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Monetary Policy Transmission and Bank Resilience in Germany Heterogeneous Effects Across Bank Types

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Monetary Policy Transmission and Bank Resilience in Germany: Heterogeneous Effects Across Bank Types

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Abstract

Monetary policy changes the stability of German banks differently based on their ownership and business goals. Existing literature shows that monetary policies stabilize markets but can also encourage institutions to take higher risks. Using monthly balance sheet data for five bank types from 1999-2021, we analyze how different monetary policy shocks affect resilience. Resilience is measured through the Z-score, which reflects a bank's capacity to absorb losses before risking insolvency. The results show that institutions tied to retail deposits and local lending, such as Sparkassen and Credit Unions, face weaker resilience after prolonged accommodative monetary policy, whereas banks with stronger links to capital markets gain resilience in the short run. Monetary policy therefore reshapes the distribution of resilience inside the German banking system as low interest rates compress margins for traditional lenders while larger banks benefit from rising asset prices.

Keywords: Resilience, Financial Stability, Monetary Policy, Unconventional Monetary Policy, Banking System, Germany.

JEL Codes: E42, E52, G21, M41.

1 Introduction

Recent crises have renewed interest in the resilience of financial systems to adverse shocks. Policymakers and public commentators increasingly discuss “resilience” as a response to external shocks (de Guindos 2023a, Schnabel 2023). Previously, monetary authorities framed their objectives in terms of financial stability (ECB 2007, Bundesbank 2021, Federal Reserve 2021, IMF 2023). This terminological shift from *financial stability* to *resilience* also reflects a subtle change in policy objectives, from preventing financial disruptions to absorbing their effects. The increasing emphasis on resilience has coincided with an expansion of central banks’ interventions in monetary and financial systems (Lagarde 2021, Lagarde 2022).

Resilience is commonly understood as the capacity of a system to withstand and adapt to unexpected external shocks. The literature distinguishes between robustness, i.e. the ability to absorb shocks and recover, and adaptability, i.e. the ability to adjust to changing economic conditions and constraints (Ostrom 2005, Aligica and Tarko 2014, Salter and Tarko 2019). Recent crises illustrate these dimensions. Following the Great Financial Crisis, banks strengthened capital and liquidity buffers through regulatory reforms, while during the European sovereign debt crisis, many institutions adjusted balance sheet exposures and funding structures in response to elevated sovereign risk.

During downturns, when resilience becomes particularly important, monetary policy is widely viewed as the primary tool for macroeconomic stabilization. Empirical evidence suggests that conventional monetary policy can stabilize economic activity during typical recessions (Leigh and Stehn 2009, Kannan et al. 2009, Bech et al. 2014, Sanchez et al. 2015, Israel 2017). However, the effectiveness of conventional policy may weaken during financial crises when monetary transmission channels become impaired (Borio 2014, Sanchez et al. 2015). In such circumstances, central banks increasingly rely on unconventional monetary policy measures to support financial intermediation and mitigate adverse spillovers to the real economy (Mishkin 2009, Borio 2014).

At the same time, a growing literature emphasizes that prolonged monetary accommodation may also generate medium-term risks for the financial system. Sustained mone-

tary easing and the expansion of central bank balance sheets may delay necessary balance sheet adjustments of financial intermediaries and contribute to financial fragility (Borio and Disyatat 2010, Borio 2014, Bouis et al. 2013). Unconventional monetary policy measures, including (targeted) longer-term refinancing operations (TLTROs), quantitative easing (QE), negative interest rate policies, and forward guidance, may further encourage excessive risk-taking, distort credit allocation, and weaken market discipline (Caruana 2012, Sanchez et al. 2015, Salter and Tarko 2019, Schnabl 2019, Israel and Latsos 2020, Israel et al. 2022).

Our study contributes to the literature on unconventional monetary policy by examining how monetary policy affects bank resilience across different German bank types. Existing research has largely focused on bank profitability, lending, and risk-taking, while less attention has been paid to the dynamic effects of monetary policy on bank resilience. Following Avalos and Mamatzakis (2023), we measure resilience using the Z-score as an indicator of banks' loss-absorbing capacity. We combine high-frequency monetary policy shocks with local projections to estimate the dynamic responses of resilience across German bank types, allowing us to trace heterogeneous effects over time without imposing strong structural restrictions.

Germany provides a useful setting for analyzing these questions because its banking system is segmented into institutionally distinct bank types with markedly different business models and functions. Sparkassen and Credit Unions remain strongly rooted in retail deposits, relationship banking, and lending to households and SMEs in local markets, whereas large commercial banks and, to a lesser extent, regional banks and Landesbanken are more closely connected to capital markets, sovereign debt markets, and international business activity. Monetary policy may therefore affect German banks differently depending on their funding structures, business models, and institutional roles within the financial system.

Our study makes three main contributions to the literature. First, we examine bank resilience separately across the five principal bank types in Germany. Using balance sheet data, we construct Z-scores for each bank type to capture differences in resilience

across the German banking system. Second, we distinguish between conventional and unconventional monetary policy measures by separately analyzing the effects of policy rate changes, short-term rate shocks, forward guidance, and quantitative easing (QE). Third, we combine high-frequency identification (HFI) of monetary policy shocks (Altavilla et al. 2019a) with local projections to estimate the dynamic responses of bank resilience over time.

Our results indicate that monetary policy affects bank resilience heterogeneously across bank types and time horizons. In particular, resilience tends to decline for institutions whose business models rely more heavily on traditional deposit-taking and relationship lending.

The paper is structured as follows. Section 2 provides a review of the literature connected to monetary policy, banking, and resilience. We then present our data in Section 3 and provide a descriptive overview of Germany’s banking sector as well as the different types of unconventional monetary policy tools. The estimation framework and results are outlined in Section 4. We conclude our paper with a discussion of the policy implications of our analysis.

2 Literature Review

Recent literature identifies two main transmission channels of monetary policy on banks: the bank-lending channel and the risk-taking channel. The bank-lending channel highlights what happens to the asset side of monetary financial institutions’ (MFIs) balance sheets and emphasizes the importance of differences in balance sheet characteristics of heterogeneous bank types (Kashyap and Stein 2000, Gambacorta and Marques-Ibanez 2011, Jiménez et al. 2012, De Santis and Surico 2013, Buch et al. 2019). The risk-taking channel of monetary policy suggests that variations in monetary policy affect financial intermediaries’ readiness to take risks, which alter the supply of credit to the real economy. For example, low interest rates might encourage bankers’ propensity for risk as they positively affect the valuation of assets and collateral (Gambacorta and Marques-Ibanez

2011, Borio and Zhu 2012, Adrian et al. 2019, Bologna and Galardo 2025, Salachas et al. 2025). Bank-specific characteristics also influence the level of financial risk borne by banks. Benbouzid et al. (2018) show that bank size has a non-monotonic relationship with CDS spreads. An important prerequisite for these channels is the pass-through of monetary policy to bank interest rates. Changes in policy rates affect banks primarily through adjustments in deposit and lending rates. For the euro area, De Bondt (2005) finds that the immediate pass-through of market rate changes to retail bank rates is below 50%, while the long-run adjustment approaches unity. More recent evidence by Michail and Louka (2025) shows that pass-through was relatively stable prior to unconventional monetary policy but became more heterogeneous afterwards.

De Santis and Surico (2013) show that the bank-lending channel is highly heterogeneous in the eurozone. Their results for Germany show that monetary policy has a more pronounced impact on the credit provision of Credit Unions and Sparkassen, which have limited liquidity and lower capital ratios. Similarly, in Italy, monetary policy has stronger effects on savings banks, which are smaller in size. More recently, Altavilla et al. (2018) have shown that more liquid and better capitalized eurozone banks are more resilient to monetary contractions. Ivashina et al. (2022), using data on loan contracts, show that monetary policy affects the composition of bank lending across different loan types, with asset-based lending and trade finance responding more strongly to policy shocks. Using a large cross-country panel of banks, Boungou (2021) finds that the lending channel remains active even under negative interest rate policies, as banks adjust credit supply and loan maturities in response.

Jiménez et al. (2012) and Ioannidou et al. (2015) use two extensive datasets on Spanish and Bolivian banks' credit registers and provide evidence that an accommodative monetary policy stance has encouraged elevated levels of risk-taking by banks before the Great Financial Crisis, possibly leading to excessive risk exposure. Jiménez et al. (2014) study the impact of monetary policy on the composition of banks' supply of credit using data on Spanish bank loans for the period between 2002 and 2008. They find that lower short-term interest rates induce weakly capitalized banks to grant more loans to risky

firms. These findings are consistent with the risk-taking channel of monetary policy. Dell’Ariccia et al. (2017) use loan-level data from U.S. banks between 1997 and 2011 and analyze the risk-taking channel of monetary policy. They find that banks’ risk-taking is positively associated with decreases in short-term policy rates. Monetary policy directly impacts the risk level of banks and thus has broader implications for overall financial stability. Adrian et al. (2019) provide further evidence for the risk-taking channel of monetary policy. They find that the effectiveness of monetary policy depends on the risk-taking behavior of financial intermediaries through their management of balance sheets in response to changing economic conditions. Salachas et al. (2025), analyzing risk-taking across developed economies and the BRICS, show that tighter monetary policy reduces banks’ exposure to risk, while loose policy encourages greater risk-taking through funding flows within multinational banking groups. Bologna and Galardo (2025) examine banks’ behavior after the removal of limits on maturity transformation in Italy and show that the regulatory change increased banks’ exposure to interest rate risk.

Grimm et al. (2023) show that when the monetary policy stance is accommodative over an extended period, the probability of financial crises increases significantly. Abadi et al. (2023) provide evidence that there is a rate—the so-called reversal interest rate—at which an accommodative monetary policy becomes contractionary for lending. This is because further monetary easing (i.e. through unconventional monetary policies) cuts into banks’ profitability, curtailing their credit supply and financial stability in the long run. Avalos and Mamatzakis (2023) examine the impact of unconventional monetary policies on the resilience of the banking sector in the eurozone between 2007 and 2018. They find that unconventional monetary policies are overall positively associated with the resilience of banks.

Monetary policy is widely regarded as a central tool for stabilizing the economy and the financial system during periods of stress. Financial stability broadly refers to the smooth functioning of financial markets and institutions and the absence of severe disruptions to financial intermediation (Gadanecz and Jayaram 2008). In this context, central banks play an important role as providers of liquidity during episodes of finan-

cial distress (Goodhart 1987). Bernanke and Gertler (1995), White (2009), and Mishkin (2011) further emphasize the role of monetary policy in maintaining financial stability. Regarding unconventional monetary policy, Carpenter et al. (2014) show that monetary easing can stabilize banks by reducing funding volatility and supporting lending activity, while Markmann and Zietz (2017) find that the ECB’s covered bond purchase program (CBPP) contributed to bank stabilization.

However, expansionary (un)conventional monetary policies can also increase the risk-appetite of financial intermediaries by encouraging the search for yield (Gambacorta 2009, Jiménez et al. 2009, Ioannidou et al. 2015, Borio and Zhu 2012, Altunbas et al. 2014, Sahuc 2016). In a low-interest-rate environment, banks possibly underestimate the risk of holding certain assets. This is because the value of equity relative to debt increases with rising asset prices. Moreover, increased bank lending activity occurs as a result of relaxed lending standards (Darracq-Paries and De Santis 2015). Relaxed lending standards, in turn, introduce higher risks to banks’ balance sheets (Ioannidou et al. 2015, Heider et al. 2019, Kabundi and De Simone 2020). Hence, banks tend to embrace greater risks in their pursuit of higher expected returns that were formerly attainable when interest rates were higher (Rajan 2005, Avalos and Mamatzakis 2023). The perceived commitment to support financial markets during downturns can exacerbate financial intermediaries’ risk-taking behavior, compromise banks’ risk-absorbing capacities, and thus jeopardize financial stability and resilience (Borio and Zhu 2012).

3 Data Description

We create a panel dataset on the German banking system, paired with variables indicating the monetary policy stance of the ECB and macroeconomic covariates. The data on the German banking system consist of monthly balance sheet information on the main German bank types from 1999 to 2021. The monetary policy variables include a variety of indicators, most importantly high-frequency shocks to identify conventional and unconventional monetary policy measures (Altavilla et al. 2019a, Jarociński and Karadi

2020, Baumgärtner and Klose 2021). To control for the macroeconomic environment, the covariates included are the CPI, industrial production, the German stock market index (DAX), the unemployment rate, the EUR/USD exchange rate and the yield on 10-year German government bonds. An overview of our dataset can be found in Table [1](#) of Appendix [A](#).

