Financial Markets and Portfolio Management (2022) 36:409–441
https://doi.org/10.1007/s11408-022-00406-x

Interest rate shocks, competition and bank liquidity creation

Thomas Kick[1,2]

Accepted: 3 February 2022 / Published online: 30 March 2022

Abstract
We study the effects of interest rate shocks (IRS) on banks' liquidity creation. A unique supervisory data set from the Deutsche Bundesbank allows identifying banks' liquidity creation for the real economy and the effects of banking market competition. Here, we employ a novel approach to account for IRS that are both *unexpected* and *effective for a bank's business model*. We find that higher individual pricing power in the market lowers banks' liquidity creation, which is in line with theory that monopolistic firms undersupply the market when utilizing their high pricing power in the *bank competition–liquidity creation nexus*. While positive IRS per se lead to an increase in bank liquidity creation, we find that a high bank-individual pricing power curbs this impact on liquidity creation significantly. Moreover, we show that monetary policy was most effective during the global financial crisis and for well-capitalized banks, whereas periods of low interest rates are characterized by the persistent increase in liability-side liquidity creation.

Keywords Bank liquidity creation · Unexpected monetary policy · Low interest rate environment · Financial crisis · Financial markets regulation · Banking market competition · Dynamic GMM

JEL Classification G21 · G28 · G30 · C23

1 Introduction

There is broad consensus in the literature that the financial system is of utmost importance for the macroeconomy. In this context, banks' raison d'être is liquidity creation for the real economy which must be both sufficiently high not to choke economic

✉ Thomas Kick
thomas.kick@bundesbank.de

1 Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main, Germany

2 Friedrich-Alexander Universität Erlangen-Nürnberg, Lange Gasse 20, 90403 Nürnberg, Germany

growth and moderate enough not to cause an overheating of the economy. The main goal of a central bank is to stabilize the creation of liquidity over the business cycle through monetary policy. When central banks raise interest rates, liquid deposits flow out of the banking system because banks may increase spreads on deposits, and thereby contract lending with stricter responses in areas with higher concentrated bank activity (Drechsler et al. 2017). On the other hand, banks create more liquidity when asset market liquidity is raised through transmission of monetary policy. Berger and Bouwman (2009) developed a comprehensive measure of liquidity creation by banks that builds the backbone for empirical research in this topic, thereby they find that liquidity creation varies substantially across banks. A question that is to be raised is: To what extend drives the structure of the banking sector, i.e. the regional competition, the variation of banks' responses to monetary policy shocks?

This paper aims to answer this question and studies the impact of competition on the liquidity creation by banks in response to interest rate shocks (IRS) using bank-level panel data over all German banks. We find that higher individual pricing power in the market lowers banks' liquidity creation. An increase in pricing power by 1 percentage point is associated with a decrease in total liquidity creation by 0.053 percentage points in the long run and is even more pronounced in the presence of unexpected interest rate shocks. The effect is driven by asset-side liquidity creation. This is in line with theory that monopolistic firms undersupply the market when utilizing their high pricing power in the *bank competition–liquidity creation nexus*. The implication for a monopolistic banking market is that banks can price long-term deposits lowly and short-term loans highly, resulting in high margins. Furthermore, an unexpected effective interest rate shock by 1 percentage point implies an average increase in total liquidity creation by 0.025 percentage points. An unexpected increase in interest rates causes present value losses in the short run, but also raises a bank's profit opportunities and, therefore, per se leads to higher liquidity creation activities in financial institutions. Banks expand their position in liquid assets while taking on fewer liquid deposits. But the pass-through of IRS also depends on the bank-specific level of competition, where we find that a high bank-individual pricing power curbs this impact on liquidity creation significantly in the *monetary policy–bank competition–liquidity creation nexus*. Our results indicate that banks decide to increase business activities to compensate for the short run present value loss of equity capital caused by the unexpected IRS and/or to gain from the more profitable business environment in the medium/long run following a positive IRS, and vice versa. Effects are in particular more pronounced in times of crisis, in which banks are forced to counteract, as well as for well capitalized banks as they are less restricted in their liquidity creation by regulation and supervisory constraints. Furthermore, we observe a sharp increase in the liquidity creation of banks in the Low Interest Rate Environment (LIRE) period, which is mainly driven by a rising liability-side liquidity creation, presumably since the LIRE allows banks to increase their earnings by transforming long-term loans they issued to excess liquidity on the liability side—which is, for example, parked overnight at other banks.

This paper contributes to the existing literature in two ways. First, we investigate the interactions of bank competition and monetary policy on liquidity creation. We measure a bank's pricing power by the adjusted Lerner index which takes into account the relative efficiency in the banking market including loan and deposit markets

(Table 1). GMM panel regression analysis accounts for variation over time and across banks. We follow Berger and Bouwman (2009) and derive the liquidity creation measure by classifying all bank activities as liquid, semi-liquid, or illiquid based on product category and maturity, and decompose them into asset-side liquidity creation, liability-side liquidity creation, and liquidity creation off the balance sheet (see Table 2). Liquidity creation reflects bank output better than lending since it takes into account both assets and liabilities. Second, the paper employs a novel approach to account for IRS that are both *unexpected* and *effective for a bank's business model*. We define *unexpected* shocks as the deviation of the interest spot rate from the previous year's implicit forward rate and scale shocks with the bank individual Basel Interest Rate Coefficient *(Basel IRC)* to account for interest rate shocks affecting banks differently. There are several reasons why the *effective* IRS should be employed instead of a simple IRS measure not taking into account banks' business model sensitivity to interest rates:

(*i*) the Basel IRC is a valid proxy for a bank's business model sensitivity to interest rate risk. Hence, banks with a business model resulting in a high Basel IRC (e.g. cooperative and savings banks) are also highly affected by an interest rate shock, while banks with a Basel IRC close to zero (e.g. some private banks) would hardly be affected by interest risk.

(*ii*) in the short run positive interest rate shocks induce high present value losses for banks with interest-rate-sensitive business models, and vice versa. We therefore hypothesize that the management of a bank with a high Basel IRC has to decide how to compensate for a short run present value loss after a positive IRS with either an increase in business activities and liquidity creation, or a shrinking of the balance sheet.

(*iii*) in the medium/long run rising interest rates also bear higher profitability for banks with interest-rate-sensitive business models (e.g. Busch and Memmel (2017), Claessens et al. (2018)). We therefore hypothesize that the management of a bank with a high Basel IRC has to decide how much to increase business activities after a positive IRS in order to gain from the more profitable environment, and vice versa.

After summarizing some related literature we proceed as follows. Section 2 discusses both the institutional background and the German banking market with a special focus on competition. Section 3 introduces the data and the methodology including the model specification and the measurement of liquidity creation and competition. Section 4 presents the results and Sect. 5 concludes.

1.1 Related literature

1.1.1 Bank liquidity creation in the context of monetary policy

Berger et al. (2016) show that there is a need to curb liquidity creation by banks in the course of capital support measures, as well as by regulatory interventions in the course of the ongoing monitoring of individual banks. Banks adjust their supply of loans and liquidity to the real economy directly in response to changes in monetary policy, thereby affecting the efficacy of monetary stimuli. Berger and Bouwman (2017)

find a positive effect on liquidity creation in response to a loosening of monetary policy for small banks. However, the effect is insignificant for medium-sized and large banks, meaning monetary policy has neither a consistent effect on these banks' on-balance nor off-balance sheet liquidity creation. Moreover, they find that the central bank's monetary policy impact on bank liquidity creation is crucial in particular during crisis periods. In contrast, Berger et al. (2016) find effects of monetary policy on liquidity creation being generally weaker during financial crises compared to normal times. They argue that banks are not willing to expand their lending during financial crises due to asymmetric information and a higher level of uncertainty which dampens the efficacy of a monetary policy loosening.

Building upon the previous work of Berger and Bouwman (2017), Chatterjee (2015) argues that monetary policy affects the borrowing costs of banks. The author finds that monetary policy induces a change in asset market liquidity and credit spreads, which both are driving factors for bank liquidity creation. This effect is again described to be more substantial for smaller banks. Pham et al. (2021) examine the effects of monetary policy on liquidity creation by Vietnamese banks, conditional on the banks' size. The results resemble those of Berger and Bouwman (2017) for the US market, i.e. contractionary monetary policy leads to a decreasing liquidity creation, and the effect is more distinct for smaller banks. Also relying on data from the Vietnamese market, Dang (2022) finds that liquidity creation is boosted after a relaxation of monetary policy, but greater market power and a more diversified funding structure might weaken the transmission effects.

1.1.2 Bank liquidity creation and competition

For the question how IRS propagate through the banking system, banks' price setting power (and therefore its competitive strength) in the market plays an important role, first in the transmission into banks' balance sheets and later as provision of liquidity for the macroeconomy. Through mergers and acquisitions, the European banking sector has undergone considerable changes, affecting banks' ability to set prices. De Guevara et al. (2005) analyze the evolution of market power and its determinants in the main banking sectors in Germany, France, the United Kingdom, Italy and Spain during the period from 1992 to 1999 by calculating the Lerner Index and find considerable cross country differences as well as a growing trend. While the UK has the greatest relative margin in setting prices, followed by Italy, France has the least, albeit the Lerner Index generally increases in all countries. This shows that despite the deregulation of the European banking system, market power continues to persist. However, there are contrary ideas about the relationship between competition and banks' liquidity supply. According to Hannan (1991), banks with higher pricing power can raise lending interest rates resulting in a reduction of firms credit demand. Furthermore, facing a less competitive environment, banks want to enhance their charter values by imposing higher loan rates and decreasing deposit rates.

All provided arguments result in provision of less liquidity. However, the opposite can be the case. Jeong and Joh (2011) provide evidence that the banking industry increases the aggregate loan supply, imposing more systemic risk on the economy when the market is concentrated. Kick and Prieto (2015) investigate the *monetary*

policy–bank competition–stability nexus and find that a low level of competition, indicated by a high Lerner index[1], is associated with a low probability of bank distress as well as a curbed monetary policy shock pass-through. Drechsler et al. (2017) study the deposit channel of monetary policy transmission and find that areas with higher concentration deposit flows were more sensitive to monetary policy rate changes. Fungáčová et al. (2014) study the effect of bank competition on the lending channel of monetary policy transmission, observing that higher bank competition fosters the transmission of monetary policy through the bank lending channel. However, this effect can only be observed for pre-crisis data. In the context of EU-15 countries, Maudos and de Guevara (2007) examine the interconnection between market power in the loan and deposit markets and cost efficiency from 1993 to 2002, reporting both an increasing degree of market power in the loan market and a shrinking level of market power in the deposit market. The corresponding welfare loss is estimated to amount to 0.54% of the European Union countries' GDP.

