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Is Climate FinTech Effective in Mitigating Climate Change Risk? An Analysis of Linear and Non-Linear Causality Tests

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Prepared by Dr Anwar Othman

Abstract

Global climate change and global warming are typically attributed to human activity, especially after the industrial revolution. There is a growing consensus among climate scientists that Climate FinTech provides great potential to protect the environment and mitigate climate change risks. In this paper, we investigate the cause-and-effect relationship between the FinTech index and carbon dioxide emissions index globally. In doing so, Granger causality test and Wavelet coherence analysis are employed to evaluate this association using daily frequency data over a period of 30 June 2015 to 31 December 2021. The study findings indicate that there is not a cause-and-effect relationship between the global FinTech index and the carbon dioxide emissions index, which indicates that FinTech adoption does not result in any global carbon dioxide emissions. In addition, the analysis of continuous wavelet coherency found that there is no statistically significant coherence between FinTech index and carbon dioxide emissions index across time horizons, and no arrows appeared in the significant area, demonstrating that financial technology adoption does not correlate with global carbon dioxide emissions. To put it another way, according to the results of this study, climate FinTech tools and applications are environmentally friendly. With the study limitations in mind, those results would be useful for governments, corporate, and policymakers looking at climate FinTech tools and applications as a potential way of reducing climate change risks and achieving sustainable development goals.

Keywords: Climate Change, Climate FinTech, Causality, Wavelet Coherence Analysis, Environment

Introduction

Earth's climate system has been measured, investigated, and modelled in extensive detail, allowing scientists to project future climate change more accurately. Almost all current climate models predict that over the next few decades, the Earth will continue to warm considerably. However, it is challenging to provide a precise forecast of how global temperatures will change in the future due to a variety of factors. First of all, it is impossible to forecast the amount of carbon dioxide (CO_2) humans will generate, as this will depend on the dynamics of global economic growth and the way society produces and utilises energy over the next few decades. As stated on the Royal Society website, "the evidence and data reviewed clearly indicate that most of the global warming experienced over the past 50 years has been attributed to human activity rather than natural causes". The second point to make is that a specific scenario of CO_2 emissions may result in a variety of outcomes due to the complexity of climate feedbacks. Last but not least, over a period of a couple of decades, variations in natural conditions can alter the effects of an underlying trend in temperature.

Numerous studies have demonstrated that global climate change could reduce human well-being (Schlenker and Roberts, 2009; Hsiang and Miguel, 2015; Dafermosa et al., 2018; and Gelzinis and Steele, 2019). Further, climate change could dramatically decrease the potential for economic growth in the future. This is because it will redirect resources away from current innovations and capital investments to climate change (Fabris, 2020). Economic well-being and growth are negatively affected by climate change through a variety of channels, such as decreased agricultural productivity, diminished productivity of workers due to increasing temperatures, rising medical costs, physical damage caused by fires, flooding, ocean acidification, biodiversity loss, and adverse effects across countries. (Fabris, 2020) By destroying infrastructure and increasing the costs of subsistence and social welfare, it also threatens macroeconomic and fiscal stability by affecting economic growth, the cost of financing, public debt, employment, inflation, and the like. These factors may contribute to the price rise of some goods and services, including agricultural products, insurance, water, etc (Fabris, 2020). Therefore, if technological or policy changes are not made to reduce emission trends from their present trajectory, global warming will continue increasing beyond an acceptable threshold and will seriously affect our environment and the natural resources on our planet.

Climate FinTech has recently been proposed to protect the environment and has made significant advances. As a broad term, climate FinTech is defined as the use of financial technology to promote economic decarbonization (Goldstein et al., 2019). This new trend is called Green FinTech or Sustainable FinTech since three industries are involved: climate, finance, and technology (Macchiavello & Siri, 2020). Climate fintech facilitates investment, saving, and spending in a way that is responsible for the planet (Goldstein et al., 2019). It involves developing innovations, applications, and platforms to facilitate such actions (Kandpal & Mehrotra, 2019, and Yazici, 2019). In a world where capital has moved toward decarbonization, global warming could be dramatically impacted. As part of the effort to reduce carbon emissions, additional investments are being made in battery technology, carbon sequestration (which refers to the removal, storage and capture of CO2 from the atmosphere), reforestation, renewable energy, electrification, and energy efficiency (Wang & Zhi, 2016). A big role of climate fintech is that it serves as a strategic intermediary for financial services by mobilizing capital and changing human behaviour (Goldstein et al., 2019). Climate Fintech's major impacts are especially felt in the consumer behavior, investment, and risk analysis areas. Several climate-related financial technology firms help consumers make more informed purchasing decisions, assist investors in building climate-focused funds and assist insurance firms in analyzing weather-related risks better (Macchiavello & Siri, 2020). These tools are useful for businesses to monitor, measure, and reduce their environmental impact.

