Effect of CO2 emissions on financial inclusion through physical financial access points

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Abstract

This study examines the effect of CO2 emissions from gaseous fuel consumption on financial inclusion through physical financial access points in non-crisis years. The findings reveal that higher CO2 emissions are associated with a high level of financial inclusion in European, Asian and developing countries, implying that CO2 emissions do not decrease the level of financial inclusion. CO2 emissions decrease the level of financial inclusion in African countries that have strong institutions and a high lending rate. CO2 emissions also decrease the level of financial inclusion in developing countries that have a high lending rate. The implication is that policymakers and banks in European, African and Asian countries should reduce their reliance on physical financial access points to increase financial inclusion. They should adopt digital financial inclusion strategies to mitigate the adverse effect of CO2 emissions on the physical financial access points provided by banks to increase financial inclusion.

Keywords: climate change, CO2 emissions, financial inclusion, institutional quality, inflation, interest rate, financial access points, bank branch, ATM, Africa, Asia, Europe, developing countries.

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1. Introduction

Climate change-induced natural disasters affect over 200 million people worldwide (UNSGSA, 2016). CO2 emissions and other climate change events, such as droughts, flooding, and adverse weather events, pose health risks on society. It makes food expensive, and it makes it difficult for people to access physical financial access points to obtain the financial services that will enable them to cope with the income shocks that accompany extreme weather conditions.

As the risk of climate change increases, it is important for people to have access to basic financial services that can help them to cope with the shocks that accompany climate change events. This has led to the need to understand how different climate change causal factors affect financial inclusion and financial wellbeing in general. This study focuses on CO2 emissions from gaseous fuel consumption as a causal factor of climate change.

This study examines the effect of CO2 emissions from gaseous fuel consumption on financial inclusion which is achieved through the physical financial access points provided by banks such as automated teller machines (ATMs) and commercial bank branches in non-crisis years. Existing studies have investigated the effect of climate change on financial wellbeing such as its effect on financial literacy, financial resilience, and financial performance during crisis (Hussain et al, 2021; Zulfikri and Faqihah, 2024). However, the existing literature has not paid attention to the effect of CO2 emissions on financial inclusion in periods where there are no financial crisis, economic crisis or pandemic. This study is unique and different from existing studies in that it focuses on the effect of CO2 emissions on financial inclusion in non-crisis years. Focusing on the non-crisis years allows us to isolate the events of the 2007-2009 global financial crisis and the COVID-19 pandemic to enable us to focus on the effect of CO2 emissions on financial inclusion in good years.

In the study, we have two predictions for the effect of CO2 emissions on financial inclusion. The first prediction is that CO2 emissions can adversely affect financial inclusion by causing changes in the environment that increase the risk of a climate change event occurring. When the climate change event occurs, it can lead to the destruction of the physical financial access points that banks provide to increase financial inclusion such as ATMs and bank branches, and this will be detrimental for financial inclusion. This argument suggests a negative effect of

CO2 emissions on financial inclusion. Conversely, we predict that banks may preempt climate change risks and carefully choose the location to install physical financial access points, such as ATMs and bank branches, to increase financial inclusion. Banks can deliberately install ATMs and open new bank branches in locations that are not prone to climate change events, and such actions help to ensure that climate change events induced by CO2 emissions do not adversely affect the physical financial access points that enable financial inclusion. When this happens, higher CO2 emissions will be associated with higher levels of financial inclusion. This implies a positive relationship between CO2 emissions and financial inclusion. In the empirical analysis, the indicator of CO2 emissions is carbon dioxide emissions from gaseous fuel consumption which captures emissions from the use of natural gas as an energy source. The indicator of financial inclusion is the financial inclusion index following the existing literature (Tram et al, 2023; Chang et al, 2023) and we find evidence to support our predictions.

This study contributes to the existing literature in the following ways. One, this study contributes to the literature that investigates the effect of CO2 emissions on the financial wellbeing of people, but which have not examined the effect of CO2 emissions on the physical financial access points provided by banks to increase financial inclusion. This study is the first study to investigate the effect of CO2 emissions on financial inclusion through physical financial access points. Two, this study is the first in the literature to investigate the effect of CO2 emissions on bank-based financial inclusion in non-crisis years. Three, the study contributes to the literature that examines the determinants of financial inclusion. We show that institutional quality and bank stability are significant determinants of financial inclusion.

The remainder of the study is structured in the following way. Section 2 presents the literature review. Section 3 presents the research methodology used in the study. Section 4 presents the empirical results. Section 5 presents the conclusion of the study.

2. Theoretical framework and literature review

2.1. Theoretical framework

The theoretical framework used in the literature to explain the consequences of CO2 emissions is the "pollution haven hypothesis". The pollution haven hypothesis states that corporations seek to locate their offices in countries that have cheap resources, cheap labour and less stringent environmental regulations so that they can carry out their business without facing severe consequences or costs for emitting pollution into the environment they operate from (Taylor, 2005; Copeland, 2008). The pollution haven hypothesis framework is the relevant theoretical framework for the present study because financial institutions also want to operate in locations that have cheap resources, cheap labour and less stringent environmental regulations so that they can carry out their financial inclusion activities without facing any severe consequences or costs for the waste and CO2 emissions they emit into the environment. If financial institutions are allowed to operate and are not required to comply with stringent environmental regulations, their CO2 emissions into the environment will increase climate change risks and could lead to climate change events that damage the physical financial access points that financial institutions use to accelerate financial inclusion.

Recent literature focuses on the effect of financial inclusion on climate change (e.g. Hussain et al, 2024; Musah et al, 2023). For instance, Chhatre et al (2023) examine the role of financial inclusion in helping households to manage climate risks. They analyse 1,082 rural households located in the semi-arid tropics in India and find that greater access to formal financial services reduces the need to keep liquid assets and it increases their ability to withstand and adapt to climate shocks. Negera et al (2025) examine the effect of financial inclusion on climate resilience among rural households in Ethiopia and find a significant positive effect of financial inclusion on the climate resilience of rural households. Barut et al (2023) examine the trade-off between economic growth and the environment while controlling for the role of financial inclusion in influencing the relationship in fragile economies. They find that financial inclusion exert a significant influence on the relationship between economic growth and the environment.

Other studies examine the link between climate change, the financial sector and financial behaviour. Churchill et al (2023) examine the impact of temperature shocks and climate

change on household financial behaviour in Vietnam from 2008 to 2016. They find that higher temperature shocks adversely affect the finances of households. Jalles (2024) examines the impact of past financial crises on climate change risks in 178 countries from 1995 to 2019 and find that countries that face a financial crisis are vulnerable to climate change risks. Udeagha and Breitenbach (2023) examine the effect of financial development on CO2 emissions in South Africa from 1960 to 2020 using the dynamic autoregressive distributed lag simulations method. They find that financial development lowers CO2 emissions in South Africa.

