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Monetary Policy and the Resilience of the German Banking System: From Deutsche Bundesbank to ECB*

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Abstract

The resilience of the German banking system is studied on the semi-aggregated level from 1968 to 2022. We distinguish between Large Banks, Regional Banks, Landesbanken, Sparkassen and Credit Unions and study their z-scores as a measure of resilience in response to the monetary policy stances of the Bundesbank and the ECB, respectively. We estimate two-way fixed effects panel regression models for both periods separately. The results suggest that monetary policy was more effective in enhancing resilience during the period of a national currency controlled by the Deutsche Bundesbank. The effect across bank types is much more heterogeneous after the inception of the ECB. In particular, decreasing resilience of Large Banks is associated with expansionary (un)conventional monetary policy in recent years.

Keywords: Resilience, Monetary Policy, Banking, Financial Stability, Germany, Deutsche Bundesbank, ECB, Credit Union, Sparkasse.
JEL-Codes: E42, E52, G21.

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1 Introduction

Resilience has recently become the new buzzword in business and economics. In Germany it was nominated the economic term of the year (Wirtschaftswort des Jahres 2022). Its etymology lies in the Latin word resiliere, which translates to "bounce back". As such, the word resilience is commonly used to refer to the ability of a system to respond and adapt to internal and external disruptions. It refers to the system's ability to help itself.

A key aspect of resilience is robustness, which refers to a system's ability to absorb shocks and recover quickly (Holling, 1973, Holling, 1996, Aligica and Tarko, 2014, Salter and Tarko, 2019). In this sense, the resilience of a system captures how much that system can endure before breaking down.

In a world where crises have become more frequent, financial stability and resilience, especially within the banking sector, have gained significant attention in public discourse and policy debates. The term of financial stability, which is closely related to resilience, is frequently used by representatives of major financial institutions (Lagarde 2021, Lagarde 2022, de Guindos 2023a, de Guindos 2023b, Schnabel 2023). It is often explicitly seen as a monetary policy goal, albeit monetary authorities around the world attach slightly different meanings to the term.

According to the ECB (2007), the financial system is stable when it is capable of withstanding shocks and financial imbalances. The Deutsche Bundesbank (2021) defines financial stability as a state in which the financial system neither causes nor amplifies macroeconomic downturns. According to the IMF (2023), financial stability is ensured when the financial system can perform its key functions of supporting the inter-temporal allocation of resources, assessing and accurately pricing financial risks and absorbing financial and economic shocks. The FED (2021) considers a financial system to be stable when households and businesses are provided with sufficient financing.

Empirical studies confirm the effectiveness of monetary policy, especially in stimulating the economy in "normal" downturns (Bech et al. 2012, Kannan et al. 2009). Nonetheless, the effectiveness of monetary policy seems to weaken during financial crises when both the private sector's financial health and the mechanisms through which monetary policy operates are compromised (Kannan et al. 2009, Borio 2012, Bech et al. 2012, Sanchez et al. 2015). Two main factors contribute to the diminished impact of monetary policy in financial crises. First, there frequently is a significant number of heavily indebted economic entities who are hesitant to take new loans and increase their spending. Second, a weakened financial system has a reduced capacity to transmit monetary policy measures to the broader economy because of higher risk aversion and uncertainty (Inaba et al. 2015).

During the global financial crisis, unconventional monetary policies were deemed necessary to alleviate the detrimental impact of a collapsing financial system on the real economy (Mishkin 2009, Borio 2012). Excessively loose monetary policies, especially the unprecedented expansion of central banks' balance sheets, can tame financial stress in the short run, but it can also cause new risks. Prolonged monetary easing can postpone necessary adjustments and extend periods of economic fragility (Borio and Disyatat 2010, Borio 2012, Caruana, 2012, Bouis et al. 2013, Grimm et al. 2023).

This poses the question of the net effect of monetary policy on financial sta-

bility and resilience? Central banks can step in and reduce liquidity shortages at any time, but have monetary policies contributed to the financial system's resilience? Given its importance, this question is under-researched, especially regarding the potentially heterogeneous effects of conventional and unconventional monetary policies.

An appropriate empirical measure of resilience should quantify the ability to tame disruptive events or to prevent them from becoming worse (Rose and Liao 2005, Erol et al. 2010). In the banking context, such a measure is an adapted version of Altman's z-score (Altman 1968). It counts the number of standard deviations the return on assets (ROA) can fall before depleting the bank's equity and thus captures a banks' loss-absorbing buffers (Boyd and Runkle 1993, Cihak and Hesse 2010). Z-scores as a metric to analyse the stability of individual banks have been widely used in the banking literature (Allen and Gale 2004, Altunbas et al. 2007, Beck et al. 2013, Fu et al. 2014, Fiordelisi and Mare 2014, Mamatzakis and Bermpei 2016), but not in the context of the resilience of a banking system in connection to monetary policy. To the best of our knowledge, there is only one study by Avalos and Mamatzakis (2023) that addresses how bank resilience is affected by monetary policy using z-scores on the level of individual banks. They focus on the whole Euro area, but only for the limited period between 2007 and 2018.

We focus on Germany and study the resilience of its banking system in connection with monetary policy since the late 1960s, for a period of 54 years. We can thus discriminate between the monetary policy of the Deutsche Bundesbank and the European Central Bank (ECB) and are able to estimate if and how conventional and unconventional monetary policies differ in their impact on resilience. We proceed by presenting the data compiled and used in this study in the following section. We then present our panel regression model and estimation results in Section 3. Section 4 presents some robustness checks. The final section concludes.

2 Data and Data Description

We have compiled a panel dataset of semi-aggregated data on the German banking system from December 1968 to December 2021. It consists of monthly balance sheet information and selected items from the profit and loss statements of the major German bank types. The second dataset complements the panel dataset with macroeconomic covariates such as monetary policy variables and indicators of economic activity and price developments from various data sources.[1]

2.1 The German Banking System

The German banking system consists of three pillars. The first pillar represents public-sector savings banks, i.e. Sparkassen and Landesbanken organized under public law. The second pillar comprises credit cooperatives, i.e. Credit Unions

[1]We use monetary policy indicators from Deutsche Bundesbank, FRED and Krippner (2013). Our monthly output indicator from the IMF covers industrial production. The price indicator is the national consumer price index retrieved from Deutsche Bundesbank. The stock market capitalization indicator is retrieved from FRED.

organized in accordance with the Cooperative Societies Act following the legal form of an economic association. The third pillar are privately organized credit banks (Large and Regional Banks), i.e. Deutsche Bank and ING-DiBa. All bank types are universal banks that participate in many different types of banking activities, such as commercial and investment banking.

