|  |  |
| --- | --- |
|  |  |
| **Working Paper 2023.2.3.15****- Vol 2, No 3** |
|  |

**TÁC ĐỘNG CỦA SỰ TIẾP XÚC VỚI BIẾN ĐỔI KHÍ HẬU ĐẾN HIỆU QUẢ HOẠT ĐỘNG CỦA NGÂN HÀNG: VAI TRÒ CỦA CHỈ SỐ CHẤT LƯỢNG MÔI TRƯỜNG PHÁP LÝ**

**Lưu Ngọc Lan[[1]](#footnote-1)**

Sinh viên K60 Khoa Kế toán Kiểm toán

*Trường Đại học Ngoại thương, Hà Nội, Việt Nam*

**Nguyễn Ngọc Hà**

Sinh viên K60 Khoa Tài chính Ngân hàng

*Trường Đại học Ngoại thương, Hà Nội, Việt Nam*

**Hoàng Thu Trang**

Sinh viên K63 Khoa Ngân hàng

*Trường Đại học Kinh tế Quốc dân*

**Kim Hương Trang**

Giảng viên khoa Tài chính Ngân hàng

*Trường Đại học Ngoại thương, Hà Nội, Việt Nam*

**Tóm tắt**

Nghiên cứu phân tích những ảnh hưởng của sự tiếp xúc với biến đổi khí hậu đến hiệu quả hoạt động của các ngân hàng tại 9 quốc gia trong khu vực Đông Á và Đông Nam Á. Nhóm tác giả xây dựng một danh sách từ khóa để đo lường mức độ tiếp xúc biến đổi khí hậu và ứng dụng phương pháp xử lý ngôn ngữ và ước lượng tác động cố định nhằm khẳng định mối quan hệ tích cực giữa mức độ tiếp xúc đối với các hiện tượng tự nhiên của biến đổi khí hậu tới hiệu quả hoạt động của ngành ngân hàng. Bên cạnh đó, nghiên cứu khẳng định vai trò trung gian của chỉ số chất lượng môi trường pháp lý trong mối quan hệ trên. Tại các nước có chỉ số chất lượng môi trường pháp lý cao hơn, tác động tích cực của biến đổi khí hậu tới hiệu quả hoạt động của ngân hàng cũng rõ rệt hơn. Từ những kết quả thu được, nhóm tác giả nhấn mạnh tầm quan trọng của việc nâng cao chỉ số chất lượng môi trường pháp lý tại các quốc gia, nhất là tại khu vực đang chịu ảnh hưởng nghiêm trọng bởi biến đổi khí hậu, nhằm cải thiện hoạt động ngân hàng.

**HOW CAN CLIMATE CHANGE EXPOSURE AFFECT BANK PERFORMANCE? THE ROLE OF REGULATORY QUALITY**

# Abstract

This study delves into the impact of climate change exposure on bank performance across nine countries in the East Asia-Pacific region. Our methodology involves employing a climate change exposure dictionary and conducting textual analysis on bank reports. The results illuminate a positive correlation between climate change physical exposure and overall bank performance in the full sample, with no discernible difference between non-subsidiaries and subsidiaries. Furthermore, we identify that the positive effects of both regulatory and physical exposure are more pronounced in countries characterized by higher regulatory quality. This research contributes to the understanding of how climate change exposure shapes the dynamics of banking firms, emphasizing the crucial role of regulatory quality in a region particularly vulnerable to climate change.

**Keywords:** climate change exposure, bank performance, regulatory environment

**JEL:** G18, G32, G38, Q54

# Introduction

Banks are crucial drivers of economic progress and play a key role in addressing sustainability and innovation in the age of circular economy (Allen & Gale, 2000; Drigă et al., 2014). Recent studies highlight climate change's potential impact on the financial system, especially in the banking sector (Batten et al., 2016; Battiston et al., 2021). Limited research on how climate change affects the Asia-Pacific banking industry underscores the need for banks to develop effective strategies amid evolving climate patterns. To address this, we explore three dimensions of climate change influence in the Asia-Pacific banking sector: physical impact, regulatory exposure, and opportunities from environmental challenges.

Post-2008 crisis, financial systems have adapted to risks, including environmental, social, and governance (ESG) factors. Assessing the impact of regulations on the link between climate change exposure and bank performance, we use The World Bank's regulatory quality index. Categorizing countries by regulatory quality levels gives us insights on how this index influences the relationship between climate change exposure and bank efficiency (Barth et al., 2013; Slattery & Nellis, 2005).

Using the textual analysis method proposed by Sautner et al. (2020), we analyze the impact of climate change exposure on a sample of 260 banks from nine Asia-Pacific countries spanning 2010-2021, offering the following contributions:

Firstly, we contribute to the theory by clarifying the term "climate change exposure" in nine vulnerable Asian countries.

Secondly, we create a new dictionary for measuring climate change exposure through textual analysis. This dictionary enhances our ability to capture the extent of climate change exposure faced by banks, providing a valuable tool for future research.

Thỉdly, by categorizing the studied countries based on regulatory quality, we offer valuable managerial implications for banks to effectively adapt to climate change challenges.

Our study reveals several key findings. Utilizing a fixed effect model and controlling for unobserved heterogeneity at multiple levels (country, firm, and year), no difference in the impact on subsidiaries and headquarters is observed and there is a positive effect of climate change physical exposure on bank profitability. In addition, in a high regulatory environment, bank performance shows a positive coefficient with both climate change physical and regulatory exposure.

Our study unfolds as follows: In Section 2 reviews existing literature and develop hypotheses. Section 3 outlines the construction of climate change exposure variables, data collection for dependent and control variables, and provides an overview of sample variable characteristics. Section 4 details model specifications. Section 5 presents and analyzes empirical results on the relationship between climate change exposure and bank performance. Finally, in Section 6, we summarize the study and draw conclusions.

