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Monetary policy transmission under pandemic uncertainty: Effect on banks' risk and capital adjustments

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Abstract

This paper investigates the effects of monetary policy on the simultaneous adjustments in asset portfolio risk and capital of banks amidst the uncertainty of the COVID-19 pandemic, focusing on the 12 largest economies from 2018 Q1 to 2021 Q4. Results indicate that banks show lower portfolio risk and capital levels when the monetary policy stance is eased. However, amid heightened pandemic uncertainty, the risk-reducing effect of monetary policy on banks amplifies, while bank capital levels remain unchanged. Heterogeneity analyses reveal that banks with higher levels of diversification and herding are more responsive to interest rates amid pandemic uncertainty, exhibiting lower risk exposure in their asset portfolios. Banks in countries adopting negative interest rate policies also tend to assume greater asset risk to accommodate the intended stimulus of monetary policies.

KEYWORDS

capital, interest rate, monetary policy, pandemic uncertainty, portfolio risk

1 | INTRODUCTION

Like economic and financial crises in the past, the COVID-19 pandemic has compelled central banks to relax their monetary policy stances to increase credit and liquidity supply for private sectors, restore market confidence, stabilize the economy, and alleviate the mounting financial risks in the financial systems. Against this backdrop, many studies have emerged to examine the effects of monetary policy responses on financial markets (Hu et al., 2022; Iyke & Maheepala, 2022; Wei & Han, 2021) and bank lending (Çolak & Öztekin, 2021) during the pandemic. Nevertheless, little is known about how banks manage their portfolio risks when faced with the interaction between easing monetary policy and pandemic uncertainty. To meet the intended stimulus of easing monetary policy during the pandemic, banks must engage in risk-bearing economic activities while meeting minimum capital requirements, necessitating a restructuring of their risk and capital portfolios. As the virus that causes COVID-19, SARS-CoV-2, transitions from a novel threat to an endemic disease, any new variants of the virus have added uncertainties to the development of the endemic worldwide. It is, thus, necessary to examine the effect of the monetary policy stance on banks' asset portfolio risk and capital adjustments amid pandemic uncertainty and to explore the possible heterogeneities in its effect.

Our study is grounded in two different strands of literature. Firstly, it pertains to studies that examine the effects of monetary policy on bank risk and capital, which yield mixed evidence. According to the risk-taking channel of monetary policy transmission, an easing monetary policy induces banks to take more risks to gamble on higher yields as lower interest rates slash interest incomes generated from loans and/or increase market prices of financial assets (Bonfim & Soares, 2018; Chen et al., 2017; de Moraes & de Mendonça, 2019; Neuenkirch & Nöckel, 2018). Conversely, the risk-reducing channel of monetary policy transmission suggests that lower interest rates discourage banks from investing in risky activities due to reduced risk premia earned and external funding costs (Girotti, 2019; López-Penabad et al., 2022; Ngambou Djatche, 2019). Comparatively, evidence on the effect of monetary policy on bank capital is scarce. Specifically, de Moraes et al. (2016) found that monetary policy affects bank capital via the risk-taking channel as increased interest rates lead to greater loan loss provisions by banks, which subsequently requires banks to maintain higher capital adequacy ratios. However, as bank capital and the associated funding costs influence the financing of bank assets, monetary policy may also affect bank risk via the bank capital channel (Gambacorta & Shin, 2018; Heuvel, 2002; Jiang & Yuan, 2022). This interrelationship therefore motivates us to investigate the simultaneous effects of monetary policy on banks' risk and capital adjustments.

Secondly, our study pertains to the literature strand focusing on the effect of the pandemic on bank risk or stability. Specifically, Duan et al. (2021) found that the pandemic increases the bank credit risks and systemic risks worldwide. To compensate for the losses caused by the pandemic, banks raised their loan rates, which might be accompanied by higher credit default rates among borrowers (Guo & Tseng, 2023). However, these repercussions could be alleviated by the deployment of expansionary monetary policy (Guo & Tseng, 2023), robust regulatory capital ratios (Anani & Owusu, 2023; Cao & Chou, 2022), credit growth limits, reserve requirements, and dynamic provisioning (Igan et al., 2023). Our study may be related to Guo and Tseng (2023) who merely provide a theoretical argument for the interrelationships among the pandemic, monetary policy and bank risk. Hence, our study complements the literature by offering empirical evidence.

Given the opposing risk-reducing channel and risk-taking channel of monetary policy transmission, linking the pandemic uncertainty to the monetary policy transmission could yield two possible results. Broadly speaking, the pandemic posed threats to bank stability as it exacerbated banks' profitability, credit default risks and pessimism about economic prospects (Elnahass et al., 2021; Tran et al., 2022). Heightened pandemic uncertainty further led banks to wait and delay their risky investments due to increased option value of waiting (Aastveit et al., 2017; Wu et al., 2022). If the risk-reducing channel dominated during the pandemic, implementing an easing monetary policy would further hamper banks' investments due to reduced risk premia earned from those investments. Similarly, an easing monetary policy helped reduce the funding costs of borrowers and relieved their financial distress (Girotti, 2019; López-Penabad et al., 2022; Ngambou Djatche, 2019), ultimately reducing banks' credit risk exposure during the pandemic. As a result, banks could demonstrate downward risk adjustments and correspondingly require lower capital buffers.

Conversely, owing to wide-ranging expansionary policies and government support for private sectors, banks are found to have mitigated credit losses that once seemed likely (Guo & Tseng, 2023). Furthermore, learning from the 2008 Global Financial Crisis, banks have demonstrated greater resilience through capital and liquidity buffers during the pandemic (Ikeda et al., 2021). In view of the economic slowdown brought on by the pandemic, banks may respond to monetary policy easing proactively by increasing their risk tolerance, extending more loan offerings and making other investments to stimulate the economy. Consequently, the risk-taking channel of monetary policy transmission dominated in the pandemic, and banks would demonstrate upward risk adjustments and correspondingly require more capital buffers.

Furthermore, banks' risk and capital responses to monetary policy amid pandemic uncertainty could be heterogeneous across bank characteristics and interest policy types. Specifically, less-diversified banks may be more sensitive to changes in monetary policy stance, as loan-based asset portfolios limit the revenue-generating avenues of these banks (Demir & Danisman, 2021; Meslier et al., 2014; Paltrinieri et al., 2021). Diversification also enhances bank profitability and reduces bank risks during adverse events like financial and pandemic uncertainties (Dang, 2022; Li et al., 2021). Further, banks with varying herding levels have been found to react to economic uncertainties (Ryuichi & Hirofumi, 2011; Toh & Zhang, 2022; Wu et al., 2020) and monetary policy differently (Bianco, 2021), but the heterogeneous influence of pandemic uncertainty on these banks is yet to be explored. Additionally, it is interesting to investigate whether banks in countries adopting negative interest policies behave differently from banks in other countries. Negative interest policies may, on one hand, induce banks to extend risky investments in the real economy to meet the intended stimulus of the policies (Acharya et al., 2019; Lambert & Ueda, 2014), while on the other hand, compress the net interest margins of banks and make them more conservative (BIS, 2019; Borio & Zhu, 2012). Since bank responses to monetary policy could be heterogeneous and unclear a priori, we further examine these heterogeneities.

Our study focuses on banks in the 12 largest economies, specifically Brazil, China, Canada, France, Germany, India, Italy, Japan, Russia, South Korea, U.K. and U.S., for two main reasons. First, as banks in major economies are generally internationally active and have global presence, their banking regulations are adapted from the universally accepted Basel's Risk-based Capital Accords, providing a level playing field and a global benchmark for financial reporting among banks. This concept of universality enables us to pool banks from different countries into a large sample and synchronize the measurements of risk, capital and other bank-specific variables. A further reason for studying the 12 largest economies is their influential role in the global economic growth and financial conditions. According to the World Bank (2022), the combined GDP values of these economies consistently exceeded 70% of the world's GDP over the years 2018–2021 (Table A1). Given their scale and interconnectedness, uncertainties about the pandemic and changes in monetary policy stances are bound to affect not only their own domestic markets but also global markets. Inevitably, banks are impacted for better or worse. Against this backdrop, an investigation into banks' responses to monetary policy amid pandemic uncertainty in major economies carries meaningful implications for the economies and the rest of the world.

Our study contributes to the extant literature mainly in three ways. First, this study advances understanding about monetary policy transmission to bank risk and capital. As mentioned above, most prior literature has studied the risk channel of monetary policy and overlooked the capital channel (Bonfim & Soares, 2018; Chen et al., 2017; Girotti, 2019; López-Penabad et al., 2022; Neuenkirch & Nöckel, 2018; Ngambou Djatche, 2019). Very often, these studies investigated bank risk and capital independently, ignoring the fact that banks make risky investment decisions by accounting for their capital buffers and meanwhile, adjust capital levels in accordance with the risk exposure. We depart from these studies by employing a simultaneous equations model with a partial adjustment (SEM-PAR) for bank risk and capital to investigate the effect of monetary policy. Our study is related to de Moraes and de Mendonça (2019), who examined monetary policy transmission to bank risk and capital simultaneously in Brazil, but we deviate from their study by considering the effect of pandemic uncertainty and the context of major economies in this picture.

Second, this study contributes to the literature by linking monetary policy transmission to bank risk and capital with COVID-19 pandemic uncertainty. The closest studies to ours are Nguyen et al. (2022) who examined the effect of monetary policy on bank risk during the pandemic in Vietnam; Spiegel (2022) who examined the global monetary policy spill-over effects on U.S. foreign banks' lending, capital and income during the pandemic; and Hardy and Zhu (2023) who examined banks' exposures to sovereign credit risks in the consequence of central bank asset purchases during the pandemic. We depart from these studies by focusing on major economies and exclusively examining the simultaneous risk and capital responses of banks to changes in monetary policy stance during the pandemic uncertainty. We also acknowledge some studies which have examined the transmission of monetary policy onto banks in the context of economic uncertainties (Aastveit et al., 2017; Duan et al., 2021; Elnahass et al., 2021; Wu et al., 2022), but their results may be subject to endogeneity bias as they fail to disentangle the effects of economic uncertainty and those of monetary policy which itself reflects the prevailing uncertainty in the economy. The COVID-19 outbreak and its evolvements are not predictable per se, and literally no economic or financial actions are made in anticipation of these pandemic shocks, thus very clean interpretation of the econometric results can be derived from the pandemic setting (Berger & Demirgüç-Kunt, 2021; Elsayed et al., 2022). In this way, our results offer more robust implications regarding bank responses to monetary policy under macro-level uncertainty.

Lastly, we extend the literature by characterizing bank responses to monetary policy during pandemic uncertainty based on banks' diversification and herding levels as well as interest policy type. We show that the risk-reducing effect of monetary policy is more pronounced among banks with higher levels of diversification and herding amid pandemic uncertainty because these banks seek financial stability by diverting from risky, interest-based businesses. Additionally, we show that banks in countries adopting negative interest rate policies are more willing to assume asset risk to accommodate the intended stimulus of easing monetary policies during the pandemic.

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 explains the empirical methodology. Section 4 reports the empirical results. Section 5 concludes.

2 | LITERATURE REVIEW

This section reviews the literature related to the effects of COVID-19 pandemic uncertainty on monetary policy transmission through bank risk and capital, as well as the literature on the heterogeneous effects of monetary policy on bank risk and capital.

2.1 | Influence of COVID-19 pandemic uncertainty on monetary policy transmission

Monetary policy transmission to the real economy can be channelled through banks' risk and capital adjustments, given the financial intermediation role of banks in an economy. From the perspective of the bank risk channel, Borio and Zhu (2012) are among the first to introduce the view of a risk-taking channel that links the monetary policy transmission with banks' risk pricing. The proposition of the risk-taking channel suggests that an easing monetary policy induces banks' risk-taking incentives to search for yields as lower interest rates slash interest incomes generated from loans and in the meanwhile increase the market values of financial assets (Bonfim & Soares, 2018; Chen et al., 2017; de Moraes & de Mendonça, 2019; Neuenkirch & Nöckel, 2018). The monetary policy-risk-taking view has also been supported by evidence that lower interest rates lead to a flatter yield curve, which affects bank profitability negatively (Borio et al., 2017; Borio & Gambacorta, 2017). Nevertheless, there exists a monetary policy-risk reducing view that suggests that lower interest rates discourage banks from investing in risky activities due to reduced risk premia earned and profitability (Girotti, 2019; López-Penabad et al., 2022; Ngambou Djatche, 2019). As for the bank capital channel, de Moraes et al. (2016) find that monetary policy affects bank capital via the risk-taking channel as increased interest rates lead to greater loan loss provisions by banks, which subsequently requires banks to maintain higher capital adequacy ratios. Besides, Gambacorta and Shin (2018) and Heuvel (2002) argue that monetary policy could influence banks' risk-taking activities via capital channel as the cost of capital determines the lucrativeness of the activities. Similarly, Jiang and Yuan (2022) find that the risk-taking channel of monetary policy is more evident among under-capitalized banks in China due to the presence of more stringent monitoring mechanisms in well-capitalized banks. Clearly, the transmission of monetary policy through bank risk and capital is complex.

