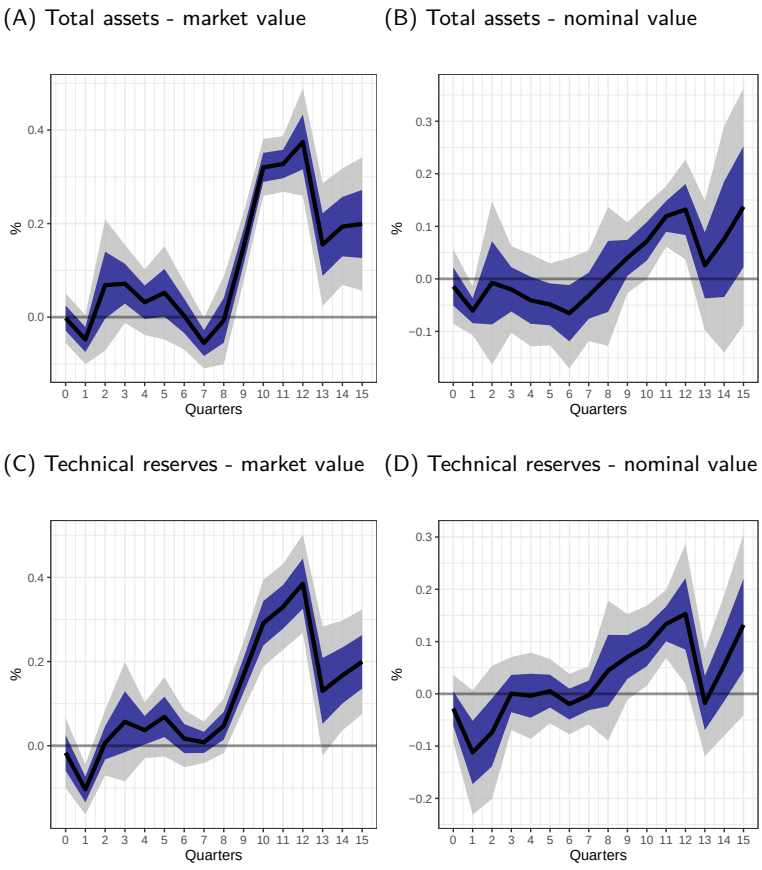


Figure B.17: Impulse responses of insurance corporations' total assets and technical reserves: with euro area GDP growth

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects. Aggregate euro area GDP growth is added as additional control variable.

