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ORIGINAL ARTICLE

The impact of eliminating reserve requirements on US banks' lending, liquidity, and profitability during COVID-19

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Abstract

The US Federal Reserve System (Fed) eliminated reserve requirements for banks in March 2020 during the first quarter of the COVID-19 pandemic to foster bank lending through expansionary monetary policy. However, we find empirical evidence that the reserve requirements elimination was not able to support bank lending but instead increased the liquidity of US banks. Moreover, the reserve requirements elimination increased the overall profitability of banks but decreased the profitability from net interest income as measured by net interest margin. Our study offers guidance for policy-makers in taking appropriate monetary policy measures during pandemics like the COVID-19 pandemic.

KEYWORDS

COVID-19, fed funds rate, lending, liquidity, monetary policy, profitability, reserve requirements

JEL CLASSIFICATION

C5, E5, E51, E52, E58, G21, G28

1 | INTRODUCTION

Reserve requirements for banks are the direct link between the Federal Reserve System (Fed) and the money supply in the economy (Dinh, 2023). Reserve requirements influence both deposits and loans of banks because disruptions on the deposit side also affect loan supply (Lubis et al., 2022). The amount of required reserve is deducted from banks' deposits to be kept separately as a reserve and, thereby, it reduces the loanable funds of banks. Reserve requirements are important for two reasons: First, they protect depositors from crises and bank runs and, second, they play a vital role as a monetary policy instrument (Di Giorgio, 1999). In the digitization era, the threat of bank runs has been intensified because bank depositors have access to instant (real-time) payment services and money transfer, and social media accelerates the spread of bank run information (Shy, 2025). For example, the collapses of First Republic Bank (FRB), Silicon Valley Bank, and Signature Bank in 2023 are recent examples of how the loss of market confidence can trigger swift and tech-enabled bank runs in the absence of reserve requirements (Dinh, 2023). Therefore, banks must ensure optimal liquidity reserves even if there are no reserve requirements from the Fed to meet short-term obligations.

Reserve requirements in the US were first introduced in 1863, which is even half a century before the Fed was established in 1913 (Dinh, 2023). However, remarkably, in March 2020, with the beginning of the COVID-19 pandemic in

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the US, the Fed announced the elimination of banks' reserve requirements which became effective in the same month (Figure 1). This decision was made in the course of Fed's policy of monetary easing for encouraging banks to lend money to households and businesses that were heavily affected by the pandemic (Board of Governors of the Federal Reserve System, 2024; Dinh, 2023; Kuang et al., 2024). The inflation rate was below 2% and the Federal funds rate was near zero at the time of this decision of the Fed (Dinh, 2023). Therefore, both monetary policy tools, that is, Fed funds rate and reserve requirements, were exhausted from the first quarter of the pandemic up to the end of 2021, in line with the Fed's target of monetary easing. Moreover, US banks had sufficient free liquidity for keeping up lending activities (Dinh, 2023). However, in the backdrop of COVID-19 and the high level of economic policy uncertainty, it was somehow unclear whether banks would continue their lending activities at the needed level. From today's perspective, it is questionable whether it was a good decision to eliminate reserve requirements—with all the possible consequences—although banks had sufficient liquidity for lending.

The recent COVID-19 pandemic has shown what dramatic consequences a spreading virus can have for the economy and society. A stable banking system is indisputably an important prerequisite to face a pandemic's consequences. A study by El-Chaarani, Abraham, and Azzi (2023) on the Middle East and North Africa (MENA) region reveals that banks' loanable funds depleted due to the withdrawal of deposits to meet personal and business needs, which led to sustained liquidity shocks during the COVID-19 crisis. Therefore, they observe that the inflow of deposits alone is insufficient for granting enough loans in the pandemic crisis, and they find that liquidity creation increases banks' profitability. This point of view well supports the Fed's decision to eliminate reserve requirements in the COVID-19 crisis to support the liquidity creation of banks. Interestingly, the decision to eliminate reserve requirements has never been changed since March 2020—even after the COVID-19 crisis and even when higher inflation and higher Fed funds rates demanded contractionary monetary policy. The study by Calomiris et al. (2023) reveals that reserve requirements cannot control bank lending when reserve requirements are not binding for most of the banks. This finding gives an important indication that the elimination of reserve requirements can promote banks' lending.

During the COVID-19 crisis, the Fed focused more on stimulating bank lending rather than preventing bank runs. This was done despite the criticism that has pointed out the important role of reserve requirements for preventing bank runs. However, reserve requirements are often criticized as not being able to guarantee banks' liquidity, and to prevent bank runs and financial panics as evidenced from the global financial crisis (Dinh, 2023). Moreover, increasing reserve requirements decreases loanable funds, promotes risk taking for achieving higher returns, and increases the probability of bank failures (Glocker, 2021). Besides, the establishment of the Federal Deposit Insurance Corporation (FDIC) insurance makes reserve requirements unnecessary as an additional security to create depositor confidence (Fayman et al., 2022). Despite the drawbacks of reserve requirements, Ben-Gad et al. (2022) suggest to policy-makers deploying reserve requirements as a macroprudential policy tool, although designed for the narrow purpose of preventing bank runs.

Our literature review reveals that the impact of eliminating reserve requirements on US banks is rarely addressed in literature. To the best of our knowledge, only a single paper of Fayman et al. (2022) empirically demonstrates that community banks show quickly increasing liquidity ratios in response to the reserve requirements elimination. Large community banks drive the changes in liquidity initially, while the larger non-community banks increase their liquidity

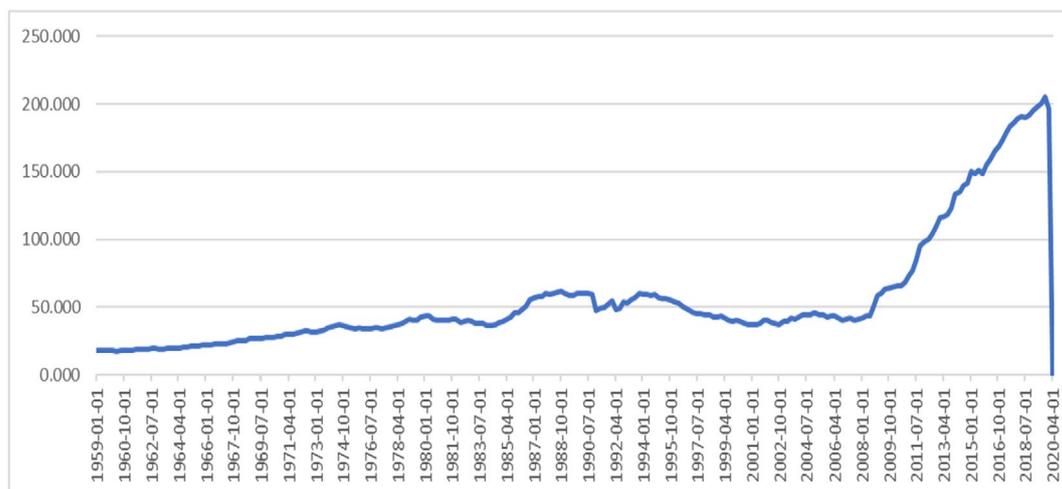


FIGURE 1 Required reserves of depository institutions (quarterly data in USD in billions). Source: FRED (2024).

in the subsequent quarter. However, the article only focuses on liquidity indicators of banks and applies *t*-tests for mean differences on the US banks' data from March 2020 quarter to September 2020 quarter only. Therefore, this study leaves space for further investigations with advanced methodology, an extended set of variables, and expanded time period. Our study uniquely highlights these specific gaps in the previous literature. Moreover, our paper differs from existing research on monetary easing because most papers identify the response of macroeconomic variables, like GDP, unemployment, and inflation, to monetary easing—whereas we analyze whether the reserve requirements elimination as a monetary easing tool leads to any impact on the banking sector.

For policy-makers and the Fed, it is of special interest to understand how banks can be supported in granting the needed level of loans to companies and individuals during crises—like the COVID-19 pandemic. Thus, it is important to find out how the decision to eliminate reserve requirements has affected banks. In our article, we analyze how the reserve requirements elimination has impacted lending, liquidity, and profitability of the insured US-chartered commercial banks in this first-ever changed economic situation. To the best of our knowledge, this important topic has not been addressed empirically in any academic paper so far. Therefore, we strive to close this research gap. Moreover, this issue will remain important because: First, COVID-19 is still around (World Health Organization, 2025), and second, other viruses may appear on the scene. For example, recently, a virus named human metapneumovirus (HMPV) is spreading and drawing epidemiologists' attention (Agius, 2025; Davidson, 2025).

