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Bank liquidity and exposure to industry shocks: Evidence from Ukraine[☆]

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A B S T R A C T

This paper examines the link between bank liquidity and exposure to industry-level shocks. Using a unique dataset of borrower industry affiliations, we propose a new measure of industry-level shocks calculated at the bank level. We construct bank-specific loan portfolio weights for each industry and apply them to two industry-level indices. Our estimates reveal the negative link between bank liquidity and industry shocks. The sensitivity of liquidity to bank exposure is higher for more liquid, better capitalized, and smaller banks, which may be explained by their ability to displace funds, either for precautionary reasons or for loan financing.

1. Introduction

The global financial crisis and the ongoing Covid-19 pandemic have highlighted the importance of banks holding an adequate liquidity buffer in order to withstand negative macro- and micro-level shocks. Recent studies suggest that the impact of financial turmoil on bank balance sheets depends on the level of liquidity risk exposure (Loutskina, 2011; Ippolito et al., 2016). Banks that hold more illiquid assets and unused loan commitments tend to increase their liquidity and reduce lending for precautionary reasons (Cornett et al., 2011). Negative shocks to the real economy may translate into high credit losses for banks, as well as low levels of capital and lending, which may induce banks to manage their liquidity in a countercyclical way (Beatty and Liao, 2011; Acharya et al., 2011; Loutskina and Strahan, 2015; DeYoung et al., 2018). This paper examines whether and how bank exposure to industry-level shocks affects their holding of liquid assets.

Measuring industry-level shocks is challenging due to the nature of the relationship between industry structure and economic shocks. The extant literature defines an industry shock as any significant change in an external factor that modifies the industry's structure. Examples of shocks are deregulation, technology, commodity prices, supply and demand conditions that induce or allow for an alteration in industry structure, for example, in the number of firms or industry competition (Jensen, 1993). One way to capture

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industry shocks is to take into account the loan portfolio structure of each bank (e.g., Acharya et al., 2006; Loutskina, 2011).[1] We propose a new measure of industry-level shocks calculated at the bank-level using unique data relating to borrower industry affiliations. We first construct bank-specific loan portfolio weights for each industry. We then apply these weights to two industry-level indices – cost-effectiveness and production – to calculate the bank loan exposures.

The main contribution of this paper is twofold. First, it adds to the literature on bank liquidity and economic distress. In previous empirical investigations (e.g., Heider et al., 2015), all banks are affected by the same shock measure, such as the interbank market spreads. We extend this literature by documenting the underexplored link between bank liquidity and bank-level shock exposure. Second, we provide new insights into how banks interact with the real economy through their loan portfolio structure. This is an important channel through which banks may affect financial stability and economic growth (Loutskina and Strahan, 2015; Berger et al., 2020; Fricke and Roukny, 2020).

The Ukrainian banking system presents a relevant case for our research for three reasons. First, in recent years, the Ukrainian banking system has been characterized by a steadily increasing, high level of liquidity, high retail and corporate deposits as banks' core funding, and corporate loan accounts comprising a large part of banks' loan portfolios. Second, during the 2012–2016 period, Ukraine experienced a period of socio-economic instability. Finally, in line with international financial practices, the National Bank of Ukraine (NBU) has introduced, and will continue implementing, several reforms, such as introducing the Basel III accords. Therefore, as Ukraine is regularly affected by different and unique types of shocks, active liquidity management by banks will help the country to withstand these shocks and sustain the economy.[2]

Our paper uncovers a number of new facts. First, we find strong evidence of a negative correlation between bank liquidity and exposure to industry-level shocks. These results suggest that, when industries experience a positive industry shock, banks tend to decrease their holdings of liquid assets to destine funding to support new lending (Cornett et al., 2011). Second, our results suggest that industry-level shocks affect bank liquidity significantly through banks' lending behaviour (Kim and Sohn, 2017; Mian and Santos, 2018). Further estimations show that the effect of industry-level shocks on bank liquidity is channelized through lending to the corporate sector and not to the retail sector. Third, the impact of industry-level shocks on bank liquidity is higher for more liquid, better capitalized, and smaller banks, which might be explained by their ability to displace funds, either for precautionary reasons or for loan financing (DeYoung and Jang, 2016). Finally, our findings remain unchanged, despite being subjected to several robustness checks.

Our findings have several policy implications. First, the results shed light on the importance of industry shocks for bank stress testing. In conducting internal stress tests, the scenario development should consider the macroeconomic situation within a country and the banks' exposure to industry-level shocks. Second, this study also has implications for liquidity regulations, designed to help banks cope with extreme risks under various conditions. Banks may face severe liquidity shocks when dealing with industry-level shocks in the context of poor liquidity management, which can increase the default risk (e.g., Diamond and Rajan, 2005; Fungácová et al., 2021). Third, considering that the Ukrainian banking system has exhibited highly persistent liquidity, if the economic conditions improve and a positive industry shock occurs, commercial banks may rapidly expand their corporate lending, leading to the natural consequences of macroeconomic stability (Agénor and El Aynaoui, 2010; Primus, 2017).

The next section of this paper provides an overview of the Ukrainian banking system and the socio-economic situation in Ukraine during the 2012–2016 period. Section 3 discusses the literature review and formulates the hypotheses. Section 4 describes the empirical strategy. Section 5 reports and discusses the results. In the final section, we conclude the study.

2. Institutional background

During the 2014-Q1 2016 period, Ukraine suffered its most serious economic crisis. Based on IMF statistics, the roots of the economic crisis began sprouting in 2012 and led to the deterioration of several macroeconomic indicators. For instance, the GDP growth rate plunged from 0.24% in 2012 to −9.8% in 2015. Meanwhile, the inflation rate surged from 0.57% in 2012 to 48.7% in 2015, incurring an almost 70% devaluation of the domestic currency by the end of 2016. Consequently, the dramatic political events surrounding the economic crisis, and the crisis itself, led to the collapse of Ukraine's banking sector.

In 2014, a systemic crisis of the Ukrainian banking sector was triggered by worsening domestic economic conditions and later aggravated by the military conflict with Russia. This led to runs on banks by depositors, resulting in the loss of one-third of all deposits by the banking system and, consequently, affecting the main indicators of the banking sector. For instance, the ratio of nonperforming bank loans (NPLs) to total loans surged from 16.5% in 2012 to 30.4% in 2016. The domestic credit-to-private sector over GDP ratio dropped from 53.8% in 2012 to 38.6% in 2016. The bank capital ratio fell from 15% in 2012 to 8% in 2015 and bank liquid reserves to total bank assets increased from 5.4% in 2012 to 11.4% in 2016.[3]

The geopolitical conflict with Russia started in the first quarter of 2014 with the Russian annexation of Crimea, followed by the military invasion of Donetsk and Luhansk. Russia continues to illegally occupy the Ukrainian regions of Crimea, the city of Sevastopol,

[1] For example, Acharya et al. (2006) employ the bank loan portfolio composition to examine how bank diversification affects risk and return. Loutskina (2011) uses the bank loan portfolio structure to analyze how securitization impacts bank liquidity and loan supply under funding shocks.

[2] Other empirical studies have exploited the special features of the Ukrainian banking system. Pham et al. (2020a) investigate the impact of the geopolitical conflict between Russia and Ukraine on the banking sector, as well as the contagion effect of this military intervention. Talavera et al. (2012) study the effect of Ukraine's macroeconomic instability on bank lending behaviour. Pham et al. (2020b) analyze the impact of multimarket competition on Ukrainian banks' performances.

[3] Bank capital ratio is defined as bank capital and reserves to total assets.

and sizable portions of the Donetsk and Luhansk regions. In economic terms, and based on IMF statistics, foreign direct investment (% of GDP) fell from 2.46% in 2013 to 0.634% at the end of 2014. The annual growth rate of the export of goods and services fell from −8% in 2013 to −14.2% at the end of 2014. Industries such as Mining and Quarrying also suffered the impact of the conflict, seeing a reduction in their operational results of −20% and − 8% of production value by the end of 2014.[4] As documented by Pham et al. (2020a), banks and branches with operations in the occupied areas were faced with numerous unpaid loans and significant deposit outflow from the conflict areas. For instance, by the end of April 2014, the deposit reduction rate in Crimea, Donetsk and Luhansk were 41%, 21% and 19%, respectively (NBU, 2014).[5]

To restore financial stability, the NBU – in collaboration with the Finance Ministry and the IMF – has carried out several reforms, some of which have already been implemented and others that are planned for the 2018–2020 period. The first stage of restoring and developing the Ukrainian financial sector was to implement a clean-up program of the banking system. This program entailed the closure of insolvent banking institutions and the recapitalization of certain distressed banks by the NBU.[6] Furthermore, new liquidity requirements were phased in during 2018, and new capital requirements were implemented in 2019 to bring Ukraine's regulatory framework in line with EU legislation.[7]

These economic transformations have led to a decline in the number of banking institutions which, in conjunction with significant capital injections, set the conditions for banks to hoard liquid assets. However, there is a liquidity risk stemming from the short-term nature of new deposits. Consequently, banks will have to manage their liquidity risk actively to finance unexpected outflows and reduce their "run" risk. Therefore, these facts and figures made the Ukrainian banking system an especially relevant case for studying the relationship between bank liquidity and exposure to industry-level shocks.

3. Relevant literature

Our paper relates to two strands of literature. The first addresses the effect of economic shocks on the behaviour of banks, and the second examines the causes of the excess liquidity phenomenon in banking systems.[8] Regarding the first strand, many studies argue that banks tend to reduce their lending to increase their holding of liquid assets (Acharya and Merrouche, 2012; De Haan and van den End, 2013). In the context of the global financial crisis, Cornett et al. (2011) provide empirical evidence that US commercial banks with more illiquid assets and unused off-balance sheet loan commitments on their balance sheets increased their holdings of liquid assets and, thus, reduced their lending during the financial crisis. Berrospide (2021) provides similar evidence by arguing that the hoarding of liquid assets by US commercial banks was driven by precautionary motives. Specifically, in order to anticipate future expected losses from security write-downs.[9]

Nevertheless, banks must also withstand shocks stemming from the macroeconomic environment. Inflation volatility may affect the value of collateral pledged by borrowers, prompting banks to charge a higher interest rate, which negatively impacts bank profitability (Agénor and El Aynaoui, 2010). Negative shocks to economic activity may translate into high credit losses for banks. However, the lack of available loan loss provisions accentuates the negative performance reported in banks' income statements (Beatty and Liao, 2011). These parallel results suggest that negative shocks at the macro-level negatively impact banks' financial results and reduce capital and lending, thereby magnifying the impact of negative shocks (Agénor and Pereira da Silva, 2017). This is in line with Acharya et al. (2011), who argue that bank liquidity is countercyclical; lower during economic upturns, higher when recessions are expected, and excessively high during crisis periods.