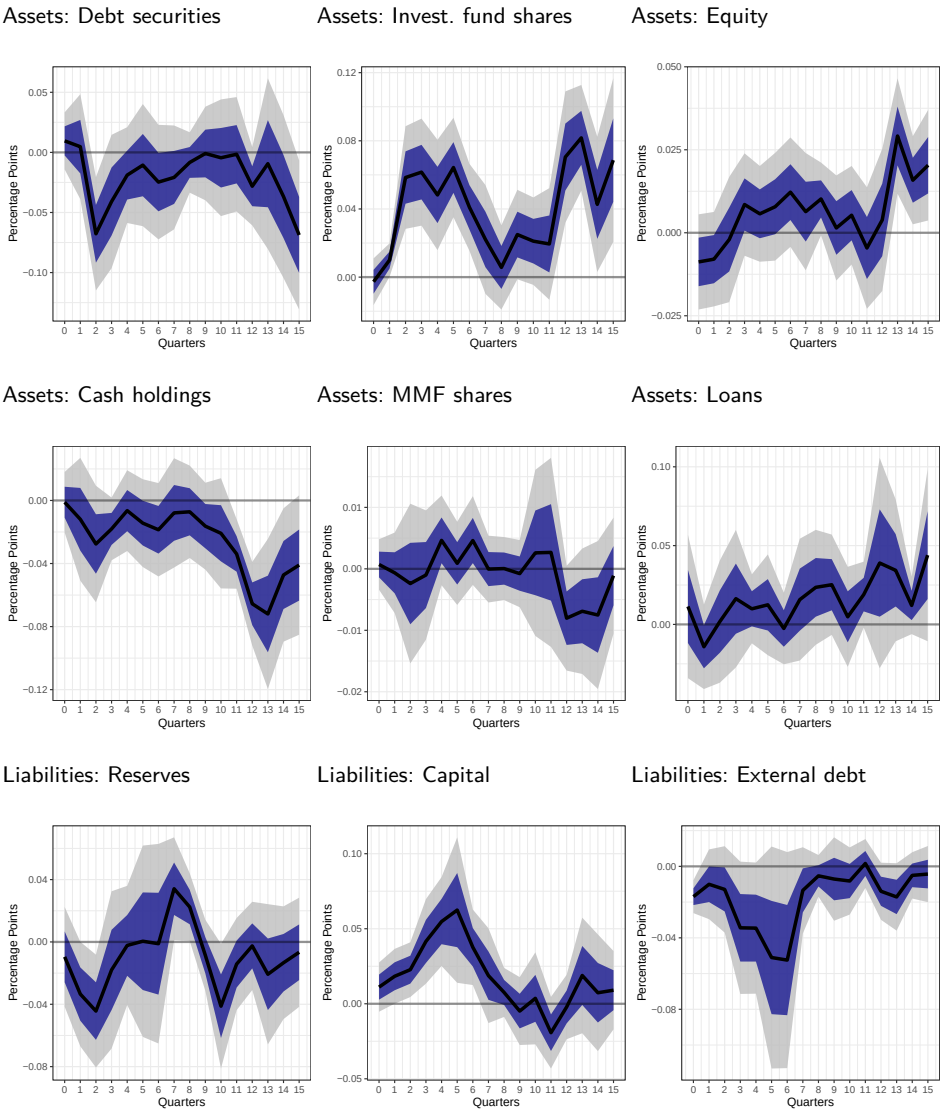


Figure B.18: Impulse responses of main asset and liability components as a share of total assets: with euro area GDP growth

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Aggregate euro area GDP growth is added as additional control variable.

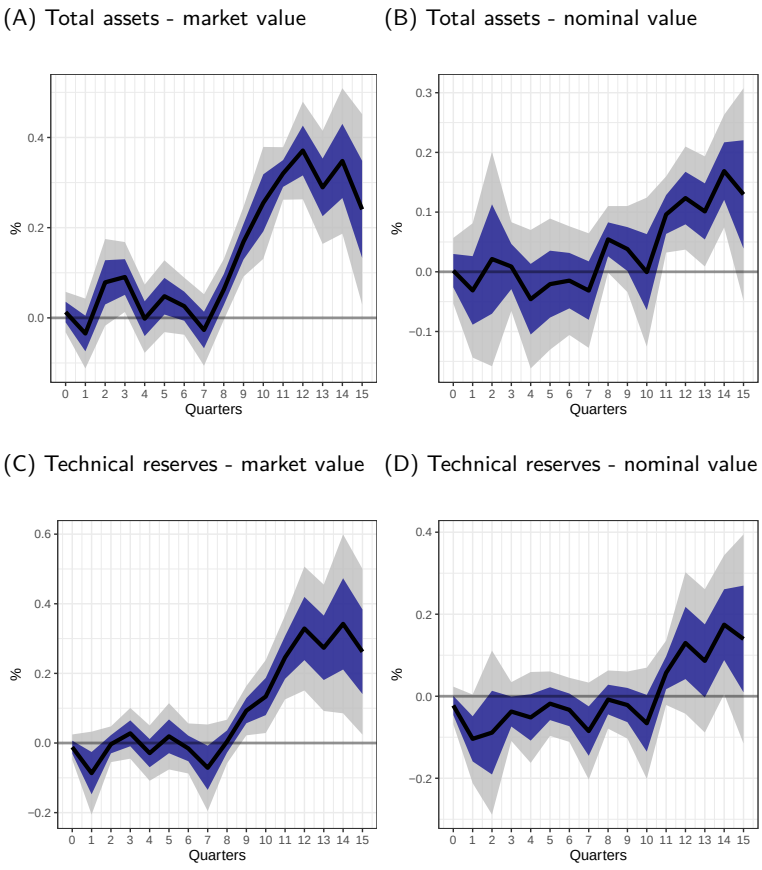


Figure B.19: Impulse responses of insurance corporations' total assets and technical reserves: sample including global financial crisis

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Nominal values calculated as in (2) to remove valuation effects. Sample from 2008 Q1 to 2021 Q4.