# Literature review and hypothesis development

Most previous studies indicate a negative impact of climate change on global economy. However, recent research offers varying perspectives, suggesting that climate change can lead to diverse outcomes for businesses.

The relationship between climate change exposure and bank performance

Climate change regulatory exposure has varied impacts on bank performance, with harsh regulations potentially causing shocks and negative consequences (Battiston et al., 2017; Galletta et al., 2021). However, most research indicates a positive correlation between climate change regulatory exposure and firm performance. Integration of environmental, social, and governance (ESG) standards in the banking industry, driven by regulations, contributes to positive outcomes (Bruna et al., 2022; Ellili, 2022; Kim et al., 2021), and banks prioritizing these issues may reduce loan risks (Birindelli et al., 2022).

Studies on climate change opportunity exposure and bank performance highlight that investing in green technology presents opportunities, especially in renewable energy and carbon reduction fields (Kadan & Tang, 2020; Martin & Wagner, 2019; Sautner et al., 2020), despite accompanying higher risk.

Similarly, examining physical climate change exposure at the firm level, its impact on performance is inconsistent. While natural calamities may evoke negative effects, companies with greater physical exposure are often less risky, utilizing insurance to protect against climate events (Sautner et al. 2020). The "productivity effect" suggests disasters drive creativity, creating new opportunities for businesses (Albala-Bertrand, 1993; Benson & Clay, 2004; Crespo Cuaresma et al., 2008; Okuyama, 2003). Overall, a higher degree of climate change exposure is positively associated with bank performance.

Drawing from research on the impact of climate change regulations on bank performance, we propose the following hypothesis:

***Hypothesis 1:*** *Climate change exposure positively influences bank performance.*

Impacts of climate change exposure in different regulatory quality environment

In response to the current climate change scenario, governments globally are implementing regulations to counter environmental shifts and promote sustainability in business. The Porter hypothesis (1991) suggests that stringent environmental policies empower companies to reduce emissions, fostering economic development. Recent studies support this, highlighting the pivotal role of robust environmental regulations in mitigating climate change, driving innovation, and boosting profits in the circular economy (Petitjean et al., 2019; Rennings & Rammer, 2011).

To assess governments' effectiveness in formulating and enforcing rational laws, we use The World Bank's Regulatory Quality index (2022) as a benchmark. Studies show the positive impact of regulations in countries with high regulatory quality, reducing carbon emissions (Ali et al., 2019; Sarwar & Alsaggaf, 2021; Wawrzyniak & Doryń, 2020). Barkemeyer et al. (2017) also indicate that countries with high regulatory quality increase media coverage on climate change, shaping public and business perceptions.

Building on studies about climate change regulations' impact on banking and the influence of regulatory quality on climate, we hypothesize:

***Hypothesis 2:*** *The effects of climate change exposure on bank performance will be more pronounced in countries with higher regulatory quality.*

# Data and empirical strategy

## *Data and variables selection*

We study bank in East Asia-Pacific, specifically Malaysia, Indonesia, Philippines, Vietnam, Singapore, Thailand, South Korea, Japan, and China. We include banks meeting two key criteria: (1) they have accounting data spanning the years 2010 to 2021 available in the BankFocus database and (2) have English annual reports and/or sustainability reports on their websites. Our dataset comprises 260 banks and financial holding companies, totaling 2,365 firm-year observations.

### Climate change exposure variables

We utilize a textual analysis approach to create our climate change exposure variables. Initially, we form our dictionary by combining three dictionaries from Sautner et al. (2020), Baz et al. (2021), and the Climate Finance Glossary by the UNDP. Subsequently, we gather annual and sustainability reports released by banks in Northeast and Southeast Asia. Relevant paragraphs addressing climate change and environmental issues are extracted from the respective sections. The subsequent step involves applying the set of climate change keywords to the selected portions of the report for firm i in year t and tallying the frequency of these keywords (Sautner et al., 2020; Baz et al., 2021; UNDP Climate Finance Glossary).

$CCEO\_{it}=\frac{tCCEO\_{it} }{TW\_{it}}x100\%$ (i)

$CCER\_{it}=\frac{tCCER\_{it} }{TW\_{it}}x100\%$ (ii)

$CCEP\_{it}=\frac{tCCEP\_{it} }{TW\_{it}}x100\%$ (iii)

Where:

$CCEO\_{it}$**,** $CCER\_{it}$**,** $CCEP\_{it}$**:** the frequency of keywords of each type that appear on the report of bank *i* in year *t*

$TW\_{it}:$ the total number of words in the selected parts in the report of bank i in year t.

$tCCEO\_{it}$**,** $tCCER\_{it}$**,** $tCCEP\_{it}$**:** total number of keywords of each type that appear on the report of bank i in year t.

### Dependent variables

We use the dependent variables mostly used in previous studies (Dietrich and Wanzenried 2010; Heffernan and Fu 2008; Pasiouras and Kosmidou 2007; Popovici 2023) - return on avarage assets (ROAA) and return on average equity (ROAE) in our study. According to Dietrich and Wanzenried (2010), ROAA is the better measure of profitability as the ROAE ignores the increased risk brought on by excessive leverage as well as the impact of legislation on leverage.

### Control variables

***Efficiency***

To assess efficiency, we employ two ratios: cost to income and non-interest expense to total assets. The literature on the impact of the cost to income ratio on firm performance is inconclusive. Mathuva (2009) indicates a negative relationship with bank profitability, while Sufian et al. (2012) suggest a positive and significant impact of bank costs on performance. Operational efficiency, measured by the ratio of non-interest expense to average assets, is crucial for bank profitability (Mehzabin et al., 2022). Empirical studies, including Amare (2021) and Mehzabin et al. (2022), have demonstrated that enhancing operational efficiency contributes to increased bank profitability.

