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# Assessment of the Relationship among Climate Change, Green Finance and Financial Stability: Evidence from Emerging and Developed Markets

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**Abstract**

This study assesses the relationship among climate change, green finance, and financial stability annually from 2013 up to 2021 for 14 countries, focusing on emerging and developed markets. It first considers whether a country's climate change impact financial stability, investigates whether green finance influences financial stability and how it affects climate change by using carbon dioxide emissions as proxy of climate change. Green finance has been measured by green of asset backed securities, green loans and bonds, while financial stability has been measured by Z-score. Using panel data, the findings indicate that there is a significantly negative effect of $CO_2$ emissions on financial stability, but positive effects of green finance on financial stability in these markets, most notably through green loans. Also, this paper examines the relationship between green finance and climate change by using Kao Residual Cointegration test of countries. In the long run, green finance negatively affects carbon dioxide emissions. Furthermore, the empirical results of the robustness test of GMM are highly consistent with the main test. This study may be extended by conducting Further research to focus on the effect of $CO_2$ emissions on financial markets with the role of financial deepening for countries.

**Keywords:** banking sector, Carbon Dioxide ($CO_2$) Emissions, climate change, developed markets, emerging markets, financial stability, foreign direct investment, global warming, green finance

**JEL Classification:** F21; G15; G21; G29; Q50; Q52; Q54.

## 1. Introduction

In the 21st century has seen a great challenge, the beginning of the health disaster, then the climate change, phenomenon of greenhouse effect and Russia's invasion of Ukraine. First, the COVID-19 epidemic has been considered the greatest global health disaster and the most significant threat since the Second World War. Where the pandemic had many adverse economic and health consequences result for implemented full or partial lockdown to slow the spread of disease in countries. Notably, prior literature indicated that the COVID-19 outbreak, and related news of epidemic have adversely impacted the banks' performance and the stability of the global financial markets (Demirguc-Kunt et al., 2020; Balboula & Metawea, 2021; Dong, 2021; Goldstein et al., 2021; Xiazi & Shabir, 2022; Darjana et al., 2022; Dong et al., 2022; Zhang et al., 2022; Uddin et al., 2022; Tomczak, 2023; Shabir et al., 2023; Ullah, 2023; Gherghina, 2023; and Costola et al., 2023). The global economy continues to gradually recover from the epidemic, Russia's war on Ukraine, and faces a more ominous challenge is the climate crisis cannot be disregarded.

In this context, climate changes increase the probability of specific food and waterborne and vector-borne contagions, and a modern case in point is a coronavirus crisis. Specifically, Since the Industrial Revolution in the late 1700s, early 1800s, and until now, the world has seen a great change in climate, including flooding, wildfires, heightened temperatures, and greenhouse effect. Human activities contribute to the increase in this phenomenon, which happens when certain greenhouse gases (GHGs) collect in Earth's atmosphere. Where global greenhouse gas emissions have increased in recent years, with unequal and ongoing contributions caused by unsustainable energy use. There have been studies about climate change and global warming, and its impact with different results. Most of the studies in the literature have revealed that climate change has significantly negative effects on global economic, various sectors, financial stability and positive impact on systemic risks that affect the

financial system (Huang et al., 2018; Boros, 2020; Ozili, 2020; Agbloyor et al., 2021; Wu et al., 2023; and Mao et al., 2023).

Other studies examine the relationship among financial system and development, foreign direct investment and CO2 emissions according to the income and development level of the countries at different times (Pao & Tsai, 2011; Kılıçarslan & Dumrul, 2017; Samour et al., 2019; De Haas & Popov, 2019; Habiba & Xinbang, 2021; Habiba & Xinbang, 2022; Hussain et al., 2023; and Hussain et al., 2023). Regarding this issue, the problem of earth climate was amplified multiplex, hence, mitigating the impacts of climate change and reducing the carbon dioxide effect is vital to get over its devastating impacts. Therefore, the financial sector has considered the ecosystem, in which green finance has become the main way to deal with climate change effects. There have been studies on subjects regarding to the impact of green finance on economic aspects, banking industry, financial stability and sustainability performance in banking sector (Zhang, 2018; Danye, 2020; Yasmin & Akhter, 2021; Putri et al., 2022; Abuatwan, 2023; Mirza et al., 2023; and Baharudin & Arifin, 2023) and other studies attempt to assess the role of green finance in carbon emissions reduction (Iqbal et al., 2021; and Guo et al., 2022) with different results and viewpoints.

Yet many challenges still cloud the horizon. To the best of my knowledge, there is some little literature about this field, hence the main purpose of this study is to assess the relationship among green finance, climate change, foreign direct investment, and financial stability by using annually data from the 2013 up to 2021 for 14 countries, focusing on emerging and developed markets. Interestingly, this study takes the perspective of financial, environmental, and economic impact. Therefore, this study focuses first considers whether a country's carbon dioxide emissions impact financial stability. Furthermore, this study investigates whether green finance influences financial stability and how it affects carbon dioxide emissions in countries, with consideration for foreign direct investment effect.

Additionally, this paper examines the relationship between green finance and carbon dioxide emissions by using Kao Residual Cointegration test of countries. In the long run, green finance negatively affects carbon dioxide emissions. Using panel data, the findings indicate that there is a significantly negative impact of $CO_2$ emissions on financial stability, but positive effects of green finance on financial stability in these markets, most notably through green loans. Consequently, the results of this study support the view that climate change and green finance have a relatively significance impact on financial stability, where the current study outcomes support with the results of Ozili (2020); Wu et al. (2023) and Ali et al. (2023), but conversely with the results of Habiba and Xinbang (2022). Furthermore, the empirical results of the robustness test of White diagonal and Panel Generalized Method of Moments (GMM) are highly consistent with the main test.

Following this introduction, Section 2 presents the problem statement. The literature review and developing hypotheses will be discussed in section 3. Section 4 describes the data and variables of this study as well as the methodology used in the empirical analysis. Section 5 illuminates the descriptive and diagnostic statistics and hypotheses' testing while concluded remarks and discussion are referred to in section 6.

## 2. The Problem Statement

More recently, the global financial crises, climate change and environmental concerns are a substantial challenge around the globe. The concerns of climate risks have attracted the interest of researchers to investigate the nexus between climate change and its impacts on financial institutions. Most of the studies in the literature have revealed that climate change has significantly negative effects on global economic, various sectors, financial stability and positive impact on systemic risks that affect the financial system (Huang et al., 2018; Boros, 2020; Ozili, 2020; Agbloyor et al., 2021; Wu et al., 2023; and Mao et al., 2023).

Simultaneously, Other studies examine that the relationships among financial system and development, foreign direct investment and $CO_2$ emissions (Pao & Tsai, 2011; Kılıçarslan & Dumrul, 2017; Samour et al., 2019; De Haas & Popov, 2019; Habiba & Xinbang, 2021, 2022; Hussain et al., 2023; Hussain et al., 2023). These studies reveal evidence that there is strong bidirectional causality between both $CO_2$ emissions and foreign direct investment, while other studies found that the banking sector development, markets development and financial inclusion significantly impact on carbon dioxide emissions whether positively or negatively according to the income and development level of the countries at different times. Therefore, this study attempts to introduce an interesting discussion as the first contribution concerning the analysis of whether a country's climate change impact financial stability.