A flourishing Climate FinTech Ecosystem requires not only the involvement of start-ups business or corporations, but also that of regulators and governments. Globally, there are increasing numbers of initiatives led by regulators, governments, and corporations that promote sustainable finance and green finance. As an example, 196 parties came to an agreement in Paris, France during the 2015 United Nations Climate Change Conference. It is an agreement that covers mitigation, adaptation, and finance in the context of climate change. Furthermore, taking the EU's taxonomy for sustainable activities as an example, which published in July 2020, so that economic activities can be evaluated against the criteria for being environmentally sustainable. In addition, the Bank for International Settlements (BIS) Innovation Hub has identified green finance as one of six priorities for the 21st century in its work programme for 2021-2022. More importantly, 43 international banks have pledged to achieve completely zero greenhouse gas emissions by the year 2050, including Bank of America, Barclays, Deutsche Bank, HSBC, and BNP Paribas. Some of these major players have already achieved this. Similarly, the China's largest bank also backed out of a $3 billion coal-fired power project in Zimbabwe over environmental concerns. In recent years, Environmental, Social, and Governance investing has increasingly been incorporated into mainstream global investment strategies. More banks are launching green projects. For instance, Goldman Sachs has pledged to invest $750 billion in sustainable finance by 2030, Citigroup has announced a $1 trillion commitment, and Bank of America has set aside $300 billion dollar for green investments (Stężycki. P, 2022).

In recent years, climate fintech has gained a lot of attention as a technology that can retool the financial sector and leverage digital transformation to benefit society and the environment. In this way, it can achieve the Paris Agreement's goals of reducing greenhouse gas emissions and strengthening climate resilience. Arup Kumar Chatterjee (2022) outlines a number of ways in which climate fintech is already playing a significant role in climate risk assessment, capital deployment, carbon credits, and offsets as well as regulatory technology for enhanced observance. With climate fintech, risk can be mitigated, efficiency can be improved, and decisions can be informed when it comes to climate change. Despite this, many Fintech users believe that adopting such a Fintech product will negatively affect the environment. For instance, by purchasing plastic products, such as credit and debit cards, consumers are more likely to have a higher carbon footprint. In this sense, fintech business models can negatively contribute to global warming or climate change (Derin Cag, 2022). Therefore, this study examines empirically the cause-and-effect relationships between the global financial technology index (as a proxy for climate FinTech) and climatic changes measured by the CO2 global index.

Literature Review

A number of significant advancements have been made in the field of financial technology to protect the environment in recent years. In the financial sector, blockchains, social networks, big data analytics, and artificial intelligence (AI) result in lower costs, better services, diminished information inequality, increased transparency, and a more diversified and stable system due to the advent of these technologies (Cao et al., 2021). There is a direct link between all of these technological solutions and financial development. Many channels can be used to explain how digital finance protect the environment and reduces carbon emissions, such as technological progress enabled by digital finance, economic growth facilitated by financial development, and environmental pollution reduced by finance development (Zhao et al., 2021). Since carbon emissions level have rapidly risen globally in recent years and contributed significantly to global climate change, a number of studies have sought to understand the relationship between the expansion of climate fintech or financial technology and the addressing of climate change.

As part of Zhou's (2022) study of the impact of digital finance development on CO2 emissions in China from 2011 to 2019, he uses panel data from 287 cities between 2011 and 2019. In order to analyze the impact of digital finance on carbon emissions, the author uses a two-way fixed-effect model and an intermediary model. The results of the empirical analysis show that digital finance has a clear effect on reducing carbon dioxide emissions in China as a whole; digital finance's impact on carbon dioxide emission intensity is regionally heterogeneous, and digital finance development in eastern China can make an influential contribution to reducing greenhouse gas emissions. The study concluded that digital finance could drive low-carbon development by optimizing and upgrading technology. Furthermore, an investigation of the impact of digital finance on household CO2 emissions (HCEs) in China was conducted by Qin et al. (2022). Results indicate a positive impact of digital finance on consumption based HCEs. According to the analysis, the scale effect appears to increase HCEs by stimulating consumption scale. Additionally, digital finance has the potential to reduce HCEs by encouraging greener consumption patterns. This is known as the composition effect.