Some studies explore the effect of financial inclusion on CO2 emissions but did not examine the effect of CO2 emissions on financial inclusion. For instance, Acheampong and Said (2024) examine the effect of financial inclusion on CO2 emissions and the moderating role of institutional quality. They undertook a cross-country analysis using 119 countries from 2004 to 2020. Interestingly, they find that financial inclusion and governance quality have a significant positive impact on CO2 emissions and the impact varies across countries at different stages of economic development. In the context of developing countries, Arshad and Parveen (2024) explore the effect of financial inclusion on CO2 emissions in 29 developing countries using the autoregressive distributed lag (ARDL) technique from 2004 to 2018 and find that higher levels of financial inclusion are associated with higher CO2 emissions. Shang et al (2024) examine the link between financial inclusion and CO2 emissions in top-emitter countries over the 2004 to 2018 period and find that higher levels of financial inclusion lead to higher ecological pollution. Li et al (2024) examine the relationship between financial inclusion, green mobility, and CO2 emissions in China from the 1990 to 2022 period and find that greater access to financial services is associated with fewer CO2 emissions, especially in the transportation sector. Zaidi et al (2021), in a study of 23 OECD countries, examine the relationship between financial inclusion, energy consumption, and CO2 emissions. They find a positive relationship between financial inclusion, energy consumption and CO2 emissions. Hussain et al (2023) analyse the relationship between CO2 emissions and financial inclusion for a panel of 74 countries from 2004 to 2020. They find an inverted U-shape relationship between CO2 emissions and inclusive financial system and the inverted U-shape relationship is more pronounced in developed, emerging and frontier economies. Shabir (2024) examines the impact of financial inclusion on CO2 emissions in Asia–Pacific Economic Cooperation countries as well as the moderating role of technological innovation and economic

globalization in the relationship. The author analyse data from 2004 to 2018 and find that financial inclusion and renewable energy consumption reduce CO2 emissions that promote environmental sustainability and decrease climate change risks.

Another strand of literature examines the link between financial inclusion and CO2 emissions in regional contexts. In an African study, Ogede et al (2024) examine the effect of income inequality on CO2 emissions in sub-Saharan African countries and the moderating role of financial inclusion and institutional quality. They find that income inequality increases CO2 emissions in African countries with high levels of financial inclusion, while institutional quality moderates the negative impact of income inequality on CO2 emissions in African countries. In a related Africa study, Musah et al (2023) focus on the role of financial inclusion in reducing greenhouse gas emissions in West African countries. Their analysis reveal that financial inclusion reduces greenhouse gas emissions which lowers climate change risks in West African countries. In a European study, Hodžić et al (2023) investigate how natural resources and financial inclusion interact with the green environment in European Union (EU) countries. They show that higher levels of financial inclusion decrease CO2 emissions. In another European study, Fareed et al (2022) examine the effect of financial inclusion on environmental degradation and the moderating role of innovation activity in 27 European countries from 1995 to 2018. They find that financial inclusion increases environmental deterioration in the Eurozone, but innovative activities negatively moderate the relationship between financial inclusion and environmental degradation. In an Asian study, Hussain et al (2024) examine the effect of financial inclusion on CO2 emissions in 26 Asian countries. They find a long run positive impact of financial inclusion on CO2 emissions in Asian countries. They also find evidence of bi-directional causality between financial inclusion and CO2 emissions.

Majority of the recent studies reviewed above focused excessively on the effect of financial inclusion on climate change and the environment in broad terms, while other studies focused on the effect of financial inclusion on CO2 emissions. However, what is missing in these studies is the feedback loop in terms of how CO2 emissions might affect financial inclusion. The literature is silent on this. Another gap we identify in the literature is that existing studies that examine the relationship between financial inclusion and CO2 emissions did not examine how the relationship might differ in non-crisis years. The lack of focus on non-crisis years in these studies makes it difficult to determine whether their results also apply to non-crisis

years, given that combining crisis data and non-crisis data can contaminate the results and lead to misleading conclusions. Building on these two gaps in the recent literature, we identify the absence of research that examine the effect of CO2 emissions on financial inclusion. The present study fills this gap in the literature by focusing on the effect of CO2 emissions from gaseous fuel consumption on financial inclusion which is achieved through physical financial access points in non-crisis years.

3. Research design

3.1. The Data

Financial inclusion and CO2 emissions annual data were obtained from the World Bank's world development indicators (WDI) database. Other economic variables were obtained from the global financial development indicators (GFDI) and the world governance indicators (WGI) of the World Bank (see table 1). When selecting the countries to include in the sample, we included countries with long reported data for most of the variables, especially the CO2 emissions variable and the financial inclusion variables. We excluded countries that did not have sufficient reported data for the CO2 emissions variable and the financial inclusion variables for up to four consecutive years. This data selection process gives us twenty-two countries in the final sample. The countries in the sample are Argentina, Brazil, Cote d'Ivoire, Georgia, Ghana, India, Indonesia, Japan, Kenya, Korea Republic, Malaysia, Mexico, Nigeria, Pakistan, Philippines, Russia, Singapore, Tanzania, Thailand, the United Kingdom, the United States and Vietnam. The sample period spans from 2011 to 2018. This sample period was selected because it isolates the effect of the 2007-2009 global financial crisis and the COVID-19 pandemic which began in late 2019 up until 2022 so that the two crisis events will not contaminate the empirical analysis. Finally, some annual data are unavailable for some countries. This yields an unbalanced panel dataset.