The remainder of this article is organized as follows: In Section 2, we present the theoretical framework, review the related literature, and develop the research hypotheses. Section 3 presents the data, sample, variables, and methodology of the article. The empirical results are presented and discussed in Section 4, and Section 5 concludes the article and discusses the policy implications.

2 | RELATED LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 | Theoretical framework

Monetary policy is guided by theoretical concepts that are formulated, for example, by monetary policy targeting rules. Today, the Taylor rule empirically represents the monetary policy in the most developed economies. The Taylor rule allows monetary policy to adapt and react to any eventual perturbation or disturbances based on new information. Therefore, this rule can be attributed to the category of flexible rules, such as contingent rules or conditional rules. The Taylor rule opposes the fixed rules, such as Friedman's rule, which proposes a constant growth rate of money supply according to the inflation target regardless of perturbations or disruptions affecting the economy. Moreover, the New Keynesian framework guides how central banks can fight against production output gap volatility and inflation volatility. Therefore, the Taylor rule and the New Keynesian theory allow central banks to modify monetary policy instruments according to a contingency plan during monetary easing (Guevara & Escot, 2021).

2.2 | Reserve requirements and the banking sector

As a monetary policy tool, reserve requirements for banks curb credit growth. However, there are doubts regarding how appropriately reserve requirements work to achieve price stability and financial stability (Glocker & Towbin, 2015). Wei et al. (2020) find that the targeted reduction in the reserve requirements ratio as complementary to the interest rate policy results in a reallocation of more credit by commercial banks to micro and small enterprises, eliminates the negative output gap, and slightly dampens the rise in unemployment, but increases financial instability (Wei et al., 2020). Moreover, Fungáčová et al. (2016) reveal that the loan growth rate is directly impacted by changes in reserve requirements, which underlines the effectiveness of monetary policy. For example, reserve requirements adjustments have helped to smooth credit growth in several Latin American countries during the expansionary and contractionary phases of the economy (Brei & Moreno, 2019). Although US banks have revealed sufficient free liquidity in the recent COVID-19 crisis, the Fed has decided to eliminate reserve requirements completely. This has raised the question of whether this decision was able to serve the purpose of the Fed to promote bank lending or only increased the available liquidity of banks without fostering banks' lending activities. Moreover, it is important to analyze how Fed's decision to eliminate reserve requirements has impacted banks' profitability during the time of Fed's monetary easing in the COVID-19 pandemic crisis. Fed's decision to eliminate reserve requirements in addition to setting the Fed funds rate to near zero to stimulate the economy can

potentially impact banks' interest income if this decision promotes bank lending. However, Fed's decision to eliminate reserve requirements might just result in more liquidity with the banks if there is no additional demand for borrowing from banks in times of economic uncertainty.

Banks usually hold additional reserves on their balance sheets prior to upcoming crises and monetary easing interventions of the Fed, not lending this portion to satisfy the reserve requirements in crises. Therefore, during post-crisis periods, the Fed's monetary easing intervention results in an overall increase in banks' reserve levels. Interestingly, only high-reserve banks respond to changes in banks' overall liquidity levels by their lending behavior (Kuang et al., 2024). While US banks had sufficient liquidity for lending, the pandemic has caused a high level of economic uncertainty which has potentially influenced banks' lending, liquidity, and profitability. The threat of a credit crunch is, thus, originating more likely from the level of uncertainty and less from liquidity problems. As a consequence, it can be questioned whether reducing or even fully eliminating reserve requirements can help in this situation to support bank lending. However, the higher level of uncertainty due to the pandemic might lead banks to calculate with higher liquidity buffers. In this case, eliminating reserve requirements can increase the liquidity buffer. In other words, it is likely that banks do not increase lending activities but increase the liquidity buffer. Moreover, reduced lending activities and higher liquidity can result in lower profitability for banks. These arguments lead us to the following hypotheses:

- H1.** The elimination of reserve requirements decreases lending by banks in the pandemic.
- H2.** The elimination of reserve requirements increases the liquidity of banks in the pandemic.
- H3.** The elimination of reserve requirements decreases the profitability of banks in the pandemic.

The ability of banks to convert liquidity into lending crucially depends on several regulatory constraints, including the level of reserve requirements. In periods of monetary easing, excess reserves are more easily distributed across banks, which also leads to changing lending responses of banks (Kuang et al., 2024). Regulatory policy on bank reserves in the expansionary monetary policy has a heterogeneous impact on the risk-taking channels and loan-level outcomes of banks (Delis et al., 2024). It was evidenced that reserve accumulation mitigates credit expansion more for primary dealer banks and foreign bank branches than in the case of non-primary dealer banks and domestic banks (Yun, 2020). Recently, Fayman et al. (2022) have revealed that the response to Fed's reserve requirements elimination was not uniform across banks. Moreover, reserve requirements can impact banks' lending—but the size of this impact depends on the specific characteristics of the economy and of the banks (Ben-Gad et al., 2022; Chawwa, 2021). These arguments indicate possible heterogeneity of the impact of eliminating reserve requirements on lending, liquidity, and profitability across banks. Therefore, we hypothesize:

- H4.** The impact of eliminating reserve requirements on (a) lending, (b) liquidity, and (c) profitability varies across banks.

3 | DATA AND METHODOLOGY

3.1 | Data and variables

We have selected the US banking sector for our study because it has experienced an exceptional situation during the COVID-19 crisis. The US has reported the highest number of confirmed COVID-19 cases globally (World Health Organization, 2025). Moreover, during the COVID-19 pandemic, the Fed has eliminated the reserve requirements for the US banks for the first time ever. At this point in time, just before the elimination of reserve requirements, the total required reserves of depository institutions in the US reached the peak (Figure 1). No other advanced economy took such a decision during the pandemic crisis.

Interestingly, the US banking sector consists of few larger and many smaller commercial banks. Our data sample consists of 87 insured US-chartered commercial banks with consolidated assets of USD 300 million or more that were selected depending on their consolidated assets sizes in descending order (Figure A1). These 87 banks represent around 85.07% of the total consolidated assets of all insured US-chartered commercial banks (Federal Reserve Statistical Release, 2022). All the sampled insured US-chartered commercial banks are subject to the Fed's decision to eliminate reserve requirements and their operations are not limited to particular regions of the US. They have many branches across the US. Our data

covers 20 quarters from March 2017 to December 2021. 12 quarters, that is, the quarters from 2017/1 to 2019/4, represent the period before the start of the COVID-19 pandemic and reserve requirements elimination in the US, and 8 quarters, that is, the quarters from 2020/1 to 2021/4, represent the period characterized by the presence of COVID-19, the elimination of reserve requirements, and expansionary monetary policy. In total, our data set comprises 1718 bank-quarter observations—taking into consideration a few missing values.

In our research models, we deploy five dependent variables: (1) loan-to-deposit (Loan/Deposit), (2) liquid assets to deposits and short-term funding (LA/DSF), (3) return on assets (ROA), (4) return on equity (ROE), and (5) net interest margin (NIM). Loan/Deposit is used as a measure of banks' lending activities, LA/DSF measures banks' available liquidity, and ROA, ROE, and NIM measure banks' profitability.

Loan/Deposit represents what percentage of its deposits a bank uses for lending, and thus, this measure serves as a proxy for banks' lending activities (El-Chaarani, Skaf, et al., 2023; Fayman et al., 2022; Calomiris et al., 2023; Le et al., 2022; Zhang & Li, 2025). Reserve requirements are applied on banks' deposits to control bank lending and are thus likely to have an effect on this ratio. Moreover, Loan/Deposit represents to what degree banks grant loans from their available deposits and whether policies are able to support banks in increasing lending activities within their means, that is, based on deposits.

LA/DSF represents how much liquid assets banks hold to pay out the obligations that result from withdrawal requests of depositors and claims of short-term funding (Chawwa, 2021; Elnahass et al., 2021; Fungáčová et al., 2016; Heitmann et al., 2023; Le et al., 2022). Reserve requirements impact banks' decision to hold liquid assets for paying out obligations and can, therefore, impact the LA/DSF ratio.