Mhlanga (2022) sought to answer the question, how can financial technology be used to address climate change-related challenges or hazards? Results of the study indicated that FinTech could increase household, individual, and business resilience in cases of rapid climate change events or gradual effects of changing rainfall patterns, rising sea levels, or saltwater intrusions. Further, the findings show that people facing climate change, as well as those in charge of dealing with it, can benefit from insurance, savings, credit, money transfers, and new digital distribution channels. Therefore, FinTech should be promoted as one of the channels for managing risks associated with climate change and achieving sustainable development goals through design patterns, government policies, and civil society initiatives. Furthermore, several scholars, such as Hussain et al. (2022) and Zaidi et al. (2021), believe that FinTech can make a significant contribution to reducing climate change, particularly when it comes to energy use and carbon dioxide emissions. Additionally, Anshari et al. (2021) claim that FinTech, such as the Digital Wallet initiative, is influential in influencing public opinion to support sustainable development. Furthermore, they suggested that a framework for increasing recycling activities and initiatives is being developed, based on the Digital Wallet platform. According to Anshari et al. (2021), a digital wallet gives all stakeholders the chance to participate in socioeconomic and sustainable activities on a single platform.

An analysis of the relationship between digital finance, development, and climate change was conducted by Galanti & Zsoy (2022). They found that the impact on CO2 emissions varied depending on the type of digital finance instruments used. For example, mobile money could mitigate the negative effects of CO2 emissions. On the other hands, bitcoin has a negative direct effect on CO2, but with a minimal impact. In addition, in Shao et al.'s (2022) study, data from 281 Chinese cities from 2011 to 2019 are used to examine the impact of digital finance on comprehensive carbon emission performance (CCEP). They found that digital finance enhances CCEP primarily through the promotion of green technology innovation and tertiary industries in urban areas with well-developed traditional finance. More so, the study by Tao et al (2022) attempts to answer the question of whether fintech development assists economies in reducing their carbon and greenhouse gas emissions. In this aspect, the study results are highly encouraging, and demonstrate that Fintech development can in fact reduce greenhouse gas emissions.

Cai and Song (2022) argue that digital finance affects carbon emissions massively. They investigated the direct, indirect, and non-linear effects of digital finance on carbon emissions. Thy found that, digital finance is capable of significantly reducing carbon emissions at the national level. The digital finance sector has also been found to decrease carbon emissions by stimulating technological innovation and upgrading the industrial structure. To fully realize the potential of reducing carbon emissions, the study recommended that policymakers must implement differentiated digital finance initiatives as well as rationalize and optimize industrial layouts. A similar debate has been sparked by Wang et al. (2022) who assert that digital financial technologies contribute to carbon emission reduction through both economic growth and structural changes in industrial sectors. Further, a study by Xue et al. (2022) of Chinese cities concludes that digital finance reduces carbon emissions more significantly in cities with more developed economies, and that the effect generates shocks for neighboring regions as well. A study by Wan et al. (2022) confirms that digital finance successfully mitigates ambient pollution, but at varying rates among regions and cities. Moreover, Xin et al. (2022) suggest that digital finance can encourage pollution-intensive enterprises to devote more time and energy to social responsibility, thus reducing pollution sources. At the macro level, Zhang and Liu, (2022) argue that digital finance promotes economic development, improves the ecological environment, and reduces pollution emissions. Moreover, an analysis by Feng et al. (2022) argued that green technology innovation was synergistic with digital finance in achieving superior efficiency at the local level, while suppressing emissions at the neighbouring level.

The spatial autoregression model (SAR) and spatial Durbin model (SDM) are used by Wu et al. (2022) to study the impact of digital finance on CO_2 emissions. The results of the study show that digital finance reduces CO_2 emissions significantly. The introduction of digital finance results in a reduction of CO_2 emissions if it promotes energy and industrial structure transformation and spreads to surrounding areas through spillover effects. In addition, it increases the number of environmentally friendly patents awarded and therefore minimizes regional CO_2 emissions. It also advances green technological progress and therefore inhibits CO_2 emissions, but decreases green technological progress in nearby areas, thus increasing CO_2 emissions due to the siphon effect. The study concluded that digital finance reduces CO_2 emissions more effectively when financial regulations, green development, and a green finance index are implemented. In addition, Zhao et al (2021) empirically examined the relationship between digital finance and carbon emissions at the provincial level in China between 2011 and 2018. In the results, it was found that digital finance had a significant inhibitory effect on carbon emissions. As a result of the study, policymakers will be able to establish an empirical basis for promoting digital finance as a means of reducing carbon emissions.