In this context, some studies indicate that a resolve of such environmental issues through green financing is necessary (Zhang, 2018; Danye, 2020; Yasmin & Akhter, 2021; Iqbal et al., 2021; Putri et al., 2022; Guo et al., 2022; Abuatwan, 2023; Mirza et al., 2023; and Baharudin & Arifin, 2023). These studies examine that the impact

of green finance on economic aspects, banking industry, financial performance and Pollution environmental with different results and viewpoints. In the light of the above debates, it is timely relevant to more examine this area, therefore the principal objective of this study is to assess the relationship among green finance, climate change, foreign direct investment, and financial stability in emerging and developed markets during the period 2013-2021. Therefore, this research study is different from the existing literature as it introduces a discussion concerning the banking sector has been interested in explaining its performance and stability with two issues: first climate change through carbon dioxide emissions, and second financial instruments through green finance. Additionally, this study interests how green finance affects carbon dioxide emissions in countries, with consideration for foreign direct investment.

The following graphs that show carbon dioxide ($CO_2$) emissions, foreign direct investment, the development of green finance (green of asset backed securities, green bonds to GDP, and green loans to GDP) for 14 countries in developed and emerging markets during from 2013 to 2019, as shown in figure 1 & 2:

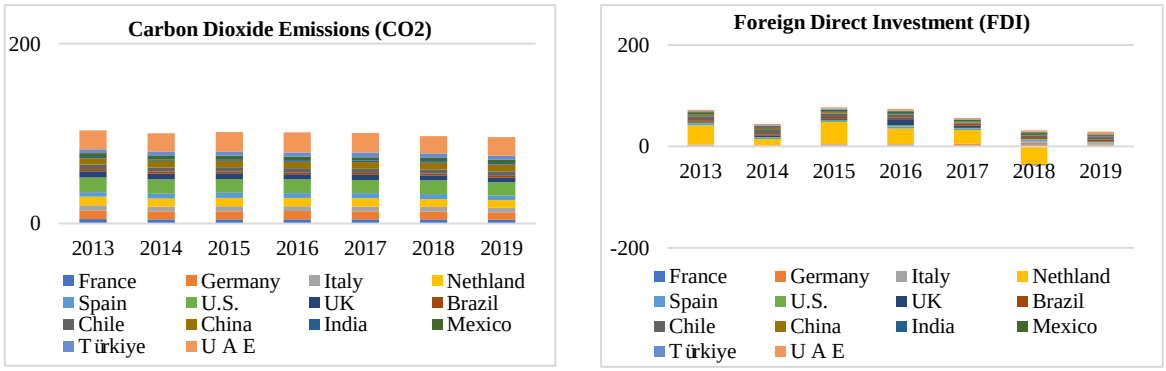


Figure 1. Carbon Dioxide Emissions and foreign direct investment in emerging and developed markets

Source: Prepared by Researcher.

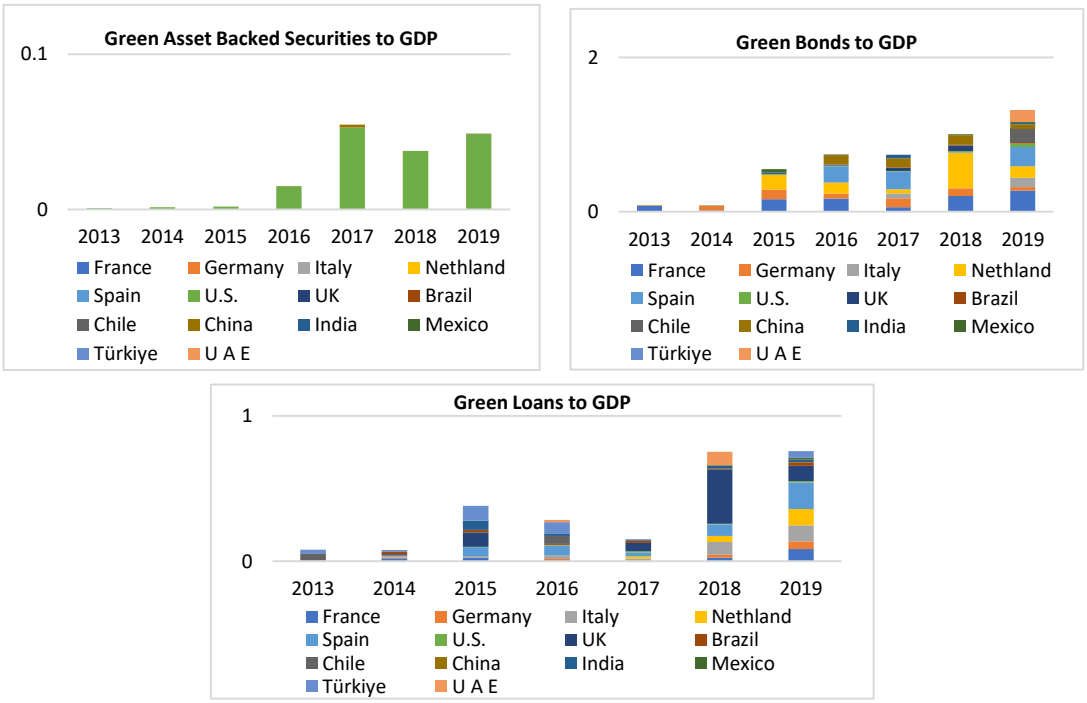


Figure 2. Green finance development in emerging and developed markets

Source: Prepared by Researcher.

This being to be obvious that many countries suffer climate change risks, as rise of carbon dioxide emissions from 2013 to 2019. previous literature that pointed out that a significant relationship between carbon dioxide emissions and foreign direct investment (Pao & Tsai, 2011; Kılıçarslan & Dumrul, 2017; and Habiba & Xinbang,

2022). above figure 1 shows net flow of foreign direct investment to GDP for 14 countries during this period. Also, figure 2 indicates that many countries have green finance from 2013 to 2019. It shows that the countries are trying to endeavor for a green environment and better future by green financing instruments.

Interestingly, this study interests two issues, climate change and green finance for 14 countries in emerging and developed markets from 2013 to 2021. As far as we know, the literature presented little evidence of this issue. Notably, developed markets are foreseen to interest the green financing instruments, while emerging markets have comparatively limited resources to deal with the climate change risks and thus are expected to care less about green finance and suffer from carbon dioxide emissions worst, as shown above figure. Overall, reducing $CO_2$ emissions will entail cooperation and sustained effort from both emerging and developed countries.

In the light of above discussions, the first motivation for this research study stems from the global concern over climate risks, environmental damage and the threat posed by increasing $CO_2$ emissions to the global economic and entire financial system. Addition, the second motive stems the global interest over studying the impact of green finance on banking sector under different market conditions and how it affects climate change in these countries, with consideration for foreign direct investment effect. In brief, this paper tries to answer the following questions:

- Does climate change affect financial stability in markets?
- Does green finance affect financial stability in markets?
- Does green finance affect carbon dioxide emissions in markets?

Overall, sample of this study includes 60 observations in 14 countries and considers two groups of control variables, which included macroeconomic variables (e.g., foreign direct investment, real effective exchange rate index, and inflation rate) in addition to determinants of banks performance, which is represented as the following ratios: noninterest income to total income, Liquid assets to deposits and short-term funding, net interest margin, and Bank credit to bank deposits.