Extant evidence regarding the effect of the COVID-19 pandemic on monetary policy transmission through bank risk and capital channels is very limited. Specifically, Nguyen et al. (2022) find evidence of a risk-taking effect of conventional monetary policy (short-term interest rates) during the pandemic in Vietnam due to increased unanticipated non-performing loans and operating costs. Employing short-term interest rates and a dummy variable for negative interest rate policy, Spiegel (2022) finds that U.S. banks increased foreign lending volumes when the home country implemented easing monetary policies during the pandemic. In contrast, Hardy and Zhu (2023) find that the perceived credit risks of banks co-moved with their holdings of sovereign debts, but the implementation of unconventional monetary policies, such as asset purchases programs, helped ease the banks' credit risk exposure during the pandemic. Guo and Tseng (2023) theorize that an expansionary monetary policy in the form of interest rate reductions, implemented during the pandemic, could help reduce borrowers' default probability and thus banks' credit risks, but this is yet to be empirically proven.

Given the mixed influences of the COVID-19 pandemic on monetary policy transmission, two opposite postulations emerge. On the one hand, while the adverse impacts of the pandemic on economic activities, such as consumption, and are widely observed, the pandemic also impairs bank profitability and stability mainly via the credit risk of loan portfolios as borrowers lose employment and incomes (Duan et al., 2021; Elnahass et al., 2021; Hu et al., 2022; Wei & Han, 2021). Out of the pressure to improve or maintain incumbent profit levels, banks are forced to venture into the uncertainty of the pandemic and act on the easing monetary policy by bearing more risks and investing in 'high-risk, high-return' assets (Nguyen et al., 2022). Banks may gamble on chronically weak or zombie firms in the hope of yielding high risk premia in the easing monetary environment, while meanwhile putting themselves at stake. Moreover, the functioning of the bank lending channel of monetary policy during the pandemic may contribute to greater credit risk and higher capitalization in banks (Spiegel, 2022). Hinging on this argument, we develop:

> **Hypothesis 1A.** The monetary policy-risk taking nexus becomes stronger in the presence of pandemic uncertainty.

On the other hand, as the pandemic uncertainty exacerbates pessimism about the economic prospects, the option value of waiting becomes more significant in banks' investment decisions, which dampens the effects of easing monetary policy (Aastveit et al., 2017; Wu et al., 2022). Such effect can also spill over and influence banks in other countries (Spiegel, 2022). The option value of waiting suggests that higher uncertainty induces banks to "wait and see", postpone credit issuances and remain highly capitalized till the market prospect becomes clearer for assessments of investment profitability. Given this reaction by banks, it is unsurprising to observe a range of easing monetary policies and generous government supports introduced during the pandemic. These measures aim to reduce the financing costs for both banks and borrowers, alleviate financial distress among borrowers, mitigate the treatment of non-performing loans in banks, and ultimately reduce overall bank risk. Therefore, we develop an opposing hypothesis as follows:

> **Hypothesis 1B.** The monetary policy-risk reducing nexus becomes stronger in the presence of pandemic uncertainty.

For brevity, we do not hypothesize the relationship between monetary policy and bank capital amid pandemic uncertainty, as bank capital generally changes in the same direction as risk exposure levels, as postulated by de Moraes et al. (2016).

2.2 | Heterogeneous influence of monetary policy on bank risk and capital

Our study focuses on heterogeneities in bank responses to monetary policy changes across bank diversification and herding levels as well as the country's interest policy type, which are underexplored in the pandemic context.

First, extant bank diversification literature has documented mixed evidence pertaining to the performance of low-diversified banks versus high-diversified banks. On the one hand, highly diversified banks have greater buffers against impediments in the conventional interest-based lending and deposit-taking segments, such as interest margin compressions, as non-interest business segments generate other income alternatives (Meslier et al., 2014; Paltrinieri et al., 2021), improved bank stability (Li et al., 2021; Williams & Rajaguru, 2022) and business expansions of banks (Dang, 2020; Dang, 2022; Toh et al., 2020). On the other hand, highly diversified banks can be more susceptible to risks and failures because unconventional activities, such as security trading and asset securitization, are less regulated and monitored by authorities (DeYoung & Torna, 2013; Liang et al., 2020). Given the gloomy investment prospects during the COVID-19 pandemic, how high-diversified banks and low-diversified banks react to an easing monetary policy is unknown a priori as the former can either be more risk-tolerant in pursuing riskier economic activities due to the shield of other income-generating alternatives, or be more risk-averse due to increased market risk exposures in the financial markets. Given the opposing hypotheses 1A and 1B, we formulate:

> **Hypothesis 2A.** The monetary policy-risk taking nexus is more pronounced among highly diversified banks during the pandemic uncertainty.

> **Hypothesis 2B.** The monetary policy-risk reducing nexus is more pronounced among highly diversified banks during the pandemic uncertainty.

Herding in the banking sector is widely observed in an adverse market environment as banks thrive to alleviate the information spillover from adverse news and to increase the likelihood of joint survival (Acharya & Yorulmazer, 2008; Quagliariello, 2009). However, the influence of bank herding on bank stability is inconclusive. Some studies find increased inefficiency in banks' asset allocations and risk accumulation on banks' balance sheets (Ryuichi & Hirofumi, 2011; Wu et al., 2020), while others find bank portfolio restructuring towards safer assets and increased capital reserves (Baum et al., 2009; Toh & Zhang, 2022). Against the backdrop of easing monetary policy in the pandemic, it is possible that banks herd towards investments in the real economy in response to the policy's call, or herd towards self-protection due to the lower interest earned and gloomy investment prospects. The influence of bank herding on the risk and capital responses of banks to monetary policy amid pandemic uncertainty has not yet been addressed in the literature.

> **Hypothesis 3A.** The monetary policy-risk taking nexus is more pronounced among banks with greater herding behaviour during the pandemic uncertainty.

> **Hypothesis 3B.** The monetary policy-risk reducing nexus is more pronounced among banks with greater herding behaviour during the pandemic uncertainty.

Third, whether negative interest rate policy improves or aggravates banks' financial soundness during the pandemic is unclear a priori. On the one hand, negative interest rates benefit banks in terms of lower debt

TABLE 1 Variable definitions.

Variable	Measurement	Data source
Bank risk (*RISK*)		
RWAR	*Ex-ante* risk: Risk-weighted assets as a percentage of total assets	Fitch Solutions, Inc. (2022)
LOANLOSS	*Ex-ante* risk: Loan loss allowances as a percentage of gross loans	Fitch Solutions, Inc. (2022)
NPL	*Ex-post* risk: Non-performing loans as a percentage of gross loans	Fitch Solutions, Inc. (2022)
Bank capital (*CAPITAL*)		
CAP	Total regulatory capital as a percentage of risk-weighted assets	Fitch Solutions, Inc. (2022)
EQUITY	Equity capital as a percentage of total assets	Fitch Solutions, Inc. (2022)
Monetary policy		
MP	Average overnight interbank interest rate in a quarter	Refinitiv (2022)
MPalternative	Average monetary policy rate in a quarter	Refinitiv (2022)
NEG_INT	A dummy variable taking the value of 1 if the country is in a negative interest environment, 0 otherwise	–
QE	Quantitative easing: Total Treasury securities, agency securities, and mortgage-backed securities held as a percentage of total assets on a central bank's balance sheet	Central banks' balance sheets
Pandemic uncertainty		
PANDUNC	The percentage of the words related to pandemic episodes in EIU country reports, multiplied by 1000	Ahir et al. (2018)
UNC	The percentage of the word "uncertain", and its variants, that appear near the pandemic terms in EIU country reports, multiplied by 1000	Ahir et al. (2018)
NCASE	Standard deviation of daily new COVID-19 cases in a quarter	Ritchie et al. (2020)
NDEATH	Standard deviation of daily new COVID-19 deaths in a quarter	Ritchie et al. (2020)
Control variables		
SIZE	Natural log of total assets of a bank	Fitch Solutions, Inc. (2022)
ROAA	Net income as a percentage of average total assets of a bank	Fitch Solutions, Inc. (2022)
LIQ	Liquid assets as a percentage of total assets of a bank	Fitch Solutions, Inc. (2022)
LG	Growth of gross loans of a bank in percentage	Fitch Solutions, Inc. (2022)
GDP	Real GDP rate of a country in percentage	Refinitiv (2022)
INFLATION	Inflation rate of a country in percentage	Refinitiv (2022)
EPU	Economic policy uncertainty index of a country	Baker et al. (2016)
ECOSUPPORT	Economic support index by governments in the COVID-19 period	Hale et al. (2021)

financing costs, and encourage them to readjust capital structure towards short-term deposits for financing of longer-term investments delivering higher returns, including zombie lending (Acharya et al., 2019). This subsequently causes banks to be poorly capitalized. In the medium term, banks also tend to demonstrate higher asset portfolio risks and delay balance sheet repairs as negative interest rates allow for an ever-greening of non-performing loans (Lambert & Ueda, 2014). On the other hand, negative interest rates may hurt bank profitability as they reduce risk premia charged by banks on asset investments. As a result, banks are reluctant to take extra leverage and risk (BIS, 2019; Borio & Zhu, 2012). Following the aforementioned opposing views, banks operating in a negative interest rate environment may either expand risk tolerance and invest in risk-accompanying real-economic activities, or reduce risk appetite as interest rates are further slashed during the pandemic. Accordingly, we hypothesize that:

Hypothesis 4A. The monetary policy-risk taking nexus is more pronounced in countries adopting negative interest rates during the pandemic uncertainty.

Hypothesis 4B. The monetary policy-risk reducing nexus is more pronounced in countries adopting negative interest rates during the pandemic uncertainty.

3 | DATA AND METHODOLOGY

3.1 | Data

The study period runs from 2018 Q1 to 2021 Q4, comprising eight quarters before and after the COVID-19 outbreak on 31st December 2019. Bank sample is from the 12 major economies, specifically Brazil, China, Canada, France, Germany, India, Italy, Japan, Russia, South Korea, U.K. and U.S., and is summarized in Table A1. To eliminate bank outliers, we trim each bank variable at the top and bottom 1%. We require each bank to have at least two consecutive observations in the periods before and after the pandemic outbreak. The sampling process leaves about 11,022 bank-quarter observations corresponding to 783 banks. All data sources used by this study are listed in Table 1.

3.2 | Empirical framework

To investigate the simultaneous effects of monetary policy on banks' risk and capital amid pandemic uncertainty, we estimate a simultaneous equations model with a partial adjustment (SEM-PAR) for bank risk and capital based on the scheme below.

$$\Delta RISK_{i,t} = \alpha(RISK^*{}_{i,t} - RISK_{i,t-1}), \tag{1a}$$

$$\Delta CAPITAL_{i,t} = \beta(CAPITAL^*{}_{i,t} - CAPITAL_{i,t-1}), \tag{1b}$$

where $\Delta RISK_{i,t}$ ($\Delta CAPITAL_{i,t}$) is the observed risk (capital) adjustment level of bank i in the current quarter t, specified as a function of a risk (capital) adjustment to the current target $RISK^*{}_{i,t}$ ($CAPITAL^*{}_{i,t}$) level from the past observed $RISK_{i,t-1}$ ($CAPITAL_{i,t-1}$) level; α and β are the adjustment parameters. Under the SEM-PAR framework, α $(\beta)=1$ implies an instantaneous risk (capital) adjustment since the actual risk (capital) level equals the target risk (capital) level. On the contrary, α $(\beta)=0$ implies no risk (capital) adjustment since the actual risk (capital) level remains unchanged from the past level. Typically, α and β lie between 0 and 1 as the adjustments of risk and capital are likely to be partial due to high adjustment costs (Jokipii & Milne, 2011; Shrieves & Dahl, 1992). The target risk and capital levels ($RISK^*{}_{i,t}$ and $CAPITAL^*{}_{i,t}$) are set internally by banks, and thus are assumedly determined by a vector of explanatory variables, as follows:

$$\begin{aligned} RISK^*_{i,t} = {} & \alpha_0 + \alpha_1 MP_{c,t} + \alpha_2 PANDUNC_{c,t} + \alpha_3 MP_{c,t} \\ & *PANDUNC_{c,t} + \alpha_4 SIZE_{i,t} + \alpha_5 ROAA_{i,t} \\ & + \alpha_6 LIQ_{i,t} + \alpha_7 LG_{i,t} + \alpha_8 GDP_{c,t} \\ & + \alpha_9 INFLATION_{c,t} + \alpha_{10} EPU_{c,t} \\ & + \alpha_{11} ECOSUPPORT_{c,t} + \alpha_{12} NEG\_INT_{c,t} \\ & + \alpha_{13} \Delta CAPITAL_{i,t}, \end{aligned} \tag{2a}$$

$$\begin{aligned} CAPITAL^*_{i,t} = {} & \beta_0 + \beta_1 MP_{c,t} + \beta_2 PANDUNC_{c,t} \\ & + \beta_3 MP_{c,t} * PANDUNC_{c,t} + \beta_4 SIZE_{i,t} \\ & + \beta_5 ROAA_{i,t} + \beta_6 LIQ_{i,t} + \beta_7 LG_{i,t} \\ & + \beta_8 GDP_{c,t} + \beta_9 INFLATION_{c,t} \\ & + \beta_{10} EPU_{c,t} + \beta_{11} ECOSUPPORT_{c,t} \\ & + \beta_{12} NEG\_INT_{c,t} + \beta_{13} \Delta RISK_{i,t}. \end{aligned} \tag{2b}$$

The variables included in our SEM-PAR framework are explained below.

