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**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**

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**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).

(i)

(ii)

(iii)

Where:

**, , :** the frequency of keywords of each type that appear on the report of bank *i* in year *t*

the total number of words in the selected parts in the report of bank i in year t.

**, , :** 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:

(1)

where represents the performance of bank *i* in year *t*, proxied by ROAA or ROAE. is the a dummy variable which equals 1 if a firm is a subsidiary in year t and 0 otherwise. , and is the indicators of bank *i*’s opportunity, regulatory, and physical climate change exposure in year *t*, respectively. is a vector of control variables that can affect bank performance. Definitions of all variables can be found in Table 1. and 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.

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Any remaining errors in this work are solely ours.

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# Appendix

Appendix 1 Keyword dictionary for measuring climate change exposure

|  |  |  |
| --- | --- | --- |
| **Keywords for measuring exposure to climate change’s opportunity (CCEO)** | | |
| renewable energy  electric vehicle  clean energy  new energy  wind power  wind energy  solar energy  plug hybrid  battery electric  solar farm  heat power  renewable resource  carbon neutral  electric hybrid  carbon free  sustainable energy  rooftop solar  grid power  solar generation  vehicle charge  issue rfp  reinvestment act  charge infrastructure  construction megawatt  guangdong province  recovery reinvestment  energy standard  ev charge  hybrid car  generation renewable  grid connect  vehicle battery  micro grid  energy wind  clean efficient  hybrid technology  energy vehicle  vehicle lot  gigawatt install | vehicle good  focus renewable  vehicle type  renewable electricity  meet energy  bus truck  energy commitment  battery charge  vehicle place  clean supply  vehicle space  expand energy  vehicle future  pure electric  carbon energy  energy research  invest renewable  cell electric  electronic consumer  install solar  community solar  ton waste  power solar  type energy  energy goal  vehicle development  energy important  energy bring  solar storage  opportunity clean  solar program  safe clean  geothermal power  gas clean  supply industrial  cost renewable  grid technology  solar battery  ton carbon | subsidy receive  vehicle electric  vehicle small  vehicle hybrid  demand wind  power world  term electric  incremental content  fully electric  energy target  target gigawatt  energy landscape  customer clean  conventional energy  mild hybrid  vehicle talk  charge network  medical electronic  vehicle offer  free energy  plus storage  vehicle opportunity  solar rooftop  solar installation  energy generation  biomass power  biodiesel  bioethanol  hydro power  hydroelectricity power  solar lights  energy saving  rechargeable battery  solar panels  green bond  green finance  financing green  financing renewable  green loan |
| **Keywords for measuring climate change regulatory exposure (CCER)** | | |
| greenhouse gas  reduce emission  carbon emission  gas emission  reduce carbon  carbon dioxide  air pollution  carbon price  energy regulatory  carbon tax  environmental standard  carbon reduction  emission trade  dioxide emission  nox emission  energy independence  epa regulation  development renewable  deliver clean  know clean  standard requirement  carbon market  trade scheme  emission intensity  impact climate  reduce air  emission free  save technology  mercury emission  place energy  carbon economy  talk clean  energy alternative  change climate  reduce nox  emission year  target energy  air resource  implement energy  control regulation  global climate  think carbon  efficient natural  promote energy  source electricity  gas regulation  issue air  florida department  nitrous oxide  produce carbon  reduce sulfur  effective energy  product carbon  low carbon | impact clean  regulation low  emission rate  commission license  recovery pollution  appeal district  emission compare  emission increase  achieve carbon  capture sequestration  clean job  emission improve  emission come  nation energy  emission issue  emission monitor  china air  capture carbon  quality permit  available control  efficient combine  environmental goal  comply environmental  nox sox  oxide emission  way comply  install low  relate climate  clean electricity  hill wind  glacier hill  tax australia  high hydrocarbon  emission ton  reduce methane  wait commission  gas carbon  stability reserve  eu ets  weight fuel  commission public  talk climate  expect carbon  castle peak  emission carbon  additive process  request public  consumer goods  plastic products  construction materials  steel works  fabricated products  electrical equipment  paris agreement | automobiles trucks  railroad equipment  precious metals  natural gas  electronic equipment  measuring and control equipment  business supplies  shipping containers  restaurants, hotels, motels  agriculture  recreation  printing  publishing  apparel  healthcare  chemicals  textiles  construction  aircraft  machinery  defense  coal  utilities  communication  computers  transportation  wholesale  retail  co2 emission  co emission  monoxide emission  alternative energy  net zero  ghg emission  ghg avoidance  carbon monoxide  n2o  air emission  bali action plan  black carbon  co2 equivalent  carbon footprint  carbon intensity  green taxonomy  green standards  adaption fund  carbon finance  certified emission reduction  clean development mechanism  copenhagen accord  emission trading |
| **Keywords for measuring climate change physical exposure (CCEP)** | | |
| global warm  coastal area  snow ice  friendly product  forest land  provide water  sea level  area florida  nickel metal  supply water  natural hazard  storm water  air water  heavy snow  warm climate  security energy  water discharge  sea water  ice product  management district  water act  management water  weather snow  service reliable | ability party  ice control  inland area  value forest  non coastal  sale forest  storm january  fight global  land forest  particularly coastal  especially coastal  golf ground  plant algeria  area coastal  large desalination  solution act  combine sewer  sewer overflow  sell forest  fluorine product  warm product  area inland  exposure coastal  city coastal | marina east  keppel marina  water management  water supply  resource management  flood victims  natural disasters  natural calamities  natural calamity  typhoon  catastrophe  tsunami  el nino  la nina  ecofriendly  clean workspace  environmentally friendly  deforestation  ocean acidification  tipping point  extreme weather  greenhouse effect  climate funds |

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