Moreover, Carbó et al. (2009) calculate net interest margins, Lerner indices, returns on assets, H-statistics, and Herfindahl-Hirschman indices for their cross-sectional study of 14 European countries for a sample period between 1995 and 2001, obtaining contrasting results across countries, within countries and over time. Denmark and Italy show the highest margins (4.7% and 3.5%) while Luxembourg and Ireland remain with the lowest (0.8% and 1.2%). On the other hand, for Denmark and Spain the study presents the highest Lerner index values (22% and 20%) whereas Luxembourg and the UK show the lowest (11% and 11%). Similar contrasting results can be observed for the rest of the measures. Hence, they argue that actual market power in the European banking market could be stronger than implied by traditional measures.

Horváth et al. (2016) conduct dynamic GMM panel estimations to analyze the Czech banking market between 2002 and 2010. They find that enhanced competition has a negative effect on liquidity creation. These findings corroborate the hypothesis that intensified competition increases the fragility of the banking system as a result of individual banks' profit reduction. Horváth et al. (2014) provide evidence for a negative Granger-causality of tighter capital requirements on liquidity creation, but the latter one also Granger-causes a reduction in capital.

On competition and bank liquidity creation Jiang et al. (2019) show that deregulatory reforms in the U.S. interbank market, which resulted in an increasing degree of competition, increased asset-side driven liquidity creation. Tran et al. (2016) find that liquidity creation has a negative relationship with a bank's performance, but a positive with regulatory capital, which holds true mainly for small banks. Ippolito et al. (2016) state that increasing competition can induce a risk reduction by the bank, and Boot and Thakor (2000) present evidence that more interbank competition goes along with an increasing amount of relationship loans. Hence, the findings also suggest an increment in liquidity creation.

Schaeck and Cihák (2012) find that competition increases banks' capital holdings, and also Schaeck and Cihák (2014) find for European countries that bank risk is negatively affected by market competition. In addition, Boyd et al. (2007) show that

[1] Note that for different concepts of competition, i.e. using the Boone indicator (Boone 2008) instead of the Lerner index, the outcomes change.

less-concentrated banking markets are characterized by lower Z-scores. Jiménez et al. (2013) find no relationship between market concentration and credit risk, but a positive effect of competition on credit risk. At the same time, however, more competition also reduces banks' exposure to risk (e.g. Beck et al. (2006) and Schaeck et al. (2009)). All in all, there exists only a rather limited body of literature that evaluates the direct interconnection between liquidity creation and the degree of competition in the banking market.

2 Institutional background and the german banking market

We study the effects of unexpected IRS on banks' liquidity creation based on a set of supervisory microdata. The German system of universal banks with its three pillars including commercial banks, savings banks and cooperative banks constitutes an excellent laboratory to investigate this research question. The commercial bank sector comprises medium-sized private regional banks and large internationally active institutions, the savings bank sector is composed of medium-sized savings banks as well as large *Landesbanks* as money center banks, which are owned by governments at the city-, county-, or state-level, and the cooperative bank sector includes rather small cooperative banks as well as a few large money center banks. All three pillars differ in ownership structure, geographical reach and core business model (Brunner et al. 2004; Kick et al. 2016). The regional demarcation principle only allows savings and cooperative banks to operate in geographically segmented markets which limits these banks' activities to their designated regions usually consisting of one or a limited number of multiple adjoining counties (Berger et al. 2016). Furthermore, the regional demarcation principle ensures that savings and cooperative banks do not engage in competition with each other since they should carry out their public responsibilities and serve the interest of their owners, respectively. In comparison to the private sector, this also means that savings and cooperative banks are not strictly profit maximizing. Over the last two decades, the German banking system has been subject to fundamental changes (see e.g. Koetter (2013)). Hence, in the German banking market the number of universal banks has decreased from 3228 banks in 1999 to 1593 banks in 2017 while aggregate total assets have increased from 4662 billion euros in 1999 to 6589 billion euros in 2017.[2]

[2] In 2017 there were 263 *Commercial banks* (47.5% of total assets), 13 *Mortgage banks* (3.5% of total assets), 399 *Savings banks and Landesbanks* (31.3% of total assets), and 918 *Cooperative banks* (17.8% of total assets) while in 1999 there were 328 *Commercial banks* (27.8% of total assets), 33 *Mortgage banks* (17.1% of total assets), 607 *Savings banks and Landesbanks* (39.7% of total assets), and 2260 *Cooperative banks* (15.5% of total assets); see Deutsche Bundesbank (2018a) and Deutsche Bundesbank (1999). Note that there are also specialized banks such as *Credit institutions with special functions* as well as *Building and loan associations* in Germany which are not included in this study.

3 Data and methodology

3.1 Data

We use annual data provided by the Deutsche Bundesbank which contains all universal banks operating in Germany between 1999 and 2017. A specific bank is excluded from the analyses if it has either no loans outstanding, zero deposits, or balance sheet items with negative values. Mergers and acquisitions (M&A) are treated in the conventional way which means that we artificially create a "new bank" independent of the pre-M&A entities, which starts operating in the M&A year. In addition, we winsorize each variable at the 2% and 98% quantile to account for outliers. Preparing the data set according to these constraints results in a sample with 26,534 bank-year observations for 2,914 banks described in Table 3.

3.2 Measuring liquidity creation

In our analysis, we adopt the measure of liquidity creation introduced by Berger and Bouwman (2009) in a slightly modified form. It is based on the notion that liquidity is created when illiquid assets are transformed into liquid liabilities. The procedure is divided into three steps as illustrated in Table 2. In the first step, all bank activities are classified as liquid, semi-liquid, or illiquid based on product category and maturity. In a second step, weights are assigned to each activity according to the classification in step 1. A bank creates more liquidity the more illiquid assets and liquid liabilities are contained in its balance sheet. Hence, a positive weight $(1/2)$ is attributed to these activities. On the contrary, a negative weight $(-1/2)$ is assigned to liquid assets and illiquid liabilities. Semi-liquid assets and liabilities are weighted with zero. Off the balance sheet, a weight of $1/2$ is assigned to illiquid guarantees. In step 3, all bank activities are combined as classified in step 1 and weighted in step 2. Three different measures can be calculated according to whether asset-side or liability-side liquidity creation as well as off-balance sheet activities are considered. The weights of $\pm 1/2$ are used because liquidity is only half determined by the source or use of funds alone (Berger and Bouwman (2009)).

In order to get a more detailed view on how monetary policy and competition affect banks' liquidity creation, the various components of liquidity creation are analyzed. Following Berger et al. (2016), we split total liquidity creation into *asset-side*, *liability-side*, and *off-balance sheet* liquidity creation.

3.3 Measuring market power and competition

For the measures of market power and competition, we resort to the methodology used in Kick and Prieto (2015). The Lerner index is applied to measure the degree of pricing power on the bank level. It represents the markup of prices over marginal costs. Since marginal costs cannot be observed directly, they have been estimated based on a stochastic frontier analysis panel approach similar to the approaches used in Koetter

et al. (2012), Kick et al. (2015), and Kick and Prieto (2015).[3] Consequently, we estimate a translog cost function taking into account funding, labor, and fixed capital as factor inputs. Customer loans, business loans, and securities represent a bank's possible outputs. Equity capital is included since it can be used to fund income-generating output and also seizes disparate risk attitudes. In addition, time trends are included to control for changes in the production technology of a bank. The Lerner index is a measure of a bank's individual pricing power in the overall banking market including loan and deposit markets.

3.4 Measuring interest rate shocks

We measure interest rate shocks as the deviation of the 1-year Bund rate from its previous year's implicit forward rate in monthly averages. The 1-year Bund rate is short enough to reflect the interest rate shocks, but also sufficiently long to capture not only changes in interest rates, but also from other potential drivers such as European Central Bank's full allotment policy, asset purchasing programs, and operations. The monthly averaging allows a bank's balance sheet exposure to be treated over a full year. We differentiate between *unexpected interest rate shocks* versus *effective unexpected interest rate shocks*, with the latter accounting for the extent a bank's business model is exposed to interest rate risk by scaling them with the Basel IRC. The Basel IRC is a standardized indicator for a bank's interest rate risk in the banking book, taking into account all material banking book positions that carry interest rate risk.[4] That is, all on-balance sheet and off-balance sheet transactions feed into the calculations, including margin income, derivatives, and liquidity reserve (e.g. Deutsche Bundesbank (2012)). The IRC is computed as the banking book exposures as the percentage of total funds due to an increase or decrease of 200 basis points of the yield curve for each bank separately. Here, the median bank suffers from the +200 bp interest rate shock with a present value loss equaling roughly one fifth of its equity capital—with large business model-driven deviations between private banks (small effects), savings banks, and cooperative banks (large effects) (e.g. Deutsche Bundesbank (2018b)). Thus, the weighting of monetary policy measures with the absolute value of the BASEL IRC gives us the bank-specific effective unexpected IRS (see Table 1 for a detailed description). Drechsler et al. (2018) find that banks hedge their interest rate risk through maturity transformations. In order to mitigate potential endogeneity issues the average value of Basel IRC is taken, while the liquidity creation is calculated based on the end-year balance sheet.

3.5 Identification issues

In order to examine the effect of effective unexpected IRS on a bank's liquidity creation and the relation to pricing power and competition, we use a panel regression model in which the EFFECTIVE UNEXPECTED IRS is specified. This is the superior

[3] A detailed description of the Lerner index can be found in the Appendix in Sect. A.1.

[4] Since 2011, the Basel IRC is reported to the Deutsche Bundesbank on a bank-by-bank basis.