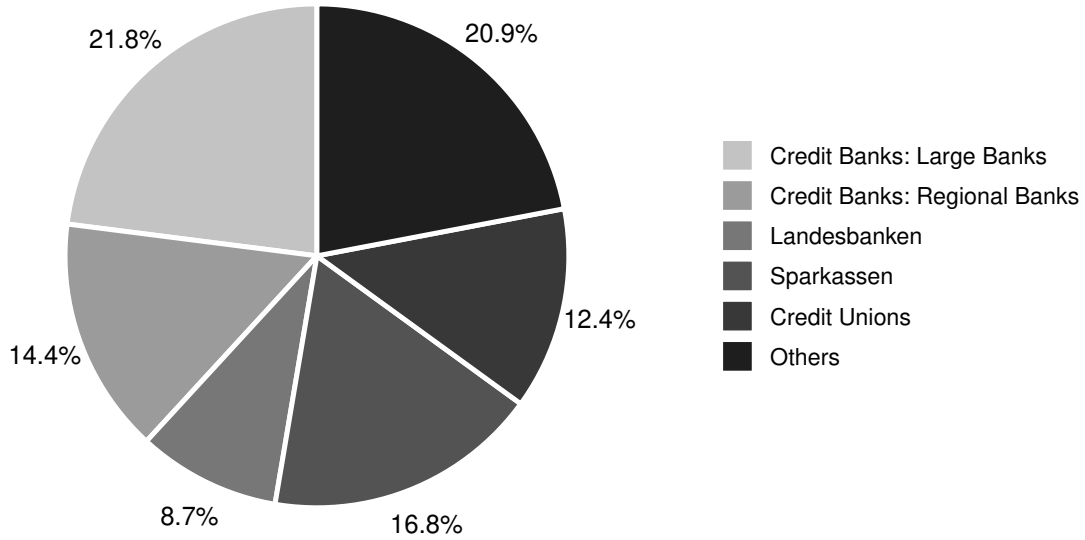
3.1 *The German Banking System*

The German banking system is organized in two tiers. The first tier is the Deutsche Bundesbank, which is integrated into the European System of Central Banks (ESCB). The second tier of the German banking system consists of three pillars. The first pillar includes public-sector savings banks, i.e. Sparkassen and Landesbanken. The second pillar comprises credit cooperatives, i.e. Credit Unions. The third pillar consists of privately organized Credit Banks that are separated into Large Banks, i.e. Deutsche Bank and Commerzbank, and Regional Banks, i.e. Volkswagen Bank and ING-DiBa. In December 2021, Large Banks, Regional Banks, Sparkassen, Landesbanken and Credit Unions held 79% of the German banking sector’s total assets (9.23 trillion euros).

The public-sector savings banks’ (Sparkassen and Landesbanken) main objective is to accommodate the saving behavior of households, to finance private real estate purchases and the business activities of small and medium-sized enterprises. Sparkassen are bound to the so-called regional principle, which restricts them to operating exclusively in their business territory. The rationale is to avoid the channeling of financial resources solely into economically advanced areas, thereby denying structurally weaker regions access to financing (Gärtner 2003). Landesbanken perform a supra-regional central bank function for Sparkassen. In December 2021, the share of Sparkassen amounted to 16.8% (1.6 trillion euros) and that of Landesbanken to 14.4% (1.3 trillion euros) of total assets of the German banking sector (Figure [1](#)).

The primary objective of Credit Unions is to support the business activities of their members. Consequently, the primary operational focus of Credit Unions lies in retail and corporate banking. Credit Unions play a significant role in financing small and medium-

Figure 1: *Share of Total Assets of German Banking Sector*



Note: Distribution of total assets in the German banking sector across institutional groups in December 2021. Source: Deutsche Bundesbank.

sized enterprises in their business territory. With 1.1 trillion euros, the share of Credit Unions in the total assets of the German banking sector was 12.4% in December 2021 (Figure 1).

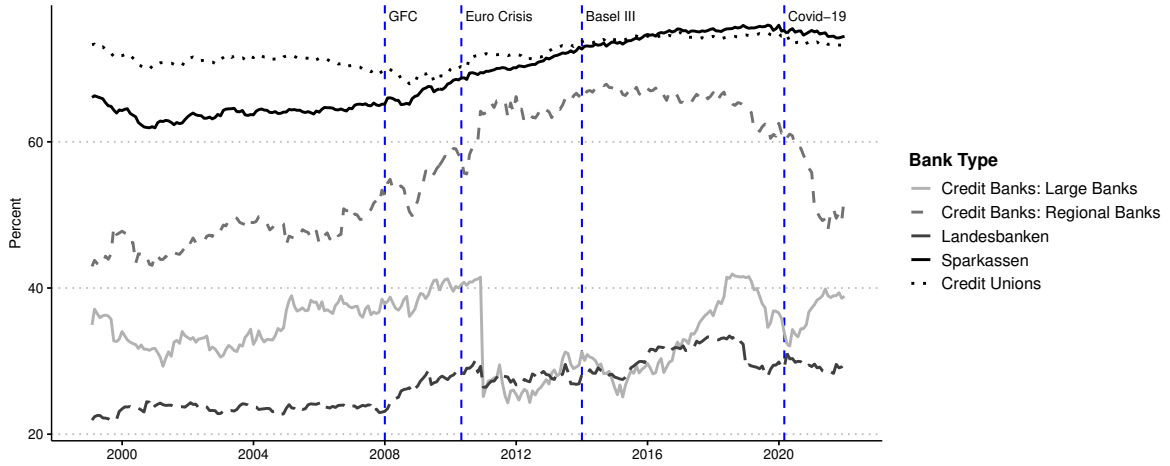
Large Banks comprise privately organized money and credit institutions, such as Deutsche Bank and Commerzbank. They conduct their business activity supra-nationally through a nationwide and international branch network. Regional Banks¹, i.e. Volkswagen Bank or ING-DiBa, are privately organized money and credit institutions, whose business activity has traditionally been limited to a specific region. The corporate structure of Large and Regional Banks as stock companies links them closely to capital markets. In contrast to Sparkassen and Credit Unions, they actively engage in foreign operations, securities business, and investment banking. With total assets of 2.8 trillion euros, the share of Large Banks and Regional Banks accounted for 30.5% of total assets of the

¹Although Regional Banks do not conduct their business activities exclusively in one region anymore, they are still referred to as Regional Banks in the Bundesbank statistics. Direct banks, such as ING-DiBa, are included in the aggregate “Regional Banks” too.

German banking sector in December 2021 (Figure 1).

Unlike Sparkassen and Credit Unions, Large Banks are particularly active in foreign markets and the securities business. Some of these differences are reflected in the deposit ratio, the real economy funding ratio, and the foreign business ratio, to each of which we now turn.

Figure 2: *Deposit Ratio*



Note: Deposit ratio for Credit Unions, Sparkassen, Landesbanken, Large Banks, and Regional Banks. The deposit ratio equals total deposits from non-monetary financial institutions (non-MFIs) divided by total assets. Source: Deutsche Bundesbank.

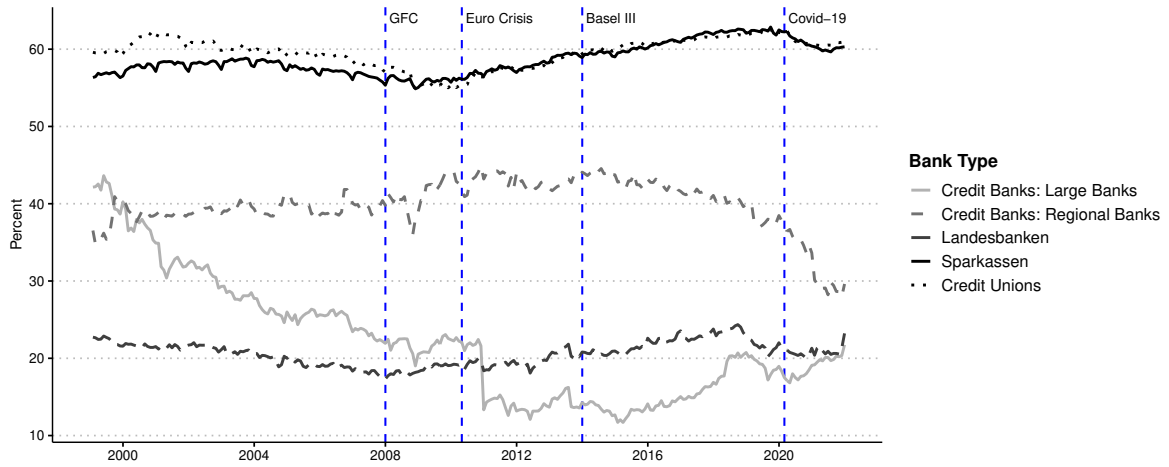
Figure 2 shows the deposit ratio of Credit Unions, Sparkassen, Landesbanken, Large Banks and Regional Banks. The deposit ratio is calculated as total deposits from non-monetary financial institutions (non-MFIs) as a share of total assets. Over the whole observation period, the deposit ratio of Credit Unions and Sparkassen has remained relatively stable around 75%. Regional Banks' deposit ratio has steadily increased until December 2019, but has fallen sharply since, while the deposit ratio of Landesbanken has increased slightly over the whole observation period. In contrast, the deposit ratio of Large Banks reveals some fluctuations but has a declining long-term trend.

Small and medium-sized banks such as Credit Unions and Sparkassen facilitate access to capital for small and medium-sized enterprises (SMEs) and thus promote regional growth (Hasan et al. 2017, Marsch et al. 2007).² Due to their local ties, small and

²Transaction and regulatory costs for issuing publicly traded shares or debt securities are high, so that small and medium-sized enterprises are discouraged from issuing them (Coleman 2006). Therefore,

medium-sized banks are better able to manage risks caused by information asymmetries (i.e. adverse selection and moral hazard) as they can collect soft and hard information through relationship banking (Baas and Schrooten 2006, Berger and Udell 2006, de la Torre et al. 2010, Shinozaki 2012, Canales and Nanda 2012, Hasan et al. 2014). Overcoming adverse selection in lending translates to lower probabilities of credit default and therefore more resilience. This is particularly true if the foreign risks of banks are comparatively low, and their financing activities lean more towards the domestic economy.³

Figure 3: *Domestic Real Economy Funding Ratio*



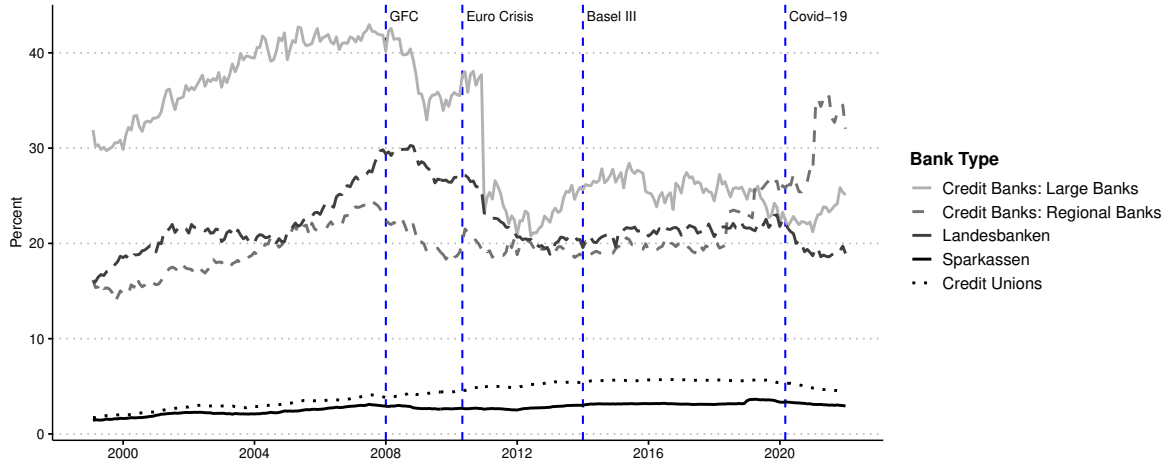
Note: The domestic real economy funding ratio for Credit Unions, Sparkassen, Landesbanken, Large Banks, and Regional Banks. The domestic real economy funding ratio is defined as loans to domestic firms and private individuals divided by total assets. Source: Deutsche Bundesbank.

Figure 3 shows the domestic real economy funding ratio. It is calculated as the share of loans to domestic companies and private individuals in total assets. The core business activity of Credit Unions and Sparkassen is indeed the financing of domestic companies and private individuals. For Credit Unions and Sparkassen, the domestic real economy funding ratio averages around 60%. For Large Banks and Regional Banks, the domestic real economy funding ratio has significantly diminished. In 1999, the ratios for Large Banks and Regional Banks were 42% and 37%, respectively. They have roughly halved and now stands at 18% for Large Banks and 23% for Regional Banks. For Landesbanken, the ratio has remained more or less constant. The decline in the domestic funding ratio compared to large companies, SMEs are dependent on financing through financial intermediaries.

³It is assumed that information asymmetries are more difficult to overcome and that default risks are higher when lending abroad due to exchange rate, regulatory and legal risks.

following the onset of the Euro Crisis likely reflects balance sheet adjustments during the crisis; the subsequent recovery may also be related to (un)conventional monetary policy easing, a pattern we analyze more formally in the pre- and post-crisis framework in the next section.

Figure 4: *Foreign Business Ratio*



Note: The foreign business ratio for Credit Unions, Sparkassen, Landesbanken, Large Banks, and Regional Banks. The foreign business ratio is defined as total deposits and borrowing from foreign MFIs and non-MFIs and total credit to foreign MFIs and non-MFIs as a share of total assets. Source: Deutsche Bundesbank.

The foreign business ratio is defined as total deposits and borrowing from foreign MFIs and non-MFIs and total credit to foreign MFIs and non-MFIs as a share of total assets (Figure 4). The foreign business ratio of Credit Unions and Sparkassen has slightly increased over the observation period but is comparatively low with a maximum of 6% of total assets. In contrast, the foreign business ratio of Large Banks, Regional Banks and Landesbanken is much higher. Large Banks' foreign business ratio strongly increased to 42% in 2007. In the aftermath of the Great Financial Crisis, it decreased considerably but still hovers between 21% and 28%. A similar development can be seen for Landesbanken. Regional Banks' foreign business ratio has increased strongly over the whole observation period and now stands at 30% of total assets. The drop in the foreign business ratio shortly after the Euro Crisis is consistent with a retrenchment of cross-border activities following the sovereign debt crisis (Popov and Van Horen 2015). The differing short- and longer-term dynamics further motivate our explicit comparison of pre- and post-crisis

behavior in the subsequent empirical analysis (Section 4).

