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Impact of Financial Inclusion on CO_2 Emissions: A Comparative Study of Developed and Developing Countries During the Period (2004-2021)

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تأثير الشمول المالي على انبعاثات ثاني أكسيد الكربون.. دراسة مقارنة بين الدول المتقدمة والنامية خلال الفترة (2004-2021)

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Abstract

Financial inclusion (FI) and CO_2 emissions have become significant topics of interest for many countries worldwide in recent years. This research paper explores the dynamic linkages between them in developed and developing countries. The study examines 22 developed and 22 developing countries over an 18-year period from 2004 to 2021 and considers other control variables that may impact CO_2 emissions, such as GDP per capita, trade as a percentage of GDP, and government effectiveness as a proxy for institutional quality. The Panel Data Regression Model is used to analyze the data. The results show that there is a relationship between FI and CO_2 emissions. In developed countries, FI has a significant negative effect on CO_2 emissions in developed countries, while it has a significant positive effect on them in developing countries. The findings suggest that country-specific measures should be put in place to ensure that higher FI does not lead to environmental degradation.

Keywords: CO_2 emissions, financial inclusion, environmental quality, developing countries, developed countries

Introduction

In recent years, the global community is increasingly concerned about excessive carbon emissions, leading to a growing focus on reducing them through international policies and environmental activism. However, to effectively address these concerns, it is crucial to thoroughly study and understand the underlying causes of carbon emissions. Human activity, particularly the burning of fossil fuels for energy, is widely recognized as a significant contributor to carbon emissions, which has prompted a shift towards renewable energy sources. Nevertheless, there are still areas where the impact on carbon emissions has yet to be studied, such as the relationship between financial inclusion (FI) and carbon emissions. The overall impact of FI on carbon emissions is more complex, with factors such as the types of financial services provided, the target population, the regulatory and legislative environment, and the degree of FI all are playing a role. While multiple scholars have attempted to reach a conclusive understanding of the effects of FI on carbon emissions using various types of regression analysis models, such as autoregressive distribution lag (ARDL) and panel vector autoregression (PVAR), as well as other models, the results have widely varied.

Unlike past studies that typically focused on certain countries or areas in their studies, this paper examines the relationship in both developing and developed countries to provide a more comprehensive understanding of the issue. The importance of the research lies in studying the effect of FI on carbon dioxide in developing and developed countries, to assess whether this effect is constant in all countries or different, and how FI affects the increase or decrease of carbon dioxide. This paper chose panel data regression to obtain results, as data was collected from 22 developed and 22 developing countries based on the availability of data and identifying the variables that most influence FI to reach accurate results.

The paper is organised into six sections Following the introduction, sections two and three provide important conceptual frameworks FI and carbon emissions. Section four analyses the previous studies that examined the relationship between carbon emissions and FI. Section five presents an econometric model, and empirical results. Section six concludes with policy recommendations.

Conceptual framework on financial inclusion and CO_2 emissions

This part will cover the definition of financial inclusion and its importance, and also tackles the dimensions, indicators, and factors of financial inclusion. Also, it will cover the conceptual framework of CO_2 emissions.

Financial inclusion and its importance

During recent decades, the term “FI” has frequently been used as it has been globally considered one of the main drivers of economic development. According to the World Bank, FI refers to the availability of affordable and useful banking and financial products

or services to all individuals and businesses regardless of their wealth or firm size (World Bank Group, 2022). Financial inclusion (FI) strives to ensure that everyone in society is included in the financial system and that the poor are efficiently utilizing their limited resources and money, by offering the most cost-effective and easy-to-use savings and loan services to them (Hirani, 2016). The World Bank estimates that approximately two billion adults still lack access to a basic bank account and, according to the IMF, most of them are poor and a large proportion are Africans (IMF, 2016).