Table 1 Variable Description

Dependent variables	
TOTAL LC	Total liquidity creation scaled by total assets (in %); see also Table 2
ASSET- SIDE LC	Asset-side liquidity creation scaled by total assets (in %); see also Table 2
LIABILITY- SIDE LC	Liability-side liquidity creation scaled by total assets (in %); see also Table 2
OFF- BALANCE SHEET LC	Liquidity creation off the balance sheet scaled by total assets (in %); see also Table 2
Dummy Variables for Sample-Splits	
LIRE DUMMY	Low interest rate environment (LIRE) dummy identifying the years 2012-2017
CRISIS DUMMY	Crisis dummy identifying the years 2007–2009 ("financial and economic crisis")
CAR DUMMY	Dummy for well and poorly capitalized banks split by the median of capital adequacy ratio (CAR). CAR is defined by Tier 1 capital divided by risk-weighted assets. The split is done by the average CAR over the years 1999-2017 (i.e. banks are not allowed to change from one to the other CAR regime over the sample period)
Pricing Power and Monetary Policy Variables	
LERNER INDEX	Inefficiency-adjusted Lerner index (i.e. calculated net of cost and income inefficiencies in the production process) derived from a stochastic frontier analysis; this measure represents the markups of prices over marginal costs and therefore reflects a bank's price setting power in the market
UNEXPECTED IRS	Unexpected interest rate shock. Deviation of the 1-year Bund rate (monthly averages) from its previous year's implicit forward rate (monthly averages). Here, the monthly averaging allows a bank's balance sheets exposure to be treated over a full year
BASEL IRC	The *Basel Interest Rate Coefficient* measures the banking book exposures as the percentage of total funds due to an increase or decrease of 200 basis points of the yield curve (the largest exposure of both scenarios) for each bank separately. Therefore, the Basel IRC is a standard measure for bank's interest rate risk sensitivity
EFFECTIVE UNEXPECTED IRS	Effective unexpected interest rate shock. Deviation of the 1-year Bund rate (monthly averages) from its previous year's implicit forward rate (monthly averages) times the absolute value of a bank's BASEL IRC. Here, the monthly averaging allows a bank's balance sheets exposure to be treated over a full year while weighting the unexpected interest rate shock with the BASEL IRC accounts for how much a bank's business model is exposed to interest rate risk

Table 1 continued

LERNER x UNEXPECTED IRS	Interaction term of Lerner index (LERNER INDEX) and the unexpected interest rate shock (UNEXPECTED IRS)
LERNER x EFFECTIVE UNEXPECTED IRS	Interaction term of Lerner index (LERNER INDEX) and the effective unexpected interest rate shock (EFFECTIVE UNEXPECTED IRS)
Bank-Specific Control Variables	
BANK SIZE	Log (ln) of total assets
SECTOR HHI	Herfindahl-Hirschman index (HHI) of the domestic loan portfolio (in %). 27-sector classification; higher values indicate a higher concentration in the domestic loan portfolio
SHARE FEE INCOME	Fee income over total operative income (in %); it includes interest income, fee income and trading income
NPL RATIO	Non-performing loans over customer loans (in %)
Controls for Bank-Individual Effects and Demand Effects	
GDP GROWTH	Output growth (real GDP) in the relevant market (in %); i.e. county-level for savings banks, cooperative banks, regional commercial banks; state-level for Landesbanks; federal-level for central cooperative banks and large private banks
BANK FIXED EFFECTS	Bank fixed effects to control for the effects of any observed or unobserved factors that affect a bank's liquidity creation on average
YEAR FIXED EFFECTS	Year dummies to control for average effects observed for all banks in a particular year (i.e. the general economic situation ("business cycle") and demand effects)

model specification as the EFFECTIVE UNEXPECTED IRS varies in the cross-section and time (while, for example, the UNEXPECTED IRS has only a time dimension) which allows to control for time fixed effects in accounting for a bank's business model reaction in the interest rate pass-through. Therefore, we estimate a dynamic specification of liquidity creation by the two-step GMM estimator, including time fixed effects in addition to bank fixed effects, an array of bank-specific variables accounting for business characteristics, and output growth (real GDP) in the relevant market.[5] Being able to specify fixed effects along time and cross-sectional dimension contrasts our identification from previous studies such as Horváth et al. (2014) and Horváth et al. (2016).

[5] Note that we refrain from specifying additional macroeconomic variables without variation in the cross-section, as the business cycle effects are already captured by the time fixed effects, and to avoid misspecification from perfect collinearity with those effects.

3.6 Model specification

We use the following panel regression models in which UNEXPECTED IRS (1) and EFFECTIVE UNEXPECTED IRS (2) are specified separately. While Model 2 is the superior specification as it allows to control for time fixed effects due to cross-sectional variation in EFFECTIVE UNEXPECTED IRS, Model 1 is contrasted to show the bias from an inferior model specification.[6]

$$\begin{aligned} LC_{i,t} = {} & \beta_0 + \beta_1 LC_{i,t-1} + \beta_2 Lerner_{i,t} + \beta_3 UnexpectedIRS_{t-1} \\ & + \beta_4 Lerner_{i,t} \times UnexpectedIRS_{t-1} + B_5' Controls_{i,t} + \gamma Bank_i + \epsilon_{i,t} \end{aligned} \tag{1}$$

$$\begin{aligned} LC_{i,t} = {} & \beta_0 + \beta_1 LC_{i,t-1} + \beta_2 Lerner_{i,t} + \beta_3 EffectiveUnexpectedIRS_{i,t-1} \\ & + \beta_4 Lerner_{i,t} \times EffectiveUnexpectedIRS_{i,t-1} + B_5' Controls_{i,t} \\ & + \gamma Bank_i + \delta Year_t + \epsilon_{i,t} \end{aligned} \tag{2}$$

$LC_{I,T}$ represents *total liquidity creation* or liquidity creation in terms of one of its components, *asset-side*, *liability-side* and *off-balance sheet* liquidity creation, scaled by total assets at bank i from year *t-1* to year t in %. To account for dynamics in liquidity creation, one lag of the dependent variable $LC_{I,t-1}$ is included. The coefficient β_2 captures the effect of the competition measure utilized, namely the inefficiency-adjusted Lerner index, measuring the pricing power of individual banks. Parameter β_3 describes the effect of the different types of IRS being contrasted. We run all regressions with the *unexpected* IRS and the *effective unexpected* IRS to highlight its significance in isolating the importance of exposure. The main coefficient of interest is β_4, representing the interaction term of the applied competition measure and the IRS. The vector B_5 represents the control variables' influence on a bank's liquidity creation. The regression approach controls for bank-specific variables taking into account business model-related characteristics such as BANK SIZE, SECTOR HHI (%), SHARE FEE INCOME (%), and NPL RATIO (%). Furthermore, GDP GROWTH (%), bank fixed effects, $BANK_i$, and year fixed effects (only Model 2), $YEAR_t$, control for the effects of any observed or unobserved factors that affect a bank's liquidity creation on average, as well as the general economic and financial situation[7] and demand effects.[8] The dynamic specification of liquidity creation is estimated by the two-step GMM estimator proposed by Arellano and Bond (1991) with a finite sample correction in the spirit of Windmeijer (2005). Instead of first differences the orthogonal deviations transformation is applied to maximize the sample size for the used panel data set with gaps. Throughout all regressions, we report the first-order and second-order autocorrelation tests and the Hansen J-statistics to examine correct lag length specification and the overidentification restrictions. For both the second-order autocorrelation test and the Hansen J-statistics, the null hypotheses cannot be rejected in the models of

[6] For comparability reasons Model 1 and 2 are based on the same dynamic GMM regression model where diagnostics are calibrated on Model 2 which induces some misspecification for Model 1 (i.e. p-values for the AR(2) are often low).

[7] E.g. European Central Bank's policy changes.

[8] A detailed variable description is given in Table 1.

main interest, which indicates that the models are well specified and the instruments are valid.

3.7 Descriptive statistics

Table 3 presents summary statistics for the total liquidity creation measure and its components, sample split dummies, pricing power and competition measures, monetary policy indicators, as well as control variables, distinguishing between different sub-samples. Panel A shows descriptive statistics for the total number of banks in the sample. We find that banks on average created liquidity of 23.21% based on the preferred total liquidity creation measure. Distinguishing between the different components of total liquidity creation, asset-side liquidity creation amounts on average to 12.18%, liability-side liquidity creation corresponds on average to 8.11%, and liquidity creation off the balance sheet is on average allotted to an amount of 2.78%. For the whole sample period, the Lerner index mean equals 0.30. The control variables provide a more detailed insight into the composition of the utilized data set. The banks in our sample are characterized by mean BANK SIZE of 19.91 (€443.408 million) and an average SECTOR HHI value of 12.82%. Furthermore, their average SHARE FEE INCOME adds up to 14.47% whereas their mean NPL RATIO is 4.00%. The average GDP GROWTH within the sample period amounts to 1.55%.

Panel B discriminates between well and poorly capitalized banks with total liquidity creation averaging 20.02% versus 26.38%, showing higher liquidity creation (mainly driven by asset-side liquidity creation) for banks with capital adequate ratios below median. The pricing power (measured by the Lerner index) does not differ substantially between well and poorly capitalized banks.

Panel C distinguishes between periods of normal times, periods characterized by financial crises and periods in which banks were confronted with a low interest rate environment. The LIRE dummy and CRISIS dummy depicted in Panel A indicate that 31% and 21% of the sample are characterized by periods attributed with LIRE and financial crises, respectively. Interestingly, in LIRE years average total liquidity creation increases to 27.01% which is mainly driven by liability-side liquidity creation. Also in LIRE times a severe increase in individual banks' pricing power can be noticed which is indicated by an average Lerner index of 0.40 in comparison with 0.28 in non-LIRE and non-crisis times.

Panels D and E show descriptive statistics for robustness checks removing both banks with capital support measures (mainly provided by bankers associations insurance schemes) on their balance sheets and banks with turnovers in their executive boards, respectively.