Table 1. Variable description and source

Variable	*Indicator Name*	*Short definition*	*Source*
FINDEX	Financial inclusion index	Principal component analysis of the number of ATMs per 100,000 adults and the number of commercial bank branches per 100,000 adults variables.	GFDI, World Bank
CCE	CO2 emissions	CO2 emissions from gaseous fuel consumption (% of total)	WDI, World Bank
ZSCORE	Banking sector insolvency risk	Measures the probability of bank insolvency risk. Higher values mean low insolvency risk and higher banking stability	GFDI, World Bank
MC	Monetary policy	Central bank interest rate	GFDI, World Bank
ISQ	Institutional governance index	Average of the six world governance indicators, namely, the voice and accountability index, political stability and absence of violence/terrorism index, government effectiveness index, control of corruption index, regulatory quality index and rule of law index.	Author, WGI.
FNI	Inflation rate	Consumer price inflation measured as the annual percentage change in the cost to the average consumer.	WDI, World Bank
EQ	Total unemployment rate	Total unemployment refers to the total share of the labour force that is without work but is available for and seeking employment.	WDI, World Bank

Source: World Bank database

3.2. Justification of the model and estimation method

The baseline regression model used in this study is similar to the financial inclusion and CO2 models used in existing studies such as Negera et al (2025) and Ozili (2025). The regression model used in this study is informed by the systems theory of financial inclusion which argues that financial inclusion outcomes are achieved through the subsystems in the larger economic system (Ozili, 2020). This implies that several internal and external factors or subsystems (e.g. environmental factors such as CO2 emissions) work together to influence the level of financial inclusion, and these factors are known as the determinants of financial inclusion. Therefore, the model in equation 1 expresses financial inclusion as a function of its various determinants and we consider CO2 emissions to be a determinant of financial inclusion in this study. The variables in the model are FINDEX = financial inclusion index. CCE = CO2 emissions. ZSCORE = banking system stability. MC = central bank interest rate. ISQ = institutional quality index. FNI = Inflation rate. EQ = total unemployment rate. i, t represents country and year. εit is the error term. The model is specified below.

$$(FINDEX)i,t = \beta 0 + \beta 1CCEi,t + \beta 2ZSCOREi,t + \beta 3MCi,t + \beta 4EQi,t + \beta 5ISQi,t + \beta 6FNIi,t + ei,t \ldots\ldots\ldots Equation\ (1)$$

The regression estimation methods used in this study are the median quantile regression method and the two stage least squares (2SLS) regression method. The median quantile regression estimator addresses outliers in the data and the potential for non-linearity with the predictor variables (Koenker, 2005; Ozili, 2025). In the quantile regression estimations, the quantile was set at the 0.5 quantile (or 50th percentile). This means that 50 percent of the data points are less than the value of the median. This means that the estimator is a median quantile regression estimator. The reason for choosing the median quantile (50th percentile) is because the results obtained from the median quantile (50th percentile) regression are not affected by outliers or extreme values in the data distribution. The median quantile gives enough room to accommodate data that are dissimilar in size. The 2SLS regression method was used as an additional test to control for potential endogeneity in the data by using the one-year lag of the explanatory variables as the 2SLS instrumental variables.

3.3. Justification of the variables included in the model

The dependent variable is the financial inclusion index. It is constructed from the principal component analysis of the number of ATMs per 100,000 adults and the number of commercial bank branches per 100,000 adults variables.

The CCE variable is the main explanatory variable that reflects CO2 emissions from gaseous fuel consumption. High CO2 emissions from gaseous fuel consumption can increase the risk of a climate change event occurring. When the climate change event occurs, it can lead to the destruction of the physical financial access points that banks provide to increase financial inclusion, such as ATMs and bank branches, and this will be detrimental for financial inclusion. This suggests a positive effect of CO2 emissions on financial inclusion. However, it is also possible that banks can preempt CO2-induced climate change risks, and they will carefully choose the location to install physical financial access points, such as ATMs and bank branches, to increase financial inclusion. Banks can deliberately install ATMs and open new bank branches in locations that are not prone to CO2-induced climate change events, and such actions help to ensure that CO2 emissions do not adversely affect financial inclusion. In

such cases, higher CO2-induced climate change events will be associated with higher financial inclusion. Therefore, we do not have a definite expectation for the effect of CO2 emissions (CCE) on financial inclusion.

Regarding the control variables, the ZSCORE variable controls for the effect of bank stability on financial inclusion. Greater bank stability promotes financial inclusion because stable banks can open new bank branches and install new ATMs in remote locations to reach the unbanked adults to increase financial inclusion (Ozili, 2024). Therefore, the ZSCORE variable is expected to have a positive relationship with financial inclusion.

The MC variable controls for the effect of monetary policy decisions on financial inclusion. Tight monetary policy via increase in the central bank interest rate will tighten financing conditions, increase the market lending rate, and make it difficult for people to access credit. This will be detrimental for financial inclusion (Oanh, 2023). Therefore, the MC variable is expected to have a negative relationship with financial inclusion.

The ISQ variable controls for the effect of institutional quality on financial inclusion. Existing studies show that high institutional quality promotes financial inclusion by introducing new regulation, or strengthening existing regulation, to remove institutional barriers to financial access and ensure that the population have greater access to basic financial services and participate actively in the financial system (Ouechtati, 2023). Therefore, the ISQ variable is expected to have a positive relationship with financial inclusion.

The FNI variable controls for the effect of inflation on financial inclusion. High inflation will compel financial institutions to reprice loans upward by increasing the cost of financial services which is detrimental to financial inclusion (Kebede et al, 2024). Therefore, a negative relationship between inflation (FNI) and financial inclusion is expected.

The EQ variable controls for the effect of unemployment on financial inclusion. When a lot of people do not have jobs or a source of income, they will have little or no incentive to own a formal account, take a loan or to participate actively in the formal financial system since they do not have a means to repay loans. This will lead to a decrease in the level of financial inclusion (Williams et al, 2023). Therefore, a negative relationship between unemployment (EQ) and financial inclusion is expected.

3.4. Descriptive statistics and correlation analysis

Regarding the data distribution, there is a wide dispersion in the CCE, ZSCORE, and FNI variables while the dispersion is smaller for the FINDEX, ISQ and EQ variables in table 2. The wide dispersion is attributed to the difference or variation between the maximum and minimum values of the variables. Meanwhile, the Pearson correlation matrix in table 3 shows that the CCE variable has a significant positive correlation with the FINDEX variable. The correlation result suggests that higher CO2 emissions are correlated with higher FINDEX which indicates greater financial inclusion. The CCE variable has a significant negative correlation with the EQ and ISQ variables. The correlation result suggests that higher CO2 emissions are correlated with lower unemployment rate and lower institutional quality. The CCE variable has a significant positive correlation with the ZSCORE, MC and FNI variables. The correlation result suggests that higher CO2 emissions are correlated with higher banking stability, higher central bank interest rate and higher inflation.