Moreover, we argue that monetary policy tools are likely to impact banks' profitability indicators, that is, ROA, ROE, and NIM (Mamatzakakis & Bermpei, 2016; Heitmann et al., 2023; Elnahass et al., 2021; Zhang & Li, 2025; El-Chaarani, Skaf, et al., 2023). Therefore, reserve requirements as a conventional monetary policy tool are likely to impact banks' profitability, for example, by influencing the loanable funds and interest income from lending activities compared with interest payments for deposits. ROA and ROE represent the overall profitability, including profitability from both interest income and non-interest income, as bank fees, whereas NIM represents profitability from only net interest income.

We consider the variable Reserve as the main independent variable (Ben-Gad et al., 2022; Brei & Moreno, 2019; Fayman et al., 2022; Fungáčová et al., 2016) because we want to find out about its impact on banks' lending, liquidity, and profitability (Chawwa, 2021; Cañón & Margaretic, 2014; Wei & Han, 2020; Wei et al., 2020; Calomiris et al., 2023; Glocker & Towbin, 2015; Brei & Moreno, 2019; Lubis et al., 2022). The variable Reserve is a dummy variable that takes the value of 0 for the period before and 1 for the period after the reserve requirements elimination. In other words, this variable divides the whole time period covered by this study into two parts. Since the reserve requirements elimination was announced and effective from March 2020, the effects could not start earlier than the first quarter of 2020 (Fayman et al., 2022). Therefore, the Reserve dummy variable ensures that banks did not perform any adjustment before the rule's effective quarter.

Our study considers several control variables that potentially impact banks' lending, liquidity, and profitability. The bank-specific control variables are: bank size as measured by the logarithm of banks' total assets (LogTA) (Temesvary & Wei, 2024; Fungáčová et al., 2016; Yun, 2020; Brei & Moreno, 2019; Calomiris et al., 2023; Zhang & Li, 2025), total equity to total assets (Equity/Assets) to represent capitalization (Luu et al., 2023; Mamatzakakis & Bermpei, 2016; Singh & Sharma, 2016), cash to total assets ratio (Cash/TA) to represent banks' cash holding (Fayman et al., 2022; Heitmann et al., 2023), LogZ-Score to represent banks' financial stability (Luu et al., 2023; Mamatzakakis & Bermpei, 2016), cost-to-income ratio (Cost/Income) as a proxy for banks' cost efficiency (Heitmann et al., 2023; Elnahass et al., 2021; Zhang & Li, 2025), and impaired loans to gross customer loans and advances, that is, non-performing loans (NPL), to reflect credit risk (Brei & Moreno, 2019; Glocker, 2021; Heitmann et al., 2023; Le et al., 2022; Mamatzakakis & Bermpei, 2016). These control variables are regularly used and well established in academic literature.

As country-specific control variables, we include Federal funds rate (Fed rate) from the Refinitiv database represented by the midpoint of Fed funds target range declared by the Federal Open Market Committee (FOMC) (Brei & Moreno, 2019; Chawwa, 2021; Dutkowsky & VanHoose, 2020; Islam & Koch, 2024; Koch & Islam, 2024; Mamatzakakis & Bermpei, 2016; Singh & Sharma, 2016) because a lower Fed funds rate compared with the interest rate on excess reserves at the Fed results in lower bank lending (Hogan, 2021), GDP growth rate (GDP) (Brei & Moreno, 2019; Fungáčová et al., 2016; Hogan, 2021; Le et al., 2022; Mamatzakakis & Bermpei, 2016; Singh & Sharma, 2016), inflation rate (Inflation) (Brei & Moreno, 2019; Le et al., 2022; Mamatzakakis & Bermpei, 2016; Singh & Sharma, 2016), unemployment rate (Unemployment) (Mamatzakakis & Bermpei, 2016; Singh & Sharma, 2016), and, finally, EPU index value (LogEPU) as a proxy to indicate economic policy uncertainty (Heitmann et al., 2023; Islam & Koch, 2024; Koch & Islam, 2024; Singh & Sharma, 2016). Most importantly, the EPU index value well captures and quantifies the uncertainties related to economic policy that result from the COVID-19 pandemic (Barrero & Bloom, 2020; EPU, 2024). At the beginning of the pandemic

in early 2020, the EPU index value spiked to historically high levels in the US, which represents well the impact of COVID-19 together with other components of the index (EPU, 2024). A full description of all variables of this study and the respective data sources is presented in Table A1.

3.2 | Methodology and model

We apply both fixed effect and random effect models to test hypotheses H1, H2, and H3, and two-step system generalized method of moments (GMM) to test the validity of the models. Moreover, we apply quantile regression to capture the variations across banks for testing hypothesis H4.

3.2.1 | Baseline models: Fixed effect and random effect

First, we start with the following basic equation and empirically investigate it by applying fixed effect (entity fixed effect) and random effect models to investigate the impact of the reserve requirements elimination on banks' lending, liquidity, and profitability.

$$Y_{i,t} = \alpha + \beta_1(Reserve)_t + \beta_j(Control)_{i,t} + \varepsilon_{i,t} \quad (1)$$

In this equation, the dependent variables indicating banks' lending, liquidity, and profitability are represented by $Y_{i,t}$ for bank i at quarter t . α denotes the constant term. The dummy variable $(Reserve)_t$ is the main independent variable. $(Control)_{i,t}$ is a vector with bank-specific and country-specific control variables. β_1 is the coefficient of the variable $Reserve$ at quarter t and the vector β_j indicates the coefficients for the vector of control variables $(Control)_{i,t}$ for entity i at quarter t . $\varepsilon_{i,t}$ stands for error term for entity i at quarter t that captures all other unobserved factors.

3.2.2 | Robustness test: Two-step system generalized method of moments (GMM)

To test the robustness of the fixed effect and random effect models (baseline models), our study applies the following two-step system GMM equation as proposed by Arellano and Bond (1991) to address the problems of potential endogeneity, reversed causality, and unobserved factors that can threaten the validity of the results (Elnahass et al., 2021; Heitmann et al., 2023). The equation contains the value of a lagged dependent variable to estimate the impact of the reserve requirements elimination on banks' lending, liquidity, and profitability.

$$Y_{i,t} = \beta_1 Y_{i,t-1} + \beta_2(Reserve)_t + \beta_3 X_{i,t} + \beta_4 Z_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2)$$

Here, $Y_{i,t}$ denotes the dependent variable for bank i at quarter t . $Y_{i,t-1}$ denotes the dependent variable for bank i at quarter $t - 1$. β_1 is the coefficient of $Y_{i,t-1}$ and it represents the impact of previous quarter's performance on current quarter's performance. $(Reserve)_t$ represents the main independent variable. β_2 is the coefficient for $Reserve$ at quarter t , indicating how changes in $Reserve$ affect $Y_{i,t}$. $X_{i,t}$ denotes a vector of endogenous variables for bank i at quarter t . β_3 is the coefficient vector of the variable vector $X_{i,t}$. $Z_{i,t}$ refers to a set of explanatory variables (possibly exogenous) for entity i at quarter t . β_4 is the coefficient for the variable vector $Z_{i,t}$. The bank-specific time-invariant effect (fixed effect) that captures unobserved heterogeneity across banks is denoted by μ_i . Finally, $\varepsilon_{i,t}$ is an error term for entity i at quarter t that captures all other unobserved factors.

As a reliable estimation method, two-step system GMM addresses endogeneity concerns, the correlation between explanatory variables and the error term, by incorporating instrumental variables. The reliability of the GMM results is evaluated using validity tests: Hansen test or Sargan test, and the serial correlation test. Instruments are trustworthy or valid, and the model is correctly specified if the null hypothesis of the Hansen test or Sargan test for the overidentifying limits is not rejected. Furthermore, second-order serial correlation, AR(2), tests the internal consistency of the GMM estimator (Yang & Masron, 2024). Moreover, two-step system GMM is an efficient estimator for panel data with a large number of entities, for example, 87 US banks, even if there are fewer time variations (Paleologou, 2022).

We apply two-step system GMM in our study rather than employing event studies or Difference-in-Differences (DiD) approaches. The two-step system GMM is preferable to event study because the former handles leads and lags properly as dynamic modeling, addresses endogeneity, is more flexible with panel data, and provides formal statistical tests (e.g., Hansen test, AR(2) tests) to assess the validity of the instruments and model specification (Heitmann et al., 2023). Event studies struggle to capture the features of endogeneity, autocorrelation, and unobserved effects properly, focus on short-term impact, and face the difficulty of identifying the event date when using bank-level panel data over time (Chen, 2017; Kargin & Lamey, 2025). On the other hand, the Difference-in-Differences (DiD) model is not applicable for our study because all the insured US-chartered commercial banks comply with the decision of eliminating reserve requirements. Therefore, we cannot divide our sample into a treatment group (affected) and a control group (not affected), which is the prerequisite of the DiD approach (Wang, 2023).