Figure 1 contrasts how liquidity creation, competition and unexpected effective IRS have evolved from 2001 to 2017. Panel (a) reveals a liability-side driven increase in average total liquidity creation in the LIRE period. Here, the increase in the liability-side driven liquidity, which occurs by transforming illiquid assets to liquid liabilities, is conducted by banks to potentially induce an increase in the banks' earnings, given that the LIRE allows banks to store excess liquidity at other banks at feasible conditions. Simultaneously, banks face decreasing potential losses from outstanding loans

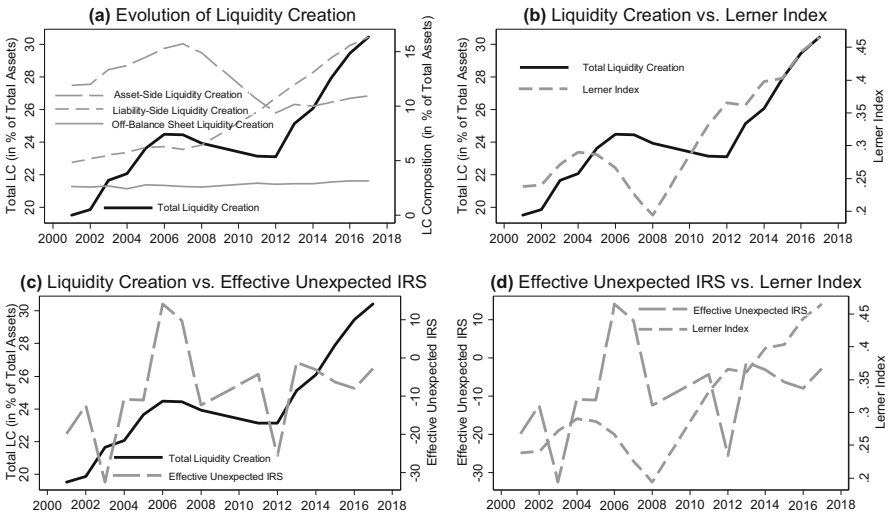

Fig. 1 Liquidity Creation, Competition, Effective Unexpected IRS

to conditions detrimental for the bank given the LIRE. Also, as presented in Panel (b), banks' pricing power (measured by the Lerner index) increases sharply in the LIRE which is mainly driven by a halving of marginal costs and a reduction of banks in the market by about 14% from 2011 to 2017. That is, universal banks in Germany react to LIRE with cost-cuttings and restructuring mergers.[9] In addition, we contrast effective unexpected IRS, which appears to be negative for almost the whole 2001–2017 period, with total liquidity creation (Panel (c)) and with the Lerner index (Panel (d)), where both indicators tend to evolve in opposite directions.

4 Results

The following subsections provide a detailed discussion of the main results as well as the outcome from various sample splits. Also, in further robustness checks possible identification concerns are addressed and the validity of the results is confirmed.

[9] Note that there is a broad body of literature that gauges market power and the degree of competitiveness in the German banking industry. Koetter (2013) documents Lerner indices equal to 0.39 on average in which large commercial banks and central savings and cooperative banks overshadow the market power of other banks with mean markups between 0.58 and 0.76. Until 2001, no sizable change in price markups can be observed before market power increases gradually in the run-up to the global financial crisis starting in 2007. During the financial crisis, bank's average revenues diminished whereas their marginal cost remained constant leading to a contraction in markups. After the crisis, marginal costs declined which resulted in a sharp increase in market power. Koetter and Poghosyan (2009) depict a similar evolution of market power for the German banking system based on latent group-specific Lerner index estimates. Analyzing a sample period from 1994 to 2004, they show that small and government-owned banks face less market power than commercial banks (which can extract larger rents due to close customer ties) where they report a mean (unadjusted) Lerner index for Germany of 0.19. Buch et al. (2013) report mean Lerner indices of 0.23 for the German bank sector between 2003 and 2006 highlighting smaller values of market power for banks with foreign branches.

4.1 Main results

Table 4 shows the main results of the dynamic GMM panel regressions including bank fixed effects and year fixed effects. Our results indicate that banks decide to increase business activities to compensate for the short run present value loss of equity capital caused by the unexpected IRS[10] and/or gain from the more profitable business environment in the medium/long run following a positive IRS, and vice versa.

Panel A depicts that TOTAL LC is characterized by persistency with a coefficient for lagged liquidity creation around 0.8 for all banks in the sample when employing the most appropriate Model 2 specification taking into account the *effective unexpected IRS* and year fixed effects. Here, also the coefficients of the LERNER INDEX are significantly negative confirming the view that higher individual pricing power in the market lowers those banks' liquidity creation.[11] This is in line with theory that monopolistic firms (in contrast to perfect competition) undersupply the market when utilizing their high pricing power. These results are in contrast to Horváth et al. (2016) who find a positive and significant effect of the Lerner index on liquidity creation in the Czech banking market between 2002 and 2010. We differ from this study in terms of banking market[12] and time period, but also that bank fixed and time fixed effects are key in our identification strategy. From Model 1, for example, we see that in a model specification without time fixed effects the significance of the Lerner index disappears. Our findings on competition and bank liquidity creation also differ from Jiang et al. (2019), who provide evidence for a positive relationship between competition and a reduced liquidity creation. However, their results are based on regulatory induced competition, while our study measures competition in terms of banks' pricing power. Additionally, their results are mainly based on evidence from the US interbank reforms with data from 1984 to 2006. Hence, the asset-side driven liquidity creation is of greater importance, rather than the liability-side driven liquidity creation following a period of low interest rates, as described in our study.

Moreover, a positive effective unexpected IRS leads to a significant increase in liquidity creation, and vice versa. While an unexpected increase in interest rates causes present value losses in the short run, it also raises a bank's profit opportunities and therefore leads to higher liquidity creation activities in financial institutions. But the effect of IRS also depends on the bank-specific level of competition. The negative coefficient on the interaction term of Lerner index and effective unexpected IRS reveals that a high bank-individual pricing power (measured by the Lerner index) curbs this impact on liquidity creation significantly.

[10] The median bank suffers from the +200 bp interest rate shock with a present value loss of roughly one fifth of its equity capital, with large business model-driven deviations between private banks (small effects) and savings banks and cooperative banks (large effects).

[11] The coefficients on the Lerner index are insignificant for Model 1 as in this specification no year fixed effects can be included due to perfect multicollinearity with UNEXPECTED IRS.

[12] Following Horváth et al. (2016) there is a particular high share of foreign owned banks in the Czech banking market and thus, foreign influence may dominate domestic bank competition characteristics. In addition, as the impact of the financial crisis on the Czech financial system was limited, it is reasonable to assume that the positive effect of bank competition on liquidity creation is not weakened as it would happen in a more affected economy.

Table 2 Liquidity Creation

Step 1: Classify all bank activities as liquid, semi-liquid, or illiquid based on product category (Cat) and maturity (Mat).

Step 2: Assign weights to the activities classified in Step 1.

ASSETS:

Illiquid assets (weight = 1/2)	**Semi-liquid assets (weight = 0)**	**Liquid assets (weight = −1/2)**
Loans to credit institutions > 1 year	Loans to credit institutions ≤ 1 year	Cash and due from other institutions
Loans to customers > 1 year	Loans to customers ≤ 1 year	Loans to credit institutions (due daily)
Premises		Exchange listed fixed income securities
Intangible assets		Exchange listed equities and other non-fixed income securities
Non exchange listed fixed income securities		Exchange listed investments in unconsolidated subsidiaries
Non exchange listed equities and other non-fixed income securities		Exchange listed participation rights
Non exchange listed investments in unconsolidated subsidiaries		
Non exchange listed participation rights		
Subordinated loans to customers		
Subordinated loans to credit institutions		
Other subordinated assets		
Other real estate owned		

LIABILITIES PLUS EQUITY:

Liquid liabilities (weight = 1/2)	**Semi-liquid liabilities (weight = 0)**	**Illiquid liabilities (weight = −1/2)**
Liabilities to credit institutions (overnight funds)	Savings deposits	Liabilities to credit institutions > 1 year
Other liabilities to customers (transaction deposits)	Time deposits	Other tradable liabilities > 1 year
	Liabilities to credit institutions ≤ 1 year	Bank's liability on bankers acceptances
	Other tradable liabilities ≤ 1 year	Subordinated debt
		Equity

Table 2 continued

OFF- BALANCE SHEET ACTIVITIES:
Illiquid guarantees (weight = $1/2$**)**
Lines of credit
Guarantees
Standby letters of credit
All other off-balance sheet liabilities
Step 3: Combine bank activities as classified in Step 1 and as weighted in Step 2 to construct two liquidity creation measures that include off-balance sheet activities ('Mat Cat Fat') and split this measure into asset-side, liability-side, and off-balance sheet liquidity creation.
Mat Cat Fat =
$+1/2$*illiquid assets + $1/2$*liquid liabilities + $1/2$*illiquid guarantees + 0*semi-liquid assets + 0*semi-liquid liabilities $-1/2$*liquid assets $-1/2$*illiquid liabilities (including equity)

Table 3 Descriptive statistics

Variable	Panel A			Panel B						Panel C					
	All Universal Banks			Well Capitalized Banks			Poorly Capitalized Banks			LIRE Years			Non-LIRE/Non-Crisis Years		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Total LC	23.21	23.79	11.51	20.02	20.65	12.07	26.38	26.41	9.95	27.01	28.31	13.30	21.55	22.35	10.36
Asset-Side LC	12.18	13.65	10.59	8.78	10.42	11.22	15.57	16.46	8.68	10.33	11.71	11.58	12.71	14.09	10.02
Liability-Side LC	8.11	6.86	5.76	8.57	7.47	6.10	7.65	6.35	5.36	13.58	13.51	6.01	5.94	5.11	4.10
Off-Balance Sheet LC	2.78	2.37	1.74	2.50	2.11	1.64	3.07	2.64	1.79	3.00	2.69	1.62	2.75	2.28	1.82
LIRE Dummy	0.31	0	0.46	0.40	0	0.49	0.23	0	0.42	1	1	0	.	.	.
Crisis Dummy	0.21	0	0.41	0.25	0	0.43	0.18	0	0.39	.	.	.	.	.	.
CAR Dummy	0.50	0	0.50	1	1	0	0	0	0	0.62	1	0.48	0.43	0	0.50
Lerner Index	0.30	0.30	0.11	0.33	0.33	0.12	0.28	0.28	0.10	0.40	0.41	0.11	0.28	0.29	0.09
Unexpected IRS	− 0.55	− 0.58	0.83	− 0.55	− 0.56	0.82	− 0.54	− 0.58	0.85	− 0.41	− 0.30	0.47	− 0.53	− 0.65	0.80
Basel IRC	− 19.23	− 19.60	6.57	− 19.19	− 19.68	7.23	− 19.27	− 19.50	5.83	− 19.87	− 19.94	7.22	− 18.95	− 19.47	6.31
Effective Unexpected IRS	− 10.50	− 9.61	17.14	− 10.57	− 8.20	17.07	− 10.42	− 10.92	17.22	− 7.99	− 4.17	9.51	− 10.04	− 12.19	16.46
Lerner x Unexpected IRS	− 0.17	− 0.14	0.26	− 0.18	− 0.14	0.27	− 0.15	− 0.15	0.24	− 0.16	− 0.08	0.18	− 0.15	− 0.17	0.24
Lerner x Effective Unexpected IRS	− 3.25	− 2.56	5.36	− 3.55	− 2.52	5.68	− 2.95	− 2.60	5.01	− 3.17	− 1.75	3.78	− 2.88	− 3.14	4.92
Bank Size	19.91	19.84	1.39	19.83	19.74	1.45	19.99	19.90	1.33	20.19	20.17	1.35	19.76	19.69	1.40
Sector HHI	12.82	10.23	7.60	13.30	10.40	8.28	12.34	10.08	6.82	12.06	9.76	6.92	13.46	10.77	7.90
Share Fee Income	14.47	13.66	5.79	15.19	14.34	6.34	13.75	13.11	5.08	19.04	18.61	6.14	12.56	12.00	4.67
NPL Ratio	4.00	3.24	3.12	3.59	2.88	2.92	4.41	3.63	3.25	2.68	2.26	1.94	4.72	3.91	3.44