Bank risk (*RISK*) represents the proportion of risky assets in the bank's portfolio. We adopt risk-weighted asset ratio (*RWAR*) as the primary measure because *RWAR* is a better *ex ante* measure of asset portfolio risk from a prudential regulatory viewpoint (Jokipii & Milne, 2011). To ensure the result robustness, we employ another *ex-ante* risk measure, that is, loan loss allowances as a proportion of gross loans (*LOANLOSS*). Unlike *RWAR*, this measure focuses only on loan portfolios of banks and reflects banks' risk perception via deliberate altering of loan loss allowances, and such an action is usually not taken at the expense of capital adequacy ratio (de Moraes et al., 2016). Further, nonperforming loan ratio (*NPL*) is adopted to capture information on the loan default risk borne by banks, which is not captured by *RWAR*. *NPL* is an *ex post* risk measure associated with bank loan portfolios only (Yaman et al., 2018).

Bank capital (*CAPITAL*) is proxied by capital adequacy ratio (*CAP*). This is a risk-based capital ratio computed by total Tiers 1 and 2 regulatory capitals in relation to risk-weighted assets. We also adopt an alternative capital measure, equity-to-assets ratio (*EQUITY*), which is a non-risk-based capital ratio, and as such it should not be seen as a trade-off against bank portfolio risk.

Monetary policies (*MP*) employed by central banks in the pandemic are diverse, including cutting policy rates, keeping policy rates to the zero-lower bound, managing market expectation actively, quantitative easing, and introducing schemes to facilitate bank lending (Wei & Han, 2021). Some of these policies are unconventional, and unadjusted or unavailable over quarters, making them difficult to be quantified.[1] Instead, many banking studies merely introduce a dummy variable for the pandemic period to broadly control for fiscal and monetary policy changes in a country (Demir & Danisman, 2021; Elnahass et al., 2021; Li et al., 2021; Neef & Schandlbauer, 2021). Thus, we resort to the interest-based instruments, specifically overnight interbank interest rates (*MP*) and monetary policy rates (*MPalternative*), as a "barometer" of monetary policy stance in a country. Overnight interbank interest rates are more commonly used in extant literature as they provide consistent information about monetary policy stance and are allowed to enter the negative zone when an unconventional monetary policy is adopted (Chen et al., 2017; Dang & Huynh, 2022; de Moraes & de Mendonça, 2019; Ngambou Djatche, 2019). As an alternative monetary policy measure, we use quantitative easing (*QE*) to gauge the size of central banks' balance sheets in influencing the money supply in countries (Lyu et al., 2024). *QE* is measured by the proportion of Treasury securities, agency securities, and mortgage-backed securities held relative to total assets on central banks' balance sheets. Unlike *MP* and *MPalternative*, a higher *QE* value indicates a looser monetary policy.

Acknowledging the limitation of interest rates as a proxy for monetary policy stance in countries adopting negative interest policies, we also follow the practices of Spiegel (2022), López-Penabad et al. (2022) and Yilmazkuday (2022) by including a dummy variable (*NEG_INT*) for countries which are in a negative interest environment (France, Germany, Italy and Japan). Daily interest rates of countries are obtained from Thompson Reuters' DataStream database and averaged to the quarterly frequency.

Pandemic uncertainty (*PANDUNC*) remains prevalent in many countries more than 2 years since the COVID-19 outbreak, adding complexities to predictions of risks and returns and hindering private investments. This study borrows index-based pandemic uncertainty data from Ahir et al. (2018) who construct indices based on the frequency of the word "pandemic" in the Economist Intelligence Unit (EIU) reports for 143 countries on a quarterly basis. A higher *PANDUNC* index suggests more discussions about pandemic by the country in the quarter, thus a greater pandemic uncertainty is implied. Additionally, three alternative *PANDUNC* measures are employed for robustness checks, specifically (i) the indices constructed by Ahir et al. (2018) based on the word count for "uncertain" and its variants that appear near the pandemic terms in EIU country reports (*UNC*), (ii) the standard deviation of daily new COVID-19 cases (*NCASE*), and (iii) the standard deviation of daily new COVID-19 deaths (*NDEATH*) of a country during a quarter. In light of our study interest, an interactive term between *MP* and *PANDUNC* is included as a key explanatory variable to investigate if pandemic uncertainty alters banks' risk and capital responses to monetary policy stance.

Bank size (*SIZE*) is measured by the natural log of a bank's total assets in a quarter. The effects of bank size on bank risk and capital are mixed. Some studies find that the comparative advantages in advanced technology adoption, extensive branch networks and capital resources allow large banks to better collect information, scrutinize customers and manage risks (Berger et al., 2005; Berger & Black, 2011). In contrast, some studies find that large banks have greater risk appetites due to the likely government bailouts in the case of failure, in consonance with the "too big to fail" philosophy (Keeley, 1990; Soedarmono et al., 2011). Small banks, on the other hand, behave more conservatively and thus are more financially solvent.

Bank profitability (*ROAA*) is measured by a bank's net income in relation to its average assets in a quarter. As income reserve constitutes a core equity, an increase in *ROAA* may render a higher capital ratio. However, whether or not a highly profitable bank is riskier is unclear as the bank may either have less incentive to undertake risky investments at the expense of franchise value or have greater risk tolerance to pursue risky yet lucrative investments (Toh & Zhang, 2022; Wu et al., 2020).

Bank liquidity (*LIQ*) is measured by liquid assets as a percentage of total assets of a bank in a quarter. Prior studies, including Goodell et al. (2021), have reported that banks resort to liquidity hoarding amid uncertainty to build capital buffers for risk absorption purpose, thus a positive relationship between *LIQ* and bank capital ratio is expected. Likewise, as increased liquidity stocks crowd out long-term, riskier assets on banks' balance sheets, a negative relationship between *LIQ* and bank portfolio risk is expected.

Loan growth (*LG*) is controlled to capture the change in bank lending during the pandemic of which the effect is transmitted to bank risk and capital. *LG* is a quantity-based loan measure which does not reflect the quality of loan issuances. If a majority of new loan issuances is of poor quality, then a higher portfolio risk is expected, or vice versa. Coupled with the funding stress in the pandemic, banks that expand loan business may encounter difficulty in raising capital efficiently to absorb risks associated with new loan issuances, thus their capital adequacy ratios may shrink.

Economic growth (GDP) is measured by the quarterly real GDP growth rate of a country to control for the cyclicality effect of economic growth on bank operation. Banks that demonstrate pro-cyclical investment activities tend to possess riskier asset portfolios and lower capital ratios when the economy grows as the perceived favourable economic prospects motivate banks to compress capital buffers and leverage investments for yields (Borio & Zhu, 2012; Valencia, 2016). On the contrary, banks that demonstrate counter-cyclical investment behaviours tend to build more capital buffers and moderate risky investments when economy grows to avoid risk accumulation on their balance sheets, which may deteriorate into *ex-post* losses when the economy deteriorates later (Stolz & Wedow, 2011; Valencia & Bolaños, 2018). Given the conflicting effects of economic growth on bank stability, some studies have also found inconclusive evidence (Toh & Zhang, 2022).

Inflation (*INFLATION*) rate has fallen in most countries during the first few months of the pandemic period before taking sharp upswings fuelled by a confluence of government stimulus policies and disruptions of supply chains in most industries (Forbes et al., 2021). Pandemic inflation is expected to affect the net worth of assets adversely and drive the risk embedded in bank asset portfolios consequently.

Economic uncertainty induced by policy changes (*EPU*) is another widely observed economic phenomenon during the pandemic. It has been found to negatively affect private investments and consumptions (Chen et al., 2019; Goodell et al., 2021), stock returns (Chiang, 2022) and bank stability (Berger & Demirgüç-Kunt, 2021; Phan et al., 2021) as increased uncertainty makes the assessments of risks and returns less accurate for informed decision making. *EPU* data is obtained from Baker et al. (2016) who construct an *EPU* index based on the volume of news articles discussing economic policy uncertainty. The index is updated for countries on a monthly basis and thus is averaged to the quarterly frequency before use.

Economic support from governments (*ECOSUPPORT*), such as income support and debt relief, was provided during the pandemic to alleviate the pandemic shocks to private sectors and financial systems. While the government policy responses have been found to be effective in mitigating financial market uncertainty and stock price reactions in the pandemic (Deev & Plíhal, 2022; Demir & Danisman, 2021), how bank risk is affected remains unknown as government support can be a two-edged sword. On one hand, government support reduces loan default risks of banks and boosts economic growth by providing financial reliefs to borrowers (Bitar & Tarazi, 2022). On the other hand, it triggers the moral hazard incentives of low credit-quality borrowers, leading to higher portfolio risk in banks. *ECOSUPPORT* is a composite score of indicators related to income support, and debt or contract relief provided by governments during COVID-19 pandemic (Hale et al., 2021). The score varies from 0 to 100.

Finally, to account for simultaneous risk and capital adjustments, Δ*CAPITAL* is included as an endogenous factor in the *RISK** equation, and Δ*RISK* is included as an endogenous factor in the *CAPITAL** equation. Substituting Equations (2a) and (2b) into Equations (1a) and (1b) yields:

$$\begin{aligned}\Delta RISK_{i,t} = {} & \alpha_0 + \alpha_1 MP_{c,t} + \alpha_2 PANDUNC_{c,t} + \alpha_3 MP_{c,t} \\ & * PANDUNC_{c,t} + \alpha_4 SIZE_{i,t} + \alpha_5 ROAA_{i,t} \\ & + \alpha_6 LIQ_{i,t} + \alpha_7 LG_{i,t} + \alpha_8 GDP_{c,t} \\ & + \alpha_9 INFLATION_{c,t} + \alpha_{10} EPU_{c,t} \\ & + \alpha_{11} ECOSUPPORT_{c,t} + \alpha_{12} NEG\_INT_{c,t} \\ & + \alpha_{13} \Delta CAPITAL_{i,t} - \alpha_{14} RISK_{i,t-1} + \varphi_{i,t}\end{aligned} \tag{3a}$$

$$\begin{aligned}\Delta CAPITAL_{i,t} = {} & \beta_0 + \beta_1 MP_{c,t} + \beta_2 PANDUNC_{c,t} \\ & + \beta_3 MP_{c,t} * PANDUNC_{c,t} + \beta_4 SIZE_{i,t} \\ & + \beta_5 ROAA_{i,t} + \beta_6 LIQ_{i,t} + \beta_7 LG_{i,t} \\ & + \beta_8 GDP_{c,t} + \beta_9 INFLATION_{c,t} \\ & + \beta_{10} EPU_{c,t} + \beta_{11} ECOSUPPORT_{c,t} \\ & + \beta_{12} NEG\_INT_{c,t} + \beta_{13} \Delta RISK_{i,t} \\ & - \beta_{14} CAPITAL_{i,t-1} + \varepsilon_{i,t}\end{aligned} \tag{3b}$$

We estimate the SEM-PAR framework by using 3SLS estimator which uses an instrumental-variables approach to produce consistent estimates and generalized least squares (GLS) to account for the correlation structure in the disturbances across the equations. Because Δ*RISK* and Δ*CAPITAL* are an explanatory variable of each other in the system of equations, the disturbance terms, φ and

TABLE 2 Summary statistics.