3.2.3 | Heterogeneity test: Quantile regression estimator

Third, we apply quantile regression to identify possible heterogeneity among the US banks (Heitmann et al., 2023; Islam & Koch, 2024; Koch & Islam, 2024). More precisely, we apply standard quantile regression for exploratory purposes in our study to see how the reserve requirements elimination correlates with lending, liquidity, and profitability indicators across the banks. Therefore, this is a descriptive pattern, not a causal effect.

Using x as the dependent variable, y as the independent variable, $\beta(\alpha)$, $\alpha \in [0, 1]$ as the interconnectedness at “ $\alpha \in [0, 1]$ ”-th quantile, and $F_x(a|y)$ as a distribution function, the equation is as follows:

$$Qx(\alpha|y) = \inf\{a | F_x(a|y) \geq \alpha\} = \sum_{k=1}^K \beta_k(\alpha) Y_k = y\beta(\alpha) \quad (3)$$

The minimization of weighted absolute deviations between x and y results in coefficient $\beta(\alpha)$ for a given τ , where $1_{\{x_n < y_n \beta(\alpha)\}}$ is a constant indicator function.

$$\beta(\alpha) = \arg \min \sum_{n=1}^n \left(\alpha - 1_{\{x_n < y_n \beta(\alpha)\}} \right) |X_n - Y_n \beta(\alpha)| \quad (4)$$

To examine the impact of the reserve requirements elimination on banks' lending, liquidity, and profitability, the following model is applied:

$$Qx(\alpha|y) = \tau(\alpha) + \sum_{k=1}^K \beta_k(\alpha) Y_k + Reserve \left[\lambda(\alpha) + \sum_{k=1}^K \theta_k(\alpha) Y_k \right] \quad (5)$$

Here, $Q(\alpha|y)$ represents the conditional quantile of the variable x given y , for a specified quantile α . $\tau(\alpha)$ denotes the intercept term for the quantile α .

$$\sum_{k=1}^K \beta_k(\alpha) Y_k \quad (6)$$

denotes the sum of the effects of the predictors Y_k at quantile α , with $\beta_k(\alpha)$ being the coefficients for each predictor β_k . The term

$$Reserve \left[\lambda(\alpha) + \sum_{k=1}^K \theta_k(\alpha) Y_k \right] \quad (7)$$

consists of the main independent variable *Reserve* that is interacting with the predictors. $\lambda(\alpha)$ is the coefficient of *Reserve* at quantile α . Finally,

$$\sum_{k=1}^K \theta_k(\alpha) Y_k \quad (8)$$

denotes the interaction terms, where each $\theta_k(\alpha)$ is the coefficient for the interaction between *Reserve* and each predictor Y_k at quantile α .

TABLE 1 Descriptive statistics.

Variables	N	Mean	SD	Pre-mean	Pre-SD	Post-mean	Post-SD	Mean difference	Two sided (p-value)	Two-sample T-test (two-tailed)
Loan/Deposit	1718	82.326	21.397	85.935	21.732	76.777	19.630	9.158	.000	8.862***
LA/DSF	1718	29.686	16.825	26.760	16.356	34.185	16.552	-7.425	.000	-9.151***
ROA	1718	0.282	0.283	0.306	0.150	0.244	0.407	0.061	.000	4.433***
ROE	1718	2.456	2.569	2.586	1.453	2.256	3.667	0.330	.009	2.605***
NIM	1715	3.904	6.509	4.084	6.619	3.629	6.331	0.454	.157	1.414
Fed rate	1718	1.104	0.877	1.733	0.509	0.137	0.107	1.595	.000	80.347***
LogAssets	1718	10.701	1.414	10.599	1.445	10.857	1.351	-0.257	.000	-3.701***
Equity/Assets	1718	12.134	3.098	12.549	3.103	11.495	2.983	1.054	.000	6.988***
Cash/Assets	1718	5.469	7.230	4.062	6.258	7.632	8.050	-3.569	.000	-10.301***
LogZ-Score	1716	5.599	1.153	5.834	1.120	5.239	1.110	0.595	.000	10.791***
Cost/Income	1717	56.427	13.396	55.970	13.198	57.128	13.675	-1.157	.080	-1.750*
NPL	1718	0.718	0.574	0.692	0.464	0.757	0.7102	-0.065	.021	-2.305**
GDP	1718	2.716	10.600	2.641	0.760	2.832	16.866	-0.190	.715	-0.365
Inflation	1718	2.381	1.957	1.691	0.630	3.443	2.694	-1.751	.000	-20.149***
Unemployment	1718	5.050	2.256	3.913	0.254	6.798	2.789	-2.884	.000	-33.157***
LogEPU	1718	4.984	0.300	4.818	0.169	5.239	0.277	-0.421	.000	-39.034***
Reserve	1718	—	—	—	—	—	—	—	—	—

***p < .01. **p < .05. *p < .1.

TABLE 2 Pearson correlation matrix.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Reserve(Dummy)	1														
2. Fed rate	-.888***	1													
3. LogAssets	.089***	-.066***	1												
4. Equity/Assets	-.166***	.158***	-.165***	1											
5. Loan/Deposits	-.209***	.179***	-.222***	.139***	1										
6. Cash/Assets	.241***	-.225***	.021	.149***	-.340***	1									
7. LogZ-Score	-.252***	.305***	-.067***	.155***	-.038	-.062***	1								
8. Cost/Income	.042*	-.060**	.108***	.087***	-.048**	-.018	-.105***	1							
9. NIM	-.034	.033	-.072***	.111***	.050**	.135***	.002	.012	1						
10. ROA	-.106***	.130***	-.028	.024	.149***	-.047*	.223***	-.241***	.03	1					
11. NPL	.055**	-.074***	.288***	-.024	.032	.024	-.166***	.231***	-.1107***	-.038	1				
12. GDP	-.062***	.029	.008	-.022	-.005	.113***	.196***	-.01	-.004	.226	.004	1			
13. Inflation	.310***	-.294***	.015	-.069***	-.111***	.198***	.112***	.011	-.013	.099***	-.037	.436***	1		
14. Unemployment	.624***	-.592***	.048**	-.078***	-.087***	.052**	-.336***	.034	-.014	-.263***	.053**	-.626***	-.295***	1	
15. LogEPU	.685***	-.487***	.065***	-.088***	-.135***	.078***	-.258***	.029	-.018	-.175***	.026	-.566***	-.211***	.747***	1

***p < .01. **p < .05. *p < .1.

TABLE 3 The impact of reserve requirements elimination on lending and liquidity indicator.

Variables	Fixed effect		Random effect		System GMM	
	Loan/Deposit	LA/DSF	Loan/Deposit	LA/DSF	Loan/Deposit	LA/DSF
Lagged Loan/Deposit	—	—	—	—	0.501*** (0.171)	—
Lagged LA/DSF	—	—	—	—	—	0.049 (0.281)
Reserve	−6.102*** (1.564)	1.680* (0.996)	−6.943*** (1.548)	2.582*** (0.990)	−7.690** (3.717)	13.501*** (3.499)
Fed rate	0.0968 (0.547)	−1.532*** (0.348)	0.033 (0.548)	−1.437*** (0.349)	2.655 (1.754)	0.841 (1.454)
LogAssets	−7.692*** (1.187)	11.275*** (0.742)	−5.518*** (0.886)	9.225*** (0.614)	−6.538** (2.676)	−15.044*** (5.190)
Equity/Assets	−0.151 (0.182)	−0.154 (0.113)	−0.082 (0.176)	−0.144 (0.112)	1.486** (0.687)	1.182 (1.938)
Cost/Income	0.002 (0.029)	−0.020 (0.018)	0.003 (0.028)	−0.021 (0.018)	−0.324* (0.180)	0.429 (0.362)
Cash/Assets	−0.402*** (0.053)	—	−0.427*** (0.052)	—	−0.181 (0.362)	—
LogZ-Score	0.307 (0.194)	−0.102 (0.124)	0.232 (0.195)	−0.079 (0.124)	0.192 (0.769)	−0.145 (0.337)
NIM	0.807** (0.338)	−0.354* (0.211)	0.453** (0.222)	−0.157 (0.158)	−7.087** (3.295)	−1.386 (3.862)
NPL	−2.062*** (0.552)	1.895*** (0.352)	−1.837*** (0.551)	1.818*** (0.353)	41.007** (18.458)	−1.159 (5.430)
GDP	0.338*** (0.097)	0.164*** (0.062)	0.335*** (0.098)	0.171*** (0.062)	−0.014 (0.134)	0.284** (0.123)
Inflation	−0.296 (0.197)	0.453 (0.125)	−0.311 (0.198)	0.484*** (0.126)	1.085 (0.690)	0.381 (0.377)
Unemployment	0.817*** (0.189)	−0.281** (0.120)	0.869*** (0.189)	−0.330*** (0.121)	0.887* (0.492)	−0.655 (0.449)
LogEPU	−1.523 (1.543)	0.362 (0.983)	−1.845 (1.551)	0.645 (0.989)	2.973 (3.364)	1.029 (1.462)
Constant	176.920*** (13.523)	−89.943*** (8.528)	157.199*** (11.287)	−71.580*** (7.651)	92.539*** (34.242)	132.764* (72.112)
Observations	1712	1712	1712	1712	1627	1627
R ²	0.092	0.209	0.116	0.219	—	—
Instruments	—	—	—	—	27	22
Groups	—	—	—	—	87	87
AR(2)	—	—	—	—	0.616	0.830
Hansen/Sargan	—	—	—	—	0.191	0.433