Other related studies have examined bank liquidity behaviour prior to the Basel III regulations. Using bank-level data for a sample of 25 OECD countries, Bonner et al. (2015) provide evidence on the main bank-specific and country-specific determinants of bank liquidity, which depends on bank liquidity regulations. DeYoung and Jang (2016) argue that US commercial banks set internal targets for their liquidity ratios, operate near to these targets, and when shocked away from these levels, they gradually adjust their positions to come back to their target liquidity levels. Similarly, DeYoung et al. (2018) report that banks increase their holding of liquid assets following negative shocks to their capital ratios, which suggest that banks consider liquidity and capital as substitutes. More recently, Berger et al. (2020) develop a measure of bank liquidity hoarding and document a positive impact of economic policy uncertainty (EPU) on banks' holding of liquid assets.

[4] Data obtained from the State Statistics Service of Ukraine (https://tinyurl.com/2fzc4w).

[5] National Bank of Ukraine, 2014: Signs of stabilization are gradually emerging in the deposit market, [Online] Available at https://tinyurl.com/y7vz92ab (Accessed November 2021).

[6] According to the third Financial Stability Report (2017), out of the 180 banks operating in 2014, around 90 banks, accounting for about one-third of pre-crisis banking assets, were declared insolvent. Moreover, the nationalization and recapitalization of important banks such as PrivatBank and the state-owned Oschadbank and Ukreximbank in 2014 required significant capital injections.

[7] The NBU has decided to gradually introduce new capital requirements, including Tier 1 capital adequacy, a capital buffer and a countercyclical capital buffer. Regarding liquidity requirements, the NBU has decided to introduce the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR).

[8] Other recent strands of literature on bank liquidity have analyzed the impact of liquidity regulations on bank behaviour (Banerjee and Mio, 2018), the role of banks as liquidity providers (Berger and Bowman, 2009; Berger et al., 2016), and the role of banks as liquidity providers and banking supervision (Nguyen et al., 2020), among others.

[9] From a theoretical perspective, Acharya et al. (2012) characterize liquidity hoarding as predatory behaviour by banks that aims to exploit urgent financing needs of other banking institutions. Heider et al. (2015) propose a model of an interbank market with counterparty risk in order to explain the hoarding of liquid assets.

Along the same lines, a growing body of literature has examined the dynamics and consequences of bank liquidity creation. Banks create liquidity by financing relatively illiquid assets with liquid liability, which favours economic transactions (Berger and Bouwman, 2009). Lei and Song (2013) show that bank capital is negatively related to liquidity creation in China, whilst Fungáčová et al. (2017) argue that this relationship depends on the existence of a deposit insurance scheme for Russian banks. Later on, Davydov et al. (2018) examine the cyclicality of bank liquidity creation, and find that it depends on the type of bank ownership. Using a sample of Russian banks, the authors discover that bank liquidity creation is positively related to GDP growth, and this relationship is more pronounced for state and foreign banks than for private banks. More recently, Zhang et al. (2021) provide evidence that excessive liquidity creation increases the systemic risk with a U shape in the Chinese banking sector. This relationship is reinforced through an increased connectedness of banks.

Concerning the phenomenon of excess liquidity in the banking systems, Agenor et al. (2004) provide a theoretical framework that is useful for analyzing the determinants of demand for precautionary excess liquidity. The authors suggest that a cyclical downturn would lead banks to anticipate a lower demand for cash by firms and individuals, leading banks to reduce their holdings of excess liquidity for precautionary reasons. This latter finding is supported by further studies of excess liquidity in developing countries, such as Nguyen and Boateng (2013, 2015).[10]

Turning to the main drivers of the involuntary accumulation of liquid assets, a structural factor that is commonly identified is the degree of financial development. Some studies suggest that in these economies, the higher cost of obtaining and processing information and the higher cost of monitoring borrowers are positively associated with the involuntary accumulation of excess liquid assets by banks (e.g., Agénor and El Aynaoui, 2010). Another set of papers argues that bank liquidity buffers should be countercyclical in economies with underdeveloped capital markets. That is, an increase in the real GDP growth would negatively impact bank liquidity. This could be explained, either through an increase in the lending activities or through the withdrawal of short-term funds by firms and individuals (Saxegaard, 2006; Deléchat et al., 2012), triggered by perceptions of future economic performance.

Furthermore, common findings suggest the degree of financial development as being a key feature that may explain the build-up of involuntary excess liquidity in developing countries (Deléchat et al., 2012). Indicators related to financial development, such as the ratio of private sector credit to GDP, the ratio of bank credit to the central government and public enterprises to GDP, and the ratio of securitized domestic debt to GDP, have been employed to examine the excess liquidity phenomenon. These studies suggest that, in bank-oriented financial systems, a higher level of credit granted to both the private and public sectors negatively impacts banks' excess liquidity, which may result from underdeveloped financial markets.

Although to a lesser extent, our study also connects to the literature on the cyclicality of bank lending. Micco and Panizza (2006) capture the business cycle through GDP growth and find that lending by state-owned banks is less procyclical than that of private banks for an international sample. More recently, Bertay et al. (2015) provide evidence that, during periods of economic downturn, lending by state-owned banks is less adversely affected than private bank lending. However, the opposite is observed during periods of rapid economic growth. Similarly, Behr et al. (2017) study the effect of government involvement in banks, in the form of a "public mandate", on the cyclicality of lending to small and medium-sized enterprises (SMEs). Using data on German banks, the authors report that the effect of this unique institutional setting reduces the sensitivity of bank lending to GDP growth. Specifically, lending by banks with state involvement is, on average, 25% less than for other types of banks.

Consequently, empirical evidence suggests that real GDP growth tends to display a positive relationship with loan supply (e.g., Nguyen and Boateng, 2015). This relationship has been documented by a large body of literature, which argues that positive credit cycles consist of periods of good economic performance and robust credit growth, as well as better investment opportunities. Furthermore, because the demand for loans and the availability of profitable lending opportunities are positively related to domestic economic conditions, bank lending behaviour is essentially procyclical (DeYoung and Jang, 2016; Kim and Sohn, 2017). This evidence is also consistent with the intuition that firms with solid investment opportunities in the short term would want to lock in credit commitments early (Mian and Santos, 2018). However, if demand conditions improve amid high banking system liquidity, banks can rapidly expand the granting of credit, leading to the natural consequences of inflation and financial stability (Guo and Li, 2011).[11]

4. Data and methodology

4.1. Data description

Our dataset is comprised of bank- and industry-level information from three sources. First, we use a unique dataset on bank-level industry loans, which contains borrower industry affiliations. Second, we employ detailed economic information of each industry sector in Ukraine, obtained from the State Statistics Service of Ukraine. Finally, we employ bank-level financial statement data from the National Bank of Ukraine. Our final dataset is an unbalanced panel comprising 710 observations from 180 banks for the 2012–2016

[10] The phenomenon of excess liquidity has been more prevalent in developing countries. To review a list of country-level studies on this subject, see Primus (2017).

[11] Several papers examine the consequences of excess liquidity, both at the macro and micro level (Acharya and Naqvi, 2012; Nguyen and Nguyen and Boateng, 2013, 2015; Martin et al., 2013; Primus, 2017).

Table 1
Descriptive Statistics.

	(1)	(2)	(3)	(6)	(7)	(8)
	N	mean	Std.Dev	p25	p50	p75
$Liquidity^{Ratio}$	710	0.161	0.147	0.067	0.121	0.204
Industry-Level variables:						
$Industry^{CostEffect}$	710	0.074	0.374	−0.138	−0.033	0.320
$Industry^{ProdValue}$	710	0.011	0.056	−0.020	0.001	0.046
Lending variables:						
$Lending^{Total}$	710	0.621	0.219	0.505	0.663	0.787
$Lending^{Corp}$	694	0.503	0.228	0.348	0.517	0.665
$Lending^{Retail}$	673	0.082	0.127	0.007	0.033	0.101
Control variables:						
Credit Risk	703	0.173	0.219	0.038	0.094	0.198
Reserve	707	0.023	0.011	0.016	0.023	0.029
Equity/TA	710	0.248	0.201	0.109	0.177	0.309
Ln(TA)	710	14.40	1.653	13.14	14.20	15.39

Notes: Table 1 reports selected descriptive statistics for the variables included in the analysis. $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. $Industry^{CostEffect}$ is the annual percentage growth rate of the cost-effectiveness ratio of enterprises within each industry merged with the *Expo* variable. $Industry^{ProdValue}$ is the annual percentage growth rate of the production value of enterprises (mln.UAH) within each industry merged with the Expo variable. $Lending^{Total}$ is the ratio between total loans and total assets. $Lending^{Corp}$ is computed by the ratio between loans granted to legal entities and total assets. $Lending^{Retail}$ is computed by the ratio between loans granted to legal entities and total assets. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets.

period. Data is limited to this period of time because of methodological changes in financial statement information.

Based on the extant literature relating to bank liquidity, we have developed a proxy variable for bank liquidity measured through a liquidity ratio ($Liquidity^{Ratio}$).[12] This measure is based on the assets side (e.g., Cornett et al., 2011, Berrospide, 2021; Acharya and Mora, 2015; Behr et al., 2017. In accordance with previous studies, we incorporate the next set of control variables. First, to capture the lending behaviour of banks, we include the ratio between total loans and total assets ($Lending^{Total}$), the ratio between corporate loans and total assets ($Lending^{Corp}$) and the ratio between retail loans and total assets ($Lending^{Retail}$).[13] Second, and to account for variables that support the precautionary reasons for demanding excess liquidity by banks, we include *Credit Risk*, *Reserve* and *Liquidity Risk* as variables (Nguyen and Nguyen and Boateng, 2013). Previous studies allow us to expect a positive effect of credit risk on the demand for excess liquidity and a negative effect of the reserve requirement rate on bank excess liquidity (Agenor et al., 2004). Third, we include the *Equity/TA* and *Ln(TA)* as control variables for bank liquidity management (Cornett et al., 2011). Finally, we control for bank-level and time-fixed effects. All variables previously mentioned are discussed in detail in Online Appendix A.