Variable	Mean	S.D.	25th	75th	Unit root *t* stats
RWAR	66.97	27.64	49.09	79.19	−10.23***
LOANLOSS	1.95	3.28	0.46	2.20	−20.37***
NPL	2.27	4.49	0.46	2.20	−20.81***
CAP	18.11	15.03	12.57	18.67	−52.40***
EQUITY	9.68	4.07	6.79	12.73	−30.05***
MP	2.06	2.36	0.16	2.67	−15.45***
MPalternative	2.03	2.39	0.25	2.50	−10.82***
PANDUNC	133.52	142.14	0.00	234.83	−16.76***
UNC	4.96	11.73	0.00	4.73	−19.65***
NCASE	38.89	79.35	0.00	35.59	21.79
NDEATH	0.63	1.08	0.00	0.96	−14.17***
SIZE	8.15	2.91	5.64	10.48	−171.57***
ROAA	1.27	2.52	0.40	1.41	−24.76***
LIQ	14.17	12.52	6.16	18.94	−9.71***
LG	10.88	35.37	1.85	10.98	−128.11***
GDP	0.70	6.38	1.31	1.83	−68.75***
INFLATION	0.65	0.77	0.24	1.08	−6.83***
EPU	230.16	115.10	145.24	304.11	−10.98***
ECOSUPPORT	25.46	32.00	0.00	55.22	−4.94***
NEG_INT	0.18	0.38	0.00	0.00	n/a
QE	68.77	33.34	44.19	92.19	−13.48***

Note: The unit root test's estimate is based on Levin et al.'s (2002) test under the null hypothesis of a unit root. A rejection of the null hypothesis implies that the variable series is stationary. *** denotes statistical significance at the 1% level. All variables are defined in Table 1.
Source: Authors' computation.

ε, among the equations are expected to be correlated. Furthermore, $RISK_{i,t-1}$ and $CAPITAL_{i,t-1}$ may be correlated with the disturbance terms of the equations due to intertemporal effects of bank risk and capital. Thus, we treat $\Delta RISK$, $\Delta CAPITAL$, $RISK_{i,t-1}$ and $CAPITAL_{i,t-1}$ as endogenous variables in the system, while the lagged values of all other explanatory variables are treated as instruments for the endogenous variables. We also perform a test of over-identifying restrictions based on Hansen's *J* statistic to ensure the validity (exogeneity) of the instruments.[2]

Time- and country-fixed effects are also controlled in the estimations to alleviate possible endogeneity issue induced by omitted variables. The definitions and summary statistics of variables used in this study are presented in Table 1 and Table 2, respectively. Also shown in Table 2 is the results of the Levin et al. (2002)'s unit root test. The data series of all variables used in our main estimations are stationary. *NCASE* is not stationary, which is not of a major concern because *NCASE* is used as an alternative proxy for pandemic uncertainty, among others, in the robustness tests. We report the correlations of key variables in Table A2, where we show low to moderate correlations between the variables. The highest correlation is between *ECOSUPPORT* and *PANDUNC*, with a correlation coefficient of 0.776, which is consistent with the stylized fact that a succession of economic support packages was introduced by governments during the pandemic to relieve the financial distress of private sectors.

4 | EMPIRICAL RESULTS

4.1 | Descriptive statistics

Table 3 shows the mean differences of key variables before and after the COVID-19 outbreak. As shown in Panel A, banks in most countries make negative risk adjustments ($\Delta RWAR$) after the pandemic outbreak, with statistically significant differences observed in Japan, South Korea, U.S. and U.K. In Panel B, no significant changes in banks' capital adjustments (ΔCAP) are observed across countries after the pandemic outbreak,

TABLE 3 Summary statistics of key variables by sample countries.

Country	Panel A: Mean of Δ*RWAR*			Panel B: Mean of Δ*CAP*			Panel C: Mean of *MP*			Panel D: Mean of *PANDUNC*		
	Pre-COVID (2018Q1–2019Q4)	Post-COVID (2020Q1–2021Q4)	*t* test of mean difference	Pre-COVID (2018Q1–2019Q4)	Post-COVID (2020Q1–2021Q4)	*t* test of mean difference	Pre-COVID (2018Q1–2019Q4)	Post-COVID (2020Q1–2021Q4)	*t* test of mean difference	Pre-COVID (2018Q1–2019Q4)	Post-COVID (2020Q1–2021Q4)	*t* test of mean difference
Brazil	0.034	−0.087	−0.196	0.037	0.084	0.221	6.214	2.956	−39.839***	0.000	291.469	54.917***
Canada	−0.007	−0.220	−0.501	0.232	0.674	0.748	1.588	0.270	−70.130***	0.000	280.126	51.140***
China	0.670	−0.827	−1.572	0.098	−0.033	−2.304**	2.600	1.930	−21.322***	0.000	343.681	34.697***
France	−0.089	−0.291	−0.899	0.371	−1.015	−0.982	−0.368	−0.424	−3.156***	0.000	241.066	36.870***
India	−0.592	2.120	0.876	0.136	0.313	0.816	5.974	4.040	−49.501***	0.000	267.172	48.880***
Italy	−0.282	−0.549	−0.538	−0.474	−0.008	1.172	−0.339	−0.479	−19.303***	0.000	283.766	52.026***
Japan	0.131	−0.646	−4.544***	0.159	0.017	−0.830	−0.005	0.017	34.648***	0.000	310.182	120.00***
South Korea	−0.021	−1.445	−4.874***	0.675	−0.721	−1.615	1.555	0.647	−28.421***	0.000	277.938	31.370***
Russia	0.215	−0.791	−0.784	−0.117	0.384	0.754	7.458	5.393	−56.897***	0.000	230.652	120.00***
U.S.	0.127	−1.044	−8.393***	−0.135	0.005	1.987**	2.319	0.411	−182.778***	0.000	234.866	200.00***
U.K.	−0.016	−0.405	−1.893*	0.337	0.150	−0.213	0.630	0.117	−20.291***	0.000	267.358	36.692***
Germany	−0.435	0.029	0.726	−0.325	0.975	0.783	−0.384	−0.504	−10.300***	0.000	251.843	22.390***

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' computation.

TABLE 4 Main estimation results.

Dependent variable	Panel A ΔRWAR	Panel A ΔCAP	Panel B ΔRWAR	Panel B ΔCAP	Panel C ΔRWAR	Panel C ΔCAP
Explanatory variable						
MP	1.015*** (3.841)	0.136** (2.246)				
MPalternative			0.747*** (2.764)	0.120* (1.958)		
QE					−0.057 (−1.499)	−0.012*** (−2.911)
PANDUNC	0.004 (1.437)	−0.002 (−1.550)	0.003 (1.320)	−0.003* (−1.893)	0.011*** (3.124)	−0.002 (−1.426)
*MP*PANDUNC*	0.002*** (2.721)	−0.000 (−0.936)				
*MPalternative*PANDUNC*			0.002* (1.959)	−0.000 (−0.070)		
*QE*PANDUNC*					−0.000*** (−3.293)	0.000 (0.650)
SIZE	−0.044 (−0.570)	−0.106** (−2.407)	−0.046 (−0.591)	−0.108** (−2.399)	−0.034 (−0.448)	−0.151*** (−3.102)
ROAA	0.960*** (9.154)	−0.023 (−0.722)	0.953*** (9.161)	−0.022 (−0.697)	0.949*** (9.211)	−0.018 (−0.550)
LIQ	−0.230*** (−10.333)	0.035*** (4.341)	−0.228*** (−10.337)	0.035*** (4.361)	−0.226*** (−10.331)	0.040*** (4.827)
LG	−0.009* (−1.871)	0.000 (0.199)	−0.010** (−1.973)	0.000 (0.202)	−0.009* (−1.859)	0.001 (0.439)
GDP	0.271*** (8.723)	−0.097*** (−6.539)	0.254*** (8.304)	−0.089*** (−6.006)	0.239*** (8.144)	−0.090*** (−6.072)
INFLATION	0.393 (1.195)	−0.324** (−2.203)	0.220 (0.690)	−0.272* (−1.884)	0.067 (0.228)	−0.192 (−1.368)
EPU	−0.004 (−1.188)	0.002 (1.272)	−0.001 (−0.347)	0.001 (1.063)	−0.005* (−1.877)	0.001 (0.785)
ECOSUPPORT	−0.030*** (−3.112)	−0.001 (−0.231)	−0.035*** (−3.662)	0.006 (0.939)	−0.032*** (−3.454)	0.008 (1.430)
NEG_INT	4.320 (1.478)	−0.121 (−0.434)	2.485 (0.860)	−0.231 (−0.839)	−7.188** (−2.100)	−0.614** (−2.303)
Δ*CAP*	2.087*** (18.009)		2.070*** (17.719)		2.036*** (17.678)	
l.RWAR	0.368*** (9.689)		0.363*** (9.650)		−0.355*** (−9.587)	
Δ*RWAR*		0.256*** (12.460)		0.258*** (12.652)		0.262*** (12.722)
l.CAP		0.071** (2.430)		0.072** (2.391)		−0.102*** (−3.141)
Constant	20.092*** (5.810)	1.295** (2.068)	20.820*** (5.925)	1.455** (2.253)	32.258*** (6.540)	3.490*** (3.339)
χ^2	595.20***	209.70***	583.02***	215.41***	586.69***	228.52***
Hansen *J*-stat (*p* value)	13.14 (0.110)	9.564 (0.297)	12.478 (0.131)	13.770 (0.131)	12.509 (0.130)	19.792** (0.011)
N	9373	9373	9373	9373	9373	9373

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) wherein the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively. The monetary policy proxies used in Panels A, B and C are overnight interbank market interest rates (*MP*), monetary policy rates (*MPalternative*) and quantitative easing (*QE*), respectively. All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated *z*-statistics is in parenthesis. The result of Hansen *J*-statistic indicates that the instruments are valid for the specified endogenous variables, except for the Δ*CAP* model in Panel C. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

except for China and U.S. that show substantial negative and positive capital adjustments, respectively. In Panel C, the negative *t*-statistics of mean differences of overnight interbank interest rates (*MP*) in most countries indicate easing monetary policy stances during the pandemic. The significant *t* statistics of mean differences of pandemic uncertainty index (*PANDUNC*) in Panel D affirm that the pandemic uncertainty facing all countries since the early 2020 was induced by COVID-19.

4.2 | Main results

The estimation results of Equations (3a) and (3b) are presented in Table 4, with Panels A, B and C dedicated to overnight interbank interest rates (*MP*), monetary policy rates (*MPalternative*) and quantitative easing (*QE*), respectively. We employ Δ*RWAR* and Δ*CAP* as the primary risk and capital adjustment indicators.

Based on the estimation of Δ*RWAR* models, we first notice that the coefficients on *MP* and *MPalternative* are positive and statistically significant, suggesting that an easing of the conventional monetary policy stance through interest rate adjustments reduces *ex ante* portfolio risk of banks, or vice versa. The estimate of *QE*, however, is insignificant, indicating that quantitative easing does not significantly influence bank risk in the absence of pandemic uncertainty. Switching to the simultaneous estimation results for Δ*CAP* models, the coefficients of *MP* and *MPalternative* are found to be positive and statistically significant, aligning with the significantly negative coefficient of *QE*. This provides evidence that bank capital channel of monetary policy matters. These results appear to support the results of Altunbas et al. (2012), Gambacorta and Shin (2018), and Heuvel (2002) that decreased interest rates reduce the debt financing costs of private sectors, which subsequently reduces the credit risk of existing loan portfolios of banks. Meanwhile, decreased interest rates diminish banks' interest income, thereby discouraging them from seeking higher yields and undertaking risky loan transactions (Wu et al., 2022). Consequently, banks readjust their capital structure towards minimal earnings and reserve retention to align with lower portfolio risk and to reduce the cost of capital. This result is consistent with the finding of de Moraes et al. (2016) that monetary policy affects bank capital through the bank-risk channel.

The coefficient of *PANDUNC* is mostly insignificant in the Δ*RWAR* models and in the Δ*CAP* models. A plausible explanation is that the pandemic period was not the best time to adjust portfolio risks and capital reserves. Although the pandemic increased the financial frictions facing banks, banks were incentivized by governments and central banks through a series of financial relief schemes aimed at relieving the financial constraints of borrowers and moderating monetary circulation in the economy (Bitar & Tarazi, 2022). Likewise, the use of macroprudential policies, such as credit growth limits, reserve requirements, and dynamic provisioning in banking, reduced investors' perceived risks of banks (Igan et al., 2023). Facilitated by the wide-ranging supportive policies, banks generally maintained their risk and capital adjustments at pre-pandemic levels.

More importantly, we find that the coefficients of *MP*PANDUNC* and *MPalternative*PANDUNC* in the Δ*RWAR* models are positive and significant, while the coefficient of *QE*PANDUNC* is significantly negative. This result supports Hypothesis 1B and indicates a more pronounced effect of easing monetary policy (lower interest rates and increased quantitative easing) on the downward risk adjustments of banks amid heightened pandemic uncertainty. In line with the argument made regarding the impact of *MP*, in the presence of the unpredictable contagiousness and fatality of COVID-19, an easing of monetary policy dampens the profitability and the "search for yield" incentive of banks. This accentuates the risk-reducing effect of monetary policy on banks. The insignificant estimates of *MP*PANDUNC*, *MPalternative*-PANDUNC*, and *QE*PANDUNC* in the Δ*CAP* models suggest that banks face a capital squeeze as the pandemic period is not the best time to reduce or hoard capital.