Table 2. Descriptive statistics

	FINDEX	CCE	ZSCORE	MC	EQ	ISQ	FNI
Mean	1.93	24.08	15.38	6.85	4.91	-0.05	4.78
Median	-0.29	18.97	15.19	6.25	3.87	-0.24	3.72
Maximum	3.17	56.01	35.0	26.00	19.65	1.51	18.67
Minimum	-1.49	0.00	3.76	-0.10	0.24	-1.178	-0.94
Std. Dev.	1.28	19.07	6.72	5.39	3.51	0.70	4.15
Observations	170	132	176	168	176	176	168

Source: Author's own work

Table 3. Pearson correlation of the variables

Variables	FINDEX	CCE	ZSCORE	MC	EQ	ISQ	FNI	AFR	EUR	ASN
FINDEX	1.00									

CCE	0.38***	1.00								
	(0.00)	-----								
ZSCORE	0.18**	-0.15*	1.00							
	(0.04)	(0.10)	-----							
MC	0.25***	0.02	-0.28***	1.00						
	(0.00)	(0.78)	(0.00)	-----						
EQ	-0.31***	-0.26***	-0.09	-0.02	1.00					
	(0.00)	(0.00)	(0.32)	(0.81)	-----					
ISQ	-0.36***	0.03	0.22**	-0.51***	0.27***	1.00				
	(0.00)	(0.73)	(0.01)	(0.00)	(0.00)	-----				
FNI	0.26***	0.07	-0.23**	0.81***	-0.05	-0.45***	1.00			
	(0.00)	(0.44)	(0.01)	(0.00)	(0.52)	(0.00)	-----			
AFR	0.22**	0.08	-0.002	0.59***	-0.20**	-0.41***	0.45***	1.00		
	(0.01)	(0.37)	(0.97)	(0.00)	(0.03)	(0.00)	(0.00)	-----		
EUR	-0.25***	0.21**	-0.41***	-0.11	0.58***	0.26***	-0.07	-0.24***	1.00	
	(0.00)	(0.02)	(0.00)	(0.25)	(0.00)	(0.00)	(0.39)	(0.00)	-----	
ASN	0.03	0.05	0.04	-0.40***	-0.31***	0.11	-0.31***	-0.46***	-0.34***	1.00
	(0.71)	(0.55)	(0.63)	(0.00)	(0.00)	(0.21)	(0.00)	(0.00)	(0.00)	-----

P-values are in parenthesis. ***, **, * represent statistical significance at the 1%, 5% and 10% levels.

Source: Author's own work

4. Empirical results

This section discusses empirical results. A coefficient is robust if it is statistically significant and has the same directional sign in the quantile and 2SLS regression estimations. If this is not the case, the result is not robust, and it is not discussed in detail.

4.1. Full sample results

4.1.1. Effect of CO2 emissions on financial inclusion: full sample

The full sample result is reported in table 4. The CCE variable is robustly significant and positively related to the FINDEX variable in columns 1, 2, 9 and 10. The result indicates that higher CO2 emissions are significantly associated with a high level of financial inclusion. It implies that banks deliberately install physical financial access points in locations that are not prone to CO2-induced climate change events, and such actions help to ensure that higher CO2 emissions do not adversely affect financial inclusion. Regarding the control variables, the ISQ coefficient is robustly significant and negatively related to the FINDEX variable in columns 1 and 2. This implies that higher institutional quality leads to lower financial inclusion. The ZSCORE coefficient is robustly significant and positively related to the FINDEX variable in columns 1 and 2 in the two regression estimations. This implies that greater banking sector stability is associated with a higher level of financial inclusion. However, the unemployment rate (EQ), the central bank interest rate (MC) and the inflation rate (FNI) do not have a significant effect on the level of financial inclusion in columns 1 and 2 of table 4.

Table 4. Effect of CO2 emissions on financial inclusion (FINDEX): full sample interaction analysis with regional dummy variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-2.116*** (0.00)	-2.203*** (0.00)	-1.696*** (0.00)	-2.775*** (0.00)	-1.887*** (0.00)	-2.133*** (0.00)	-2.308*** (0.00)	-2.553*** (0.00)	-2.526*** (0.00)	-3.680*** (0.00)
CCE	0.027*** (0.00)	0.032*** (0.00)	0.023** (0.01)	0.041*** (0.00)	0.033*** (0.00)	0.033*** (0.00)	0.030*** (0.00)	0.028*** (0.00)	0.099*** (0.00)	0.139*** (0.00)
CCE*AFR			0.006 (0.53)	-0.023 (0.11)					-0.069*** (0.00)	-0.123*** (0.00)
CCE*EUR					-0.016 (0.46)	-0.011 (0.75)			-0.081*** (0.00)	-0.121** (0.04)
CCE*ASN							-0.016 (0.34)	0.009 (0.44)	-0.083*** (0.00)	-0.105*** (0.00)
AFR			-0.276 (0.49)	-0.062 (0.88)					0.392 (0.13)	0.911 (0.11)
EUR					0.195 (0.84)	0.147 (0.91)			0.839 (0.42)	1.753 (0.24)
ASN							0.525 (0.22)	0.155 (0.69)	0.891 (0.15)	1.212** (0.01)
ZSCORE	0.057*** (0.00)	0.086*** (0.00)	0.047*** (0.00)	0.105*** (0.00)	0.043** (0.01)	0.081*** (0.00)	0.060*** (0.00)	0.090*** (0.00)	0.054*** (0.00)	0.106*** (0.00)
MC	0.052 (0.23)	0.069 (0.47)	0.068 (0.23)	-0.132 (0.27)	0.051 (0.23)	0.058 (0.58)	0.065 (0.13)	0.092 (0.36)	0.071 (0.12)	0.113 (0.39)
EQ	-0.008 (0.63)	-0.031 (0.36)	-0.029 (0.16)	-0.031 (0.38)	-0.023 (0.68)	-0.029 (0.64)	-0.003 (0.89)	-0.012 (0.74)	-0.032 (0.63)	-0.065 (0.33)
ISQ	-0.456*** (0.00)	-0.665*** (0.00)	-0.399** (0.01)	-0.748*** (0.00)	-0.249 (0.12)	-0.613*** (0.00)	-0.464*** (0.00)	-0.642*** (0.00)	-0.347 (0.13)	-0.741*** (0.00)
FNI	-0.002 (0.97)	-0.033 (0.79)	-0.021 (0.74)	-0.077 (0.58)	-0.0002 (0.99)	-0.019 (0.89)	-0.014 (0.78)	-0.043 (0.74)	-0.019 (0.69)	-0.042 (0.79)
Adjusted R^2	26.06	40.27	25.15	41.21	25.84	39.63	25.67	40.64	29.62	44.47
F-statistic		11.43		9.70		8.56		8.77		7.45
Quasi-LR statistic	74.04		73.12		79.51		89.14		129.85	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

4.1.2. Moderating role of institutional quality and monetary policy

In this section, we examine the moderating effect of institutional quality and monetary policy action on the relationship between CO2 emissions and financial inclusion. This analysis is important because strong institutions may introduce regulations and policies that mitigate CO2 emissions into the environment. The central bank and strong institutions may also use regulations to ensure that there is greater access to basic financial services for people living in locations prone to climate change risks thereby increasing financial inclusion (Ouechtati, 2023). We examine this effect by interacting the ISQ and MC variables with the CCE variable to determine the moderating effect of institutional quality and central bank interest rate on the relationship between CO2 emissions and financial inclusion. The result is reported in table 5. The CCE*ISQ variable is robustly significant and negatively related to the FINDEX variable in the quantile and 2SLS estimations in columns 7 and 8. This implies that CO2 emissions have an adverse effect on financial inclusion in countries with strong institutional quality. Furthermore, the CCE*MC variable is robustly insignificant in relation to the FINDEX variable in both the quantile and 2SLS estimations in columns 3-4 and 7-8.