Zhang and Liu (2022) examine how innovation in digital finance and green technologies affect carbon emissions efficiency to formulate effective policies in China. Digital finance and green technology innovation were empirically analyzed using panel data sets from 2011 to 2017 based on a spatial econometric model. Study results show that combining digital finance and green technology innovation promotes local carbon emission efficiency through a synergistic effect. In order to reduce urban carbon emissions efficiently, the study recommends that China integrates digital finance with green technology, develops supporting policies and measures tailored to local conditions. This will allow China to achieve both theoretically and practically its "carbon neutralization" goal. Additionally, using panel data collected between 2010 and 2020 from 60 emerging and non-emerging economies, Yu et al (2022) examined how green digital finance affects climate change mitigation from a resource-constrained perspective. Study findings indicate that digitally accessible green finance can facilitate the development of environmentally friendly and renewable energy resources and the reduction of CO2 emissions.

Impact of FinTech on SDGs

A study by Puschmann, et al. (2020) used literature review analysis to explore Green FinTech's role in climate change mitigation. From a literature review and market analysis, it appears that green FinTech is impacting the financial services industry along the entire value chain encompassing customer-to-customer (C2C), business-to-business (B2B), and business-to-government (B2G) interactions. Hinson et al. (2019) assert that FinTech and its integration with other (green) technologies, as well as digital agriculture, play an essential role when it comes to achieving, for instance, SDG 12 and its target of responsible production. They offer the advantage of reducing trade-offs and enhancing synergies between social and environmental SDGs, like SDG1 and SDG15, without consuming more natural resources. A study, Nassiry (2018), examines how fintech is changing the landscape of green finance. It argues that fintech can unlock new green finance technologies, including blockchain and the

Internet of Things (IoT). The study discusses four broad areas of fintech applications in green finance. These include blockchain for sustainable development, decentralized electricity markets, carbon credits and climate finance, and financial instrument innovation, such as sustainable bonds. An overview of the study's recommendations for policymakers looking to harness fintech to achieve the SDGs and build a climate-resilient and low-carbon economy. In a study published in 2021, Michael examined the potential effects of FinTech policies on the UN's SDGs. Study results give little credence to the claim that FinTech can improve the SDG scores of developing countries. The role of government in developing resilient economies will probably remain critical. It is likely that FinTech policies and practices will have a similar U-shaped impact on sustainable development. Such effects are most likely to affect environmental/social goals rather than economic ones.

Thus, by fulfilling the Sustainable Development Goals (SDGs) of the United Nations and implementing the Paris Agreement, policymakers will be able to mitigate climate change risks using the most innovative climate FinTech solutions. However, the solutions being developed are still in their early stages. There has been no comprehensive study of climate FinTech solutions to mitigate climate change risk, nor have frameworks been developed for analyzing these solutions in detail. In this study, we tried to fill up that gap by empirically examining the cause-and-effects relationship between global financial technology index and climatic changes measured by the CO_2 global index.

Methodology

Data Sources and Variables Measurement

In this study, daily frequency data of global FinTech index obtained from Indxx's respected website and Carbon dioxide (CO_2) global index obtained from data stream database over the period 30 June 2016 to 31 December 2021 were analysed, with a total of 1815 observations daily. The Indxx Global Fintech Thematic Index is defined and developed by Indxx "to track the performance of companies listed in developed markets that offer technology-driven financial services that are disrupting existing business models in financial services and banking". The initial value of the index is 1,000 with a base date of June 30, 2015, as presented by Figure (1). As defined by Indxx, FinTech index includes these sub-themes: P2P and Marketplace Lending, Mobile Payments, Crowdfunding, Blockchain and Alternative Currencies, Personal Finance Software, Automated Wealth Management and Trading, and Enterprise Solutions.