Turning attention to control variables, we note that the negative coefficient on *SIZE* is statistically insignificant in the Δ*RWAR* models but significant in the Δ*CAP* models. The result seemingly supports the findings of Berger et al. (2005) and Berger and Black (2011) that larger banks are better equipped with customer screening and monitoring technologies that help them reduce the risks of loans portfolios and thus the required capital charges. Knowing that they are likely to be bailed out in a distress, larger banks also have an incentive to maintain lower capital ratios provided that they meet the minimum regulatory capital requirement. Further, we note that the coefficient on *ROAA* is positive and statistically significant in the Δ*RWAR* models but insignificant in the Δ*CAP* models, which suggests that highly profitable banks are likely to accept riskier portfolios without having to make substantial restructuring of their incumbent capital portfolios. Further, the coefficient of *LIQ* is significantly negative in the Δ*RWAR* model and significantly positive in the Δ*CAP* model, which collectively implies that highly liquid banks are more stable as they demonstrate lower portfolio risk levels and higher capital ratios. Interestingly, the coefficient on *LG* is negative and significant in the Δ*RWAR* models, suggesting that an increase in loan growth may not always render a substantial increase in bank portfolio risks if newly extended loans are of high quality and/or if borrowers are relieved by financial aids and loan moratoriums during the pandemic to a certain extent.

Moreover, economic growth (*GDP*) is positively related to risk adjustments and negatively related to capital adjustments by banks, suggesting a pro-cyclicality of banks' investments as banks expand riskier portfolios and compress capital buffers in an economic upturn (Valencia, 2016). Banks respond to rising inflation by scaling down capital buffers, plausibly due to the discouraging business environment. We further note that economic policy uncertainty (*EPU*) does not influence banks' risk and capital adjustments significantly. However, economic support from governments (*ECOSUPPORT*) shows efficacy in driving bank portfolio risks downwards as financial aids and loan moratoriums promoted by governments help relieve the financial burdens of borrowers during the pandemic. This result is evidenced by the negative and significant coefficient on *ECOSUPPORT* in the $\Delta RWAR$ model, which supports the finding of Bitar and Tarazi (2022). The insignificant estimate on *NEG_INT* indicates that a negative interest-rate environment does not play a significant role in the risk and capital adjustment decisions of banks.

Taking together the significant coefficient on ΔCAP (and $\Delta RWAR$) in the $\Delta RWAR$ (and ΔCAP) models, we find that banks indeed consider capital buffers (and portfolio risk) simultaneously when making risk (capital) adjustment decisions, supporting the finding by Mateev et al. (2021) for banks in MENA region. Finally, the coefficient on *l.RWAR* in the $\Delta RWAR$ models and the coefficient on *l.CAP* in the ΔCAP models lie within the [0, 1] interval, affirming that banks always adjust risk and capital levels towards the target levels and that the adjustments are partial.

4.3 | Channel tests

To affirm our earlier argument that lower interest rates diminish banks' interest income and discourage them from seeking yields, which subsequently leads to lower risk exposures by banks, we test for the presence of "bank profitability" and "search for yield" channels. Bank profitability (*NIM*) is captured using the ratio of net interest income to total earning assets. Whereas, the "search for yield" (*SFY*) incentive of a bank is measured by the year-to-year change in the bank's quarterly *ROAA* since a growth of *ROAA* over the past four quarters implies stronger motives for yield search (Wu et al., 2022).

To investigate the channels, we develop a system of simultaneous equations wherein Equation (4a) establishes the link between *MP* and *NIM* (*SFY*), while in Equation (4b), *NIM* (*SFY*) is included as an explanatory variable of risk adjustment ($\Delta RWAR$). All the explanatory variables in Equations (3a) and (3b) are retained in Equations (4a) and (4b), except for *ROAA*, which is excluded due to a high correlation with *NIM* and *SFY*. The coefficient α_1 of *MP* in Equation (4a) captures the effect of *MP* on *NIM* (*SFY*) during a normal period, whereas the coefficient α_3 of the interaction term *MP*PANDUNC* captures the effect of a shift from a normal period to a pandemic period on the relationship between *MP* and *NIM* (*SFY*). Thus, if the sum of the coefficient estimates of *MP* and *MP*PANDUNC* (α_1+α_3) is significantly positive, then a positive effect of monetary interest rates on banks' profitability (or incentives to search for yields) is observed during the pandemic uncertainty.[3] Meanwhile, if the estimated β_1 of *NIM* (*SFY*) in Equation (4b) is significantly positive, then we can conclude the existence of the *NIM* (*SFY*) channel through which interest rates positively influence banks' risk adjustments during both normal and pandemic periods.

$$\begin{aligned} NIM_{i,t}(SFY_{i,t}) = {} & \alpha_0 + \alpha_1 MP_{c,t} + \alpha_2 PANDUNC_{c,t} \\ & + \alpha_3 MP_{c,t} * PANDUNC_{c,t} \\ & + \alpha_4 SIZE_{i,t} + \alpha_5 LIQ_{i,t} \\ & + \alpha_6 LG_{i,t} + \alpha_7 GDP_{c,t} \\ & + \alpha_8 INFLATION_{c,t} + \alpha_9 EPU_{c,t} \\ & + \alpha_{10} ECOSUPPORT_{c,t} \\ & + \alpha_{11} NEG\_INT_{c,t} + \varepsilon_{i,t}, \end{aligned} \tag{4a}$$

$$\begin{aligned} \Delta RISK_{i,t} = {} & \beta_0 + \beta_1 NIM_{i,t}(SFY_{i,t}) + \beta_2 MP_{c,t} \\ & + \beta_3 PANDUNC_{c,t} + \beta_4 MP_{c,t} * PANDUNC_{c,t} \\ & + \beta_5 SIZE_{i,t} + \beta_6 LIQ_{i,t} + \beta_7 LG_{i,t} \\ & + \beta_8 GDP_{c,t} + \beta_9 INFLATION_{c,t} \\ & + \beta_{10} EPU_{c,t} + \beta_{11} ECOSUPPORT_{c,t} \\ & + \beta_{12} NEG\_INT_{c,t} + \beta_{13} \Delta CAPITAL_{i,t} \\ & - \beta_{14} RISK_{i,t-1} + \varphi_{i,t}. \end{aligned} \tag{4b}$$

Table 5 reports the estimated results for the bank profitability channel and the "search for yield" channel in Panels A and B, respectively. We note that the estimated coefficient α_1 of *MP* is significantly positive in the *NIM* and *SFY* equations, suggesting that easing interest policies reduce banks' interest margins and incentives to search for yields during normal times. Although the coefficient α_3 of *MP *PANDUNC* is significantly negative in

TABLE 5 Channel tests.

	Panel A: Bank profitability channel		Panel B: Search for yield channel	
Dependent variable	***NIM***	**Δ*RWAR***	***SFY***	**Δ*RWAR***
Explanatory variable				
NIM		21.801*** (9.788)		
SFY				4.013*** (7.934)
MP (α_1)	0.470*** (34.956)	−5.163*** (−8.811)	0.215*** (7.926)	1.030*** (2.990)
PANDUNC (α_2)	0.002*** (5.054)	−0.020*** (−4.157)	0.002*** (2.778)	−0.002 (−0.694)
*MP*PANDUNC* (α_3)	−0.001*** (−7.528)	0.015*** (8.105)	−0.001*** (−9.561)	0.007*** (6.218)
$\alpha_1 + \alpha_3$ (χ^2)	0.469*** (1225.48)		0.214*** (62.34)	
Control variables	Yes	Yes	Yes	Yes
χ^2	4871.45***	571.18***	175.04***	248.51***
N	9335	9335	7369	7369

Note: This table reports the estimation results of the simultaneous Equations (4a) and (4b). The dependent variables presented in Panel A are *NIM* and Δ*RWAR*, while those in Panel B are *SFY* and Δ*RWAR*. In both panels, monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The statistical significance of α_1+α_3 is tested using Stata's "test" command after the regression estimation. The estimated *z*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively. Source: Authors' estimations.

the *NIM* and *SFY* equations, the combined coefficient α_1+ α_3 is significantly positive, affirming a positive effect of interest rates on banks' interest margins and incentives to search for yields during the pandemic uncertainty. Simultaneously, we observe positive and significant coefficients of *NIM* and *SFY* in the *ΔRWAR* equation. These results, thus, support our earlier arguments that lower interest rates reduce banks' interest margins and incentives to search for yields, which discourages banks from holding interest-sensitive credit assets in their portfolios and leads to downwards risk adjustments by banks.

4.4 | Robustness tests

4.4.1 | Alternative bank risk and capital indicators

To check the robustness of the main results, we change the measurements of the dependent variables in Equations (3a) and (3b) by using the adjustments of loan loss allowance ratio (Δ*LOANLOSS*) and non-performing loan ratio (Δ*NPL*) as Δ*RISK* indicator, and the adjustment of equity ratio (Δ*EQUITY*) as Δ*CAPITAL* indicator. Unlike Δ*RWAR* and Δ*CAP*, these alternative indicators do not consider a trade-off between asset portfolio risk and capital directly because their measurements are not risk-weighted. Table 6 presents the estimation results based on Δ*LOANLOSS* and Δ*EQUITY* in Panel A and the estimation results based on Δ*NPL* and Δ*EQUITY* in Panel B.

First, we note that the positive effects of interest rates (*MP*) on banks' risk and capital adjustments remain intact, which affirms that banks tend to bear lower portfolio risks and meanwhile, maintain less capital buffers when debt financing becomes cheaper for borrowers and banks. Second, the coefficient of *PANDUNC* is generally insignificant, implying that the risk and capital adjustment levels of banks are not significantly impacted by pandemic uncertainty. More importantly, the coefficient of *MP*PANDUNC* is significantly positive across the risk and capital adjustment models, affirming a more pronounced effect of easing monetary policy on slashing bank portfolio risks amid pandemic uncertainty. In response, banks hoard more equity capital to ensure stability.

4.4.2 | Alternative pandemic uncertainty indicators

We re-estimate Equations (3a) and (3b) by employing three alternative pandemic uncertainty indicators, which are *UNC*, *NCASE* and *NDEATH*. Higher values of these indicators imply higher pandemic uncertainty in the country during the quarter. The new estimation results are presented in Table 7, Panels A-C.

On looking across the panels, we note that the coefficient of *MP* remains positive and significant in both the Δ*RWAR* and Δ*CAP* models, thus the evidence that banks simultaneously adjust portfolio risks and capital downward when interest rates are cut remains intact. In

TABLE 6 Using alternative dependent variables.

	Panel A		Panel B	
Dependent variable	**Δ*LOANLOSS***	**Δ*EQUITY***	**Δ*NPL***	**Δ*EQUITY***
Explanatory variable				
MP	0.032*** (4.439)	0.143*** (3.507)	0.011 (0.658)	0.151*** (3.136)
PANDUNC	0.000 (1.535)	0.000 (0.059)	−0.000** (−2.429)	0.000 (0.241)
*MP*PANDUNC*	0.000*** (5.424)	0.000*** (3.904)	0.000*** (3.102)	0.000*** (3.868)
Control variables	Yes	Yes	Yes	Yes
χ^2	3018.69***	676.32***	255.97***	297.48***
N	7017	7017	6918	6918

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) based on alternative dependent variables. The risk adjustment measure and the capital adjustment measure used in Panel A are Δ*LOANLOSS* and Δ*EQUITY*, respectively, while those in Panel B are Δ*NPL* and Δ*EQUITY*, respectively. In both panels, monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated *z*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

TABLE 7 Using alternative pandemic uncertainty indicators.

	Panel A: Using *UNC* as *PANDUNC* proxy		Panel B: Using *NCASE* as *PANDUNC* proxy		Panel C: Using *NDEATH* as *PANDUNC* proxy	
Dependent variable	**Δ*RWAR***	**Δ*CAP***	**Δ*RWAR***	**Δ*CAP***	**Δ*RWAR***	**Δ*CAP***
Explanatory variable						
MP	0.858*** (3.423)	0.101* (1.787)	0.870*** (3.058)	0.095 (1.603)	0.855*** (2.875)	0.133** (2.205)
PANDUNC	0.024 (1.137)	−0.007 (−0.502)	−0.001 (−0.307)	−0.002 (−1.263)	−0.275 (−1.156)	0.050 (0.488)
*MP*PANDUNC*	−0.002 (−0.247)	0.004 (0.929)	0.007 (1.203)	−0.001 (−0.573)	0.592** (2.322)	−0.075 (−0.757)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
χ^2	585.42***	206.55***	595.46***	215.76***	594.39***	211.35***
N	9373	9373	9373	9373	9373	9373

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) based on alternative pandemic uncertainty measures. *PANDUNC* in Panels A, B and C are represented by *UNC*, *NCASE* and *NDEATH*, respectively. In all the panels, the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively, and the monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated *z*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

consistency with our main results, pandemic uncertainty does not affect banks' risk and capital adjustments, as evidenced by the insignificant estimate of *PANDUNC* across the models. Furthermore, the coefficient of *MP*PANDUNC* is significantly positive in the Δ*RWAR* model in Panel C, affirming a downward adjustment in bank risk when the monetary policy stance is eased during pandemic uncertainty.

