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Stress testing market risk of German financial intermediaries

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Alexander Falter
Michael Kleemann
Lena Strobel
Hannes Wilke

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

Non-technical summary

The Deutsche Bundesbank's Financial Stability Review 2021 presents analyses for the resilience of financial intermediaries subject to market risk scenarios as part of its financial stability assessment. This paper describes the methodology underlying these analyses.

The macroprudential market risk stress test presented in this paper assesses the resilience of the financial system to market price shocks, focusing on banks, insurance companies, and investment funds. For this purpose, we develop market stress scenarios that describe in detail a presumed shock to financial markets. The shock is translated into assumptions on market risk drivers and asset price declines for individual securities held by German financial intermediaries. Subsequently, we compute losses of securities portfolios to assess the impact of market stress on individual financial intermediaries.

The presented approach takes into account intermediary specific particularities affecting the extent to which intermediaries are affected by market risk. For example, actual losses of banks due to market price declines are largely affected by valuation rules for portfolios on banks' balance sheets, whereas for insurers, scenario implied adjustments to solvency capital requirements (SCR) are taken into account, which are associated to built-in regulatory measures with counter-cyclical effects. Moreover, we consider that banks and insurers hold large amounts of shares in German investment funds. These aspects are important to assess the stability of the German financial system in a consolidated perspective.

Banks and insurers are partly financed by equity or own funds, which allows them to absorb losses to a certain degree. Therefore, assessing losses in terms of equity or own funds of banks and insurers is reasonable in order to assess whether the financial system can still fulfil its role even in times of distress. Meanwhile, investment funds are substantially interconnected with each other via fund share crossholdings and prone to fund share redemptions that might trigger pro-cyclical fire sales of securities in times of stress. The risk assessment for the German fund sector is therefore focused on the severity of these amplification and spill-over effects.

We illustrate our methodology with two distinct risk scenarios, based on historical distributions of market stress. These scenarios represent two severe shocks to distinct risk drivers: on the one hand a strong increase in risk-free rates, on the other hand a strong surge in risk premiums. By applying these two scenarios at different points in time, we illustrate the extent to which the sensitivities of securities portfolios of German financial intermediaries towards increases in risk free rates or surges in risk premiums have changed since the end of 2018.

Nicht-technische Zusammenfassung

In ihrem Finanzstabilitätsbericht 2021 analysiert die Deutsche Bundesbank die Widerstandsfähigkeit von Finanzintermediären gegenüber Marktrisikoszenarien. In diesem Papier werden die Methoden beschrieben, welche den Analysen zugrunde liegen.

Der hier vorgestellte makroprudenzielle Marktrisikostresstest dient dazu, die Widerstandsfähigkeit des Finanzsystems gegenüber Marktpreisschocks einzuschätzen. Der Stresstest umfasst deutsche Banken, Versicherer und Investmentfonds. Hierfür werden zunächst detaillierte Marktstressszenarien entwickelt. Dabei wird jeder Schock in Annahmen zu Marktrisikofaktoren und schließlich in Preisrückgänge der einzelnen Wertpapiere in den Portfolien der Finanzintermediäre übersetzt. Anschließend werden die Portfolioverluste aggregiert, um die Auswirkungen des Marktstresses auf den einzelnen Intermediär sowie das Finanzsystem als Ganzes beurteilen zu können.

Die dargestellte Stresstestmethodik ermöglicht es, Risiken bzw. Szenarien intermediärsübergreifend und gleichzeitig methodisch konsistent zu analysieren, ohne relevante intermediärsspezifische Besonderheiten zu vernachlässigen. So wird etwa im Zuge von Marktpreisrückgängen die Verlusthöhe bei Banken von bilanziellen Bewertungsregeln der jeweiligen (Teil-)Portfolien beeinflusst. Bei Versicherern werden szenariobedingte Auswirkungen auf die Solvenzkapitalanforderungen (SCR) berücksichtigt, die auf antizyklisch wirkende regulatorische Vorgaben zurückzuführen sind. Außerdem berücksichtigt der hier vorgestellte Stresstest, dass Banken und Versicherer in hohem Umfang Anteile an deutschen Investmentfonds halten. Diese Aspekte sind wichtig, um die Stabilität des deutschen Finanzsystems holistisch beurteilen zu können.

Banken und Versicherer verfügen über Eigenkapital bzw. Eigenmittel, wodurch sie Verluste bis zu einem gewissen Grad selbst tragen können. Daher ist es sinnvoll, Verluste aus Risikoszenarien der Eigenmittelausstattung von Banken und Versicherern gegenüberzustellen und so zu beurteilen, ob das Finanzsystem auch in Krisenzeiten seine Aufgaben erfüllen kann. Hingegen stehen bei Investmentfonds deren starke direkte Vernetzung durch das gegenseitige Halten von Fondsanteilen sowie deren Anfälligkeit gegenüber gehäuften Rückgaben von Fondsanteilen im Vordergrund. Letztere können in Stresssituationen prozyklisch wirkende Notverkäufe von Wertpapieren auslösen. Die Risikobewertung für den deutschen Fondssektor konzentriert sich daher auf das Ausmaß dieser Verstärkungs- und Spillover-Effekte.

Wir veranschaulichen unsere Methodik anhand exemplarischer Stresstestergebnisse für zwei Risikoszenarien, die auf historischen Verteilungen von Marktstressindikatoren basieren. Diese Szenarien stellen unterschiedliche Risikotreiber dar: einerseits einen starken Anstieg der risikofreien Zinsstruktur und andererseits einen signifikanten Anstieg der Risikoprämien. Wir berechnen szenariobedingte Portfolioverluste im Zeitablauf und dokumentieren die Entwicklung der Sensitivität der Wertpapierportfolien deutscher Finanzintermediäre gegenüber einem Anstieg der Risikoprämien oder der risikolosen Zinsen seit Ende 2018.

“Stress testing the market risk of German financial intermediaries”

Alexander Falter, Michael Kleemann, Lena Strobel and Hannes Wilke[1]

Abstract

The macroprudential market risk stress test presented in this paper proposes a framework to assess the vulnerability of the German financial system with respect to market price shocks, focusing on banks, insurers and investment funds in a consistent manner. A common market risk scenario is translated into price declines for individual financial assets and into incurred losses at the level of individual financial intermediaries. We illustrate our approach with two technical scenarios, derived as percentiles of historic market price movements, representing (i) a significant shock in risk premiums triggering repricing of assets considered risky and (ii) a shock in the yield curve, implying sharp increases in the risk-free rates. Moreover, our approach takes into account specificities in the transmission of market risk to individual financial intermediaries. This includes for banks the calculation of market losses according to the holding purpose and accounting treatment of portfolios. For insurers, adjustments of solvency capital requirements are considered. Meanwhile, second-round amplification and spill-over effects on security and fund share prices are discussed for investment funds due to their high interconnectedness and their susceptibility to redemptions which might trigger asset liquidations.

JEL Codes: C53, G21, G22, G23

Keywords: Stress testing, market risk, financial intermediaries, financial stability.

[1] Alexander Falter (alexander.falter@bundesbank.de), Michael Kleemann (michael.kleemann@bundesbank.de), Lena Strobel (lena.strobel@bundesbank.de) und Hannes Wilke (hannes.wilke@bundesbank.de), Deutsche Bundesbank, Directorate Financial Stability, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, Germany. The views expressed in this paper represent the authors‘ personal opinions and not necessarily reflect those of the Deutsche Bundesbank, the Eurosystem, or their staff.

1 Motivation

Financial market stress can have tremendous effects on the stability of the financial system and the economy; in particular, debt-fuelled asset crises led to significant output losses (Reinhart and Rogoff 2012; Jordà et al. 2015; Muir 2017). Macroprudential stress tests are valuable tools to analyse potential downward risks and threats to financial stability but also to communicate early concerns to both market participants and the public. Therefore, various national and international institutions use stress tests to assess risks for specific types of financial intermediaries such as banks, insurers, or investment funds. However, there are only few stress tests or scenario analyses involving more than one type of intermediary simultaneously.[2]

Banks, insurers and investment funds manage large securities portfolios and are exposed to sudden changes in market prices; thus, they could contribute to a pro-cyclical reaction of the financial system, e.g. via fire sales or deleveraging (Adrian et al. 2014; Ellul et al. 2018; Fricke and Fricke 2021; Förstemann and Feodoria 2015). Moreover, there is strong direct and indirect interconnectedness within the financial system.

Assessing market risk separately for each type of intermediary might miss important aspects in terms of interconnectedness, portfolio similarity, but also beneficial effects, e.g. due to diversification across intermediaries. A broad picture of the impact of large scale asset declines on the entire financial sector is, thus, of utmost importance for a proper financial stability assessment. We therefore present a top-down stress test methodology for the financial asset portfolios of German financial intermediaries, i.e. the macroprudential market risk stress test to:

- assess ex ante the effects of risk scenarios.
- monitor changes in the sensitivity of the securities portfolio valuations of German financial intermediaries against large backdrops of asset prices.
- shed light on whether the financial system as a whole is able to absorb losses without harming the real economy, or whether the financial system might even amplify the stress by additional transmission mechanisms within the financial sector.

This paper lays out the theoretical foundation and general procedure of the macroprudential market risk stress test. In subsection 2.1, we explain the calibration of stress scenarios, including the procedure to map these to security-specific price changes. Next, we show how market price scenarios are applied to German banks (subsection 2.2), insurers (subsection 2.3) and investment funds (subsection 2.4) in order to assess the vulnerability of financial intermediaries with respect to market risk. We illustrate our approach using two technical scenarios in section 3: (i) a risk premium shock accounting for a surge in risk aversion implying lower prices of risky

[2] The recent integrated bank-investment fund analysis at the Eurosystem (Sydow et al. 2021) or the system wide stress tests of the International Monetary Fund (Adrian et al. 2020) are cases in point.

securities and (ii) a yield curve shock mimicking an increase in risk-free rates. Section 4 concludes and lays out important aspects for future research.

2 A macroprudential market risk stress test of the German financial system

We apply an integrated top-down stress test setup that accounts to a certain degree for the direct and indirect interconnectedness in the German financial system.

In a first step, we stress German banks, insurers and investment funds simultaneously with the same scenario assumptions. After design and calibration of the market risk scenario, the scenario is translated to the security level, subject to issuer- and instrument-specific characteristics. Subsequently, a first round of market losses is calculated.

In a second step, we take into account holdings of German banks and insurers in German investment funds twofold. We use the stress test results of German funds to calculate losses of banks and insurers from their holdings in investment funds where possible ("look-through"). Moreover, we take into account that losses in the investment fund sector are passed on to the respective fund holders. This allows for a consistent and consolidated picture of system-wide spill-over effects and stress propagation within the German financial system.

Third, while assessing the overall risks in the financial system, we take the intermediaries' business models into account. We consider the absorbing capacity of banks and insurers and assess potential amplification effects within the fund sector.

A significant share of banks' and insurance companies' assets are financed by equity or own funds. These serve as loss absorbing capacity and signal to stakeholders that the firm is able to withstand a certain level of distress. From a financial stability perspective, losses in terms of equity or own funds are important measures to assess whether the financial system can still fulfil its role even in times of distress.

