The Impact of Climate Risk on Bank Profitability through Liquidity Creation Channel:

Empirical Evidence from G-7 Countries

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Abstract

This study investigates the impact of climate change-induced risk on bank profitability in the G-7 countries from 2001 to 2022. Using dynamic panel GMM estimation to analyze banking industry data with climate risk factor, the study finds that climate risk has a negative effect on bank profitability. The study also shows that bank liquidity creation plays a key role in transmitting the negative impact of climate risk on bank profitability. Additionally, the study's results are robust and hold up under different measures of bank liquidity creation. The study's findings suggest that policymakers may need to create climate risk management policies to mitigate the adverse effects of climate change on the banking sector.

Keywords: Bank Profitability, Climate Risk, Liquidity Creation

JEL Classification: G21, Q51, Q54, Q56

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1. Introduction

The challenges humanity faces due to climate change are not a future story anymore. Climate change adversely affects the environment, society, and economy. As a result of consistent global temperatures rise for the last few decades, extreme weather events, rising sea levels, and droughts are becoming more frequent, causing widespread destruction and loss of life. For example, in 2021, Hurricane Ida caused widespread damage and flooding in the southern United States, resulting in at least 82 deaths and billions of dollars in economic losses. In 2020, wildfires ravaged parts of Australia, burning over 46 million acres of land and killing over one billion animals. These disasters illustrate the severe impacts of climate change and the urgent need to take action to mitigate its effects.

Nevertheless, it is difficult to deem that current financial industry is immune to these changes, as climate risk has the potential to impact banks and their profitability in several ways. Banks assume climate risk through their lending, investment, and underwriting activities, as well as their physical assets and operations. The impacts of climate change, such as the increased frequency and severity of natural disasters, can cause credit and investment losses, disrupt business operations, and increase insurance and operational costs. Furthermore, regulatory and policy changes to mitigate climate change could significantly affect banks' operations, compliance costs, and profitability.

In order to mitigate these forecasted impacts, banking sector is especially crucial throughout the overall financial industry's eco-system as it plays a crucial role in facilitating the transition to a low-carbon economy and managing the risks associated with climate change. Given the scale and complexity of the challenge, climate risk management has become a key priority for regulators, investors, and companies worldwide. However, as with any new risk, there are significant uncertainties and knowledge gaps surrounding climate risk management, which pose significant challenges to banks and their stakeholders.

Out of those unknowns, we would like to explore the underlying channel through which climate risk affects bank performance. Climate change-induced risk directly influences a country's economy through physical channels (Kahn et al., 2021; Huang, Kerstein, & Wang, 2018; Huynh et al., 2020; Javadi & Masum, 2021; Baker & Adu-Bonnah, 2008). In addition, the transition channel of climate risk indirectly affects corporate performance and decisions (see, Bose et al. (2020) and Nguyen et al. (2020)). Zhang, Chang, & Xuan (2022) explore climate change affects bank performance through its physical channel, like natural disasters. Moreover, Li & Pan (2022) argue that climate change transition risk represses bank performance. Furthermore, there exists a contradiction among scholars regarding the impact of climate risk on bank liquidity creation. Berger et al. (2017); Wang, Lee, and Chen (2022); Berger et al. (2022); Baker, Bloom, & Davis (2016); Gatev and Strahan (2006); Pennacchi, (2006); Carroll (2001); Berger et al. (2022); Wang, Lee, and Chen (2022) opine in favour of a positive association. In contrast, climate-induced risk could lead to lessening bank liquidity creation (Bos, Li, & Sanders, 2022; Cornett et al., 2021; Wu & Shen, 2013; Zhang, Zhang, & Lu, 2022).

A significant number of research works has been conducted in the field of climate change with a focus on firm performance, such as stock return volatility (Bouslah, Kryzanowski, and Mzali, 2013) and credit risk (Oikonomou et al., 2014). Moreover, there exists a growing literature on climate change risk with macroeconomic aggregates and corporate decisions, namely, climate risks and monetary policy (Batten, Sowerbutts, and Tanaka, 2020); climate change and long-term macroeconomic effects (Kahn et al., 2021); climate risk and firm performance (Huang, Kerstein, and Wang, 2018); climate risk and cost of equity capital (Huynh, Nguyen, and Truong, 2020); carbon risk and corporate acquisition (Bose, Minnick, and Shams, 2021); climate policy and firms' return and volatility (Diaz-Rainey et al., 2021); and carbon risk and corporate investment (Phan et al., 2021). On the other hand, there exists enormous literature in the field of climate risk with a focus on the bank performance (climate change and cost of bank loans (Javadi & Masum, 2021; Li & Pan, 2022); quality of loan portfolio (Zhang, Chang, & Xuan, 2022). However, a research issue must be explored primarily on the underlying channel through which climate risk could influence bank performance. This study opines that there exist inconsistencies and gaps in the prevailing literature. Therefore, the main aim of this study is to explore the underlying channel through which climate risk may undermine bank profitability. This study investigates how and what extant climate risk could influence bank profitability in which bank liquidity creation acts as an underlying channel.