4.4.3 | Addressing endogeneity concern

Our aforementioned results for the SEM-PAR framework are estimated using the 3SLS estimator, with fixed-year and country effects controlled. This approach helps address endogeneity induced by a correlation of the disturbances across the equations, as well as omitted variable bias. However, one may argue that endogeneity can be induced by reverse causation between the bank-specific dependent variables and the bank-specific control variables. For example, banks' credit risk exposure may affect bank profitability inversely due to the accumulation of potential credit losses (Athanasoglou et al., 2008). To address reverse causation, we lag all bank-specific control variables by one quarter in the estimation of the SEM-PAR and apply both 3SLS and 2SLS estimators.[4] The results of this robustness test are reported in Table 8. As evidenced by the positive and significant coefficients

TABLE 8 Addressing endogeneity.

Dependent variable	Panel A: 3SLS estimator with lagged bank-specific variables		Panel B: 2SLS estimator with lagged bank-specific variables	
	Δ*RWAR*	**Δ*CAP***	**Δ*RWAR***	**Δ*CAP***
Explanatory variable				
MP	1.281*** (3.836)	0.021 (0.340)	1.672*** (4.560)	0.065 (0.990)
PANDUNC	0.003 (0.933)	−0.003* (−1.874)	0.002 (0.530)	−0.003* (−1.650)
*MP*PANDUNC*	0.002** (2.198)	−0.000 (−0.557)	0.003*** (2.620)	−0.0002 (−0.760)
Control variables	Yes	Yes	Yes	Yes
χ^2/F stat	134.61***	57.16***	4.67***	1.44*
N	9384	9384	9384	9384

Note: This table reports the 3SLS and 2SLS estimation results for the simultaneous Equations (3a) and (3b) with all bank-specific variables lagged by one quarter in Panels A and B, respectively. In both panels, the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively, and the monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated with time and country fixed-effects controlled. The estimated *t*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

of *MP* and *MP*PANDUNC* in the Δ*RWAR* model, we affirm our main results that interest rates positively drives banks' risk adjustment levels, and this effect is magnified in the presence of pandemic uncertainty.

4.5 | Heterogeneity analyses

We further investigate whether banks respond to monetary policy amid pandemic uncertainty heterogeneously across bank diversification and herding levels, as well as the country's interest policy type.

4.5.1 | Influence of bank diversification

To explore whether high-diversified banks react to monetary policy differently from low-diversified banks amid pandemic uncertainty, we perform a sub-sample analysis based on bank diversification. We split the bank sample into low-diversified banks and high-diversified banks for each country using the median of business diversification as the cut-off point. Business diversification is calculated as non-loan assets as a proportion of total assets of a bank since loan business is the prime income source of banks (Dang, 2020; Toh et al., 2020). Moving away from loan business implies a more diversified business model, or vice versa.

The estimated results are reported in Table 9. Upon comparing the results for low-diversified banks in Panel A and high-diversified banks in Panel B, we note a few observations. First, the positive coefficient on *MP* is significant for both Δ*RWAR* and Δ*CAP* of low-diversified banks, but is only significant for Δ*RWAR* of high-diversified banks, suggesting that the former is more responsive to interest rate changes than the latter in terms of risk and capital adjustments. As low-diversified banks have greater proportional interest-sensitive loans in asset portfolios, a rise in interest rate increases financing costs of borrowers and subsequently the credit risk exposure of banks. Correspondingly, capital buffers are raised to absorb the additional risk exposure. High-diversified banks are more immune to interest risk as they are highly supported by non-interest incomes, which supports prior evidence that diversification enhances bank stability (Li et al., 2021; Williams & Rajaguru, 2022).

Second, we note that the coefficient on *PANDUNC* is significantly positive in the Δ*RWAR* model and is significantly negative in the Δ*CAP* model for low-diversified banks, which suggests that the banks are more fragile as pandemic uncertainty rises. The result supports prior evidence that heavy loan-based portfolios expose low-diversified banks to risks that may jeopardize their franchise value (Li et al., 2021; Williams & Rajaguru, 2022). Lastly, the interactive term *MP*PANDUNC* is found to be significantly positive in the Δ*RWAR* model for high-diversified banks. The result supports Hypothesis 2B and suggests that high-diversified banks experience downwards portfolio risk adjustments when interest rates are slashed amid pandemic uncertainty. Business diversification appears to shield banks from portfolio risk exposures during the pandemic uncertainty as banks are better poised to interest risk by restructuring their asset portfolios towards non-interest sensitive assets.

TABLE 9 Influence of bank diversification.

Dependent variable	Panel A: Low-diversified banks		Panel B: High-diversified banks	
	Δ*RWAR*	Δ*CAP*	Δ*RWAR*	Δ*CAP*
Explanatory variable				
MP	2.563*** (3.890)	0.105* (1.750)	0.656** (2.400)	0.009 (0.070)
PANDUNC	0.011** (1.960)	−0.003* (−1.800)	−0.003 (−0.120)	−0.002 (−0.790)
*MP*PANDUNC*	−0.001 (−0.600)	0.000 (0.910)	0.002*** (2.890)	−0.001 (−1.410)
Control variables	Yes	Yes	Yes	Yes
χ^2	154.57***	60.23***	359.82***	230.04***
N	4384	4384	4227	4227

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) based on "low-diversified banks" and "high-diversified banks" subsamples in Panels A and B, respectively. In both panels, the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively, and the monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated z-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' computation.

4.5.2 | Influence of bank herding

To explore how herding possibly alters banks' risk and capital responses to monetary policy and pandemic uncertainty, we follow Wu et al.'s (2020) approach of measuring bank herding (*HERD*). We use the ratio of bank loans to deposits (*LD*) to indicate the financial intermediation level of a bank, then calculate the degree of dispersion of the bank's *LD* from the median level of its peer in the country *c* and quarter *t*.

$$HERD_{i,t} = \left(LD_{i,t} - LD_{c,t}^{\text{median}}\right)^2 / LD_{c,t}^{\text{median}}. \qquad (5)$$

A higher *HERD* value implies a lower degree of bank herding. We use the median of *HERD* value as a cut-off point to split the full bank sample into banks with low herding degree and banks high herding degree, then we re-estimate Equations (3a) and (3b) for these subsamples.

The results reported in Table 10 show that banks generally experience substantial risk increments when interest rates (*MP*) rise, or vice versa, regardless of banks' herding levels. We also find that the effect of pandemic uncertainty (*PANDUNC*) remains insignificant for both risk and capital adjustments of banks across the subsamples. On looking at the significantly positive coefficient on the interactive term *MP*PANDUNC* in Panel B, we note that the positive effect of interest rates on risk adjustments amplifies among banks with high herding degree as pandemic uncertainty increases, supporting Hypothesis 3B. The results reveal that banks that herd assume lower risks when monetary policy is eased amid pandemic uncertainty, as spillovers from adverse news are contained and alleviated within the herd. Meanwhile, their capitalization levels improve. This, in turn, contributes to the joint survival of banks.

4.5.3 | Influence of negative interest rate policy

To investigate whether negative interest rate policy induces banks to respond to monetary policy and pandemic uncertainty heterogeneously, we estimate Equations (3a) and (3b) separately for countries adopting a negative interest rate policy (France, Germany, Italy and Japan) and countries adopting a zero or positive interest rate policy during the pandemic.

Based on the results reported in Table 11, we first find a positive and statistically significant coefficient on *MP* in the Δ*RWAR* model in both Panels A and B, which suggests that banks demonstrate lower portfolio risk levels when interest rates drop, regardless of whether they operate in a negative interest rate environment or not. The result of *PANDUNC* in Panel A shows that the negative effect of pandemic uncertainty on banks' risk adjustments is more salient in countries adopting negative interest policies than in other countries.

On looking closer at the interactive term *MP*PANDUNC* in the Δ*RWAR* model, we note that the estimated coefficient is negative in Panel A, while a positive sign is observed in Panel B. This suggests that during periods of high pandemic uncertainty, the risk-reducing effect of an interest rate cut diminishes in countries adopting negative interest rate policies, while it is amplified in countries adopting zero and positive interest rate policies. Due to the dampening effect of pandemic uncertainty on

TABLE 10 Influence of bank herding.

Dependent variable	Panel A: Banks with low herding degree ΔRWAR	Panel A: ΔCAP	Panel B: Banks with high herding degree ΔRWAR	Panel B: ΔCAP
Explanatory variable				
MP	0.950** (2.470)	−0.130 (−1.060)	1.644*** (3.870)	0.076** (0.692)
PANDUNC	0.007 (1.550)	−0.004 (−1.550)	0.001 (0.160)	−0.002 (−1.130)
*MP*PANDUNC*	0.001 (0.940)	−0.000 (−0.720)	0.002** (2.070)	−0.000* (−1.810)
Control variables	Yes	Yes	Yes	Yes
χ^2	212.95***	307.96***	470.19***	281.57***
N	3929	3929	4067	4067

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) based on "banks with low herding degree" and "banks with high herding degree" subsamples in Panels A and B, respectively. In both panels, the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively, and the monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated *z*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

TABLE 11 Influence of negative-interest rate policy.

Dependent variable	Panel A: Countries adopting negative interest rates ΔRWAR	Panel A: ΔCAP	Panel B: Countries adopting zero and positive interest rates ΔRWAR	Panel B: ΔCAP
Explanatory variable				
MP	4.331*** (4.970)	−3.086 (−1.000)	0.747** (2.010)	0.154** (1.980)
PANDUNC	−0.005* (−1.741)	−0.001 (−1.220)	0.002 (0.410)	−0.001 (−0.580)
*MP*PANDUNC*	−0.008** (−2.250)	−0.004 (−0.750)	0.002*** (2.730)	−0.005 (−1.340)
Control variables	Yes	Yes	Yes	Yes
χ^2	435.21***	199.04***	476.21***	169.34***
N	1686	1686	7687	7687

Note: This table reports the estimation results of the simultaneous Equations (3a) and (3b) for banks in countries adopting negative interest rates and for banks in countries adopting zero and positive interest rates. In both panels, the risk and capital adjustment measures are Δ*RWAR* and Δ*CAP*, respectively, and the monetary policy is proxied by overnight interbank market interest rates (*MP*). All variables are defined in Table 1. All the simultaneous equations models are estimated using the 3SLS method with time and country fixed-effects controlled. The estimated *z*-statistics is in parenthesis. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' estimations.

business investments and economic outlooks, the monetary policy transmission to the real economy may be as well constrained, adding challenges to central banks' efforts in restoring economic growth and market confidence. Running up against the limits of what they can achieve with conventional monetary policy, central banks will turn to unconventional monetary policy as the last resort (BIS, 2019). Particularly, the introduction of negative interest rate policy can overturn the usual pattern of interest payment flows in the economy and broaden the perceptions of the range of possible rates, thus influencing the formation of commercial banks' forecasts of interest rate movements and investment returns. Thus, it is not surprising to observe that banks encountering negative interest rates are more willing to invest in the real economy in response to the intended stimulus of unconventional monetary policy during pandemic uncertainty as compared to other bank counterparts. Hypothesis 4A is thus supported.

5 | CONCLUSION

The COVID-19 pandemic has severely disrupted the global economy, and this has forced policymakers to devise various policies to prevent a financial crisis. However, there is still little understanding regarding the transmission of monetary policy through bank risk and capital under the pandemic uncertainty. Applying a SEM-PAR estimation on banks from the 12 largest economies over the period 2018 Q1 to 2021 Q4, this paper documents several key findings. First, we find that banks' portfolio risk and capital levels co-move with interest rates positively. Since interest-based activities are the primary sources of risk and income of banks, an easing monetary policy stance reduces banks' profitability and earnings reserves, thereby slashing their incentives to finance risky investments in the real economy. Meanwhile, banks demand less capital buffers as lower financing costs alleviate the credit risk and financial distress of borrowers and banks. Our result thereby enriches the monetary policy transmission literature as most of the extant evidence advocates for the risk-taking effect of monetary policy which hinges on the pre-pandemic context.

Second, we find that the effect of an easing monetary policy on downward risk adjustments by banks becomes stronger amid heightened pandemic uncertainty as the pandemic-related shocks blur the economic prospects and induce banks to act more conservatively. However, we also find that bank capitalization is not significantly adjusted during the pandemic which is arguably not the best time to slash or build up capital. This result contributes to the scarce literature on monetary policy transmission during the pandemic as extant evidence mainly emphasizes financial market risks and neglects bank risk. Our result signals that bank stability could be threatened by growing portfolio risks yet compressed capital buffers as worldwide interest rates have started rising recently, despite the ongoing uncertainty caused by the pandemic.