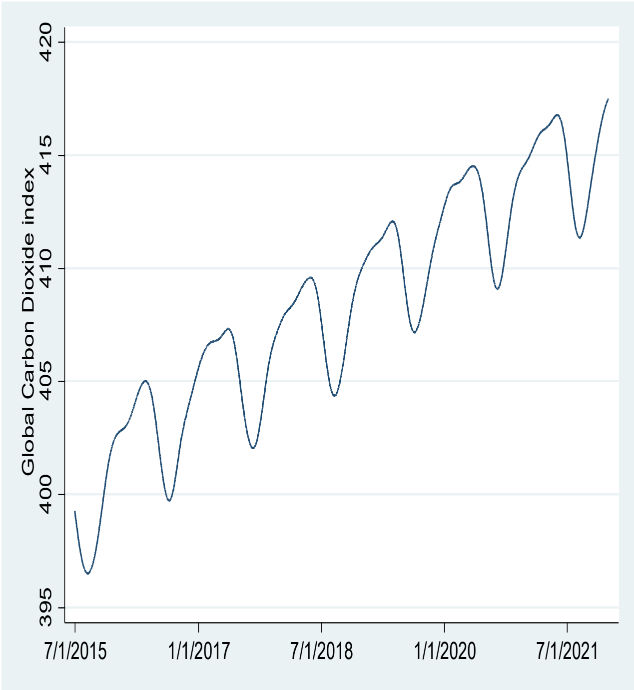
Figure (1) Global FinTech index

Sources: *prepared by Author*

In other hand, in the atmosphere, CO_2 represents a greenhouse gas that acts to absorb heat from our planet and radiate it (Kellogg & Schware, 2019). Infrared energy is continuously emitted by the Earth's land and ocean surfaces as a result of sunlight heating them. In the same way that bricks in a fireplace absorb heat after a fire has gone out, greenhouse gases absorb heat and slowly release it over time. In the absence of the greenhouse effect, Earth would have a temperature lower than freezing. Global warming, however, has disrupted Earth's energy budget, trapped more heat and raising Earth's average temperature. A study by Rebecca Lindsey (2020) indicates that atmospheric carbon dioxide contributes to two-thirds of global warming.

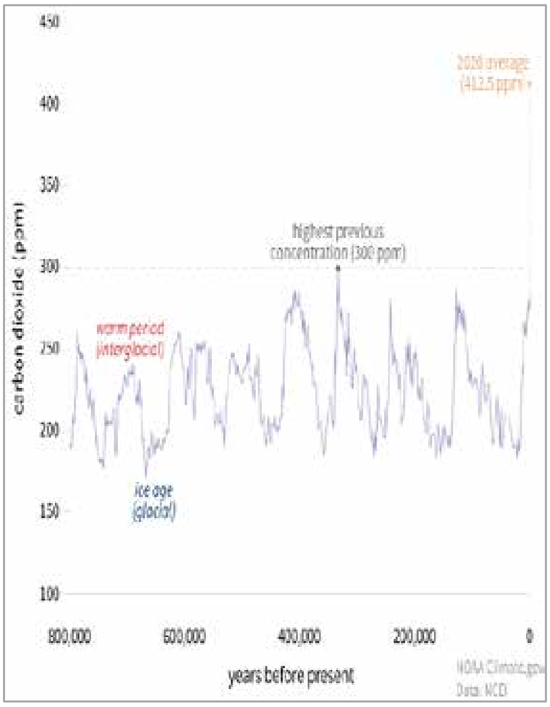
As shown in Figure (2), global average atmospheric carbon dioxide reached 417.5 parts per million by 31 December 2021, despite the economic slowdown caused by the COVID-19 pandemic. The amount of carbon dioxide in the atmosphere is greater than it has ever been in the last 800,000 years as depicted in Figure (3). CO_2 levels were at this level over 3 million years ago, during the Mid-Pliocene Warm Period, when temperatures were 2°–3°C (3.6°–5.4°F) higher than the pre-industrial era, and sea levels were 15–25 meters (50–80 feet) higher (Rebecca Lindsey, 2020).

Fig (2) Carbon dioxide index over the period of the study



Sources: *prepared by Author*

Fig (3) Carbon dioxide index over 800,000 years



Sources: www.climate.gov

Methods of Analysis

In this study, the relationship between the FinTech index and global carbon dioxide emissions was examined using linear and non-linear causal effects. Linear relationships were tested for causality using Granger, and nonlinear relationships were tested using coherence wavelet analysis. By using wavelet analysis, information related to variables is preserved compared to traditional methods which require data differentiation, such as the Granger causality test. A Granger causality test was used to determine the causal relationship between FinTech and carbon dioxide emissions, while a Wavelet Coherence framework was used to examine the evolution and interaction of several time series over time and across frequency domains. An analysis of the wavelet coherence can identify regions of high co-movement in time-frequency domains more effectively than causality tests. Therefore, Wavelet Coherence is used to provide more robust evidence of the connection between climate FinTech and global climate change, as measured by global FinTech index and CO_2 respectively.