Assuming that information asymmetries are more difficult to resolve and default risks are higher in foreign business, Large Banks, Regional Banks, and Landesbanken are likely more exposed to contagion effects from international economic developments because of their comparatively large foreign exposure (Corsetti et al. 1999, Hoffmann and Schnabl 2008). Credit Unions and Sparkassen, by contrast, remain primarily focused on domestic lending activities and have comparatively limited foreign exposure in their balance sheets. This may reduce their vulnerability to international financial contagion.

On the other hand, Large Banks and Landesbanken maintain closer links to international capital and asset markets. To the extent that unconventional monetary policy supports these markets through liquidity provision and asset-price effects, such policies may strengthen the resilience of these institutions in the short run. Closer links to capital and asset markets may also strengthen the risk-taking channel of monetary policy for Large Banks and Landesbanken, as rising asset valuations and abundant liquidity can encourage greater risk exposure during prolonged periods of monetary accommodation. Moreover, Sparkassen and Credit Unions remain vulnerable to prolonged accommodative monetary policy through margin compression and profitability effects in low-interest-rate environments.

3.2 *Monetary Policy*

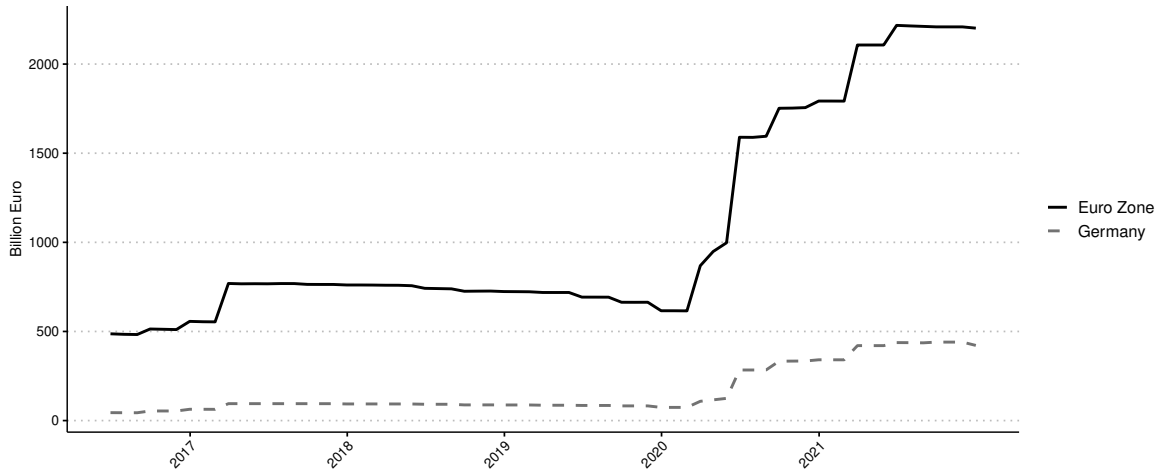
The ECB started to introduce unconventional monetary policy measures to counter the long-lasting effects of the Great Financial Crisis of 2008 (Driffill 2016). At the core of the ECB's unconventional monetary policy measures are longer-term refinancing operations (LTROs), asset purchase programs, negative interest rate policies and forward guidance.

LTROs are transactions that provide liquidity to the banking system for a longer period than the main refinancing operations. They aim to support credit flows and stabilize financial markets during periods of economic stress and uncertainty. LTROs have been a regular instrument in the toolbox of the ECB's liquidity management since its inception. Typically, LTROs used to have maturities of three months. Since June 2009,

however, these loans became increasingly unconventional as maturities were prolonged, first to a year and then up to three years in December 2011 (Dwyer et al. 2023).

LTROs were soon followed by targeted longer-term refinancing operations (TLTROs) in 2014, 2016 and 2019. While both LTROs and TLTROs involve providing financial institutions with longer-term funding and liquidity, TLTROs are designed to encourage banks to lend directly to specific actors in the real economy. In contrast to generic LTROs, TLTROs offer funds at favorable rates to certain institutions. Dwyer et al. (2023) find that TLTROs increased bank loans by 16.4% of total assets in non-crisis countries and by 14.6% of total assets in crisis countries. From 2016 until 2022, (T)LTROs increased from 507 billion euros to 2,062 billion euros. Over the same period, the share of (T)LTROs provided to the German banking system averaged 14.7% (Figure 5).

Figure 5: (T)LTROs



Note: Outstanding volume of Targeted Longer-Term Refinancing Operations (TLTROs), multi-year loans provided by the European Central Bank to commercial banks, from 2016 to 2022 for the euro area and for Germany. The German banking system accounts on average for 14.7% of total (T)LTRO funding over this period. Source: ECB.

The asset purchase programs of the ECB can be categorized into the purchase of covered bonds, the purchase of public sector securities, the purchase of corporate sector securities and the purchase of asset-backed securities.

To counter the negative impact of the Great Financial Crisis on the covered bond market, the ECB initiated its first unconventional asset purchase program—the covered bond purchase program—in 2009. The objective of the covered bond purchase program

(CBPP) was to enhance liquidity in the covered bond market, reduce money market term rates, address challenges in bank funding, and mitigate adverse credit conditions, with the aim of promoting growth (Driffill 2016). The CBPP was laid out in three phases. In July 2009, the ECB announced the first CBPP and purchased 60 billion euros of covered bonds until June 2010. To respond to the sovereign debt crisis, the Eurosystem bought 16.4 billion euros of covered bonds from November 2011 to October 2012 under CBPP II to stimulate funding to credit institutions and enable lending. Finally, under CBPP III the Eurosystem purchased covered bonds from October 2014 to December 2018 amounting to 262 billion euros. These measures were reintroduced from November 2019 until June 2022 to mitigate the economic consequences of COVID-19, with purchases amounting to 302 billion euros (Dwyer et al. 2023).

The asset purchase program (APP), known as quantitative easing, was announced in September 2014. Quantitative easing aims to lower long-term interest rates by large-scale purchases of securities.⁴ The increased money supply is intended to support growth, combat deflationary pressures, and enhance overall financial stability. The APP consists of the CBPP III, the asset-backed securities purchase program (ABSPP), the public sector purchase program (PSPP) and the corporate sector purchase program (CSPP). Under the ABSPP, the ECB bought asset-backed securities, including loans to households and businesses. In November 2014, the ECB started to purchase asset-backed securities under the ABSPP until December 2018, and restarted net purchases from November 2019 until June 2022. Under the PSPP, the ECB bought public sector securities such as nominal and inflation-linked government bonds. The first purchases under the PSPP started in March 2015 until December 2018. Between January 2019 and October 2019, the ECB reinvested only the principal payments⁵ from maturing securities before restarting net purchases between November 2019 and June 2022. The CSPP⁶ was introduced to purchase corporate bonds issued by non-financial institutions. The purchases started in

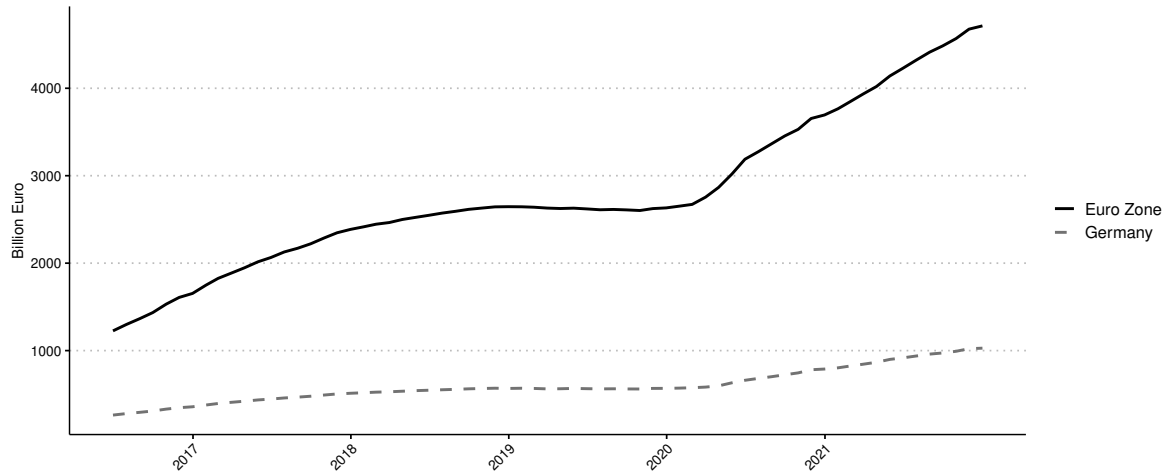
⁴Quantitative easing mainly works through the portfolio rebalancing channel and the signaling channel of monetary policy (Dell’Ariccia et al. 2018).

⁵This is also the case for the ABSPP and CSPP.

⁶According to the ECB, the objective of the CSPP is to enhance the impact of the Eurosystem’s asset purchases on the financing conditions of the real economy. There are concerns that the CSPP disproportionately benefits large enterprises in contrast to SMEs (Betz and De Santis 2022).

June 2016 and ended in December 2018 before being restarted between November 2019 and June 2022. Since 2016, the asset purchases under the APP have increased from 1,445 billion euros to 4,921 billion euros, of which 21% were allocated to Germany (Figure 6).

Figure 6: *ECB's Securities Held for Monetary Policy Purposes*



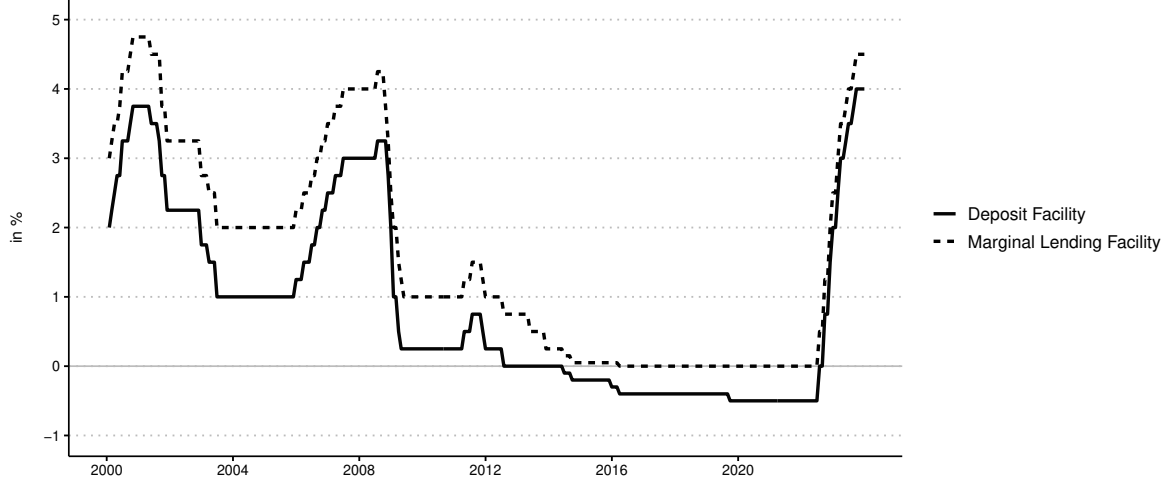
Note: Securities held for monetary policy purposes by the Eurosystem 2016-2023, with 21% allocated to Germany. Source: ECB.

The ECB's negative interest rate policy is the third unconventional monetary policy measure. The idea of negative interest rates on excess reserves is to incentivize commercial banks to increase lending and purchase financial assets (Dell'Ariccia et al. 2018).⁷ In June 2014, the ECB lowered the deposit facility rate to -10 basis points. The deposit facility remained negative (-50 basis points) until June 2022 (Figure 7). The large-scale asset purchases of the ECB increased the excess reserves of commercial banks instead of reducing them.

In order to reinforce the effect of unconventional liquidity provision, the ECB used forward guidance as an additional monetary policy tool to inform market participants about the future trajectory of monetary policy, for instance by announcing that interest rates will remain low for a specific time or that a certain amount of assets will be purchased (Dell'Ariccia et al. 2018).

⁷When central banks charge for holding excess reserves, it becomes costly for financial institutions to do so. Thus, banks are motivated to either lend out these reserves or to purchase financial assets instead.

Figure 7: *ECB Interest Rates*



Note: Key interest rates. Source: ECB.

3.3 Resilience

Resilience generally refers to the capacity of a system to withstand and adapt to external shocks (Ostrom 2005). The literature distinguishes between robustness, i.e. the ability to absorb shocks, and adaptability, i.e. the ability to adjust to changing conditions (Holling 1973, Holling 1996, Aligica and Tarko 2014, Salter and Tarko 2019).