We also focus on the fact that the G-7 countries are primarily responsible for leading climate change policy protocols, according to the Intergovernmental Panel on Climate Change (IPCC) and the

United Nations Framework Convention on Climate Change (UNFCCC). The IPCC's 2021 report recognises the G-7 countries' efforts in implementing policies to mitigate climate change and move towards low-carbon and resilient societies.[2] Similarly, the UNFCCC's 2021 synthesis report on Nationally Determined Contributions highlights the G-7 countries' ambition in their NDCs and their significant steps in transitioning to a low-carbon economy.[3]

Considering these backgrounds, the main research question of this study is whether climate change-induced risk negatively affects bank profitability through its liquidity creation channel in the G-7 economies. We collect climate risk data from the Notre Dame Global Adaptation Initiative (ND-GAIN) of the University of Notre Dame. In addition, our study collects G-7 economies' bank-level annual data from the Fitch Connect database. We incorporate both universal and wholesale commercial banks active from 2001 to 2022. Likewise, this study collects macroeconomic data from the World Bank. We use the dynamic panel GMM estimator initially proposed by Hansen (1982) and Arellano & Bond (1991) and extended by Arellano & Bover (1995) and Blundell & Bond (1998). This study employs the dynamic panel GMM estimation to address the endogeneity issue. We find that climate change induced -risk negatively affects bank profitability. Moreover, this study explores how bank liquidity creation plays a significant role in their negative association as the underlying channel. Therefore, bank liquidity creation acts as the underlying channel in the negative influence of climate risk on bank profitability. The results are robust to the alternative measures of bank liquidity creation.

We believe our study contributes to the extant climate risk and bank profitability literature in two ways. First, the existing literature explores the relationship between climate risk and bank performance. For instance, Lee et al. (2022) examine the effect of climate risk on bank liquidity creation. Furthermore, Maso et al. (2022) investigate whether disaster-induced risk affects bank loan performance. Additionally, Zhang, Chang, & Xuan (2022) explore the influence of climate on bank performance. Therefore, the existing research focuses on the link between climate change and bank

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[2] IPCC. (2021). Climate Change 2021: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report. Retrieved from https://www.ipcc.ch/report/ar6/wg3/.

[3] UNFCCC. (2021). Synthesis report on the aggregate effect of the intended nationally determined contributions. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-determined-contributions-ndcs.

performance. In contrast, our study explores the underlying channel through which climate change-induced risk influences bank profitability. Second, this study uses its own bank liquidity creation data set rather than Bouwman's (2009)[4] Bank liquidity creation data using the most recent period up to 2022.

The rest of this paper is structured as follows. Section 2 presents a literature review and hypothesis development, and Section 3 covers data and methodologies. Further, Section 4 incorporates results and discussion. Finally, Section 5 presents the conclusion.

2. Literature Review and Hypothesis

Anticipated worldwide warming and intensified pressure on corporations regarding disclosing their exposure to climate-induced risk. However, whether firms' financial performance (return) adversely reacts to the exceptionally high temperatures is inconclusive. Moreover, investors cannot predict the economic implications of extreme warming as a first-order physical climate risk (Pankratz, Bauer, & Derwall, 2023). Bernstein, Gustafson, & Lewis (2019) explore that there is no association between sea level rise and rental rates of properties. Their findings intensify the necessity for the formulation of optimal climate change-oriented policy.

Financial intermediaries – banks, their regulatory bodies, and central banks are responsible for formulating and implementing effective policies to minimise the adverse effects of climate change-associated risk (Brunnermeier & Landau, 2022). Human-originated climate change is the reason for increased sea levels, flooding in the coastal area, extreme heat and agricultural distraction (Linnenluecke, Stathakis, & Griffiths, 2011). Kingwell & Xayavong (2017) argue that firms' exposure to the draught could reduce their financial performance. Climate change could drive opportunities and threats for business entities by expediting or slowing down business activities (WEF, 2019). Progressively adverse climate circumstances originate systematic risk for business firms worldwide. The possibility of loss due to significant storms, heat waves, and flooding could lessen firms' earnings and cash flows.

[4] See Bouwman's website (http://web.mit.edu/cbouwman/www/data.html) provides the database. This database includes the dollar amount of liquidity created by virtually every bank in the U.S. from 1993-2003, calculated using our four liquidity creation measures (our preferred "cat fat" measure, "cat nonfat", "mat fat" and "mat nonfat"), plus several alternative specifications used in our robustness checks.