Note: Hausman test (p -value): Loan/Deposit (0.000), LA/DSF (0.000). Standard errors in brackets.

* $p < .1$. ** $p < .05$. *** $p < .01$.

3.3 | Descriptive statistics

The descriptive statistics for the sample of 87 US banks used in this study are presented in Table 1. The preliminary results of the two-sample t -tests reveal a statistically significant difference in the dependent variables except for NIM between the period with reserve requirements (“Pre-Mean”) and the period without reserve requirements (“Post-Mean”). Loan/Deposit has declined, which might be due to the slower economy and higher economic policy uncertainty during

TABLE 4 The impact of reserve requirements elimination on profitability indicators.

Variables	Fixed effect			Random effect			System GMM		
	ROA	ROE	NIM	ROA	ROE	NIM	ROA	ROE	NIM
Lagged ROA	—	—	—	—	—	—	0.030 (0.034)	—	—
Lagged ROE	—	—	—	—	—	—	—	0.035 (0.033)	—
Lagged NIM	—	—	—	—	—	—	—	—	0.845*** (0.122)
Reserve	0.155*** (0.051)	1.323*** (0.464)	-0.258** (0.115)	0.122** (0.050)	0.987** (0.449)	-0.259** (0.114)	0.100** (0.046)	0.748* (0.387)	-0.861* (0.519)
Fed rate	0.004 (0.017)	0.001 (0.161)	0.169*** (0.039)	0.011 (0.018)	0.056 (0.161)	0.168*** (0.039)	0.018* (0.010)	0.100 (0.096)	-0.041 (0.079)
LogAssets	-0.066* (0.039)	-0.599* (0.353)	-0.435*** (0.087)	0.009 (0.007)	0.054 (0.062)	-0.431*** (0.086)	0.006 (0.007)	0.025 (0.068)	-0.544 (0.793)
Equity/Assets	0.037*** (0.005)	0.149*** (0.053)	0.060*** (0.013)	0.008** (0.003)	-0.136*** (0.027)	0.060*** (0.013)	0.005 (0.004)	-0.136*** (0.032)	-0.051 (0.110)
Loan/Deposits	0.000 (0.001)	0.003 (0.007)	0.004** (0.002)	0.002*** (0.000)	0.012*** (0.004)	0.004** (0.001)	0.001 (0.001)	0.011 (0.009)	0.001 (0.011)
Cash/Assets	0.000 (0.002)	0.008 (0.015)	0.032*** (0.003)	-0.001 (0.001)	-0.005 (0.011)	0.033*** (0.003)	-0.001 (0.002)	0.001 (0.012)	0.018 (0.031)
LogZ-Score	0.040*** (0.006)	0.349*** (0.057)	-0.024* (0.014)	0.039*** (0.006)	0.339*** (0.055)	-0.024* (0.014)	0.037** (0.016)	0.318** (0.134)	-0.004 (0.022)
Cost/Income	-0.008*** (0.001)	-0.072*** (0.008)	-0.005** (0.002)	-0.005*** (0.001)	-0.050*** (0.005)	-0.005** (0.002)	-0.005*** (0.001)	-0.045*** (0.009)	0.002 (0.008)
GDP	0.005 (0.003)	0.044 (0.029)	0.003 (0.007)	0.004 (0.003)	0.042 (0.029)	0.003 (0.007)	0.004* (0.002)	0.0378** (0.018)	0.035 (0.040)
Inflation	-0.007 (0.006)	-0.071 (0.058)	0.014 (0.014)	-0.009 (0.006)	-0.083 (0.058)	0.014 (0.014)	-0.007 (0.008)	-0.056 (0.075)	0.089 (0.059)
Unemployment	-0.035*** (0.006)	-0.319*** (0.056)	0.046*** (0.013)	-0.033*** (0.006)	-0.297*** (0.056)	0.046*** (0.013)	-0.029*** (0.011)	-0.250** (0.113)	0.068 (0.058)
LogEPU	0.009 (0.051)	0.050 (0.456)	0.071 (0.113)	-0.005 (0.051)	-0.065 (0.461)	0.071 (0.113)	0.013 (0.023)	0.200 (0.181)	0.706 (0.500)
Constant	0.684 (0.462)	8.376** (4.140)	7.246*** (1.025)	0.088 (0.243)	3.991* (2.167)	7.191*** (1.248)	0.065 (0.251)	2.588 (2.147)	3.714 (8.598)
Observations	1715	1715	1712	1715	1715	1712	1627	1627	1624

(Continues)

TABLE 4 (Continued)

Variables	Fixed effect			Random effect			System GMM		
	ROA	ROE	NIM	ROA	ROE	NIM	ROA	ROE	NIM
R ²	.075	.051	.019	.166	.202	.019	—	—	—
Instruments	—	—	—	—	—	—	32	32	29
Groups	—	—	—	—	—	—	87	87	87
AR(2)	—	—	—	—	—	—	0.923	0.964	0.360
Hansen/Sargan	—	—	—	—	—	—	0.464	0.642	0.063

Note: Hausman test (p-value): ROA (0.000), ROE (0.000), NIM (0.995). Standard errors in brackets.

* $p < .1$. ** $p < .05$. *** $p < .01$.

TABLE 5 Quantile regression for the impact of reserve requirements elimination on Loan/Deposit.

	(Q20)	(Q40)	(Q60)	(Q80)	(Q90)
Variables	Loan/Deposit	Loan/Deposit	Loan/Deposit	Loan/Deposit	Loan/Deposit
Reserve	-1.193 (4.514)	-6.571* (3.587)	-5.861** (2.753)	-3.058 (3.022)	-0.426 (3.856)
Fed rate	1.061 (1.513)	-0.711 (1.303)	-0.228 (0.969)	0.504 (0.988)	1.832 (1.535)
LogAssets	-3.155*** (0.329)	-2.956*** (0.284)	-2.894*** (0.348)	-2.276*** (0.553)	-2.292*** (0.742)
Equity/Assets	1.704*** (0.128)	1.474*** (0.180)	1.010*** (0.165)	0.162 (0.380)	-0.622** (0.241)
Cost/Income	0.032 (0.041)	-0.134*** (0.050)	-0.187*** (0.036)	-0.117* (0.063)	-0.011 (0.075)
Cash/Assets	-1.363*** (0.119)	-1.141*** (0.052)	-0.822*** (0.119)	-0.842*** (0.158)	-0.954*** (0.141)
LogZ-Score	-0.890 (0.645)	-1.239** (0.565)	-1.019*** (0.373)	-0.619 (0.604)	-0.571 (0.733)
NIM	0.071* (0.040)	0.090 (0.143)	0.220 (0.146)	2.101 (1.915)	3.605*** (1.395)
NPL	4.786*** (0.654)	3.238*** (1.100)	2.047* (1.062)	0.929 (0.928)	-0.768 (0.784)
GDP	0.420 (0.345)	0.502** (0.240)	0.452* (0.243)	0.508** (0.223)	0.544* (0.324)
Inflation	-0.642 (0.594)	0.244 (0.561)	-0.323 (0.422)	-0.208 (0.433)	-0.179 (0.594)
Unemployment	0.720 (0.594)	0.558 (0.624)	1.031** (0.524)	0.892** (0.434)	0.659 (0.560)
LogEPU	-7.653 (4.740)	-1.242 (3.756)	-1.925 (2.567)	0.212 (2.763)	3.066 (3.817)
Constant	123.574*** (25.859)	115.184*** (20.430)	129.950*** (13.728)	116.245*** (17.706)	106.057*** (25.461)
Observations	1712	1712	1712	1712	1712

Note: Standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

the pandemic crisis. Therefore, it is necessary to find out how Fed's decision to eliminate reserve requirements has contributed to promoting bank lending in the pandemic crisis. The liquidity indicator, LA/DSF, also increased statistically significantly. The profitability indicators, ROA and ROE, increased significantly after the elimination of banks' reserve requirements in the pandemic crisis—while NIM did not increase significantly. Turning to the control variables, statistically significant differences are found for most of the bank-specific and country-specific variables between the two periods “Pre”/“Post.”