Sparkassen (Savings Banks) are credit institutions whose core business is to accommodate the saving behaviour of the broad population, to assist small and medium-sized enterprises in financing their business activities, to promote housing through real estate financing and to support their municipality through municipal loans. Two central principles apply to Sparkassen. First, according to the regional principle a Sparkasse must operate exclusively in its business territory. The regional principle prevents financial resources from flowing exclusively to economically developed regions, thus depriving structurally weaker regions of financing opportunities (Gaertner 2003). Second, according to the subsidiarity principle, each local Sparkasse performs all banking activities independently but cooperates with other Sparkassen or other entities of the Sparkassen-Finanzgruppe[2] where is needed (Luetke-Uhlenbrock 2007).

Credit Unions were founded as self-help associations of craftsmen and traders. According to §1 of the Cooperatives Act, the statutory objective of credit cooperatives is to promote the business of their members. Thus, the main business activity of credit cooperatives is retail and corporate banking. Credit Unions are regarded as the bank for small and medium-sized enterprises which operate mostly regionally. Credit Unions place their members at the centre of action.

Large Banks (Großbanken) comprise money and credit institutions, such as Deutsche Bank and Commerzbank, traditionally conducting their business activity supra-nationally. Large Banks have a wide branch network, which usually covers an international business area. Regional Banks[3], i.e. Volkswagen Bank or ING-DiBa, are credit institutions that conduct(ed) their banking business in a specific geographical region. Both bank types are each managed in the form of a stock company and are thus strongly oriented toward the capital market. In addition to traditional retail and corporate banking, they are particularly active in foreign and securities business as well as investment banking (Eim 2004).

In our analysis we will restrict the focus on Large and Regional Banks, Sparkassen, Landesbanken and Credit Unions as they hold around 80% of total assets of the German banking system. In Figure 1, we can see the share of total bank assets of these bank types in Germany in 1970, 1998[4] and 2021. We can see that the structure of the German banking system has remained quite stable in times of Deutsche Bundesbank but has changed somewhat since the introduction of the Euro. The most significant change is the rising share of

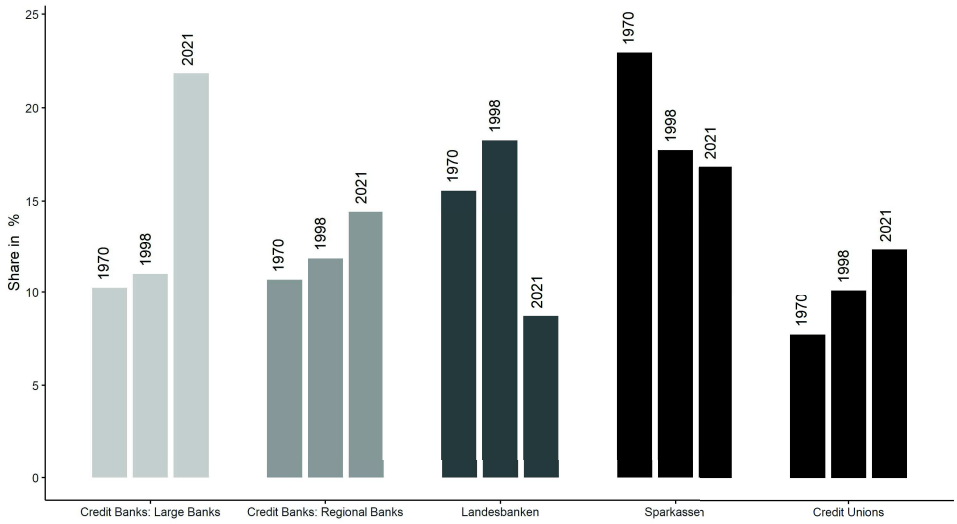
[2]The Sparkassen-Finanzgruppe is organized in a three-tier system. At the lowest level there are the individual local Sparkassen, which form the foundation of the Sparkassen-Finanzgruppe. The second level comprises the supra-regional Landesbanken, which act as the central banks of the local Sparkassen, as giro centers and as central institutions for the payment transactions of the individual Sparkassen. The central institution of the Sparkassen-Finanzgruppe is Deka Bank, which is the investment bank of the financial group (Ettmann and Wolff 2019).

[3]Traditionally, Regional Banks conducted their business activity solely in one region. Today, they often operate nation-wide, but are still considered as Regional Banks in the Deutsche Bundesbank statistics. The aggregate "Regional Banks" also comprises direct banks, such as ING-DiBa.

[4]The Euro was introduced as an accounting currency in 1999.

assets held by Large and Regional Banks, which has increased from 20.9% to 36.3%, and the declining share of Landesbanken from 18.2% in 1998 to 8.4% in 2021. The share of the Sparkassen has also declined from 23% in 1970 to 15% in 2021. The share of Credit Unions increased from 8% in 1970 to 11% in 2021.

Figure 1
Share of Total Assets of German Bank Types



Source: Deutsche Bundesbank, own calculations.

In the banking literature, z-scores are widely used to measure the stability of an individual bank (Cihak and Hesse 2010, Fiordelisi and Mare, 2014, Beck et al. 2013, Fu et al. 2014, Avalos and Mamatzakis 2023). The z-score is computed as the sum of the ROA and the equity ratio over the standard deviation of the ROA.[5] It is inversely related to the probability of a bank's insolvency. The standard deviation of the ROA is a measure of return volatility. The z-score measures the number of standard deviations the return realization can fall before a bank's equity is depleted (Cihak and Hesse 2010).