4.2. Measuring exposure to industry shocks

Based on the extant literature, we define an industry shock as any significant change in an external factor that modifies the industry structure. In this respect, empirical research has suggested factors such as changes in demand and supply conditions and input costs and the regulatory environment (Jensen, 1993; Mitchell and Mulherin, 1996). One way to estimate industry shocks is to measure directly the economic consequences experienced by the industry's agents. Therefore, we measure the effect of industry-level shocks on production value and cost-effectiveness according to bank exposure to each industry in terms of its loan portfolio structure. We select these two economic indicators at the industry level for three reasons. First, cost-effectiveness may capture technological shocks that affect the participants within an industry. Specifically, cost-effectiveness shocks are mainly driven by technological shocks, which result from innovations and technological developments affecting firms' productivity (Berger and Mester, 2003; Saltari and Travaglini, 2009; Ghulam, 2021). Second, production value may reflect shocks to supply and demand conditions. That is to say, production value shocks can be induced by demand shocks either, for instance, through a reduction of consumer spending or a decline in international trade that negatively affects the production value (Hashiguchi et al., 2017; Del Rio-Chanona et al., 2020).

We develop two bank-specific measures of industry-level shocks as follows. First, we construct bank-specific loan portfolio weights

[12] For a robustness check of our bank liquidity variable, we have developed an alternative variable measured as the excess of short-term liquid assets over the statutory reserve requirement maintained at the NBU by Ukrainian banks, represented by an excess liquidity ratio ($Liquidity^{Excess}$). These results are presented in Section 5.2.

[13] We focus on retail and corporate loans, as the relevance of mortgage loans over total loans is low. According to the Financial Stability Report issued by the NBU (June 2018), the percentage of mortgage loans over retail loans ranges from 11.8% in 2014 to 13.5% in 2016. The report also mentions that the amount of mortgage loans is still small as of June 2018.

Table 2
Descriptive statistics - subsample.

	High liquidity		Low Liquidity		Difference
	Mean	Std. Dev.	Mean	Std. Dev.	Diff***
$Liquidity^{Ratio}$	0.254	0.152	0.063	0.033	0.191***
$Industry^{CostEffect}$	0.034	0.341	0.112	0.402	−0.078***
$Industry^{ProdValue}$	0.005	0.057	0.019	0.056	−0.014***
$Lending^{Total}$	0.557	0.192	0.685	0.226	−0.128***
$Lending^{Corp}$	0.455	0.182	0.552	0.258	−0.097***
$Lending^{Retail}$	0.080	0.098	0.085	0.151	−0.005
Credit Risk	0.155	0.206	0.194	0.242	−0.040**
Reserve	0.025	0.010	0.021	0.011	0.003***
Equity/TA	0.225	0.178	0.277	0.234	−0.052***
Ln(TA)	14.51	1.599	14.27	1.681	0.234*

Notes: Table 2 reports the mean, the standard deviation and the test of difference in means for the variables included in the analysis and for the subsample of banks with high and low liquidity. $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. $Industry^{CostEffect}$ is the annual percentage growth rate of the cost-effectiveness ratio of enterprises within each industry merged with the *Expo* variable. $Industry^{ProdValue}$ is the annual percentage growth rate of the production value of enterprises (mln.UAH) within each industry merged with the Expo variable. $Lending^{Total}$ is the ratio between total loans and total assets. $Lending^{Corp}$ is computed by the ratio between loans granted to legal entities and total assets. $Lending^{Retail}$ is computed by the ratio between loans granted to legal entities and total assets. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets.

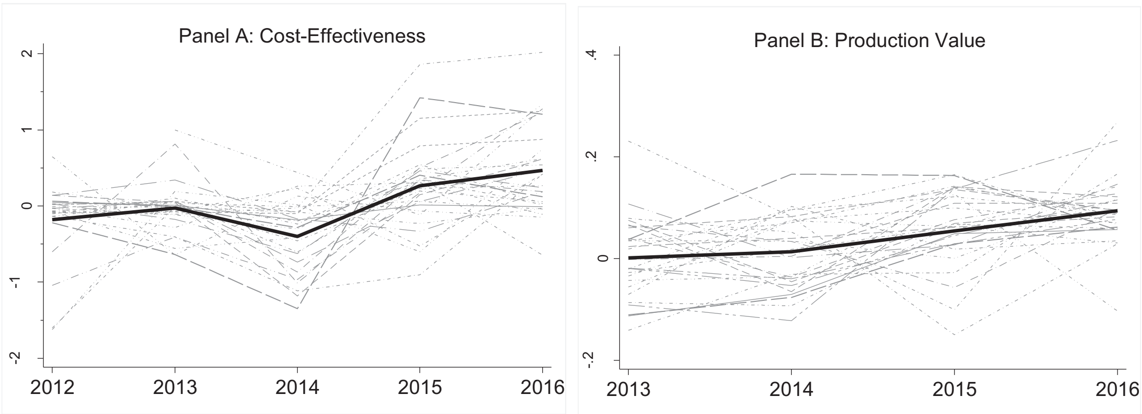

Fig. 1. This figure displays the dynamics over time of $Industry^{CostEffect}$ and $Industry^{ProdValue}$ for each industry and at the aggregate level. In Panel A, each line represents the behaviour over time of $Industry^{CostEffect}$ for each industry and, the bold line, at the aggregate level. In Panel B, each line represents the behaviour over time of $Industry^{ProdValue}$ for each industry and, the bold line, at the aggregate level.

for each industry J, where $J = 1.......29$ is the ratio between the amount of loans granted to industry J and the total amount of loans granted to all industries by the bank b in the year t ($Exposure_{bjt}$).[14] Second, we compute industry-level indices as the annual growth rate of two economic indicators for each industry J. The economic indicators are the cost-effectiveness and the production value of each industry denoted by $I_{Jt} = \{CostEffect_{jt}, ProdValue_{jt}\}$. The cost-effectiveness represents the firms' operational performance, and the production value reflects firms' production value within each industry. Then, for each industry, we compute the logarithm differences between the value of each indicator in year t and year $t-1$, respectively.

These indices will allow us to capture any major changes in external factors that trigger positive or negative shocks in the industry's cost-effectiveness and production value. In other words, they will enable us to gauge the economic consequences experienced by the industry's firms as a result of an industry shock.

Third, to obtain our two bank-specific measures of industry shocks, we apply these industry-level indices to the bank-specific loan portfolio weights for each industry ($Exposure_{bjt}$), given by:

$$Industry_{bt} = \sum_{j=1}^{j=29} Exposure_{bjt} \times I_{jt}$$

[14] See Online Appendix B for industry classifications.

Table 3
Pearson Correlation Matrix.

	$Liquidity^{Ratio}$	$Lending^{Total}$	$Lending^{Corp}$	$Lending^{Retail}$	Credit Risk	Reserve	Equity/TA	Ln(TA)	$Industry^{CostEffect}$
$Lending^{Total}$	−0.49***								
$Lending^{Corp}$	−0.33***	0.78***							
$Lending^{Retail}$	−0.04	0.12***	−0.43***						
Credit Risk	−0.06	−0.24***	−0.18***	−0.02					
Reserve	0.08**	0.04	−0.01	0.03	0.01				
Equity/TA	0.03	−0.15***	0.02	−0.17***	−0.02	−0.56***			
Ln(TA)	−0.09**	0.09**	−0.02	0.18***	0.18***	0.26***	−0.62***		
$Industry^{CostEffect}$	−0.12***	−0.11***	−0.08**	−0.04	0.02	−0.00	0.05	0.02	
$Industry^{ProdValue}$	−0.17***	−0.02	0.05	−0.07*	0.06*	0.10	−0.05	0.09**	0.39***

Notes: Table 3 reports the Pearson correlation coefficients for the variables included in the analysis *$Liquidity^{Ratio}$* is the ratio between short-term liquid assets and total assets. *$Industry^{CostEffect}$* is the annual percentage growth rate of the cost-effectiveness ratio of enterprises within each industry merged with the *Expo* variable. *$Industry^{ProdValue}$* is the annual percentage growth rate of the production value of enterprises (mln.UAH) within each industry merged with the Expo variable. *$Lending^{Total}$* is the ratio between total loans and total assets. *$Lending^{Corp}$* is computed by the ratio between loans granted to legal entities and total assets. *$Lending^{Retail}$* is computed by the ratio between loans granted to legal entities and total assets. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

The shock measures allow us to capture the effect of bank exposure to industry-level shocks on production value and cost-effectiveness, based on the bank's loan portfolio structure. To some extent, these variables resemble Bartik-type instruments (e.g., Goldsmith-Pinkham et al., 2020), created by interacting with local industry weights and industry growth rates (shocks). The weights reflect differential exposure to common shocks.

4.3. Descriptive statistics

Table 1 presents summary statistics for variables employed in the study. Our focus is on the bank liquidity variable, the lending variables and, especially, upon our key bank-specific measures of industry-level shocks.

We can observe that during the 2012–2016 period, the liquidity ratio ($Liquidity^{Ratio}$) of Ukrainian banks exhibits a mean of 16.1%, meaning that the short-term liquid assets, this being the addition of Cash and Cash Equivalents and Trading Securities, represent 16.1% of the Ukrainian banking system's assets. Regarding the bank lending variables, total lending exhibits a mean equal to 62.1% of the total assets of the Ukrainian banking system. Considering that total lending consists of loans granted to the corporate and retail sector, corporate and retail lending report a mean of 50.3% and 8.2%, respectively. These statistics reflect the importance of the corporate sector for the Ukrainian banking system.

Table 2 reports descriptive statistics of the variables used in our study across banks with high and low liquidity. We can observe that low liquidity banks exhibit higher exposure to industry-level shocks, compared to high liquidity banks. This evidence highlights the importance of liquidity management for banks when they are faced with exogenous shocks. In addition to this, low liquidity banks show higher ratios of total loans and corporate loans over total assets, relative to high liquidity banks.

Fig. 1 shows the behaviour over time of $Industry^{ProdValue}$ for each industry and at the aggregate level. Panel A shows the dynamics over time of $Industry^{CostEffect}$ for each industry and at the aggregate level. First, the differing performance of $Industry^{CostEffect}$ across all industries can be clearly observed, which suggests that firms within a particular industry exhibit a different behaviour than firms operating in another industry. Second, while certain industries exhibit a more volatile performance, others show a more stable conduct pattern over time. Third, despite the heterogeneous performance across all industries, the positive trend of $Industry^{CostEffect}$ has been evident at the aggregate level since 2014. Similarly, Panel B exhibits the dynamics over time of $Industry^{ProdValue}$ for each industry and at the aggregate level, and it also confirms the variation of indices across sectors.

Table 3 displays correlations between the variables of the study. We can observe a negative and statistically significant correlation between our bank liquidity variable and the bank lending variables, except for retail lending, which is not significant. These results suggest that, in order to increase the granting of credit, banks must reduce their holdings of liquid assets, which is in line with the arguments of previous studies (Cornett et al., 2011).