Meanwhile, funds' assets are mostly financed by issuing fund shares to retail and institutional investors, including banks and insurers. Fund shares are typically redeemable at short notice which substantially decreases their ability to absorb fund losses. As fund losses have to be borne by fund investors, these have strong incentives to redeem their fund shares early, especially in times of distress. Therefore, the fund sector is particularly prone to redemption pressure which might force funds into fire-selling their assets and exerting further downward pressure on asset prices (Fricke and Wilke 2020). The strength of fund sector amplification and spill-over effects are important to assess the sector's aggregate vulnerability and its impact on the financial system in times of distress.

Finally, for different types of financial intermediaries, the risk assessment requires additional considerations. For example, the valuation treatment of portfolios on banks' balance sheets differs according to their holding purpose (e.g. trading versus long-term investment, see subsection 2.2). We take into account counter-cyclical elements of insurers' solvency capital requirements (SCR). As the fund sector is highly susceptible to redemptions and, consequently, securities liquidations, the risk assessment for German funds focuses on second-round amplification effects in the form of downward price effects on securities and fund shares.

2.1 Scenario design, calibration and mapping

2.1.1 Design and calibration

Basically, there are narrative-driven and technical approaches to stress-testing as well as combinations thereof. Both approaches have different implications, strengths and weaknesses. The table below summarises the respective inputs and calibration approaches that are typical for the two basic approaches.

Table 1

Scenario calibration based on	Narrative-driven	Technical
Historical market price distributions		X
Market events	X	X
Model projections / estimations	X	X
Expert judgement	X	
Applications	Assessment of vulnerability with respect to specific shocks, tailor-made	Assessment of vulnerability with respect to standardized shock, comparison over time

The narrative approach is suitable to analyse rather specific or tailor-made shocks or shocks subject to certain assumptions, such as macro-financial assumptions (e.g. projected changes of yield curves or equity returns) that may be embedded in a broader (economic) narrative. The origin of a shock is crucial for the calibration. For instance, a scenario could investigate the vulnerability of the German financial system against an increase of credit risk in the HY energy segment of the US, a general deterioration of investor sentiment, or dwindling confidence in the solvency of certain countries. To calibrate shocks arising from such scenarios, we use theoretical model projections or empirical estimations. For instance, fair value models for equities or bonds or residual income models are used to assess both shock levels; correction of highly valued assets might amplify stress.[3] Finally, scenarios that represent “what if” considerations or that can hardly be derived from empirical data often require theoretical model projections or expert judgement for shock calibration.

[3] See Deutsche Bundesbank (2021a) for results of a market risk assessment making use of a severity function approach and Bayesian VAR modelling in liaison with bridge equations (beta factor); moreover, the report contains results of fair value models to assess bond market valuation (IMF 2019) or a stock market residual income model of Claus and Thomas 2001) to determine the drivers of stock market developments.

Meanwhile, technical stress scenarios are usually derived from historical distributions of market price returns. Such technical or standardised scenarios are particularly suitable to assess the development of the resilience with respect to market risk factors over time (see section 3). For the derivation of these scenarios, we use historical data on returns of equity indices as well as spreads of bond price and credit default swap (CDS) indices. For all indices, we derive distributions of index changes over a period of one week (5 trading days), one month (21 trading days), and 3 months (63 trading days), depending on the time horizon best suited for calibrating standardised stress levels. Given the historical distributions, we then derive stress values for specific percentiles, for value-at-risk related measures, and/or average returns/spreads for specific intervals and for expected shortfall related measures, both utilising series on a daily basis.[4] The choice of a historical scenario or percentile strongly affects the severity of a scenario.

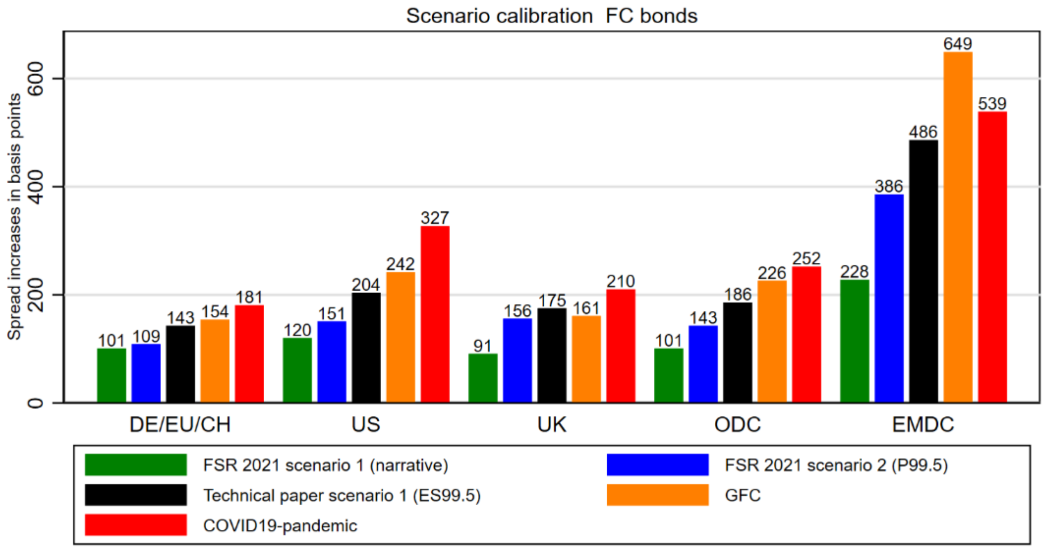
This aspect can be used to assess the scenario strengths of narrative approaches. Figures 1 and 2 illustrate the extent to which different scenario designs can yield different outcomes. The figures show spread increases in basis points for both financial corporation (FC) and non-financial corporation (NFC) bonds for different scenario designs with varying severity. The time horizon of historical stress was set at 21 trading days. The green bar shows the assumptions of the conditional narrative-driven scenario of the Financial Stability Review 2021 (FSR 2021), representing an economic stagnation. The blue bars (historical distribution at the 99.5 percentile) represent a rather severe and at the same time rare scenario that is also used in the FSR 2021 to illustrate an unconditional and severe shock.[5] The black bars denote the respective expected shortfall beyond the 99.5 percentile. This can be considered an extremely adverse scenario. For comparison, the orange and red bars represent the maximum stress within 21 trading days during the Great Financial Crisis of 2008 (GFC) and the COVID-19 pandemic market stress episode (1 February to 30 April 2020). This historical period induced even stronger bond price declines, at least within a 21-day stress horizon. A comparison of these scenarios shows that the narrative scenario of the FSR 2021 also exhibits significant increases in risk premiums, yet the stress is rather low compared to the other technical scenarios and historical episodes.[6] The figure also shows that both the GFC and the COVID19 pandemic were outstanding market melt-downs for corporate bonds that even surpass the expected shortfall beyond the historical 99.5 percentile.

[4] We also apply random sampling, i.e. building the average of a huge number of randomly drawn subsamples, to control for a potential return autocorrelation in the time series data.

[5] In fact, percentile and expected shortfall scenarios are derived from univariate distributions, i.e. the overall stress might be even higher compared to a 99.5 percent scenario derived from a joint or multivariate distribution. However, broadly rising risk premiums across all asset classes in times of high distress are the general rationale.

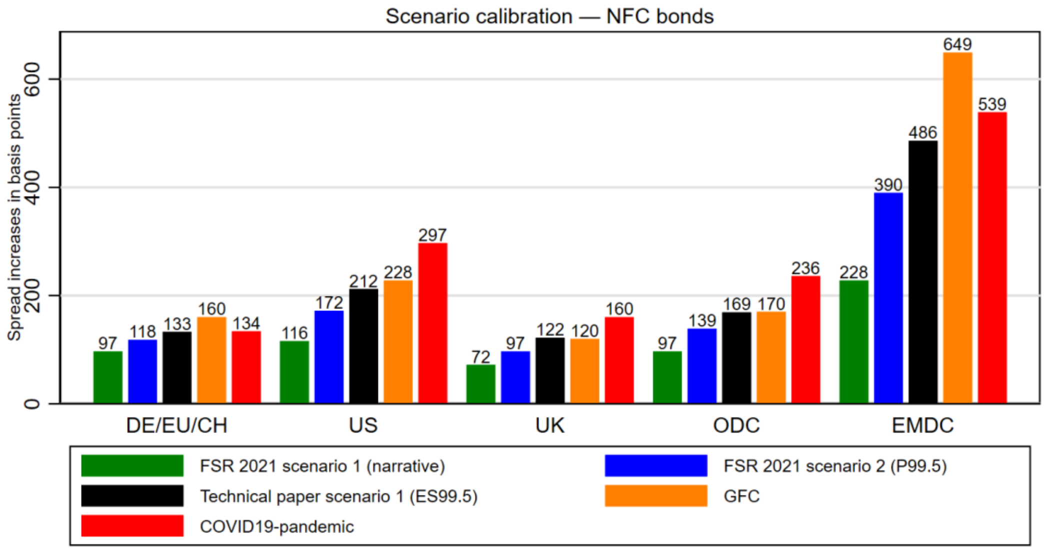
[6] The scenario was developed as an adverse deviation of macrofinancial developments conditional on the Bundesbank macroeconomic forecast, based on a severity function approach. See Deutsche Bundesbank 2021b; Mokinski 2017.

Figure 1



FC=financial corporations; ODC=Other developed countries; EMDC=Emerging and Developing countries

Figure 2



NFC=Non-financial corporations; ODC=Other developed countries; EMDC=Emerging and Developing countries

Scenario mapping

The scenario mapping consists of a two-step approach. In order to break down a general scenario into specific paths of asset prices, first we use information on issuer and instrument-specific characteristics to map each security to a specific bucket. Security buckets are defined by characteristics of both the type of issuer and the type of the security; see Table 2. For this purpose, we use the Centralised Securities Database (CSDB) that represents the security reference data collected by euro area central banks, enriched by market data suppliers. The CSDB contains information on issuer and instrument characteristics, e.g. the issuer country or sector. For NFC securities, a further refinement according to their two-digit NACE code is also possible. Instrument-specific characteristics used include the type of a security and details such as whether a bond is collateralised, a zero coupon bond or a floater. Moreover, information on ratings is collected, from which we establish credit quality steps. For calculation of the modified duration, the CSDB provides information on the bond duration, coupon type, payment frequency, and yield to maturity.

Table 2

Variable	Description	Identified buckets
Region/Country	Region/Country of the issuing entity	Germany, France, Italy, Spain, other EA countries, other EU countries, UK, US, JP, other developed countries, emerging markets
Type	Type of issued security	Equity, bonds, covered bond, securitization, fund share
Sector	Sector of issued security	Public/central government, financial sector, non-financial corporation
Credit quality step	Credit quality step of fixed income instruments	AAA, AA, A, BBB, BB, <=B, without rating
Modified duration bucket	Modified duration as measure of interest rate risk for each bond	0-2Y / 2-5Y / 5-10Y / 10-15 Y / 15-20Y/ 20+Y
Residual maturity	Residual bond maturity in years	1Y,2Y,…29Y,>=30Y
Coupon type	Type of coupon payment for bonds	Fixed, floating, zero, stepped, index-linked, complex
Optional: Branch	NACE	2-digit NACE code

In a second step, we map a market price index to each bucket in order to derive stress parameters. For each equity bucket, we use a corresponding stock index. For buckets of debt instruments we map a corresponding CDS or bond index. Depending on the type of scenario, we rely on historical distributions (see subsection 2.1.1), model estimates or expert judgement to calibrate the scenario. A detailed list of the indices used can be found in the appendix.