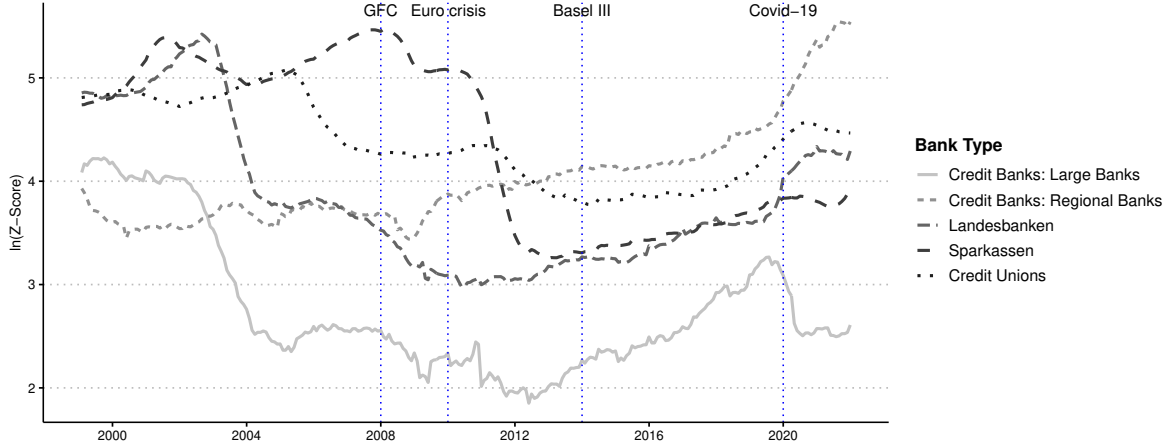
In the banking literature, the Z-score is widely used as an indicator of bank stability and resilience because it captures the distance from insolvency in terms of profitability, capitalization, and earnings volatility (Altman 1968, Cihak and Hesse 2010). In its adapted form, the Z-score measures the distance between expected returns and the insolvency threshold in units of the standard deviation of returns. Unlike previous studies that construct Z-scores at the individual-bank level (Beck et al. 2013, Fiordelisi and Mare 2014, Avalos and Mamatzakis 2023), we calculate Z-scores across different segments of the German banking system. The Z-score is defined as:

$$z_{i,t} = \frac{roa_{i,t} + er_{i,t}}{\sigma(roa_i)}, \quad (1)$$

where $z_{i,t}$ is the Z-score of bank type i at time t , $roa_{i,t}$ is the return on assets of bank type i at time t , $er_{i,t}$ is the equity ratio of bank type i at time t , and $\sigma(roa_i)$ is the standard deviation of the return on assets calculated for each bank type over the entire sample

period. A detailed description of the Z-score, including its individual components and alternative specifications, is provided in Appendix [B](#)

Figure 8: *Bank-Type Resilience*



Note: Monthly log Z-scores for the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. The Z-score is calculated as $z_{i,t} = \frac{roa_{i,t} + er_{i,t}}{\sigma(roa_i)}$, where $z_{i,t}$ denotes the Z-score of bank type i at time t , $roa_{i,t}$ is the return on assets of bank type i at time t , $er_{i,t}$ is the equity ratio of bank type i at time t , and $\sigma(roa_i)$ is the standard deviation of the return on assets. For the purpose of visualization, series are computed over a 10-year rolling window. Source: Bundesbank.

Figure [8](#) shows the monthly bank-type Z-score for the five main bank types in Germany since 1999. We observe that all bank types exhibit considerable volatility. Regional Banks are the only bank type that has experienced a continuous rise in resilience. The Z-score of Large Banks decreased significantly until 2012 and has only started to increase slowly since then. The Landesbanken have also seen a significant decrease in the Z-score, but an upward trajectory since 2012. The Z-score of Sparkassen was on a rising trend until they took a double hit from the Great Financial Crisis and the Euro Crisis, which resulted in a sharp decline in their resilience. Since then, Sparkassen have been on a rising trajectory. Between 2005 and the introduction of Basel III, Credit Unions' resilience was on a steady decline. Since then, their Z-scores have increased.

Monetary policy can influence bank resilience through several channels, and the overall effect is an empirical question. The next section therefore examines how different (un)conventional monetary policy shocks affect the Z-scores of major German bank types.

4 Empirical Model

Our empirical analysis uses a monthly panel of German bank types classified according to supervisory categories. The dependent variable is bank resilience, measured by the Z-score introduced in Section 3. We combine the bank-type data with monthly macro-financial controls, monetary policy variables and shock series to examine how conventional and unconventional monetary policy affect the resilience of different segments of the German banking system. The next subsection describes the sample construction, while the following subsections present and interpret the main empirical results.

4.1 *Sample Construction*

The dependent variable is constructed as the 12-month log difference of the Z-score, $\Delta_{12} \log(Z_{b,t}) \equiv 100 \times [\log(Z_{b,t}) - \log(Z_{b,t-12})]$, so our impulse responses are interpreted as changes in the growth rate of resilience. Negative responses indicate that resilience growth slows relative to baseline, i.e., the Z-score deteriorates relative to its baseline path.

We transform control variables to reflect the monthly frequency and to remove low-frequency trends. In our baseline monthly specification, industrial production, price levels, and stock prices enter in one-month log changes and first differences, while 10-year bond yields, unemployment and exchange rates enter in first differences. These transformations place the regressors on approximately stationary scales and help ensure that estimated responses capture adjustment dynamics to monthly innovations rather than level effects. A descriptive overview of the data and sources can be found in Table 1 of Appendix A.

Our baseline specification uses a full control set: the stock price index, industrial production as an output proxy, CPI, 10-year bond yields, the unemployment rate, and the exchange rate.⁸ It includes a common lag structure for both the dependent variable and controls. In practice, each horizon-specific regression conditions on 12 lags of the

⁸We include industrial production as a proxy of monthly GDP and the consumer price index to control for the macroeconomic environment in Germany. The German stock market index controls for economic expectations. The yield of 10-year German government bonds is included to control for the liquidity and funding conditions in German financial markets.

dependent variable and 12 lags of the control vector. This lag length is chosen to accommodate slow-moving adjustment in bank resilience and macro-financial conditions at the monthly frequency while remaining conservative in terms of short-run dynamics.

To maximize comparability across shocks and bank types, we define a baseline estimation sample using the dependent variable and a core subset of controls. Because the shock series differ in their coverage (the Jarociński-Karadi shock series begins in 1999 whereas the shock series of Altavilla et al. and Baumgärtner-Klose begin in 2002), and some controls are unavailable in parts of the sample, the estimation window varies across specifications. Each regression uses the longest sample for which all variables in that specification are observed. An overview of the sample periods for each specification is provided in Table 2 of Appendix A.

Our empirical design treats the shock series as predetermined with respect to bank resilience innovations at the monthly frequency. The identifying assumption is that the policy shocks (ε_t) are orthogonal to contemporaneous innovations in bank resilience growth once lagged outcomes and macro-financial controls are included. This assumption is standard in monthly local-projection applications, where monetary policy shocks are measured using high-frequency or externally constructed series and then aggregated to the monthly level (Gertler and Karadi 2015, Ramey 2016). Under this framework, the impulse response coefficients trace the dynamic effect of an unexpected tightening or easing innovation on the subsequent path of bank resilience growth, conditional on the information summarized by lags and controls.

To satisfy this identifying assumption, we rely on two shock series that isolate exogenous policy innovations from the central bank’s endogenous response to economic conditions: Jarociński and Karadi (2020) and Altavilla et al. (2019a). Jarociński and Karadi (2020) distinguish “pure” monetary policy shocks from information shocks. The authors isolate policy innovations by observing the sign of the correlation between interest rate surprises and stock market returns. A tightening surprise increases interest rates and lowers the present value of future dividends, causing stock prices to drop. This negative co-movement is interpreted as a pure monetary policy shock. If the central bank

raises rates because it observes strengthening economic fundamentals, the market may focus on the improved growth outlook rather than the higher borrowing costs. In this scenario, both interest rates and stock prices increase. These positive co-movements are interpreted as information shocks, which represent news about the state of the economy.

In a second approach, we use the monetary policy shock series by Altavilla et al. (2019a) and follow the approach by Baumgärtner and Klose (2021) to decompose the monetary policy shocks into a conventional (target) and an unconventional component. The unconventional shock includes three dimensions: timing, forward guidance, and QE. High-frequency shocks are aggregated to the monthly level by summing all ECB event shocks within each month. The original dataset covers ECB policy announcements from January 2002 to September 2018. The series are regularly updated, so we use the updated data from January 2002 to December 2021. This dataset is used to extract monetary policy shocks from changes in returns of various financial instruments around ECB press releases and ECB press conferences. These changes are assumed to reflect information released during ECB announcements and press conferences. Baumgärtner and Klose (2021) use principal components to identify and isolate latent factors in the high-frequency data of Altavilla et al. (2019a), similar to Brand et al. (2010) and Swanson (2017). The factor model employed is of the form:

$$X^\omega = F^\omega \Lambda^\omega + \epsilon^\omega, \quad (2)$$

where X^ω is the change in the financial market variable, F^ω is a $(N \times T)$ matrix of latent factors, Λ^ω denotes factor loadings and ϵ^ω represents idiosyncratic variation. The superscript ω indexes the press release and press conference windows.

Using the rank test of Cragg and Donald (1997), we identify four monetary policy factors. The first factor, extracted from the ECB press release window, captures conventional monetary policy surprises because it loads primarily on the 1-month overnight index swap (OIS) rate, which closely reflects unexpected changes in short-term policy rates. The remaining three factors are identified during the ECB press conference window and capture different dimensions of unconventional monetary policy.

The second factor primarily loads on short-maturity OIS rates below one year and is interpreted as a short-term forward-guidance (“Timing”) factor. Economically, it captures changes in market expectations about the near-term path of monetary policy. The third factor primarily loads on OIS rates with maturities between two and five years and is interpreted as a medium-term forward-guidance factor reflecting changes in expected future interest-rate paths. The fourth factor (“QE”) primarily loads on 10-year OIS rates and captures the effects of large-scale asset purchases on longer-term financing conditions and asset valuations.

All factors are identified through restrictions on the rotation matrix. The Timing and Forward Guidance factors are restricted not to load on the one-month OIS rate so that they remain distinct from immediate policy-rate surprises. In addition, the variance of the QE factor is minimized in the pre-QE period (before August 2008), reflecting the limited role of asset purchases before the Great Financial Crisis. After rotation, the factors are scaled to economically interpretable units corresponding to changes in OIS rates at different maturities: *Target* to the 1-month OIS rate, *Timing* to the 6-month OIS rate, *Forward Guidance* to the 2-year OIS rate, and *QE* to the 10-year OIS rate.

4.2 Local Projections

We estimate dynamic responses using local projections. For each bank type b and horizon h , we estimate the following horizon-specific regression:

$$y_{b,t+h} = \alpha_{b,h} + \beta_{b,h} \varepsilon_t + \sum_{j=1}^p \phi_{b,h,j} y_{b,t-j} + \sum_{j=0}^p \Gamma_{b,h,j} X_{t-j} + u_{b,t+h}, \quad (3)$$

where $y_{b,t}$ denotes the transformed resilience measure, ε_t is the monetary policy shock series, X_t is the vector of macro-financial controls, and $p = 12$ in the baseline specification. The coefficient $\beta_{b,h}$ captures the response of bank resilience at horizon h for bank type b . We estimate impulse responses from impact up to five years (60 months), with particular emphasis on medium-run dynamics. Local projections are well suited to this setting because they allow response dynamics to differ flexibly across horizons and bank types.

This is especially useful when balance-sheet adjustment, profitability, and credit-risk dynamics evolve gradually over time.

Because the shock series are measured in different units, impulse-response magnitudes are not directly comparable across specifications. We therefore focus primarily on the sign, persistence, and statistical significance of responses across bank types and policy dimensions. Confidence intervals are computed using Newey-West heteroskedasticity and autocorrelation robust standard errors. We report 95 percent confidence bands and interpret long-horizon estimates cautiously given the increasing statistical uncertainty at extended horizons. Our discussion therefore focuses primarily on the first two years following a monetary policy shock.

Our baseline specification uses 12 monthly lags to account for persistence in bank resilience and macro-financial conditions. A one-year lag structure is appropriate at the monthly frequency because bank balance sheets and lending conditions typically adjust gradually over time. Alternative lag lengths ($p = 3$ and $p = 6$) produce qualitatively similar results, indicating that the findings are robust to the choice of lag structure.

4.3 *Main Results*

We begin by examining the impulse responses to the monetary policy shocks identified by Jarociński and Karadi (2020). Negative responses indicate a deterioration in bank resilience relative to baseline. Single-horizon local-projection estimates are noisy because each horizon is a separate regression. We thus summarize each impulse response by the average of the horizon-specific local-projection coefficients over two horizon bands: a short-run window (months 1-3) and a long-run window (months 20-24). We report additional cumulative responses in Table 6 of Appendix A. A pure monetary policy shock—a policy tightening associated with falling stock prices—is expected to weaken bank resilience through valuation, funding, and liquidity channels. By contrast, an information shock—a tightening accompanied by rising stock prices—reflects improved economic expectations and may therefore support bank resilience despite higher interest rates.

The responses to Jarociński and Karadi’s shocks reveal substantial heterogeneity

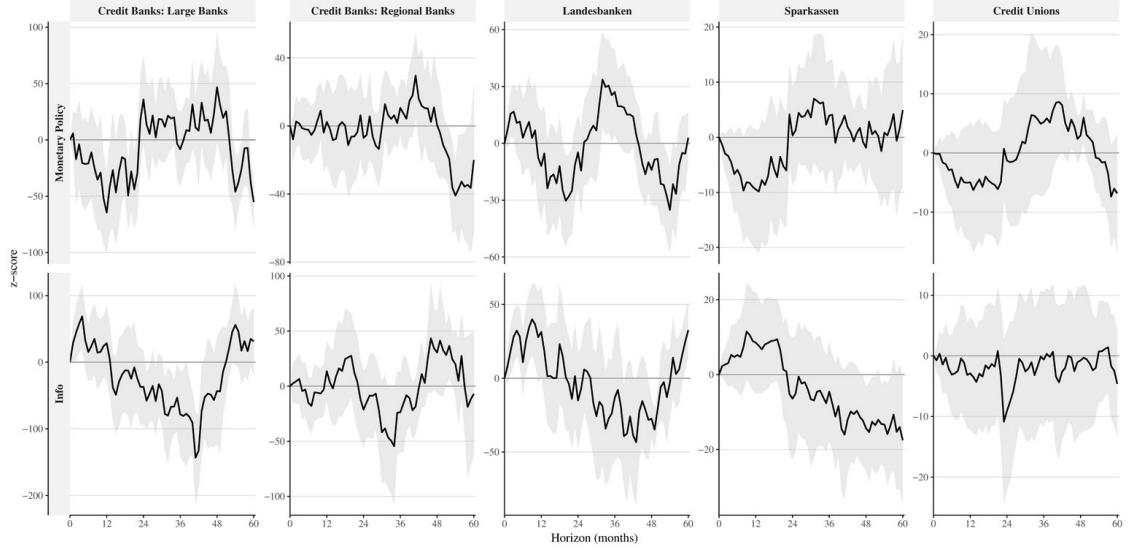
across German bank types (Figure 9 and Table 5 of Appendix A). In the baseline specification, contractionary monetary policy shocks reduce resilience growth for Large Banks, whereas Sparkassen experience short-run increases in resilience. Information shocks, by contrast, improve the resilience of Large Banks, suggesting that stronger economic expectations may offset part of the negative effects associated with higher interest rates. Interpreted symmetrically, these results imply that accommodative monetary policy tends to weaken resilience for Sparkassen while supporting resilience for Large Banks.