## 3. Literature Review and Research Hypotheses

This section tries to present some of the previous work that has been conducted in three fields: 1) the impact of climate change and global warming on financial sector and global economic; 2) the relationship among financial system and development, foreign direct investment and $CO_2$ emissions; and 3) the impact of green finance on carbon emissions and financial sector. The outcomes of climate risk have attracted the interest of researchers to investigate the nexus between climate change, factors that caused its aggravation and its impacts on the financial sector. Interestingly, some researchers point out that climate change has significantly negative effects on global economic, various sectors, financial stability and positive impact on systemic risks that affect the financial system, but the results vary across the periods, industries and samples (Huang et al., 2018; Agbloyor et al., 2021; Wu et al. 2023; Mao et al., 2023 and Ali et al., 2023).

According to Huang et al. (2018) address what and how climate risk impacts on firm performance and financing decisions for publicly listed firms using financial data for these firms and the Global Climate Risk Index as a proxy of climate risk in 55 countries over the period from 1993 to 2012. The authors found evidence that climate risk has negatively impact on firm earnings and economic performance but is positively associated with earnings volatility. Those firms also tend to hold more cash to maintain organizational resilience to climate-related risk. In addition, the results find that the climate risk influence firm performance varies across. Additionally, Agbloyor et al. (2021) investigate the effect of carbon dioxide emissions as proxy of climate change on banking stability for 122 countries during 2000 to 2013. These results indicate an inverted U-shaped relationship between variables in this study. In other words, banking stability improves when per capita of $CO_2$ emissions initial levels but reduces after a certain threshold of per capita of these emissions. In this context, Mao et al. (2023) analyze the impact of climate risk on systemic risk by taking the end of monthly price and return of 20 global asset indicators data, covering the equity, forex, commodity, and bond markets as a case for five countries from the period of 1990 to 2017. The results of this study find that climate risk leads to cross-market contagion of risk, which increase systemic risks by using a dynamic network model.

Consequently, these results support the view of Wu et al. (2023). As highlighted by Wu et al. (2023), whether climate change affects financial stability for China during 2005 to 2020. The results of this study find that there is a negative relationship between temperature deviation and financial stability during the sample period but varied across the samples and indicate that the negative effect requires adjust policies and promotes macroprudential stress tests of these risks. Ali et al. (2023) find that the effect of emissions led to a significant decrease the bank stability at worldwide through lower of deposit and asset quality in 305 listed banks during from

2010 to 2021, although the results reveal the banks led to lower emissions through non-financial (ESG) activities. In this study, caused of concern about world-wide climate-related risk has led to interest in the issue associated with an analyzation of the effect of climate change on financial stability in various markets, with the banking sector considered.

Regarding the relationships among financial systems and development, foreign direct investment and $CO_2$ emissions, some researchers refer to these relationships with different results and viewpoints Pao and Tsai (2011); Kılıçarslan and Dumrul (2017); Samour et al. (2019); De Haas and Popov (2019); Habiba and Xinbang (2021); Habiba and Xinbang (2022); Hussain et al. (2023); Hussain et al. (2023). Interestingly, Pao and Tsai (2011) address what and how economic growth and financial development impacts on environmental deterioration using a panel causality and cointegration model and in BRIC countries over the period from 1980 to 2007. The authors examine the relationship among energy consumption, real GDP, foreign direct investment and $CO_2$ emissions in these countries. They found evidence that there is strong bidirectional causality between both $CO_2$ emissions and foreign direct investment and output emissions and output-energy consumption. While there is strong unidirectional causality from energy consumption to $CO_2$ emissions, also from real GDP to foreign direct investment. In addition, these results support the Pollution Haven hypothesis during this period.

In this context, Kılıçarslan and Dumrul (2017) analyze the impact of foreign direct investment on carbon dioxide ($CO_2$) emissions in Turkey and using Johansen Cointegration test and vector error correction model from the period of 1974 to 2013. The results of this study find that foreign direct investment positively impacts $CO_2$ emission level in the long run. In other words, these results support the Pollution Haven hypothesis during this period. From Samour et al. (2019) examines whether the banking sector development influences on $CO_2$ emissions for Turkey during 1980 to 2014. The results indicate that turkey experienced increases in $CO_2$ emissions as result for the banking sector development during the period of this study.

Additionally, De Haas and Popov (2019) analyzes the impact of the financial systems structure on carbon emissions in 48 countries and 16 industries by using panel data from the period of 1990 to 2013. The results of this study find that financial systems based on equity financing relative to bank lending have a positive impact on environmental quality and reduce of per capita of $CO_2$ emissions. Adversely, Habiba and Xinbang (2021) examine the impact of overall financial development and its sub-indices such as: access, depth and efficiency of both markets or institutions on the carbon dioxide ($CO_2$) emissions by using annually data of 41 European Union and 43 Sub-Saharan Africa countries from 2000 to 2018. Their results reveal that financial institutions, markets development and their sub-indices reduce $CO_2$ emissions for the European Union a prominent compared by SSA countries. Furthermore, their results indicate that the foreign direct investment inflows and the use of renewable energy reduces $CO_2$ emissions.

While Habiba and Xinbang (2022) examine the impact of financial development on $CO_2$ emissions by using a disaggregated analysis and annual data of 46 countries of Sub-Saharan Africa from 1991 to 2016. This study further analyzes whether there is an effect of renewable energy consumption and per capita income, trade openness, urbanization and foreign direct investment on carbon dioxide emissions. Their results reveal that financial markets and institution development increase $CO_2$ emissions for these countries and financial institution development provides major adversely impact for environment quality compared to financial markets development, while foreign direct investment inflows and increasing use of renewable energy reduces $CO_2$ emissions. In addition to the impact of financial development on $CO_2$ emissions is different across income levels in the countries of this study.

In this context, Hussain et al. (2023) investigate whether financial inclusion influences $CO_2$ emissions for 26 Asian countries during 2004 to 2014, and with divided the sample to developed and emerging Asian economies. The results of this study find that there is a bidirectional causality between these variables during the sample period and indicate that the financial inclusion has a long-run positive impact on $CO_2$ emissions for emerging countries compared to developed countries. Similarly, Hussain et al. (2023) address what and how financial inclusion impacts on carbon emissions in 102 countries, divided according to income levels over the period from 2004 to 2020. The authors examine the relationship between financial inclusion and carbon emissions from the perspective of economic, environmental and regulatory effects and found evidence that financial inclusion has a positive impact on carbon emission after a certain threshold of financial inclusion, implying that the nonlinear effect of this relationship and has a significant N-Shaped in emerging countries, while a weak N-Shaped in developed countries.

Regarding the impact of green finance on carbon emissions and financial sector, most of the studies in the literature have revealed that there are positive or negative effects of green finance on financial performance

according to countries and periods Putri et al. (2022); Abuatwan (2023); Mirza et al. (2023); Baharudin and Arifin (2023) and Ali, et al. (2023). Specifically, the following outcomes which regard the impact of green credit on financial performance are drawn from the experiential studies of Zhang (2018); and Yasmin and Akhter (2021). The authors found that green credit will increase the cost of operations in the short term and affect the growth of profits. Other studies expect a positive impact in the long run profits after the application of the green credit policy.

In this context, Zhang (2018) analyze the relationship between green credit and financial performance in China during the period of 2005 to 2017. The results find that green credit has a positive impact on bank's performance, while the profit growth ratio went slow during the period of 2013 to 2015 because of environmental and financial aspects. Additionally, Yasmin and Akhter (2021) assure the positive impact of green credit on the bank profitability in Bangladesh.