***Bank size***

Larger banks are better positioned than smaller banks to take advantage of economies of scale in transactions, which has the obvious consequence that they will typically enjoy a higher level of profits. This fact is captured by size. Bikker and Hu (2002), Goddard and Wilson (2004) and Philip Molyneux (1992) find size is positively related to profitability. The size of the bank is also included as an independent variable to account for size related economies and diseconomies of scale. Therefore, we use the total assets of the firms as a proxy for bank size.

***Leverage***

According to Nakao et al. (2007), top environmental performers, who utilize less leverage, align with top financial performers, indicating their shared interests. Besides, the ratio of equity to total assets positively influences return on assets (ROA) but negatively affects return on equity (ROE) (Fatih Macit, 2012). In this study, we use the equity to assets ratio as proxy for leverage.

***Liquidity***

Previous empirical studies showed the significant relationship between bank profitability and loan quality (Trujillo-Ponce, 2013; Venkatesh & Suresh, 2014). Net loans to total assets and liquid assets to deposit and borrowings were used to measure the liquidity ratio of banks. Higher ratios may be indicative of better bank performance because of increases in interest income. In our study, we use these two loans ratios to proxy for liquidity.

***Asset quality***

The impaired loans to equity represent unrecoverable debts that are not covered by equity, highlighting the loan portfolio's weakness in relation to the bank's capital. A higher percentage of such loans signifies a more unfavorable position for the bank (Venkatesh & Suresh, 2014). In this study we use the ratio of impaired loans to equity to proxy for asset quality of a bank in the context of climate change exposure assessment.

***Subsidiary dummy***

The dummy variable in our study indicates whether the collected indexes are derived from the headquarters or subsidiaries of the firms. Using financial data obtained from BankFocus, we filtered the data based on the type of firms: parent firms or subsidiaries. A value of 0 is assigned if the observed firms are headquarters or independent firms, and a value of 1 is assigned if the firms are subsidiaries.

## *Empirical specification*

To investigate the relationship between climate change exposure and bank performance in two group of regulatory quality level, we employ the following model in two sub-samples:

$Y\_{it}=α+β\_{1}CCEO\_{it}+β\_{2}CCER\_{it}+β\_{3}CCEP\_{it}+β\_{4}Subsidiary\_{it}+β\_{5}Subsidiary\_{it}×CCEO\_{it}+β\_{6}Subsidiary\_{it}×CCER\_{it}+β\_{7}Subsidiary\_{it}×CCEP\_{it}+X\_{it}γ+u\_{t}+θ\_{i}+ε\_{it}$ (1)

where $Y\_{it}$ represents the performance of bank *i* in year *t*, proxied by ROAA or ROAE. $Subsidiary\_{it}$ is the a dummy variable which equals 1 if a firm is a subsidiary in year t and 0 otherwise. $CCEO\_{it}$, $CCER\_{it}$ and $CCEP\_{it}$is the indicators of bank *i*’s opportunity, regulatory, and physical climate change exposure in year *t*, respectively. $X\_{it}$ is a vector of control variables that can affect bank performance. Definitions of all variables can be found in Table 1. $u\_{t}$ and $θ\_{i}$ represents time and firm fixed effects, respectively. Model (1) is estimated using the fixed effect estimator.

## Descriptive statistics

The descriptive statistics of the main regression variables in our study are shown in Table 1. Since headquarters and subsidiaries operate in the same country, they share similar levels of climate change exposure. Within our sample, headquarters and independent banks account for 81.48% of the total observations, while subsidiaries make up the remaining 18.52%. While there may be variations in the financial data between subsidiaries and headquarters due to separate disclosures in financial statements, the climate change exposure data for both types of banks are generally aligned.

|  |  |  |
| --- | --- | --- |
|  | **Full sample** | **Sub-sample** |
| **Headquarter and independent banks** | **Subsidiaries** |
| **Variable** | **Obs** | **Mean** | **Obs** | **Mean** | **Obs** | **Mean** |
| ROAA | 2,300 | 0.79 | 1,862 | 0.84 | 438 | 0.56 |
| ROAE | 2,300 | 8.28 | 1,862 | 8.78 | 438 | 6.17 |
| CCEO | 2,365 | 0.17 | 1,927 | 0.17 | 438 | 0.17 |
| CCER | 2,365 | 0.34 | 1,927 | 0.34 | 438 | 0.32 |
| CCEP | 2,365 | 0.12 | 1,927 | 0.12 | 438 | 0.14 |
| Cost to income | 2,287 | 64.62 | 1,849 | 65.22 | 438 | 62.12 |
| Net loans to total assets | 2,320 | 56.93 | 1,891 | 55.56 | 429 | 63.01 |
| Equity to total assets | 2,337 | 13.08 | 1,899 | 13.44 | 438 | 11.52 |
| Total assets | 2,337 | 17.11 | 1,899 | 17.13 | 438 | 17.00 |
| Non interest expense to average assets | 2,300 | 2.53 | 1,862 | 2.64 | 438 | 2.06 |
| Impaired loans to equity | 2,148 | 18.73 | 1,727 | 19.34 | 421 | 16.22 |
| Liquid assets to deposit and borrowings | 2,294 | 26.71 | 1,867 | 27.74 | 427 | 22.18 |

Notes: Table 1 summarizes the main regression variables in this study. CCEO, CCER, CCEP are abbreviations for climate change opportunities, regulatory and physical exposure respectively. ROAA and ROAE are shown in percentage (%). The total assets variable is measured at the natural logarithm of bank’s total assets.The average ROAA of 0.79 in our sample indicates a relatively close mean value compared to the study conducted by Dietrich et al. (2010), where they reported a mean ROAA of 0.68. Similarly, the mean value of ROAE in our study is 8.27, which is in close proximity to the mean ROAE of 7.59 reported by Dietrich et al. (2010).