These differences are consistent with the distinct business models of German banks. Sparkassen rely heavily on retail deposits and relationship lending, making them more exposed to prolonged margin compression in low-interest-rate environments. Large Banks, in contrast, are more closely linked to capital markets and may benefit more strongly from improved valuation and liquidity conditions during periods of monetary accommodation. The results also align with the stylized patterns observed in Section 3 (Figure 8), where Sparkassen experienced a deterioration in resilience relative to pre-crisis levels, while Large Banks showed a gradual recovery.

To distinguish the pre-crisis environment from the period following the Global Financial Crisis—when unconventional monetary policy became increasingly important—we split the sample in 2010. The post-crisis results reveal a clearer divergence across German banking models (Table 5 of Appendix A). In particular, accommodative monetary policy is associated with declining resilience for Sparkassen in both the short and longer run. Similar resilience losses emerge for Regional Banks, Landesbanken, and Credit Unions at different horizons, although some of these effects are partially offset by positive information shocks reflecting improved economic expectations.

By contrast, the pre-crisis period shows substantially weaker and less systematic effects across bank types. Significant responses are largely limited to Credit Unions and Landesbanken. Whereas Credit Unions experience persistent resilience losses following accommodative monetary policy shocks, Landesbanken exhibit resilience gains in the longer run. Overall, the results suggest that the transmission of monetary policy to bank resilience became more heterogeneous after the financial crisis, particularly as unconven-

Figure 9: *Banking Resilience by Bank-Type after Jarociński and Karadi (2020) Monetary Policy and Information Shocks*



Note: Impulse responses of bank-type resilience to a monetary policy tightening measured by Monetary Policy and Information Shocks (Jarociński and Karadi, 2020). Each panel reports local-projection estimates for the Z-score of the corresponding German bank type at horizons 0-60 months after a positive policy shock. The solid line shows the point estimate and the shaded area is the 95% confidence band. Responses are shown in Z-score units (standardized), so values below zero imply a fall in resilience relative to baseline. Estimates use the baseline specification with monthly controls and 12 lags.

tional monetary policy measures became more prominent.

Our results are consistent with broader evidence that prolonged monetary accommodation places particular pressure on deposit-funded banking models. Using more than forty years of German banking data, Busch and Memmel (2017) show that low-interest-rate environments compress deposit margins, reduce net interest income, and weaken banks' ability to build capital through retained earnings. Evidence from German supervisory survey data points in the same direction. Busch et al. (2022) find that banks with stronger asset-liability pass-through mismatches experience larger declines in net interest income when interest rates fall and can offset only a limited share of these losses through fees or cost reductions.

This mechanism is particularly relevant for Sparkassen, whose business models rely heavily on retail deposits and relationship lending. In our results, Sparkassen exhibit declining resilience following accommodative monetary policy shocks after 2010, whereas larger and more market-oriented institutions remain comparatively stable or even benefit

from accommodative monetary policies. These findings suggest that prolonged low-rate environments may affect bank resilience unevenly across banking models.

International evidence points to similar transmission channels. Claessens et al. (2018) show across a large cross-country bank panel that prolonged low-interest-rate environments compress net interest margins and bank profitability, while Heider et al. (2019) find that negative policy rates affect deposit-heavy euro-area banks particularly strongly because deposit rates cannot adjust downward to the same extent as lending rates. These mechanisms help explain why accommodative monetary policy is associated with declining resilience among deposit-oriented banks in our sample.

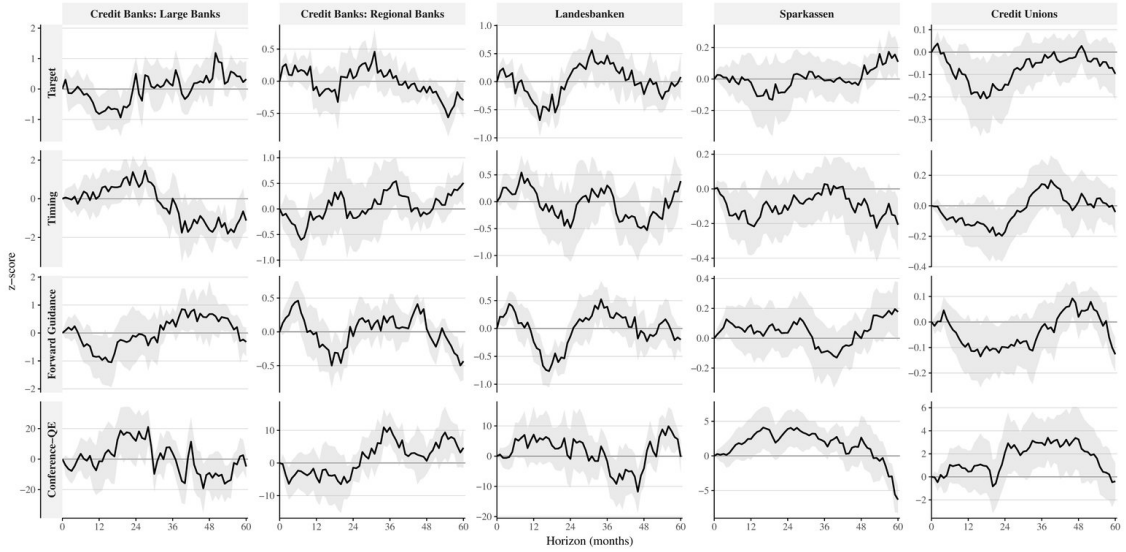
At the same time, the literature also highlights a risk-taking channel of monetary policy. Using Spanish credit-register data, Jiménez et al. (2012) show that low policy rates encourage weaker-capitalized banks to expand lending to riskier firms, potentially increasing future loan losses and balance-sheet vulnerability. Our findings are consistent with this broader interpretation. Accommodative monetary policy is associated with declining resilience among the more vulnerable German bank types, although our results do not allow us to distinguish whether this primarily reflects margin compression, greater exposure to credit risk, or increased return volatility from riskier portfolios.

4.4 Multi-Dimensionality of (Un)Conventional Monetary Policy

We next examine the impulse responses to the high-frequency monetary policy shocks developed by Altavilla et al. (2019a): Target, Timing, Forward Guidance, and Conference-QE (Figure 10). This decomposition allows us to distinguish between conventional policy-rate surprises and different dimensions of unconventional monetary policy, including short-term policy communication, forward guidance about the future path of interest rates, and large-scale asset purchases. We use these shocks to assess whether different monetary policy channels affect the resilience of German bank types differently in the short and medium run. Mean responses and subsample results are reported in Tables 4 and 5 of Appendix A.

The Altavilla decomposition reveals important differences across monetary policy

Figure 10: *Banking Resilience by Bank-Type after a Unit Shock to Altavilla et al. (2019a) Policy Dimensions*



Note: Impulse responses of bank-type resilience to a monetary policy tightening measured by Altavilla et al. (2019a) shocks across different policy dimensions: Target, Timing, Forward Guidance and Conference-QE. Each panel reports local-projection estimates for the Z-score of the corresponding German bank type at horizons 0-60 months after a positive policy shock. The solid line shows the point estimate and the shaded area shows the 95% confidence band. Responses are shown in Z-score units (standardized), so values below zero imply lower growth of resilience relative to the baseline. Estimates use the baseline specification with monthly controls and 12 lags.

channels. In the short run, accommodative Target and Forward Guidance shocks reduce resilience growth for Sparkassen and Regional Banks. This finding confirms the result from the Jarociński and Karadi shocks. Bank types that rely heavily on retail deposits and local lending margins are particularly vulnerable to prolonged monetary accommodation.

Over longer horizons, however, Regional Banks, Sparkassen, and Landesbanken exhibit improvements in resilience following accommodative Target, Forward Guidance, and QE shocks. This pattern suggests that the negative effects of lower interest margins may gradually be offset by improved liquidity conditions, higher asset valuations, and stronger funding conditions associated with unconventional monetary policy. By contrast, Large Banks and Credit Unions appear more vulnerable in the longer run, although these findings are less robust in the subsample analysis.

The post-2010 period highlights the growing importance of unconventional monetary policy channels. For Large Banks, accommodative Target and Timing shocks are

associated with increases in resilience, consistent with stronger benefits from liquidity support and improved capital-market conditions. Regional Banks display more mixed responses: conventional rate-channel shocks reduce resilience in the short run, whereas Forward Guidance and QE shocks improve resilience over longer horizons. This suggests that unconventional monetary policy may partly offset the adverse effects of prolonged low interest rates through improved funding and valuation conditions.

Sparkassen, however, continue to exhibit declining resilience following accommodative Forward Guidance and QE shocks after 2010. This finding reinforces the view that deposit-oriented banking models remain particularly vulnerable to prolonged monetary accommodation, even when broader unconventional policy measures support financial markets and liquidity conditions.

The Altavilla decomposition highlights that different dimensions of monetary policy affect German banking models through distinct transmission channels. Target and Forward Guidance shocks reduce resilience for Sparkassen and Regional Banks. By contrast, Landesbanken and some larger institutions benefit more strongly from improved liquidity and valuation conditions associated with unconventional monetary policy. These findings are consistent with evidence for euro-area banks. Altavilla et al. (2018) show that monetary easing compresses lending margins but may simultaneously improve other balance-sheet positions, making the overall effect on bank profitability ambiguous. Altavilla et al. (2019b) further emphasize that monetary policy transmission depends strongly on bank balance-sheet characteristics and business models. Our results support this view by showing that the same monetary policy shocks generate markedly different resilience responses across German bank types.⁹

⁹Appendix [C](#) further reports supplementary results using shadow rate measures (Krippner 2016, Wu and Xia 2016) as indicators of the overall policy stance of the ECB. In Appendix [D](#), we report impulse response functions for one additional method of monetary policy shock decomposition by Baumgärtner and Klose (2021). The results confirm a long-term decline in resilience growth for Sparkassen across dimensions and sub-periods and a long-term increase in resilience growth for Large Banks.

5 Conclusion

Germany is the largest economy in the euro area, and the resilience of its banking system is therefore important not only for Germany but also for the broader European financial system. This paper examined how conventional and unconventional monetary policy affect the resilience of different German bank types using high-frequency monetary policy shocks and local projections. We measure resilience using the Z-score, which captures the distance between a bank’s profitability and capitalization on the one hand and the volatility of its returns on the other, thereby approximating how large a buffer a bank has before losses threaten solvency.

Our results show that monetary policy affects bank resilience heterogeneously across German banking models. Conventional monetary easing is associated with resilience gains for some institutions in the short run, particularly Large Banks, but weaker resilience for Sparkassen and Credit Unions over longer horizons. These differences become more pronounced after the Global Financial Crisis, when unconventional monetary policy measures became more important.

Decomposing monetary policy into different transmission channels further highlights this heterogeneity. Expansionary Target and Forward Guidance shocks reduce resilience growth for Sparkassen and Regional Banks in the short run, whereas Large Banks and Landesbanken tend to benefit more strongly from liquidity, funding, and valuation effects associated with unconventional monetary policy. Over longer horizons, some of these effects weaken or reverse, suggesting that monetary policy reshapes the distribution of resilience across bank types rather than producing uniform effects across the banking system.

Our findings are consistent with the view that prolonged accommodative monetary policy affects banks differently depending on their funding structures and business models. Deposit-oriented institutions that rely heavily on traditional lending and retail deposits appear more vulnerable to prolonged margin compression, whereas more market-oriented institutions may benefit from improved liquidity and asset-price conditions. However, the precise mechanisms underlying these resilience dynamics—such as the relative importance

of margin compression, credit-risk exposure, or balance-sheet valuation effects—cannot be identified directly within our empirical framework and remain an important avenue for future research.

From a policy perspective, our results suggest that the effects of monetary policy on financial resilience are not uniform across the banking system. Policymakers may therefore benefit from paying closer attention to how different monetary policy instruments interact with heterogeneous banking models, particularly in prolonged low-interest-rate environments.