Financial inclusion as a main driver of economic and social development

Additionally, FI has broad positive implications not only for the global economy but also for social welfare. An inclusive financial system helps promote the effective distribution of economic resources and, hence, can substantially decrease the overall cost of capital. Furthermore, FI facilitates day-to-day living, elevates people's standard of living, promotes saving, ensures the presence of a well-functioning financial system that reduces the time and risk in transacting money, and nurtures entrepreneurship. Consequently, evidence has shown that improved financial inclusivity could raise a country's GDP by as much as 30%. This is due to the lack of financial inclusivity, which is usually associated with billions of untapped potential or unutilized resources (Lochy, 2020).

Financial inclusion dimensions and indicators

The indicators of FI are important in setting national FI targets and they help in monitoring progress toward them. Moreover, policymakers need to have accurate measurements to enable them to diagnose the state of FI, agree on targets, identify barriers, craft policies, and monitor and measure their impact (World Bank, 2015).

Financial inclusion dimensions (Toppan, 2022)

The financial inclusion index (FII) is a multidimensional index that measures FI in a nation using a variety of indicators within each dimension. These dimensions are related to financial services.

Access. The first dimension is access; it focuses on the availability and accessibility of financial services and products to consumers. It is measured on a demographic basis, for example, the number of bank branches per 10,000 people.

Usage of financial services**.** The following dimension is usage; it focuses on how the financial services and products are used, and the frequency of their usage. A necessary prerequisite is to access these services, however, it does not guarantee their usage**.**

Quality of financial products**.** The third dimension is quality; it focuses on the ability of financial services and products to pair up with the consumers' needs and awareness of these products and services. It can be measured via surveys that include complex and detailed information.

Financial inclusion indicators

To measure the financial inclusion, data collection is the most common used tool to get accurate indicators.

Data collection**. Collecting data is mainly done through supply- and demand-side surveys, such** as the World Bank Global Findex, the IMF Financial Access Survey, the World Bank Enterprise Survey, and the World Bank Global Payments Systems Survey (Ecrown, 2016).

Supply-side surveys. This type of survey helps in measuring the access indicators. It collects data or reports from financial providers on the availability of financial services provided by financial institutions for financial regulators to include some aspects such as geographical access; availability of bank branches; point of sale (POS) devices; pricing; penetration; and usage of products and services (World Bank, 2015).

Demand-side surveys. This type of survey helps in measuring the usage indicators of financial services by consumers to classify their met and unmet financial needs, the barriers faced upon expanding the formal financial sector, and the socioeconomic and demographic characteristics of the users such as their genders, ages, and incomes. Data are collected directly from the users such as households, firms, and MSMEs which make them more costly and less frequently collected than the supply-side surveys, however, they tend to be more accurate and detailed (Chakrabarty,2012).

Factors of financial inclusion

The factors of financial inclusion are divided into three categories: Socioeconomic-related factors, Infrastructure-related factors, and Banking sector-related factors. The study will illustrate each category below in details.

Socioeconomic-related factors

These factors may include socioeconomic-related factors such as income, employment, inequality, literacy, among others. Studies have shown that people who are financially excluded usually belong to low-income groups, ethnic minorities, and immigrants. Moreover, countries that have high levels of FI, have low levels of income inequality. The geographic factor is also important as people living in rural areas, distant from urban financial centers, are more likely to be financially excluded. Another factor that may be associated with socioeconomic factors is employment. People who are unemployed or employed in the informal sector are less likely to participate in the financial system.

Infrastructure-related factors

Some infrastructure-related factors affect the accessibility of financial services such as a road network, telephone and television network, and access to information through newspapers and the Internet.

Banking sector-related factors

Indeed, there must be some banking sector-related factors, such as the health of the banking sector and the interest rates. For example, evidence has shown that the better the banking sector can provide credit to lower-income groups, the higher the FI (Sarma & Pais, 2011).

Financial inclusion challenges

Developing countries face various challenges when it comes to FI, as following:

Financial literacy

It refers to the combination of consumers'/investors' understanding of financial products and concepts and their ability to evaluate financial risks and opportunities, make wise decisions, and take effective actions to improve their financial well-being. In developing countries, people are not able to make financial decisions or even select the appropriate financial products and services because of a lack of awareness and financial illiteracy.