Our self-constructed climate change exposure index consists of three components: climate change opportunities (CCEO), climate change regulatory exposure (CCER), and climate change physical exposure (CCEP). It is worth noting that all these variables are expressed as percentages. The mean value of the climate change exposure index (CCEO) is 0.16. This indicates a relatively modest level of exposure to potential benefits arising from climate change-related factors. In contrast, banks in our sample exhibit a higher degree of exposure to climate change regulatory factors. The mean value of climate change regulatory exposure (CCER) is 0.33%, with the highest recorded percentage reaching 4.17%. This suggests that banks face varying levels of regulatory challenges and requirements related to climate change across different jurisdictions. Regarding climate change physical exposure (CCEP), the average value is 0.12%, indicating that, on average, banks in our sample have a relatively minor level of exposure to climate-related physical phenomena.

**Table 1:** Cross-relation matrix for the main regression variables

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | ROAA | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | ROAE | 0.3637\* | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | Subsidiary | -0.0707\* | -0.0816\* | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 4 | CCEO | 0.0104 | -0.0171 | 0.0091 | 1 |  |  |  |  |  |  |  |  |  |  |
| 5 | CCER | 0.0412 | 0.001 | -0.0138 | 0.3034\* | 1 |  |  |  |  |  |  |  |  |  |
| 6 | CCEP | 0.0067 | -0.0257 | 0.0301 | 0.0509 | 0.0788\* | 1 |  |  |  |  |  |  |  |  |
| 7 | Stock price volatility | -0.035 | 0.0403 | -0.0301 | 0.0086 | -0.0205 | 0.0367 | 1 |  |  |  |  |  |  |  |
| 8 | Cost to income | -0.1491\* | -0.1655\* | -0.0057 | -0.0103 | -0.0299 | 0.0242 | 0.0144 | 1 |  |  |  |  |  |  |
| 9 | Net loans to total assets | -0.1260\* | -0.0146 | 0.1641\* | -0.0131 | -0.0312 | 0.0777\* | -0.1707\* | -0.0536 | 1 |  |  |  |  |  |
| 10 | Equity to total assets | 0.2764\* | -0.1428\* | -0.0473 | 0.017 | 0.0464 | 0.0590\* | -0.0609\* | -0.0131 | -0.2310\* | 1 |  |  |  |  |
| 11 | Total assets | -0.0221 | 0.1588\* | -0.0223 | 0.2701\* | 0.2434\* | 0.0188 | 0.1547\* | -0.0814\* | -0.0372 | -0.3868\* | 1 |  |  |  |
| 12 | Non interest expense to average assets | -0.0871\* | -0.1231\* | -0.0934\* | -0.1197\* | -0.0848\* | -0.0183 | -0.0426 | 0.0523 | 0.0157 | 0.1819\* | -0.4590\* | 1 |  |  |
| 13 | Impaired loans to equity | -0.1102\* | -0.3377\* | -0.035 | -0.0531 | -0.0152 | -0.0211 | 0.021 | 0.0068 | 0.1161\* | -0.0421 | -0.0767\* | 0.1464\* | 1 |  |
| 14 | Liquid assets to deposit and borrowings | 0.0738\* | -0.0327 | -0.0257 | 0.0876\* | 0.1183\* | -0.0053 | 0.0414 | -0.0022 | -0.3491\* | 0.4000\* | -0.0805\* | 0.0054 | -0.0554 | 1 |

Notes: Table 3 reports the correlation matrix among variables. Asterisk \* indicates significance at 1% level. ROAA and ROAE are measured at percentage. CCEO, CCER, CCEP stand for climate change opportunities, regulatory and physical exposure respectively.

Table 3 shows the cross-relation matrix for the main regression variables. The subsidiary variable has a negative relationship with both ROAA and ROAE. The correlation coefficient for subsidiary and ROAA is -0.0707 (p<0.01), indicating a weak negative relationship. Similarly, the correlation coefficient for subsidiary and ROAE is -0.0816 (p<0.01), suggesting a slightly stronger negative relationship.

# Results and discussions

**Table 2:** Impacts of climate change exposure on performance of headquarters, independent banks and subsidiaries

|  |  |
| --- | --- |
|  | ROAA |
| Subsidiary | -0.036 |
|  | (0.903) |
|  |  |
| CCEO | 0.027 |
|  | (0.792) |
|  |  |
| CCER | 0.11 |
|  | (0.159) |
|  |  |
| CCEP | 0.36\*\*\* |
|  | (0.004) |
|  |  |
| Subsidiary x CCEO | -0.031 |
|  | (0.915) |
|  |  |
| Subsidiary x CCER | -0.095 |
|  | (0.670) |
|  |  |
| Subsidiary x CCEP | -0.39 |
|  | (0.201) |
|  |  |
| Cost to income\_ | -0.00055\*\*\* |
|  | (0.000) |
|  |  |
| Net loans to total assets | -0.0091\*\* |
|  | (0.019) |
|  |  |
| Equity to total assets | 0.032\*\*\* |
|  | (0.000) |
|  |  |
| Total assets | 0.0095 |
|  | (0.897) |
|  |  |
| Non-interest expense to average assets\_ | -0.41\*\*\* |
|  | (0.000) |
|  |  |
| Impaired loans to equity | 0.0013 |
|  | (0.519) |
|  |  |
| Liquid assets to deposits and borrowings | 0.0022\*\* |
|  | (0.026) |
|  |  |
| Intercept | 1.67 |
|  | (0.203) |
| *N* | 2080 |
| *R*2 | 0.49 |

Notes: Table 4 reports the effect of climate change exposure on bank performance from a fixed effect model, considering subsidiary factor. CCEO, CCER, CCEP stand for climate change opportunities, regulatory and physical exposure respectively. Subsidiary equals 1 if the bank is a subsidiary, and 0 otherwise. P-value are in parentheses. Asterisks \*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% respectively.