Concerning our main variables of interest, the correlation between the two industry-level shock variables is 0.39 and statistically significant at the 1% level. This result allows us to hypothesize that when the production value of firms within each industry increases, the operational result of firms also increases, which reflects an increase in the cost-effectiveness of firms within their respective industries.

4.4. Econometric specification

To examine whether and how bank exposure to industry-level shocks affects the holding of liquid assets by banks, we propose Eq. (1) which takes the following form:

$$Liquidity_{bt} = \beta_0 + \beta_1 Industry_{bt} + \beta_2 Industry_{bt} \times Lending_{bt} + \beta_3 Lending_{bt} + X_{bt}\delta + \epsilon_b + \mu_t + \varepsilon_{b,t} \quad (1)$$

where $Liquidity_{bt}$ represents the bank liquidity of bank b in the year t, measured by the bank liquidity ratio ($Liquidity^{Ratio}$). The variable $Industry_{bt}$ is one of the two bank-specific measures of bank exposure to industry-level shocks ($Industry^{CostEffect}$ or $Industry^{ProdValue}$). Thus, these variables will allow us to examine the direct effects of bank shock exposure on bank liquidity. These key bank-specific measures of bank shock exposure are considered to be exogenous variables, as they are the results of the economic environment. Additionally, $Lending_{bt}$ represents one of our three proxy variables of bank lending behaviour ($Lending^{Total}$, $Lending^{Corp}$ or $Lending^{Retail}$). The interaction term between $Industry_{bt} \times Lending_{bt}$ allows us to examine the indirect impact of bank exposure to industry-level shocks through the lending behaviour of banks on bank liquidity.

Vector X_{bt} is a set of control variables for bank b at time t, which contains the *Credit Risk* (loan loss provisions over total loans), *Reserve* (amount of required reserves over total assets), *Equity/TA* (bank equity over total assets) and *Ln(TA)* (natural logarithm of total assets). We also include a set of fixed effects at different aggregation levels to control for unobservable firm-invariant and time-invariant fixed effects. Fixed effects are included at the bank-level (ϵ_b) and year-level (μ_t). Year fixed effects allow us to control for system-wide shocks and regulatory conditions (e.g., Mourouzidou-Damtsa et al., 2019). Finally, ε_{bt} is the error term.

Consequently, Eq. (1) is estimated employing two-way fixed effect regressions, which allows us to control for both bank-fixed effects and time-fixed effects within the same model. We are aware of the potential issues related to this estimation approach (e.g., potential endogeneity). This point is addressed in detail in our robustness check section below.

Table 4
Bank Liquidity and Industry Shocks: Total Lending.

	(1)	(2)	(3)	(4)	(5)	(6)
$Industry^{CostEffect}$	−0.089*	−0.226***			−0.199***	
	(0.025)	(0.050)			(0.050)	
$Industry^{CostEffect} \times Lending^{Total}$		0.281***			0.243***	
		(0.054)			(0.054)	
$Industry^{ProdValue}$			−0.342***	−0.845***	−0.570**	
			(0.131)	(0.251)	(0.240)	
$Industry^{ProdValue} \times Lending^{Total}$				1.035***	0.738**	
				(0.368)	(0.345)	
PC1						−0.070***
						(0.017)
$PC1 \times Lending^{Total}$						0.090***
						(0.020)
$Lending^{Total}$	−0.447***	−0.494***	−0.447***	−0.459***	−0.492***	−0.457***
	(0.053)	(0.052)	(0.051)	(0.050)	(0.051)	(0.048)
Credit Risk	−0.001	0.001***	0.001	0.001**	0.001***	0.001***
	(0.043)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Reserve	1.345	1.795	1.408	1.761	1.995*	2.023*
	(1.132)	(1.161)	(1.121)	(1.117)	(1.155)	(1.142)
Equity/TA	0061	0.090**	0.065	0.080*	0.097**	0.095**
	(0.046)	(0.043)	(0.042)	(0.042)	(0.043)	(0.043)
Ln(TA)	0021	0.026*	0.020	0.020	0.024*	0.023
	(0.012)	(0.015)	(0.014)	(0.014)	(0.015)	(0.014)
Observations	700	700	700	700	700	700
R-squared	0.356	0.481	0.352	0.472	0.486	0.485

Notes: Table 4 reports the regression results of Eq. (1). $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. $Industry^{CostEffect}$ is the annual percentage growth rate of the cost-effectiveness ratio of enterprises within each industry merged with the *Expo* variable. $Industry^{ProdValue}$ is the annual percentage growth rate of the production value of enterprises (mln.UAH) within each industry merged with the Expo variable. $Lending^{Total}$ is the ratio between total loans and total assets. $Lending^{Corp}$ is computed by the ratio between loans granted to legal entities and total assets. $Lending^{Retail}$ is computed by the ratio between loans granted to legal entities and total assets. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

5. Results discussion

5.1. Main results

Table 4 reports the results for the different estimations of Eq. (1). Columns (1) and (2) examine the effect of bank exposure to industry-level shocks on cost-effectiveness ($Industry^{CostEffect}$). Likewise, in Columns (3) and (4), we explore the impact of bank exposure to industry-level shocks on production value ($Industry^{ProdValue}$). The final two columns present the simultaneous effect of both bank shock exposure variables, and Column (6) displays the results when the principal component from $Industry^{CostEffect}$ and $Industry^{ProdValue}$ is taken into consideration. These estimations regard total lending ($Lending^{Total}$) as a proxy variable of bank lending behaviour. In this way, we examine the direct effects of bank shock exposure and their indirect impact through bank lending behaviour on bank liquidity.

Regarding our two key variables of bank shock exposure, Table 4 displays a negative and statistically significant effect on bank liquidity. Column (1) shows that bank exposure to industry-level shocks on cost-effectiveness ($Industry^{CostEffect}$) impacts negatively on banks' liquidity ratio ($Liquidity^{Ratio}$). Similarly, column (2) demonstrates that a positive industry-level shock to cost-effectiveness leads to a reduction in banks' liquidity ratio. For instance, if the magnitude of bank shock exposure to an industry-level shock to cost-effectiveness is 20 percentage points higher, banks' liquidity ratio is likely to decrease by 4.52 percentage points.

As mentioned in the previous section, because the average sample mean of $Liquidity^{Ratio}$is relatively low, only a substantial change in bank shock exposure generates an economically significant effect on bank liquidity. This result allows us to infer that a higher performance at the industry level, this being a positive industry shock, is positively associated with GDP growth and with a higher demand for funds by firms and individuals. Therefore, banks with higher exposure to industry-level shocks would reduce their holdings of liquid assets due to an increase in the demand for loans and/or by the withdrawal of funds from wholesale deposits (Saxegaard, 2006; Deléchat et al., 2012).

By examining the indirect effect of bank shock exposure through bank lending behaviour on bank liquidity, column (2) reports the coefficient estimate of the interaction term between $Industry^{CostEffect}$ and $Lending^{Total.}$.The coefficient of $Industry^{CostEffect} \times Lending^{Total}$ is statistically significant at the 1% level and it indicates that, if the magnitude of bank shock exposure to an industry-level shock to cost-effectiveness increases by 20 percentage points, for a bank with a loan ratio of 60%, banks' liquidity buffer would increase by 3.4 percentage points. In combination with the economic effect from the standalone term $Industry^{CostEffect}$, our results suggest that in net, banks' liquidity buffer would decrease by 1.12 percentage points, which is equivalent to 7.6% of the standard deviation of $Liquidity^{Ratio}$.

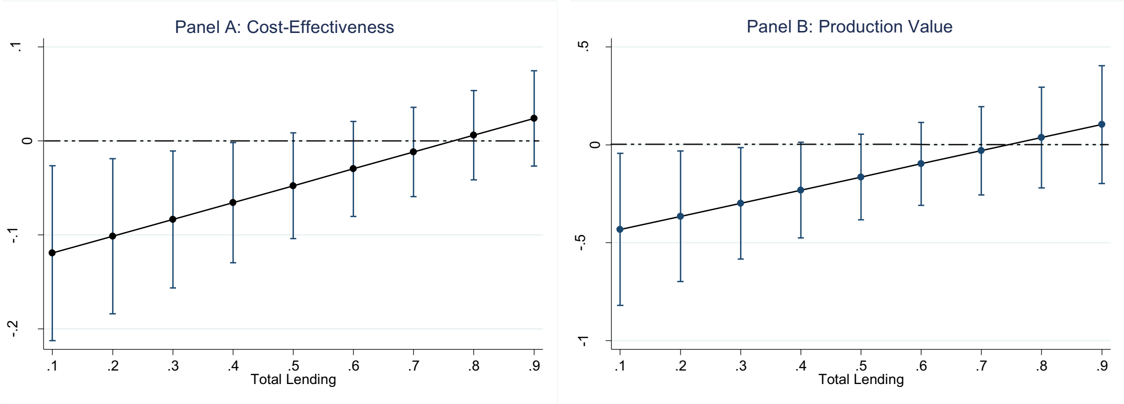

Fig. 2. Marginal effects of industry-level shocks.
This figure presents the marginal effects of bank-specific measures of industry-level shocks on bank liquidity at different levels of lending. Panel A presents the marginal effects of $Industry^{CostEffec}$ on $Liquidity^{Ratio}$ at different levels of $Lending^{Total}$. Similarly, Panel B shows the marginal effects of $Industry^{ProdValue}$ on $Liquidity^{Ratio}$ at different levels of $Lending^{Total}$.

This finding suggests that, when industries experience a positive shock to cost-effectiveness and the granting of loans increases, banks with higher shock exposure tend to increase their liquidity. This result is in line with the argument that firms with strong investment opportunities in the short term would want to lock in credit commitments early (Mian and Santos, 2018) and with the inherent pro-cyclicality of bank lending (DeYoung and Jang, 2016; Kim and Sohn, 2017).

In terms of our second bank shock exposure variable, Column (3) of Table 4 reports that bank exposure to industry-level shocks to the production value ($Industry^{ProdValue}$) negatively affect bank liquidity. Column (4) shows that a positive industry-level shock to the production value leads to a decline in banks' liquidity ratio. For example, if the magnitude of bank exposure to an industry-level shock to the production value is 10 percentage points higher, banks' liquidity ratio would decrease by 8.45 percentage points, on average. This result suggests that a higher performance at the industry level, reflected by a higher production value, is positively related to GDP growth and, in turn, higher demand for funds by firms and individuals. Column (4) also shows a positive and significant interaction term between $Industry^{ProdValue}$ and $Lending^{Total}$, reflecting the effect of bank shock exposure through banks' lending behaviour on bank liquidity. In particular, when industries experience a positive shock to production value and the granting of loans increases, banks with higher exposure to industry-level shocks would increase the holding of liquid assets.