Valid identification documents

Lack of documentation is considered a barrier that affects the adoption of financial services, and provision of valid identification documents (ID) is another challenge for developing countries. Valid ID helps provide and obtain financial services needed for people to interact with the formal financial sector, as it helps them transfer large payment flows like wages and social benefits transfer into operating accounts (Appaya & Varghese, 2019).

***Consumer protection and regulation*s**

These constitute another barrier in developing countries. Financial access expanded through payment services like mobile money and e-money products, so it is important to establish trustworthy platforms to safeguard consumer data and make them confident to use e-payments. To benefit from FI, countries must publish key product information and adopt secure and trustworthy standards to facilitate for consumers to choose their financial products and services.

Usefulness

The last constraint is usefulness. Accounts must be easy to use by people. It is found that 355 million people prefer remitting money in cash rather than using their accounts.

Therefore, the three main challenges that create a huge gap between developing and developed countries in the field of FI are cost, lack of technology, and awareness. Due to those challenges, initiatives have been in place to tackle them. One of such initiatives is the Financial Inclusion Global Initiative (FIGI). FIGI funds China, Egypt, and Mexico tend to tackle the main challenges that affect FI access which are security, e-payment, and digital ID for services. The program provides tailored support relevant to digital FI like diagnostic assessments, advisory services, technical assistance, capacity building, improving the regulatory infrastructure, and pilots for innovative approaches. Another initiative is the Universal Financial Access Initiative (2020). It mainly focuses on people who are financially excluded, and tries to promote FI by improving financial literacy, creating an enabling suitable regulatory environment for making transaction, giving attention to women and the rural population, and encouraging them to use financial services (World bank, 2018).

CO_2 emissions

Carbon dioxide is one of the greenhouse gases (GHG), today, it accounts alone for 65% of greenhouse gas emissions, which is the reason behind the growing global concern towards the case of CO_2 emissions. The main sources for carbon dioxide emissions are primarily anti-environmental activities that economies undertake, in the hope for achieving accelerated economic growth, which in the end, as a side effect, leads to intensive GHG emissions as carbon dioxide (CO_2).

The disturbance in the carbon cycle (The CO_2 cycle that involves the land, plants, animals, and atmosphere), happens through deforestation, which eliminates plants that are considered natural sinks of carbon dioxide. The major sources of CO_2 emissions are transportation, electric power, and industry. This is a fact due to the significant dependence of these activities mainly on the process of fossil fuel combustion, such as natural gas and coal, which is considered the number one process responsible for CO_2 emissions (EPA, 2023).

Furthermore, it is quite important to know the effects of CO_2 emissions on the economy as well as on the environment. The relation between both seems to be a loop due to the interrelatedness of both. As emissions increase, they tend to affect the environment negatively through pollution and resource destruction as well as biodiversity loss, which results in a decrease in output and economic growth (Borhan et al., 2012). At the same time, accelerated economic growth and population growth also mean accelerated industrialization and an increase in transportation, congestion, and traffic—almost all of these processes rely on fossil fuel combustion leading to enormous amounts of GHG emissions and further environmental deterioration (Balibey, 2015). Moreover, it is equally important to mention that economic growth does not necessarily have a negative effect on GHG emissions in general or carbon dioxide emissions specifically. There seems to be a case where the effect is positive, this happens when the economic growth is sustainable in itself or what it refers to as green growth. Green growth occurs with consideration of the effects of economic

growth on the environment and emissions and is attainable by decreasing emissions or abating them (Dong et al., 2015).

Mitigation and adaptation

Mitigation

Both mitigation and adaptation are necessary for coping with GHGs and their impacts. Mitigation refers to coping with the emissions themselves. It means taking measures to reduce the sources of these gases themselves or enhance their sinks. It does not seek to reduce the impacts or find ways to adapt to them, but rather to confront the sources of those gases. Therefore, by finding measures to lessen the amounts of CO_2 emissions from their sources as well as enhancing the means to store them, the countries could mitigate CO_2 emissions (European Environment Agency, 2022).