Table 3 presents the results for Model (1), showing the relationship between climate change exposure and bank performance. Consistent with previous studies by Sautner et al. (2020) and Cuaresma et al., (2008), our findings in the baseline estimation partly support Hypothesis 1, indicating a positive correlation between the degree of physical exposure to climate change and bank performance. Specifically, a one-unit increase in climate change physical exposure is associated with a significant 0.359 percentage increase in ROAA (β=0.359, p<0.01) and a 1.406 percentage increase in ROAE (β =1.406, p<0.05). One possible explanation for this is that banks that prioritize and address the physical impacts of climate change are more likely to take proactive measures to safeguard themselves against climate-related events. By doing so, they enhance their ability to protect their profitability and financial stability. This finding also supports the idea that firms with higher levels of climate change physical exposure actively manage their risks, leading to improved financial performance. Furthermore, companies that demonstrate a strong commitment to addressing climate change physical exposure tend to be perceived more favorably by investors and stakeholders. This positive perception may attract more investment capital and positively impact the overall financial performance of these banks. Therefore, adopting a proactive approach to managing physical exposure to climate change may present a strategic advantage for banks seeking enhanced financial performance and long-term sustainability.

In contrast, we do not observe any conclusive and significant links between returns and the regulatory or opportunity exposure. This could be explained by several factors. For instance, despite the growing concerns and efforts, the regulations related to environmental risks in Asia-Pacific region are still limited, as some countries are still in the initial stage of issuing guidance and standard for banks to actively identify opportunity and adapting to low-carbon transition . In this sense, banks might not take into account their exposure to the potential changes in environmental regulations in decision making, which diminishes the observed impact on bank performance.

Moreover, our analysis demonstrates that the interaction terms involving exposure to climate change opportunities, climate change regulatory exposure, climate change physical exposure, and subsidiary status do not exert a statistically significant impact on either ROAA or ROAE. This implies that the subsidiary status of a bank does not affect the influence of climate change exposure on its performance. One possible explanation for this finding is that, within our sample, both headquarters and subsidiaries share the same climate change exposure index since they operate in the same country.

Regulatory quality could affect the extent to which firms’ operations are affected to climate change, especially climate change-related regulations. To investigate this possibility, we estimate Model (1) by sub-samples of high- versus low-regulatory quality.

**Table 4:** Effects of climate change exposure on bank performance in different regulatory quality environment

|  |  |  |
| --- | --- | --- |
|  | **High regulatory quality** | **Low regulatory quality** |
| Subsidiary | -0.0226 | -0.293 |
|  | (0.946) | (0.636) |
|  |  |  |
| CCEO | 0.0358 | -0.0499 |
|  | (0.834) | (0.489) |
|  |  |  |
| CCER | 0.199\* | -0.0326 |
|  | (0.086) | (0.554) |
|  |  |  |
| CCEP | 0.470\*\*\* | 0.00397 |
|  | (0.002) | (0.979) |
|  |  |  |
| Subsidiary x CCEO | 0.0619 | 0.810 |
|  | (0.857) | (0.462) |
|  |  |  |
| Subsidiary x CCER | -0.236 | -0.219 |
|  | (0.368) | (0.611) |
|  |  |  |
| Subsidiary x CCEP | -0.575\* | 0.253 |
|  | (0.094) | (0.682) |
|  |  |  |
| Cost to income | -0.000257 | -0.00149\*\*\* |
|  | (0.102) | (0.000) |
|  |  |  |
| Net loans to total assets | 0.0141\*\* | -0.0170\*\*\* |
|  | (0.013) | (0.000) |
|  |  |  |
| Equity to total assets | 0.0118\*\* | 0.140\*\*\* |
|  | (0.034) | (0.000) |
|  |  |  |
| Total assets | -0.236\*\* | 0.0369 |
|  | (0.032) | (0.596) |
|  |  |  |
| Non-interest expense to average assets\_ | -0.508\*\*\* | -0.0422 |
|  | (0.000) | (0.287) |
|  |  |  |
| Impaired loans to equity | 0.00109 | -0.0134\*\*\* |
|  | (0.639) | (0.000) |
|  |  |  |
| Liquid assets to deposits and borrowings | 0.00433\*\*\* | -0.00945\*\*\* |
|  | (0.000) | (0.001) |
|  |  |  |
| Intercept | 4.687\*\* | 0.665 |
|  | (0.015) | (0.632) |
| *N* | 1360 | 720 |
| *R*2 | 0.477 | 0.805 |

Notes: Table 4 reports the effect of climate change exposure on bank performance from a fixed effect model, divided by regulatory quality level based on the World Bank Governance Indicators 2022. CCEO, CCER, CCEP stand for climate change opportunities, regulatory and physical exposure respectively. Dependent variable is ROAA. P-value are in parentheses. Asterisks \*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% respectively.

Columns 1 and 2 of Table 4 display the results for the groups of high- and low-regulatory quality countries, respectively. On the one hand, we find no significant relationship between climate change exposure and performance of banks in the countries with low regulatory quality. This result, to some extent, supports our earlier argument that when operating in the low (climate change-related) regulatory environment, banks might not have any incentives to take into account climate change exposure in their decision making (e.g., investment decision, risk management) which then affects their performance. On the other hand, in the countries with high regulatory quality, climate change physical exposure can increase ROAA of headquarters and independent banks at the significant level of p< 0.01 while it can exert a negative impact on ROAA of subsidiaries (β=-0.105 (0.470-0.575), p<0.1).