Augmenting previous research (Beck et al. 2013, Fiordelisi and Mare 2014, Avalos and Mamatzakis 2023), we calculate aggregated z-scores for each bank type instead of individual banks. Therefore, our z-score is suitable to assess the stability and resilience of different bank types in the aggregate and thus the banking system overall. Our z-score measure is given by:

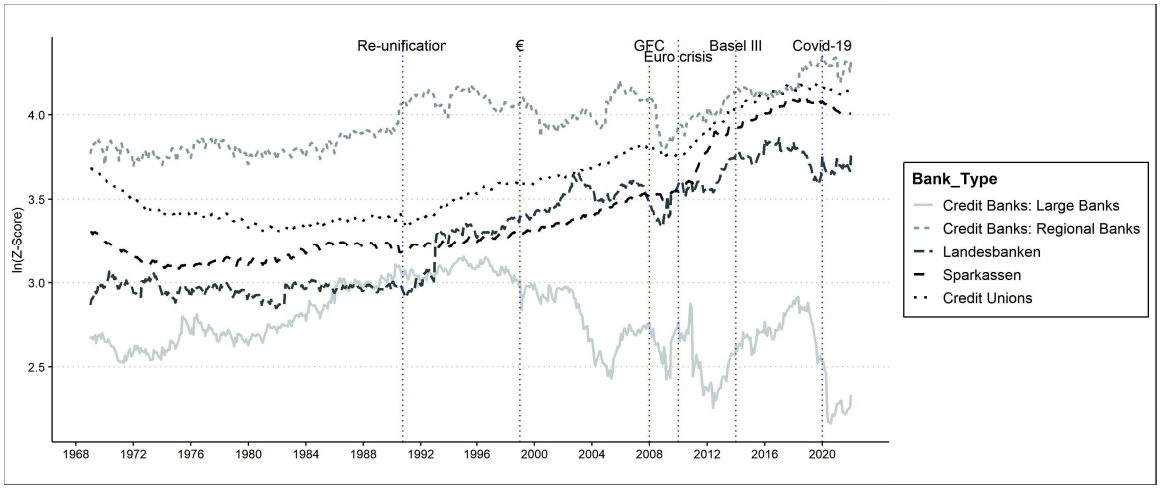
$$z_{i,t} = \frac{roa_{i,t} + er_{i,t}}{\sigma(roa_i)} \tag{1}$$

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

[5]As the profit and loss statements are only available on an annual basis, we approximate the monthly net income by interpolating the values between January and November of each respective year from the annual net income in the year before and the year in question. We then divide the resulting values by the monthly sum of total assets to receive a monthly proxy for the return on assets of each bank type.

t, and $\sigma(roa_i)$ is the standard deviation of the ROA calculated for each bank type over the entire period from 1968 to 2021. We also calculate the standard deviation as a rolling window over time for robustness checks.

Figure 2
Z-scores as Resilience Indicator of Different Bank Types in Germany



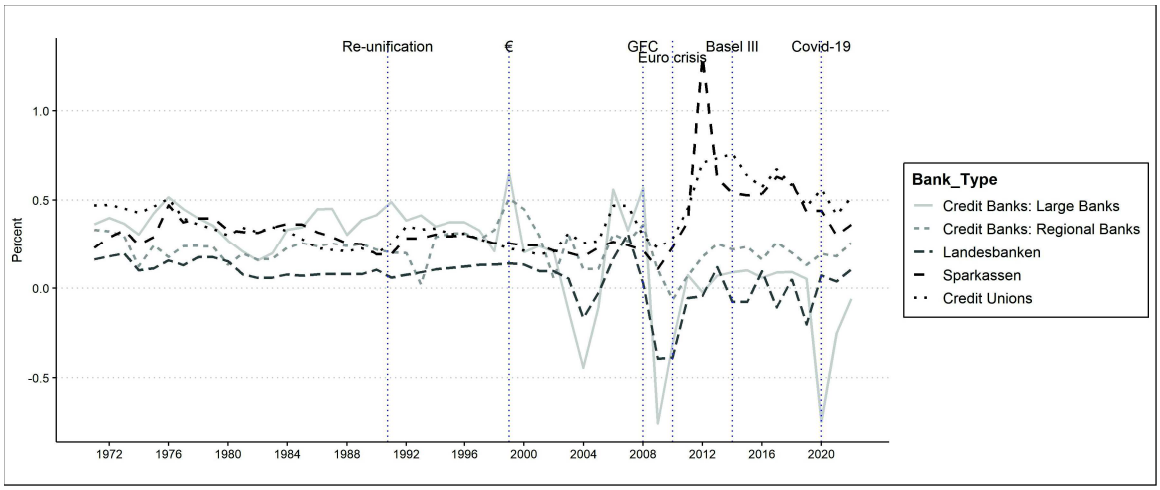
Source: Deutsche Bundesbank, own calculations.

Figure 2 shows the z-score as a measure of resilience for each of the bank types included in our data set. In times of the Deutsche Bundesbank (1957-1998), the resilience indicator was on a rising trajectory with a low variance for each bank type. This speaks for a resilient banking system with pronounced robustness and adaptability. The z-score was highest for the Regional Banks, followed by Credit Unions and Sparkassen. The z-score was lowest for the Large Banks and Landesbanken.

Since the introduction of the Euro in 1999, the resilience score has continued to increase for Regional Banks, Credit Unions, Sparkassen and Landesbanken, but has decreased for Large Banks. Even though the Great Financial Crisis (GFC) hit Regional Banks and Landesbanken significantly, both bank types quickly bounced back and have been on a rising path since. The resilience score of Credit Unions only dropped marginally in response to the GFC and quickly recovered. The resilience score of Sparkassen is not affected at all, neither by the GFC, nor the Euro crisis. For Large Banks, the z-score behaves distinctively different compared to all other bank types. We observe a declining trend in resilience since the introduction of the Euro with a sharp drop during the GFC, the Euro crisis and the Covid-19 crisis. Furthermore, we observe a sharp increase in bank resilience for all bank types between 2012 and 2014, when Basel III was (officially) implemented. The increased volatility of the bank type z-scores during the Euro period speaks for a weakened robustness. However, the mean reversion for all bank types but Large Banks is indicative for a pronounced adaptability of the German banking system. Altogether, it can be assumed that since the introduction of the Euro, the resilience of the German banking system is somewhat weaker than in times of the Deutsche Mark (DM).

We also scrutinize the components of our resilience indicator. In Figure 3,

Figure 3
Return on Assets of German Bank Types



Source: Deutsche Bundesbank, own calculations.