In contrast, extreme adverse weather could intensify the volatility of their earnings and cash flows. Firms located in severe weather conditions in geographical areas play could drive to create financial slack by holding more cash and, thus, institutional resilience to the climatic threat. In addition, the extent of climate change-induced adverse impacts varies from industry to industry (Huang, Kerstein, & Wang, 2018). Climatic adverse events, like drought, influence rural wages in the long run elsewhere and immediately affect Brazil's labour market (Mueller & Osgood, 2009). Eleftheriadis & Anagnostopoulou (2015) argue that a significant association between firms' earnings capability and firm climate change-oriented disclosure does not exist. It is inevitable to emphasise the four issues concerning climate change, namely the amalgamation between climate-oriented policies, integration of climate into practice, climate services, and climate data to effectively manage climate change-induced risk (Tadesse, 2010).

The period of low rainfall intensifies water outages in which low-income and lower-middle-income economies act as driving forces. Water outages magnify the reduction of firm productivity located in less developed economies (Islam & Hyland, 2019). Li & Pan (2022) explore the transition form of climate risk repressively influencing bank performance, but the degree of such influence lessens in case of an increase in bank size. Moreover, economic policy uncertainty acts as a moderating variable in their association. Furthermore, the size of the bank loan plays an essential role in reducing the impact of climate change-induced transition risk on bank performance. Climate change could cause a loss in the banking sector due to damage to the physical assets of borrowers and depositors and a reduction in earning capacity and income level (Feridun & Gungor, 2020). O'Connell (2023) argues that capital, deposits, liquidity, productivity, expense control, size, concentration, inflation, and growth of the loan influence bank profitability. Non-performing loans, interest income, loans and advances, net income, and GDP affect bank performance in the context of loan loss provisions. Maso et al.(2022) explore that disaster risk positively affects bank loan loss provision. Non-performing loan ratio negatively affects forest land (Zhang, Chang, & Xuan, 2022). Based on the above discussion, this study proposes the following hypothesis:

H1. Climate change-induced risk adversely affects bank profitability of G-7 countries.

Bank profitability negatively reacts to bank liquidity creation. In addition, Bank size and capital ratio positively affect bank profitability, whereas operating efficiency and loan quality negatively influence it. Furthermore, macroeconomic factors, namely GDP and inflation, have a mixed effect (Sahyouni & Wang, 2018). There exists a positive impact of bank liquidity creation on profitability. Furthermore, bank profitability positively reacts to both liability and off-balance sheet liquidity creation, while a negative association exists between assets-side liquidity creation and profitability (Duan & Niu, 2020). A contradictory view exists regarding the impact of climate change-induced risk on bank liquidity creation. A group of scholars, namely Bos, Li, & Sanders (2022); Cort'es and Strahan (2017); Koetter, Noth, & Rehbein (2020); El Ghoul et al. (2011; Huynh et al. (2020); Javadi & Masum, (2021); Nguyen et al. (2020); Hu, Wang, & Wang (2021); Yao et al. (2021); Wu & Shen (2013). In contrast, Berger et al. (2017); Wang, Lee, and Chen (2022); Berger et al. (2022); Batten, Sowerbutts, & Tanaka (2020) argue that climate risk negatively affects bank liquidity creation.

Climate change is a threat to the economy of a country in various forms, namely an increase in flooding; climate change-related risks could trigger macroeconomic risks through their devastating effects on macroeconomic aggregates, like GDP, employment rate, and stability (Batten, Sowerbutts, & Tanaka, 2020; Burke, Hsiang, & Miguel, 2015; Kahn et al., 2021; Rezai et al., 2018). Investors switch to bank deposits from their direct investments due to an increase in macroeconomic risks. As a result, banks experience abundant deposits, which induces banks to excessive lending by lessening the lending standard. In this situation, two consequences would happen an increase in bank liquidity creation and a decrease in loan quality due to an increase in loan loss provisions (Acharya & Naqvi, 2012). Therefore, we hypothesise the following hypothesis:

H2. Climate risk negatively affects bank profitability of G-7 countries through liquidity creation channel.

3. Data and Methodology

This study collects G-7 economies' bank-level annual data from the Fitch Connect database. We incorporate both universal and wholesale commercial banks active from 2001 to 2022. Our study retrieves climate risk data from the Notre Dame Global Adaptation Initiative (ND-GAIN) of the

University of Notre Dame in three dimensions: sensitivity, exposure, and adaptive capacity (Lee et al., 2022). Furthermore, we collect macroeconomic and economic policy uncertainty data from the World Bank and the Economic Policy Uncertainty website that Baker, Bloom, and Davis developed.[5] Our study converts monthly EPU composite index data into yearly to match with other variables. Appendix A defines all the variables. For the comprehensive analysis, we collected a maximum of 39,794 observations for each relevant variable. Table 1 summarises the descriptive statistics.

[Please insert Table 1 about here]

The table shows that the mean of bank profitability is higher than the measure of climate change risk in our study. In addition, the standard deviation of bank profitability is greater than climate change-induced risk, which implies that the volatility of bank profitability is higher than its climate change–induced risk. Appendix A defines all variables.