Third, we show that the positive effect of monetary policy on risk adjustment amid pandemic uncertainty is more evident among highly diversified banks which possess more non-interest income alternatives. Banks with stronger herding behaviour are also more responsive to monetary policy during the pandemic because they herd together to enhance joint survivals within the industry. Further, we observe that while banks in countries adopting negative interest rate policies show greater prudence through holding less risky asset portfolios in easing monetary conditions, they are more willing to assume riskier assets amid pandemic uncertainty to attain the intended stimulus of the monetary policy. In contrast, banks in countries adopting positive interest polices remain conservative in risk-taking despite the easing monetary policy stance in the pandemic. To our knowledge, the differentiated effects of monetary policy on bank risk and capital during the pandemic across these bank and country heterogeneities have not been investigated by prior studies, which makes our study contribution valuable.

Our results give rise to a reconsideration of the transmission of monetary policy in the presence of pandemic uncertainty. For central banks, there is a need to assess the monetary policy stance in conjunction with pandemic uncertainty in order to neutralize the effect of monetary policy on bank risk which may not be adequately insulated by a lukewarm adjustment of bank capital buffers during the lingering pandemic uncertainty. If banks are not well capitalized and fortified, raising interest rates amid pandemic uncertainty to fight against post-pandemic inflation may cause deteriorations in banks' asset quality and subsequently lead to "second moment shocks" to the economy. These potential vulnerabilities need to be carefully monitored to ensure that the monetary condition is conductive for sustainable economic growth and will not trigger "second moment shocks" when pandemic-related economic stimulus is phased out. In this case, the integration of monetary and macroprudential policies needs to be strengthened to balance the trade-off between unemployment and inflation, while maintaining financial system stability. More importantly, the policy must also be appropriately adaptive considering the heterogeneity in banks' profiles as banks exhibiting high diversification and herding levels are inherently safer and risk averse, and thus more reactive to changing monetary policy stance.

Additionally, we observe banks' risk-taking behaviour in countries adopting negative interest rates when the monetary policy is eased amid pandemic uncertainty as opposed to the bank risk-slashing behaviour in other countries. This result implies that cutting interest rates in conjunction with negative interest policies, which aims at overcoming the negative impacts of the pandemic on real-economic activities, is effective in inducing banks to be more risk-tolerant and proactive in loan issuances to support the easing monetary stance of the central bank. Hence, our finding could be viewed as a support for such unconventional policies to revamp the economy. However, we urge the central banks not to ignore the financial risks that these policies may cause in the longer term because the recent rise of interest rates may aggravate the risk of chronically weak banks being tied to chronically weak borrowers. As economies recover from the pandemic, regulators need to reinvigorate efforts to strike a macroprudential stance with timely recognition of bank losses and capital buffers to ensure bank stability which remains an enduring concern during global epidemics.

This study is subject to a few limitations. Firstly, while three alternative monetary policy measures, including a dummy variable for a negative interest-rate environment, are employed in our cross-country study, unconventional policies like quantitative easing may not be sufficiently considered due to our panel-data study design. Future works may focus on a specific country and employ an event study methodology to examine the effects of a monetary policy announcement on bank stability during the pandemic. Secondly, the scope of bank risk in this study is limited to portfolio risk only. Future works may explore banks' systemic risk to reveal how the interlinkage between monetary policy and pandemic influences banking sector stability via systemic risk.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

[1] We acknowledge some studies that employed an event study method to examine the impact of announced fiscal and monetary policy measures on the abnormal stock returns of corporate firms during the COVID-19 pandemic (see, for example, Deev & Plíhal, 2022; Heyden & Heyden, 2021). However, the event-study method employs daily/high frequency time-series data, which is not suitable for the scope of our banking research that relies on quarterly panel data.

[2] The null hypothesis of the test of over-identifying restrictions is that the instruments are valid for the specified endogenous variables, which means that the instruments are not significantly correlated with the error terms and are correctly excluded from the estimated model.

[3] The statistical significance of $\alpha_1 + \alpha_3$ is tested using Stata's "test" command after the regression estimation.

[4] Unlike the 3SLS estimator, the 2SLS estimator does not consider a correlation of disturbances across the equations in the system, thus a covariance matrix of disturbances is not used in the estimation.

REFERENCES

Aastveit, K. A., Natvik, G. J., & Sola, S. (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance*, *76*, 50–67. https://doi.org/10.1016/j.jimonfin.2017.05.003

Acharya, V. V., Eisert, T., Eufinger, C., & Hirsch, C. (2019). Whatever it takes: The real effects of unconventional monetary policy. *The Review of Financial Studies*, *32*(9), 3366–3411. https://doi.org/10.1093/rfs/hhz005

Acharya, V. V., & Yorulmazer, T. (2008). Information contagion and bank herding. *Journal of Money, Credit and Banking*, *40*(1), 215–231.

Ahir, H., Bloom, N., & Furceri, D. (2018). The world uncertainty index. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3275033

Altunbas, Y., Gambacorta, L., & Marques-Ibanez, D. (2012). Do bank characteristics influence the effect of monetary policy on bank risk? *Economics Letters*, *117*(1), 220–222. https://doi.org/10.1016/j.econlet.2012.04.106

Anani, M., & Owusu, F. (2023). Regulatory capital and bank risk-resilience amid the Covid-19 pandemic: How are the Basel reforms faring? *Finance Research Letters*, *52*, 103591. https://doi.org/10.1016/j.frl.2022.103591

Athanasoglou, P. P., Brissimis, S. N., & Delis, M. D. (2008). Bank-specific, industry-specific and macroeconomic determinants of bank profitability. *Journal of International Financial Markets Institutions and Money*, *18*(2), 121–136. https://doi.org/10.1016/j.intfin.2006.07.001

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, *131*(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Baum, C. F., Caglayan, M., & Ozkan, N. (2009). The second moments matter: The impact of macroeconomic uncertainty on the allocation of loanable funds. *Economics Letters*, *102*(2), 87–89. https://doi.org/10.1016/j.econlet.2008.11.019

Berger, A. N., & Black, L. K. (2011). Bank size, lending technologies, and small business finance. *Journal of Banking & Finance*, *35*(3), 724–735. https://doi.org/10.1016/j.jbankfin.2010.09.004

Berger, A. N., & Demirgüç-Kunt, A. (2021). Banking research in the time of COVID-19. *Journal of Financial Stability*, *57*, 100939. https://doi.org/10.1016/j.jfs.2021.100939

Berger, A. N., Miller, N. H., Petersen, M. A., Rajan, R. G., & Stein, J. C. (2005). Does function follow organizational form? Evidence from the lending practices of large and small banks. *Journal of Financial Economics*, *76*(2), 237–269. https://doi.org/10.1016/j.jfineco.2004.06.003

Bianco, T. (2021). Monetary policy and credit flows. *Journal of Macroeconomics*, *70*, 103362. https://doi.org/10.1016/j.jmacro.2021.103362

BIS. (2019). Unconventional monetary policy tools: A cross-country analysis. BIS CGFS Papers No. 63. https://www.bis.org/publ/cgfs63.pdf

Bitar, M., & Tarazi, A. (2022). A note on regulatory responses to COVID-19 pandemic: Balancing banks' solvency and contribution to recovery. *Journal of Financial Stability*, *101009*, 101009. https://doi.org/10.1016/j.jfs.2022.101009

Bonfim, D., & Soares, C. (2018). The risk-taking channel of monetary policy: Exploring all avenues. *Journal of Money, Credit and Banking*, *50*(7), 1507–1541. https://doi.org/10.1111/jmcb.12500

Borio, C., & Gambacorta, L. (2017). Monetary policy and bank lending in a low interest rate environment: Diminishing effectiveness? *Journal of Macroeconomics*, *54*, 217–231. https://doi.org/10.1016/j.jmacro.2017.02.005

Borio, C., Gambacorta, L., & Hofmann, B. (2017). The influence of monetary policy on bank profitability. *International Finance*, *20*(1), 48–63. https://doi.org/10.1111/infi.12104

Borio, C., & Zhu, H. (2012). Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism? *Journal of Financial Stability*, *8*(4), 236–251. https://doi.org/10.1016/j.jfs.2011.12.003

Cao, Y., & Chou, J. Y. (2022). Bank resilience over the COVID-19 crisis: The role of regulatory capital. *Finance Research Letters*, *48*, 102891. https://doi.org/10.1016/j.frl.2022.102891

Chen, M., Wu, J., Jeon, B. N., & Wang, R. (2017). Monetary policy and bank risk-taking: Evidence from emerging economies. *Emerging Markets Review*, *31*, 116–140. https://doi.org/10.1016/j.ememar.2017.04.001

Chen, P.-F., Lee, C.-C., & Zeng, J.-H. (2019). Economic policy uncertainty and firm investment: Evidence from the U.S. market. *Applied Economics*, *51*(31), 3423–3435. https://doi.org/10.1080/00036846.2019.1581909

Chiang, T. C. (2022). Evidence of economic policy uncertainty and COVID-19 pandemic on global stock returns. *Journal of Risk and Financial Management*, *15*(1), 28.

Çolak, G., & Öztekin, Ö. (2021). The impact of COVID-19 pandemic on bank lending around the world. *Journal of Banking & Finance*, *133*, 106207.

Dang, V. D. (2020). Do non-traditional banking activities reduce bank liquidity creation? Evidence from Vietnam. *Research in International Business and Finance*, *54*, 101257. https://doi.org/10.1016/j.ribaf.2020.101257

Dang, V. D. (2022). Bank liquidity creation under micro uncertainty: The conditioning role of income structure. *Economic Modelling*, *112*, 105852. https://doi.org/10.1016/j.econmod.2022.105852

Dang, V. D., & Huynh, J. (2022). Bank funding, market power, and the bank liquidity creation channel of monetary policy. *Research in International Business and Finance*, *59*, 101531. https://doi.org/10.1016/j.ribaf.2021.101531

de Moraes, C. O., & de Mendonça, H. F. (2019). Bank's risk measures and monetary policy: Evidence from a large emerging economy. *The North American Journal of Economics and Finance*, *49*, 121–132. https://doi.org/10.1016/j.najef.2019.04.002

de Moraes, C. O., Montes, G. C., & Antunes, J. A. P. (2016). How does capital regulation react to monetary policy? New evidence on the risk-taking channel. *Economic Modelling*, *56*, 177–186. https://doi.org/10.1016/j.econmod.2016.03.025

Deev, O., & Plíhal, T. (2022). How to calm down the markets? The effects of COVID-19 economic policy responses on financial market uncertainty. *Research in International Business and Finance*, *60*, 101613. https://doi.org/10.1016/j.ribaf.2022.101613

Demir, E., & Danisman, G. O. (2021). Banking sector reactions to covid-19: The role of bank-specific factors and government policy responses. *Research in International Business and Finance*, *58*, 101508. https://doi.org/10.1016/j.ribaf.2021.101508

DeYoung, R., & Torna, G. (2013). Nontraditional banking activities and bank failures during the financial crisis. *Journal of Financial Intermediation*, *22*(3), 397–421. https://doi.org/10.1016/j.jfi.2013.01.001

Duan, Y., Ghoul, S. E., Guedhami, O., Li, H., & Li, X. (2021). Bank systemic risk around COVID-19: A cross-country analysis. *Journal of Banking & Finance*, *133*, 106299. https://doi.org/10.1016/j.jbankfin.2021.106299

Elnahass, M., Trinh, V. Q., & Li, T. (2021). Global banking stability in the shadow of Covid-19 outbreak. *Journal of International Financial Markets Institutions and Money*, *72*, 101322. https://doi.org/10.1016/j.intfin.2021.101322

Elsayed, A. H., Naifar, N., & Nasreen, S. (2022). Financial stability and monetary policy reaction: Evidence from the GCC countries. *The Quarterly Review of Economics and Finance*, *87*, 396–405. https://doi.org/10.1016/j.qref.2022.03.003

Fitch Solutions Inc. (2022). Bank financial data. Retrieved from fitch connect database.

Forbes, K., Gagnon, J., & Collins, C. G. (2021). Pandemic inflation and nonlinear, global Phillips curves. Published on VOX, CEPR Policy Portal. https://voxeu.org/article/pandemic-inflation-and-nonlinear-global-phillips-curves

Gambacorta, L., & Shin, H. S. (2018). Why bank capital matters for monetary policy. *Journal of Financial Intermediation*, *35*, 17–29. https://doi.org/10.1016/j.jfi.2016.09.005

Girotti, M. (2019). How monetary policy changes bank liability structure and funding cost. *Oxford Economic Papers*, *73*(1), 49–75. https://doi.org/10.1093/oep/gpz058

Goodell, J. W., Goyal, A., & Urquhart, A. (2021). Uncertainty of uncertainty and firm cash holdings. *Journal of Financial Stability*, *56*, 100922. https://doi.org/10.1016/j.jfs.2021.100922

Guo, W. C., & Tseng, P. L. (2023). COVID-19, bank risk, and capital regulation: The aggregate shock and social distancing. *The Quarterly Review of Economics and Finance*, *92*, 155–173. https://doi.org/10.1016/j.qref.2023.09.004

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., & Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 government response tracker). *Nature Human Behaviour*, *5*, 529–538.