Interestingly, a pilot study by Putri et al. (2022) provide evidence that banks profitability increased immediately after their depending on green banking like corporate social responsibility funds and have capital adequacy ratio, while the number of ATMs not significance impact on profitability in Indonesia during from 2010 to 2020. Abuatwan (2023) find that the effect of green finance led to a significant promote sustainability performance in short and long term in Palestinian banking during January to April in 2023 by analyzing questionnaires for 104 credit managers of eight banks. Similarly, Mirza et al. (2023) empirically results indicated that banks' sustainable SME lending exerts a positive effect on profitability, and it has a negative impact on the default risk in the BRIC by using quarterly data during the period 2011 to 2021. Many researchers have explored the relationship between green finance and institutions' value. According to Baharudin and Arifin (2023), the green finance fosters the firm value based on the Tobin Q model for four banking companies listed in Indonesia during from 2019 to 2021.

Other studies attempt to assess the role of green finance in carbon emissions reduction with specific viewpoints. Iqbal et al. (2021) analyze the impact of green finance on reducing environmental pollution in developed relative to emerging countries by using data envelopment analysis composite indicator during from 2011 to 2030 in European and Asian countries. Their results reveal that green financing leads to reducing environmental pollution significantly and their findings confirmed by using a sensitivity analysis to this study data. Additionally, Guo et al. (2022) examine what and how green finance impacts on carbon emissions reduction of the 11 cities in China over the period from 2006 to 2019. The authors found evidence that green finance has a prominent adverse direct impact on carbon emissions, but the spillover impact on neighboring regions is insignificant.

This study is different from previous literature in four aspects: (1) this study measured climate change and its impact on financial stability for countries as consider an independent variable at times and dependent variable at other times; and (2) this current study measured impact of green finance on carbon dioxide ($CO_2$) emissions for both cases of whether the foreign direct investment exists or not in countries, which included as follow: France, Germany, Italy, Netherlands, Spain, U.S., and UK, Brazil, Chile, China, India, Mexico, Turkey, and UAE. In addition, (3) this study measured the impact of green finance on financial stability during 2013 to 2021. (4) this study sample and period differ from other previous studies. In the light of above discussions, the consequences of climate change have attracted the interest of this study to assess the nexus among climate change, green finance and financial stability in emerging and developed markets during the period 2013-2021. According to the literature review and problem statement discussed above, this study aims at testing the following hypothesis:

$H_1$: Financial stability is significantly driven by climate change in emerging and developed markets.

$H_2$: Financial stability is significantly driven by green finance in emerging and developed markets.

$H_3$: Climate change is significantly driven by green finance in emerging and developed markets.

Hypothesis testing criteria:

$H_{O1}$: There is no significant effect of climate change on financial stability for emerging and developed markets.

$H_{A1}$: There is a significant effect of climate change on financial stability for emerging and developed markets.

$H_{O2}$: There is no significant effect of green finance on financial stability for emerging and developed markets.

$H_{A2}$: There is a significant effect of green finance on financial stability for emerging and developed markets.

$H_{O3}$: There is no significant effect of green finance on climate change for emerging and developed markets.

$H_{A3}$: There is a significant effect of green finance on climate change for emerging and developed markets.

## 4. Research Methodology

### *4.1 Research Sample and Method*

To assess the relationship among green finance, climate change, foreign direct investment, and financial stability, our developed and emerging markets analysis includes the following 14 counties: developed markets (France, Germany, Italy, Netherlands, Spain, U.S., and UK) and emerging markets (Brazil, Chile, China, India, Mexico, Turkey, and UAE). The countries are chosen as the most representative developed and emerging markets according to data availability during the period from 2013 to 2021.

This data was collected from the Institute of International Finance (IIF), the International Monetary Fund (IMF) and World Development Indicators (WDI) database of the World Bank. Overall, our sample included 60 observations in 14 countries. This paper used quantitative methods using data panel time series (data panel), the Ordinary Least Squares method (OLS) to test the regression model and Generalized Method of Moments/Dynamic Panel Data (GMM/DPD) to support the empirical results of this study, and Kao Residual Cointegration test to examine the relationship between variables of this study.

### *4.2 Research Variables*

- **Climate Change**

This paper empirically investigates how financial stability reacts to Carbon Dioxide emissions impact as a proxy of climate change is very important for financial analysts, bankers, and investors to assert can support the idea of considering investments by green finance may be positive impact on banking sector. In addition, this paper empirically examines the impact of green finance on carbon dioxide emissions as measured by carbon dioxide emissions (metric tons per capita) for 14 countries.

- **Green Finance**

To assess the relationship among green finance, climate change, and financial stability in emerging and developed markets during the period from 2013 to 2021, the researcher uses the green asset backed securities to GDP ratio (G-ABS), the green bonds to GDP ratio (GB), and the green loans to GDP ratio (G-LNS) as a measure of green finance.

- **Financial stability**

Regarding concern about world-wide climate-related risk has led to interest in the issue associated with an analyzation of how financial stability reacts to $CO_2$ emissions impact. Additionally, the consequences of climate change have attracted the interest of this study to investigate the nexus between green finance and its impacts on financial stability. Interestingly, financial stability is addressed as the ability of the financial system to resolve risks and is measured by the bank's Z-score ratio, as estimated by (Return of Assets + equity/assets) / Standard deviation of ROA).

- **Control variables**

Banks play a vital role in many operations in the economies. On the other hand, many economic factors and bank performance can affect financial stability. Here, more important determinants are taken to identify their impact on independent variables concerning economic factors: foreign direct investment, inflation as measured by the annual growth rate of the GDP implicit deflator, and real effective exchange rate index (2010 = 100). Regarding available determinants of banks performance, which is represented as the following ratios: noninterest income to total income, Liquid assets to deposits and short-term funding, net interest margin, and Bank credit to bank deposits. Overall, these variables used in the model are defined in Table 1, as follow:

Table 1. Description of variables and abbreviation

| Type | Variable | Abbreviation |
|---|---|---|
| Independent | Green asset backed securities (ABS) to GDP | G-ABS |
| | Green bonds of GDP | GB |
| | Green loans of GDP | G-LNS |
| | Bank Z-SCORE | ZSCORE |
| Dependent | Carbon Dioxide ($CO_2$) Emissions (metric tons per capita) | LOG ($CO_2$) |
| | Foreign Direct Investment, net inflows of GDP ratio | FDI |
| Control | Real Effective Exchange Rate Index (2010 = 100) | Exc |
| | Inflation, GDP Deflator (annual %) | INF_GDP |
| | Bank Noninterest Income to Total Income | NII |
| | Liquid Assets to Deposits and Short-term Funding | LIQ_ASSE |
| | Bank Net Interest Margin | NIM |
| | Bank Credit to Bank Deposits | CRED_DEP |

Source: Prepared by Researcher.