[Please insert Table 2 about here]

Table 2 is the correlation matrix among capital, deposit assets ratio, loan growth, non-performing loan ratio, common equity tier 1 capital ratio, loan-deposit ratio, bank size, GDP, and inflation. The figures in the table confirm that the variables are not strongly correlated in our study since the correlation coefficient between the variables is less than 0.50.

[Please insert Table 3 about here]

Table 3 presents the output of the variance inflation factor (VIF), showing that the variance inflation factor is sound as the average VIF (1.08) for the variables is less than 10, according to the standard of Wooldridge (2016).

We use the dynamic panel GMM estimator initially proposed by Hansen (1982) and Arellano and Bond (1991) and extended by Arellano and Bover (1995) and Blundell and Bond (1998). We estimate the following dynamic model:

$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_1 CREXP_{j,t-1} + \beta_2 LCA + \beta_3 CREXPLCA + k_1 ROA_{j,t-1} + k_2 ROA_{j,t-2} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (1)$$

[5] http://www.policyuncertainty.com/index.html. This website contains monthly cross-country EPU, USA climate policy uncertainty and firm-level political risk data.

Where $\mathrm{ROA}_{j,t}$ is the proxy for bank profitability by bank *i* in year *t* and dependent variable, CREXP is the proxy for climate risk which analyses climate risk from the exposure (CREXP) dimension. This indicator of climate risk investigates how human beings and the economy react to the climate atmosphere in the future (Lee et al., 2022). The independent variable, CREXPLCA is the interaction between the proxy for bank liquidity creation measure climate risk, and LCA is the bank liquidity creation measure. We use this variable as an underlying variable. Construction of this index requires a three-step procedure: (i) cataloguing of all assets, liability, and off-balance sheet items as liquid, semi-liquid, or semi-liquid; (ii) allocating weights to the items grouped in step 1; and (iii) combination of items grouped in step 1 and 2 in various ways. $\mathrm{X}_{j,t-1}$ is a matrix of control variables: capital ratio, deposit assets ratio, loan growth, non-performing loan ratio, common equity tier 1 capital ratio, loan-deposit ratio, bank size, GDP growth rate and inflation. We run further models to see the effect of each explanatory variable separately as follows:

$$\mathrm{ROA}_{j,t} = \propto + \beta_1 CREXP_{j,t-1} + \beta_2 LCA + k_1 ROA_{j,t-1} + k_2 ROA_{j,t-2} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (2)$$

$$\mathrm{ROA}_{j,t} = \propto + \beta_1 CREXP_{j,t-1} + k_1 ROA_{j,t-1} + k_2 ROA_{j,t-2} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (3)$$

$$\mathrm{ROA}_{j,t} = \propto + \beta_2 LCA + k_1 ROA_{j,t-1} + k_2 ROA_{j,t-2} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (4)$$

$$\mathrm{ROA}_{j,t} = \propto + \beta_3 CREXPLCA + k_1 ROA_{j,t-1} + k_2 ROA_{j,t-2} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (5)$$

3. Results

This study applies a panel dynamic estimator to explore the influence of climate change–induced risk on bank profitability. The results of models in Table 4 illustrates the results of the dynamic panel GMM estimator to explore the relationship between climate risk and bank profitability through the possible underlying channel. In which, the dependent variable is bank profitability (ROA) and climate risk (CREXP) are dependent and independent variables, respectively. We use a set of bank-specbank-specific control variables: capital ratio, deposit assets ratio, loan growth rate, non-performing loan ratio, common equity tier 1 ratio, loan ratio, bank size, gross domestic product, and inflation, respectively. Moreover, this study employs a set of macro-specific variables, like, GDP and inflation. Appendix A defines all variables.

[Please insert Table 4 about here]

We can infer several stylised facts from Table 4. First, reviewing the result of Models (1) to (3), climate change induced-risk enters with a negative and significant coefficient, implying that an increase in climate risk may cause a decrease in bank profitability. Regarding control variables, we experience a significant positive influence on bank profitability of capital ratio, deposit ratio, bank size, non-performing loan ratio, loan ratio, and inflation. In contrast, loan growth, common equity tier 1 ratio, and GDP negatively affect bank profitability in our study. This implies a negative influence of climate risk on bank profitability in the G-7 economies throughout the two decades (from 2001 to 2022), consistent with our Hypothesis 1.

While this inference implies that climate change-related risks affect the profitability of banks, which then affects the overall performance of the banking industry, it does not show whether the negative impact of climate risk affects the banking sector's output by affecting its ability to create liquidity. Thus, we added variable that refer bank liquidity creation (LCA) an interaction term (CREXPLCA) that looks at the relationship between climate risk and bank liquidity creation.

We observe that bank liquidity creation may be an influential factor for bank profitability by reviewing the results of models (1) and (4), as we can observe the significance of the LCA variable, consistent with Duan & Niu (2020). At the same time, the table shows that the suggested interaction term (CREXPLCA) is significant for Model (1). This implies that their collective impact on bank profitability is negative on banks profitability. Additionally, the result of Model (2) reports that the influence of LCA coefficient is insignificant, suggesting that the influence of bank liquidity on banks' profitability might be relatively limited compared to the climate risk factor.