2.1.2 Deriving stress at the security-level

The bucket-specific stress parameters (subsection 2.1.2) are broken down to the security level – for all securities held by German banks, insurers and investment funds.[7]

Equity instruments

The stress parameters for individual equity instruments, such as stocks, are directly calculated as value changes in percent of the respective buckets.

Fixed income instruments

For fixed income instruments, spread increases in basis points are derived at the bucket level (scenario spread increase). Spreads reflect the riskiness of marketable assets relative to a benchmark. The increase of a spread thus also indicates an increase in credit risk.

We use a methodology for spread risk on bonds and loans developed by the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) that determines spread risk capital charges for insurers under Solvency II and is based on historical data.

The relative value change of asset i according to its modified duration and credit quality step is:

$$\%asset_{i,credit,t} = a + (b - dur_{low}) * ModDur_{i,t} * intensity_i$$

where parameters *a* and *b* represent stress parameters of the CEIOPS calibration that depend on the rating notch and modified duration category of the respective bond. dur_{low} represents the lower bound of the modified duration category, i.e. 2y for the category "2-5y". $ModDur_{i,t}$ represents the modified duration, i.e. the price sensitivity of asset *i* at time *t* with respect to a change in spreads or interest rates. The exact values of *a* and *b* are listed in Article 176(3) of the corresponding Delegated Regulation[8]. In order to distinguish stress across countries, sectors and over time, we introduce the shock intensity. The *intensity* is the ratio of the assumed scenario spread increase of asset *i* relative to the baseline spread increase that would fit the *a* and *b* parameters given a certain credit quality step and modified duration.[9] A scenario spread increase above the baseline spread increase implies higher stress compared to the formula and vice versa.

We derive the modified duration of a security with CSDB information on the duration of the bond, the current yield and coupon payments according to the following formula:

$$ModDur_{i,t} = BondDur_{i,t}(1 + ytm_{i,t} / freq_i)$$

[7] For information on securities holdings we rely on the WP invest, Solvency II data and Investment Funds Statistics, which are explained in greater detail in the next subsections.

[8] Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II).

[9] The baseline spread can be derived by combining formula above with the general relationship between asset price changes and the modified duration: $\%asset_{i,credit,t} = -spread_{i,t} * ModDur_{i,t}$

where $BondDur_{i,t}$, $ytm_{i,t}$ *and* $freq_i$ are the bond duration, yield to maturity and payment frequency of the coupon as obtained from the CSDB per fixed-income security *i* at time *t*. Sufficient information to compute the modified duration is not available for all bonds. In this case, we use either the bond duration or a linear combination of the residual maturity, with the scaling parameter shrinking with increasing maturity or empirical estimations from CSDB data to approximate the modified duration.

Most bonds are not only subject to increasing credit spreads, but also to changes in risk free rates. We assume changes in the yield curve to account for changes in the risk-free rate. The change in value due to changes in risk-free rates for asset *i* with a residual maturity of *t* is assumed to be:

$$\%asset_{i,yc,t} = -\Delta yieldc_t * ModDur_{i,t}/100$$

with $\Delta yieldc_t$ being the calculated change of the risk-free rate in basis points for residual maturity *t*. For floating bonds that usually co-move with risk-free rates via their reference rates, $\%asset_{i,yc,t}$ is assumed to be zero.

Finally, calculate the overall change in asset prices of fixed-income securities as multiplicative combination of both asset changes moments, i.e.

$$\begin{aligned}\%asset_{i,overall,t} &= \left(1 + \%asset_{i,credit,t}\right)\left(1 + \%asset_{i,yc,t}\right) - 1 \\ &= \%asset_{i,credit,t} + \%asset_{i,yc,t} + (\%asset_{i,credit,t} * \%asset_{i,yc,t})\end{aligned}$$

The multiplicative approach better incorporates the convexity effects of large shocks compared to a purely additive approach.[10]

Fund shares

The CSDB does not provide information on fund share price developments. Losses of most German funds can be calculated from the losses of their portfolios in the stress test procedure.[11] Meanwhile, some (predominantly foreign) funds lack detailed portfolio information and require an approximation. We assume that these funds move linear to equity/bond prices of their target markets. Mixed funds correlate with a linear combination of equity and bond funds of the respective region.[12] As funds are usually either actively managed or have risk-mitigating techniques, we rescale losses of equity funds to 50% of losses of corresponding equity indices, bond funds to 15% of corresponding equity indices and mixed funds to 25% of corresponding equity indices. This takes into account that funds should have smaller losses due to diversification effects compared to investing in single indices or assets.

[10] While the multiplicative approach yields smaller asset price changes compared to adding both yield curve and credit spread stress, both the additive and multiplicative approaches overestimate asset price changes compared to a discounted-cash-flow approach.

[11] We are able to estimate fund losses for 67% of German banks' fund holdings and 80% of insurers' fund holdings as of 2021q1.

[12] In line with Baranova et al. 2017) we use the main target of the fund instead of the country of domicile to approximate bond stress.

2.2 Banking sector market loss calculation

2.2.1 Market risk in the banking sector

Banks are subject to a variety of risks, including credit risk, market risk, operational risk and liquidity risk. In order to assess banks' robustness to these risks, stress tests are conducted in a bottom-up or top-down fashion. Given the differing nature of those risks, both in terms of their origin and treatment by financial institutions, stress testing usually employs a modular approach, i.e. the stress testing framework usually consists of separate stress testing modules for each risk category. Vulnerabilities derived from each individual module can provide information on the combined impact of stress testing scenarios on solvency or liquidity target ratios, such as the supervisory minimum capital requirements or the liquidity coverage ratio. The market risk stress test as described in this paper can be informative on its own or be used as a market risk module in a more comprehensive top-down stress testing framework, such as the stress testing framework to assess deleveraging potential in the German banking sector in times of crisis.[13]

While credit risk rather than market risk is usually considered the main risk category for the German banking sector, the effects of market price changes on banks' balance sheets may also be sizeable. Market price changes may lead to a sudden revaluation of those portfolios which are subject to market pricing risk. Such portfolios include equities, bonds and fund shares as well as derivative products. Losses due to revaluation of such portfolios may ultimately weaken banks' capital positon.[14] Banks hold portfolios subject to market pricing risk for a variety of purposes, including trading, liquidity, collateral and (long-term) investment (Bolton and Jeanne 2011; Acharya and Steffen 2015; Adrian et al. 2014). Holding purposes play a role in determining whether portfolios are assigned to the banking book or the trading book.[15] Accounting principles such as the International Financial Reporting Standards (IFRS) and the German Commercial Code (Handelsgesetzbuch: HGB), in turn, provide rules for the accounting valuation of portfolios according to their holding purpose and assignment to either the banking or trading book.[16]

In accordance with banks' trading and risk management strategies, the positioning within trading book portfolios may be adapted frequently and change on a daily basis. Derivative trading and hedging strategies are an important part of banks' trading activities, in particular for the larger banks, and hence a source of trading income. Trading portfolios are marked-to-market, i.e. changes in market value are realised in banks' profit and loss accounts instantly.

[13] For more details, see Pelzer et al. (2021.

[14] An increase of market price volatility may also impact own funds requirements for market risk, particularly for banks that use internal models to determine own funds requirements for market risk. This transmission channel of market risk on banks' capital positions is not considered here.

[15] Regulation (EU) 2019/876 (CRR2) point (86) stipulates that "'trading book' means all positions in financial instruments and commodities held by an institution either with trading intent or to hedge positions held with trading intent […]".

[16] While the IFRS are currently being applied by a few, predominantly larger financial institutions, the German HGB is applied by the vast majority of German banks.

By contrast, security portfolios assigned to the banking book are held for liquidity or investment purposes, for example in order to receive interest income. Their holding periods are typically longer, i.e. changes in banking book security portfolios are less frequent than in traded portfolios. Portfolio valuations in the banking book typically diverge from observed market values to a certain degree. For example, the German HGB does not allow for valuations higher than at amortised cost in banking book portfolios held for liquidity purposes (strict lower-of-cost-or-market principle).[17] This leads to the build-up of hidden reserves in times of increasing market prices, as parts of banks' portfolios remain undervalued on balance sheets. In times of sudden market downturns these hidden reserves are advantageous for banks as they act as buffers – only if the market price of an individual security falls below its book value might the bank have to realise a loss due to the revaluation of the security. Another HGB particularity is the option of valuing securities held for liquidity purposes even slightly below amortised cost or current market value (§340f HGB) and hence to build up further reserves, which increases hidden buffers even more. Finally, the HGB provides a depreciation option[18] for long-term investment portfolios within the banking book, in case market price decreases are deemed temporary. This can further soften the impact of a sudden market downturn on banks' security portfolios. While valuation standards under the IFRS are generally more attuned to mark-to-market valuation, the option to treat security portfolios at amortised cost exists as well, which can lead to accounting valuations diverging from observed market values, i.e. hidden reserves or charges.[19]

2.2.2 Scope and data

In order to account for the aforementioned heterogeneity in characteristics and valuation rules, the impact of the market risk scenario on banks' profit and loss account is determined using separate approaches for the trading book and the banking book.

Trading book losses are determined using banks' market price sensitivities with respect to market risk factors such as interest, spread or equity price movements. These market price sensitivities take the overall positioning of the trading book into account, which results from long and short positions of securities and derivative products. These sensitivities are reported as part of the Single Supervisory Mechanism (SSM) Short-Term Exercise for Supervisory Review and Evaluation Process (SREP) purposes by SSM banks. Where these sensitivities are not available, information from the historical distribution of trading income and losses is used to proxy the impact of adverse market developments.

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[17] §253 (4) HGB, the strict lower-of-cost-or-market principle ("strenges Niederstwertprinzip"), stipulates that a security must enter the balance sheet at the minimum value, comparing its value at amortised cost and current market value.

[18] §253 (1) and (2) HGB, the moderate lower-of-cost-or-market principle ("gemildertes Niederstwertprinzip"), allows applicants to not realise revaluation losses of securities held for long-term investment purposes where the market price decrease is deemed temporary.

[19] IFRS 9 specifies conditions under which securities are classified and valued at amortised cost.

Within the banking book, marketable securities are revalued. Marketable securities held by banks are reported within the Securities Holdings Statistics (WP Invest) and can be classified as equities, debt instruments or fund shares. The coverage of the stress test with respect to such securities in the banking book is almost universal.[20] For an important share of funds held by banks, revaluation is facilitated by the fund stress test – this corresponds to a look-through approach from the perspective of banks (see subsection 2.4.2).[21] The revaluation of securities may induce the realisation of losses for individual banks according to assumptions with respect to accounting treatment. The resulting market loss in the banking book is a conservative estimate as potentially loss-mitigating effects of hedging strategies are not considered.

The impact of the market price shock on banks' balance sheets is assumed to occur instantly, i.e. banks revalue portfolios sensitive to market price risk without delay, keeping portfolios constant. This is a simplification as market crashes usually unfold over periods of time and for some banks even little scope might be helpful in limiting losses by closing out positions – provided they anticipate market price movements correctly.