To illustrate the indirect effects of our two measures of bank shock exposure through bank lending behaviour on bank liquidity, Fig. 2 shows the marginal effects of $Industry^{CostEffec}$ (Panel A) and $Industry^{ProdValue}$ (Panel B) on bank liquidity at different levels of $Lending^{Tota}$. From both panels, we can observe that the impact of industry-level shocks on bank liquidity is higher at lower levels of bank lending. To examine the direct and indirect effects of bank exposure to industry-level shocks on bank liquidity, we augment our baseline model to include each bank shock exposure variable and its interaction with total lending. Consequently, Column (5) displays similar results to those in Columns (1) to (4).

Finally, we use principal component analysis to construct a common index across both bank shock exposure variables ($Industry^{CostEffect}$ and $Industry^{ProdValue}$). Column (6) of Table 4 reports the estimation results for the first principal component from $Industry^{CostEffect}$ and $Industry^{ProdValue}$ (*PC1*) and the coefficient estimate of the interaction term between *PC1* and $Lending^{Total}$. The results exhibit the same relationship with bank liquidity as in the previous columns.

Regarding the bank lending variable, $Lending^{Total}$ exhibits a negative and statistically significant effect on bank liquidity in all four columns, suggesting that efforts to build up balance sheet liquidity displace funds to support lending (Cornett et al., 2011; Berrospide, 2021; De Haan and van den End, 2013), which is more pronounced in times of macroeconomic instability (Brei and Schclarek, 2015). The magnitude of the coefficient estimates on $Lending^{Total}$ ranges from −0.447 to −0.494, with an average value equal to 0.466. This evidence suggests that an increase of 5 percentage points in the granting of credit would lead to a reduction by 2.3 percentage points in the holdings of liquid assets by banks.

This inverse relationship has been well-established by the literature on bank-lending behaviour, which argues that banks can resort to liquid assets to finance their lending and, in turn, banks with higher liquidity tend to increase their lending more quickly compared to less liquid banks (e.g., Allen et al., 2014). Furthermore, because the demand for loans and the availability of profitable lending opportunities are positively related to the domestic economic conditions, the inherent procyclicality of bank lending affects bank liquidity management (DeYoung and Jang, 2016; Kim and Sohn, 2017).

However, our results show an insignificant effect of credit risk on bank liquidity, contrary to previous studies (Nguyen and Boateng, 2013). Similarly, our estimations fail to provide evidence of a significant effect of *Reserve* on $Liquidity^{Ratio}$, as suggested by previous

Table 5
Bank Liquidity and Industry Shocks: Corporate and Retail Lending.

	(1)	(2)	(3)	(4)
Panel A: Corporate Lending				
$Industry^{CostEffect}$	−0.152***		−0.135***	
	(0.047)		(0.052)	
$Industry^{CostEffect} \times Lending^{Corp}$	0.184***		0.145***	
	(0.045)		(0.044)	
$Industry^{ProdValue}$		−0.628***	−0.478**	
		(0.198)	(0.200)	
$Industry^{ProdValue} \times Lending^{Corp}$		0.824***	0.744**	
		(0.296)	(0.289)	
PC1				−0.049***
				(0.013)
$PC1 \times Lending^{Corp}$				0.062***
				(0.017)
$Lending^{Corp}$	−0.357***	−0.330***	−0.354***	−0.328***
	(0.052)	(0.050)	(0.054)	(0.048)
Observations	694	694	694	694
R-squared	0.223	0.219	0.239	0.236
Panel B: Retail Lending				
	(1)	(2)	(3)	(4)
$Industry^{CostEffect}$	0.028		0.058*	
	(0.028)		(0.029)	
$Industry^{CostEffect} \times Lending^{Retail}$	0.094		0.096	
	(0.095)		(0.085)	
$Industry^{ProdValue}$		−0.556***	−0.636***	
		(0.186)	(0.193)	
$Industry^{ProdValue} \times Lending^{Retail}$		0.307	0.263	
		(0.405)	(0.355)	
PC1				−0.017*
				(0.010)
$PC1 \times Lending^{Retail}$				0.017
				(0.029)
$Lending^{Retail}$	−0.322**	−0.281*	−0.300**	−0.286*
	(0.155)	(0.145)	(0.147)	(0.153)
Observations	673	673	673	673
R-squared	0.263	0.268	0.275	0.262

Notes: Table 5 reports the regression results of Eq. (1). Table 5 exhibits the results controlling for $Lending^{Corp}$ (Panel A) and $Lending^{Retail}$ (Panel B). All regressions include bank-level control variables. For detailed variable descriptions, see Online Appendix A. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

papers (Agenor et al., 2004). Moreover, bank capital and bank size have a positive and economically significant effect on bank liquidity. These latter findings support the argument that these factors can attract more deposits and capital inflows which, in underdeveloped financial markets, may explain the accumulation of liquid assets (Diamond and Rajan, 2000). The results in Table 4 suggest that if the *Equity/TA* increases by two standard deviations, $Liquidity^{Ratio}$ increases by 2.5 percentage points.[15] Additionally, if bank size increases by ten percentage points, $Liquidity^{Ratio}$ would increase by 0.22 percentage points (DeYoung and Jang, 2016).

The results observed, thus far, provide evidence of the direct effects of bank shock exposure and their indirect impact through the lending behaviour of banks on bank liquidity, providing support to the inherent procyclicality of bank lending (Kim and Sohn, 2017). Consequently, it is worth including in the analysis the potential effect of the two types of loans that explain our proxy variable of bank lending behaviour, specifically, the loans granted to the corporate ($Lending^{Corp}$) and retail sectors ($Lending^{Retail}$). The inclusion of these variables will help us to examine the extent to which bank liquidity is influenced by each type of loan. Additionally, this analysis will allow us to examine whether the indirect effect of bank exposure to industry-level shocks through the lending behaviour of banks on bank liquidity is conditional upon a specific type of loan.

Table 5 displays the results for the different estimations carried out using Eq. (1), including separate estimations for $Lending^{Corp}$ (Panel A) and $Lending^{Retail}$ (Panel B), as well as its interaction term with our proxy variables of bank shock exposure. For presentation purposes, we do not report the results for the control variables.

Firstly, in all the estimations results reported in Panel A of Table 5, the loans granted to the corporate sector show a negative and statistically significant effect on banks' holdings of liquid assets. These results support the inverse relationship between bank lending

[15] We calculate this number as two standard deviation of *Equity/TA* (0.201) multiplied by the coefficient estimate (0.061) reported in column (1) of Table 4.

Table 6
Bank Liquidity and Positive and Negative Industry Shocks: Total Lending.

	(1)	(2)	(3)
Positive Industry^{CostEffect}	−0.286***		−0.244***
	(0.061)		(0.070)
Positive Industry^{CostEffect} × Lending^{Total}	0.358***		0.277***
	(0.072)		(0.083)
Negative Industry^{CostEffect}	−0.069		−0.055
	(0.106)		(0.132)
Negative Industry^{CostEffect} × Lending^{Total}	0.089		0.115
	(0.137)		(0.174)
Positive Industry^{ProdValue}		−1.297***	−0.864**
		(0.397)	(0.401)
Positive Industry^{ProdValue} × Lending^{Total}		1.710***	0.931*
		(0.576)	(0.572)
Negative Industry^{ProdValue}		−0.214	−0.186
		(0.404)	(0.462)
Negative Industry^{ProdValue} × Lending^{Total}		0.138	0.270
		(0.589)	(0.666)
Lending^{Total}	−0.528***	−0.501***	−0.528**
	(0.057)	(0.058)	(0.065)
Credit Risk	0.001***	−0.001***	0.001
	(0.000)	(0.000)	(0.000)
Reserve	1.984*	1.748	2.055*
	(1.169)	(1.121)	(1.153)
Equity/TA	0.099**	0.081*	0.100**
	(0.044)	(0.042)	(0.043)
Ln(TA)	0.036*	0.020	0.024*
	(0.020)	(0.014)	(0.015)
Observations	700	700	700
R-squared	0.401	0.376	0.413

Notes: Table 6 reports the regression results of Eq. (1) incorporating positive and negative shocks as the main explanatory variables. *Liquidity^{Ratio}* is the ratio between short-term liquid assets and total assets. *Positive Industry^{CostEffect}* is equal to the actual *Industry^{CostEffect}* if this is higher than zero, and zero otherwise. *Negative Industry^{CostEffect}* is equal to the actual *Industry^{CostEffect}* if this is lower than zero, and zero otherwise. *Positive Industry^{ProdValue}* is equal to the actual *Industry^{ProdValue}* if this is higher than zero, and zero otherwise. *Negative Industry^{ProdValue}* is equal to the actual *Industry^{ProdValue}* if this is lower than zero, and zero otherwise. *Lending^{Total}* is the ratio between total loans to total assets. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln (TA)* is the natural logarithm of total assets. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

and liquidity on the right side of bank balance sheets, as earlier mentioned, specifically between *Lending^{Corp}* and *Liquidity^{Ratio}*. In other words, when the granting of credit to the corporate sector increases, banks reduce the level of liquid assets that they hold in order to displace funds to support new lending (Cornett et al., 2011; Berrospide, 2021; De Haan and van den End, 2013). The magnitude of the coefficient estimates on *Lending^{Corp}* ranges from −0.328 to −0.357, with an average value of 0.342. This suggests that an increase of 5 percentage points in the granting of credit to the corporate sector would lead to a reduction by 1.8 percentage points in banks' liquidity ratio.

Secondly, and in line with the results shown in Table 4, industry-level shocks to cost-effectiveness still exhibit a negative and statistically significant effect on bank liquidity. In other words, if the magnitude of bank exposure to industry-level shock on cost-effectiveness is 20 percentage points, banks' liquidity ratio would decrease by 3.0 percentage points, on average. Similarly, these results suggest that a higher operational performance at the industry level is positively related to GDP growth and, thus, higher demand for funds by firms and individuals, which could be explained by positive expectations for the economy (Mian and Santos, 2018).

Thirdly, with respect to the indirect effect of bank exposure to industry-level shocks through the lending behaviour of banks on bank liquidity, Column (1) of Panel A reports a positive and statistically significant coefficient estimate of the interaction term between *Industry^{CostEffect}* and *Lending^{Corp}*. When industries experience a positive shock to cost-effectiveness, and the granting of loans to the corporate sector is higher, banks tend to increase their liquidity. Hence, when firms' operational performance within each industry improves and the amount of bank credit granted to the corporate sector increases, firms can finance their growth opportunities and invest part of their returns in liquid bank assets.