In the case of control variables of the baseline models, bank profitability (ROA) positively reacts to the capital ratio (CEQTA), deposit ratio (DPTA), non-performing loan ratio (NPLGL), loan ratio (GLDP), bank size (BS), inflation (INF). In contrast, loan growth and GDP negatively affect bank profitability (ROA) in our study. Finally, the common equity tier 1 capital ratio (CEQ1C) is insignificant, indicating that it does not influence bank profitability in our study.

Therefore, it is a rational inference that bank liquidity creation may act as an underlying channel in the negative influence of climate change-induced risk on bank profitability in the G-7 economies from 2001 to 2022, consistent with our Hypothesis 2.

4. **Robustness Checks**

We perform robustness tests to check the validity of the baseline findings by employing alternative measures of liquidity creation to explore the influence of climate risk on bank profitability empirically. We re-estimate the baseline model by using cat nonfat (CNFA), mat fat (MFA), and mat nonfat (MNFA) based alternative measures of bank liquidity as a robustness test.

Columns 1, 2, and 3 of Table 5 present the re-estimation findings of the dynamic panel GMM estimator to investigate the association between climate change-induced risk and bank profitability through the underlying channel (CNFA, MFA, and MNFA) in which dependent and independent variables are bank profitability (ROA) and climate risk (CREXP), respectively. This study uses a set of bank-specific control variables: capital ratio, deposit assets ratio, loan growth rate, non-performing loan ratio, common equity tier 1 ratio, loan ratio, bank size, gross domestic product, and inflation, respectively. Moreover, this study employs a set of macro-specific variables, like, GDP and inflation. Appendix A defines all variables.

[Please insert Table 5 about here]

Our study finds some major conclusions from Table 5. First, column 1 of the table reports that the climate risk measure (CREXP) appears with negative and significant coefficients (-10.833). We assume that an increase of 1 percentage point in climate risk contributes to a 10.833 point decrease in bank profitability. Furthermore, the interactions of climate change–induced risk and CNFA-based alternative bank liquidity creation measures are positive and significant (5.479), inferring that their joint influence on bank profitability is positive. Additionally, the coefficient on the CNFA-based bank liquidity creation (CNFA) is negative (-2.171), implying that bank profitability negatively reacts to its CNFA-based liquidity creation in contrast to Duan & Niu (2020). Moreover, In the case of control variables, bank profitability (ROA) positively reacts to the capital ratio (CEQTA), deposit ratio

(DPTA), non-performing loan ratio (NPLGL), loan ratio (GLDP), bank size (BS), inflation (INF). In contrast, in our study, GDP negatively affect bank profitability (ROA). Finally, loan growth (LGR), non-performing loan ratio (NPLG), and common equity tier 1 capital ratio (CEQ1C) are insignificant, indicating that it does not influence bank profitability in our study.

Second, column 2 of Table 5 reports that the climate risk measure (CREXP) appears with negative and significant coefficients (-0.003). We assume that an increase of 1 percentage point in climate risk contributes to a 0.003 – point decrease in bank profitability. Furthermore, the interactions of climate change–induced risk and MFA-based alternative bank liquidity creation measure are positive and significant (0.746), inferring that their joint influence on bank profitability is positive. Additionally, the coefficient on the MFA-based bank liquidity creation (MFA) is negative (-0.297), implying that bank profitability negatively reacts to its MFA -based liquidity creation in contrast to Duan & Niu (2020). Moreover, In the case of control variables, bank profitability (ROA) positively reacts to the capital ratio (CEQTA), deposit ratio (DPTA), non-performing loan ratio (NPLGL), bank size (BS), and inflation (INF). In contrast, in our study, GDP negatively affects bank profitability (ROA). Finally, loan growth (LGR), common equity tier 1 capital ratio (CEQ1C), and loan ratio (GLDP) are insignificant, indicating that it does not influence bank profitability in our study.

Third, column 3 of Table 5 reports that the climate risk measure (CREXP) appears with negative and significant coefficients (-9.739). We assume that an increase of 1 percentage point in climate risk contributes to a 9.739 point decrease in bank profitability. Furthermore, the interactions of climate change–induced risk and MNFA-based alternative bank liquidity creation measures are positive and significant (4.819), inferring that their joint impact on bank profitability is positive. Additionally, the coefficient on the MNFA-based bank liquidity creation (MNFA) is negative (-2.108), implying that bank profitability negatively reacts to its MNFA-based liquidity creation in contrast to Duan & Niu (2020). Moreover, In the case of control variables, bank profitability (ROA) positively reacts to the capital ratio (CEQTA), deposit ratio (DPTA), bank size (BS), and inflation (INF). In contrast, in our study, common equity tier 1 capital ratio (CEQ1C) and GDP negatively affect bank profitability (ROA). Finally, loan growth (LGR), non-performing loan ratio (NPLGL), and loan ratio are insignificant, indicating that it does not influence bank profitability in our study. Therefore, Table 6 confirms that our baseline results are robust to the alternative measures of bank liquidity creation.