Table 3 continued

Variable	Panel A			Panel B						Panel C					
	All Universal Banks			Well Capitalized Banks			Poorly Capitalized Banks			LIRE Years			Non- LIRE/Non- Crisis Years		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
GDP Growth	1.55	1.64	3.84	1.49	1.59	3.82	1.60	1.70	3.86	1.42	1.59	2.38	2.09	1.96	3.77

Variable	Panel C (cont'd)			Panel D			Panel E								
	Crisis Years			Without Capital Support			Board Turnover Same Year			Board Turnover Within Two Years			Board Turnover Within Three Years		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Total LC	22.95	24.11	10.79	23.24	23.82	11.54	23.29	23.82	11.44	23.24	23.77	11.42	23.10	23.60	11.37
Asset- Side LC	13.37	14.80	10.47	12.18	13.65	10.60	12.24	13.63	10.46	12.21	13.55	10.43	12.16	13.48	10.38
Liability- Side LC	6.93	6.59	4.42	8.14	6.87	5.78	8.19	6.95	5.73	8.19	6.94	5.73	8.09	6.82	5.73
Off- Balance Sheet LC	2.57	2.23	1.58	2.79	2.38	1.74	2.76	2.37	1.70	2.76	2.37	1.69	2.76	2.37	1.69
LIRE Dummy	.	.	.	0.32	0	0.47	0.32	0	0.47	0.33	0	0.47	0.32	0	0.47
Crisis Dummy	1	1	0	0.22	0	0.41	0.22	0	0.41	0.22	0	0.41	0.22	0	0.41
CAR Dummy	0.53	1	0.50	0.50	1	0.50	0.50	1	0.50	0.50	0	0.50	0.50	0	0.50
Lerner Index	0.24	0.25	0.10	0.31	0.30	0.11	0.31	0.31	0.11	0.32	0.31	0.11	0.32	0.31	0.11
Unexpected IRS	− 0.85	− 0.64	1.26	− 0.55	− 0.58	0.83	− 0.55	− 0.58	0.83	− 0.55	− 0.56	0.82	− 0.53	− 0.56	0.83
Basel IRC	− 19.18	− 19.67	6.27	− 19.26	− 19.61	6.56	− 19.49	− 19.69	6.37	− 19.59	− 19.74	6.31	− 19.65	− 19.78	6.27
Effective Unexpected IRS	− 16.41	− 12.02	26.01	− 10.46	− 9.49	17.15	− 10.61	− 9.71	17.09	− 10.58	− 9.76	17.05	− 10.25	− 9.63	17.19
Lerner x Unexpected IRS	− 0.24	− 0.12	0.39	− 0.17	− 0.15	0.26	− 0.17	− 0.15	0.26	− 0.17	− 0.15	0.26	− 0.17	− 0.15	0.26
Lerner x Effective Unexpected IRS	− 4.75	− 2.20	8.21	− 3.27	− 2.58	5.39	− 3.34	− 2.66	5.41	− 3.37	− 2.72	5.43	− 3.30	− 2.73	5.46

Table 3 continued

Variable	Panel C (cont'd)			Panel D			Panel E								
	Crisis Years			Without Capital Support			Board Turnover Same Year			Board Turnover Within Two Years			Board Turnover Within Three Years		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Bank Size	19.97	19.90	1.38	19.90	19.84	1.40	19.79	19.72	1.34	19.69	19.62	1.31	19.60	19.55	1.29
Sector HHI	11.75	9.31	7.30	12.84	10.24	7.61	12.74	10.28	7.34	12.80	10.38	7.26	12.91	10.51	7.24
Share Fee Income	13.87	13.52	4.52	14.48	13.67	5.81	14.57	13.82	5.68	14.64	13.91	5.69	14.62	13.87	5.71
NPL Ratio	3.54	2.98	2.62	3.86	3.18	2.91	3.94	3.23	3.01	3.92	3.23	2.98	3.91	3.22	2.96
GDP Growth	−0.24	0.76	5.26	1.55	1.64	3.84	1.57	1.66	3.84	1.59	1.69	3.83	1.65	1.76	3.84

This table presents summary statistics for the total liquidity creation measures and its components, sample split dummies, pricing power and competition measures, monetary policy indicators, as well as control variables for 26534 bank years (2914 banks) in the sample. Panel A shows descriptive statistics for the total number of banks in the sample. In Panel B, the sample is split into well and poorly capitalized banks measured by CAR. Panel C describes the sub-samples LIRE years, Non-LIRE/Non-Crisis years and Crisis years. Panel D excludes bank-year observations for banks that received capital support measures. In Panel E, bank-year observations that exhibit a board turnover either in the same year, within the last two years or within the last three years are excluded. For a detailed variable description see Table 1

Table 4 Overview Interest Rate Shocks and Liquidity Creation

Variable	Panel A		Panel B				Panel C					
	All Universal Banks		Well Capitalized Banks		Poorly Capitalized Banks		LIRE Years		Non- LIRE/Non-Crisis Years		Crisis Years	
	Total LC		Total LC		Total LC		Total LC		Total LC (%)		Total LC (%)	
Lagged LC, Pricing Power, Monetary Policy												
L.LC	0.6002***	0.8155***	0.6994***	0.7930***	0.5281***	0.8619***	0.6115***	0.9191***	0.5916***	0.8478***	0.5036***	0.5227***
	[13.7972]	[16.2974]	[14.2707]	[14.9351]	[10.9716]	[18.0200]	[5.0647]	[5.6855]	[12.4098]	[16.8094]	[5.9751]	[6.4049]
Lerner Index	0.7439	− 5.3311***	1.2556	− 4.1367**	− 0.1426	− 6.2435***	− 2.1491	− 2.9742**	1.6864*	− 5.2182***	− 10.4828***	− 5.1755***
	[1.0596]	[− 3.7528]	[1.3265]	[− 2.3409]	[− 0.1555]	[− 4.8804]	[− 1.5859]	[− 2.1607]	[1.8912]	[− 3.6816]	[− 5.3445]	[− 3.3909]
Unexpected IRS	0.1426		0.4573**		0.1237		1.6443***		− 0.1887		1.7119***	
	[1.0791]		[2.2089]		[0.6682]		[3.1610]		[− 1.3353]		[7.6054]	
Lerner x Unexpected IRS	1.1602***		0.6719		0.6130		− 2.0693		1.4304***		− 3.7751***	
	[2.6636]		[1.0788]		[0.9336]		[− 1.6195]		[2.8123]		[− 4.8370]	
Effective Unexpected IRS		0.0253**		0.0373***		0.0176		− 0.0452		0.0022		0.0607***
		[2.5220]		[2.5982]		[1.4372]		[− 1.3233]		[0.1909]		[3.4650]
Lerner x Effective Unexpected IRS		−0.0941***		− 0.1132***		− 0.0996***		− 0.0474		− 0.0594*		− 0.1653***
		[− 3.3529]		[− 2.9662]		[− 3.0873]		[− 0.8231]		[− 1.7675]		[− 3.9383]
Controls												
Bank Size	− 0.4657	3.4686**	0.1298	2.4015	− 0.6192	4.9722**	3.1749	8.4850**	0.3957	3.3926***	3.0309***	− 1.2130
	[− 0.8280]	[2.2233]	[0.1957]	[1.5651]	[− 0.7929]	[2.1013]	[1.0045]	[2.5685]	[0.6972]	[2.7729]	[− 0.3377]	[− 0.4725]
Sector HHI	− 0.0510	− 0.0302	− 0.0579***	− 0.0594*	− 0.0338	0.0268	− 0.2876	− 0.1461	− 0.0805***	− 0.0259	− 0.0032	− 0.0456
	[− 3.2069]	[− 1.0811]	[− 2.8036]	[− 1.8167]	[− 1.6271]	[0.8839]	[− 1.1812]	[− 0.4763]	[− 5.1034]	[− 0.9951]	[− 0.0758]	[− 0.9285]

Table 4 continued

Variable	Panel A		Panel B				Panel C					
	All Universal Banks		Well Capitalized Banks		Poorly Capitalized Banks		LIRE Years		Non- LIRE/Non-Crisis Years		Crisis Years	
	Total LC		Total LC		Total LC		Total LC		Total LC (%)		Total LC (%)	
Share Fee Income	0.3402***	1.0602***	0.2117***	0.7228*	0.4816***	1.2716***	0.2166	0.2397	0.2027***	1.1762***	0.8382***	0.0350
	[9.1312]	[3.0827]	[5.4563]	[1.7676]	[9.0350]	[3.6247]	[1.5893]	[1.2720]	[4.6165]	[4.1996]	[10.1741]	[0.0895]
NPL Ratio	− 0.0111	− 0.0237	− 0.0420	− 0.0128	0.0216	− 0.0681**	− 0.3402***	− 0.3666***	− 0.0079	− 0.0110	− 0.1112***	− 0.0450
	[− 0.5109]	[− 0.8432]	[− 1.2775]	[− 0.2901]	[0.8323]	[− 2.4605]	[− 3.2968]	[− 3.0821]	[− 0.3096]	[− 0.3881]	[− 2.5839]	[− 0.9716]
GDP Growth	0.0242***	-0.0155*	0.0302***	− 0.0137	0.0234**	− 0.0155	− 0.0205	− 0.0215	− 0.0449***	− 0.0068	0.0373**	0.0163
	[3.2783]	[-1.8430]	[3.0157]	[− 1.1761]	[2.1423]	[− 1.3922]	[− 1.0734]	[− 1.1184]	[− 4.9003]	[− 0.6752]	[2.0517]	[0.8642]
Bank Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	26,534	26,534	13,621	13,621	12,913	12,913	6646	6646	15,244	15,244	4644	4644
Number of Banks	2914	2914	1239	1239	1675	1675	1611	1611	2765	2765	1723	1723
p-Value AR(1) Test	0	0	0	0	0	0	0	0	0	0	0	0
p-Value AR(2) Test	0.1280	0.2256	0.0572	0.1040	0.7252	0.5405	0.0959	0.0663	0.4977	0.4934	0.0475	0.6803
p-Value of Hansen Test	0	0.3426	0	0.2051	0	0.4242	0	0	0	0.1648	0.0113	0.0729