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Appendix

A Additional Figures and Tables

Table 1: *Data Overview*

Variable	Bank Type	Series Key/Source	Transformation
Net income	Large Banks	BBBP1.A.DE.N.GB.G010.X.1.Z5.0000.Z01.D	Lerp, Δ_{12} log
Net income	Regional Banks	BBBP1.A.DE.N.RB.G010.X.1.Z5.0000.Z01.D	Lerp, Δ_{12} log
Net income	Landesbanken	BBBP1.A.DE.N.LB.G010.X.1.Z5.0000.Z01.D	Lerp, Δ_{12} log
Net income	Sparkassen	BBBP1.A.DE.N.SK.G010.X.1.Z5.0000.Z01.D	Lerp, Δ_{12} log
Net income	Credit unions	BBBP1.A.DE.N.GN.G010.X.1.Z5.0000.Z01.D	Lerp, Δ_{12} log
Total equity	Large Banks	BBBK1.M.OU1590	Lerp, Δ_{12} log
Total equity	Regional Banks	BBBK1.M.OU1637	Lerp, Δ_{12} log
Total equity	Landesbanken	BBBK1.M.OU1778	Lerp, Δ_{12} log
Total equity	Sparkassen	BBBK1.M.OU1825	Lerp, Δ_{12} log
Total equity	Credit unions	BBBK1.M.OU1919	Lerp, Δ_{12} log
Total assets	Large Banks	BBBK1.M.OU0824	Lerp, Δ_{12} log
Total assets	Regional Banks	BBBK1.M.OU0874	Lerp, Δ_{12} log
Total assets	Landesbanken	BBBK1.M.OU1024	Lerp, Δ_{12} log
Total assets	Sparkassen	BBBK1.M.OU1074	Lerp, Δ_{12} log
Total assets	Credit unions	BBBK1.M.OU1174	Lerp, Δ_{12} log
Monetary Policy		Jarociński and Karadi (2020)	Levels
Information		Jarociński and Karadi (2020)	Levels
Target		Altavilla et al. (2019a)	Levels
Timing		Altavilla et al. (2019a)	Levels
Forward Guidance		Altavilla et al. (2019a)	Levels
Conference-QE		Altavilla et al. (2019a)	Levels
Release-QE		Baumgärtner and Klose (2021)	Levels
Krippner SR		Krippner (2016)	Levels
Wu-Xia SR		Wu and Xia (2016)	Levels
Stock Prices		SPASTT01DEM661N	Δ ln
IP		DEUPROINDMISMEI	Δ ln
CPI		DEUCPIALLMINMEI	Δ ln
10yr BUND		IRLTLT01DEM156N	Δ
UR		LMUNRRTTDEM156S	Δ
ER		CCUSMA02DEM618N	Δ

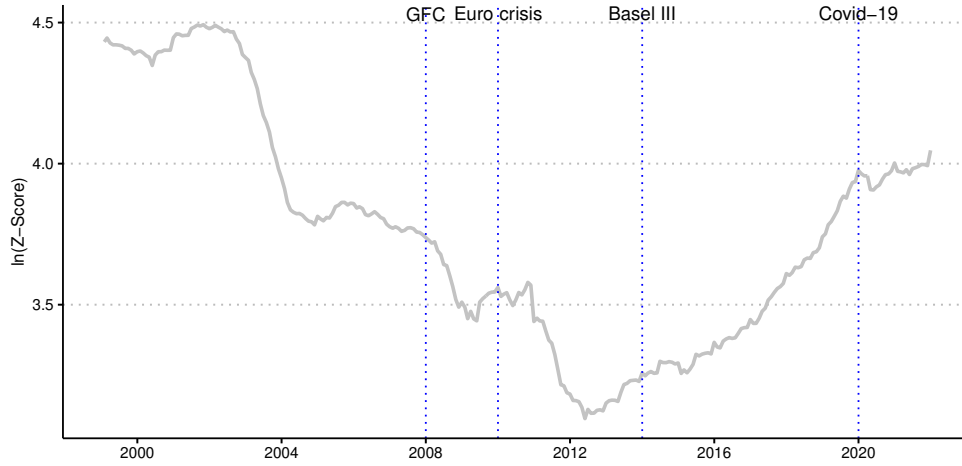
Notes: Return on assets (ROA) is computed as net income divided by total assets. The equity ratio (ER) is computed as total equity divided by total assets. The Z-Score is calculated as $Z = \frac{ROA+ER}{\sigma(ROA)}$, where $\sigma(ROA)$ denotes the standard deviation of ROA for the entire sample period (1999-2022). All bank series are yearly and transformed to monthly via linear interpolation. Monetary Policy and Information are shock decompositions by Jarociński and Karadi (2020); Target, Timing, Forward Guidance, and Conference-QE are shock decompositions based on Altavilla et al. (2019a). Release-QE is an alternative Conference-QE specification based on Baumgärtner and Klose (2021). Krippner Shadow Rate applies to a specification using the shadow-rate (see Appendix C). Wu-Xia is an alternative shadow-rate. Δ ln denotes log-diff transformation; Δ first differences. IP is industrial production; UR is unemployment rate; ER is exchange rate. Bank series are from the banking statistics of the statistical series of the Deutsche Bundesbank. Macroeconomic series are from FRED.

Table 2: *Sample Periods by Specification*

Specification	Sample Period	No. of Obs.
Monetary Policy	Jan 1999–Dec 2021	276
Information	Jan 1999–Dec 2021	276
Target	Jan 2002–Sep 2021	237
Timing	Jan 2002–Sep 2021	237
Forward Guidance	Jan 2002–Sep 2021	237
Conference-QE	Jan 2002–Sep 2021	237
Release-QE	Jan 2002–Sep 2021	237
Krippner SR	Jan 1995–Dec 2021	324
Wu-Xia SR	Jan 1995–Dec 2021	324

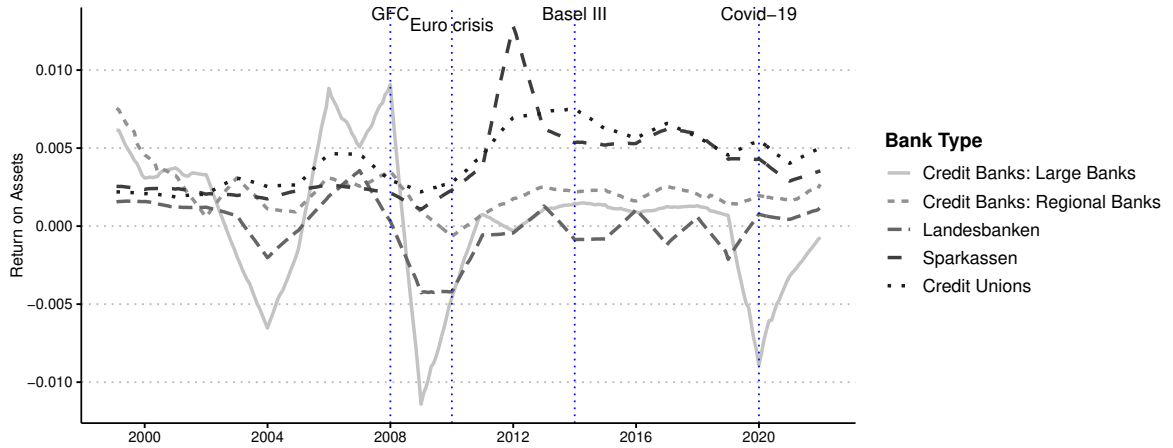
Note: Sample periods for different specifications for measuring the impact of monetary policy to bank-type resilience. Monetary Policy and Information are shock decompositions by Jarociński and Karadi (2020); Target, Timing, Forward Guidance, and Conference-QE are shock decompositions based on Altavilla et al. (2019a). Release-QE is an alternative Conference-QE specification based on Baumgärtner and Klose (2021). Krippner Shadow Rate applies to a specification using the shadow-rate (see Appendix [C](#)). Wu-Xia is an alternative shadow-rate.

Figure 1: *Z-score All Bank Types*



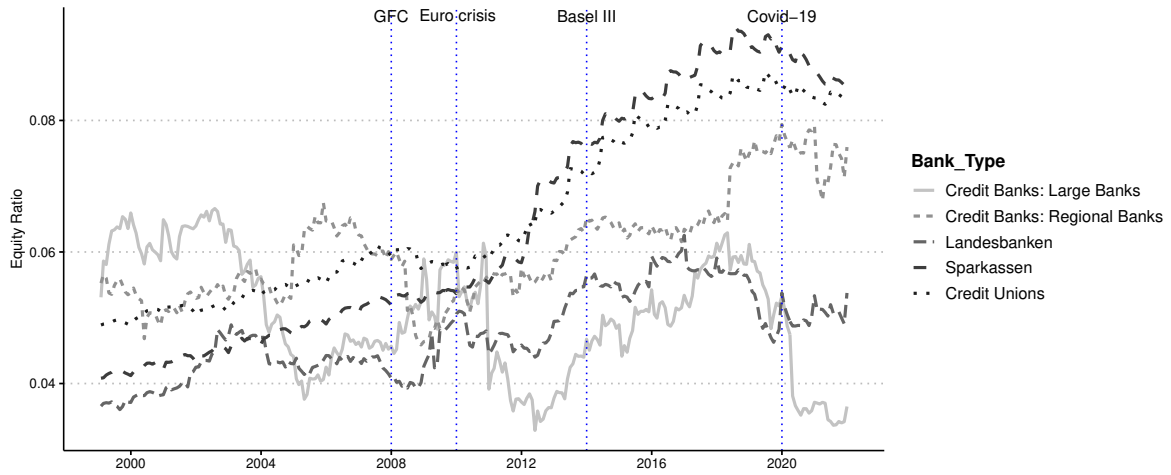
Note: Monthly log Z-scores for the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. The Z-score is calculated as $z_{i,t} = \frac{roa_{i,t} + er_{i,t}}{\sigma(roa_i)}$, where $z_{i,t}$ denotes the Z-score of bank type i at time t , $roa_{i,t}$ is the return on assets of bank type i at time t , $er_{i,t}$ is the equity ratio of bank type i at time t , and $\sigma(roa_i)$ is the standard deviation of the return on assets. For the purpose of visualization, series are computed over a 10-year rolling window. Source: Bundesbank.

Figure 2: *Return on Assets*



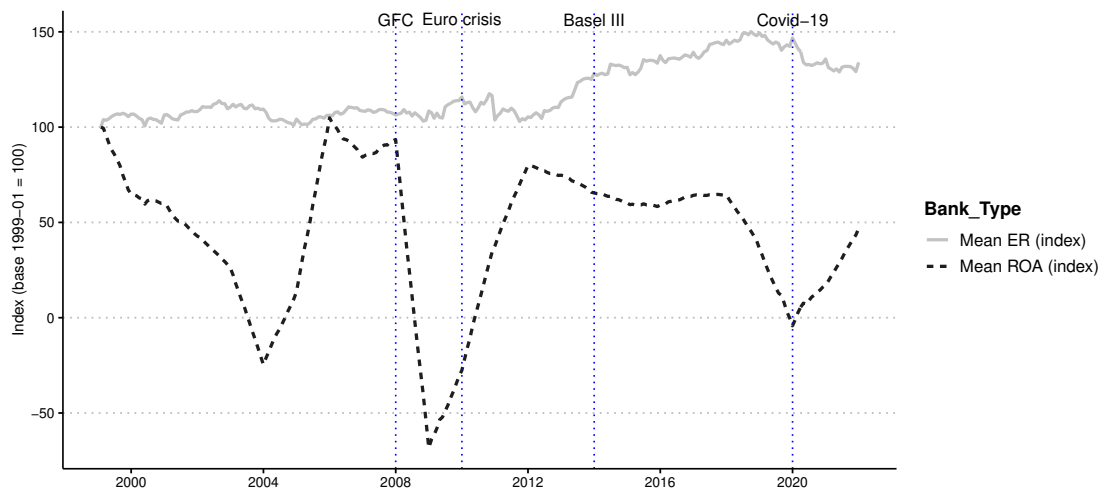
Note: Monthly return on assets for the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. Source: Bundesbank.

Figure 3: *Equity Ratio*



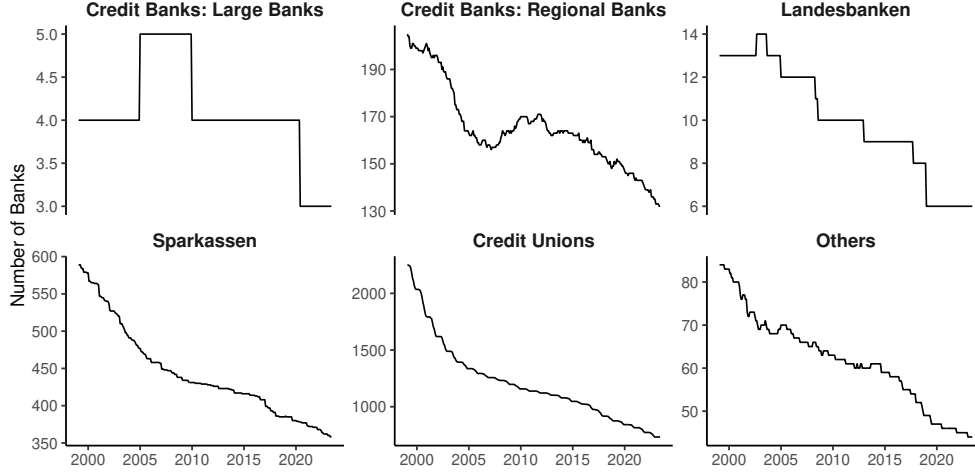
Note: Monthly equity ratio for the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. Source: Bundesbank.

Figure 4: *Mean ROA and ER All Bank Types*



Note: Average monthly return on assets (ROA) and equity ratio (ER) for the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. Source: Bundesbank.

Figure 5: *Number of Banks by Bank Type*



Note: Number of banks over time across the five main German bank types—Large Banks, Regional Banks, Landesbanken, Sparkassen, and Credit Unions. Source: Bundesbank.