Along the same lines, Column (2) in Panel A shows that bank exposure to industry-level shocks to production value impacts bank liquidity negatively. Hence, a higher performance at the industry level, reflected through firms' higher production value, is positively related to GDP growth and, in turn, to higher demand for funds by firms and individuals. Consequently, a positive industry-level shock to production value leads to banks negatively adjusting their holding of liquid assets. For instance, if the magnitude of bank exposure to industry-level shock on production value is ten percentage points higher, the holding of liquid assets by banks would decrease by 6.3 percentage points, on average. Furthermore, the coefficient estimate of the interaction term between *Industry^{ProdValue}* and *Lending^{Corp}* is

Table 7
Bank Lending and Positive-Negative Industry Shocks.

	(1)	(2)	(3)	(4)	(5)	(6)
Positive Industry^{CostEffect}	−0.059		−0.060			
	(0.056)		(0.056)			
Negative Industry^{CostEffect}		−0.031	−0.033			
		(0.048)	(0.048)			
Positive Industry^{ProdValue}				0.082		0.029
				(0.247)		(0.243)
Negative Industry^{ProdValue}					1.095***	1.092***
					(0.395)	(0.393)
Credit Risk	−0.113*	−0.109	−0.113*	−0.109	−0.109*	−0.109*
	(0.066)	(0.067)	(0.067)	(0.067)	(0.065)	(0.065)
Reserve	0.434	0.453	0.428	0.447	0.175	0.172
	(1.851)	(1.851)	(1.854)	(1.842)	(1.830)	(1.825)
Equity/TA	0.194	0.189	0.192	0.192	0.168	0.168
	(0.129)	(0.129)	(0.129)	(0.130)	(0.125)	(0.125)
Ln(TA)	0.031	0.030	0.030	0.031	0.031	0.031
	(0.038)	(0.038)	(0.038)	(0.038)	(0.037)	(0.037)
Observations	700	700	700	700	700	700
R-squared	0.102	0.100	0.103	0.100	0.119	0.119

Notes: Table 7 reports the regression results on the link between positive/negative industry-level shocks and bank lending. In all columns the dependent variable is $Lending^{Total}$, which is the ratio between total loans and total assets. *Positive Industry*^{CostEffect} is equal to the actual *Industry*^{CostEffect} if this is higher than zero, and zero otherwise. *Negative Industry*^{CostEffect} is equal to the actual *Industry*^{CostEffect} if this is lower than zero, and zero otherwise. *Positive Industry*^{ProdValue} is equal to the actual *Industry*^{ProdValue} if this is higher than zero, and zero otherwise. *Negative Industry*^{ProdValue} is equal to the actual *Industry*^{ProdValue} if this is lower than zero, and zero otherwise. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

positive and economically significant, reflecting the indirect effect of bank exposure to industry-level shocks through the lending behaviour of banks on bank liquidity. Thus, when industries experience a positive shock to firms' production value and the granting of credit by banks to legal entities increases, banks tend to increase their level of liquid assets.

Additionally, when the impact of bank exposure to cost-effectiveness shocks, in addition to production value shocks and its respective interaction with corporate lending, are included simultaneously in the same regression, Column (3) of Panel A, the outcomes remain the same. These results support our previous findings regarding the direct effect of bank exposure to industry-level shocks on cost-effectiveness, on production value and its indirect effect through bank lending on bank liquidity. In addition, and similar to the results displayed in Column (5) of Table 4, both interaction terms exhibit a positive and statistically significant effect on bank liquidity, which reflects the role of corporate lending in the transmission of industry-level shocks to bank liquidity. Finally, Column (4) of Panel A displays the estimation results for the first principal component from *Industry*^{CostEffect} and *Industry*^{ProdValue} (*PC1*) and the coefficient estimate of the interaction term between *PC1* and $Lending^{Corp}$. The results exhibit the same relationship with bank liquidity as in previous columns.

With respect to our third proxy variable of bank lending behaviour ($Lending^{Retail}$), the estimates presented in Panel B of Table 5 provide weak evidence of a statistically significant effect of retail loans on bank liquidity. Likewise, the results do not show statistically significant results concerning the direct effect of bank exposure to industry-level shocks on cost-effectiveness and its indirect effect through bank lending on bank liquidity. However, the results show a significant effect of bank exposure to industry-level shocks on production value, but not its indirect effect through bank lending on bank liquidity.

These results allow us to argue that it is the granting of credits to the corporate sector, and not the retail sector, that is the main channel through which the industry-level shocks impact bank liquidity. The estimates support the argument that a positive industry-level shock is positively associated with GDP growth, with a higher demand for funds, and, therefore, banks with higher exposure to industry-level shocks will reduce their holdings of liquid assets. Likewise, our results suggest that when firms' financial performance within each industry improves and the amount of bank credit available in the economy is higher, firms exploit their growth opportunities and invest part of their returns in liquid bank assets. This is in line with the argument that firms with strong investment opportunities in the short term would want to lock in credit commitments early (Mian and Santos, 2018) and with the inherent procyclicality of bank lending (Kim and Sohn, 2017).

A natural question emerges if bank liquidity is symmetric to the positive and negative shocks. In Table 6, we examine the effect of positive and negative shocks on bank liquidity. To this end, we expand Eq. (1) by replacing the variables of bank shock exposure (*Industry*^{CostEffect} or *Industry*^{ProdValue}) with two variables capturing either positive or negative shocks. By including both types of shocks in the same estimation model, we can examine whether bank liquidity is asymmetric to positive or negative shocks (e.g., Behr et al., 2017; Davydov et al., 2018). *Positive Industry*^{CostEffect} is equal to the actual *Industry*^{CostEffect} if this is higher than zero, and zero otherwise. *Negative Industry*^{CostEffect} is equal to the actual *Industry*^{CostEffect} if this is lower than zero, and zero otherwise. *Positive Industry*^{ProdValue} is

Table 8
Bank Liquidity and Industry Shocks: Liquidity, Capital and Size.

	Liquidity Ratio		Capital Ratio		Bank Size	
	High	Low	High	Low	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Cost-Effectiveness						
$Industry^{CostEffect}$	−0.272***	−0.014	−0.246***	−0.159	−0.266***	−0.302***
	(0.067)	(0.016)	(0.067)	(0.099)	(0.097)	(0.074)
$Industry^{CostEffect} \times Lending^{Total}$	0.390***	0.015	0.321***	0.232**	0.316***	0.359***
	(0.083)	(0.019)	(0.081)	(0.112)	(0.101)	(0.084)
$Lending^{Total}$	−0.483***	−0.023	−0.515***	−0.463***	−0.555***	−0.565***
	(0.074)	(0.019)	(0.057)	(0.082)	(0.089)	(0.056)
Observations	349	351	348	352	354	346
R-squared	0.431	0.124	0.499	0.364	0.440	0.505
Panel B: Production Value						
$Industry^{ProdValue}$	−1.106*	0.017	−0.723**	−0.910	−0.747*	−0.708**
	(0.639)	(0.072)	(0.294)	(0.547)	(0.378)	(0.296)
$Industry^{ProdValue} \times Lending^{Total}$	1.400*	−0.056	1.067***	1.060	0.904	0.728*
	(1.058)	(0.109)	(0.354)	(0.801)	(0.062)	(0.394)
$Lending^{Total}$	−0.465***	−0.016	−0.495***	−0.433***	−0.495***	−0.525***
	(0.078)	(0.019)	(0.060)	(0.073)	(0.095)	(0.057)
Observations	349	351	348	352	354	346
R-squared	0.386	0.123	0.459	0.344	0.369	0.450

Notes: Table 8 reports the regression results of Eq. (1). Panel A presents the estimations results for $Industry^{CostEffect}$. Panel B exhibits the regression results for $Industry^{ProdValue}$. In each panel, Columns (1), (3) and (5) report the regression results for the subsample where the variable Liquidity Ratio, Capital Ratio and Bank Size is greater than the sample median, respectively. Columns (2), (4) and (6) report the regression results for the subsample where the variable Liquidity Ratio, Capital Ratio and Bank Size is lower than the sample median, respectively. All regressions include bank-level control variables. For detailed variable descriptions, see Online Appendix A. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

equal to the actual $Industry^{ProdValue}$ if this is higher than zero, and zero otherwise. *Negative* $Industry^{ProdValue}$ is equal to the actual $Industry^{ProdValue}$ if this is lower than zero, and zero otherwise.

Overall, our results are driven by positive shocks, instead of negative shocks. Specifically, we can observe that banks adjust their liquidity holdings in the same way for positive and negative shocks. However, the impact of positive shocks is more pronounced in both magnitude and statistical significance. The results reported in Table 6, suggest that one standard deviation change in *Positive* $Industry^{CostEffect}$ leads to a change in banks' liquidity ratio of 8.3 percentage points (Column 1), while a similar change in *Positive* $Industry^{ProdValue}$ leads to a change in banks' liquidity ratio of 5.3 percentage points (Column 2). For instance, the results suggest that if *Positive* $Industry^{CostEffect}$ increases by two standard deviations, $Liquidity^{Ratio}$ decreases by 16.6 percentage points. The interaction terms between these positive shocks and $Lending^{Total}$ exhibit a positive and statistically significant effect on bank liquidity (Columns 1 and 2), supporting our argument that when industries experience a positive shock and the granting of loans increases, banks with higher shock exposure tend to increase their liquidity. Specifically, this means that a 10 percentage points increase in *Positive* $Industry^{ProdValue}$, for a bank with a loan ratio of 60%, banks' liquidity buffer would increase by 10.3 percentage points.

Therefore, we can observe that banks adjust their liquidity holdings in the same way for positive and negative shocks. However, the impact of positive shocks is more pronounced in both magnitude as well as statistical significance. Furthermore, the positive and statistically significant effect of the interaction term *Positive* $Industry^{ProdValue} \times Lending^{Total}$, and *Positive* $Industry^{ProdValue} \times Lending^{Total}$ on bank liquidity supports our argument that when industries experience a positive shock and the granting of loans increases, banks with higher shock exposure tend to increase their liquidity.

This study focuses on bank liquidity, but we acknowledge the importance of the "lending" channel. Consequently, in Table 7, we examine the impact of positive and negative shocks on bank lending. In general, we find that bank lending does not react differently to positive/negative shocks. Specifically, our results only report a positive and statistically significant effect of negative shocks to production value on bank lending.

5.2. Robustness checks

We extend our analysis by exploring the robustness of our main results. First, we develop an alternative variable of bank liquidity, computed as the excess of short-term liquid assets over the statutory reserve requirement maintained at the NBU by Ukrainian banks, represented by an excess liquidity ratio ($Liquidity^{Exces}$).[16] Second, as our results may well depend on the heterogeneity on the banks'

[16] For brevity, the full results are not reported in this section but instead are presented in Online Appendix C.

balance sheet composition, we split the sample by several bank-specific characteristics, such as the level of liquid assets, bank capital, and the size of each bank. Third, we apply several econometric methods to address endogeneity issues. Finally, we explore the impact of expected and unexpected elements of industry shocks.