The following data sources are used for the analysis of market risk for the banking sector:

- **Securities Holdings Statistics (WP Invest):** The WP Invest contains a registry of securities that banks hold for their own account (Depot A). This includes information on whether securities are part of the banking book or the trading book as well as both their market and book valuation. For some banks the WP invest is available at the banking group level, including securities held in foreign branches and subsidiaries. The data are available on a monthly basis.
- **Centralised Securities Database (CSDB):** The CSDB contains further information on individual securities (identified by their ISIN), including information on issuer, instrument types, pricing as well as rating data.
- **SSM Short Term Exercise (STE) collected for SREP purposes:** The STE market risk template contains sensitivities of the trading book with respect to market risk factors (such as movements of interest rates, spreads or equity prices) as reported by SSM banks on a quarterly basis.
- **FINREP, COREP and further regulatory banking statistics:** These statistics provide bank-level information on balance sheet and profit and loss items, capital and capital requirements, available on a monthly or quarterly basis.

[20] Excluded are securities where missing information or a complex valuation function do not allow for an approximation at the security level (mainly certificates, hybrid instruments and linked securities).

[21] For funds issued abroad, Exchange Traded Funds (ETFs) and funds with predominantly real-estate exposures a look-through is not possible. For these funds shares, losses are proxied as described in subsection 2.1.3.

2.2.3 Methodology: calculating market losses for individual banks

In this subsection the approaches to calculate market losses in the trading book and the banking book are explained in greater detail:

Trading book losses

Trading book sensitivities are used to derive trading book losses for SSM banks. These sensitivities convey information on how the value of the trading book changes, given a small change in an underlying market risk factor. For the purpose of this exercise, the market risk scenario provides changes in the following risk factors: interest rates, spreads and equity prices (see section 2).

Corresponding sensitivities are reported by banks for granular risk buckets that further break down the above risk factors: interest rate risk sensitivities relate to interest rate risk buckets that are de-fined by maturities and currencies, while spread risk sensitivities are given for spread risk buckets broken down according to the type of issuer (government, financial, non-financial), the geographic location of issuer and the maturity. Equity sensitivities are available for equity buckets broken down by geographic location.

For every bucket, the trading loss is then determined by multiplying the corresponding sensitivity by the change in the underlying risk factor given by the scenario, which is applied in basis points (bp) for interest rate and spread risk sensitivities and percent (%) for equity price sensitivities.

For banks where trading book sensitivities are not available, the bank-specific historical distribution of quarterly trading loss ratios is deployed, i.e. historical trading loss as a share of historical risk weighted assets (RWA) for market risk. The trading loss for individual banks is then given by multiplying the 5th percentile of the historical distribution by the bank's current market risk RWA.

Market loss in the banking book

In order to revalue banks' securities holdings in the banking book we apply a discount in market value. These discounts are derived specifically for each market scenario on a security-by-security basis (see subsection 2.1). This yields, in a first step, market values of securities held by banks after repricing.

In a second step, realised losses or book losses for the banking book are computed, reflecting the accounting treatment of individual securities portfolios.

The accounting treatment of securities portfolios is taken into account by drawing on information from two sources. First, the WP Invest provides both balance sheet and market values for individual securities. If for an individual security the book value is higher than its market value, this may indicate a deviation from mark-to-market valuation, for example due to at-cost valuation (IFRS) or due to a long-term investment holding purpose that entails revaluation options for banks that apply the German HGB.[22] Only for those securities portfolios, for which, according to the above reasoning, the accounting treatment would prescribe the realisation of market losses, it is assumed that the market price shock will be reflected on the balance sheet. For such securities portfolios, the market losses realised by banks in their banking book then correspond to the difference between the current book value and the market value after the market price shock. A previous undervaluation of securities with respect to their observed market values (hidden reserves) consequently mitigates the realisation of losses to some degree. Second, bank-level information from FINREP on securities portfolios subject to different valuation treatments provides additional insight into the share of securities not subject to mark-to-market valuation. Where appropriate, book losses are scaled accordingly, in order to achieve an overall alignment.

[22] Here, WP invest data as of the last annual financial reporting date (i.e. end-of-year data) are considered because banks may opt against mid-year reporting changes to the accounting valuation.

2.3 Insurance sector loss calculation and impact on solvency

2.3.1 Top-down stress tests for insurers

Stress testing insurers based on top-down approaches is more than challenging as insurers are subject to various and very different sources of risks. Their products are complex and their business models are highly heterogeneous across both business lines and countries. Therefore, supervisors tend to rely on bottom-up stress tests that are conducted by the insurers themselves but still based on supervisory guidelines. The insurance stress test exercise conducted regularly by EIOPA is probably the most prominent example in the European Union. Nevertheless, supervisors often apply top-down approaches within the scope of bottom-up stress tests as part of their quality assurance.

Regardless of the difficulties, top-down stress tests constitute an important tool for macroprudential supervisors and macroprudential surveillance. In parallel to national supervision, the International Monetary Fund (IMF) carries out regular assessments of national financial sectors through its Financial Stability Assessment Program (FSAP). Insights obtained by the Fund's staff are a vital and comprehensive source of comparative information on the various national approaches to macroprudential surveillance and top-down stress testing. Accordingly, Jobst et al. (2014) provide a review of system-wide solvency stress tests for insurers based on a comparison of national practices and insights from the Fund's FSAP.

The implementation of Solvency II in the European Union (EU) in 2016 marked a major evolutionary step also in the availability of solvency reporting figures to supervisors. At the same time, Solvency II forced national authorities in the EU to fundamentally review their stress test frameworks in order to bring them in compliance with the new solvency regime.[23] The following features are common to most of these more recently presented approaches: (1) An incomplete but representative sample was used, comprising the largest domestic insurance groups or solo insurance undertakings. (2) The Solvency II Quantitative Reporting Templates form the main source of data. (3) The risk coverage focusses on market risk, including interest rate risk, equity risk, and spread risk. Sometimes property risk or an additional single-factor shock are considered as well, the latter assuming the default of the most relevant financial sector counterparty or a mass lapse event. (4) Shocks are assumed to occur instantaneously at the beginning of the stress test horizon. (5) Stressed balance sheet positions regularly comprise stocks, bonds, and securities portfolios for the assets and technical provisions for the liabilities. (6) In some cases, solvency capital requirements for certain risk modules or the loss-absorbing capacity of technical provisions are adjusted after the shock. (7) Stress test outcomes are usually reported in terms of losses to eligible own funds and new solvency ratios.

[23] For the case of Germany, IMF 2016 provides a good overview of national implementation challenges. More recently, a number of FSAP reports presented top-down stress test approaches suited for certain EU countries under Solvency II, specifically for Sweden, France, Denmark and Italy (IMF 2017, 2019, 2020a, 2020b).

2.3.2 Scope and data

The insurer stress test presented here is performed at the solo entity level and thus excludes business performed by foreign subsidiaries. The sample covers more than 250 German insurers with total assets of around €2 trillion in 2020. In general, the scenario shocks are applied to both investment assets and insurance liabilities. On the asset side, a look-though is applied for assets held in funds established under German law. Unless stated otherwise, assets and liabilities associated with index-linked, and unit-linked business are – to the extent possible – excluded from the analysis. Market risks associated with these products are typically borne by the policyholder. The coverage of market risk factors regularly includes interest rate risk, equity risk, and spread risk as well as the associated portfolios that are sensitive to these risks. Depending on the nature of the shock, which can be rather temporary or permanent, non-traded or non-marketable assets holdings are covered.[24] Property and currency risks as well as derivative exposures are not considered.[25] If reference is made to the German insurance sector as a whole, the relevant scope is the sum of all German insurance solo undertakings and lines of business. For aggregate figures, sample composition may change according to reporting gaps and quality. Reporting coverage of certain figures may also vary across insurance undertakings depending on whether they use the standard formula or partial or full internal models. For the latter case, certain figures are inferred based on cross-asset or peer group comparisons.

The following Solvency II Quantitative Reporting Templates are used as the main source of data: Balance sheet (S.02.01), Asset-by-asset investment holdings (S.06.02), Collective investment undertakings - look-through approach (S.06.03), Technical provisions (S.12.01), Projection of future gross cash flows (S.13.01), Own funds (S.23.01), Solvency Capital Requirement - for undertakings (S.25.01-03), Solvency Capital Requirement - Market risk (S.26.01). In order to facilitate a look-through for assets held in German funds, complementary data on asset holdings of German investment funds (Investment Fund Statistics, IFS), and a security-by-security reference database (Centralised Securities Database, CSDB) are utilised.

[24] The exemplary results presented in section 3 cover neither those assets nor non-traded participation holdings.

[25] Derivatives, which form a relatively small part of German insurers' assets and liabilities, are not modelled explicitly as granular data on derivative positions lack sufficient reporting quality. If necessary, risk-mitigating impacts of derivatives can be implicitly covered by the complementary use of overall portfolio sensitivities to risk factors according to insurers' regulatory reporting. However, this approach is not necessarily consistent with an asset-by-asset re-valuation strategy.

Re-calculating portfolios and capital charges

Adverse scenario losses for individual insurers are derived by applying the asset price changes derived in subsection 2.1 to the market values of the relevant balance sheet components. All scenario shocks are assumed to occur instantaneously. On the asset side, risk factors are applied asset-by-asset wherever data quality permits. For the remaining parts of the investment portfolio, risk factors are imputed based on asset similarity and the respective information available.[26] Haircuts on fixed-income assets are derived from changes in the term structure of risk-free rates (per currency) as well as the asset-specific widening of spreads. Stressed equity portfolios include participations – unless stated otherwise. On the liability side, technical provisions after stress are approximated with the stressed term structure - including the volatility adjustment if applicable.

The re-calculation of the solvency capital requirements (SCR) after stress is limited to selected risk modules. In the market risk module, the capital charge for equity risk is proportionately adjusted in line with the change in exposures due to the stress. Furthermore, the equity risk capital charge is corrected for the symmetric equity adjustment after the fall in equity prices. Consequently, the capital charge used for the re-calculation of the SCR is considerably lower after stress.

In contrast, the spread risk charge is regularly left unchanged as the fall in prices of bonds and securities is assumed to reflect higher default risk and to be associated with anticipated rating migration. In case the adverse scenario explicitly envisages rating migrations, spread risk charges are adjusted accordingly. The capital charge for life underwriting risk and health underwriting risk is assumed to change proportionately with the technical provisions after the application of the stressed discount curve. All other components, including the capital charge for property risk, counterparty default risk, non-life underwriting risk and operational risk are assumed to be unchanged. For internal model users, the calculations including the aggregation of capital charges in the SCR calculation are made in a simplified approach broadly in line with the standard formula. The loss-absorbing capacity of technical provisions and of deferred taxes is assumed to remain constant.

[26] Relevant information typically comprises: the issuer credit rating, issuer country, issuer NACE code, financial instrument type, and modified duration.