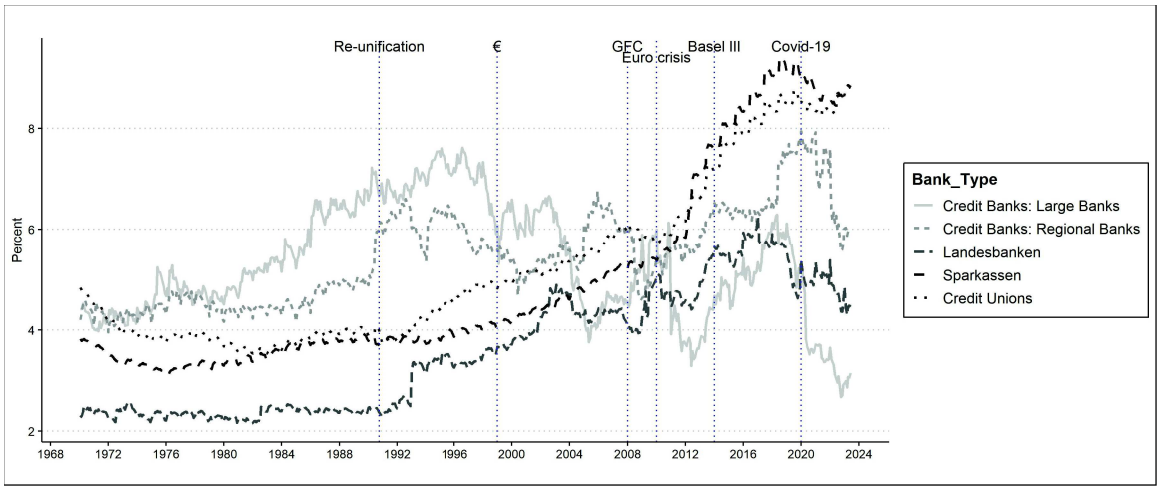
the ROA of each bank type is shown. A clear difference between the DM period and the Euro period is visible regarding the level and volatility of the ROA of each bank type. From 1970 to 1998, the ROA is very stable for all bank types with Large Banks, Sparkassen and Credit Unions having the highest ROA over different sub-periods.

Since the introduction of the Euro, the volatility of the ROA increased for all bank types and we can observe a declining trend for Large Banks and Landesbanken with a negative ROA in 2004, in the aftermath of the GFC and during the Covid-19 pandemic. Credit Unions and Sparkassen performed quite differently as their ROA only slightly decreased in response to the GFC and increased strongly after 2010 to remain on a much higher level than the ROA of all other bank types. Regional Banks' ROA has remained stable during both monetary regimes.

Figure 4 shows the balance sheet equity ratio. During the DM period, the equity ratios of all German bank types increased. Only Sparkassen and Credit Unions had short phases of decreasing equity ratios during the 1970s and the early 1980s. Since the late 1990s, the equity ratio of Large Banks has started to decrease. Credit Unions and Sparkassen have been on a rising trajectory. For Large Banks we can see a declining trend with a more pronounced volatility. Today, Sparkassen and Credit Unions have the highest balance sheet equity ratio of around 9%, while Large Banks have the lowest equity ratio of around 3%.

There is a difference between the balance sheet equity ratio and regulatory capital ratios. The regulatory capital ratio is the percentage of a bank's equity to its risk-weighted assets, while the balance sheet equity ratio is the percentage of a bank's equity to its total assets. According to Basel III, banks are required to hold at least 4.5% of core capital relative to risk-weighted assets. Tier 1 capital must amount to at least 6% (Additional Tier 1 capital of 1.5%), and

Figure 4
Equity Ratio of German Bank Types



Source: Deutsche Bundesbank, own calculations.

total capital (Tier 1 and Tier 2)[6] must be at least 8% (BIS 2022).

Under Basel III, some asset categories such as government bonds, central bank reserves, deposits with highly rated banks or short-term claims on banks, for instance, receive a risk-weight of zero[7] which explains the divergence between regulatory capital ratios and balance sheet equity ratios of Large Banks, Regional Banks and Landesbanken in particular.

2.2 Monetary Policy in Germany

In this paper, we cover two different monetary regimes in Germany: The DM and the Euro period. After World War II, Germany went through far-reaching institutional reforms. The 1948 currency and economic reform contributed to Germany's economic miracle. The keystones of the reform were free-market formation of prices, a stable currency and free competition. In 1957, the Bundesbank was established. With the introduction of the Euro in 1999, the Bundesbank was integrated into the European System of Central Banks (ESCB). From 1999 onwards, the ECB sets and conducts the monetary policy for the European Monetary Union (EMU) in coordination with the national central banks of the Euro member states.

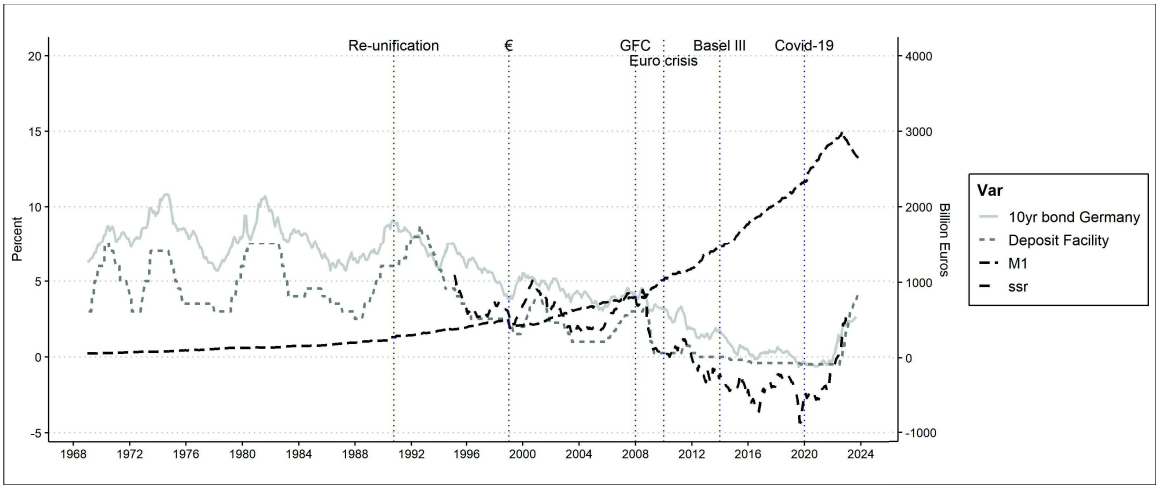
The Bundesbank's primary mandate was to ensure price stability. The commitment to price stability was anchored in the Bundesbank Act of 1957, which established the independence of the institution. The Bundesbank's independence from political influence allowed it to focus on long-term price stability rather than short-term political goals. The credible independence of the Bundesbank was central to anchoring inflation expectations and maintaining trust

[6]Tier 1 capital refers to common equity and retained earnings. Tier 2 capital refers to subordinated debt and hybrid instruments enhancing resilience. For a more detailed description see BIS (2019).

[7]However, it is important to note that a risk-weight of zero does not necessarily mean that these asset categories carry no risk.

of the financial markets. To control inflation, the Bundesbank employed a monetary targeting framework. To ensure long-term economic stability, the Bundesbank pursued a relatively restrictive monetary policy. From 1969 to 1998, the deposit facility rate as the key interest rate averaged 4.8% (Figure 5).