*4.3 Research Model*

The models used in this study were found in established existing literature. A panel regression will be most applicable to represent such a linear relationship through main equations for forecasting Financial Stability and Climate change. Notably, the study used three statistical approaches, including the Ordinary Least Squares (OLS), Fixed Effects Model (FEM), and Random Effects Model (REM) suitable to panel data. After that, the Hausman test was used to determine whether the FEM model or the REM model were suitable for research. The estimated equations of this study are as follows:

*Models of ZSCORE*

Through literature review, financial stability can be predicted by different factors as follows:

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 CO2_{it} + a_2 FDI_{it} + a_3 G\_ABS_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (1)$$

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 CO2_{it} + a_2 FDI_{it} + a_3 GB_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (2)$$

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 CO2_{it} + a_2 FDI_{it} + a_3 G\_LNS_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (3)$$

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 G\_ABS_{it} + a_2 CO2_{it} + a_3 FDI_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (4)$$

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 GB_{it} + a_2 CO2_{it} + a_3 FDI_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (5)$$

$$LOG\ (\widehat{ZSCORE})_{it} = a_0 + a_1 G\_LNS_{it} + a_2 CO2_{it} + a_3 FDI_{it} + a_4 Exc_{it} + a_5 INF\_GDP_{it} + e_{it} \quad (6)$$

*Models of CO2*

According to literature review, climate change can be predicted by different factors as follows:

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 G_{ABS_{it}} + a_2 FDI_{it} + a_3 Exc_{it} + a_4 INF_{GDP_{it}} + a_5 NII_{it} + a_6 LIQ_{ASSE_{it}} + a_7 NIM_{it} + a_8 CRED\_DEP_{it} + a_9 ZSCORE_{it} + e_{it} \quad (7)$$

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 G_{ABS_{it}} + a_2 Exc_{it} + a_3 INF_{GDP_{it}} + a_4 NII_{it} + a_5 LIQ_{ASSE_{it}} + a_6 NIM_{it} + a_7 CRED\_DEP_{it} + a_8 ZSCORE_{it} + e_{it} \quad (8)$$

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 GB_{it} + a_2 FDI_{it} + a_3 Exc_{it} + a_4 INF_{GDP_{it}} + a_5 NII_{it} + a_6 LIQ_{ASSE_{it}} + a_7 NIM_{it} + a_8 CRED\_DEP_{it} + a_9 ZSCORE_{it} + e_{it} \quad (9)$$

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 GB_{it} + a_2 Exc_{it} + a_3 INF_{GDP_{it}} + a_4 NII_{it} + a_5 LIQ_{ASSE_{it}} + a_6 NIM_{it} + a_7 CRED\_DEP_{it} + a_8 ZSCORE_{it} + e_{it} \quad (10)$$

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 G_{LNS_{it}} + a_2 FDI_{it} + a_3 Exc_{it} + a_4 INF_{GDP_{it}} + a_5 NII_{it} + a_6 LIQ_{ASSE_{it}} + a_7 NIM_{it} + a_8 CRED\_DEP_{it} + a_9 ZSCORE_{it} + e_{it} \quad (11)$$

$$LOG\ \widehat{(CO2)}_{it} = a_0 + a_1 G_{LNS_{it}} + a_2 Exc_{it} + a_3 INF_{GDP_{it}} + a_4 NII_{it} + a_5 LIQ_{ASSE_{it}} + a_6 NIM_{it} + a_7 CRED\_DEP_{it} + a_8 ZSCORE_{it} + e_{it} \quad (12)$$

Where $a_0$ is a constant, and $a_1$ to $a_9$ is the coefficient of the exogenous variables. In addition, $ZSCORE_{it}$ reflects the financial stability of country $i$ at time t proxied by the ZSCORE, while $G\_ABS_{it}$ $GB_{it}$, and $G\_LNS_{it}$ expresses the green finance of country $i$ at time t, as reflected by their green finance instruments such as green asset backed securities to GDP ratio, green bonds of GDP ratio, green loans of GDP ratio, respectively. $i$ refers to the bank sector number in a certain country, but $t$ refers to a certain year from 2013 to 2021. $FDI_{it}$, $Exc_{it}$, $INF\_GDP_{it}$, $NII_{it}$, $LIQ\_ASSE_{it}$, $NIM_{it}$, $CRED\_DEP_{it}$ denote to the control variables, while $e_{it}$ is the error term. Additionally, this study holds importance in the sense that $LOG\ \widehat{(CO2)}_{it}$ to measure climate change has been tested as a good predictor of financial stability in these markets. Therefore, considering the impact of both climate change and green financing instruments will help in the best understanding of financial stability.

## 5. Empirical Results and Discussion

A descriptive statistic is used in this study to describe the object under study through data samples that have been processed by statistical test tools. The results of the descriptive statistical test are shown in table 2. Additionally, this study conducts correlation matrix and unit root tests to ensure that the results are strong against alternative empirical specifications and possible biases. Using panel analysis according to fixed effect model, results indicate that hypotheses regarding the significance of the independent variables impact could be accepted.

*5.1 Descriptive Statistics Analysis*

Table 2. Descriptive statistics of major variables

| Variable | N | Mean | Median | Minimum | Maximum | Std. Dev. | Skewness | Kurtosis | Jarque-Bera |
|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$** | 60 | 6.690163 | 5.412677 | 2.050675 | 16.11119 | 3.771910 | 1.234934 | 3.773157 | 16.74504 |
| **G_ABS** | 60 | 0.002680 | 0.000000 | 0.000000 | 0.052914 | 0.010419 | 4.055779 | 18.13268 | 736.9885 |
| **GB** | 60 | 0.047315 | 0.007819 | 0.000000 | 0.461709 | 0.085007 | 2.606171 | 11.17135 | 234.8487 |
| **G_LNS** | 60 | 0.018695 | 0.004039 | 0.000000 | 0.182780 | 0.034844 | 2.695454 | 10.82426 | 225.7025 |
| **FDI** | 60 | 4.299716 | 2.470556 | -36.14035 | 43.48723 | 10.01157 | 1.041975 | 12.04749 | 215.4996 |
| **Exc** | 60 | 97.74130 | 97.33882 | 69.61118 | 130.0448 | 13.22364 | 0.139614 | 3.169372 | 0.266638 |
| **INF_GDP** | 60 | 2.535737 | 1.772440 | -0.223723 | 8.103604 | 2.150352 | 1.083575 | 3.228189 | 11.87153 |
| **NII** | 60 | 39.48255 | 37.77304 | 16.82816 | 66.32076 | 11.86809 | 0.189726 | 2.018974 | 2.765988 |
| **LIQ_ASSE** | 60 | 33.48558 | 22.79868 | 12.38296 | 91.23676 | 19.64909 | 1.109692 | 3.250863 | 12.47149 |
| **NIM** | 60 | 2.776887 | 2.792201 | 0.713500 | 7.454359 | 1.695629 | 0.758385 | 2.765538 | 5.888902 |
| **CRED_DEP** | 60 | 128.2170 | 110.9085 | 60.51690 | 327.0919 | 67.97357 | 1.794533 | 5.287542 | 45.28561 |
| **ZSCORE** | 60 | 20.30470 | 17.15218 | 7.761494 | 56.34550 | 12.71700 | 1.838436 | 5.432244 | 48.58800 |

Source: Outputs of data processing using Eviews 13.

Tables 2 summarize the descriptive statistics of all variables for developed and emerging markets during the period from 2013 to 2021. As shown from the table above, all variables are asymmetrical, and the skewness is positive for all variables. Meanwhile, table 3 presents a correlation matrix for all variables, as follows:

Table 3. Correlation matrix

| Variable | $CO_2$ | FDI | G-ABS | GB | G-LNS | EXC | NII | LIQ_ASSE | NIM | CRED_DEP | INF_GDP | ZSCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$** | 1.000000 | | | | | | | | | | | |
| | ----- | | | | | | | | | | | |
| | 0.064792 | 1.000000 | | | | | | | | | | |
| **FDI** | 0.6228 | ----- | | | | | | | | | | |
| | 0.564940 | -0.069370 | 1.000000 | | | | | | | | | |
| **G_ABS** | 0.0000 | 0.5984 | ----- | | | | | | | | | |
| | 0.075989 | -0.216275 | -0.074874 | 1.000000 | | | | | | | | |
| **GB** | 0.5639 | 0.0970 | 0.5696 | ----- | | | | | | | | |
| | -0.125099 | -0.166612 | -0.088214 | 0.371424 | 1.000000 | | | | | | | |
| **G_LNS** | 0.3409 | 0.2033 | 0.5027 | 0.0035 | ----- | | | | | | | |
| | 0.585874 | -0.062924 | 0.331788 | 0.126707 | -0.104740 | 1.000000 | | | | | | |
| **EXC** | 0.0000 | 0.6329 | 0.0096 | 0.3347 | 0.4258 | ----- | | | | | | |
| | -0.142879 | -0.161443 | -0.063898 | 0.111825 | 0.444416 | -0.313706 | 1.000000 | | | | | |
| **NII** | 0.2761 | 0.2178 | 0.6277 | 0.3950 | 0.0004 | 0.0147 | ----- | | | | | |
| | -0.267523 | -0.008650 | -0.188578 | -0.003924 | 0.037894 | -0.344629 | 0.530165 | 1.000000 | | | | |
| **LIQ_ASSE** | 0.0388 | 0.9477 | 0.1490 | 0.9763 | 0.7738 | 0.0070 | 0.0000 | ----- | | | | |
| | -0.240231 | -0.050517 | 0.100706 | -0.352408 | -0.310335 | -0.436012 | -0.373823 | -0.095672 | 1.000000 | | | |
| **NIM** | 0.0645 | 0.7015 | 0.4439 | 0.0058 | 0.0158 | 0.0005 | 0.0033 | 0.4671 | ----- | | | |
| | -0.128863 | -0.027894 | -0.239234 | 0.064393 | -0.185084 | 0.563614 | -0.527288 | -0.307135 | -0.134139 | 1.000000 | | |
| **CRED_DEP** | 0.3265 | 0.8325 | 0.0656 | 0.6250 | 0.1568 | 0.0000 | 0.0000 | 0.0170 | 0.3069 | ----- | | |
| | -0.436347 | -0.107854 | -0.075549 | -0.189806 | -0.144678 | -0.554291 | -0.186718 | 0.148179 | 0.709813 | -0.082423 | 1.000000 | |
| **INF_GDP** | 0.0005 | 0.4121 | 0.5662 | 0.1464 | 0.2701 | 0.0000 | 0.1532 | 0.2585 | 0.0000 | 0.5313 | ----- | |
| | 0.756015 | -0.188361 | 0.674620 | -0.129872 | -0.128249 | 0.388027 | -0.049390 | -0.253296 | 0.172803 | -0.229052 | -0.148141 | 1.000000 |
| **ZSCORE** | 0.0000 | 0.1495 | 0.0000 | 0.3227 | 0.3288 | 0.0022 | 0.7078 | 0.0509 | 0.1867 | 0.0783 | 0.2586 | ----- |

Source: Outputs of data processing using Eviews 13.

This study employs the Augmented Dickey and Fuller (ADF) and Phillips and Perron (PP) unit root tests to find out whether the variables contain unit root. Unit root test results are presented in Table 4, as follows:

Table 4. Panel unit root tests

| Variable / Chi−square | Level | | First difference | | |
|---|---|---|---|---|---|
| | ADF−Fisher | PP−Fisher | ADF−Fisher | PP−Fisher | Conclusion |
| **$CO_2$** | 31.2938 | 41.1387 | 104.984*** | 103.681*** | 1 st Difference |
| **ZSCORE** | 32.0046 | 37.1623 | 139.447*** | 133.595*** | 1 st Difference |
| **FDI** | 64.5147*** | 70.4595*** | 154.733*** | 181.655*** | In level |
| **G_ABS** | 1.51033 | 1.47506 | 14.1413*** | 14.1264*** | 1 st Difference |
| **GB** | 35.6717 | 54.1269*** | 188.780*** | 198.608*** | In level |
| **G_LNS** | 46.2347*** | 60.4807*** | 167.064*** | 200.176*** | In level |
| **EXC** | 55.7882*** | 51.1486*** | 104.980*** | 91.9796*** | In level |
| **NII** | 68.1740*** | 52.6482*** | 130.006*** | 136.864*** | In level |
| **LIQ_ASSE** | 42.6949** | 26.5300 | 75.5439*** | 87.0132*** | In level |
| **NIM** | 44.3043** | 45.3357** | 121.233*** | 126.906*** | In level |
| **CRED_DEP** | 31.4918 | 36.8396* | 66.7772*** | 65.2482*** | In level |
| **INF_GDP** | 40.0637* | 38.6672* | 123.651*** | 119.495*** | In level |

*Note.* ***, ** and * indicate significant levels of 1%, 5% and 10%, respectively.

This study employs these unit root tests to find out whether the variables contain unit root. According to Table 4, using the unit root approach proposed by Augmented Dickey and Fuller (1979) and Phillips and Perron (1988), FDI, GB, G_LNS, EXC, NII, LIQ_ASSE, NIM, CRED_DEP and INF_GDP variables are stationary in level, while the others are stationary in the first difference, this means that there is a different level of stationery in the models.

*5.1 The Panel Regression Results and Hypotheses Testing*

To assess the relationship among green finance, climate change, foreign direct investment, and financial stability in emerging and developed markets annually during the period from 2013 through 2021, this study use panel analysis according to fixed effect model after conducting several tests. The results of the panel analysis according to fixed effect model are shown in tables 5, 6 and 7. A panel regression model provides the following results:

Table 5. Climate change and financial stability

| Variables / The effect of | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | | log(z-score) | |
| **Constant** | 4.412315 (0.344160) *** | 4.305016 (0.351502) *** | 4.114297 (0.364029) *** |
| **$CO_2$** | -0.216183 (0.039463) *** | -0.182845 (0.035463) *** | -0.156652 (0.037581) *** |
| **G_ABS** | -3.391940 (2.104856) | | |
| **GB** | | 0.256933 (0.186933) | |
| **G_LNS** | | | 0.563827 (0.269091) ** |
| **FDI** | -0.001249 (0.001499) | -0.000611 (0.001660) | -0.001181 (0.001476) |
| **EXC** | -0.000873 (0.002652) | -0.002175 (0.002461) | -0.001984 (0.002412) |
| **INF_GDP** | -0.008730 (0.011714) | -0.013083 (0.011570) | -0.012816 (0.011337) |
| **R-squared** | 0.962798 | 0.962379 | 0.963818 |
| **Adjusted R-squared** | 0.953650 | 0.953128 | 0.954921 |
| **S.E. of regression** | 0.098508 | 0.099061 | 0.097148 |
| **F-statistic** | 105.2460 | 104.0296 | 108.3286 |
| **Prob (F-statistic)** | 0.000000 | 0.000000 | 0.000000 |

*Note.* Each cell contains the estimated parameters, with Std. Error between brackets, where * denotes p-value of 10%, ** indicates 5% and *** denotes 1%.

Using a panel regression model provides the following results, when assessing the relationship between $CO_2$ emissions and financial stability of the research sample, results support in all models the negative effect of country's climate change on financial stability by log (z-score) in emerging and developed markets with explanation power of 0.953650, 0.953128 and 0.954921, respectively.

In this context, this study finds that the financial stability in markets was significantly driven by $CO_2$ emissions. Findings indicate the negative impact of the $CO_2$ emissions on financial stability, implied by financial stability has decreased in response to climate change through $CO_2$ emissions for 14 countries. Hence, results indicate that the country's $CO_2$ emissions can be used to predict financial stability through log (z-score) during 2013 to 2021. Therefore, the results indicate that hypothesis regarding the significance of this impact could be accepted.