This table shows the two-step GMM regression results of the baseline specification. The orthogonal deviation transformation is applied to the model. The upper part of the table shows the estimation results for the effects of two interest rate shocks (IRS) and their interaction with a measure for pricing power in the market (Lerner index). In each column the dependent variable is total liquidity creation scaled by total assets (Total LC). The lower part of the table contains coefficients from control variables. The regression in Panel A includes the baseline results for all universal banks. Panel B shows the results when the sample is divided into well and poorly capitalized banks measured by CAR. Panel C includes the results for sub-samples characterized by LIRE years, Non-LIRE/Non-Crisis years and Crisis years. For a detailed variable description see Table 1. All specifications include bank fixed effects, while the Model 2 specifications (employing the *effective* unexpected IRS) in addition control for year fixed effects. The finite sample Windmeijer (2005) correction is applied to the standard errors and t-statistics are depicted in brackets. */**/*** denote the significance at the 10%/5%/1% levels, respectively

Table 5 Interest Rate Shocks and Liquidity Creation Decomposition

Variables	Total LC		Asset- Side LC		Liability- Side LC		Off- Balance Sheet LC (%)	
Lagged LC, Pricing Power, Monetary Policy								
L.LC	0.6002***	0.8155***	0.7722***	0.8290***	0.9561***	0.6182***	0.7026***	0.7486***
	[13.7972]	[16.2974]	[23.3413]	[23.2885]	[32.8516]	[6.4226]	[30.3537]	[25.5197]
Lerner Index	0.7439	− 5.3311***	− 1.1295*	− 4.9599***	0.7710***	1.7676**	0.6603***	− 0.6652***
	[1.0596]	[− 3.7528]	[− 1.8185]	[− 4.8459]	[2.7804]	[2.1309]	[6.3449]	[− 2.5847]
Unexpected IRS	0.1426		0.9572***		− 0.6127***		− 0.0592***	
	[1.0791]		[6.9971]		[− 12.3174]		[− 2.9631]	
Lerner x Unexpected IRS	1.1602***		0.0845		0.5454***		0.1061*	
	[2.6636]		[0.1875]		[3.4175]		[1.6523]	
Effective Unexpected IRS		0.0253**		0.0429***		−0.0138***		−0.0005
		[2.5220]		[4.9106]		[− 3.7017]		[− 0.2670]
Lerner x Effective Unexpected IRS		− 0.0941***		− 0.1086***		0.0339***		− 0.0121***
		[− 3.3529]		[− 4.7692]		[3.4222]		[− 2.6749]
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES
Observations	26,534	26,534	26,534	26,534	26,534	26,534	26,534	26,534
Number of Banks	2914	2914	2914	2914	2914	2914	2914	2914
p-Value AR(1) Test	0	0	0	0	0	0	0	0

Table 5 continued

Variables	TOTAL LC		ASSET- SIDE LC		LIABILITY- SIDE LC		OFF- BALANCE SHEET LC (%)	
p-Value AR(2) Test	0.1280	0.2256	0.0062	0.0055	0.1052	0.8038	0.0009	0.0402
p-Value of Hansen Test	0	0.3426	0	0.0503	0	0.08519	0	0

This table shows the two-step GMM regression results when the dependent variable, total liquidity creation scaled by total assets (TOTAL LC), is decomposed into its components. All regressions include interaction terms of pricing power in the market (Lerner index) with two interest rate shocks (IRS), and the same set of control variables as in the regressions shown in Table 4. Columns (1)–(2) depict the baseline results for comparison reasons. Columns (3)–(8) show the results for asset-side liquidity creation (ASSET- SIDE LC), liability-side liquidity creation (LIABILITY- SIDE LC) and off-balance sheet liquidity creation (OFF- BALANCE SHEET LC) as dependent variables. For a detailed variable description see Table 1. All specifications include bank fixed effects, while the Model 2 specifications (employing the *effective* unexpected IRS) in addition control for year fixed effects. The finite-sample Windmeijer (2005) correction is applied to the standard errors and t-statistics are depicted in brackets. */**/*** denote the significance at the 10%/5%/1% levels, respectively

Table 6 Interest Rate Shocks and Liquidity Creation – Robustness Tests

Variable	Panel D		Panel E					
	No Capital Support		Board Turnover Same Year		Board Turnover Within Two Years		Board Turnover Within Three Years	
	Total LC		Total LC		Total LC		Total LC	
Lagged LC, Pricing Power, Monetary Policy								
L.LC	0.5942***	0.7999***	0.5841***	0.8148***	0.5848***	0.7418***	0.5529***	0.7911***
	[13.0955]	[16.4533]	[13.8271]	[15.8082]	[11.0400]	[11.6759]	[12.2367]	[13.5773]
Lerner Index	0.6894	− 4.8571***	0.5742	− 5.5240***	0.4673	− 6.9139***	0.3162	− 4.8577***
	[0.9566]	[− 3.6397]	[0.7392]	[− 3.9873]	[0.5372]	[− 3.3404]	[0.3546]	[− 4.5976]
Unexpected IRS	0.1967		0.1029		0.2020		0.3599**	
	[1.4452]		[0.7027]		[1.2108]		[2.0176]	
Lerner x Unexpected IRS	0.9713**		1.3807***		1.1557**		0.7741	
	[2.1804]		[2.8838]		[2.1329]		[1.3353]	
Effective Unexpected IRS		0.0236**		0.0274**		0.0340**		0.0243**
		[2.3655]		[2.4064]		[2.3885]		[1.9804]
Lerner x Effective Unexpected IRS		−0.0945***		−0.0912***		− 0.1172***		− 0.0973***
		[− 3.4366]		[− 3.1477]		[− 3.1256]		[− 3.3571]
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES
Observations	25,992	25,992	21,665	21,665	17,550	17,550	14,491	14,491
Number of Banks	2882	2882	2796	2796	2616	2616	2444	2444
p-Value AR(1) Test	0	0	0	0	0	0	0	0

Table 6 continued

Variable	Panel D		Panel E					
	No Capital Support		Board Turnover Same Year		Board Turnover Within Two Years		Board Turnover Within Three Years	
	Total LC		Total LC		Total LC		Total LC	
p-Value AR(2) Test	0.1198	0.2250	0.1500	0.2554	0.1299	0.3689	0.1670	0.3334
p-Value of Hansen Test	0	0.2034	0	0.2209	0	0.4218	0	0.1645

As a test of robustness, this table shows additional two sub-samples. The dependent variable in all specifications is total liquidity creation scaled by total assets (Total LC). All regressions include interaction terms of the pricing power in the market (Lerner index) with two interest rate shocks (IRS), and the same set of control variables as in the regressions shown in Table 4. Panel D excludes bank-year observations for banks that received capital support measures. In Panel E, bank-year observations that exhibit a board turnover either in the same year, within the last two years or within the last three years are excluded. For a detailed variable description see Table 1. All specifications include bank fixed effects, while the Model 2 specifications (employing the *effective* unexpected IRS) in addition control for year fixed effects. The finite-sample Windmeijer (2005) correction is applied to the standard errors and t-statistics are depicted in brackets. */**/*** denote the significance at the 10%/5%/1% levels, respectively

The first and the second columns of Panel A contrast results from unexpected versus effective unexpected IRS.[13] The second column shows that an increase in EFFECTIVE UNEXPECTED IRS by one percentage point increases TOTAL LC ceteris paribus by 0.025 percentage points. Considering the interaction terms with the competition measure, the interaction with the Lerner index demonstrates statistical significance at the 1% level. The remaining control variables' coefficients for BANK SIZE, SECTOR HHI (%), SHARE FEE INCOME (%), NPL RATIO (%), and GDP GROWTH are in line with expectations, with a bank's size and its income sources (proxied by fee income over total income) highly significant in almost all regressions based on the relevant Model 2 specification. Berger and Bouwman (2017) show that monetary policy loosening results in higher liquidity creation for small banks during normal times but the effect is less prominent for periods of crisis. One major takeaway from the interaction of policy rates and competition is the strong correlation between liquidity creation and monetary policy in the financial crisis period. This correlation indicates how banks respond to changes in monetary policy, but most important it also reveals how banks with high market power respond in a crisis. Table 4 shows that the main coefficient of interest (on the interaction term) is driven primarily by the crisis period sample and is only marginally significant in non-crisis years. Therefore, an alternative interpretation of the full sample result is that low policy rates are implemented in response to a financial crisis when lending drastically declines (and banks with high interest rate risk exposure are more affected by crises).

4.2 Well versus poorly capitalized banks

Both regressions are repeated with different sub-samples. Banks are split by the median of the CAPITAL ADEQUACY RATIO, defined by Tier 1 Capital over Risk-Weighted Assets. Panel B in Table 4 presents the results for banks considered to be well versus poorly capitalized. One finding is that the negative impact of pricing power on liquidity creation is significantly greater for poorly capitalized banks than for well capitalized banks in the Model 2 specification (employing the *effective* unexpected IRS), whereas the effect of pricing power remains insignificant for both subsamples of the Model 1 specification (employing the *simple* unexpected IRS). This becomes a particularly crucial feature in the context of a bank's economic condition. It is striking that in both model specifications the effects of the *(effective) unexpected IRS* on total liquidity creation are significantly stronger for well capitalized banks, while significance disappears for poorly capitalized banks. This indicates that, following an interest rate shock, both more and less healthy banks adjust their total liquidity creation subject to different objectives (such as profit maximization in an imperfect banking market) and restrictions (such as regulatory and supervisory constraints). Taking into account banks' actual interest rate risk in the banking book (as measured by the Basel IRC) well capitalized banks increase TOTAL LC in response to a monetary policy shock whereas this effect is still curbed by banks' high price markups stemming from operating in rather monopolistic markets. One has to distinguish between different objectives

[13] Note that multiplying the unexpected IRS with the absolute value of a bank's Basel IRC scales the effective unexpected IRS on average by factor 20.

of liquidity creation for banks in different economic conditions. Looking at the significantly stronger negative Lerner index reaction of poorly capitalized banks in the Model 2 specification, a non-healthy bank exhibiting a relatively strong market position, but with lesser degrees of freedom in capital management, could come under pressure to operate with a lower liquidity creation in order to prevent the violation of regulatory capital requirements.