5.2.1. Subsample analysis

In this section, we explore whether the effects of bank exposure to industry-level shocks on bank liquidity is conditional upon banks' balance sheet composition, such as the level of liquid assets, bank capital as well as size of each bank. Table 8 displays the results for the different estimates of Eq. (1) by splitting the level of liquid assets ($Liquidity^{Ratio}$), the capital ratio (*Equity/TA*), as well as the size (the logarithm of total assets) of each bank. Panel A and B report the estimation results taking into account our key variables of bank exposure to industry-level shocks: Cost-Effectiveness and Production Value, respectively. In each panel, Columns (1), (3) and (5) report the regression results for the subsample, where the variable $Liquidity^{Ratio}$, *Equity/TA* and *Ln(TA)* is greater than the sample median, respectively. Similarly, Columns (2), (4) and (6) report the regression results for the subsample, where the variable $Liquidity^{Ratio}$, *Equity/TA* and *Ln(TA)* is lower than the sample median.

From the results in Column (1) of Table 8, we find that our two variables of bank exposure to industry-level shocks exhibit a negative and statistically significant impact on bank liquidity when banks hold a higher level of liquid assets. Conversely, Column (2) of Table 8 shows that bank exposure to industry-level shocks has no significant effect on bank liquidity when banks hold a lower level of liquid assets. Column (1) shows that the indirect effect of bank exposure to industry-level shocks ($Industry^{CostEffect} \times Lending^{Total}$*and* $Industry^{ProdValue} \times Lending^{Total}$) on bank liquidity is positive and statistically significant when banks hold a higher level of liquid assets. In contrast, Column (2) shows that the indirect effect of bank exposure to industry-level shocks on bank liquidity is not significant when banks hold a lower level of liquid assets. The results are in line with our previous findings and would suggest that banks holding more liquid assets on their balance sheet may reduce their holdings of liquid assets and increase their lending more quickly (Primus, 2017).

We now split the sample using the capital ratio. When we do this, Panel A shows that industry-level shocks on cost-effectiveness ($Industry^{CostEffect}$) negatively impacts bank liquidity, only when banks hold a higher level of capital. Similarly, Panel B shows that bank exposure to industry-level shocks on production value ($Industry^{ProValue}$) negatively affects bank liquidity, only when banks hold a higher level of capital. Regarding the indirect effect of bank shock exposure resulting from the lending behaviour of banks on bank liquidity, we can observe different results between Panel A and B. Panel A displays a positive and statistically significant effect for the interaction term between $Industry^{CostEfec}$ and $Lending^{Total}$ in both subsamples. However, Panel B shows a positive and statistically significant effect for the interaction term between $Industry^{ProdValue}$ and $Lending^{Total}$, only when banks hold a higher level of capital (Column 3). In general, the results are similar to those reported in previous sections and support the argument that banks that rely more on stable sources of funding, such as capital, are better able to withstand economic shocks and continue lending, compared to other banks. (Cornett et al., 2011).

With respect to bank size, Panel A allows us to observe a negative and statistically significant effect of bank exposure to industry-level shock on the cost-effectiveness ($Industry^{CostEfect}$) on bank liquidity in both subsamples. However, this effect is more pronounced for small banks (Column 6). In terms of bank exposure to industry-level shocks on production value ($Industry^{ProdValue}$), Panel B shows a negative and statistically significant impact on bank liquidity, which is again more pronounced for small banks. Regarding the indirect effect of bank shock exposure resulting from the lending behaviour of banks on bank liquidity, we can observe similar results in Panels A and B. Specifically, Column (6) shows that the indirect effect of bank exposure to industry-level shocks ($Industry^{CostEffect} \times Lending^{Total}$*and* $Industry^{ProdValue} \times Lending^{Total}$) on bank liquidity is positive and statistically significant when banks are relatively small in size. This differing impact on banks, according to their size, may be explained by the business model that they follow, as well as the policy actions and regulations implemented based on bank size (Kim and Sohn, 2017; DeYoung et al., 2018).

Overall, the results in Table 8 provide support to our previous findings relating to the effect of bank exposure to industry-level shocks on bank liquidity. Moreover, the results suggest that the effect of bank shock exposure on bank liquidity may differ depending upon several bank-specific characteristics that could mitigate the effect.

5.2.2. IV and GMM-SYS estimations

Our main results presented in Section 5 may be subject to endogeneity issues arising from three main sources. The first is omitted variables, which refers to explanatory variables that are likely to influence bank liquidity and should be included in the baseline model, but are not because they are not directly observable.[17] The second source is reverse causality. In the case of our study, for instance, it is likely that banks decide to increase their holding of liquid assets when they expect an increase in their liquidity risk and, in turn, reduce the granting of credit. The third source is measurement error, which occurs when a study incorporates explanatory variables that are difficult to measure accurately because they are not directly observable.

We apply several econometric methods to address endogeneity concerns. First, we reduce the probability of the omitted-variable bias by augmenting our main model with variables that are likely to affect bank liquidity. We then include a proxy of foreign exchange exposure (FXRR), based on the assumption that those banks with positive and unhedged net foreign liabilities may be tempted to hoard

[17] For simplicity, the results are not reported here but they are available upon request. However, the results remain unchanged to those reported in previous sections.

Table 9
Bank Liquidity and Industry Shocks, IV estimations.

	(1)	(2)	(3)
Panel A: Total Lending			
$Industry^{CostEffect}$	−0.151**		−0.105*
	(0.077)		(0.084)
$Industry^{CostEffect} \times Lending^{Total}$	0.224***		0.166*
	(0.090)		(0.089)
$Industry^{ProdValue}$		−0.734***	−0.562**
		(0.290)	(0.287)
$Industry^{ProdValue} \times Lending^{Total}$		0.782*	0.595
		(0.487)	(0.465)
$Lending^{Total}$	−0.452***	−0.309**	−0.384**
	(0.179)	(0.169)	(0.191)
Observations	522	522	522
R-squared	0.330	0.302	0.339
Hansen J	0.793	0.778	0.908
Panel B: Corporate Lending			
$Industry^{CostEffect}$	−0.076*		−0.035*
	(0.053)		(0.060)
$Industry^{CostEffect} \times Lending^{Corp}$	0.130**		0.077*
	(0.054)		(0.048)
$Industry^{ProdValue}$		−0.471**	−0.396*
		(0.214)	(0.220)
$Industry^{ProdValue} \times Lending^{Corp}$		0.470*	0.342
		(0.337)	(0.324)
$Lending^{Corp}$	−0.233*	−0.101*	−0.112*
	(0.130)	(0.145)	(0.148)
Observations	518	518	518
R-squared	0.189	0.145	0.158
Hansen J	0.743	0.953	0.967
Panel C: Retail Lending			
$Industry^{CostEffect}$	0.038		0.061*
	(0.034)		(0.034)
$Industry^{CostEffect} \times Lending^{Retail}$	0.083		0.091
	(0.088)		(0.088)
$Industry^{ProdValue}$		−0.385*	−0.492**
		(0.199)	(0.204)
$Industry^{ProdValue} \times Lending^{Retail}$		0.156	0.148
		(0.545)	(0.557)
$Lending^{Retail}$	−0.182	−0.129	−0.083
	(0.522)	(0.501)	(0.527)
Observations	500	500	500
R-squared	0.06	0.071	0.087
Hansen	0.518	0.933	0.732

Notes: Table 9 presents the estimations results for Eq. (1) applying the IV estimation using heteroskedasticity-based instruments (ivreg2h). $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. Panels A, B and C exhibits the results controlling for $Lending^{Total}$, $Lending^{Corp}$. and $Lending^{Retail}$, respectively. All regressions include bank-level control variables. For detailed variable descriptions, see Online Appendix A. We control for unobservable firm-invariant and time-invariant fixed effects. Robust standard errors are in parentheses. Hansen is Hansen J statistics, *p*-value reported. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

liquid assets for precautionary reasons (Agenor et al., 2004).[18] We also include a measure of profitability (*ROA*), which may impact bank liquidity through the lending channel. For instance, banks with high profitability tend to have strong balance sheets, because profitability is positively associated with high capital ratios and, thus, is positively associated with lending activity (Kim and Sohn, 2017). Finally, we find that our previous results, exhibited in Tables 4 and 5, remain robust to the inclusion of *FXRR* and *ROA*.[19]

Second, to further mitigate endogeneity concerns, we use an instrumental variable approach following Lewbel (2012), who relies on heteroscedasticity in the errors to achieve identification. The main advantages of this approach are that no external instruments are necessary to provide instrument identification and that the associated estimator commonly takes the standard form of the generalized method of moments (GMM), thus improving the IV estimator efficiency. In the first stage, each of the endogenous variables is regressed on all exogenous variables using ordinary less squares (OLS). The predicted residuals at this stage are then multiplied by the exogenous

[18] Specifically, those banks that are exposed to currency depreciation may attempt to hoard liquid assets to satisfy unexpected withdrawals because of the likelihood of an increase in the value of debt payment in local currency.
[19] The results are available upon request.

Table 10
Bank Liquidity and Industry Shocks, GMM-System estimations.