Table 5. Moderating effect of institutional quality and monetary policy on the relationship between CO2 emissions on financial inclusion (FINDEX) : full sample interaction analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-1.735*** (0.00)	-2.023*** (0.00)	-2.055*** (0.00)	-2.254*** (0.00)	-2.062*** (0.00)	-2.056*** (0.00)	-1.680*** (0.00)	-2.423*** (0.00)
CCE	0.029*** (0.00)	0.031*** (0.00)	0.022*** (0.00)	0.034** (0.01)	0.018** (0.02)	0.027** (0.01)	0.034*** (0.00)	0.056** (0.01)
CCE*ISQ	-0.015*** (0.00)	-0.009 (0.29)					-0.016** (0.04)	-0.022* (0.06)
CCE*MC			-0.001 (0.22)	-0.0002 (0.87)			-0.0004 (0.89)	-0.006 (0.21)
CCE*ISQ*MC					-0.003 (0.17)	-0.001 (0.62)	0.0007 (0.86)	-0.004 (0.28)
ZSCORE	0.042*** (0.00)	0.078*** (0.00)	0.056*** (0.00)	0.086*** (0.00)	0.062** (0.01)	0.082*** (0.00)	0.033** (0.01)	0.078*** (0.00)
MC	0.057 (0.16)	0.061 (0.54)	0.052 (0.21)	0.075 (0.51)	0.056 (0.23)	0.063 (0.50)	0.062* (0.07)	0.175 (0.32)
EQ	-0.029* (0.09)	-0.030 (0.37)	-0.015 (0.38)	-0.030 (0.38)	-0.013 (0.44)	-0.032 (0.35)	-0.030* (0.09)	-0.023 (0.49)
ISQ	0.077 (0.60)	-0.449* (0.10)	-0.272* (0.05)	-0.679*** (0.00)	-0.103 (0.55)	-0.594** (0.02)	0.045 (0.76)	-0.230 (0.46)
FNI	-0.022 (0.63)	-0.029 (0.81)	-0.009 (0.86)	-0.036 (0.79)	-0.012 (0.55)	-0.036 (0.78)	-0.022 (0.61)	-0.111 (0.54)
Adjusted R^2	28.58	40.43	25.74	39.81	26.08	43.62	27.59	40.83
F-statistic		10.24		9.69		9.74		8.09
Quasi-LR statistic	96.18		84.83		82.39		103.06	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

4.2. Regional Heterogeneity

4.2.1. Regional interaction analysis

We also examine the effect of CO2 emissions on financial inclusion in the African countries, Asian countries, and European countries in the sample to determine whether regional differences exert some influence on the relationship between CO2 emissions and financial inclusion. In the analysis, we introduced three regional dummy variables into the model, namely, the AFR, EUR and ASN dummy variables. The AFR dummy variable equals 1 if the country is an African country and zero otherwise. The EUR dummy variable equals 1 if the country is a European country and zero otherwise. The ASN dummy variable equals 1 if the country is an Asian country and zero otherwise. The three dummy variables are interacted with the CCE variable, and we assess their effect on the financial inclusion index variable. The result is reported in table 4 and we discuss only significant results. The CCE*AFR, CCE*ASN and CCE*EUR variables are robustly significant and negatively related to the FINDEX variable in the quantile and 2SLS estimations in columns 9 and 10. This indicates that CO2 emissions have an adverse effect on financial inclusion in African, Asian and European countries. The implication is that higher CO2 emissions can lead to the destruction of the physical financial access points provided by banks such as ATMs and commercial bank branches in African, Asian and European countries, which is detrimental to financial inclusion.

4.2.2. Moderating role of institutional quality and monetary policy with regional dummy variables

We also examine the moderating effect of institutional quality and central bank monetary policy action on the relationship between CO2 emissions and financial inclusion in the African, Asian, and European countries in the sample. We examine this effect by interacting the CCE, ISQ and MC variables with the regional dummy variables. The result is reported in table 6. The CCE*ASN*ISQ*MC variable is robustly significant and negatively related to the FINDEX variable in the quantile and 2SLS estimations in columns 5, 6 and 8. The result indicates that CO2 emissions decrease the level of financial inclusion in Asian countries with strong institutional quality and high central bank interest rate. Meanwhile, the CCE*AFR*ISQ*MC and CCE*EUR*ISQ*MC variables are robustly insignificant in relation to the FINDEX variable in both the quantile and 2SLS estimations in columns 1-8. We also examine the effect of CO2

emissions on financial inclusion in the developing countries in the sample in table 7. Only the CCE*NDC variable is robustly significant and positively related to the FINDEX variable in the quantile and 2SLS estimations in columns 9 and 10. The result implies banks in developing countries seem to deliberately install physical financial access points in locations that are not prone to climate change events, and such actions help to ensure that CO2-induced climate change events do not have an adverse effect on financial inclusion in developing countries.