4.3 Normal times, crisis and low interest rate environment

Panel C in Table 4 presents the regression results for sample splits by periods. The years 2007 to 2009, which are characterized by the global financial crisis, normal times, and the low interest environment that began 2012 are analyzed separately. A look on the effects of effective unexpected IRS on total liquidity creation reveals that monetary policy was more effective during crisis years—in contrast to only unexpected IRS which shows a similar reaction not only during crisis years, but also in the LIRE period. Also for non-LIRE years the interaction term of Lerner index and effective unexpected IRS is in line with the findings from the full sample—that liquidity creation caused by effective unexpected IRS is curbed by a high pricing power in the market, while this effect disappears in LIRE years. As for the full sample in our preferred Model 2 specification, in each regime being analyzed (normal times vs. crisis vs. LIRE) a higher degree of competition (i.e. low bank individual pricing and market power) fosters the efficacy of monetary policy and therefore supports banks' liquidity creation. In addition, one can observe that, if the banking market becomes more competitive, the efficacy of monetary policy on banks' liquidity creation increases.

4.4 Liquidity creation and its components

In the following, liquidity creation is split into its components in order to obtain a more detailed perspective. Asset-side and liability-side liquidity creation and liquidity creation off the balance sheet enter the regressions as dependent variables separately. The results are presented in Table 5. In the Model 2 specification, ASSET- SIDE LC shows the same pattern as TOTAL LC. On the one hand, positive IRS increase asset-side liquidity creation and, on the other hand, lower degrees of pricing power in the market (and therefore more efficient competitive environments) increase asset-side liquidity creation significantly. Addressing liability-side liquidity creation, different results with respect to the Lerner index can be observed. Interestingly, a higher bank-individual market power goes along with a significant increase in liability-side liquidity creation, which is in line with the assumption that banks use a high pricing power in the market to create additional liquidity on the liability-side (instead of the asset-side, or off the balance sheet). In addition, also the coefficient of the interaction term of Lerner index and effective unexpected IRS turns to a positive sign which means that a positive IRS on banks' liability-side increases liquidity creation for banks with higher individual pricing power in the market, and vice versa. Regarding off-balance sheet liquidity creation, results are in line with both TOTAL LC and ASSET- SIDE LC for our preferred Model 2 specification employing the *effective* unexpected IRS.

4.5 Robustness tests

Following Berger et al. (2016), we perform further tests to check the robustness of the results in Table 6. The baseline regression is estimated again for sub-samples excluding either bank-year observations with capital support measures (provided by the bankers associations' protection schemes to member institutions in severe distress) or exhibiting turnovers in the respective bank's executive board. While Panel D presents the regression results for the sample excluding observations which are subject to capital support measures, Panel E is divided into three specifications to distinguish between board turnovers either in the same year, within the last two years, or within the last three years of each bank-year observation. Turnovers in the board of a bank and capital injections are eligible to influence a bank's liquidity creation. Since the regressions do not control for these effects, we test the influence of these events on the baseline coefficients by omitting the relevant observations. The results are in line with those from the baseline model. The coefficients of main interest are statistically significant and show the expected signs.

5 Conclusion

This paper investigates how effective unexpected interest rate shocks influence banks' liquidity creation and which role a bank's pricing power in the market plays in this transmission process. In order to identify these effects we use data from universal banks in Germany comprising private-sector, public-sector, and cooperative banks. The Lerner Index, as a measure of a bank's individual pricing power, is implemented to account for different degrees of competition. For identifying the dynamic behavior of liquidity creation we rely on dynamic GMM panel estimations that are robust to several robustness checks. We find several important results.

First, when employing the most appropriate model specification taking into account the *effective unexpected IRS* and year fixed effects, we find that higher individual pricing power in the market lowers banks' liquidity creation, which is in line with theory that monopolistic firms undersupply the market when utilizing their high pricing power in the *bank competition–liquidity creation nexus*. Here, pricing long-term deposits lowly and short-term loans highly provide high margins in a monopolistic banking market. In addition, while an unexpected increase in interest rates causes present value losses in the short run, at the same time it raises a bank's profit opportunities in the medium/long run and, therefore, per se leads to higher liquidity creation activities in financial institutions. But the pass-through of IRS also depends on the bank-specific level of competition, where we find that a high bank-individual pricing power (measured by the Lerner index) curbs this impact of *effective unexpected IRS* on liquidity creation significantly in the *monetary policy–bank competition–liquidity creation nexus*.

Second, the negative impact of pricing power on liquidity creation is greater for poorly capitalized banks than for well capitalized banks. This indicates that, following an interest rate shock, both more and less healthy banks adjust their total liquidity creation subject to different objectives (such as profit maximization in an imperfect

banking market) and restrictions (such as regulatory and supervisory constraints). As for the *effective* adaption of the unexpected IRS, the effects are driven by asset-side and off-balance sheet liquidity creation while liability-side liquidity creation shows opposite effects—which is in line with the observation that banks use a high pricing power in the market to create additional liquidity on the liability-side. However, similar conclusions cannot be drawn when the *simple* unexpected IRS specification is employed, given that the overall effect of pricing power on liquidity creation is insignificant in this specification.

Third, we have noticed a sharp increase in liability-side driven liquidity creation during periods of low interest rates, which caused the total liquidity creation by banks to increase significantly in the same period as well. Given the improved opportunities for banks to store excess deposits at other banks with little cost (while old, illiquid assets may prove detrimental to the bank) the creation of additional liability-side liquidity creation may be caused by the decreased opportunity cost for the bank to possess excess liquidity.

Lastly, we show that monetary policy was most effective during the global financial crisis.

Given the important role of both monetary policy and bank liquidity creation for the macroeconomy, the findings on the *bank competition–liquidity creation nexus* and the *monetary policy–bank competition–liquidity creation nexus* provide new insights into the debates about the optimal design of efficient financial markets.

Acknowledgements The author thanks Allen Berger, Bo Bian, Christa Bouwman, Ramona Busch, Claire Célérier, Min Ciu, Daniel Foos, Rainer Haselmann, Bjoern Imbierowicz, Tobias Kawalec, Michael Koetter, Philipp Koziol, Christoph Memmel, Jochen Mankart, Christian Merkl, Huyen Nguyen, Andreas Pfingsten, Esteban Prieto, Benedikt Ruprecht, Klaus Schaeck, and Shikhar Singla, as well as participants at the Bundesbank Seminar on Banking and Finance and the Southern Finance Association Conference (Asheville) for comments and suggestions that helped significantly improve this paper. Markus Schmid (the editor) and an anonymous referee added further perspectives to this paper and helped greatly by improving focus and presentation. The views expressed are those of the author and do not necessarily coincide with the views of the Deutsche Bundesbank or the Eurosystem.

Funding Open Access funding enabled and organized by Projekt DEAL.

Appendix

A.1 Lerner index

Complementary to the derivation in Kick et al. (2015), an efficiency-adjusted Lerner index is used in order to measure market power. It is defined as the mark-up (price

minus marginal costs) over the level of the output price. Since marginal costs cannot be observed directly, a translog cost function is estimated. The translog cost function has total operating costs (TOC) as the dependent variable. The total output (TOUT) of a bank is defined as the sum of loan and security portfolios.[14]

$$\begin{aligned}\ln TOC_{i,t} = \gamma + \gamma_O \ln TOUT_{it} + \frac{1}{2}\gamma_{OO} (\ln TOUT_{it})^2 + \sum_{h=1}^{3} \gamma_h \ln w_{hit} \\ + \frac{1}{2}\sum_{h=1}^{3}\sum_{m=1}^{3} \gamma_{hm} \ln w_{hit} \ln w_{mit} + \sum_{h=1}^{3} \gamma_{hO} \ln w_{hit} \ln TOUT_{it} \\ + \gamma_E \ln Eq_{it} + \frac{1}{2}\gamma_{EE} (\ln Eq_{it})^2 + \gamma_{EO} \ln Eq_{it} \ln TOUT_{it} \\ + \sum_{h=1}^{3} \gamma_{hE} \ln w_{hit} \ln Eq_{it} + \gamma_T Tr + \frac{1}{2}\gamma_{TT} (Tr)^2 \\ + \gamma_{TO} Tr \ln TOUT_{it} + \sum_{h=1}^{3} \gamma_{Th} Tr \ln w_{hit} \\ + \gamma_{TEq} Tr \ln Eq_{it} + \epsilon_{it}. \end{aligned} \tag{A.1}$$

In line with the majority of the literature, we assume that three different inputs generate a bank's output, namely borrowed funds, labor, and physical capital. We take borrowed funds as an input rather than an output of the banking firm in order to stay consistent with the financial intermediation approach (Sealey and Lindley (1977)). Furthermore, as suggested by Mester (1997), equity capital is included because it can be used to fund income-generating output and additionally represents disparate risk attitudes. By including time trends, technical change in a bank's production technology is captured. In order to deal with outliers, input prices are winsorized at the upper and lower percentile. Homogeneity of degree one in input prices is imposed by dividing the price of labor and physical capital as well as total operating costs by the price of borrowed funds. Output prices are assumed to be exogenously determined and given by total revenues over total assets.

Marginal costs mc_{it} are derived from

$$\begin{aligned} mc_{it} = \Big[\gamma_O + \gamma_{OO} \ln TOUT_{it} + \sum_{h=1}^{3} \gamma_{hO} \ln w_{hit} \\ + \gamma_{EO} \ln Eq_{it} + \gamma_{TO} Tr\Big] \frac{TOC_{it}}{TOUT_{it}}. \end{aligned} \tag{A.2}$$

The translog cost function is estimated based on a stochastic frontier analysis panel approach similar to the approaches used in Koetter et al. (2012), Kick et al. (2015), and Kick and Prieto (2015). In this estimation, cost inefficiency is defined as the

[14] For a detailed description of the Lerner index variables, see Table 7.