Figure 5
German Monetary Policy Indicators



Source: Deutsche Bundesbank, FRED, Krippner (2013).

According to the Treaty on the Functioning of the European Union, the ESCB's primary objective is price stability (§127). Furthermore, it is an independent system of central banks (§130) prohibited to finance government expenditure (§123) (Schnabl and Sepp 2021).

The central banks' role is to establish a key interest rate that is not too low. It should discourage private commercial banks from funding investment projects with low anticipated profits and higher default risks.[8] Commercial banks use savings to fund corporate investments based on the evaluation of the expected returns at risk-adjusted loan conditions. To address information asymmetries, small and medium-sized banks have been maintaining long-term relationships (relationship banking) with small and medium-sized enterprises within their business territory (Berger and Udell 2006).

Since the beginning of the European financial and debt crisis in 2009, the ECB's monetary policy changed fundamentally. The ECB lowered the key interest rates to below zero (see Figure 5) and expanded its bond purchases from 2012 onwards. The Euro system's volume of asset purchases has reached about €5,000 billion until the end of 2022. At the same time, the balance sheet of the Euro system and the amount of central bank money M0 grew sharply, increasing by an average annual rate of about 15% between 2012 and 2022.

Long-lasting loose monetary policies pose the danger of undermining the capital allocation function of interest rates (Schnabl 2019). With the advent of unconventional monetary policies, the ECB has introduced tools such as outright purchases of government, corporate and covered bonds as well as the provision

[8]See Schularick and Taylor (2012) and Grimm et al. (2023) on the role of loose monetary policy and the likelihood of (financial) crises.

of long-term credit lines for banks to stimulate the economy. These measures have not only increased the overall volume of credit available to governments, households and businesses but have also created the possibility to steer the economy in line with political goals (Schnabl 2022).

3 Model and Estimation Results

To study the effect of conventional and unconventional monetary policy on the resilience of the German banking system in general, and more specifically on the different bank types constituting the German banking system, we estimate a monthly two-way fixed effects model for the DM period (1968-1998) and the Euro period (1999-2021). We include bank-type fixed effects y_i, which account for unobserved heterogeneities across bank types, and time fixed effects δ_t, which account for unobserved changes over time that affect all bank types.

In the first step, we estimate the effect of monetary policy on the whole German banking system without distinguishing between different bank types. For the period of the DM period, we use the deposit facility rate r_t as an indicator of the monetary policy stance of the Bundesbank:[9]

$$ln(z_t) = \beta_1 r_t + \beta' X_t + \delta_1 + \epsilon_{i,t} \tag{2}$$

For the Euro period, we use Krippner's short shadow rate (ssr_t) as a monetary policy indicator because it incorporates unconventional monetary policy measures:[10]

$$ln(z_t) = \beta_2 ssr_t + \beta' X_t + \delta_1 + \epsilon_{i,t} \tag{3}$$

In the second step, we estimate the effect of monetary policy on the resilience of various bank types: Large Banks, Regional Banks, Sparkassen, Landesbanken and Credit Unions. This allows us to assess and account for the institutional heterogeneity in the German banking system. We again estimate two separate models for the DM and Euro periods:

$$ln(z_{i,t}) = \beta_1 r_t + \sum_{j=1}^{4} [\beta_{j+2}(bank_{i,t}\ x\ r_t)] + \beta' X_t + \gamma_i + \delta_1 + \epsilon_{i,t} \tag{4}$$

$$ln(z_{i,t}) = \beta_2 ssr_t + \sum_{j=1}^{4} [\beta_{j+6}(bank_{i,t}\ x\ ssr_t)] + \beta' X_t + \gamma_i + \delta_1 + \epsilon_{i,t} \tag{5}$$

[9] The deposit facility rate reflects the interest banks receive for money deposited with the central bank overnight. By adjusting the deposit facility, the central bank can influence the overall level of interest rates in the economy, which in turn affects borrowing, lending, spending and investment. For more details see Borio and Disyatat (2010).

[10] The Krippner short-term shadow rate is a suitable summary statistic that incorporates both conventional and unconventional monetary policy measures of the ECB. The influence of asset purchases on the yield curve is translated into changes in the short-term interest rate. This is especially valuable because the zero lower bound often restricts conventional interest rate measures, making it challenging to compare the outcomes of unconventional monetary policy actions with the outcomes of conventional interest rate reductions. For more details, see Krippner (2020).

In the first step (equations (2) and (3)), the explanatory variable z_t corresponds to our resilience measure, the z-score of the whole German banking system in month t. In the second step (equations (4) and (5), the explanatory variable $z_{i,t}$ corresponds to the z-score of German bank type i in month t. The monthly z-score is transformed with the natural logarithm to reduce the skewness of its distribution. This has the side-effect that we can interpret our results as semi-elasticities.

In the first two regressions, coefficients β_1 and β_2 account for the effect of monetary policy measures on the resilience of the whole banking system during the DM and Euro period. The corresponding coefficients β_1 and β_2 in equations (4) and (5) account for the effect of monetary policy on the resilience of Large Banks which serve as the baseline bank type. The interaction terms of the monetary policy variable and the dummy variables $bank_{i,t}$ isolate the heterogeneous additional effects of monetary policy on other bank types: Credit Unions (β_3 and β_7), Landesbanken (β_4 and β_8), Regional Banks (β_5 and β_9), and Sparkassen (β_6 and β_{10}). For example, the sum of β_1 and β_4 in equation (4), captures the estimated effect of monetary policy on the resilience of Landesbanken during the DM period, while the sum of β_2 and β_{10} from equation (5) captures the estimated effect of unconventional and conventional monetary policy measures on Sparkassen in the Euro period.

We include three additional control variables (X_t) on the price level and the real economic performance. The price level is measured by the year-on-year percentage change of the monthly consumer price index. Real economic performance is captured by the year-on-year percentage change of the industrial production index since the conventional GDP measure is not available on a monthly basis. We also include the stock market capitalization to control for the expectation of future economic activity.

Table 1 summarizes the estimation results of the baseline models (1) to (4) with robust standard errors making the inference robust to heteroskedasticity and auto-correlation. Models (1) and (2) show the estimation results of the baseline estimation without the bank type interaction term, for both the DM period and the Euro period, respectively. In both cases, the effect of the policy rate on banking resilience is statistically significant and negative, that is, a reduction in the policy rate is associated with increased resilience. More precisely, a reduction of the deposit facility rate is on average associated with an increase by a factor of more than 2 ($-\beta_1$) of the resilience of the German banking system during the DM period.