Granger Causality Test

The definition of causality given by Granger (1969) is that variable X is causal if its history is useful in predicting the future state of Y, regardless of what X's history has been. So, if X improves the prediction of Y by including it as a predictor, then X is called the Granger causality of variable Y. To present the model mathematically, we can use the following questions:

$$Y_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{j=1}^{n} \beta_j X_{t-j} + \mu_{1t} \qquad (1)$$

$$X_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{j=1}^{n} \sigma_j X_{t-j} + \mu_{2t} \qquad (2)$$

Where Y_t and X_t are denoted for CO_2 and FinTech variables under the study investigation, μ_{1t} and μ_{2t} refer to error terms. While t and n indicate for time periods and the number of lags (2 lags) for the applied model respectively. Granger causality is classified into four types: unidirectional, bidirectional, neither unilateral nor bilateral.

i. If $\sum_{i=1}^{m} \gamma_j$ and $\sum_{i=1}^{m} \delta_j = 0$, it can be established that X and Y do not help to predict one another or both variables are independents.

ii. If $\sum_{i=1}^{m} \gamma_j$ and $\sum_{i=1}^{m} \delta_j \neq 0$ we conclude that X_t and Y_t have bi-directional causality.

iii. If $\sum_{i=1}^{m} \gamma_j \neq 0$ and $\sum_{i=1}^{m} \delta_j = 0$, the conclusion will be changes in Y can aid to predict future values of X then again not the other way around.

iv. Finally, if $\sum_{i=1}^{m} \gamma_j = 0$ and $\sum_{i=1}^{m} \delta_j \neq 0$, the decision will be unidirectional

The F-test for these four classified hypotheses is given by the following formula reported by Asteriou and Hall (2006):

$$F = \frac{(RSSr - RSSur)/m}{RSSur/(n-k)} \qquad (3)$$

The Wavelet Coherence Test

In order to understand the co-movement of FinTech and CO_2 indexes and to examine their interdependence in frequency and time frame, we use Morlet's wavelet coherence framework (1982).

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{b}} \varphi\left(\frac{t-a}{b}\right), \Psi(.) \subset L^2(\mathbb{R}) \qquad (4)$$

where:

a specifies the wavelet's exact position in the time domain and by *b*, we can determine its frequency domain position.

As a result, wavelet variance can be normalized through factor $\frac{1}{\sqrt{b}}$ as established by Yang, et al (2017).

According to Rua and Nunes (2009) as well as Yang, et al (2017), continuous wavelet transformations are used. The defined form of CWT is as follows:

$$W_x(a,b) = \int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{b}}\Psi\left(\frac{t-a}{b}\right)dt \tag{5}$$

A projection of the CWT is provided by $w_{x(a,b)}$ on the basis of the projection of the mother wavelet Ψ applying the sample time series $x(t) \in l^2$ (R). In the following equation, we see how CWT decomposes and reconstructs a function $x(t) \in l^2$ (R) is estimated.

$$x(t) = \frac{1}{C_\psi}\int_0^{\infty}\left[\int_{-\infty}^{\infty} W_x(a,b)\psi_{a,b}(t)da\right]\frac{db}{b^2}, b > 0 \tag{6}$$

In a power spectrum analysis, variances may be expressed as follows::

$$\|x\|^2 = \frac{1}{C_\psi}\int_0^{\infty}[|W_x(a,b)|^2\, da]\frac{db}{b^2}, b > 0 \tag{7}$$

As a result, $|W_x(a,b)|$'s square power reflects the wavelet power spectrum, which can be explained the local variance for *x* (t) on a scale-by-scale basis (Yang, et al, 2017).

As described by Torrence and Webster (1999), coherence between two time series can be expressed as follows:

$$\mathrm{R}_{\mathrm{n}}^2(b) = \frac{\mathrm{I}B\left(b^{-1}W_n^{xy}(b)\right)\mathrm{I}^2}{B\left(b^{-1}\mathrm{I}W_n^{x}(b)\right)\mathrm{I}^2 . B\left(b^{-1}\mathrm{I}W_n^{y}(b)\right)\mathrm{I}^2} \tag{8}$$

Whereas *B* stands with respect to a smoothing parameter, and *b* denotes a wavelet scale. Time series Y is depicted by Wn^x (*b*) as a continuous transform. A cross-wavelet transform is shown in Wn^x (*b*) for time series X and Y.