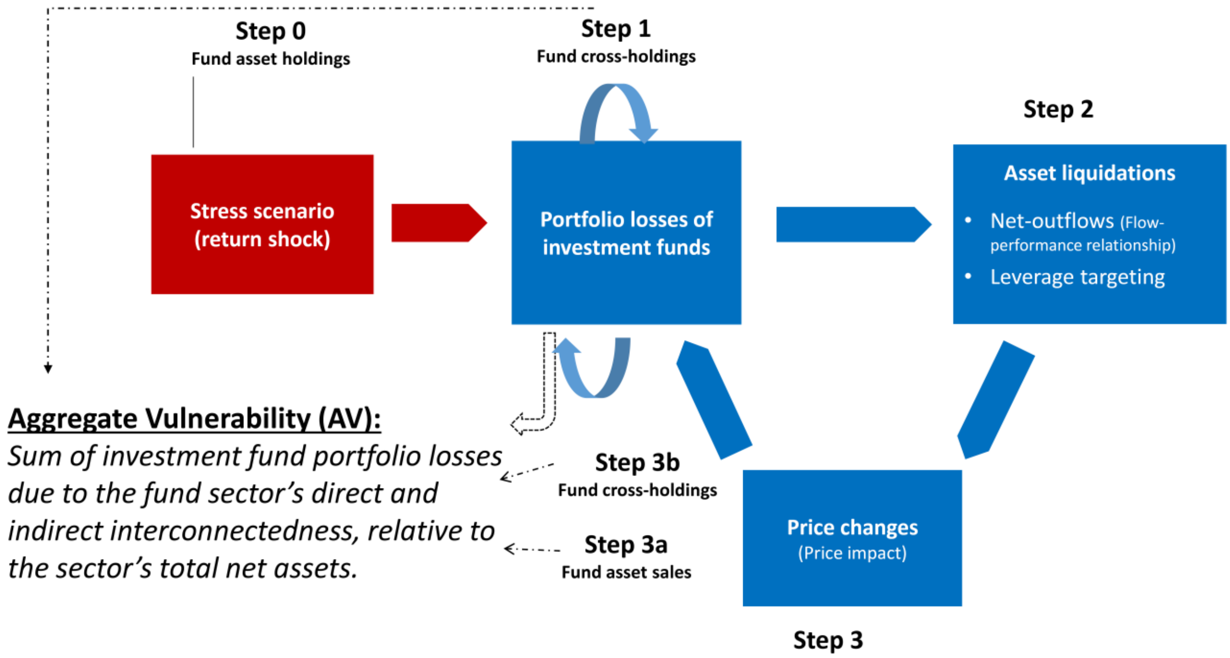
2.4 Macroprudential stress test framework for the investment fund sector

To assess the vulnerability of the investment fund sector and to quantify amplifying effects of investment funds, the macroprudential funds sector stress test framework of Fricke and Wilke (2020) is applied.[27] This section describes the data sources (subsection 2.4.1), the stress test framework (subsection 2.4.2) and major model parameters (subsection 2.4.3).

2.4.1 Data

Included are all open-end equity funds, bond funds, mixed funds, and fund-of-funds reporting to the investment fund statistics (IFS), both retail funds and specialized funds. The data are provided at the level of individual fund share classes, which matters because fund shareholders' redemption decisions may depend on share class-specific features. IFS data are complemented with the Eurosystem's Securities Holdings Statistics (SHS) to obtain information on the holder structure for each investment fund over time and the Eurosystem's Centralised Security Database (CSDB) to obtain granular information on the individual securities in funds' asset portfolios.

Figure 3



[27] The macroprudential stress test framework was also presented in the Bundesbank's Financial Stability Review 2019, see Deutsche Bundesbank 2019.

2.4.2 Modelling framework[28]

This subsection gives a brief overview of the macroprudential stress testing model. The model assumes a broad universe of investment funds (see subsection 2.4.1) which collectively face an abrupt and severe but plausible price shock to their asset holdings. This shock hits funds' asset portfolios at the security level and directly relates to the shock scenarios specified in subsection 2.1.3 ("Security stress derivation"). Funds' assets holdings consist of marketable assets (i.e., stocks and bonds) – which can be liquidated – as well as fund shares and other non-marketable assets, neither of which can be liquidated. Funds' asset holdings are financed by a mix of debt and fund shares issued to fund investors. Essentially, these fund shares can be redeemed by fund investors in the model without delay. Figure 3 provides a high-level overview.

The model comprises four steps:

<u>Step 0:</u>

In step 0, the initial shock is imposed on funds' bond and equity portfolios.

<u>Step 1:</u>

Here, the shock propagation mechanism starts: the initial portfolio losses from step 0 trigger further losses as they spread to other funds through the funds cross-holdings network.

<u>Step 2:</u>

Resulting from steps 0 and 1, funds face higher leverage ratios and negative portfolio returns. In step 2, consequently, fund managers may need to liquidate assets for two reasons:

a) In response to negative portfolio returns, fund investors redeem some of their fund shares: Empirically, fund investors tend to put their money into funds with good past performance while they tend to withdraw their money from funds with bad past performance (flow-performance relationship, FPR). In order to service redemption requests in the event of a return shock, fund managers then have to liquidate parts of their asset portfolio.

b) Funds' leverage ratios increase mechanically due to the initial shock (Step 0), fund-cross-holdings losses (Step 1) and investors redeeming their fund shares (Step 2a) Fund managers target their leverage und therefore liquidate additional assets in order to deleverage. This assumption seems consistent as fund managers need to specify the composition of their funds' assets and liabilities in their sales prospectuses and thus are not likely to deviate from these set goals.

[28] For more details on the model framework, see Fricke and Wilke (2020).

Step 3:

In order to deleverage and generate liquidity to pay out redeeming fund investors, fund managers liquidate assets. Funds' common asset liquidations negatively affect market prices as funds have to sell into a distressed market and funds' selling pressure may cluster. This leads to:

a) losses on funds' bond and equity holdings.

b) losses on funds' cross-holdings (as in Step 1).

Here, it is assumed that fund managers liquidate assets proportionally to the post-shock portfolio weights and that asset liquidations only involve marketable assets.

The **fund sector's aggregate vulnerability (AV)** is defined as the sum of funds' portfolio losses due to their common asset liquidations (indirect connectedness; Step 3a) and their fund cross-holdings (direct connectedness; Steps 1 and 3b), normalised by the fund sector's aggregated pre-shock total net assets (TNA).

$$AV = (Loss^{Firesales} + Loss^{Crossholdings})/TNA$$

The AV measures the percentage of aggregate total net assets that would be wiped out by funds' asset liquidations and funds' fund share crossholdings, in response to the initial shock. Therefore, the AV directly measures the strength of the fund sector's reaction to the initial shock, reflecting a variety of common fund-sector related risk factors:

Table 3

Factor	Effect of factor increase on AV	Intuition
Leverage	↑	With increased leverage more assets need to be liquidated due to the leverage targeting channel.
Flow-performance relationship	↑	A stronger relationship between poor past performance and net outflows leads to more fund asset sales after a return shock.
Market liquidity	↓	With lower market liquidity, funds' asset sales will have a stronger impact.
Indirect connectedness	↑	With higher indirect connectedness within the fund sector (portfolio overlap), funds can affect each other more strongly due to their asset sales. Diversification effects may be at work.
Direct connectedness	↑	With higher direct connectedness within the fund sector (cross-holdings), losses can propagate more easily through the network. Diversification effects may be at work.

A fund's contribution to the AV is given by its **systemicness, $\boldsymbol{S_i}$. $\boldsymbol{S_i}$** captures a given fund i's contribution to the AV, i.e., the losses that arise due to fund i's asset sales, and that propagate to other funds through fund i's common asset holdings and though the fund cross-holdings network:

$$S_i = S_i^{Firesales} + S_i^{Crossholdings}$$

The fund-level systemicness measure is applied to identify those funds that drive the overall vulnerability (pockets of risk).

2.4.3 Parameter calibration[29]

Flow-performance relationship (FPR): Fricke and Wilke (2020) use standard regressions to estimate the FPR – i.e. the sensitivity of fund flows to past returns. An important advantage of the IFS is that investment funds report their inflows and outflows separately for each month. Therefore relative netflows can be calculated directly as

$$Flow_{i,t} = (Inflow_{i,t} - Outflow_{i,t})/TNA_{i,t-1}$$

Based on these flows, the authors then estimate the following equation, based on Fama-MacBeth regressions:

$$Flow_{i,t} = \alpha_t + \beta_t * Controls_{i,t} + \gamma_t * Return_{i,t-1} + \varepsilon_{i,t}$$

The key parameter is γ_t, which denotes the sensitivity of fund flows ($Flow_{i,t}$) to past returns ($Return_{i,t-1}$). $Controls_{i,t}$ is a vector of standard controls such as fund size, fund age or lagged fund flows. Note that the FPR is estimated dynamically, meaning that the strength of the FPR is allowed to vary over time. The FPR parameters are computed separately for each fund type and for retail/institutional funds. The Fama-MacBeth approach estimates the above relationship separately for each cross-section t and averages these coefficients to provide point estimates. In everything that follows, unless stated otherwise, we use Newey-West standard errors with four lags. Following the literature, individual fund share classes younger than one year and/or with TNA below €1 million are dropped. Moreover, extreme flows/returns below -80% or exceeding +200% of lagged TNA are filtered out.

Leverage targeting: Leverage ratios of German investment funds are rather small and well below the regulatory maximum. Based on empirical regressions, Fricke and Wilke (2020) show that German funds' financial leverage tends to be mean-reverting which indicates that fund managers in fact target their desired leverage ratios.

[29] For more details on the empirical parameter calibration approach, see Fricke and Wilke (2020), pages 27-30.

Price impact of asset liquidations: We use the standard Amihud (2002) ratio as our measure of price impact:

$$PriceImpact_{k,t} = |Return_{k,t}| \; / \; Volume_{k,t}.$$

The Amihud ratio is the absolute return on asset k divided by the nominal trading volume over the same period. The Amihud ratio is linear in nature and tends to overestimate the actual impact of funds' fire sales on security prices for large trading volumes.[30] Note that cash is always assumed to have a price impact of 0. As expected, equities tend to be the most liquid instruments, followed by sovereign bonds, whereas (financial and non-financial) corporate bonds tend to be the least liquid instruments. As the initial shock scenario features a broad shock to securities prices, fund managers that face selling pressure have to liquidate their assets into illiquid asset markets. To account for this, the 90%th percentile (across all sample months) of the observed price impact parameter is used for each asset.

[30] Empirical evidence suggests that price impact follows a square-root law, i.e., is a concave function (see e.g. Engle et al. 2012).