The effect of an expansionary (un)conventional monetary policy on banking resilience during the Euro period, however, is much smaller. A reduction of the Krippner shadow rate by one percentage point is associated with an average increase of only 6% ($-\beta_2$) of the z-score as a resilience indicator. The results suggest that during the DM period, monetary policy might have had a stronger handle on the resilience of the banking system than during the Euro period.

Models (3) and (4) include the interaction terms between the respective monetary policy variable and the bank type dummy variables. The coefficients β_1 and β_2 now account for the effect of (un)conventional monetary policy on the resilience of Large Banks. In Model (3), the effect is statistically significant and comparable in size and sign to the overall effect in model (1). A reduction of the deposit facility by one percentage point is associated with a doubling ($-\beta_1$) of Large Banks' z-score. The effect is slightly less pronounced for Regional

Table 1
Estimation Results for the Baseline Model

	Explained Variable: ln(Z-Score)			
	Model 1 – DM	Model 2 – Euro	Model 3 – DM	Model 4 – Euro
β_1 – deposit facility	-2.6430^{***}		-2.6492^{***}	
	(0.6886)		(0.6807)	
β_2 – ssr		-0.0583^{***}		0.0235^{**}
		(0.0164)		(0.0106)
β_3 – df x Credit Unions			0.0062	
			(0.0044)	
β_4 – df x Landesbanken			-0.0031	
			(0.0040)	
β_5 – df x Regional Banks			0.0154^{***}	
			(0.0037)	
β_6 – df x Sparkassen			0.0126^{***}	
			(0.0039)	
β_7 – ssr x Credit Unions				-0.1118^{***}
				(0.0040)
β_8 – ssr x Landesbanken				-0.0800^{***}
				(0.0040)
β_9 – ssr x Regional Banks				-0.0704^{***}
				(0.0043)
β_{10} – ssr x Sparkassen				-0.1465^{***}
				(0.0042)
Time Fixed Effects	Yes	Yes	Yes	Yes
Bank Type Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.6165	0.4271	0.6253	0.7871
Adj. R^2	0.5196	0.2818	0.5292	0.7322
Observations	1800	1380	1800	1380
Years	1968-1998	1999-2021	1968-1998	1999-2021

*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.
For models with interaction terms, the default bank type is Large Banks. All regressions include time fixed effects and bank type fixed effects. Robust standard errors are applied (White 1980, White 1984, Arellano 1987). Industrial production, CPI and stock market capitalization are controlled for in all regressions.

Banks ($-(\beta_1 + \beta_5)$) and Sparkassen ($-(\beta_1 + \beta_6)$). There is no statistically significant difference between Large Banks, Landesbanken and Credit Unions during the DM period as far as the estimated effects of monetary policy on their resilience is concerned. Hence, overall, there are only minor differences in the estimated effects of monetary policy on the resilience of different bank types. Given the definition of our resilience measure, the increase in resilience can be most likely linked to an increase in the bank type's ROA or a reduction in its volatility. Conventional monetary policy was thus capable of taming financial distress homogeneously across all bank types.[11]

For the Euro period captured in Model (4), the heterogeneous effects of

[11] During the DM period, the bank type z-scores indicate that the German banking system was resilient per se. Yet, with a symmetric monetary policy stance, the Deutsche Bundesbank was able to stabilize the German banking system and promote its resilience. Since the introduction of the Euro, however, the ECB pursues an asymmetric monetary policy stance potentially jeopardizing the resilience of the German banking system instead of promoting it. For more details on (a)symmetric monetary policies see Hoffmann and Schnabl (2011).

(un)conventional monetary policy on banking resilience are more pronounced. A one percentage point reduction in the short-term shadow rate is now associated with a 2% reduction in Large Banks' z-score. The decrease in the loss-absorbing buffers is most likely associated with an increase in the volatility of ROA as the result of more risky assets in Large Banks' balance sheets.

The effect of an expansionary (un)conventional monetary policy on banking resilience turns positive for all the other bank types, with the effect being most pronounced for Credit Unions ($9\% = -(\beta_1 + \beta_7)$) and Sparkassen ($12\% = -(\beta_2 + \beta_{10})$). The estimated effects on different bank types thus vary between -3% for Large Banks and +12% for Sparkassen.

This suggests that during the DM period, an expansionary monetary policy stance could positively influence the resilience of the German banking system in general and across all bank types. During the Euro period, however, heterogeneous effects of monetary policy on the resilience of the German banking system are visible. While an expansionary monetary policy stance still affects the resilience of the whole German banking system positively, there are partial adverse effects if the heterogeneity of the banking system is considered. The resilience of Large Banks is negatively related to expansionary monetary policies. The effects on Credit Unions and Sparkassen are positive.

4 Robustness Checks

The estimation results are robust to variations of the monetary policy variable as shown in Table 2. Models 5 and 6 use the 10-year German government bond yield instead of the deposit facility rate and the Krippner shadow rate for the DM and Euro periods, respectively. The main effect of expansionary monetary policy on Large Banks is still highly significant and positive (Model 5). A one percentage point reduction in the 10-year German government bond yield is associated with a 24% ($-\beta_1$) increase of Large Banks' resilience during the DM period. The interaction term with Credit Unions is now significant and positive indicating an attenuated effect of an expansionary monetary policy stance of 20% ($-(\beta_1 + \beta_2)$). There are similar results for Regional Banks (22% $=-(\beta_1 + \beta_4)$) and Sparkassen (20% $=-(\beta_1 + \beta_5)$), but no significant difference for Landesbanken. The effects thus vary between 20% and 24%.

The results in Model (6) are comparable in size and significance to the results of the baseline estimation in Model (4). A one percentage point reduction of the 10-year German government bond yield is associated with a 3% decrease ($-\beta_1$) in Large Banks' resilience during the Euro period. Credit Unions and Sparkassen seem to be the main beneficiaries of an expansionary monetary policy stance in terms of their resilience indicator. A one percentage point reduction in the government bond yield is on average associated with a 12% ($-(\beta_1+\beta_2)$) increase in Credit Unions' resilience and a 16% ($-(\beta_1 + \beta_5)$) increase for Sparkassen. Landesbanken ($-(\beta_1 + \beta_3)$) and Regional Banks ($-(\beta_1 + \beta_4)$) are estimated to become more resilient with a 7% increase in their z-scores.