Table 3: *Summary of Main Empirical Findings*

Bank Type/ Instrument	Large Banks	Regional Banks	Landesbanken	Sparkassen	Credit Unions
Monetary Policy	↑↑	↑↑	↑↑	↓↑	↑↑
Information	↓↑	↓↓	↑↑	↓↑	↓↑
Target	↓↑	↓↓	↓↑	↓↑	↓↑
Timing	↓↓	↑↓	↑↑	↓↑	↑↑
Forward Guidance	↓↑	↓↑	↑↑	↓↑	↓↓
Conference-QE	↓↓	↑↑	↑↓	↑↓	↓↓

Note: Entries report local-projection estimates of the response of bank-type resilience (Z-score) to expansionary monetary policy shocks. Left arrows are short-run (1-3 months) effects; right arrows are long-run (20-24 months) effects. Black arrows are statistically significant, gray arrows are statistically not significant. High-frequency Monetary Policy and Information shocks are estimated using the identification strategy of Jarociński and Karadi (2020). Target, Timing, Forward Guidance and Conference-QE shocks are from Altavilla et al. (2019a).

Table 4: *Impulse Responses by Bank Type and Shock*

Shock	Horizon	Credit Banks: Large Banks	Credit Banks: Regional Banks	Landesbanken	Sparkassen	Credit Unions
Monetary Policy Jarociński and Karadi (2020)	short-term	-5.064	-1.252	-0.646	13.151*	-2.557
	long-term	-9.603*	-3.360	-3.413	-19.893*	-2.069
	short-term	43.564*	4.516	-0.607	18.412*	2.673
	long-term	-26.236	2.080	-4.828	-6.075	-0.560
Target Altavilla et al. (2019)	short-term	0.010	0.197*	0.018	0.170*	0.020
	long-term	-0.243*	0.085	-0.157*	-0.099*	-0.071
	short-term	0.012	-0.138	-0.016	0.204*	-0.024
	long-term	1.040*	0.025	-0.177*	-0.346	-0.120
Timing Altavilla et al. (2019)	short-term	0.132	0.195*	-0.004	0.231*	0.048
	long-term	-0.224	-0.189*	-0.105*	-0.413*	0.043
	short-term	-6.104	-3.493*	-0.107	-0.203	0.243
	long-term	15.292*	-4.682*	0.446	2.198	2.880*
Forward Guidance Altavilla et al. (2019)	short-term	-0.419	-0.198	0.047	-0.248	-0.036
	long-term	-1.172*	0.005	0.183	-0.459	0.586*
Conference-QE Altavilla et al. (2019)	short-term	-0.419	-0.198	0.047	-0.248	-0.036
	long-term	-1.172*	0.005	0.183	-0.459	0.586*
	short-term	-0.419	-0.198	0.047	-0.248	-0.036
	long-term	-1.172*	0.005	0.183	-0.459	0.586*
Release-QE Baumgärtner and Klose (2021)	short-term	-0.419	-0.198	0.047	-0.248	-0.036
	long-term	-1.172*	0.005	0.183	-0.459	0.586*
	short-term	-0.419	-0.198	0.047	-0.248	-0.036
	long-term	-1.172*	0.005	0.183	-0.459	0.586*

*, mean confidence interval excludes 0 (mean lower > 0 or mean upper < 0) over the same horizon window.

Note: Entries report local-projection estimates of the response of bank-type resilience (Z -score) to contractionary monetary policy shocks. The dependent variable is the 12-month log difference of the Z -score, $\Delta_{12} \log(Z_{b,t}) = 100 [\log(Z_{b,t}) - \log(Z_{b,t-12})]$. Shocks are taken from Jarociński and Karadi (2020), Altavilla et al. (2019a), and Baumgärtner and Klose (2021), as shown in the first column. “Short-term” and “long-term” summarize responses over the corresponding horizon windows of 1-3 months and 20-24 months respectively.

Table 5: *Impulse Responses by Bank Type, Shock, and Period Subsets*

Shock	Horizon	Credit Banks: Large Banks				Credit Banks: Regional Banks				Landesbanken				Sparkassen				Credit Unions			
		Pre	Post	2010	2010	Pre	Post	2010	2010	Pre	Post	2010	2010	Pre	Post	2010	2010	Pre	Post	2010	2010
		2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010
Monetary Policy Jarociński and Karadi (2020)	short-term	-2.818	-38.578*	-5.722	10.159*	5.255	17.798*	-0.273	-4.145	-1.360	-1.259										
	long-term	-10.607	-68.618	7.106	0.047	-31.666*	2.348	1.544	-8.033	3.705*	8.780*										
	short-term	18.757*	46.842	-2.980	10.218	3.559	7.057	-0.556	10.021*	-2.011*	-0.726										
	long-term	-55.587*	25.311	11.986	-20.671*	-0.270	-40.810*	-1.847	18.914*	10.832*	-9.238*										
Target Altavilla et al. (2019)	short-term	0.439*	-0.667*	-0.007	0.169*	-0.056	0.039	0.044*	0.050	0.020	-0.031										
	long-term	-0.787	-0.111	1.069	-0.199	0.107	-0.068	0.050	0.154	-0.036	0.008										
	short-term	0.247	0.569	-0.371*	0.180*	0.140	0.381*	-0.012	-0.014	-0.060*	-0.037										
	long-term	0.261*	-0.724*	1.953*	0.005	-0.371*	-0.420*	0.089*	0.004	0.342*	-0.024*										
Forward Guidance Altavilla et al. (2019)	short-term	0.136	-0.387	0.308*	-0.009	0.092	0.020	-0.006*	0.109*	0.006*	0.014										
	long-term	0.308*	-0.224	-1.874*	-0.184*	-0.655*	-0.421*	-0.073*	0.009	-0.205*	-0.017										
Conference-QE Altavilla et al. (2019)	short-term	-2.315	-11.169	-2.061*	-5.016*	2.266*	-4.170*	0.056*	0.186	0.344*	-0.110										
	long-term	-55.665*	-1.851	19.655*	-5.038*	19.727*	-2.164	0.468*	2.451*	-1.309*	-0.155										
Release-QE Baumgärtner and Klose (2021)	short-term	1.217*	-0.574	-0.857*	0.030	-0.368*	-0.291	-0.039*	-0.152*	-0.065	0.083										
	long-term	-4.039*	-0.980	4.334*	0.844*	-1.123*	0.347	0.336*	0.058	1.550*	0.124										

**: mean confidence interval excludes 0 (mean lower > 0 or mean upper < 0) over the same horizon window.

Note: Entries report local-projection estimates of the response of bank-type resilience (Z -score) to contractionary monetary policy shocks for two subsets, pre- and post-2010. The dependent variable is the 12-month log difference of the Z -score, $\Delta_{12} \log(Z_{b,t}) = 100 [\log(Z_{b,t}) - \log(Z_{b,t-12})]$. Shocks are taken Jarociński and Karadi (2020), Altavilla et al. (2019a), and Baumgärtner and Klose (2021), as shown in the first column. “Short-term” and “long-term” summarize responses over the corresponding horizon windows of 1-3 months and 20-24 months respectively.

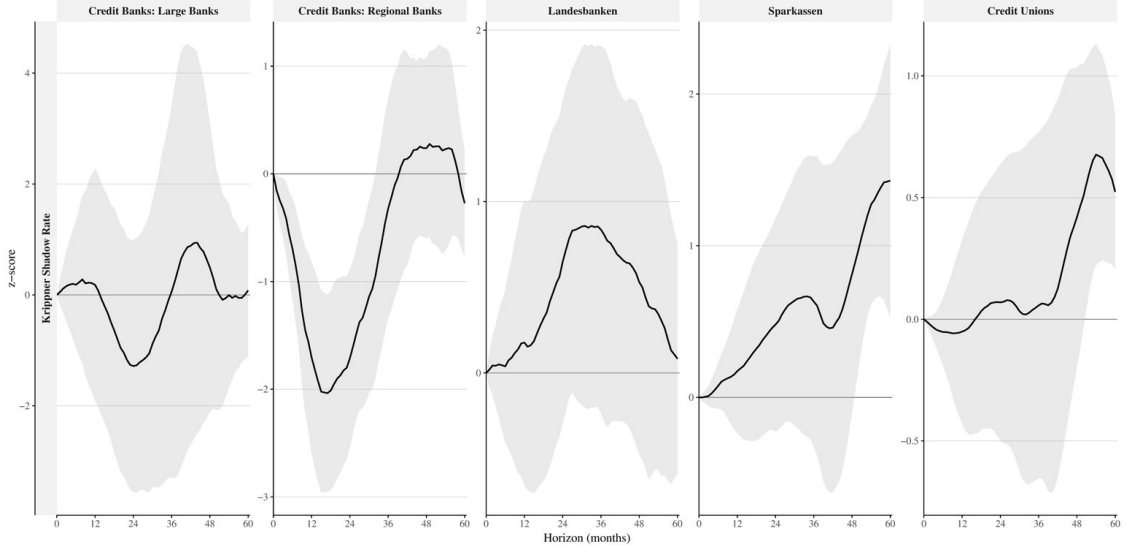
Table 6: Cumulative Impulse Responses by Bank Type, Shock, and Period Subsets

Shock	Horizon	Credit Banks: Large Banks			Credit Banks: Regional Banks			Landesbanken			Sparkassen			Credit Unions		
		Pre	Post		Pre	Post		Pre	Post		Pre	Post		Pre	Post	
		2010	2010		2010	2010		2010	2010		2010	2010		2010	2010	
Monetary Policy																
Jarociński and Karadi (2020)	Cumul. $h = 24$	-23.106	-63.858		-3.128	3.739		-8.486	8.092		0.354	-11.573		-1.573	1.304	
Information																
Jarociński and Karadi (2020)	Cumul. $h = 24$	14.275	-2.864		29.588	-6.988		14.426	-21.893		1.030	17.246*		2.891	-3.717	
Target																
Altavilla et al. (2019)	Cumul. $h = 24$	-22.941	-36.483		16.755	-7.670		-14.293	-9.992		2.026	4.993		-2.212	-2.193	
Timing																
Altavilla et al. (2019)	Cumul. $h = 24$	16.211	-18.178		27.192	3.488		7.369	-3.221		3.015*	-2.692		3.287	-0.869	
Forward Guidance																
Altavilla et al. (2019)	Cumul. $h = 24$	-20.659	-29.267		-40.783*	-2.647		-12.596	-8.877		-3.202*	1.117		-5.654*	-1.533	
Conference-QE																
Altavilla et al. (2019)	Cumul. $h = 24$	-11.507	-22.983		17.137	-7.527		14.521	-9.301		0.597	1.908		2.339	-0.646	
Release-QE																
Baumgärtner and Klose (2021)	Cumul. $h = 24$	20.121	5.025		38.951	6.063		-9.218	1.795		3.189	2.747		8.657	3.936	

**': mean confidence interval excludes 0 (mean lower > 0 or mean upper < 0) over the cumulative $h = 24$ window.

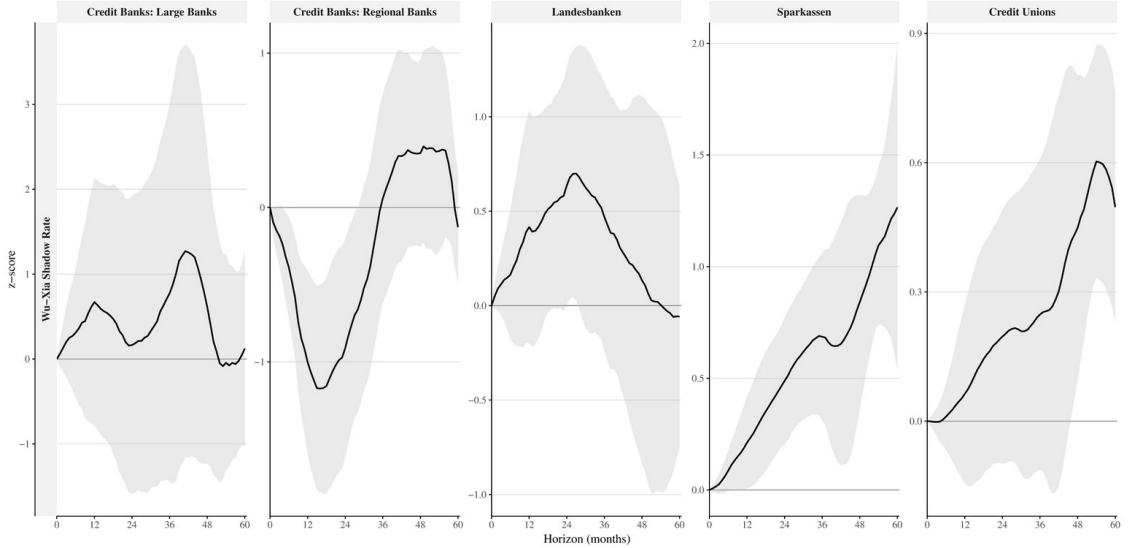
Note: Entries report cumulative local-projection estimates at horizon $h = 24$ of the response of bank-type resilience (Z -score) to contractionary monetary policy shocks for two subsets, pre- and post-2010. The dependent variable is the 12-month log difference of the Z -score, $\Delta_{12} \log(Z_{b,t}) = 100 [\log(Z_{b,t}) - \log(Z_{b,t-12})]$. Shocks are taken from Jarociński and Karadi (2020), Altavilla et al. (2019a), and Baumgärtner and Klose (2021), as shown in the first column.