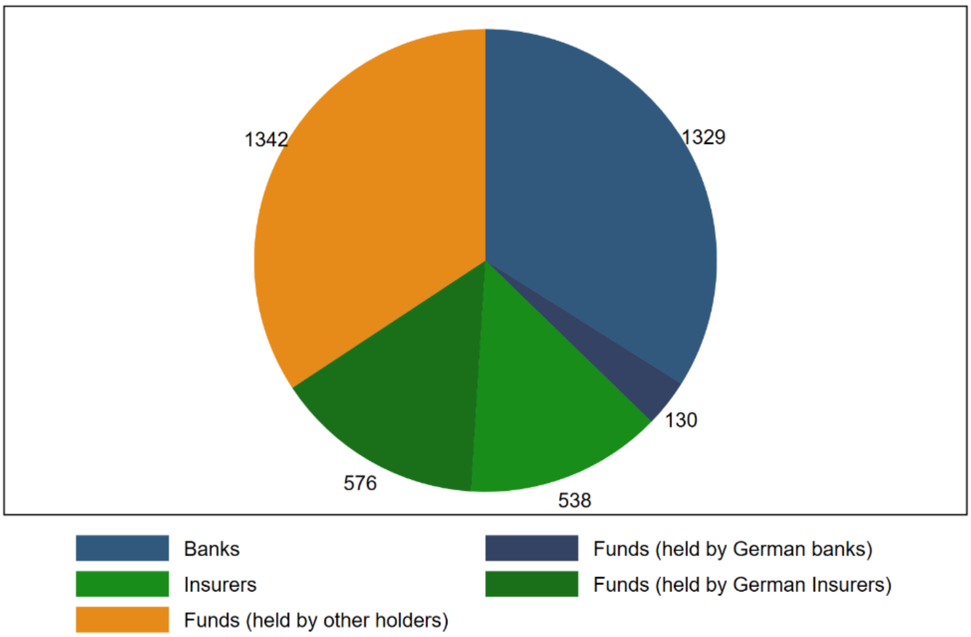
3 Case study – risk premium and yield curve shocks

In order to illustrate the outcomes of the macroprudential market risk stress test, we apply two scenarios that are derived technically from historical distributions of market returns and spread changes observed between January 1999 and June 2021 based on a window of 21 trading days. Scenario 1 denotes a risk premium shock, i.e. a broad shock to equity prices and bond spreads. The scenario is approximated as the average stock market stress and bond spread increase that is observed during episodes beyond the 99.5 percentile (i.e. an expected shortfall). Scenario 2 describes a yield curve shock, i.e. a shock to the risk-free rates. The scenario is approximated as the a 99.5 percentile increase at the short end (1-year remaining maturity) plus the 99.5 percentile of the yield curve steepness, i.e. the difference between the yield curve at 10 years residual maturity and 1 year residual maturity over 21 trading days in the sample period.[31] The scenario is characterised by pronounced increases in the yield curve of 150 to 200 bps for maturities beyond 20 years. Usually strong increases at the short-end of the yield curve coincide with a flattening of the yield curve; this scenario therefore represents an extreme stress, in particular for investors in long-term bonds. In order to separately assess the impact of risk premiums compared to risk-free rate shocks, the yield curve is held constant in the risk premiums shock scenario, while risk premiums are held constant in the yield curve shock scenario. Detailed scenario assumptions can be found in the Appendix.

Figure 4

Portfolio composition of German financial intermediaries

Market values in €bn, 2021Q1

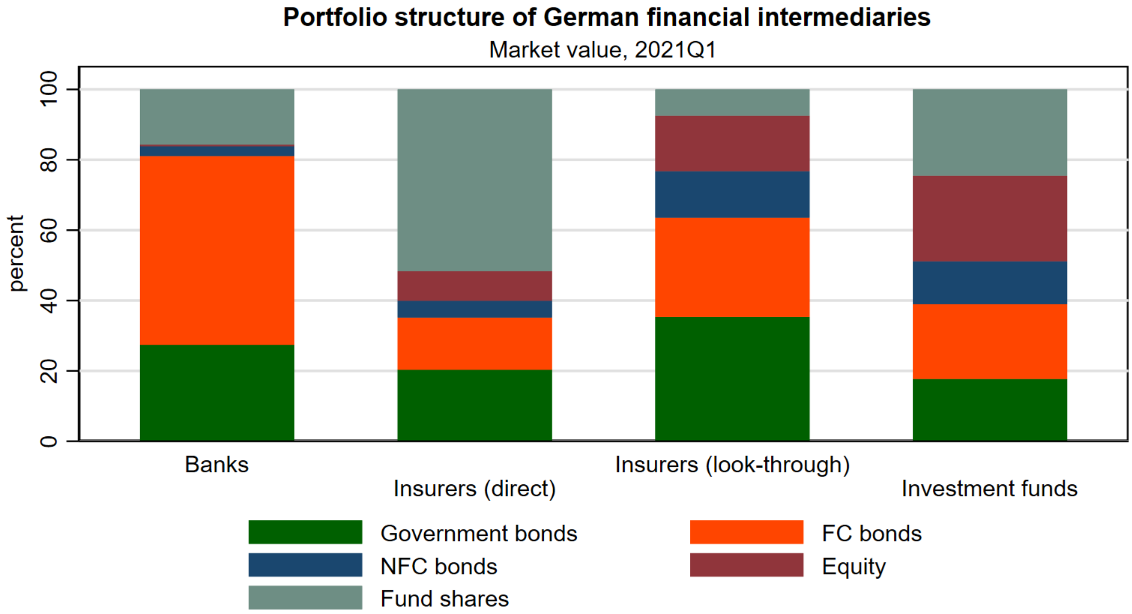


[31] Further maturities are derived from a linear approximation, where the 30-year maturity represents the upper bound of yield increases.

3.1 Portfolio composition of banks, insurers and investment funds

The heterogeneity in the business models of banks, insurers and investment funds is also reflected in the size and composition of their securities portfolios. Overall, German financial intermediaries held € 3,915 bn worth of securities subject to market risk in their portfolios at March 31, 2021 (Figure 4). At € 2,048 bn, i.e. more than half of all securities, the lion's share is held by investment funds. This sum encompasses German investment fund holdings on behalf of banks and insurers of around € 130 bn and € 576 bn respectively. Banks hold around € 1,329 bn directly in their portfolio, while insurers' remaining direct holdings amount to € 538 bn. Hence, at the end of the first quarter of 2021 insurers held slightly more than half of their market-risk sensitive assets indirectly via investment funds.

Figure 5



In terms of asset composition, banks mainly invest in financial and government bonds; they only hold a minor amount of equities directly on their balance sheet, although indirect holdings via funds increase banks' exposure to equities.[32] For insurers the asset composition is broken down into directly held assets and assets held indirectly through German investment funds for which a look-through is feasible. Insurers invest predominantly in fixed-income products. Their government and financial bond positions are of large and of similar size, significantly outweighing those of corporate bonds. Insurers' holdings of marketable equities are rather small. While there is a substantial amount of participation holdings on insurers' balance sheets, a large fraction of those is considered nonmarketable and therefore not covered by the stress test. About half of the considered marketable assets of insurers are held indirectly through German investment funds. For investment funds, aggregate bond holdings are large as well but the

[32] For banks, Figures 5 and 6 show the asset composition of securities of the banking book in order to facilitate the interpretation of asset level results for the banking book shown in subsection 3.2.

fund sector also holds substantial positions in equities and fund shares. The latter highlights the importance of direct interconnectedness within the fund sector. Compared to banks and insurers, investment funds hold the largest equity portfolio, both in absolute terms and relative to their total securities holdings. Figure 5 compares the asset structure of German financial intermediaries in relative terms.

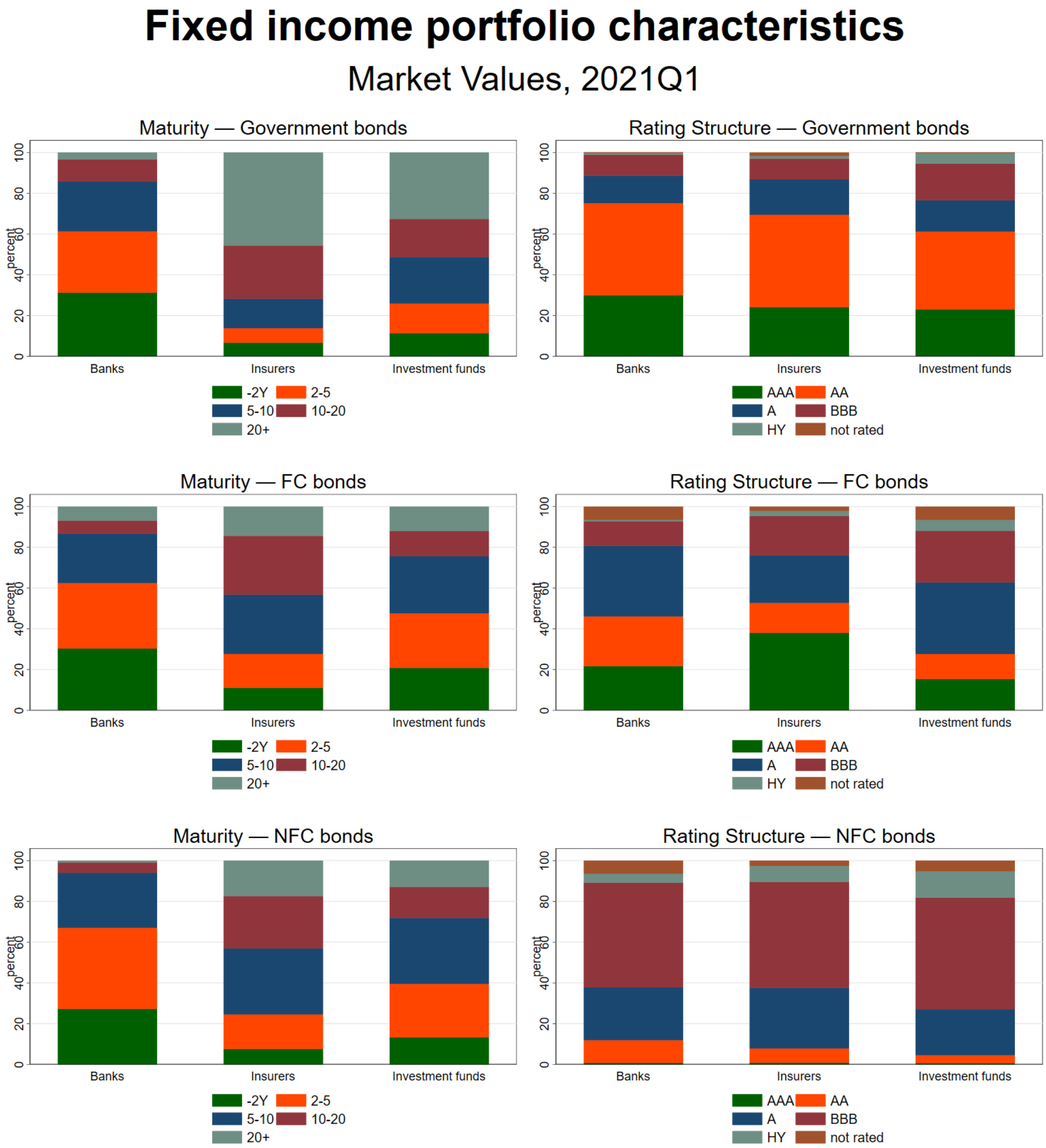
The fixed-income portfolios of German intermediaries also reflect differences in their business models. While insurers, in particular life-insurers, seek to match long maturities of insurance policies on the liability side, maturities of banks' investments are relatively shorter. Meanwhile, banks prefer rather safe and liquid assets. For example, 75% of government bonds are rated AA or better and 80% of financial bonds are rated A or better. Moreover, banks hold almost no high-yield bonds and 62% of fixed income securities held by banks have a maturity of less than five years. On the other hand, insurers' business models are less prone to liquidity risks. They consequently prefer to hold larger fractions of illiquid assets in order to earn associated premiums. Residual maturities in the considered investment portfolios of insurers are rather long, averaging 21 years for government, 11 years for financial and 12 years for corporate bonds.

The risk profile of insurers' fixed-income portfolios is characterised by high credit ratings, which are comparable to the good credit risk profile of banks' portfolios described above. This pattern matches both the low risk preference of insurers and the better ability of high-quality issuers to issue long-term debt. In recent years, insurers have made increased use of investment funds. Compared to their direct portfolio investment, the fund investment of the insurance sector exhibits a somewhat higher risk profile.