Furthermore, the impact of climate change regulatory exposure on ROAA is positive in Column 1, supporting our Hypothesis 2 that high regulatory quality environment can faciliate bank performance in the context of being exposed to regulatory change and transition challenges driven by climate change issues. As we observed, there is no difference between the impact of climate change regulatory exposure on bank performance in headquarters and subsidiaries in high regulatory quality country. This can be explained by the fact that both subsidiaries and headquarters operate in the same regulatory environment within a country, whereby the existence of subsidiary would not have any significant control effect on the relationship between climate change regulatory exposure and their performance.

# Conclusion

This study examines the impact of climate change exposure on bank performance value in nine Asian countries from 2010 to 2021. It contributes to the existing literature by developing a new approach to measure climate change exposure based on information in bank reports. The study also explores the differential effects of climate change exposure on headquarters and subsidiaries within banking organizations. Our results are also robust among different estimation with statistically significant and positive link between climate change physical exposure and bank performance.

Empirically, we find that banks in countries with high regulatory quality can benefit from climate change exposure, particularly regulatory and physical exposure, emphasizing the importance of a supportive regulatory environment.

Implications drawn from the results suggest that multinational banks with subsidiaries in different countries need to consider climate change regulatory exposure when conducting business. Bank managers should be aware of the regulatory environment in each jurisdiction and comply with climate change regulations. They should explore opportunities for sustainable investments in host countries to leverage the potential benefits arising from climate change. More importantly, governments, especially those in countries with low regulatory quality, should improve the regulatory framework, including environmental regulations, to promote bank resilience and adaptation to climate change challenges.

The study acknowledges certain limitations that can be addressed in future research. Firstly, access to and examination of a larger number of annual and sustainability reports from banks in the studied regions would provide stronger evidence of the relationship between climate change exposure and bank performance. Secondly, a more comprehensive language model to measure climate change exposure should be adopted to better measure other aspects of the text data further than frequency, such as: topic and sentiment.

In further research, we will follow Gorodnichenko, Pham, and Talavera (2021) and employ the state-of-the-art natural language processing (NLP) tools to develop an algorithm for keyword self-generation. Future research should also explore the interaction between the regulatory environment and climate change exposure, particularly in terms of climate change opportunities exposure, to gain insights into the role of regulations in shaping bank responses to climate change challenges.

**Acknowledgement**

We would like to express our deepest gratitude to Dr. Tho Pham, Senior Lecturer at the University of York, UK, for her invaluable guidance and supervision in the areas of data collection and natural language processing methods as well as her advice on the whole paper. Her expertise played a pivotal role in the successful completion of this work, and we are truly grateful for her unwavering support.

Additionally, we are also thankful to the Call of Science competition by YRC and the Department of Scientific Management at Foreign Trade University for their ongoing training, continuous support, and various beneficial activities throughout the year.

Special thanks are due to VEAM for bestowing upon us the Promising Research Idea awards and providing constructive feedback during the 14th Vietnam Economist Annual Meeting (2023).

Furthermore, our appreciation extends to the ACBES Committee for their insightful comments and recommendations during the 5th Asia Conference on Business and Economic Studies. Their valuable input has significantly enriched the quality of this paper.

Any remaining errors in this work are solely ours.

# References

# Albala-Bertrand, J. M. (1993), "Natural disaster situations and growth: A macroeconomic model for sudden disaster impacts”, *World Development*, Vol. 21 No. 9, pp. 1417–1434.

# Ali, H. S., Zeqiraj, V., Lin, W. L., Law, S. H., Yusop, Z., Bare, U. A. A. & Chin, L. (2019), "Does quality institutions promote environmental quality?" *Environmental Science and Pollution Research*, Vol. 26 No. 11, pp. 10446–10456.

# Allen, F. & Gale, D. (2000), "Financial Contagion”, *Journal of Political Economy*, Vol. 108 No. 1, pp. 1–33.

# Amare, A. (2021), "Capital structure and profitability: Panel data evidence of private banks in Ethiopia”, *Cogent Economics and Finance*, Vol. 9 No. 1.

# Barkemeyer, R., Figge, F., Hoepner, A., Holt, D., Kraak, J. M. & Yu, P. S. (2017), "Media coverage of climate change: An international comparison”, *Environment and Planning C: Politics and Space*, Vol. 35 No. 6, pp. 1029–1054.

# Barth, J. R., Caprio, G. & Levine, R. (2013), "Bank regulation and supervision in 180 countries from 1999 to 2011”, *Journal of Financial Economic Policy*, Vol. 5 No. 2, pp. 111–219.

# Batten, S., Sowerbutts, R. & Tanaka, M. (2016), "Let’s Talk About the Weather: The Impact of Climate Change on Central Banks”, *SSRN Electronic Journal*.

# Battiston, S., Dafermos, Y. & Monasterolo, I. (2021), "Climate risks and financial stability”, *Journal of Financial Stability*, Vol. 54, p. 100867.

# Battiston, S., Mandel, A., Monasterolo, I., Schütze, F. & Visentin, G. (2017), "A climate stress-test of the financial system”, *Nature Climate Change*, Vol. 7 No. 4, pp. 283–288.

# Benson, C. & Clay, E. J. (2004), "Understanding the Economic and Financial Impacts of Natural Disasters”, *THE WORLD BANK*.

# Bikker, J. A. & Hu, H. (2002), "Cyclical patterns in profits, provisioning and lending of banks and procyclicality of the new Basel capital requirements”, *BNL Quarterly Review* (Issue 221).

# Birindelli, G., Bonanno, G., Dell’Atti, S. & Iannuzzi, A. P. (2022), "Climate change commitment, credit risk and the country’s environmental performance: Empirical evidence from a sample of international banks”, *Business Strategy and the Environment*, Vol. 31 No. 4, pp. 1641–1655.