The economic interpretation of our findings is that the banking industry's performance adversely reacts to climate change–induced risk through the bank liquidity creation channel. Adverse effect of such risk is taken place in the real economy in different ways which are follows: first, this risk could lead to corporate firms to make investment less and amplify unemployment and decrease purchasing power of households for homes and consumer durables; second, the said risk could play a significant role in lessening the supply of financial services, namely credits by banking financial institutions to both households and corporate firms; third, reduction in the supply of financial services by banks further harms real economy through decrease in household spending; fourth, a decrease in demand for corporate and industrial loans by corporate and households acts as an influential driving force for further reduction in banking industry output; and final, climate change – induced risk could play a significant role in lessening supply of credit due to higher liquidity hoarding by banks in order to protect themselves against amplified risks of liquidity shocks (Berger et al., 2017; Berger et al., 2020).

6. Conclusion

This study empirically explores the impact of climate risk on bank profitability on the G-7 economies' yearly panel data for 2001 to 2022. We use the dynamic panel GMM estimator in Arellano and Bond (1991) framework. We find that climate change risk negatively influences bank profitability in which liquidity creation acts as an underlying channel in the G-7 economies, consistent with our Hypotheses 1 and 2. This finding is consistent with that of Berger et al. (2017).

Our study contributes to the present climate risk and bank profitability literature in two ways. First, the existing literature examines the relationship between climate risk and bank performance, namely, climate risk and bank liquidity creation (Lee et al., 2022), disaster risk and loan quality (Maso et al., 2022), and climate change and bank performance (Zhang, Chang, & Xuan, 2022). Thus, the existing study gives more weight to the link between climate change and bank performance. In contrast, our study investigates the underlying channel through which climate change-induced risk influences bank profitability. Additionally, this study uses its own bank liquidity creation data set rather than Bouwman's (2009) bank liquidity creation data using the most recent period up to 2022.

The outcome of this research issue could have policy implications in the form of formulation of effective management of climate change management-oriented policy to minimise the devastating effect of climate risk on the banking sector. Furthermore, this study carries implications for further studies in different ways. First, the extent to which the credit default mechanism acts as a transmission channel in the impact of climate change on bank loan quality could be studied. Second, how climate change-oriented risk influences the performance of non-banking financial institutions could be explored.

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Tables

Table 1: Summary statistics of the variables of interest

This table provides a summary statistics analysis for our main variable of interest. Appendix provides variable definitions. ***, **, and * indicate 1%, 5%, and 10% level, respectively.

Variable	Obs	Mean	Std. Dev.	Min	Max
LLPGL	39794	6.005	2.005	-4250	1.009
CEQ1C	39794	5.001	6.001	7.004	3.001
NPLGL	39794	2.006	3.003	0	1.008
LGR	39794	3.007	9.005	-100	5.000
CREXP	39794	0.395	0.036	0.346	0.519
GDP	39794	0.594	1.293	-11.030	7.524
INF	39794	0.568	0.698	-1.352	3.856
LCA	19610	-8950340	1.007	1.006	1.001
CNFA	19610	4493577	1.003	-6.008	7.001
MFA	19610	1730408	1.004	-1.005	5.005
MNFA	19610	6048.364	1.001	5.001	1.002
ROA	19610	315731.900	1611694	-156.700	3.005
ROE	39776	2505669	2.008	-93.000	1.003
BS	19610	15.490540	8.408	1.678	31.767
GLDP	39705	6490540	2.006	-0.040	2.006
CEQTA	19610	0.117	1.159	-155.212	8.934
DPTA	19610	3.006	4.006	0	3.001

Table 2: Correlation matrix among key variables

This table provides the results of the correlation matrix CREXP, LCA, CEQTA, DPTA, LGR, NPLGL, CEQ1C, GLDP, BS, GDP, and INF. Appendix presents variable definitions.

	CREXP	LCA	CEQTA	DPTA	LGR	NPLGL	CEQ1C	GLDP	BS	GDP	INF
CREXP	1.000										
LCA	0.048	1.000									
CEQTA	-0.010	0.001	1.000								
DPTA	-0.018	0.151	0.0439	1.000							
LGR	-0.013	0.001	0.000	0.013	1.000						
NPLGL	0.1462	0.007	0.002	-0.025	-0.004	1.000					
CEQ1C	-0.013	-0.409	0.007	-0.078	-0.002	-0.004	1.000				
GLDP	0.001	0.007	0.000	-0.119	-0.001	-0.004	-0.008	1.000			
BS	0.080	-0.210	0.003	0.125	0.005	0.008	0.3553	0.029	1.000		
GDP	-0.107	0.004	-0.004	0.001	0.012	-0.070	0.000	0.006	-0.033	1.000	
INF	0.038	0.003	0.003	0.008	-0.042	0.009	-0.106	-0.061	0.025	-0.013	1.000

Table 3: Estimation of variance inflation factor

This table presents the variance inflation factor analysis results to examine whether multicollinearity is a problem in our study. Appendix provides variable definitions.