Hardy, B., & Zhu, S. (2023). Covid, central banks and the bank-sovereign nexus. *BIS Quarterly Review*. https://www.bis.org/publ/qtrpdf/r_qt2303h.htm

Heuvel, S. J. V.d. (2002). Does bank capital matter for monetary transmission? *FRBNY Economic Policy Review*, *8*(1), 259–265.

Heyden, K. J., & Heyden, T. (2021). Market reactions to the arrival and containment of COVID-19: An event study. *Finance Research Letters*, *38*, 101745.

Hu, C., Shen, Z., Yu, H., & Xu, B. (2022). Uncertainty shocks and monetary policy: Evidence from the troika of China's economy. *Economic Research*, *35*(1), 971–985. https://doi.org/10.1080/1331677X.2021.1952088

Igan, D., Mirzaei, A., & Moore, T. (2023). Does macroprudential policy alleviate the adverse impact of COVID-19 on the resilience of banks? *Journal of Banking & Finance*, *147*, 106419. https://doi.org/10.1016/j.jbankfin.2022.106419

Ikeda, Y., Kerry, W., Lewrick, U., & Schmieder, C. (2021). Covid-19 and bank resilience: Where do we stand? BIS Bulletin, No. 44. https://www.bis.org/publ/bisbull44.htm

Iyke, B. N., & Maheepala, M. M. J. D. (2022). Conventional monetary policy, COVID-19, and stock markets in emerging economies. *Pacific-Basin Finance Journal*, *76*, 101883. https://doi.org/10.1016/j.pacfin.2022.101883

Jiang, H., & Yuan, C. (2022). Monetary policy, capital regulation and bank risk-taking: Evidence from China. *Journal of Asian Economics, 82*, 101512. https://doi.org/10.1016/j.asieco.2022.101512

Jokipii, T., & Milne, A. (2011). Bank capital buffer and risk adjustment decisions. *Journal of Financial Stability*, *7*(3), 165–178. https://doi.org/10.1016/j.jfs.2010.02.002

Keeley, M. C. (1990). Deposit insurance, risk, and market power in banking. *The American Economic Review*, *80*(5), 1183–1200. https://doi.org/10.2307/2006769

Lambert, F., & Ueda, K. (2014). *The effects of unconventional monetary policies on Bank* (Vol. 14, p. 1). IMF.

Levin, A., Lin, C.-F., & James Chu, C.-S. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, *108*(1), 1–24.

Li, X., Feng, H., Zhao, S., & Carter, D. A. (2021). The effect of revenue diversification on bank profitability and risk during the COVID-19 pandemic. *Finance Research Letters*, *43*, 101957. https://doi.org/10.1016/j.frl.2021.101957

Liang, S., Moreira, F., & Lee, J. (2020). Diversification and bank stability. *Economics Letters*, *193*, 109312. https://doi.org/10.1016/j.econlet.2020.109312

López-Penabad, M. C., Iglesias-Casal, A., & Silva Neto, J. F. (2022). Effects of a negative interest rate policy in bank profitability and risk taking: Evidence from European banks. *Research in International Business and Finance*, *60*, 101597.

Lyu, Y., Zhang, X., Cao, J., Liu, J., & Yang, M. (2024). Quantitative easing and the spillover effects from the crude oil market to other financial markets: Evidence from QE1 to QE3. *Journal of International Money and Finance*, *140*, 102989. https://doi.org/10.1016/j.jimonfin.2023.102989

Mateev, M., Tariq, M. U., & Sahyouni, A. (2021). Competition, capital growth and risk-taking in emerging markets: Policy implications for banking sector stability during COVID-19 pandemic. *PLoS One*, *16*(6), e0253803. https://doi.org/10.1371/journal.pone.0253803

Meslier, C., Tacneng, R., & Tarazi, A. (2014). Is bank income diversification beneficial? Evidence from an emerging economy. *Journal of International Financial Markets Institutions and Money*, *31*, 97–126. https://doi.org/10.1016/j.intfin.2014.03.007

Neef, Ö. D.-d., & Schandlbauer, A. (2021). COVID-19 and lending responses of European banks. *Journal of Banking & Finance*, *133*, 106236. https://doi.org/10.1016/j.jbankfin.2021.106236

Neuenkirch, M., & Nöckel, M. (2018). The risk-taking channel of monetary policy transmission in the euro area. *Journal of Banking & Finance*, *93*, 71–91. https://doi.org/10.1016/j.jbankfin.2018.06.003

Ngambou Djatche, M. J. (2019). Re-exploring the nexus between monetary policy and banks' risk-taking. *Economic Modelling*, *82*, 294–307. https://doi.org/10.1016/j.econmod.2019.01.016

Nguyen, T. D., Le, A. H., Thalassinos, E. I., & Trieu, L. K. (2022). The impact of the COVID-19 pandemic on economic growth and monetary policy: An analysis from the DSGE model in Vietnam. *Economies*, *10*(7), 1–19.

Paltrinieri, A., Dreassi, A., Rossi, S., & Khan, A. (2021). Risk-adjusted profitability and stability of Islamic and conventional banks: Does revenue diversification matter? *Global Finance Journal*, *50*, 100517. https://doi.org/10.1016/j.gfj.2020.100517

Phan, D. H. B., Iyke, B. N., Sharma, S. S., & Affandi, Y. (2021). Economic policy uncertainty and financial stability—Is there a relation? *Economic Modelling*, *94*, 1018–1029. https://doi.org/10.1016/j.econmod.2020.02.042

Quagliariello, M. (2009). Macroeconomic uncertainty and banks' lending decisions: The case of Italy. *Applied Economics*, *41*(3), 323–336. https://doi.org/10.1080/00036840601007286

Refinitv. (2022). DataStream macroeconomic analysis. DataStream database.

Ritchie, H., Mathieu, E., Rodés-Guirao, L., Appel, C., Giattino, C., Ortiz-Ospina, E., Hasell, J., Macdonald, B., Dattani, S., Beltekian, D., Ortiz-Ospina, E., & Roser, M. (2020). *Coronavirus Pandemic (COVID-19)*. https://ourworldindata.org/coronavirus

Ryuichi, N., & Hirofumi, U. (2011). Herd behaviour by Japanese banks after financial deregulation. *Economica*, *78*(312), 618–636. https://doi.org/10.1111/j.1468-0335.2010.00870.x

Shrieves, R. E., & Dahl, D. (1992). The relationship between risk and capital in commercial banks. *Journal of Banking & Finance*, *16*(2), 439–457. https://doi.org/10.1016/0378-4266(92)90024-T

Soedarmono, W., Machrouh, F., & Tarazi, A. (2011). Bank market power, economic growth and financial stability: Evidence from Asian banks. *Journal of Asian Economics*, *22*(6), 460–470. https://doi.org/10.1016/j.asieco.2011.08.003

Spiegel, M. M. (2022). Monetary policy spillovers under COVID-19: Evidence from lending by U.S. foreign bank subsidiaries. *Journal of International Money and Finance*, *122*, 102550. https://doi.org/10.1016/j.jimonfin.2021.102550

Stolz, S., & Wedow, M. (2011). Banks' regulatory capital buffer and the business cycle: Evidence for Germany. *Journal of Financial Stability*, *7*(2), 98–110. https://doi.org/10.1016/j.jfs.2009.09.001

Toh, M. Y., Gan, C., & Li, Z. (2020). Bank diversification, competition and liquidity creation: Evidence from Malaysian banks. *The Singapore Economic Review*, *65*(4), 1127–1156. https://doi.org/10.1142/S0217590819500103

Toh, M. Y., & Zhang, Y. (2022). Bank capital and risk adjustment responses to economic uncertainty: Evidence from emerging southeast Asian economies. *Research in International Business and Finance*, *60*, 101576. https://doi.org/10.1016/j.ribaf.2021.101576

Tran, D. V., Hassan, M. K., Alam, A. W., & Dau, N. (2022). Banks' financial soundness during the COVID-19 pandemic. *Journal of Economics and Finance*, *46*(4), 713–735. https://doi.org/10.1007/s12197-022-09591-x

Valencia, F. (2016). Bank capital and uncertainty. *Journal of Banking and Finance*, *69*(S1), S1–S9. https://doi.org/10.1016/j.jbankfin.2015.06.010

Valencia, O. C., & Bolaños, A. O. (2018). Bank capital buffers around the world: Cyclical patterns and the effect of market power. *Journal of Financial Stability*, *38*, 119–131. https://doi.org/10.1016/j.jfs.2018.02.004

Wei, X., & Han, L. (2021). The impact of COVID-19 pandemic on transmission of monetary policy to financial markets. *International Review of Financial Analysis*, *74*, 101705. https://doi.org/10.1016/j.irfa.2021.101705

Williams, B., & Rajaguru, G. (2022). The evolution of bank revenue and risk in the Asia-Pacific region. *Pacific-Basin Finance Journal*, *71*, 101693. https://doi.org/10.1016/j.pacfin.2021.101693

World Bank. (2022). World development indicators. https://databank.worldbank.org/source/world-development-indicators

Wu, J., Yan, Y., Chen, M., & Jeon, B. N. (2022). Monetary policy, economic uncertainty and bank risk: Cross-country evidence. *Journal of International Money and Finance*, *122*, 102580. https://doi.org/10.1016/j.jimonfin.2021.102580

Wu, J., Yao, Y., Chen, M., & Nam Jeon, B. (2020). Economic uncertainty and bank risk: Evidence from emerging economies. *Journal of International Financial Markets Institutions and Money*, *68*, 101242. https://doi.org/10.1016/j.intfin.2020.101242

Yaman, H., Omar, A., Azlan, A., & Hafezali, I. H. (2018). Determinants of ex-post and ex-ante credit risk: A novel panel analysis and comparative evidence from foreign and local Malaysian banks. *Journal of Economic & Management Perspectives*, *12*(1), 98–128.

Yilmazkuday, H. (2022). COVID-19 and monetary policy with zero bounds: A cross-country investigation. *Finance Research Letters*, *44*, 102103.

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APPENDIX A

TABLE A1 Number of banks and GDP of sample countries.

Country	No. of banks	GDP (trillion USD) 2018	2019	2020	2021
Brazil	40	1.92	1.87	1.45	1.61
Canada	34	1.73	1.74	1.65	1.99
China	53	13.89	14.28	14.69	17.73
France	10	2.79	2.73	2.63	2.94
Germany	8	3.98	3.89	3.85	4.22
India	23	2.70	2.83	2.67	3.17
Italy	26	2.09	2.01	1.89	2.10
Japan	126	5.04	5.12	5.04	4.94
South Korea	9	1.72	1.65	1.64	1.80
Russia	120	1.66	1.69	1.49	1.78
U.K.	14	2.90	2.88	2.76	3.19
U.S.	320	20.53	21.37	20.89	23.00
Total GDP of sample countries (a)		60.95	62.07	60.64	68.46
Total world GDP (b)		86.41	87.65	84.91	96.10
% Contribution to the world GDP (a/b)		70.53	70.82	71.41	71.24

Source: World Bank (2022); Authors' computation.

TABLE A2 Correlation matrix.

	RWAR	*CAP*	*MP*	*PANDUNC*	*SIZE*	*ROAA*	*LIQ*	*LG*	*GDP*	*INFLATION*	*EPU*	*ECOSUPPORT*	*NEG_INT*
RWAR	1.000												
CAP	−0.085	1.000											
MP	0.463	0.281	1.000										
PANDUNC	−0.121	−0.028	−0.319	1.000									
SIZE	−0.373	−0.301	−0.355	0.095	1.000								
ROAA	0.333	0.182	0.271	−0.065	−0.196	1.000							
LIQ	−0.238	0.210	0.015	0.082	0.083	0.024	1.000						
LG	0.005	0.098	0.085	0.022	−0.074	0.048	0.073	1.000					
GDP	0.041	−0.006	0.006	−0.121	0.013	−0.083	−0.018	0.035	1.000				
INFLATION	0.183	0.152	0.266	−0.015	−0.268	0.147	0.025	0.031	−0.007	1.000			
EPU	0.206	0.194	0.219	0.330	−0.144	0.107	0.109	0.088	−0.023	−0.038	1.000		
ECOSUPPORT	−0.171	−0.043	−0.342	0.776	0.119	−0.085	0.093	0.015	0.034	−0.038	0.142	1.000	
NEG_INT	−0.389	−0.173	−0.461	0.076	0.387	−0.188	0.090	−0.055	−0.065	−0.351	−0.418	0.210	1.000

Source: Authors' computation.