# Bruna, M. G., Loprevite, S., Raucci, D., Ricca, B. & Rupo, D. (2022), "Investigating the marginal impact of ESG results on corporate financial performance”, *Finance Research Letters*, Vol. 47, p. 102828.

# Crespo Cuaresma, J., Hlouskova, J. & Obersteiner, M. (2008), "Natural disasters as creative destruction? Evidence from developing countries”, *Economic Inquiry*, Vol. 46 No. 2, pp. 214–226.

# Dietrich, A. & Wanzenried, G. (2010), "Determinants of bank profitability before and during the crisis: Evidence from Switzerland”, [http://ssrn.com/abstract=1370245](http://ssrn.com/abstract%3D1370245)

# Drigă, I., Prof, A. & Dura, C. (2014), "The financial sector and the role of banks in economic development."

# Ellili, N. O. D. (2022), "Impact of ESG disclosure and financial reporting quality on investment efficiency”, *Corporate Governance: The International Journal of Business in Society*, Vol. 22 No. 5, pp. 1094–1111.

# Fatih Macit. (2012), "EB-12-V32-I1-P55."

# Galletta, S., Mazzù, S., Naciti, V. & Vermiglio, C. (2021), "Sustainable development and financial institutions: Do banks’ environmental policies influence customer deposits?" *Business Strategy and the Environment*, Vol. 30 No. 1, pp. 643–656.

# Goddard, J. & Wilson, J. O. S. (2004), "THE PROFITABILITY OF EUROPEAN BANKS: A CROSS-SECTIONAL AND DYNAMIC PANEL ANALYSIS\*”, *The Manchester School*, Vol. 72 No. 3.

# Gorodnichenko, Y., Pham, T. & Talavera, O. (2021), "Central Bank Communication on Social Media: What, To Whom, and How?", <https://tinyurl.com/ycww7na4>

# Heffernan, S. & Fu, X. (2008), "The Determinants of Bank Performance in China".

# Kadan, O. & Tang, X. (2020), "A Bound on Expected Stock Returns”, *The Review of Financial Studies*, Vol. 33 No. 4, pp. 1565–1617.

# Kim, S., Kumar, N., Lee, J. & Oh, J. (2021), "ESG Lending”, *SSRN Electronic Journal*.

# MARTIN, I. W. R. & WAGNER, C. (2019), "What Is the Expected Return on a Stock?" *The Journal of Finance*, Vol. 74 No. 4, pp. 1887–1929.

# Mathuva, D. M. (2009), "Capital Adequacy, Cost Income Ratio and the Performance of Commercial Banks: The Kenyan Scenario”, *The International Journal of Applied Economics and Finance*, Vol. 3 No. 2, pp. 35–47.

# Mehzabin, S., Shahriar, A., Hoque, M. N., Wanke, P. & Azad, Md. A. K. (2022), "The effect of capital structure, operating efficiency and non-interest income on bank profitability: new evidence from Asia”, *Asian Journal of Economics and Banking*.

# Nakao, Y., Amano, A., Matsumura, K., Genba, K. & Nakano, M. (2007), "Relationship between environmental performance and financial performance: An empirical analysis of Japanese corporations”, *Business Strategy and the Environment*, Vol. 16 No. 2, pp. 106–118.

# Okuyama, Y. (2003), "Economics of Natural Disasters: A Critical Review Economics of Natural Disasters: A Critical Review Yasuhide Okuyama", <https://researchrepository.wvu.edu/rri_pubs/131>

# Pasiouras, F. & Kosmidou, K. (2007), "Factors influencing the profitability of domestic and foreign commercial banks in the European Union”, *Research in International Business and Finance*, Vol. 21 No. 2, pp. 222–237.

# Petitjean, Q., Jean, S., Gandar, A., Côte, J., Laffaille, P. & Jacquin, L. (2019), "Stress responses in fish: From molecular to evolutionary processes”, *Science of The Total Environment*, Vol. 684, pp. 371–380.

# Philip Molyneux, J. T. (1992), "Determinants of European bank profitability: A note”, *Journal of Banking & Finance*, Vol. 16 No. 6, pp. 1173–1178.

# Popovici, M.-C. (2023), "Mihăiţă-Cosmin Popovici Title: Measuring banking efficiency by using ROAA and ROAE: Evidence from the European Union (Issue 1)", <https://www.ceeol.com/search/article-detail?id=266722>

# Rennings, K. & Rammer, C. (2011), "The Impact of Regulation-Driven Environmental Innovation on Innovation Success and Firm Performance”, *Industry & Innovation*, Vol. 18 No. 3, pp. 255–283.

# Sarwar, S. & Alsaggaf, M. I. (2021), "The role of governance indicators to minimize the carbon emission: a study of Saudi Arabia”, *Management of Environmental Quality: An International Journal*, Vol. 32 No. 5, pp. 970–988.

# Sautner, Z., Van Lent, L., Vilkov, G. & Zhang, R. (2020), "Firm-level climate change exposure", Available at: [www.accounting-for-transparency.deElectroniccopyavailableat:https://ssrn.com/abstract=3642508](http://www.accounting-for-transparency.deelectroniccopyavailableat:https/ssrn.com/abstract%3D3642508)

# Slattery, D. J. & Nellis, J. G. (2005), "Product development in UK retail banking”, *International Journal of Bank Marketing*, Vol. 23 No. 1, pp. 90–106.

# Sufian, F., Kamarudin, F., Halida, N. & Noor, H. M. (2012), "The Revenue Efficiency and determinants of domestic Islamic Banks in Malaysia banking sector”, *JKAU: Islamic Econ*, Vol. 25 No. 2, pp. 199–228.