Models (7) and (8) use the natural logarithm of the monetary base M1 as the monetary policy variable. The sign of the natural logarithm of M1 and its interaction terms is now reversed as compared to the baseline results and again statistically significant. This confirms the previous results as increases in M1, as opposed to decreases in interest rates, are associated with monetary

Table 2
Variations of the Monetary Policy Variable

	MP Var: 10yr Gov. Bond		MP Var: Ln(M1)	
	Model 5 - DM	Model 6 - Euro	Model 7 - DM	Model 8 - Euro
β_1 – Monetary Policy Variable	-0.2439^{***}	0.0337^{***}	0.2343^{***}	-0.3318^{***}
	(0.0557)	(0.0126)	(0.0164)	(0.0608)
β_2 – MP x Credit Unions	0.0371^{***}	-0.1538^{***}	-0.2760^{***}	0.9674^{***}
	(0.0049)	(0.0044)	(0.0063)	(0.0276)
β_3 – MP x Landesbanken	0.0062	-0.1062^{***}	-0.1224^{***}	0.6448^{***}
	(0.0045)	(0.0045)	(0.0079)	(0.0287)
β_4 – MP x Regional Banks	0.0241^{***}	-0.1020^{***}	-0.1005^{***}	0.6277^{***}
	(0.0043)	(0.0049)	(0.0067)	(0.0312)
β_5 – MP x Sparkassen	0.0386^{***}	-0.1985^{***}	-0.2198^{***}	1.2359^{***}
	(0.0043)	(0.0046)	(0.0064)	(0.0288)
Time Fixed Effects	Yes	Yes	Yes	Yes
Bank Type Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.6482	0.8310	0.8305	0.8325
Adj. R^2	0.5581	0.7873	0.7871	0.7892
Observations	1800	1380	1800	1380
Years	1968-1998	1999-2021	1968-1998	1999-2021

*** p < 0.01, ** p < 0.05, *p < 0.1.
For models with interaction terms, the default bank type is Large Banks. All regressions include time fixed effects and bank type fixed effects. Robust standard errors are applied (White 1980, White 1984, Arellano 1987). Industrial production, CPI and stock market capitalization are controlled for in all regressions.

expansion. During the DM period, more expansionary monetary policies are again estimated to stabilize the German banking sector across the board with a somewhat weaker effect on Credit Unions and Sparkassen. Since the introduction of the Euro in 1999 this has changed. An expansion of the money stock is associated with losses in resilience for Large Banks and gains in resilience for all other banks, especially Sparkassen.

The evidence thus far points towards meaningful correlations between monetary policy and bank resilience in Germany. We have included time and bank type fixed effects to absorb unobserved heterogeneity. However, there remains the possibility of endogeneity regarding the monetary policy variables and the error term. To address this, we use an instrumental variable approach. We use the two-stage least square generalization (G2SLS) proposed by Balestra and Varadharajan-Krishnakumar (1987). We instrument the monetary policy variable (deposit facility for the DM period and Krippner shadow rate for the Euro period), the industrial production index and the CPI with their first lags.

Table 3 presents the results of this model specification. By and large, the

Table 3
G2SLS

	Explained Variable: ln(Z-Score)	
	Model 9 - DM	Model 10 - Euro
β_1 – deposit facility	-0.1053^{**}	
	(0.0528)	
β_2 – df x Credit Unions	0.0069	
	(0.0044)	
β_3 – df x Landesbanken	-0.0031	
	(0.0040)	
β_4 – df x Regional Banks	0.0156^{***}	
	(0.0037)	
β_5 – df x Sparkassen	0.0131^{***}	
	(0.0039)	
β_6 – ssr		0.0149
		(0.0114)
β_7 – ssr x Credit Unions		-0.1114^{***}
		(0.0040)
β_8 – ssr x Landesbanken		-0.0797^{***}
		(0.0040)
β_9 – ssr x Regional Banks		-0.0703^{***}
		(0.0043)
β_{10} – ssr x Sparkassen		-0.1460^{***}
		(0.0042)
Time Fixed Effects	Yes	Yes
Bank Type Fixed Effects	Yes	Yes
Controls	Yes	Yes
R^2	0.6280	0.7877
Adj. R^2	0.5326	0.7328
Observations	1795	1375
Years	1968-1998	1999-2021

*** p < 0.01, ** p < 0.05, *p < 0.1.
For models with interaction terms, the default bank type is Large Banks. All regressions include time fixed effects and bank type fixed effects. Robust standard errors are applied (White 1980, White 1984, Arellano 1987). Industrial production, CPI and stock market capitalization are controlled for in all regressions.

results are robust to the change in the estimation strategy and comparable in sign and size to the baseline results.

Model 9 shows the results for the DM period. As before, expansionary monetary policy leads to a stabilization and increase in German bank resilience during the DM period. Large banks benefit the most from an expansionary monetary policy stance ($-\beta_1 = 0.1$), while the effect is attenuated for Regional Banks ($-(\beta_1 + \beta_5) = 0.09$) and Sparkassen ($-(\beta_1 + \beta_6) = 0.09$). Model 10 confirms the previous results for the Euro period. Large banks are negatively affected by an (un)conventional monetary policy expansion. A one percentage point reduction in the interest rate leads to a 1% decrease in resilience ($-\beta_2$). Credit Unions and Sparkassen, on the other hand, increase their resilience by 10% ($-(\beta_2 + \beta_7)$) and 13% ($-(\beta_2 + \beta_{10})$), respectively. Landesbanken ($-(\beta_2 + \beta_8)$) and Regional Banks ($-(\beta_2 + \beta_9)$) increase their resilience only slightly in response to an interest rate reduction.