	(1)	(2)	(3)
Panel A: Total Lending			
$Industry^{CostEffect}$	−0.177*		−0.147*
	(0.094)		(0.089)
$Industry^{CostEffect} \times Lending^{Total}$	0.208*		0.218**
	(0.109)		(0.084)
$Industry^{ProdValue}$		−1.320***	−1.103***
		(0.445)	(0.411)
$Industry^{ProdValue} \times Lending^{Total}$		1.199*	1.216**
		(0.682)	(0.559)
$Lending^{Total}$	−0.511***	−0.547***	−0.656***
	(0.141)	(0.144)	(0.126)
Observations	649	649	649
AR(2)	0.714	0.359	0.646
Hansen J	0.613	0.843	0.270
Panel B: Corporate Lending			
$Industry^{CostEffect}$	−0.083*		−0.053
	(0.046)		(0.069)
$Industry^{CostEffect} \times Lending^{Corp}$	0.144***		0.111*
	(0.045)		(0.067)
$Industry^{ProdValue}$		−1.142***	−1.055***
		(0.259)	(0.279)
$Industry^{ProdValue} \times Lending^{Corp}$		1.130**	0.939*
		(0.514)	(0.513)
$Lending^{Corp}$	−0.225***	−0.414***	−0.374***
	(0.054)	(0.115)	(0.107)
Observations	643	643	643
AR(2)	0.245	0.947	0.763
Hansen J	0.315	0.694	0.663
Panel C: Retail Lending			
$Industry^{CostEffect}$	−0.034		0.033
	(0.071)		(0.078)
$Industry^{CostEffect} \times Lending^{Retail}$	0.408		0.207
	(0.313)		(0.194)
$Industry^{ProdValue}$		−1.078**	−1.226**
		(0.422)	(0.564)
$Industry^{ProdValue} \times Lending^{Retail}$		0.110	0.512
		(0.494)	(0.585)
$Lending^{Retail}$	−0.528	−0.229	−0.234
	(0.547)	(0.259)	(0.287)
Observations	621	621	621
AR(2)	0.865	0.297	0.606
Hansen	0.033	0.011	0.019

Notes: Table 10 presents the estimations results for Eq. (1) using the dynamic panel system Generalized Method of Moments estimator (GMM-Sys). $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. Panels A, B and C exhibits the results controlling for $Lending^{Total}$, $Lending^{Corp}$. and $Lending^{Retail}$, respectively. All regressions include bank-level control variables. For detailed variable description see Online Appendix A. We control for unobservable firm-invariant and time-invariant fixed effects. Instrument set includes from t-1 to t-3 lags for the difference and level equations. Hansen is the Hansen J statistic (p-value reported) and AR(2) is the test of second-order autocorrelation (p-value reported). Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

variables that are mean-centered to construct an internal instrument for each exogenous variable, given by $Z_j = \left(X_j - \overline{X}\right)\varepsilon$, where ε is a vector of residuals from this first stage regression of each endogenous variable on all the exogenous regressors, including a constant term. In the second stage, the endogenous variables are instrumented by the aforementioned internally generated instruments, in addition to external instruments.

Within the second stage, we consider separately each one of our lending variables ($Lending^{Total}$, $Lending^{Corp}$, and $Lending^{Retail}$) as endogenous, and these are instrumented by the internally generated instruments. In addition to those instruments, and following Fang et al. (2009) and Jiang et al. (2017), we construct two external instruments using the total lending variable and firm-operational performance at the industry level. Specifically, we compute each external instrument as the average value of the other banks in the same year size category. These variables are then included in their contemporaneous and one lag values as exogenous instruments of each one of our endogenous variables. In Table 9, we can observe the estimation results for Eq. (1) by applying the IV estimation using

Table 11
Bank Liquidity and Industry Shocks: Total Lending.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Expected	Expected	Unexpected	Unexpected	Expected	Expected	Unexpected	Unexpected
$Industry^{CostEffect}$	−0.169*	−0.802***	−0.047	−0.198***				
	(0.099)	(0.253)	(0.036)	(0.061)				
$Industry^{CostEffect} \times Lending^{Total}$		0.983***		0.245***				
		(0.304)		(0.076)				
$Industry^{ProdValue}$					−0.416*	−2.161***	−0.402**	−0.364
					(0.236)	(0.556)	(0.192)	(0.481)
$Industry^{ProdValue} \times Lending^{Total}$						2.917***		−0.072
						(0.742)		(0.711)
$Lending^{Total}$	−0.426***	−0.502***	−0.440***	−0.432***	−0.436***	−0.523***	−0.435***	−0.435***
	(0.054)	(0.062)	(0.056)	(0.053)	(0.054)	(0.063)	(0.055)	(0.055)
Credit Risk	0.012	0.011	0.003	0.005	0.006	0.013	0.005	0.006
	(0.046)	(0.045)	(0.046)	(0.043)	(0.044)	(0.040)	(0.046)	(0.046)
Reserve	0.271	0.621	0.194	0.226	0.252	0.674	0.161	0.158
	(1.062)	(0.982)	(1.086)	(1.141)	(1.077)	(1.048)	(1.068)	(1.069)
Equity/TA	0.030	0.025	0.026	0.036	0.027	0.069	0.016	0.016
	(0.062)	(0.064)	(0.062)	(0.063)	(0.062)	(0.062)	(0.061)	(0.061)
Ln(TA)	0.031*	0.029	0.030	0.033*	0.029	0.030*	0.030	0.030
	(0.019)	(0.018)	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)
Observations	700	700	700	700	700	700	700	700
R-squared	0.329	0.358	0.323	0.342	0.326	0.372	0.326	0.326

Notes: Table 11 reports the regression results on the link between expected/unexpected industry-level shocks and bank liquidity. In all columns the dependent variable $Liquidity^{Ratio}$ is the ratio between short-term liquid assets and total assets. Expected and unexpected shocks reflect the predicted and residuals elements of each AR(1) process defined for each $Industry^{CostEffect}$ and $Industry^{ProdValue}$. *Credit Risk* is the credit risk variable computed as loan loss provisions over total loans. *Reserve* is the amount of required reserves over total assets. *Equity/TA* is computed as bank equity over total assets. *Ln(TA)* is the natural logarithm of total assets. We control for unobservable firm-invariant and time-invariant fixed effects. We estimate all regressions by using the two-way fixed effects. Robust standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

heteroskedasticity-based instruments (*ivreg2h*).[20] The results remain equal to those presented previously, and the Hansen over-identification test fails to reject the hypothesis that our instruments are exogenous. For simplicity, we only report the results for our key variables.

Finally, another potential concern is that the relationship between bank liquidity, bank shock exposure and lending, among other bank-specific characteristics, may be dynamically endogenous. For example, past bank exposure to industry-level shocks may influence current bank liquidity and bank shock exposure. Similarly, past lending behaviour may impact the current level of on-balance sheet liquidity, as well as new credit production. Therefore, a dynamic panel system, the Generalized Method of Moments (GMM-SYS) estimator, is used to control for lagged bank shock exposure and uses the banks' past information as instruments. The appropriateness of this set of instruments is formally evaluated by the Hansen test for overidentifying restrictions and the Arellano-Bond tests for error autocorrelation.[21]

Despite the system, GMM approach is often regarded as more efficient among other dynamic panel data estimators, such as the difference GMM approach or three-stage least squares, in which there remains potential problems with over-instrumentation and in terms of the extent to which endogeneity is adequately addressed. Regarding the consequences of instrument proliferation or over-instrumentation in GMM estimation, several studies have documented potential distortions in the estimated parameters, due to the overfitting of the endogenous regressors and on weakening the power of the over-identification tests. As a result, recent studies have suggested the use of principal components analysis (PCA) as a way to reduce the number of instruments and improve the GMM estimator's properties.

Consequently, we have applied a principal components analysis to deal with the potential problem of instrument proliferation in the estimation of the GMM-Sys. In Table 10, we report the results for the different estimations carried out by Eq. (1), including, separately, in each estimation the variables $Lending^{Total}$, $Lending^{Corp}$, $Lending^{Retail}$, exhibited in Panel A, B and C, respectively. In all estimations, the Hansen and Arellano-Bond AR(2) tests show that our instruments are appropriate and that there is no detectable second-order serial correlation. For brevity, we only report the results for our key variables, which again remain equal to those estimated previously. Thus, we conclude that the results presented in this paper are robust.

5.2.3. Expected and unexpected shocks

In this section, we examine how banks manage their liquidity holdings in response to expected and/or unexpected shocks. Following previous studies (e.g., Hur and Rhee, 2020), we split our industry shocks into expected and unexpected components. To do

[20] See Kuzman et al. (2018), Loy et al. (2016), and Bremus and Buch (2015).

[21] See, for example, Baum et al. (2008), who acknowledge the importance of the persistence of the key indicators of Ukrainian banks.

this, for each industry time series, we run AR(1) process and use the predicted and residuals components as expected and unexpected shocks, respectively. Afterwards, we employ our loan portfolio weights to general bank-level measures of shocks, and we repeat our main analysis with both types of shocks. Consequently, in Table 11, we examine the impact of expected and unexpected shocks on bank liquidity. In general, we find similar results to those reported previously, with the expected element to be slightly stronger. Our findings suggest expected shocks that have been well signalled lead banks to hoard liquidity in anticipation of future expected losses, while unexpected shocks that are correctly perceived on impact provoke slightly similar response. Specifically, while the unexpected shocks induce liquidity adjustments about the current period, the expected shocks imply major adjustments of banks' holdings of liquid assets according to new expectations about the future.

6. Conclusions

This paper examines the link between bank liquidity and bank shock exposure. Using a unique dataset of borrower industry affiliations, we propose a new measure of bank exposure to industry-level shocks, calculated at the bank level. Specifically, we measure the effect of industry-level shocks on production value and cost-effectiveness based on bank loan exposures to each industry. We have analyzed this in the context of the Ukrainian banking system, which presents a well-suited case for our research due to several events that highlight the importance of bank liquidity.

Our findings can be summarized as follows. First, we find strong evidence of a negative effect of bank exposure to industry-level shocks on bank liquidity. These results suggest that, when industries experience a positive industry shock, banks with higher exposure to industry-level shocks tend to manage their liquidity ratios in a countercyclical way, which could be explained by precautionary motives. Second, our results suggest that bank exposure to industry-level shocks significantly affects bank liquidity through the lending behaviour of banks. Further estimations show that the effect of bank exposure to industry-level shocks on bank liquidity is channelized through lending to the corporate sector, and not to the retail sector. Third, the impact of bank shock exposure on bank liquidity is higher for more liquid, better capitalized and smaller banks, which may be explained by their ability to displace funds, either for precautionary reasons or for loan financing (Cornett et al., 2011; DeYoung et al., 2018).

Our results have several policy implications. First, the results shed light on the importance of industry shocks for bank stress testing. In conducting internal stress tests, the scenario development should consider, not only the macroeconomic situation within a country, but also the banks' exposure to industry level-shocks. Second, this work has implications for liquidity regulations, designed to help banks cope with extreme risks in various scenarios. Banks may face severe liquidity shocks when dealing with industry-level shocks in the context of poor liquidity management, which can increase the level of default risk (e.g., Diamond and Rajan, 2005; Fungácová et al., 2021). Third, considering that the Ukrainian banking system has exhibited highly persistent liquidity, if the economic conditions improve, involving a positive industry shock, commercial banks may rapidly expand corporate lending, leading to the natural consequences of macroeconomic stability.

Our results also raise ideas for potential future investigations. Additional research could be conducted on whether and how central bank interventions, such as capital injections, can affect the link between bank liquidity and exposure to industry-level shocks. Moreover, exploring how geographical and regulatory changes alter the industries' structures and, in turn, the level of bank exposure, is another interesting challenge for future research to pursue.

CRediT authorship contribution statement

Jose Arias: Methodology, Investigation, Writing – original draft. **Oleksandr Talavera:** Conceptualization, Writing – review & editing, Project administration. **Andriy Tsapin:** Data curation, Methodology.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ememar.2022.100942.

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