Table 6. Moderating effect of institutional quality and monetary policy on the relationship between CO2 emissions on financial inclusion (FINDEX) in the regions with regional dummy variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-1.708*** (0.00)	-2.390* (0.05)	-1.859** (0.00)	-2.157*** (0.00)	-2.032*** (0.00)	-2.175*** (0.00)	-1.295* (0.07)	-1.955*** (0.00)
CCE	0.023** (0.03)	0.033*** (0.00)	0.028*** (0.00)	0.032*** (0.00)	0.026*** (0.00)	0.023*** (0.00)	0.019 (0.25)	0.010 (0.44)
CCE*AFR*ISQ*MC	-0.002 (0.56)	-0.0001 (0.96)					-0.002 (0.57)	-0.003 (0.23)
CCE*EUR*ISQ*MC			-0.0002 (0.93)	0.002 (0.66)			0.0001 (0.95)	-0.0003 (0.94)
CCE*ASN*ISQ*MC					-0.007* (0.07)	-0.009** (-0.01)	-0.008 (0.16)	-0.011** (0.02)
AFR	-0.364 (0.40)	-0.507 (0.33)					-0.413 (0.50)	-0.443 (0.39)
EUR			-0.309 (0.62)	0.020 (0.97)			-0.155 (0.87)	-0.422 (0.62)
ASN					0.127 (0.64)	0.047 (0.86)	0.007 (0.98)	0.097 (0.79)
ZSCORE	0.047*** (0.00)	0.096*** (0.00)	0.045** (0.02)	0.083*** (0.00)	0.052*** (0.00)	0.087*** (0.00)	0.033 (0.19)	0.089*** (0.00)
MC	0.079 (0.19)	0.128 (0.29)	0.042 (0.30)	0.059 (0.57)	0.056 (0.14)	0.108 (0.28)	0.069 (0.24)	0.143 (0.24)
EQ	-0.032 (0.12)	-0.037 (0.31)	0.0003 (0.99)	-0.029 (0.57)	-0.011 (0.66)	-0.023 (0.51)	-0.031 (0.59)	-0.055 (0.34)
ISQ	-0.395** (0.01)	-0.716*** (0.00)	-0.373** (0.03)	-0.707*** (0.00)	-0.396*** (0.00)	-0.589*** (0.00)	-0.319 (0.18)	-0.509* (0.09)
FNI	-0.029 (0.65)	-0.079 (0.58)	0.002 (0.96)	-0.019 (0.89)	-0.008 (0.87)	-0.087 (0.49)	-0.024 (0.70)	-0.129 (0.39)
Adjusted R^2	25.38	38.40	25.03	40.02	27.83	42.72	26.62	38.27
F-statistic		8.64		8.58		9.90		6.56
Quasi-LR statistic	75.54		74.96		80.60		72.35	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

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Table 7. Effect of CO2 emissions on financial inclusion (FINDEX) in developing countries: interaction analysis with regional dummy variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-2.224*** (0.00)	-2.814*** (0.00)	-2.744*** (0.00)	-2.654*** (0.00)	-3.862** (0.01)	-1.848* (0.07)	-3.592*** (0.00)	-2.948*** (0.00)	-1.971*** (0.00)	-3.348*** (0.00)
CCE	0.015 (0.14)	0.026* (0.07)	0.019 (0.20)	0.018* (0.10)	0.047** (0.02)	0.001 (0.97)	0.042** (0.01)	0.030*** (0.00)	0.022*** (0.00)	0.031* (0.06)
CCE*NDC	0.025** (0.04)	0.010 (0.54)							0.076** (0.03)	0.045*** (0.69)
CCE*NDC*ISQ			-0.033 (0.21)	-0.039* (0.08)					0.038 (0.45)	0.001 (0.99)
CCE*NDC*MC					-0.001 (0.46)	0.004 (0.13)			-0.006* (0.08)	-0.007 (0.56)
CCE*NDC*ISQ*MC							0.0006 (0.82)	-0.0009 (0.66)	-0.004 (0.43)	-0.006 (0.83)
NDC	0.208 (0.58)	0.787 (0.18)	0.547 (0.14)	0.930* (0.06)	1.183 (0.13)	0.715 (0.23)	1.165* (0.07)	1.042** (0.04)	-0.151 (0.67)	0.640 (0.43)
ZSCORE	0.066*** (0.00)	0.095*** (0.00)	0.079*** (0.00)	0.088*** (0.00)	0.094*** (0.00)	0.075*** (0.00)	0.0386*** (0.00)	0.095*** (0.00)	0.056*** (0.00)	0.105*** (0.00)
MC	0.034 (0.44)	0.021 (0.84)	0.039 (0.39)	0.026 (0.80)	0.055 (0.26)	-0.076 (0.56)	0.042 (0.38)	0.020 (0.84)	0.082*** (0.00)	0.143 (0.37)
EQ	-0.025 (0.25)	-0.040 (0.24)	-0.013 (0.49)	-0.039 (0.24)	-0.007 (0.81)	-0.050 (0.18)	-0.015 (0.57)	-0.045 (0.18)	-0.047** (0.03)	-0.027 (0.53)
ISQ	0.051 (0.78)	-0.275 (0.29)	0.111 (0.65)	-0.059 (0.84)	-0.218 (0.29)	-0.121 (0.69)	-0.098 (0.62)	-0.216 (0.45)	-0.162 (0.19)	-0.104 (0.72)
FNI	0.004 (0.95)	0.011 (0.93)	-0.0001 (0.99)	-0.016 (0.91)	0.002 (0.96)	0.052 (0.72)	-0.098 (0.62)	0.006 (0.97)	-0.023 (0.40)	-0.071 (0.60)
Adjusted R^2	28.08	42.40	28.64	43.24	28.43	27.38	27.75	42.05	29.33	46.57
F-statistic				10.95		10.95		10.09		8.61
Quasi-LR statistic	85.85	93.73	90.17		72.98		73.14		138.00	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

4.2.3. Regional subsample interaction analysis with country fixed effects

We re-estimate the results for the effect of CO2 emissions on financial inclusion according to regional subsamples in tables 8 to 11. In the African countries subsample, the median quantile regression results show that the CCE*ISQ and CCE*MC variables are negatively significant in columns 3, 5 and 9 in table 8. In the Asian countries subsample, the median quantile regression results show that the CCE variable has a positive significant effect on the FINDEX variable in column 1 of table 9. This indicates that higher CO2 emissions are associated with higher levels of financial inclusion through physical financial access points in Asian countries. In the European countries subsample, the median quantile regression results show that the CCE variable has a significant positive effect on the FINDEX variable in column 1 of table 10. In the developing countries subsample, the median quantile regression results show that the CCE variable has a positive significant effect on the FINDEX variable while the CCE*MC variable is negatively significant in column 5 in table 11.