# Trujillo-Ponce, A. (2013), "What determines the profitability of banks? Evidence from Spain”, *Accounting and Finance*, Vol. 53 No. 2, pp. 561–586.

# Venkatesh, J. & Suresh, M. C. (2014), "Comparative performance evaluation of selected commercial banks in kingdom of Bahrain using CAMELS method", [http://ssrn.com/abstract=2418144](http://ssrn.com/abstract%3D2418144)

# Wawrzyniak, D. & Doryń, W. (2020), "Does the quality of institutions modify the economic growth-carbon dioxide emissions nexus? Evidence from a group of emerging and developing countries”, *Economic Research-Ekonomska Istraživanja*, Vol. 33 No. 1, pp. 124–144.

# Appendix

Appendix 1 Keyword dictionary for measuring climate change exposure

|  |
| --- |
| **Keywords for measuring exposure to climate change’s opportunity (CCEO)** |
| renewable energyelectric vehicleclean energynew energywind powerwind energysolar energyplug hybridbattery electricsolar farmheat powerrenewable resourcecarbon neutralelectric hybridcarbon freesustainable energyrooftop solargrid powersolar generationvehicle chargeissue rfpreinvestment actcharge infrastructureconstruction megawattguangdong provincerecovery reinvestmentenergy standardev chargehybrid cargeneration renewablegrid connectvehicle batterymicro gridenergy windclean efficienthybrid technologyenergy vehiclevehicle lotgigawatt install | vehicle goodfocus renewablevehicle typerenewable electricitymeet energybus truckenergy commitmentbattery chargevehicle placeclean supplyvehicle spaceexpand energyvehicle futurepure electriccarbon energyenergy researchinvest renewablecell electricelectronic consumerinstall solarcommunity solarton wastepower solartype energyenergy goalvehicle developmentenergy importantenergy bringsolar storageopportunity cleansolar programsafe cleangeothermal powergas cleansupply industrialcost renewablegrid technologysolar batteryton carbon | subsidy receivevehicle electricvehicle smallvehicle hybriddemand windpower worldterm electricincremental contentfully electricenergy targettarget gigawattenergy landscapecustomer cleanconventional energymild hybridvehicle talkcharge networkmedical electronicvehicle offerfree energyplus storagevehicle opportunitysolar rooftopsolar installationenergy generationbiomass powerbiodieselbioethanolhydro powerhydroelectricity powersolar lightsenergy savingrechargeable batterysolar panelsgreen bondgreen financefinancing greenfinancing renewablegreen loan |
| **Keywords for measuring climate change regulatory exposure (CCER)** |
| greenhouse gasreduce emissioncarbon emissiongas emissionreduce carboncarbon dioxideair pollutioncarbon priceenergy regulatorycarbon taxenvironmental standardcarbon reductionemission tradedioxide emissionnox emissionenergy independenceepa regulationdevelopment renewabledeliver cleanknow cleanstandard requirementcarbon markettrade schemeemission intensityimpact climatereduce airemission freesave technologymercury emissionplace energycarbon economytalk cleanenergy alternativechange climatereduce noxemission yeartarget energyair resourceimplement energycontrol regulationglobal climatethink carbonefficient naturalpromote energysource electricitygas regulationissue airflorida departmentnitrous oxideproduce carbonreduce sulfureffective energyproduct carbonlow carbon | impact cleanregulation lowemission ratecommission licenserecovery pollutionappeal districtemission compareemission increaseachieve carboncapture sequestrationclean jobemission improveemission comenation energyemission issueemission monitorchina aircapture carbonquality permitavailable controlefficient combineenvironmental goalcomply environmentalnox soxoxide emissionway complyinstall lowrelate climateclean electricityhill windglacier hilltax australiahigh hydrocarbonemission tonreduce methanewait commissiongas carbonstability reserveeu etsweight fuelcommission publictalk climateexpect carboncastle peakemission carbonadditive processrequest publicconsumer goodsplastic productsconstruction materialssteel worksfabricated productselectrical equipmentparis agreement | automobiles trucksrailroad equipmentprecious metalsnatural gaselectronic equipmentmeasuring and control equipmentbusiness suppliesshipping containersrestaurants, hotels, motelsagriculturerecreationprintingpublishingapparelhealthcarechemicalstextilesconstructionaircraftmachinerydefensecoalutilitiescommunicationcomputerstransportationwholesaleretailco2 emissionco emissionmonoxide emissionalternative energynet zeroghg emissionghg avoidancecarbon monoxiden2oair emissionbali action planblack carbonco2 equivalentcarbon footprintcarbon intensitygreen taxonomygreen standardsadaption fundcarbon financecertified emission reductionclean development mechanismcopenhagen accordemission trading |
| **Keywords for measuring climate change physical exposure (CCEP)** |
| global warmcoastal areasnow icefriendly productforest landprovide watersea levelarea floridanickel metalsupply waternatural hazardstorm waterair waterheavy snowwarm climatesecurity energywater dischargesea waterice productmanagement districtwater actmanagement waterweather snowservice reliable | ability partyice controlinland areavalue forestnon coastalsale foreststorm januaryfight globalland forestparticularly coastalespecially coastalgolf groundplant algeriaarea coastallarge desalinationsolution actcombine sewersewer overflowsell forestfluorine productwarm productarea inlandexposure coastalcity coastal | marina eastkeppel marinawater managementwater supplyresource managementflood victimsnatural disastersnatural calamitiesnatural calamitytyphooncatastrophetsunamiel ninola ninaecofriendlyclean workspaceenvironmentally friendlydeforestationocean acidificationtipping pointextreme weathergreenhouse effectclimate funds |

1. Tác giả liên hệ, Email: k60.2112820038@ftu.edu.vn [↑](#footnote-ref-1)