Finally, the aggregate fixed-income portfolio of German investment funds is tilted towards long maturities: 35% of total fixed-income holdings have maturities of ten or more years which is heavily driven by the investment fund sector's large position in very long-term government bonds. In fact, one euro in three of funds' government portfolio is channelled into bonds with a maturity exceeding 20 years. While investment funds tend to take on term risk in their government bond portfolio, they shift towards credit risk in their corporate bond holdings: 61% of their government bond holdings but only 5% of their corporate bond holdings are rated AA or better. Moreover, high-yield bonds make up 13% of funds' total corporate bond holdings while their corporate BBB bond holdings are large (55% of their total corporate bond holdings), which makes them exposed to "fallen angels".[33]

[33] "Fallen angels" are securities or companies that are downgraded from an investment grade (BBB or better) to a high yield rating (below BBB). Due to institutional and partly regulatory factors the market for high-yield securities is not as deep as the market for investment-grade securities. Becoming a fallen angel, thus, generally results in very high increases in financing costs and spreads and additional increases in a company's default risk (Deutsche Bundesbank 2020).

Figure 6


Fixed income portfolio characteristics
Market Values, 2021Q1
Maturity — Government bonds
Rating Structure — Government bonds
Maturity — FC bonds
Rating Structure — FC bonds
Maturity — NFC bonds
Rating Structure — NFC bonds
percent
0
20
40
60
80
100
Banks
Insurers
Investment funds
-2Y
2-5
5-10
10-20
20+
AAA
AA
A
BBB
HY
not rated

3.2 Results

Table 4 summarises the impact of both a risk premium and a yield curve shock on the securities portfolios (as at 2021Q1) of German banks, insurers and investment funds. For all intermediaries, initial losses[34] are reported both in absolute terms and in relation to the stressed (sub-)portfolios to facilitate comparison.[35] In Scenario 1 (shock to risk premiums), overall initial losses in market value are substantially lower for banks (-5.5% of their securities holdings in the banking book) than initial losses to funds (-14.4% of their total securities holdings) or insurers (-13.1% of their marketable securities holdings). Overall, this is consistent with the structural differences in maturity and rating characteristics of the securities portfolios held by banks, insurers and investment funds highlighted above. For instance, banks' government bond and financial bond portfolios are exposed to losses in market value of -2.7% and -5.9%, respectively, which is considerably lower than the projected losses for the insurers (-6.6% and -9.8%) or the investment fund sector (government bonds: -9.4%, financial bonds: -10.3%). Funds also sustain substantially larger initial losses on their corporate bond holdings than banks (- 18.5% for funds versus -9.2% for banks). For banks, balance sheet or book losses are crucial to assess vulnerabilities with respect to the scenario. Book losses differ from changes in market value due to particularities in the accounting treatment of securities of the banking book (see subsection 2.2). In Scenario 1, banks' book losses are -2.3% and hence substantially lower than market value decreases of -5.5%.

Portfolio compositions also drive substantial differences across intermediaries in their vulnerability with respect to a yield curve shock (Scenario 2). For example, losses in market value in banks' portfolios are less pronounced compared to insurers and investment funds due to the rather short duration of their bond holdings and their limited equity holdings. In contrast, aggregate fund losses are much more pronounced because of funds' larger equity holdings and the higher sensitivity of their bond portfolio towards yield changes (see above). Insurers' balance sheets are particularly sensitive to changes in the yield curve. Results for scenario 2 presented in Table 4 show substantial losses for insurers' stressed assets of 16.3% in market values. This sensitivity mirrors the long maturities of insurers' investments. However, insurers' balance sheets are also characterised by long-term liabilities, whose recognised present values decrease with increasing risk-free rates. For the yield curve scenario, the present value reduction in liabilities even overcompensates for the asset losses for the insurance sector as a whole. However, this positive net effect is also driven by different base values. While the revalued marketable assets considered in the stress test represent only half of insurers' total assets, liabilities valuation gains arising from changes in risk-free rates emerge from a considerably larger fraction of total liabilities.[36]

[34] Note that these losses are market losses and in many cases are not realized until intermediaries decide to sell their assets (or fund investors choose to redeem their shares).

[35] For the banking sector losses of the trading book are computed for the overall exposure to market price risk and hence cannot be broken down to individual classes of securities (see subsection 2.2.3).

[36] Indeed, for scenarios that are purely driven by increases in risk-free rates, valuation gains on the liability side likely overcompensate for valuation losses on the asset side. In contrast, for scenarios that are also characterised by considerable increases in credit risk spreads, asset losses are more likely to dominate.

In order to provide an intuition for loss absorption capacity, losses of the banking and insurance sector are reported in relation to their own funds in the definition relevant to their respective regulatory solvency requirements. These are common equity tier 1 (CET 1) capital for banks and eligible own funds (to meet the SCR) for insurers, respectively. For instance, the risk premiums shock (scenario 1) would imply projected book losses for German banks of about 6.1% of CET1 stemming from losses in the banking book and the trading book. Insurers would suffer losses of around 26.7% of their eligible own funds.

For the fund sector, an intuition of the severity of the fund sectors' vulnerability to the modelled scenario is given by the amount of additional second-round losses that emerge within the fund sector in response to the initial shock, i.e. the level of shock amplification by the fund sector. Therefore, second-round losses from amplification effects within the fund sector are reported next to the immediate losses associated with the assumed asset price declines induced by the scenario. The fund sector's aggregate vulnerability (AV) is also provided, which quantifies the overall amplification effect emanating from the fund sector (see subsection 2.4), i.e., German funds' aggregate second-round losses divided by the fund sector's pre-shock net assets. In the yield curve shock scenario additional sales of funds would lead to decreases in net assets of the funds sector of around 3.7%.

The system-wide perspective also facilitates the identification of spill-over risks within the financial system. For example, most of the initial and second-round portfolio losses within the German fund sector do not stay within the fund sector but propagate to the rest of the financial sector, e.g. insurers. This holds true especially for second-round losses within the fund sector which thus amplify the initial shock not only for German funds themselves but also for the wider financial system (Fricke and Wilke 2020).

Table 4

Market risk stress test - Results

Data as of 2021 Q1 Aggregate losses

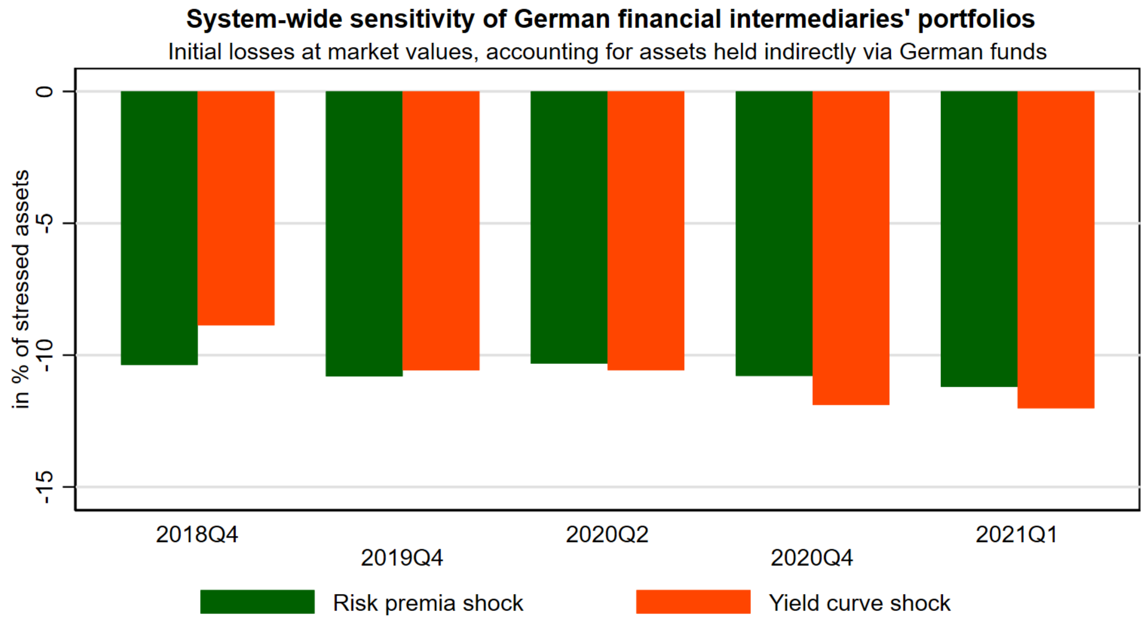
	Banks Banking book					Insurers directly held				Investment funds			
	Holdings at market value in €bn	**Change market value in €bn**	**Change market value in %**	**Book losses %**	**in % CET1**	**Holdings at market value in €bn**	**Change market value in €bn**	**Change market value in %**	**in % own funds**	**Holdings at market value in €bn**	**Change market value in €bn**	**Change market value in %**	**Add. second round %**
Scenario 1 – Risk premia shock (ES 99.5)													
Total	1.272	-68,2	-5,5%	-2,3%	-5,6%	1.114	- 145,95	-13,1%	-26,7%	2.030	- 291,70	-14,4%	-4,1%
… of which by asset class													
……….Government Bonds	338	-9	-2,7%	-0,8%	-0,5%	227	- 14,9	-6,6%	-2,7%	352	- 33,2	-9,4%	-7,1%
……….FC Bonds	700	-38,7	-5,9%	-2,6%	-3,5%	165	- 16,1	-9,8%	-2,9%	379	- 39,2	-10,3%	-2,4%
……….NFC Bonds	38	-3,5	-9,2%	-4,6%	-0,3%	53	- 8,4	-15,9%	-1,5%	234	- 43,3	-18,5%	-2,2%
……….Equities	3	-0,5	-26,9%	-5,9%	0,0%	93	- 25,5	-27,4%	-4,7%	496	- 127,0	-25,6%	-0,4%
……….Fund Shares	193	-16,5	-8,6%	-3,4%	-1,2%	576	- 81,0	-14,1%	-14,8%	569	- 49,1	-8,6%	-7,4%
…of which by region													
……….Germany	526	-21,8	-4,4%	-1,9%	-0,5%	260	- 39,0	-15,9%	-7,1%	232	- 33,4	-14,4%	-3,7%
……….EA ex Germany	318	-16,1	-5,1%	-2,2%	-0,3%	489	- 48,1	-9,8%	-8,8%	525	- 66,6	-12,7%	-4,6%
……….USA	53	-3,6	-6,7%	-2,1%	-0,1%	104	- 18,1	-17,4%	-3,3%	290	- 60,6	-20,9%	-0,5%
Other *)		-2,4			-0,5%								-3,9%
Scenario 2 – Yield curve shock (percentile 99.5)													
Total	1.272	-67,3	-5,5%	-1,9%	-4,7%	1.114	- 182,0	-16,3%	-33,2%	2.030	-300,4	-14,8%	-3,9%
… of which by asset class													
……….Government bonds	338	-18,2	-5,4%	-1,9%	-1,3%	227	- 43,7	-19,3%	-8,0%	352	-60,7	-17,3%	-7,7%
……….FC bonds	700	-33,1	-5,0%	-1,8%	-2,4%	165	- 19,2	-11,6%	-3,5%	379	-26,8	-7,1%	-2,8%
……….NFC bonds	38	-1,4	-3,6%	-1,3%	-0,1%	53	- 5,8	-10,9%	-1,1%	234	-23,4	-10,0%	-2,1%
……….Equities	3	-0,4	-23,2%	-4,4%	0,0%	93	- 19,7	-21,2%	-3,6%	496	-140,5	-28,3%	-0,4%
……….Fund shares	193	-14,3	-7,4%	-2,5%	-0,9%	576	- 93,6	-16,3%	-17,1%	569	-48,9	-8,6%	-6,2%
…of which by region													
……….Germany	526	-28,5	-5,8%	-1,8%	-0,5%	260	- 42,9	-16,5%	-7,8%	232	-32,9	-14,2%	-3,8%
……….EA ex Germany	318	-16,6	-5,3%	-2,3%	-0,4%	489	- 87,5	-17,8%	-16,0%	525	-86,5	-16,5%	-4,9%
……….USA	53	-2,6	-4,9%	-1,3%	0,0%	104	- 15,1	-14,5%	-2,8%	290	-67,1	-23,2%	-0,5%
Other *)		-0,2			0,0%		- 248,1		-45,3%				-3,7%

FC=Financial corporations; NFC=Non-financial corporations, EA=Euro area.