The phase patterns

Following Bloomfield (2004), we analyzed the dependency and causality between global FinTech index and global CO_2 index systems using wavelet phase differences. It is possible to determine the phase difference between x(t) and y(t) using the following equation:

$$\emptyset_{xy} = tan^{-1}\left(\frac{\Im\{B\left(b^{-1}W_{xy}(a,b)\right)\}}{\Re\{B\left(b^{-1}W_{xy}(a,b)\right)\}}\right), \quad with\ \psi_{xy} \in [-\pi,\pi] \tag{9}$$

The phase patterns of wavelet coherence maps are indicated by arrows. Phase patterns can also reveal causal relationships between variables. It can be explained that, right-pointing arrows indicate that X (t) and Y (t) are in phase. In contrast, X (t) and Y (t) are antiphase if the arrow is directed to the left. The arrow can also show how the two variables relate to one another. When an arrow points left-up or right-down, it indicates that X (t) follows Y (t). Whenever the arrow points right-up or left-down, Y (t) follows X (t) (Pal & Mitra, 2017 and Yang et al., 2017).

Findings and Analysis

The findings in Table 1 show that there is no cause-and-effect relationship exist between global FinTech index adoption and carbon dioxide (CO_2) emissions. In other words, the carbon dioxide (CO_2) emissions are therefore independent of the adoption of FinTech across the globe.

Table (1): Pairwise Granger Causality Tests

Null Hypothesis:	obs	F-Statistic	Prob.
FinTech does not Granger Cause CO_2	1815	0.64721	0.5236
CO_2 does not Granger Cause FinTech		1.73634	0.1765

To examine both frequency and time interdependence between the global FinTech index and the global CO_2 index, the study applied a wavelet coherence framework, specifically wavelet phase differences. Due to the fact that on wavelet coherence maps, the arrows indicate phase patterns that can also reveal causal relationships between variables. Figure 4 shows the wavelet coherence analysis findings in three dimensions, including frequency, time, and wavelet coherence. Wavelet coherency can be seen as the red-blue scale colour spectrum in which a deeper red colour corresponds with an increasing wavelet coherency while a deeper blue colour corresponds to a decreasing wavelet coherency. Furthermore, when wavelet decomposition is applied to a time series, vertical and horizontal axes indicate frequency and time (represented by the time scale). Using the wavelet coherence analysis presented in Figure (4), we find that wavelet coherency is statistically insignificant at 5%, providing evidence that there is no correlation between financial technology adoption and global carbon dioxide (CO_2) emissions. Further, as there are no arrows appearing in the significant area, it seems that these indices are not in phase and are not moving together across different horizons.