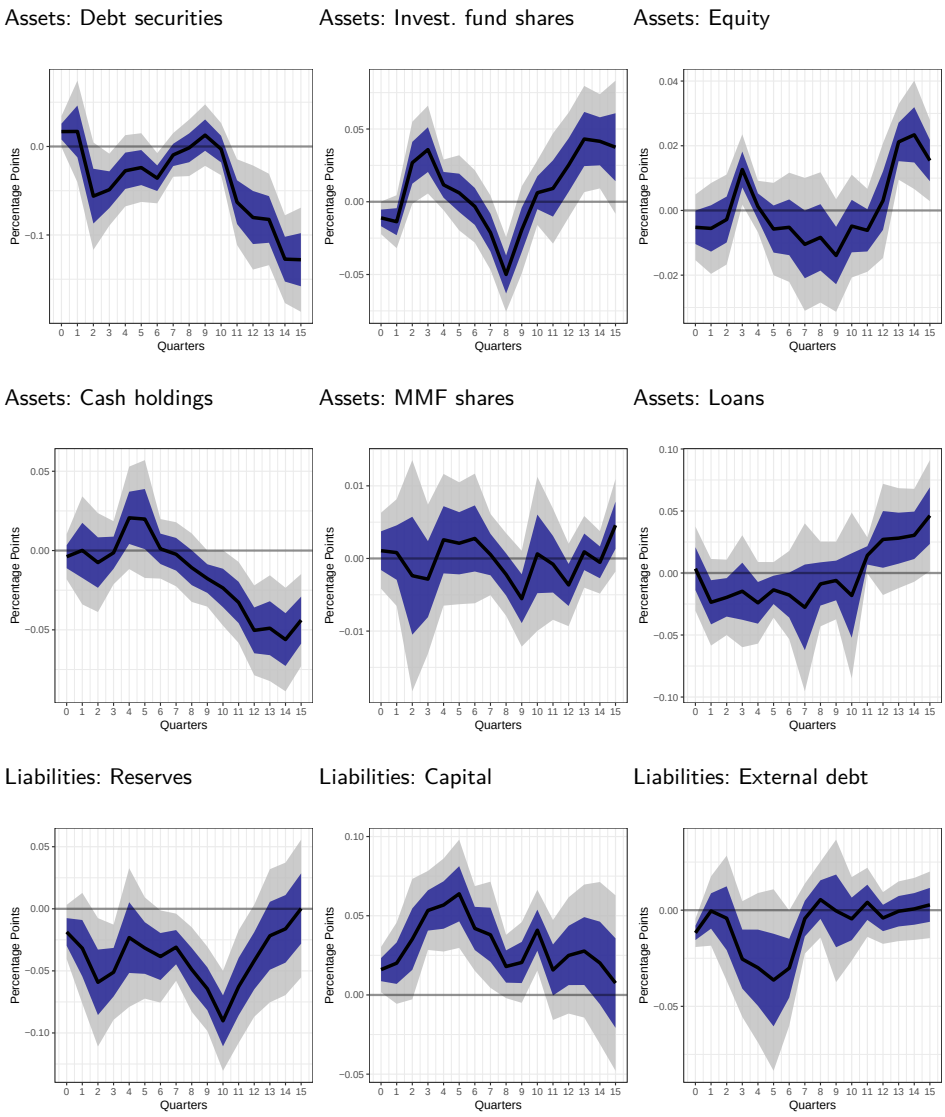


Figure B.20: Impulse responses of main asset and liability components as a share of total assets: sample including global financial crisis

Notes: Impulse responses based on Model (5) to an expansionary high-frequency monetary policy shock inducing a 1 basis point decrease of the term structure factor. Shaded areas denote 95% (grey) and 68% (blue) confidence intervals. Sample from 2008 Q1 to 2021 Q4.

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