Sources: WP Invest, COREP, FINREP, Solvency II, Investment Fund Statistics, CSDB, Bloomberg, ICE, Bundesbank calculations
Deutsche Bundesbank
*) Banks: Trading Book losses; Insurers: Revaluation change in interest-sensitive liabilities (complete balance sheet); Investment funds: Aggregate vulnerability (AV) as sum of second round-losses, divided by pre-shock net assets

Comparing losses over time can yield important insights into development of risk drivers. Figure 7 shows German financial intermediaries' aggregate initial market losses as a percentage of their aggregate security holdings for both the risk premium and yield curve shock scenario, over time.[37] The results suggest that initial losses associated with a risk premium shock have remained rather constant since the end of 2018; meanwhile, market value losses associated with a yield curve shock, i.e. an increase in risk-free rates, have increased since the end of 2018, reflecting German financial intermediaries' increased portfolio sensitivity to changes in interest rates.

Figure 7



[37] For the German banking sector, Figure 7 includes all securities held by banks, i.e. not only securities of the banking book but also securities of the trading book.

4 Conclusion

In this paper, we present a market risk stress testing framework for the German financial sector which encompasses banks, insurers and investment funds. First, we illustrate the design of a common market risk scenario, deriving shocks from historical market price movements and translating these to the level of individual securities. We then show how market losses with respect to the common scenario can be determined in a consistent manner for banks, insurers and investment funds, taking specificities in the transmission of market risk to each type of financial intermediary into account. Our joint approach allows for a comparison of stress effects across banks, insurers and investment funds in order to uncover similarities and differences in their vulnerability with respect to market risk. Our case study shows that differences emerge from portfolio heterogeneity in terms of maturities or ratings across intermediaries.

Furthermore, our joint approach facilitates the identification of spill-over effects within the financial system. Banks and insurers hold significant amounts of fund shares. Consequently, via these direct linkages, investment funds' portfolio losses propagate to banks and insurers and could thus exert pressure on the financial system as a whole.

Moreover, our framework accounts for second-round amplification effects within the investment fund sector. Due to their asset and liability structure, funds are particularly prone to market price declines and abrupt fund share redemptions by performance-sensitive fund investors. In order to deleverage and cater to investors redeeming their shares, funds might be forced to liquidate assets, adding to price pressures on markets (Fricke and Fricke 2021; Fricke and Wilke 2020).

Additional transmission channels of market risk within the financial system represent a potential avenue for future research. First, besides fund holdings, other direct linkages across sectors can be of relevance for second-round effects, e.g. bonds issued by banks that are held by other financial intermediaries. Second, when exposed to large-scale losses or liquidity outflows, banks and insurers, too, might be forced to liquidate parts of their security portfolios in order to meet target capital or liquidity ratios (Brunnermeier and Pedersen 2009; Brunnermeier and Sannikov 2014; Ellul et al. 2018; Adrian et al. 2014), thus exerting indirect pressure on each other's securities holdings. Taking into account these direct and indirect linkages might lead to a more precise loss estimate, but also deliver valuable insights in terms of propagation risk in an interconnected financial system.

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6 Appendix

6.1 Indices used for scenario calibration

Type	Region	Sector	Index	Source
EQ	DE	FC/NFC	CDAX	Bloomberg
EQ	EAnonDE	FC/NFC	Eurostoxx 50	Bloomberg
EQ	EUnonEA	FC/NFC	Stoxx Europe 600	Bloomberg
EQ	US	FC/NFC	S&P 500	Bloomberg
EQ	UK	FC/NFC	FTSE 100	Bloomberg
EQ	JP	FC/NFC	Nikkei	Bloomberg
EQ	ODC	FC/NFC	MSCI World	Bloomberg
EQ	EMDC	FC/NFC	MSCI EM	Bloomberg

EQ=Equity, (N)FC=(Non-)Financial corporations. DE=Germany, EAnonDE=Euro Area ex Germany, EUnonEA=European Union ex Euro Area. US=United States, UK=United Kingdom, JP=Japan, ODC=other developed countries, EMDC=Emerging markets and developing countries.

Type	Region	Sector	Index	Source	Unit
Bonds	DE/EAnonDE/EUnonEA	FC	EUR Financials (EB00)	Ice Bofa ML	OAS in bp
Bonds	US	FC	USD Banks Brokerage (C0P0)	Ice Bofa ML	OAS in bp
Bonds	UK	FC	GBP Financials (UF00)	Ice Bofa ML	OAS in bp
Bonds	JP	FC	JPY Financials (JF00)	Ice Bofa ML	OAS in bp
Bonds	ODC	FC	Global Financials (BF0F)	Ice Bofa ML	OAS in bp
Bonds	EMDC	FC	Emerging Markets Corporate plus (EMNS)	Ice Bofa ML	OAS in bp
Covered bonds	DE/EANnonDE/EUnonEA	FC	EUR Jumbo covered (ECVO)	Ice Bofa ML	OAS in bp
Covered bonds	US/EMDC	FC	USD Covered Bond (CV00)	Ice Bofa ML	OAS in bp
Covered bonds	UK/JP/ODC	FC	Ungew. MW von ECV0 – CV00	Ice Bofa ML	OAS in bp
Securitization	DE/EANnonDE/EUnonEA	FC	EUR ABS/MBS (EA00)	Ice Bofa ML	OAS in bp
Securitization	US/EMDC	FC	USD Fixed Floating ABS (R010)	Ice Bofa ML	OAS in bp
Securitization	UK/JP/ODC	FC	Ungew. MW von EA00 – R010	Ice Bofa ML	OAS in bp

(N)FC=(Non-)Financial corporations. DE=Germany, EAnonDE=Euro Area ex Germany, EUnonEA=European Union ex Euro Area. US=United States, UK=United Kingdom, JP=Japan, ODC=other developed countries, EMDC=Emerging markets and developing countries

Type	Region	Sector	Index	Source	Unit
Bonds	DE/EA/EU	NFC	EUR Industrials (EJ00)	Ice Bofa ML	OAS in bp
Bonds	US	NFC	USD Industrials (CIL0)	Ice Bofa ML	OAS in bp
Bonds	UK	NFC	GBP Industrials (UR00)	Ice Bofa ML	OAS in bp
Bonds	JP	NFC	JPY Industrials (JC00)	Ice Bofa ML	OAS in bp
Bonds	ODC	NFC	Global Corporate (GB0C)	Ice Bofa ML	OAS in bp
Bonds	EMDC	NFC	Emerging Markets Corporate plus (EMNS)	Ice Bofa ML	OAS in bp
Bonds	DE	Gov	DE Generic Govb10y (GTDEM10y)	Bloomberg	Spread – YC in bp
Bonds	EAnonDE / EUnonEA	Gov	EA All Govbonds 10y generic (EUSRA10)	Bloomberg	Spread – YC in bp
Bonds	US	Gov	Generic USD Treasury (USGG10ygovt)	Bloomberg	Spread – YC in bp
Bonds	UK	Gov	Generic UK GovBond 10y (GTGBP10y)	Bloomberg	Spread – YC in bp
Bonds	JP	Gov	Generic JP GovBond 10y (GTJPY10y)	Bloomberg	Spread – YC in bp
Bonds	ODC	Gov	World Gov ex USA (N0G1)	Ice Bofa ML	Spread – YC in bp
Bonds	EMDC	Gov	EM External Debt (EMGD)	Ice Bofa ML	OAS in bp
YC	EUR		EUR Swapcurve (EUSA1/2/10)	Bloomberg	Delta in bp
YC	USD/ODC/EM		USD Swapcurve (USSA1/2/10)	Bloomberg	Delta in bp
YC	GBP/JPY		BPSW1/2/10/JPSW1/2/10	Bloomberg	Delta in bp

(N)FC=(Non-)Financial corporations; Gov=Government. DE=Germany, EAnonDE=Euro Area ex Germany, EUnonEA=European Union ex Euro Area. US=United States, UK=United Kingdom, JP=Japan, ODC=other developed countries, EMDC=Emerging markets and developing countries.

6.2 Scenario details

Equity loss in %

Region	RP	YC
DE	-27,5	*
US	-23,9	*
JP	-26,8	*
CH	-20,1	*
JP	-26,8	*
UK	-23,3	*
EAnonDE	-26,2	*
EUnonEA	-24,6	*
ODC	-25	*
EMDC	-28,8	*

RP=Risk premium shock, YC=Yield curve shock.

*Equity losses due to changes in the yield curve are derived using residual income models (Claus and Thomas 2001). Losses (in %) vary over time depending on yield curve and earnings expectations assumptions.

Yield Curve changes in bp

Maturity	Currency	RP	YC
0-2Y	EUR	0	52,0
2-5Y	EUR	0	83,9
5-10Y	EUR	0	115,8
11-15Y	EUR	0	134,9
16-20Y	EUR	0	146,4
20+Y	EUR	0	153,3
0-2Y	USD	0	60,1
2-5Y	USD	0	105,3
5-10Y	USD	0	150,4
11-15Y	USD	0	177,5
16-20Y	USD	0	193,7
20+Y	USD	0	203,5
0-2Y	other	0	56,1
2-5Y	other	0	94,6
5-10Y	other	0	133,1
11-15Y	other	0	156,2
16-20Y	other	0	170,1
20+Y	other	0	178,4

RP=Risk premium shock, YC=Yield curve shock.

Fixed income risk premium changes in bp

Type	Region	RP-FC	RP-NFC	Gov(RP)	YC-FC	YC-NFC	YC- Gov
Bonds	DE/ CH	143,4	132,7	27,6	0	0	0
	EAnonDE/EUnonEA	143,4	132,7	56,6	0	0	0
	EMDC	486,3	486,3	285,8	0	0	0
	JP	54,9	27,6	19,2	0	0	0
	ODC	186,4	169,2	74,8	0	0	0
	UK	174,7	122,3	35	0	0	0
	US	204	211,6	25,8	0	0	0
Covered	DE/EA/EU/CH	52,9	-	-	0	0	0
	EMDC	122,5	-	-	0	0	0
	JP/UK/ODC	87,7	-	-	0	0	0
	US	122,5	-	-	0	0	0
Securitization	DE/EA/EU/CH	84	-	-	0	0	0
	EMDC	200	-	-	0	0	0
	JP/UK/ODC	84	-	-	0	0	0
	US	200	-	-	0	0	0

RP=Risk premium shock, YC=Yield curve shock. FC=Financial corporation bonds, NFC=Non-financial corporation bonds, Gov=Government bonds