Table 8. Subsample analysis: Effect of CO2 emissions on financial inclusion (FINDEX) in the African countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-3.706* (0.05)	1.417 (0.64)	-0.152 (0.87)	2.233 (0.66)	-2.215* (0.07)	1.606 (0.52)	-3.676 (0.14)	4.981 (0.95)	0.649 (0.22)	2.244 (0.81)
CCE	0.011 (0.37)	0.038 (0.58)	-0.075*** (0.00)	0.029 (0.78)	0.079*** (0.00)	0.058 (0.69)	0.017 (0.87)	-0.023 (0.99)	-0.116** (0.03)	0.095 (0.74)
CCE*ISQ			-0.208*** (0.00)	-0.021 (0.92)					-0.385*** (0.00)	0.075 (0.83)
CCE*MC					-0.006*** (0.00)	-0.002 (0.85)			0.005 (0.21)	-0.006 (0.78)
CCE*ISQ*MC							0.002 (0.94)	-0.015 (0.96)	0.017** (0.01)	-0.013 (0.78)
ZSCORE	0.112 (0.14)	-0.056 (0.53)	-0.038 (0.51)	-0.066 (0.59)	0.004 (0.94)	-0.068 (0.48)	0.105 (0.29)	-0.018 (0.99)	-0.1002*** (0.00)	-0.032 (0.87)
MC	0.013 (0.87)	-0.017 (0.71)	-0.003 (0.86)	-0.031 (0.78)	0.107 (0.12)	-0.003 (0.98)	0.032 (0.88)	-0.183 (0.96)	0.007 (0.71)	-0.055 (0.89)
EQ	-0.296* (0.07)	0.186 (0.62)	0.008 (0.91)	0.318 (0.73)	-0.338** (0.02)	0.214 (0.45)	-0.363 (0.39)	1.048 (0.95)	-0.041 (0.55)	0.554 (0.81)
ISQ	-2.527*** (0.00)	2.304 (0.58)	0.447 (0.28)	3.853 (0.72)	-3.007*** (0.00)	2.584 (0.42)	-3.047 (0.54)	12.397 (0.95)	-0.086 (0.85)	6.440 (0.81)
FNI	0.196** (0.02)	-0.002 (0.97)	0.044 (0.20)	-0.019 (0.91)	-0.084 (0.18)	-0.016 (0.85)	0.189** (0.04)	-0.069 (0.96)	0.029 (0.40)	-0.052 (0.85)
Country Fixed effect	-	Yes	-	Yes		Yes	-	Yes	-	Yes
Adjusted R^2	60.13	97.73	65.67	92.63	62.75	95.41	47.07	49.53	76.79	81.96
F-statistic		132.59		137.29		246.03		303.92		309.29
Quasi-LR statistic	41.05		129.82		65.19		37.94		194.36	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

Table 9. Subsample analysis: Effect of CO2 emissions on financial inclusion (FINDEX) in the Asian countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-2.494*** (0.00)	2.687 (0.38)	2.827*** (0.00)	2.767 (0.49)	-2.138*** (0.00)	11.759 (0.78)	-2.256*** (0.00)	4.153 (0.36)	-2.000 (0.47)	-5.064 (0.81)
CCE	0.017* (0.07)	-0.090 (0.39)	0.027*** (0.00)	-0.093 (0.49)	0.001 (0.94)	-0.338 (0.82)	0.005 (0.79)	-0.132 (0.49)	-0.003 (0.97)	0.119 (0.80)
CCE*ISQ			-0.018 (0.38)	0.006 (0.94)					0.001 (0.98)	-0.054 (0.82)
CCE*MC					0.005 (0.36)	0.015 (0.82)			0.005 (0.82)	-0.019 (0.66)
CCE*ISQ*MC							-0.009 (0.44)	-0.005 (0.50)	-0.002 (0.85)	-0.016 (0.58)
ZSCORE	0.136*** (0.00)	-0.074 (0.22)	0.124*** (0.00)	-0.074 (0.24)	0.122*** (0.00)	-0.206 (0.72)	0.132*** (0.00)	-0.086 (0.28)	0.121*** (0.00)	0.057 (0.86)
MC	0.374*** (0.00)	-0.207 (0.48)	0.318*** (0.00)	-0.199 (0.42)	0.196 (0.27)	-1.492 (0.79)	0.254 (0.17)	-0.477 (0.32)	0.132 (0.80)	0.550 (0.80)
EQ	-0.354*** (0.00)	0.385 (0.46)	-0.255** (0.02)	0.379 (0.46)	-0.227* (0.07)	0.847 (0.82)	-0.285** (0.04)	0.509 (0.56)	-0.202 (0.13)	0.221 (0.59)
ISQ	0.027 (0.94)	-0.642 (0.77)	0.521 (0.41)	-0.912 (0.71)	-0.019 (0.96)	4.249 (0.86)	0.106 (0.79)	1.354 (0.74)	-0.049 (0.99)	1.329 (0.72)
FNI	0.196** (0.02)	0.034 (0.74)	-0.148** (0.02)	0.029 (0.69)	-0.153 (0.24)	0.267 (0.81)	-0.140 (0.14)	0.092 (0.55)	-0.129 (0.15)	-0.053 (0.85)
Country Fixed effect	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes
Adjusted R^2	41.81	98.65	42.43	98.56	51.31	83.62	41.42	97.34	39.69	97.98
F-statistic		658.59		598.62		627.27		695.45		587.97
Quasi-LR statistic	56.99		75.18		75.27		68.97		79.78	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

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Table 10. Subsample analysis: Effect of CO2 emissions on financial inclusion (FINDEX) in the European countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-0.525 (0.22)	0.904 (0.93)	-0.087 (0.88)	-1.594 (0.59)	-0.267 (0.65)	-0.237 (0.93)	-0.237 (0.62)	-1.126 (0.68)	0.655 (0.54)	-2.899 (0.91)
CCE	0.009* (0.10)	-0.030 (0.85)	0.001 (0.92)	0.011 (0.86)	0.005 (0.57)	-0.017 (0.75)	0.005 (0.47)	-0.006 (0.94)	-0.013 (0.59)	0.013 (0.97)
CCE*ISQ			0.006 (0.38)	-0.011 (0.65)					0.012 (0.45)	0.011 (0.95)
CCE*MC					0.001 (0.55)	0.0001 (0.82)			0.001 (0.83)	-0.009 (0.93)
CCE*ISQ*MC							-0.001 (0.37)	-0.001 (0.73)	-0.0003 (0.90)	-0.011 (0.91)
ZSCORE	0.015 (0.25)	-0.043 (0.87)	0.006 (0.60)	0.015 (0.75)	0.008 (0.66)	-0.011 (0.79)	0.004 (0.79)	0.007 (0.86)	-0.007 (0.66)	0.016 (0.94)
MC	-0.002 (0.76)	-0.043 (0.83)	-0.004 (0.57)	-0.008 (0.90)	-0.030 (0.49)	-0.038 (0.65)	-0.017 (0.32)	-0.017 (0.79)	-0.034 (0.59)	0.122 (0.94)
EQ	-0.050*** (0.00)	-0.039 (0.94)	-0.064*** (0.00)	0.025 (0.91)	-0.054*** (0.00)	-0.008 (0.97)	-0.055*** (0.00)	0.014 (0.96)	-0.083** (0.02)	0.041 (0.97)
ISQ	-0.414*** (0.00)	-0.897 (0.89)	-0.590** (0.03)	0.924 (0.78)	-0.372*** (0.00)	0.784 (0.81)	-0.336** (0.02)	0.955 (0.81)	-0.697 (0.22)	2.821 (0.91)
FNI	-0.006 (0.35)	-0.013 (0.86)	-0.005 (0.38)	-0.003 (0.89)	-0.006 (0.52)	-0.004 (0.88)	-0.007 (0.30)	-0.001 (0.98)	-0.007 (0.34)	-0.004 (0.97)
Country Fixed effect	-	Yes	-	Yes	-	Yes		Yes	-	Yes
Adjusted R^2	90.84	89.55	91.57	97.46	90.43	97.55	92.54	96.25	91.74	47.23
F-statistic		636.26		489.16		800.71		669.01		399.66
Quasi-LR statistic	199.22		221.44		190.05		226.71		248.03	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