A Pearson correlation matrix is presented in Table 2 for all independent variables including the reserve requirements dummy variable (Reserve) and the control variables. The correlation coefficients reveal no problem of perfect multicollinearity.

4 | RESULTS AND DISCUSSION

4.1 | Baseline models: Fixed effect and random effect results

The results of the fixed effect and random effect models are presented in Tables 3 and 4. The results of Table 3 reveal that the elimination of reserve requirements decreases the loan-to-deposit ratio (Loan/Deposit) of US banks in the pandemic

TABLE 6 Quantile regression for the impact of reserve requirements elimination on LA/DSF.

	(Q20)	(Q40)	(Q60)	(Q80)	(Q90)
Variables	LA/DSF	LA/DSF	LA/DSF	LA/DSF	LA/DSF
Reserve	5.223** (2.200)	3.334* (1.961)	6.648** (2.611)	6.888 (4.315)	6.830 (4.631)
Fed rate	0.514 (0.786)	-1.275* (0.682)	-1.506* (0.838)	-1.479 (1.432)	-1.654 (1.546)
LogAssets	3.016*** (0.348)	4.124*** (0.310)	4.714*** (0.344)	5.609*** (0.283)	7.794*** (0.326)
Equity/Assets	0.078 (0.119)	-0.091 (0.083)	-0.418*** (0.108)	-0.783*** (0.133)	0.111 (0.407)
Cost/Income	0.012 (0.025)	0.056*** (0.020)	0.089*** (0.028)	0.256*** (0.048)	0.287*** (0.035)
LogZ-Score	-1.102*** (0.277)	-0.462* (0.266)	-0.201 (0.307)	-0.273 (0.478)	-1.092 (0.714)
NIM	0.182*** (0.028)	0.127*** (0.034)	0.166* (0.099)	0.103*** (0.029)	-0.042 (0.036)
NPL	0.838 (0.689)	1.501*** (0.485)	0.796 (0.757)	-1.564* (0.899)	-1.948** (0.912)
GDP	0.197 (0.166)	0.247 (0.168)	0.233 (0.225)	0.329 (0.303)	0.001 (0.279)
Inflation	0.761** (0.330)	0.795** (0.322)	0.078 (0.425)	0.207 (0.600)	0.146 (0.629)
Unemployment	-0.301 (0.311)	-0.397 (0.323)	-0.679 (0.455)	-0.654 (0.586)	-0.757 (0.583)
LogEPU	0.818 (2.159)	1.296 (2.006)	1.436 (2.518)	2.261 (3.901)	-3.555 (5.108)
Constant	-17.599 (10.970)	-27.523*** (10.474)	-26.488* (13.658)	-34.922* (20.502)	-25.647 (28.697)
Observations	1712	1712	1712	1712	1712

Note: Standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

crisis. This economically implies that banks do not lend more relative to deposits when they do not need to keep reserve in the pandemic crisis. Instead, we observe a lower loan-to-deposit ratio. In other words, the elimination of reserve requirements in the pandemic crisis did not increase bank lending.

These results might be explained by a lower demand for loans during times of higher economic uncertainty, by higher savings of depositors from stimulus programs of government, like the Paycheck Protection Program that supports small firms to cover operational expenses, maintain payroll, and retain employees (US Department of the Treasury, 2020), and by higher savings for future consumption. From the perspective of monetary policy, this implies that the elimination of reserve requirements cannot increase the money supply in the economy through traditional lending, but it increases deposits in banks during pandemic crises when the Fed funds rate remains near zero. These findings are in line with Vrontis et al. (2024). They find that it is challenging for small and medium enterprises (SMEs) to perform well in the COVID-19 pandemic crisis that may also adversely impact loan demand. The authors explain this by changing customer behaviors due to the crisis.

Turning to the liquid assets to deposit and short-term funding (LA/DSF), it is evidenced from Table 3 that the reserve requirements elimination increases liquid assets of banks more compared with deposits and short-term funding. This finding economically implies that when reserve requirements were eliminated, the accumulated volume of required reserve held by banks became available for lending. However, loan demand declined in the economy during the pandemic crisis forcing banks to hold more safe liquid assets which might be the reason for higher bank liquidity. This finding is in line with Zhang and Li (2025) who argue that lending facility tools of monetary policy have a positive impact on enhancing bank liquidity.

TABLE 7 Quantile regression for the impact of reserve requirements elimination on ROA.

Variables	(Q20)	(Q40)	(Q60)	(Q80)	(Q90)
	ROA	ROA	ROA	ROA	ROA
Reserve	0.062*** (0.021)	0.050** (0.021)	0.076*** (0.017)	0.098*** (0.020)	0.130*** (0.032)
Fed rate	0.030*** (0.007)	0.034*** (0.006)	0.041*** (0.006)	0.054*** (0.006)	0.062*** (0.012)
LogAssets	-0.007** (0.003)	-0.002 (0.002)	0.000 (0.002)	0.005*** (0.002)	0.013** (0.005)
Equity/Assets	0.003*** (0.001)	0.002** (0.001)	0.004*** (0.001)	0.003*** (0.001)	0.003** (0.001)
Loan/Deposits	-0.000 (0.000)	0.000 (0.000)	0.001** (0.000)	0.001*** (0.000)	0.003*** (0.000)
Cash/Assets	-0.003*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.001** (0.000)	0.000 (0.001)
LogZ-Score	0.011*** (0.002)	0.002 (0.002)	-0.010*** (0.003)	-0.018*** (0.003)	-0.031*** (0.004)
Cost/Income	-0.004*** (0.000)	-0.005*** (0.000)	-0.005*** (0.000)	-0.005*** (0.000)	-0.004*** (0.000)
GDP	0.003** (0.002)	0.005*** (0.001)	0.004*** (0.001)	0.006*** (0.002)	0.003 (0.002)
Inflation	0.002 (0.002)	0.002 (0.003)	0.001 (0.003)	0.003 (0.004)	-0.005 (0.005)
Unemployment	-0.016*** (0.004)	-0.012*** (0.003)	-0.013*** (0.003)	-0.008* (0.004)	-0.010* (0.005)
LogEPU	0.006 (0.022)	0.019 (0.020)	-0.007 (0.017)	-0.007 (0.019)	0.001 (0.033)
Constant	0.446*** (0.115)	0.399*** (0.110)	0.584*** (0.094)	0.516*** (0.113)	0.357* (0.184)
Observations	1715	1715	1715	1715	1715

Note: Standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

The analysis of the profitability indicators as illustrated by Table 4 reveals that the elimination of reserve requirements significantly increased both ROA and ROE in the pandemic crisis. The results economically imply that overall profitability of banks increased in the pandemic crisis although the traditional lending of banks declined.

These findings reflect well that banks earned a significant portion of non-interest income as fees from the US Small Business Administration (SBA) for processing and issuing forgivable loans under the Paycheck Protection Program that will be repaid (“forgiven”) by the SBA (US Department of the Treasury, 2020). As the traditional lending interest rate was low in the economy, banks provided such forgivable loans with negligible interest rate but guaranteed by US SBA and earned fees from SBA ranging from 1% to 5% without taking any risk (US Department of the Treasury, 2020). However, this Paycheck Protection Program also injected money into the economy through firms and individual employees and has increased bank deposits compared with traditional bank loans. Moreover, lower operating costs of banks due to home office in the lockdown and enhanced digital banking in the pandemic crisis might also have contributed to higher ROA and ROE of the banks.