Table 6. Green finance and financial stability

| Variables / The effect of | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | log(z-score) | | |
| **Constant** | 4.412315 (0.344160) *** | 4.305016 (0.351502) *** | 4.114297 (0.364029) *** |
| **G_ABS** | -3.391940 (2.104856) | | |
| **GB** | | 0.256933 (0.186933) | |
| **G_LNS** | | | 0.563827 (0.269091) ** |
| **$CO_2$** | -0.216183 (0.039463) *** | -0.182845 (0.035463) *** | -0.156652 (0.037581) *** |
| **FDI** | -0.001249 (0.001499) | -0.000611 (0.001660) | -0.001181 (0.001476) |
| **EXC** | -0.000873 (0.002652) | -0.002175 (0.002461) | -0.001984 (0.002412) |
| **INF_GDP** | -0.008730 (0.011714) | -0.013083 (0.011570) | -0.012816 (0.011337) |
| **R-squared** | 0.962798 | 0.962379 | 0.963818 |
| **Adjusted R-squared** | 0.953650 | 0.953128 | 0.954921 |
| **S.E. of regression** | 0.098508 | 0.099061 | 0.097148 |
| **F-statistic** | 105.2460 | 104.0296 | 108.3286 |
| **Prob (F-statistic)** | 0.000000 | 0.000000 | 0.000000 |

*Note.* Each cell contains the estimated parameters, with Std. Error between brackets, where *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This study assesses the relationship between green finance and financial stability also of the research sample by using a panel regression model. The results reveal the positive effects of green finance on financial stability through green loans of GDP ratio (G-LNS) with explanation power of 0.954921. So, this study finds that the financial stability was significantly driven by green loans, implied by financial stability has increased in response to use the green loans for 14 countries. Therefore, the results indicate that hypothesis regarding the significance of this impact could be accepted.

Notably, a panel regression model provides the following effects: When assessing the relationship between green finance and $CO_2$ emissions of the study sample, results support the negative effect of G_ABS on country's climate change through $CO_2$ emissions in markets for both cases of whether the foreign direct investment exists or not with explanation power of 0.996761 and 0.996509, respectively.

Simultaneously, results support the positive effects of Foreign direct investment on country's $CO_2$ emissions through green asset backed securities to GDP ratio (G-ABS) and green bonds of GDP ratio (GB) with explanation power of 0.996761 and 0.996356, respectively. In addition, results reveal the positive effects of net interest income ratio (NII) and bank credit to bank deposits ratio (CRED_DEP) in all models, as determinants of banks performance on $CO_2$ emissions with explanation power of 0.996761, 0.996509, 0.996356, 0.996183, 0.996443 and 0.996312, respectively.

Additionally, the results indicate the negative effects of liquidity (LIQ_ASSE), profitability (NIM), and financial stability (ZSCORE) in all models, as determinants of banks performance on $CO_2$ emissions in markets. While the results reveal the positive effects of real effective exchange rate (Exc) and Inflation (INF_GDP), as determinants of economic characteristics on $CO_2$ emissions in markets.

In this context, this study finds that the $CO_2$ emissions reduction was significantly driven by green asset backed securities to GDP ratio (G-ABS). Therefore, results indicate that hypotheses regarding the significance of this impact could be accepted according to fixed effect model. Hence, results indicate that the green finance can be used to predict country's $CO_2$ emissions through green asset backed securities (more than other green financing instruments) during 2013 to 2021.

Table 7. Green finance and climate change

| Variables / The effect of | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| | LOG ($CO_2$) | | | | | |
| **Constant** | 1.615691 (0.142683) *** | 1.658018 (0.146612) *** | 1.729882 (0.141621) *** | 1.763361 (0.143592) *** | 1.751024 (0.140770) *** | 1.784738 (0.141710) *** |
| **G_ABS** | -1.432477 (0.622010) ** | -1.352284 (0.644557) ** | | | | |
| **GB** | | | 0.031322 (0.080828) | -0.045617 (0.069100) | | |
| **G_LNS** | | | | | -0.191809 (0.178214) | -0.247122 (0.177993) |
| **FDI** | 0.000977 (0.000473) ** | | 0.001037 (0.000599) * | | 0.000804 (0.000504) | |
| **NII** | 0.002825 (0.001199) ** | 0.002923 (0.001243) ** | 0.002786 (0.001340) ** | 0.003262 (0.001343) ** | 0.003035 (0.001257) ** | 0.003132 (0.001278) ** |
| **LIQ_ASSE** | -0.001551 (0.000615) ** | -0.001710 (0.000633) *** | -0.001331 (0.000684) * | -0.001660 (0.000672) ** | -0.001400 (0.000642) ** | -0.001528 (0.000648) ** |
| **NIM** | -0.026033 (0.008437) *** | -0.025609 (0.008758) *** | -0.028238 (0.008892) *** | -0.028167 (0.009101) *** | -0.029079 (0.008802) *** | -0.028841 (0.008961) *** |
| **CRED_DEP** | 0.001044 (0.000444) ** | 0.001021 (0.000461) ** | 0.001200 (0.000483) ** | 0.001069 (0.000488) ** | 0.000952 (0.000500) * | 0.000869 (0.000507) * |
| **ZSCORE** | -0.007349 (0.003036) ** | -0.008701 (0.003078) *** | -0.008009 (0.003206) ** | -0.009092 (0.003218) *** | -0.007419 (0.003220) ** | -0.008279 (0.003232) ** |
| **EXC** | 0.001597 (0.001205) | 0.001566 (0.001251) | 0.000356 (0.001150) | 0.000440 (0.001176) | 0.000333 (0.001135) | 0.000350 (0.001156) |
| **INF_GDP** | 0.005937 (0.003745) | 0.004110 (0.003779) | 0.004040 (0.003887) | 0.002933 (0.003924) | 0.004779 (0.003886) | 0.003601 (0.003884) |
| **R-squared** | 0.997749 | 0.997515 | 0.997468 | 0.997283 | 0.997528 | 0.997375 |
| **Adjusted R-squared** | 0.996761 | 0.996509 | 0.996356 | 0.996183 | 0.996443 | 0.996312 |
| **S.E. of regression** | 0.030462 | 0.031628 | 0.032313 | 0.033073 | 0.031925 | 0.032506 |
| **F-statistic** | 1009.838 | 991.6387 | 897.1902 | 906.674893 | 919.2281 | 938.6352 |
| **Prob (F-statistic)** | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Kao Residual Cointegration Test ADF** | -7.033226 *** | -5.148984*** | -5.996464*** | -4.946531*** | -5.983895*** | -4.992917*** |

*Note.* Each cell contains the estimated parameters, with Std. Error between brackets, where * denotes p-value of 10%, ** indicates 5% and *** denotes 1%. Augmented Dickey-Fuller (ADF) Test indicates t-statistics and p-value.

### *5.2 Robustness Tests*

In this study conducted several robustness tests to ensure that the results were strong against alternative empirical specifications and possible biases. To check the robustness of the results, model diagnostics tests were performed, which proved the impact significance of the green finance on financial stability, most notably by the green loans of GDP ratio side.