Variable	VIF	1/VIF
BS	1.190	0.850
CEQ1C	1.180	0.850
INF	1.120	0.892
GDP	1.110	0.892
DPTA	1.060	0.944
CREXP	1.050	0.953
NPLGL	1.040	0.964
GLDP	1.020	0.981
CEQTA	1.000	0.997
LGR	1.000	0.999
Mean VIF	1.08	

Table 4: Dynamic panel GMM estimation for the relationship between climate risk & bank profitability through liquidity creation channel

In this table, we report the results of the Arellano and Bond (1991) dynamic panel GMM estimator to examine the relationship between climate risk and bank profitability through liquidity creation channel in G7 economies. The models we estimate are:

$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_1 \mathrm{CREXP}_{\mathrm{j},t-1} + \beta_2 \mathrm{CREXPLCA} + \beta_3 \mathrm{LCA} + \mathrm{k}_1 \mathrm{ROA}_{\mathrm{j},t-1} + \gamma \mathrm{X}_{\mathrm{j},t-1} + \mathrm{n}_{\mathrm{i}} + \epsilon_{\mathrm{it}} \quad (1)$$
$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_1 CREXP_{j,t-1} + \beta_2 LCA + k_1 ROA_{j,t-1} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (2)$$
$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_1 CREXP_{j,t-1} + k_1 ROA_{j,t-1} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (3)$$
$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_2 LCA + k_1 ROA_{j,t-1} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (4)$$
$$\mathrm{ROA}_{\mathrm{j,t}} = \propto + \beta_3 CREXPLCA + k_1 ROA_{j,t-1} + \gamma X_{j,t-1} + n_j + \epsilon_{it} \quad (5)$$

The model employs one lag of ROA as a regressor variable. The dependent variable is bank profitability, whereas climate risk is the independent variable. This study incorporates LCA and CREXPLCA to examine if bank liquidity creation acts as an underlying channel in the effect of climate risk on bank profitability. We use capital ratio, deposit ratio, loan growth, non-performing loan ratio, common equity tier 1 capital ratio, loan deposit ratio, bank size, loan ratio, GDP, and inflation to control the model. Appendix provides variable definitions. Standard errors are reported in parentheses. ***, **, and * indicate 1%, 5%, and 10% levels, respectively.

	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**
$\mathbf{ROA_{t-1}}$	-0.003***	-0.003***	-0.003**	-0.771***	-0.002***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
CREXP	-12.476***	-12.366***	-12.366***		
	(1.188)	(1.188)	(1.188)		
LCA	0.178**	-0.001		-0.001***	
	(0.069)	(0.002)		(0.000)	
CREXPLCA	-0.464**				0.003
	(0.179)				(0.006)
CEQTA	0.192***	0.192***	0.192***	98745.120***	0.187***
	(0.005)	(0.005)	(0.005)	(22667.070)	(0.005)
DPTA	0.198***	0.196***	0.196***	-0.000***	0.186***
	(0.017)	(0.178)	(0.178)	(0.000)	(0.017)
LGR	-1.007*	-1.007	-1.007	2.004***	-1.003
	(1.000)	(1.000)	(1.000)	(8.002)	(1.007)
NPLGL	0.001**	0.001**	0.001**	1.003	0.000*
	(0.000)	(0.000)	(0.000)	(1.001)	(0.000)
CEQ1C	-2.001	-1.005	-1.005	6.008	-1.009
	(5.000)	(5.000)	(5.000)	(5.003)	(5.003)
GLDP	0.001*	1.000*	1.000*	-0.000	1.009*
	(9.007)	(9.007)	(9.007)	(0.000)	(9.007)
BS	0.056***	0.056***	0.056***	-136986.400***	0.047***
	(0.000)	(0.003)	(0.003)	(3345.787)	(0.002)
GDP	-0.001**	-0.001*	-0.001*	-502.965	-0.001*
	(0.004)	(0.004)	(0.004)	(2158.526)	(0.000)
INF	0.004**	0.004*	0.004*	-234.343	0.004*
	(0.001)	(0.001)	(0.001)	(8901.868)	(0.001)
CONS	3.558***	3.513***	3.513***	2249051.000***	-1.185***
	(0.455)	(0.455)	(0.455)	(55087.850)	(0.059)
No. of observations	8037	8037	8037	8037	8037
No. of panels	776	776	776	776	776

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Dynamic panel GMM estimation for the relationship between climate risk & bank profitability through alternative measures of liquidity creation channel