Our results in the context of the US differ from the situation of the banks of the Middle East and North Africa (MENA) region where both ROA and ROE declined in the COVID-19 pandemic crisis compared with pre-pandemic situation (El-Chaarani, Skaf, et al., 2023). The reasons for these deviations of the results can be due to the Paycheck Protection Program of the government, and higher non-interest income and cost efficiency of the US banks in the pandemic period.

As opposed to the other two performance indicators (Table 4), the elimination of reserve requirements decreased NIM during the expansionary monetary policy in the pandemic crisis. This result economically implies that banks had higher liquidity and deposits in the pandemic crisis, and the reserve requirements elimination injected more loanable funds for

TABLE 8 Quantile regression for the impact of reserve requirements elimination on ROE.

Variables	(Q20)	(Q40)	(Q60)	(Q80)	(Q90)
	ROE	ROE	ROE	ROE	ROE
Reserve	0.264 (0.187)	0.355** (0.177)	0.553*** (0.141)	0.705*** (0.194)	0.890*** (0.338)
Fed rate	0.156** (0.061)	0.215*** (0.056)	0.331*** (0.047)	0.391*** (0.064)	0.502*** (0.142)
LogAssets	-0.056** (0.025)	-0.049*** (0.017)	-0.029** (0.014)	0.014 (0.016)	0.070 (0.051)
Equity/Assets	-0.144*** (0.008)	-0.168*** (0.009)	-0.183*** (0.007)	-0.210*** (0.007)	-0.234*** (0.010)
Loan/Deposits	-0.001 (0.002)	0.001 (0.003)	0.002 (0.002)	0.007*** (0.003)	0.019*** (0.003)
Cash/Assets	-0.023*** (0.005)	-0.017*** (0.006)	-0.011*** (0.004)	0.010 (0.007)	0.023*** (0.006)
LogZ-Score	0.081*** (0.023)	0.019 (0.020)	-0.064*** (0.021)	-0.148*** (0.027)	-0.293*** (0.050)
Cost/Income	-0.041*** (0.002)	-0.043*** (0.002)	-0.045*** (0.002)	-0.048*** (0.002)	-0.042*** (0.004)
GDP	0.042*** (0.015)	0.042*** (0.012)	0.038*** (0.011)	0.038** (0.017)	0.035 (0.031)
Inflation	0.023 (0.028)	0.026 (0.030)	0.039* (0.022)	0.019 (0.033)	-0.039 (0.048)
Unemployment	-0.150*** (0.035)	-0.123*** (0.038)	-0.082*** (0.023)	-0.081** (0.032)	-0.093* (0.051)
LogEPU	0.230 (0.186)	0.150 (0.181)	0.003 (0.135)	0.000 (0.158)	0.109 (0.363)
Constant	5.516*** (0.994)	6.585*** (1.076)	7.593*** (0.746)	7.923*** (0.915)	7.099*** (1.961)
Observations	1715	1715	1715	1715	1715

Note: Standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

banks but loan demand declined. Since the Fed funds rate was stable at near zero, it resulted in a higher decline of the lending interest rate compared with the deposit interest rate, which rarely declines. Therefore, although profitability of the US banks increased, profitability in terms of net interest income declined.

Finally, the Hausman test in Tables 3 and 4 reveals that the fixed effect model is better than the random effect model except for the fixed effect model with dependent variable NIM. Therefore, the random effect model is consistent only for the model with dependent variable NIM.

Finally, we cannot reject the hypotheses H1, H2, and H3, and our findings imply that eliminating reserve requirements has not positively impacted bank lending (H1), increased liquidity (H2), and decreased profitability (H3) from net interest income (NIM). However, we reject hypothesis H3 concerning profitability measured by ROA and ROE, which reveals that the reserve requirements elimination did not adversely impact these two profitability indicators.

4.2 | Robustness test: Two-step system generalized method of moments (GMM) results

The validity of the results of the fixed effect and random effect models has been tested with the two-step system GMM that accounts for potential endogeneity resulting from a causal relationship between the dependent and the independent variables, measurement errors, and omitted variable bias. The results of the two-step system GMM are shown together with the other results in Tables 3 and 4. The lagged values of potentially endogenous variables have been used as instrument variables so that Loan/Deposit, LA/DSF, ROA, ROE, and NIM in later quarters could not be the cause of lagged

TABLE 9 Quantile regression for the impact of reserve requirements elimination on NIM.

	(Q20)	(Q40)	(Q60)	(Q80)	(Q90)
Variables	NIM	NIM	NIM	NIM	NIM
Reserve	−0.013 (0.121)	0.045 (0.120)	−0.133 (0.127)	−0.106 (0.148)	−0.250 (0.281)
Fed rate	0.142*** (0.042)	0.150*** (0.045)	0.124*** (0.043)	0.201*** (0.053)	0.177* (0.103)
LogAssets	−0.111*** (0.018)	−0.118*** (0.012)	−0.102*** (0.010)	−0.074*** (0.010)	0.025 (0.027)
Equity/Assets	0.057*** (0.006)	0.059*** (0.005)	0.079*** (0.008)	0.101*** (0.008)	0.108*** (0.014)
Loan/Deposits	0.017*** (0.001)	0.017*** (0.001)	0.017*** (0.002)	0.017*** (0.002)	0.030*** (0.002)
Cash/Assets	0.011*** (0.004)	0.017*** (0.003)	0.034*** (0.009)	0.060*** (0.006)	0.286*** (0.051)
LogZ-Score	−0.034*** (0.012)	−0.058*** (0.012)	−0.073*** (0.017)	−0.130*** (0.019)	−0.173*** (0.045)
Cost/Income	−0.005*** (0.001)	−0.006*** (0.002)	−0.010*** (0.002)	−0.009*** (0.002)	−0.013*** (0.003)
GDP	−0.009 (0.010)	−0.008 (0.007)	−0.008 (0.007)	−0.015* (0.008)	0.001 (0.022)
Inflation	0.006 (0.016)	0.001 (0.015)	−0.001 (0.016)	−0.008 (0.019)	0.017 (0.038)
Unemployment	0.018 (0.018)	0.007 (0.014)	0.010 (0.015)	0.011 (0.019)	0.057 (0.046)
LogEPU	−0.074 (0.120)	−0.104 (0.125)	−0.026 (0.124)	−0.111 (0.155)	−0.104 (0.267)
Constant	2.292*** (0.633)	2.898*** (0.658)	2.760*** (0.701)	3.019*** (0.776)	0.848 (1.407)
Observations	1712	1712	1712	1712	1712

Note: Standard errors in parentheses.

*** $p < .01$. * $p < .1$.

values in earlier quarters. The GMM coefficients of the reserve requirements (Reserve) dummy variable validate the results of the fixed effect and random effect estimators. Moreover, it is revealed that the elimination of reserve requirements could not promote bank lending but increased liquidity in US banks during the pandemic crisis. Turning to banks' profitability, it is shown that the reserve requirements elimination increased banks' ROA and ROE but decreased NIM. These results might be explained by stimulus programs, like the Paycheck Protection Program, that were set up by the US government during the crisis. Taking part in this program, banks lend money without interest (decreasing NIM) but they earn from loan processing and issuance fees paid by government (increasing ROA, ROE). The decision of eliminating reserve requirements can also impact such non-interest income through the availability of funding for these stimulus programs.

In Tables 3 and 4, the second-order autocorrelation AR(2) p -values in the Arellano–Bond test confirm that the models are not subject to issues of autocorrelation. Moreover, the insignificant p -values of the Hansen or Sargan test confirm the validity of the instruments.

4.3 | Heterogeneity test: Quantile regression results

Finally, we apply quantile regression to capture the heterogeneity of the impact of the reserve requirements elimination on US banks' lending, liquidity, and profitability in the pandemic crisis. The results of Table 5 reveal that the reserve requirements elimination has significantly decreased Loan/Deposit only at the two middle quantiles (Q40 and Q60). This

finding economically implies that the impact of the reserve requirements elimination is only vivid for banks with moderate levels of Loan/Deposit—whereas banks with higher and lower levels of Loan/Deposit are not significantly impacted by the reserve requirements elimination.