Table 7 Variables lerner index estimation

	Variable name	Description
TOC	TOTAL OPERATING COST	Sum of interest, fee and administrative expenses
TOUT	TOTAL OUTPUT	Total earning output measured as the sum of interest-bearing assets and securities
w_1	COST OF FIXED ASSETS	Other administrative expenses excluding personnel expenses
w_2	COST OF LABOR	Personnel expenditure over number of full-time employee equivalents
w_3	COST OF BORROWED FUNDS	Interest expenses over total interest-paying liabilities
EQ	TOTAL CAPITAL	Total equity capital
TR	TIME TREND	Time trend starting with zero
PBT	PROFITS BEFORE TAX	Profit before tax

difference between potential minimum and observed costs. The error term ϵ_{it} consists of two parts. On the one hand, v_{it} captures the random error term and is assumed to be i.i.d. normally distributed with mean zero and variance σ_v. On the other hand, the component u_{it} describes the systematic deviation from the optimal cost structure due to inefficiency and is assumed to be i.i.d. with a truncated-normal distribution and a variance σ_u. It is assumed that σ_v and σ_u are independent of each other. Maximum likelihood methods (see e.g. Battese and Coelli (1988), Orea and Kumbhakar (2004), and Greene (2005)) are applied to estimate Eq. (A.1).

The Lerner index can alternatively be calculated as $\frac{AR-MC}{AR}$, where AR represents average revenues and equals average profit plus average costs. In order to also integrate profit inefficiencies into the Lerner index, total operating costs are substituted by profits before tax (PBT). Using predicted total operating costs and profits before tax from these estimations, the Lerner index is calculated as

$$\frac{\text{PBT} + \text{TOC} - \text{MC} \times \text{TOUT}}{\text{PBT} + \text{TOC}} \tag{A.3}$$

Variables included in the estimation of the Lerner index are described in Table 7.

References

Arellano, M., Bond, S.: Some tests for specification of panel data: Monte Carlo evidence with an application for employment equations. Rev. Econ. Studies **58**, 277–299 (1991)

Battese, G.E., Coelli, T.J.: Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. J. Econ. **38**(3), 387–399 (1988)

Beck, T., Demirgüç-Kunt, A., Levine, R.: Bank concentration, competition, and crises: first results. J. Bank. Finance **30**(5), 1581–1603 (2006)

Berger, A.N., Bouwman, C.H.: Bank liquidity creation. Rev. Financial Stud. **22**, 3779–3837 (2009)

Berger, A.N., Bouwman, C.H.: Bank liquidity creation, monetary policy, and financial crises. J. Financial Stability **30**, 139–155 (2017)

Berger, A.N., Bouwman, C.H., Kick, T., Schaeck, K.: Bank risk taking and liquidity creation following regulatory interventions and capital support. J. Financial Intermed **26**, 115–141 (2016)
Boone, J.: A new way to measure competition. Econ J **118**(531), 1245–1261 (2008)
Boot, A.W., Thakor, A.V.: Can relationship banking survive competition? J Finance **55**(2), 679–713 (2000)
Boyd, J.H., De Nicolò, G., Jalal, A.M.: Bank risk-taking and competition revisited: New theory and new evidence. Working paper, International Monetary Fund (2007)
Brunner, A., Decressin, J., Hardy, D., Kudela, B.: Germany's Three-Pillar-Banking System. Cross Country Perspectives in Europe. International Monetary Fund, Occasional Paper, 233, Washington (2004)
Buch, C., Koch, C.T., Koetter, M.: Do banks benefit from internationalization? Revisiting the market power-risk nexus. Rev. Finance **17**, 1401–1435 (2013)
Busch, R., Memmel, C.: Banks' net interest margin and the level of interest rates. Credit Capital Markets **50**(3), 363–392 (2017)
Carbó, S., Humphrey, D., Maudos, J., Molyneux, P.: Cross-country comparisons of competition and pricing power in European banking. J. Int. Money Finance **28**, 115–135 (2009)
Chatterjee, U.K.: Bank liquidity creation and asset market liquidity. J. Financial Stability **18**, 139–153 (2015)
Claessens, S., Coleman, N., Donnelly, M.: "Low-For-Long" interest rates and banks' interest margins and profitability: Cross-country evidence. J. Financial Intermed. **35**, 1–16 (2018)
Dang, V.D.: Bank funding, market power, and the bank liquidity creation channel of monetary policy. Res. Int. Bus. Finance **59**, 101531 (2022)
De Guevara, J.F., Maudos, J., Pérez, F.: Market power in European banking sectors. J. Financial Services Res. **27**, 109–137 (2005)
Deutsche Bundesbank: Banking Statistics—Statistical Supplement 1 to the Monthly Report. Technical report (1999)
Deutsche Bundesbank: The role of the "Basel interest rate shock" in the supervisory assessment of interest rate risks in the banking book. Technical report (2012)
Deutsche Bundesbank: Banking Statistics—Statistical Supplement 1 to the Monthly Report. Technical report (2018)
Deutsche Bundesbank: Financial Stability Review. Technical report (2018)
Drechsler, I., Savov, A., Schnabl, P.: The deposits channel of monetary policy. Quarterly J. Econ. **132**(4), 1819–1876 (2017)
Drechsler, I., Savov, A., Schnabl, P.: Banking on deposits: Maturity transformation without interest rate risk. No. w24582. National Bureau of Economic Research (2018)
Fungáčová, Z., Solanko, L., Weill, L.: Does competition influence the bank lending channel in the euro area? J. Bank. Finance **49**, 356–366 (2014)
Greene, W.: Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. J. Econ. **126**, 269–303 (2005)
Hannan, T.: Bank commercial loan markets and the role of market structure: evidence from surveys of commercial lending. J. Bank. Finance **15**, 133–149 (1991)
Horváth, R., Seidler, J., Weill, L.: Bank capital and liquidity creation: Granger-causality evidence. J. Financial Serv. Res. **45**(3), 341–361 (2014)
Horváth, R., Seidler, J., Weill, L.: How bank competition influences liquidity creation. Econ. Modell. **52**, 155–161 (2016)
Ippolito, F., Peydro, J.L., Polo, A., Sette, E.: Double bank runs and liquidity risk management. Universitat Pompeu Fabra Working Paper, 1497 (2016)
Jeong, H., Joh, S.: Risk Taking of "TBTF" Banks in a Concentrated Market: Evidence from Surviving Banks after a Financial Crisis. Working paper (2011)
Jiang, L., Levine, R., Lin, C.: Competition and bank liquidity creation. J. Financial Quant. Anal. **54**(2), 513–538 (2019)
Jiménez, G., Lopez, J.A., Saurina, J.: How does competition affect bank risk-taking? J. Financial Stab. **9**(2), 185–195 (2013)
Kick, T., Koetter, M., Poghosyan, T.: Bank recapitalization, regulators and repayment. J. Money Credit Bank. **48**(7), 1467–1494 (2016)
Kick, T., Pausch, T., Ruprecht, B.: The winner's curse—evidence on the danger of aggressive credit growth in banking. Deutsche Bundesbank Discussion Paper No 32 (2015)
Kick, T., Prieto, E.: Bank risk taking and competition: evidence from regional banking markets. Rev. Finance **19**(3), 1185–1222 (2015)

Koetter, M.: Marktstrukturen und Wettbewerb im deutschen Bankwesen, *Jahresgutachten 2013/14: Gegen eine rückwärtsgewandte Wirtschaftspolitik*, Chapter 5, 226–237. Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2013)
Koetter, M., Kolari, J., Spierdijk, L.: Enjoying the quiet life under deregulation? Evidence from adjusted Lerner indices for U.S. banks. Review of Economics and Statistics *94*(2): 462–480 (2012)
Koetter, M., Poghosyan, T.: The identification of technology regimes in banking: Implications for the market power-fragility nexus. J. Bank. Finance **33**, 1413–1422 (2009)
Maudos, J., de Guevara, J.F.: The cost of market power in banking: Social welfare loss vs. cost inefficiency. J. Bank. Finance **31**, 2103–2135 (2007)
Mester, L.J.: Measuring efficiency at U.S. banks: Accounting for heterogeneity matters. Journal of Operational Research *98*(2): 230–242 (1997)
Orea, L., Kumbhakar, S.: Efficiency measurement using a latent class stochastic frontier model. Empirical Econ. **29**, 169–183 (2004)
Pham, H.S.T., Le, T., Nguyen, L.Q.T.: Monetary policy and bank liquidity creation: does bank size matter? Int. Econ. J. **35**(2), 205–222 (2021)
Schaeck, K., Cihák, M.: Banking competition and capital ratios. Euro. Financial Manag. **18**(5), 836–866 (2012)
Schaeck, K., Cihák, M.: Competition, efficiency, and stability in banking. Financial Manag. **43**(1), 215–241 (2014)
Schaeck, K., Cihák, M., Wolfe, S.: Are competitive banking systems more stable? J. Money Credit Bank **41**(4), 711–734 (2009)
Sealey, C.W., Lindley, J.T.: Inputs, outputs, and a theory of production and cost and depository financial institutions. J. Finance **32**(4), 1251–1265 (1977)
Tran, V.T., Lin, C.T., Nguyen, H.: Liquidity creation, regulatory capital, and bank profitability. Int. Rev. Financial Anal **48**, 98–109 (2016)
Windmeijer, F.: A finite sample correction for the variance of linear efficient two-step GMM estimators. J. Econ. **126**, 25–51 (2005)

Thomas Kick is head of the Stress Testing Section in the Banking Supervision Department of the Deutsche Bundesbank. He coordinates several stress testing exercises at the Bundesbank, is co-chair of the BaFin/Bundesbank LSI Stress Testing Expert Panel, and a member of the EBA Stress Testing Task Force. He is an editor of the Bundesbank Discussion Paper Series, a research coordinator of the area *Safeguarding Financial Stability in an Era of Transformation* at the Bundesbank Research Centre, and he serves as a lecturer at the University of Erlangen-Nürnberg. His research has focused on banking structure and regulation, competition and efficiency in banking markets, financial stability, stress testing, and corporate governance in banking. He holds a doctorate (Dr. rer. pol) from the Faculty of Business Administration at the University of Münster.