In this table, we present the results of the Arellano and Bond (1991) dynamic panel GMM estimator to examine the relationship between climate risk and bank profitability through the alternative measure of liquidity creation channel in G7 economies. The model we estimate is

$$ROA_{j,t} = \propto + \beta_1 CREXP_{j,t-1} + \beta_2 CREXPLCA + \beta_3 LCA + k_1 ROA_{j,t-1} + k_2 \gamma X_{j,t-1} + n_i + \epsilon_{it}$$

The model employs one lag of ROA as a regressor variable. The dependent variable is bank profitability, whereas climate risk is the independent variable. This study incorporates LCA and CREXPLCA to examine if bank liquidity creation acts as an underlying channel in the effect of climate risk on bank profitability. We use capital ratio, deposit ratio, loan growth, non-performing loan ratio, common equity tier 1 capital ratio, loan deposit ratio, bank size, loan ratio, GDP, and inflation to control the model. Appendix provides variable definitions. Standard errors are reported in parentheses. ***, **, and * indicate 1%, 5%, and 10% levels, respectively.

	(1) CNFA	(2) MFA	(3) MFNA
ROA_{t-1}	-0.003***	-0.003***	-0.002***
	(0.000)	(0.000)	(0.000)
CREXP	-10.833***	-12.206***	-9.739***
	(1.179)	(1.186)	(1.150)
CREXPCNFA	5.479***		
	(0.397)		
CNFA	-2.171***		
	(0.157)		
CREXPMFA		0.746***	
		(0.170)	
MFA		-0.297***	
		(0.066)	
CREXPMNFA			4.819***
			(0.340)
MNFA			-2.108***
			(0.134)
CEQTA	0.184***	0.189***	0.085***
	(0.009)	(0.005)	(0.008)
DPTA	0.210***	0.197***	0.241***
	(0.0170	(0.017)	(0.017)
LGR	-8.004	-1.006	-9.005
	(9.009)	(1.000)	(9.009)
NPLGL	0.001	0.001**	0.000
	(0.000)	(0.000)	(0.000)
CEQ1C	-1.009	-2.007	-2.002
	(4.008)	(5.000)	(4.07)
GLDP	1.006*	1.005	1.003
	(9.006)	(9.007)	(9.004)
BS	0.052***	0.055**	0.047***
	(0.003)	(0.003)	(0.003)
GDP	-0.001**	-0.001**	-0.003*
	(0.000)	(0.000)	(0.000)
INF	0.004**	0.004**	0.003*
	(0.001)	(0.001)	(0.001)
CONS	2.987***	3.457***	2.657***
	(0.451)	(0.454)	(0.001)
No. of observations	8037	8037	8037
No. of panels	776	776	776

*** p<0.01, ** p<0.05, * p<0.1

Appendix: Definitions and sources of variables

Variable	Definition	Source
Panel A: Liquidity creation measures (bank level)		
LC	Bank total liquidity creation which computed by using (0.50×ILLQDA) +(0.5× ILLQDL) -(0.5×LQDA) - (0.5×ILLQDL) - (0.5×TEQ)	Fitch Connect
LCA	Normalised bank total liquidity creation which is computed as bank total liquidity creation divided by total assets	Fitch Connect
CNFA	Normalised CNFA-based alternative measure of bank total liquidity creation, which is computed as bank total liquidity creation divided by total assets	Fitch Connect
MFA	Normalised mat fat-based alternative measure of bank liquidity creation is computed as bank liquidity creation divided by total assets (T.A.)	Fitch Connect
MNFA	Mat nonfat-based alternative measure of bank liquidity creation and computed based on (0.5×ILLQDA) +(0.5×LQDL) +(0×semiliquid assets) +(0×semiliquid liabilities) -(0.5×LQDA) -(0.5×ILLQDL) -(0.5×TEQ)	Fitch Connect
Panel B: Bank-specific control variables (bank level)		
RWATA	Risk-weighted assets ratio and computed as risk-weighted assets divided by total assets	Fitch Connect
CEQ1C	Common equity tier 1 capital ratio and it is computed as common equity tier 1 capital divided by total capital	Fitch Connect
GLDEP	Gross loans bank deposit ratio Gross loans divided by bank total deposit	Fitch Connect
NPLGL	Non-performing loans ratio and computed as non-performing loans divided by gross loans	Fitch Connect
LLPGL	Loan loss provision ratio and loan loss provision divided by gross loans	Fitch Connect
CEQTTA	Common equity to total assets ratio and computed as common equity divided by total assets	Fitch Connect
ROE	Return on equity which is net income (*NINCM*) divided by total equity (*TEQ*)	Fitch Connect
B.S.	Bank size which is Log of total assets	Fitch Connect
Panel C: Climate risk		
CREXP	Proxy for climate change induced – risk from exposure aspect	https://gain.nd.edu/
Panel D: Macroeconomic specific control variables		
INF	Inflation rate and computed as the current period consumer price index (*CPI*) minus the previous period *CPI* divided by the previous period (CPI)	https://data.worldbank.org
GDP	GDP growth rates	https://data.worldbank.org