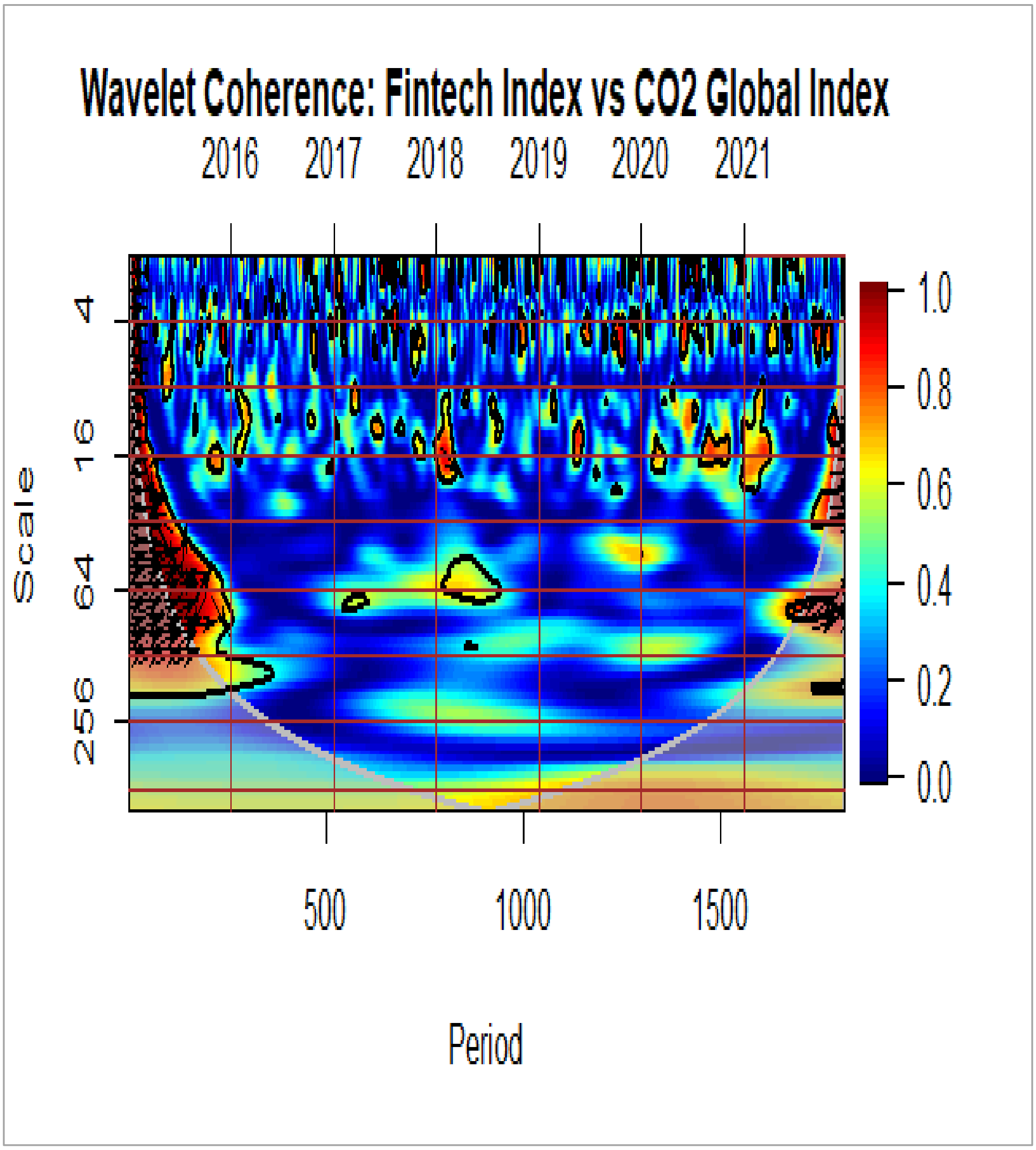


Figure (4): Wavelet Coherence Analysis between global FinTech index and Carbon global index

Conclusion and Recommendations

Over the past few decades, the majority of global climate changes and planet warming have been attributed to human activity rather than natural causes particularly after industrial revolution. A growing number of scientists believe Climate FinTech tools will protect the environment and mitigate climate change risks. Many believe FinTech instruments should be developed as a means of implementing environmentally friendly activities in every aspect of human life. Hence, the study's objective was to investigate the cause-and-effect relationship between global FinTech index as a proxy for FinTech activities and global carbon dioxide emissions index. Granger causality test and continuous wavelet coherence analysis were used to investigate this association using frequency daily data from 30 June 2015 to 31 December 2021. As a result of the study, it was found that there is no cause-and-effect relationship existed between the global FinTech index and the carbon dioxide index. The findings were also robust by using continuous wavelet coherence analysis which showed that wavelet coherency was not statistically significant, and no arrows appeared in the significant area, demonstrating the metrics are not moving together across different horizons and that there is no correlation between financial technology adoption and global CO_2 emissions. These findings confirm that climate FinTech tools and applications are environmentally friendly. The results presented here will be of interest to governments and corporate policy makers, regulators, investors, local and international organizations, and others who are evaluating climate FinTech tools and applications as a potential strategic direction for protecting our environment and mitigating climate change risk.

In this study, several limitations were revealed. This includes the short timeframe used for the study analysis, which cannot be avoided since the Global Fintech index was stabilized in June 2016. In addition, the FinTech index (as a proxy for climate fintech) does not adequately represent all FinTech firms, particularly start-ups and entrepreneurs in many emerging markets. In addition, the FinTech index reflects the financial performance of FinTech companies rather than their technical capabilities. Since FinTech activities are very slight and produce relatively low carbon footprint emissions globally when compared to other industries, it is more likely to capture their effect by examining its impact at the micro, local, or regional levels. Thus, addressing these limitations in future research will provide a more comprehensive understanding of the associations between FinTech's activities, and climate change risk mitigation. Moreover, for further research, more insight into the relationship between climate FinTech and climate change can be gained by expanding the study model to include other climate change measurements. These include global average surface temperatures, a changing cryosphere, rising sea levels, acidifying oceans, and extreme weather events.

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