Figure 6: *Banking Resilience by Bank-Type and the Krippner-Shadow Rate*



Note: Conditional association between changes in the monetary policy stance and bank-type resilience, measured by Krippner's shadow rate (Krippner 2016). Each panel reports local-projection estimates for the Z-score of the corresponding German bank type at horizons 0-60 months following a positive change in the shadow rate (tighter policy stance). The solid line shows the point estimate and the shaded area shows the 95% confidence band. Responses are shown in Z-score units (standardized), so values below zero imply lower growth of resilience relative to baseline. Estimates use the baseline specification with monthly controls and 12 lags.

Figure 7: *Banking Resilience by Bank-Type and the Wu-Xia Shadow Rate*



Note: Conditional association between changes in the monetary policy stance and bank-type resilience, measured by Wu-Xia's shadow rate (Wu and Xia 2016). Each panel reports local-projection estimates for the Z-score of the corresponding German bank group at horizons 0-60 months following a positive change in the shadow-rate (tighter policy stance). The solid line shows the point estimate and the shaded area is the 95% confidence band. Responses are shown in Z-score units (standardized), so values below zero imply a fall in resilience relative to baseline. Estimates use the baseline specification with monthly controls and 12 lags.

Table 7: *Impulse Responses by Bank Type and Shadow Rates*

Shadow Rate	Horizon	Credit Banks: Large Banks	Credit Banks: Regional Banks	Landesbanken	Sparkassen	Credit Unions
Shadow Rate Krippner (2016)	short-term	0.109	-0.238*	-0.023	0.035	0.005
	long-term	-1.142	-1.822*	0.066	0.525	0.432
Shadow Rate Wu and Xia (2016)	short-term	0.132	-0.142	-0.001	0.084	0.016
	long-term	0.226	-0.991*	0.181	0.578*	0.443*

**): mean confidence interval excludes 0 (mean lower > 0 or mean upper < 0) over the same horizon window.

Note: Entries report local-projection estimates of the conditional association between changes in the monetary policy stance and bank-type resilience. The dependent variable is the 12-month log difference of the Z-score, $\Delta_{12} \log(Z_{b,t}) = 100 [\log(Z_{b,t}) - \log(Z_{b,t-12})]$. The policy stance is measured by the shadow rate series of Krippner (2016) and Wu and Xia (2016), as shown in the first column. Because shadow rates are endogenous indicators of the overall policy stance rather than identified exogenous shocks, the reported coefficients should be interpreted as descriptive associations, not causal effects. "Short-term" and "long-term" summarize responses over the corresponding horizon windows of 1–3 months and 20–24 months respectively.

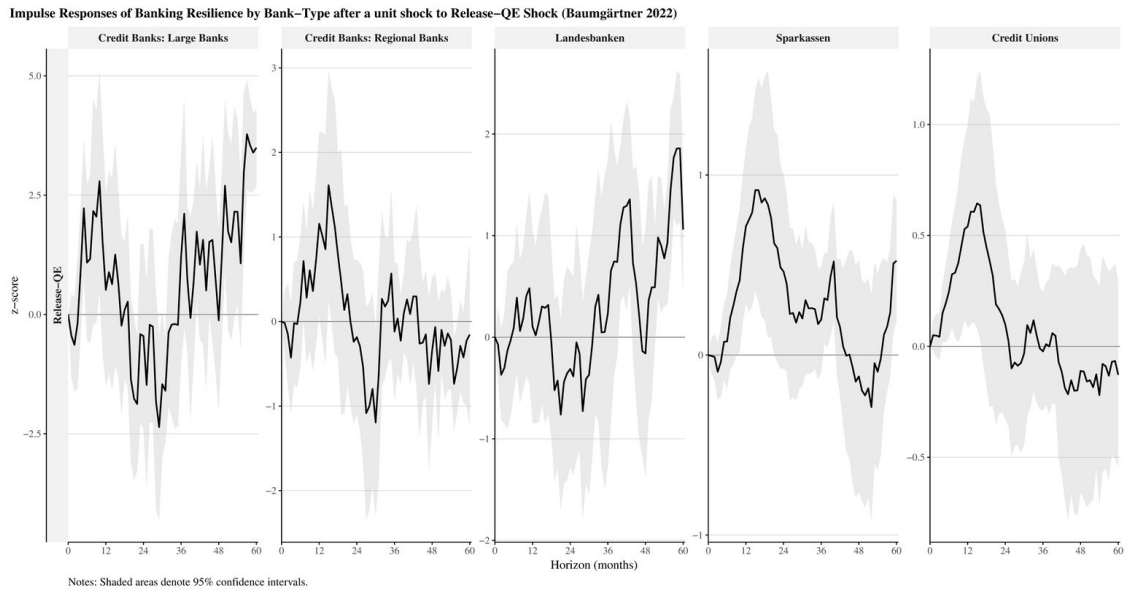
Table 8: *Impulse Responses by Bank Type, Shadow Rates, and Period Subsets*

Shadow Rate	Horizon	Credit Banks: Large Banks			Credit Banks: Regional Banks			Landesbanken			Sparkassen			Credit Unions		
		Pre	Post		Pre	Post		Pre	Post		Pre	Post		Pre	Post	
		2010	2010		2010	2010		2010	2010		2010	2010		2010	2010	
Shadow Rate	short-term	-0.118	-0.286		-0.474	0.254		-0.082	0.019		-0.251*	0.341*		-0.145	0.148	
Krippner (2016)	long-term	-2.603*	0.431		-4.474	1.672*		4.755*	4.187*		-0.859*	0.775		-1.248*	0.747	
Shadow Rate	short-term	-0.533	0.219		-0.487	0.096		-0.185	0.445*		-0.289*	0.270*		-0.191*	0.318*	
Wu and Xia (2016)	long-term	-1.814	3.705*		-3.810	0.482		4.978*	2.391*		-0.769*	1.417*		-1.165*	0.787*	

**: mean confidence interval excludes 0 (mean lower > 0 or mean upper < 0) over the same horizon window.

Note: Entries report local-projection estimates of the conditional association between changes in the monetary policy stance and bank-type resilience for two subsets, pre- and post-2010. The dependent variable is the 12-month log difference of the Z-score, $\Delta_{12} \log(Z_{b,t}) = 100 [\log(Z_{b,t}) - \log(Z_{b,t-12})]$. The policy stance is measured by the shadow rate series of Krippner (2016) and Wu and Xia (2016), as shown in the first column. Because shadow rates are endogenous indicators of the overall policy stance rather than identified exogenous shocks, the reported coefficients should be interpreted as descriptive associations, not causal effects. “Short-term” and “long-term” summarize responses over the corresponding horizon windows of 1–3 months and 20–24 months respectively.

Figure 8: *Banking Resilience by Bank-Type after Baumgärtner & Klose Release-QE Shock*



Note: Impulse responses of bank-type resilience to a monetary policy tightening measured by Release-QE shock (Baumgärtner & Klose, 2021). Each panel reports local-projection estimates for the Z-score of the corresponding German bank group at horizons 0-60 months after a positive policy shock. The solid line shows the point estimate and the shaded area is the 95% confidence band. Responses are shown in Z-score units (standardized), so values below zero imply a fall in resilience relative to baseline. Estimates use the baseline specification with monthly controls and 12 lags.

B Z-score as Resilience Proxy

In the banking literature, the Z-score is a widely used measure of individual bank stability (Cihak and Hesse 2010; Beck et al. 2013; Fiordelisi and Mare 2014; Fu et al. 2014; Avalos and Mamatzakis 2023). It is defined as the sum of the return on assets (ROA) and the equity ratio, divided by the standard deviation of ROA. Conceptually, the Z-score captures the distance to insolvency and is inversely related to the probability of bank failure. The standard deviation of ROA reflects the volatility of returns and thus the riskiness of a bank's earnings stream.

In our framework, the Z-score corresponds to the two dimensions of resilience. The inclusion of ROA dynamics relates to the adaptability dimension. ROA is closely linked to a bank's annual net income and therefore reflects changes in profitability in response to varying external conditions. For each bank type, ROA is calculated as net income divided by total assets. With higher ROA, banks have greater capacity to generate profits relative to the asset base. Following the Great Financial Crisis in 2008, we observe that heterogeneity across the main bank types in Germany became more pronounced, as the respective ROA trajectories increasingly diverged over time (Figure 2 of the Appendix A). Aggregated across bank-types, the Z-score has increased after the Great Financial Crisis (Figure 1 of Appendix A). However, this increase is not driven equally across bank types. Relative to pre-crisis levels, a shift in resilience from smaller to larger banks appears to have taken place (Figure 8).

At the same time, the equity ratio represents the robustness component: it indicates the extent to which a bank can absorb losses before its capital buffer is depleted. For each bank type, the equity ratio is calculated as equity divided by total assets. A higher equity ratio is associated with a higher probability of surviving shocks. We also observe substantial heterogeneity in the evolution of equity ratios across the different bank types (Figure 3 in Appendix A). In our baseline specification (Equation 1), the standard deviation serves as a proxy for return volatility, quantifying the riskiness of bank profitability. Alternative constructions of time-varying Z-scores differ in how the moments of ROA are estimated. The literature uses rolling windows, full-sample moments, or exponentially

weighted moments (Lepetit and Strobel 2013; Bouvatier et al. 2023). As a robustness check, we compute Z-scores using rolling windows, but find that results remain largely unchanged.

Our empirical analysis relies on data aggregated at the level of bank types (i.e., pillars of the German banking system), rather than at the level of individual institutions or for the banking sector as a whole. The Deutsche Bundesbank collects supervisory data for all banks operating in Germany and aggregates balance sheet and profit-and-loss (P&L) items within each bank type (Table 1 in Appendix A). The aggregation is performed by summing the respective balance sheet and income statement positions across all institutions belonging to a given group. Hence, the resulting figures represent the consolidated totals for each bank type and are not based on weighting schemes. For detailed information on the sampling process, see Bundesbank (2026a) and Bundesbank (2026b).

While individual bank-level observations are not publicly available from the Bundesbank, our sample includes a large number of institutions that are not publicly listed and is therefore distinct from datasets focusing on listed banks, as is common in studies relying on micro-level market data (e.g., Koutsomanoli-Filippaki and Mamatzakis 2009; Anginer et al. 2014). Since the underlying supervisory data originate from individual bank-level information, we also document the evolution of the number of banks within each bank type for our sample period (Figure 5 in Appendix A). Across all major bank types, the number of institutions has declined markedly during the sample period. This decline reflects consolidation processes rather than market exits due to failure. Within Sparkassen and Credit Unions in particular, mergers between previously independent local institutions have been frequent (Dagott 2024).

C Shadow Rates

To capture the overall stance of monetary policy when the policy rate is constrained by the effective lower bound, we consider two shadow rate specifications as supplementary evidence. The central idea is to recover a latent short rate implied by the yield curve—even when observed short rates are near zero—by embedding an effective lower bound into an arbitrage-free term-structure model. In this class of models, the economy behaves as if there were an underlying “shadow” short rate that can move below zero, but market rates are observed only through the lens of the lower-bound distortion. The resulting shadow rate therefore summarizes both conventional policy changes and unconventional measures that operate through longer maturities and expectations (Krippner 2016).

It is important to emphasize that the shadow rates in our specification are endogenous indicators of the overall policy stance. Unlike the high-frequency surprises used in our main analysis, they do not isolate exogenous policy innovations but instead reflect the systematic response of monetary policy to prevailing macro-financial conditions. The local projection coefficients should therefore not be interpreted as causal effects of monetary policy, but rather as conditional associations between the policy stance and subsequent changes in bank resilience. This follows Kumar et al. (2023), who use the Wu-Xia shadow rate to characterize the US policy stance at the effective lower bound but show that identifying the shadow rate itself as an exogenous shock yields implausible responses, and therefore base causal inference on a separately identified high-frequency instrument.

In a first supplementary specification, we use the Krippner (2016) shadow rate. A positive change in the shadow rate corresponds to a tighter overall policy stance (a higher implied short rate, less accommodation), while a negative change corresponds to easier conditions, including accommodation delivered through forward guidance and balance-sheet policies when the observed short rate itself is at or near the lower bound (Krippner 2016).

As a further robustness check, we replace the Krippner shadow rate with the Wu-Xia shadow rate (Wu and Xia 2016). The authors construct a shadow rate from a lower-

bound-consistent term-structure framework in which the shadow short rate is inferred from the cross-section of yields, delivering a single summary series intended to remain informative about the stance of policy during the ZLB/ELB period. Conceptually, both shadow rate measures compress conventional and unconventional accommodation into one scalar indicator, though they differ in their estimation details. The Wu-Xia specification primarily serves to verify that the patterns documented with the Krippner measure are not an artifact of a particular shadow-rate construction. We therefore substitute the Wu-Xia shadow rate while holding our baseline specifications fixed.

Across specifications, the resulting conditional associations are broadly comparable: a tighter policy stance is associated with a decline in resilience growth for Regional Banks and an increase in resilience growth for Sparkassen and Credit Unions (see Figures 6 and 7). Detailed mean responses and subsample results are reported in Tables 7 and 8 of Appendix A.

D *Additional Monetary Policy Dimensions*

As an additional robustness test, we use the Release-QE shock from Baumgärtner and Klose (2021), which isolates the surprise component at the moment of the press release by focusing on a narrower event window. This shock serves to validate the Conference-QE shock of Altavilla et al. (2019a). Our results using Release-QE largely confirm the results found using the Conference-QE shock, with the exception of Large Banks, where we observe a sign flip (Table 4). Nevertheless, an increase (decrease) as a response to a contraction (expansion) of this unconventional monetary policy channel is particularly pronounced for Sparkassen and Credit Unions, a finding that can also be observed in our shadow rate models (Figure 8).