The results of Table 6 disclose that the reserve requirements elimination significantly increased LA/DSF at the lower and middle quantiles (Q20, Q40, and Q60). This finding implies that the impact of the reserve requirements elimination is only prominent in the banks with lower and middle levels of LA/DSF. Therefore, the reserve requirements elimination promoted banks' liquidity by increasing LA/DSF for the banks in the lower and middle quantiles, and the coefficients of Reserve are heterogeneous across banks.

Turning to the profitability indicators, Tables 7 and 8 reveal that the reserve requirements elimination increased both ROA and ROE of banks and the impact is more pronounced in the middle and upper quantiles. The results economically reveal that the reserve requirements elimination increased profitability more for banks with a higher level of ROA and ROE. Finally, Table 9 reveals that the impact of the reserve requirements elimination on NIM does not significantly vary across banks.

Therefore, we cannot reject our alternative hypothesis (H4) for (a) lending, (b) liquidity, and (c) profitability, except for NIM. This implies that the impact of the reserve requirements elimination on lending, liquidity, and profitability (in terms of ROA and ROE) varies across banks. Only for the profitability measure NIM, we could not identify variation across banks.

5 | CONCLUSION AND POLICY IMPLICATION

The first-ever decision of the Fed to eliminate the reserve requirements in the US in a pandemic crisis and the continuation of this decision even after the pandemic crisis have directed us to analyze the relationship between the elimination of reserve requirements and banks' lending, liquidity, and profitability. Our empirical findings reveal that the elimination of reserve requirements was not able to support banks' lending during the COVID-19 pandemic although US banks were equipped well with liquidity from the beginning. We find that the reserve requirements elimination could not increase banks' lending but increases banks' liquidity and profitability in the pandemic crisis. This impact is heterogeneous across banks. However, the reserve requirements elimination decreases profitability in terms of NIM and does not show any heterogeneity concerning the NIM across banks.

The findings of our study on the application of a conventional monetary policy tool, reserve requirements, in the pandemic crisis contradict the application of the Taylor rule and New Keynesian theory, but support the deployment of fixed rules, such as the Friedman's rule. More precisely, our findings do not call for a modification of the applied conventional monetary policy instrument, that is, reserve requirements, by the Fed in the given perturbation and disturbance by COVID-19. Rather, our results support the application of fixed rules proposing a constant growth rate of money supply because the reserve requirements elimination fails to serve Fed's purpose in the pandemic crisis.

The findings suggest to policy-makers that a reserve requirements elimination cannot make considerable differences to promote lending of banks but increases liquidity through holding more liquid assets and increases profitability from non-interest income in the pandemic crisis. Therefore, policy-makers shall rethink to resume reserve requirements in the pandemic like COVID-19 to control access liquidity that can potentially result in higher inflation in the pandemic period and cannot be controlled only through the Fed funds rate.

Moreover, as the impact of the reserve requirements elimination varies across banks, it could be worth for policy-makers to think about applying different percentages of reserve requirements for the different banks based on banks' heterogeneity and according to their characteristics. These differentiated treatments can help banks to better handle liquidity crises and the problem of excess liquidity. Moreover, as temporary complementary policies, the Fed can relieve capital buffer (capital adequacy ratio) to free up capital for loans and loan classification standards to avoid overprovisioning and encourage lending in the pandemic crisis of COVID-19. However, these policies may not be appropriate to serve the Fed's financial stability objectives in the long term.

Finally, our findings are useful for countries that are planning to eliminate reserve requirements following the decision of the Fed. Since pandemics like COVID-19 will potentially never disappear from the globe, the findings of the paper shall guide policy-makers to take appropriate measures concerning monetary policy in a pandemic.

Since the decision of eliminating banks' reserve requirements is still effective in the US, further research can explore the post-pandemic effect of the decision on higher inflation rate and how only the Fed funds rate can control such an

inflation rate. Moreover, since capital buffers based on the regulatory capital adequacy ratio are claimed as an alternative to reserve requirements, further research can empirically explore the necessity of the reserve requirements in this context.

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DATA AVAILABILITY STATEMENT

Data will be made available on request.

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APPENDIX A

TABLE A1 Variable description and source.

Variables	Description	Data source
Loan-to-deposit ratio (loan/deposit)	The ratio measures banks' total loans compared with total deposits, expressed as percentage	BankFocus
Liquid assets to deposits and short-term funding (LA/DSF)	The ratio divides total liquid assets by total deposits and short-term funding and it is expressed as percentage	BankFocus
Return on assets (ROA)	It divides net income by total assets and it is expressed as percentage	BankFocus
Return on equity (ROE)	It divides net income by total equity and it is expressed as percentage	BankFocus
Net interest margin (NIM)	Interest income minus interest expenses is divided by interest earning assets to measure this ratio and it is expressed as percentage	BankFocus
Reserve requirements (Reserve)	This is a dummy variable represents the value of 1 in the quarters with no reserve requirements, that is, 2020 and 2021, and 0 otherwise, that is, in periods with reserve requirements	Authors' estimation
Federal funds rate (Fed rate)	The Fed funds rate is disclosed by Federal Open Market Committee (FOMC) of the Federal Reserve System and expressed as percentage	Refinitiv
Bank size (LogAssets)	It is represented by natural logarithm of banks' total assets	BankFocus, Authors' estimation
Capitalization (Equity/Assets)	The ratio measures total equity to total assets and is expressed as percentage	BankFocus
Cash to total assets (Cash/Assets)	The ratio divides cash and cash equivalents by total assets and it is expressed as a percentage	BankFocus
LogZ-Score	It measures the natural logarithm of the ratio of ROA added to capitalization and divided by the standard deviation of ROA, calculated using three-quarter rolling windows. It represents financial stability of bank	BankFocus, Authors' estimation
Cost-to-income (Cost/Income)	Total operating expenses are divided by total operating revenues. The ratio is expressed as a percentage and indicates the cost efficiency of a bank	BankFocus
Impaired loans to gross customer loans and advances (NPL)	The ratio is measured by dividing impaired loans or non-performing loans by total outstanding loans and it is expressed as percentage	BankFocus
GDP growth rate (GDP)	Quarterly real gross domestic product (GDP) growth rate (YoY)	Fed Bank of St. Louis
Inflation rate (Inflation)	Quarterly inflation rate (YoY)	Trading Economics
Unemployment rate (Unemployment)	Quarterly unemployment rate	Fed Bank of St. Louis
Economic policy uncertainty (LogEPU)	It measures the natural logarithm of economic policy uncertainty index value of the US	EPU, Authors' estimation

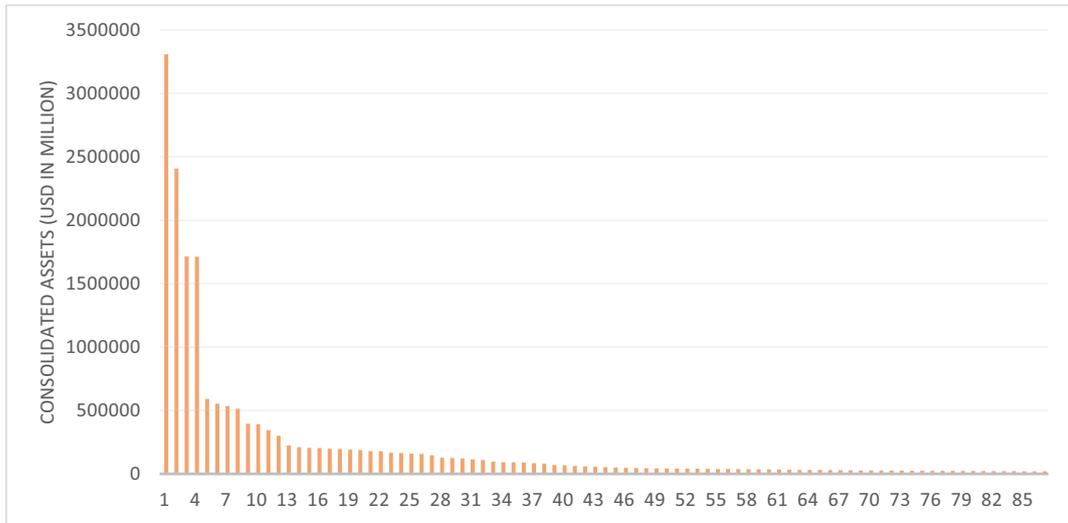


FIGURE A1 Consolidated assets of the sample of 87 US banks. Source: Federal Reserve Statistical Release (2022).