Table 4
Further Controls

	Explained Variable: ln(Z-Score)		Explained Variable: ln(Z-Score10) (10-year rolling window)	
	Model 11 - DM	Model 12 - Euro	Model 13 - DM	Model 14 - Euro
β_1 – deposit facility	-1.3141^{***}		-5.4723^{**}	
	(0.0768)		(2.2387)	
β_3 – df x Credit Unions	0.0119^{***}		-0.0049	
	(0.0034)		(0.0112)	
β_4 – df x Landesbanken	0.0229^{***}		0.1346^{***}	
	(0.0034)		(0.0172)	
β_5 – df x Regional Banks	0.0236^{***}		0.1005^{***}	
	(0.0031)		(0.0162)	
β_6 – df x Sparkassen	0.0219^{***}		-0.0541^{***}	
	(0.0030)		(0.0129)	
β_2 – ssr		0.0137		0.1184^{***}
		(0.0099)		(0.0375)
β_7 – ssr x Credit Unions		-0.0937^{***}		-0.0165
		(0.0040)		(0.0107)
β_8 – ssr x Landesbanken		-0.0782^{***}		0.0125
		(0.0039)		(0.0126)
β_9 – ssr x Regional Banks		-0.0698^{***}		-0.2725^{***}
		(0.0039)		(0.0119)
β_{10} – ssr x Sparkassen		-0.1448^{***}		0.1658^{***}
		(0.0040)		(0.0137)
β_{11} – balance sheet indicator	2.7628^{***}	-0.9673^{***}		
	(0.0901)	(0.0782)		
Time Fixed Effects	Yes	Yes	Yes	Yes
Bank Type Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.7543	0.8049	0.3661	0.7100
Adj. R^2	0.6911	0.7543	0.2016	0.6351
Observations	1805	1380	1210	1380
Years	1968-1998	1999-2021	1968-1998	1999-2021

*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.
For models with interaction terms, the default bank type is Large Banks. All regressions include time fixed effects and bank type fixed effects. Robust standard errors are applied (White 1980, White 1984, Arellano 1987). Industrial production, CPI and stock market capitalization are controlled for in all regressions.

Table 4 presents further robustness checks. In Model 11 and 12, we control for the heterogeneous balance sheet characteristics of the German bank types in our baseline estimations. To do so, we have constructed a single indicator[12] combining a variety of balance sheet information based on the related literature on the bank lending channel of monetary policy (i.e. Kashyap and Stein 2000, Bernanke 2007, Ashcraft and Campello 2007, Gambacorta and Marques-Ibanez 2011, De Santis and Surico 2013, Ciccarelli et al. 2013, Buch et al. 2019). The balance sheet indicator is used to control for the bank lending channel of

[12]The balance sheet indicator is constructed by using a variance-equal-weights-approach (see also Illing and Liu 2006, Morales and Estrada 2010 and Cardarelli et al. 2011). It is based on the following balance sheet information: deposit ratio, liquidity ratio, foreign liabilities ratio, foreign assets ratio, real economy funding ratio, government proxy ratio, inter-financial linkage ratio, bank funding gap ratio, investment banking ratio and size.

monetary policy.

In Model 13 and 14, we use a variation of our resilience indicator as a further robustness check. We compute the standard deviation of $roa_{i,t}$ on the basis of a 10-year-rolling window looking back in time.

The results in Model 11 yield different results regarding the interactions between the deposit facility and Credit Unions (β_3) and Landesbanken (β_4), which are now highly statistically significant and positive. The other results are in line with the results of Model 3 regarding size and significance of the coefficients. During the DM period, a more expansive monetary policy stance leads to a more resilient banking system regarding all bank types. Also, the balance sheet indicator is highly significant and positive. Model 12 shows the results of the baseline estimation including our balance sheet indicator for the Euro period. Now, the main effect (β_2) reflecting the effect for Large Banks is insignificant but still positive and comparable in size to the baseline estimation in Model 4. In contrast to the consistently positive effect of an expansionary monetary policy stance during the DM period, the positive sign reflects a negative impact of loose monetary policy on the resilience of Large Banks. The other coefficients for the interactions between monetary policy and the different bank types are almost identical in size and significance compared to the baseline estimation in Model 4. The results underline the heterogeneity of how monetary policy impacts bank type resilience during the DM period and the Euro period.

By and large, the results in Model 13 are in line with the results of Model 3. A reduction in the deposit facility rate leads to a stabilization and increase in German bank resilience during the DM period. The effect is most pronounced for Sparkassen ($-(\beta_1 + \beta_5) = 5.52$). Model 14 yields different results regarding the interaction between the ssr and Credit Unions (β_7) and Sparkassen (β_{10}). Now, a reduction in the short-term shadow rate leads to a decrease in resilience by 11% ($-(\beta_2+\beta_7)$) for Credit Unions, and 28% ($-(\beta_2+\beta_{10})$) for Sparkassen. The other results are in line with the baseline estimates in Model 4. Monetary expansion is associated with a reduction in resilience for Large Banks ($-\beta_2 = -0.12$) and Landesbanken ($-(\beta_2 + \beta_8) = -0.13$) and an increase in resilience for Regional Banks ($-(\beta_2 + \beta_9) = 0.15$).

5 Conclusion

The question of whether monetary policy, and especially unconventional monetary policy tools, are an effective means to maintain a more resilient and stable banking system remains a subject of ongoing debate. Recent research suggests that when the monetary policy stance is very accommodative over a long period of time, the probability of financial instability and financial crises increases (Grimm et al. 2023). Abadi et al. (2023) deliver a possible explanation why that is. They show that there exists an interest rate at which accommodative monetary policy is counterproductive for bank lending. Further monetary easing, especially through unconventional monetary policies, reduces bank profitability, constrains credit supply, and jeopardizes banking resilience and financial stability. The presented results provide evidence that conventional monetary policy easing was an appropriate means to increase the resilience of the German banking system during the DM period. However, since the introduction of the Euro, the way monetary policy is conducted changed significantly. Loose monetary

policy can still increase the resilience of the banking system as a whole, but also introduces significant risks. Large banks, which make up 21.8% of the German banking system and are often considered too big to fail, are increasingly negatively affected by unconventional monetary easing. One plausible explanation might be the fact that Large Banks are particularly active in the riskier foreign and securities business as well as investment banking (Eim 2004). In contrast, Sparkassen and Credit Unions have increased their resilience in response to the loose monetary policy stance of the ECB. This might be accredited to their strong and consistent business model. Sparkassen and Credit Unions are characterized as relationship banks which resolve information asymmetries in their banking business more effectively as they have been maintaining consistent relationships (relationship banking) with households and small and medium-sized enterprises within their business territory (Berger and Udell 2006, Shinozaki 2012). Therefore, these banks are less prone to introduce risks to their balance sheets by participating in more risky banking activities such as foreign and securities business or investment banking. This can also be seen in the balance sheets of Sparkassen and Credit Unions which have virtually zero foreign business activities, a very low inter-financial linkage and no investment banking activity. The presented evidence suggests that the low-interest rate environment in recent years has created problems for monetary policy to maintain a stable and resilient banking system. During the DM period, conventional interest rate cuts have been very effective in improving resilience. At the zero-lower bound they have become unfeasible. However, unconventional monetary policies seem to be less effective. Insofar as monetary policy attempts to improve resilience, a transition towards an environment of higher interest rates might be worthwhile.

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