In addition, the results supported the impact significance of climate change on financial stability, also the impact significance of the green finance on $CO_2$ emissions, most notably by the green asset backed securities to GDP ratio side. Therefore, robustness checks by using dynamic effect model assure the significance of these effects, as follow:

Table 8. Effects of climate change on financial stability

| Variables / The effect of | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | log(z-score) | | |
| **Constant** | 4.412315 (0.406254) *** | 4.305016 (0.406203) *** | 4.114297 (0.390466) *** |
| **$CO_2$** | -0.216183 (0.061017) *** | -0.182845 (0.051160) *** | -0.156652 (0.048777) *** |
| **G_ABS** | -3.391940 (1.753235) * | | |
| **GB** | | 0.256933 (0.161547) | |
| **G_LNS** | | | 0.563827 (0.218284) ** |
| **FDI** | -0.001249 (0.000958) | -0.000611 (0.001255) | -0.001181 (0.000960) |
| **EXC** | -0.000873 (0.002213) | -0.002175 (0.001945) | -0.001984 (0.001839) |
| **INF_GDP** | -0.008730 (0.006886) | -0.013083 (0.006662) * | -0.012816 (0.006542) * |
| **R-squared** | 0.962798 | 0.962379 | 0.963818 |
| **Adjusted R-squared** | 0.953650 | 0.953128 | 0.954921 |
| **S.E. of regression** | 0.098508 | 0.099061 | 0.097148 |
| **F-statistic** | 105.2460 | 104.0296 | 108.3286 |
| **Prob (F-statistic)** | 0.000000 | 0.000000 | 0.000000 |

*Note*. Std. Error in parentheses. The symbols where *, ** and *** indicate denote statistical significance at the 10%, 5% and 1% levels, respectively.

This paper holds significance in the sense that $CO_2$ emissions have been tested as a good predictor of financial stability. Additionally, this study holds significance in the sense that $G\_ABS_{it}$, $GB_{it}$ and $G\_LNS_{it}$ to measure the green finance has been tested as a good predictor of financial stability. The findings provide the significance of $CO_2$ emissions negative effect on financial stability, with explanation power in all models of 0.953650, 0.953128, and 0.954921, respectively.

In addition, the results support the significance of $G\_LNS_{it}$ positive effect on financial stability in markets, with explanation power of 0.954921. The robustness test results prove that there is a positive impact of the green finance from 2013 to 2021 on financial stability. Also, these findings show that there is a negative impact of climate change on financial stability in emerging and developed markets.

The results support the significance of $G\_ABS_{it}$ negative effect on $CO_2$ emissions, with explanation power of 0.996761 (with FDI effect), 0.996509 (without FDI impact) and $and$ $G\_LNS_{it}$ with explanation power of 0.996312 (without FDI influence). So, the results proved the green finance has been tested as a good predictor of $CO_2$ emissions. Addition to, findings provide the significance of $FDI_{it}$, $NII_{it}$, $CRED\_DEP_{it}$, $Exc_{it}$ and $INF\_GDP_{it}$ positive effect on $CO_2$ emissions, while reveal the significance of $LIQ\_ASSE_{it}$, $NIM_{it}$ and $ZSCORE_{it}$ negative impact on $CO_2$ emissions. The robustness tests results show that the $CO_2$ emissions seem to be sensitive to the investment in green finance, most notably by green asset backed securities and green loans. Hence, results indicate that green finance can be used to predict climate change from 2013 to 2021.

Table 9. Effects of green finance on climate change

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| | LOG ($CO_2$) | | | | | |
| **Constant** | 1.615691 (0.123363) *** | 1.658018 (0.125591) *** | 1.729882 (0.121623) *** | 1.763361 (0.120709) *** | 1.751024 (0.129321) *** | 1.784738 (0.130238) *** |
| **G_ABS** | -1.432477 (0.354296) *** | -1.352284 (0.378653) *** | | | | |
| **G_GB** | | | 0.031322 (0.066067) | -0.045617 (0.043031) | | |
| **G_LNS** | | | | | -0.191809 (0.143674) | -0.247122 (0.145027) * |
| **FDI** | 0.000977 (0.000362) *** | | 0.001037 (0.000438) ** | | 0.000804 (0.000316) ** | |
| **NII** | 0.002825 (0.000980) *** | 0.002923 (0.001017) *** | 0.002786 (0.001048) ** | 0.003262 (0.001007) *** | 0.003035 (0.000967) *** | 0.003132 (0.000997) *** |
| **LIQ_ASSE** | -0.001551 (0.000512) *** | -0.001710 (0.000512) *** | -0.001331 (0.000534) ** | -0.001660 (0.000501) *** | -0.001400 (0.000527) ** | -0.001528 (0.000524) *** |
| **NIM** | -0.026033 (0.006028) *** | -0.025609 (0.006342) *** | -0.028238 (0.007248) *** | -0.028167 (0.007498) *** | -0.029079 (0.007423) *** | -0.028841 (0.007685) *** |
| **CRED_DEP** | 0.001044 (0.000367) *** | 0.001021 (0.000380) ** | 0.001200 (0.000383) *** | 0.001069 (0.000376) *** | 0.000952 (0.000423) ** | 0.000869 (0.000441) * |
| **ZSCORE** | -0.007349 (0.002367) *** | -0.008701 (0.002498) *** | -0.008009 (0.002789) *** | -0.009092 (0.002911) *** | -0.007419 (0.002871) ** | -0.008279 (0.002862) *** |
| **EXC** | 0.001597 (0.000946) * | 0.001566 (0.000959) | 0.000356 (0.001047) | 0.000440 (0.001052) | 0.000333 (0.001094) | 0.000350 (0.001111) |
| **INF_GDP** | 0.005937 (0.002995) * | 0.004110 (0.003128) | 0.004040 (0.003028) | 0.002933 (0.003223) | 0.004779 (0.003054) | 0.003601 (0.003013) |
| **R-squared** | 0.997749 | 0.997515 | 0.997468 | 0.997283 | 0.997528 | 0.997375 |
| **Adjusted R-squared** | 0.996761 | 0.996509 | 0.996356 | 0.996183 | 0.996443 | 0.996312 |
| **S.E. of regression** | 0.030462 | 0.031628 | 0.032313 | 0.033073 | 0.031925 | 0.032506 |
| **F-statistic** | 1009.838 | 991.6387 | 897.1902 | 906.674893 | 919.2281 | 938.6352 |
| **Prob (F-statistic)** | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

*Note.* Std. Error in parentheses. The symbols where *, ** and *** indicate denote statistical significance at the 10%, 5% and 1% levels, respectively.

## 6. Conclusions and Discussion

This paper contributes to assessment the relationship among climate change, green finance, and financial stability annually from 2013 up to 2021 for 14 countries, focusing on emerging and developed markets. This study first considers whether a country's carbon dioxide emissions impact financial stability for 14 countries. Furthermore, this study investigates whether green finance influences financial stability and how it affects carbon dioxide emissions. Green finance has been measured by green of asset backed securities, bonds and loans to GDP, while carbon dioxide emissions as proxy of climate change and financial stability has been measured by Z-score.

Using panel data, the findings show that there is a significantly negative effect of $CO_2$ emissions on financial stability, but positive effects of green finance on financial stability, most notably through green loans. Also, this paper examines the relationship between green finance and climate change by using Kao Residual Cointegration test of countries. In the long run, green finance negatively affects carbon dioxide emissions. Results indicate that banks which lend to green enterprises will have higher financial stability and be led to lower $CO_2$ emissions. Additionally, results reveal that banks that use green asset backed securities will be led to lower carbon dioxide emissions than green loans. Overall, the findings suggest that there are incentives for banks to extend more green loans to companies and use green asset backed securities, which will help foster financial stability and sustainability targets. Furthermore, the empirical results of the robustness test of GMM are highly consistent with the main test. This study may be extended by conducting Further research to focus on the effect of $CO_2$ emissions on financial markets with the role of financial deepening for countries.

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