Table 11. Subsample analysis: Effect of CO2 emissions on financial inclusion (FINDEX) in the developing countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS	Median QR	2SLS
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
B_0	-2.932*** (0.00)	-1.487 (0.91)	-2.598*** (0.00)	-1.477 (0.92)	-3.434*** (0.00)	5.767 (0.67)	-3.045*** (0.00)	5.229 (0.81)	-3.498 (0.00)	-3,722* (0.09)
CCE	0.036*** (0.00)	0.026 (0.88)	0.019 (0.40)	0.027 (0.89)	0.067*** (0.00)	-0.126 (0.79)	0.038** (0.04)	-0.046 (0.91)	0.049 (0.29)	0.043 (0.82)
CCE*ISQ			-0.030 (0.44)	0.030 (0.88)					-0.027 (0.77)	-0.107 (0.81)
CCE*MC					-0.003* (0.06)	0.009 (0.77)			-0.003 (0.61)	-0.003 (0.86)
CCE*ISQ*MC							0.0005 (0.86)	-0.016 (0.87)	-0.0005 (0.96)	0.006 (0.89)
ZSCORE	0.115*** (0.00)	0.132 (0.88)	0.107*** (0.00)	0.146 (0.89)	0.134*** (0.00)	-0.262 (0.57)	0.121*** (0.00)	-0.336 (0.79)	0.143*** (0.00)	0.166*** (0.00)
MC	0.028 (0.54)	-0.183 (0.77)	0.009 (0.80)	-0.205 (0.80)	0.041 (0.44)	-0.073 (0.81)	0.027 (0.59)	0.057 (0.89)	0.049 (0.40)	0.068 (0.71)
EQ	0.001 (0.98)	-0.201 (0.85)	0.0004 (0.98)	-0.259 (0.86)	0.009 (0.76)	0.315 (0.65)	0.004 (0.91)	0.512 (0.83)	0.017 (0.59)	0.023 (0.62)
ISQ	-0.033 (0.92)	-1.906 (0.85)	0.099 (0.78)	-2.783 (0.86)	-0.172 (0.63)	2.678 (0.64)	-0.074 (0.85)	5.394 (0.84)	-0.055 (0.89)	-0.118 (0.87)
FNI	0.032 (0.57)	0.186 (0.80)	0.041 (0.40)	0.217 (0.83)	0.037 (0.51)	-0.126 (0.68)	0.036 (0.52)	-0.281 (0.85)	0.024 (0.67)	0.009 (0.96)
Country Fixed effect	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes
Adjusted R^2	32.27	88.41	32.41	79.10	33.71	80.74	31.52	51.89	33.72	44.64
F-statistic		438.09		411.69		478.79		469.92		8.91
Quasi-LR statistic	61.62		64.05		65.89		61.80		70.23	

P-values are in parenthesis. ***, **, * denote statistical significance at the 1%, 5% and 10% levels. The 2SLS instruments are the lagged independent variables

Source: Author's own work

5. Conclusion

This study was motivated by the lack of research on the impact of CO2 emissions on financial inclusion through physical financial access points. Our analysis covered twenty-two countries over the 2011 to 2018 non-crisis period. The study found that higher CO2 emissions are associated with a high level of financial inclusion in Asian countries, European countries and developing countries which imply that CO2 emissions do not decrease the level of financial inclusion. Rather, higher CO2 emissions are associated with a higher level of financial inclusion. Conversely, we found that CO2 emissions decrease the level of financial inclusion in African countries that have strong institutions and a high lending rate. CO2 emissions also decrease the level of financial inclusion in developing countries that have a high lending rate.

The implication of the findings is four-fold. One, policymakers in African countries and developing countries should reduce their reliance on physical financial access points to increase financial inclusion. They should adopt digital financial inclusion strategies to overcome the adverse effect of CO2 emissions on the physical financial access points provided by banks to increase financial inclusion. Two, policymakers in Asian countries should pay close attention to how CO2 emissions affect financial inclusion. They should identify the physical financial access points, including ATMs and bank branches, which might be affected by CO2 emissions and develop financial inclusion policies to safeguard these physical financial access points from the adverse effect of climate change events. Three, policymakers should identify effective safeguards that can be introduced to increase financial inclusion for people living in CO2 emissions prone locations. Four, policymakers and central banks should constantly review existing financial inclusion policies and ensure that they have safeguards to mitigate CO2-induced climate change risks.

The findings of the study are relevant to society because it makes a case for why society should rely more on digital financial inclusion strategies rather than relying on physical financial access points to increase financial inclusion. The findings demonstrate that CO2-induced climate events can damage the physical financial access points in climate change prone communities, and it can leave people without access to credit and banking services for a sustained period of time, which will disrupt their livelihoods and make them worse-off in society. This calls for urgent action on the part of policymakers, private firms and non-

governmental organisation to prioritise digital financial inclusion strategies for members of society who may be affected by climate change risks so that they can have access to financial services which they can use to withstand the shocks that accompany climate risk events.

The limitation of the study is that it used CO2 emissions from gaseous fuel consumption as a proxy for CO2 emissions. There may be other CO2 emissions proxy indicators that could offer new insights. Another limitation of the study is that the study used only two financial inclusion indicators to construct a financial inclusion index that captures financial inclusion through physical financial access points. There may be other financial inclusion indicators that could offer new insights. Future studies can examine the effect of other CO2 emissions indicators on financial inclusion. Future studies can also suggest what policymakers and central banks can do to mitigate the adverse effect of CO2 emissions on financial inclusion. Such studies should identify the type of financial inclusion frameworks, monetary policy actions and institutional frameworks that are effective in mitigating the adverse effect of CO2 emissions on financial inclusion.

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