Mitigation in developed and developing countries. An important distinction must be made between these countries in the discussion of mitigation and adaptation strategies. It is matter of fact that a greater percentage of worldwide GHG emissions are caused by developed countries. This fact, however, leads some developing countries to resist mitigating GHG emissions, as they perceive that the problem should be addressed by those who caused it. Also, due to their low income and financial resources, developing countries face difficulties in taking mitigation measures toward GHG emissions. In addition to financial limitations, developing countries have other constraints in the fight against GHG emissions, one of which is that they often lack the necessary degree of awareness about GHG emissions and their severe negative impacts. Even when they do have the awareness, developing countries often face other severe human problems such as poverty and hunger that place halting GHG emissions at their lowest priority. Developing countries often have low human capital as indicated by insufficient education and health, making them unable to implement mitigation measures.

Adaptation

Adaptation does not mean halting GHG emissions, but rather adapting to their unavoidable effects (Chandler et al., 2002**)**. It refers to measures taken to adapt to prevailing current or future effects of CO_2 emissions. More specifically, it means forecasting the detrimental impacts of emissions and adopting measures to lessen or prevent them.

Adaptation in developed and developing countries. Adaptation measures in countries are lower than mitigation ones. Adaptation is often perceived to provide low financial returns when compared to mitigation.

Nevertheless, developing countries pursue more adaptation than mitigation strategies because they are less expensive to implement (singh, 2022). Also, two main factors make adaptation so important to the developing world. For one, developing countries rely heavily on natural resources to sustain their economies; those natural

resources are heavily affected by GHG emissions. Another factor is that these countries do not have the necessary strength and resources to withstand the dire effects of GHG emissions, making them especially vulnerable (Gagnon and Agrawala, 2006).

Initiatives

There is an increasing knowledge of the severe consequences of GHG emissions daily, resulting in a considerable number of initiatives globally and locally to limit GHGs and their effects. One of the developed countries that have implemented various comprehensive programs to combat GHG emissions is Japan, targeting a 46% reduction of its GHG emissions by 2030 and carbon neutrality by 2050. Japan has taken several initiatives across different sectors in line with those ambitions. In the energy sector, it has utilized renewable energy with an increase from 10% in 2010 to 23% in 2020. The United Kingdom (UK) is also one of the countries with the highest achievements in climate protection based on the 2022 Climate Change Performance Index (CCPI). Of its many initiatives, UK forestry efforts have been in place to more than double the number of trees in the country as a means of carbon capture (Climate Action Tracker, 2022).

Along lines, an example of a developing country that has undertaken considerable effort is Egypt. Egypt's nationally determined contribution (NDC), demonstrated undertaking major mitigation and adaptation measures. Regarding mitigation efforts, Egypt has implemented various ambitious programs in almost all sectors of the economy. In the transportation sector, it has extended its Greater Cairo metro network by adding new lines in an attempt to lessen pollution. In addition, Egypt has taken significant initiatives in the energy sector tending to reaching a 10% reduction of its GHG emissions by 2030. It has adopted ambitious programs to switch to the use of blue and green hydrogen. Egypt has also taken several energy-efficient actions, targeting a 42% increase of renewable energy use via electric power contribution by 2035 (Wes, 2022).

Literature review

The present focus on FI benefits economies and individuals, but the environmental impact is unclear. Building on previous research efforts, this study aims to assess the effect of FI on the environment. The existing literature is primarily based on smaller-scale studies conducted within single countries, with relatively limited research conducted on a larger, generalized scale. This might explain why the results differ and it cannot be concluded whether there is a more likely positive or negative relationship. Adding to that, no replicated studies have been conducted to validate the findings, and smaller-size studies would not be able to reach a generalized conclusion regarding their relationship. Moreover, the time frames used in previous studies are usually within the previous decade. Our contribution is to make a comparative study on a large data set of developed and developing countries within the most recent time frame; 2004 to 2021.

Theoretical perspective

Scholars have given contrasting perspectives on the influence of FI on carbon emissions. Some researchers argue that FI increases carbon emissions since it aids in the development of the financial sector, which provides easy access to consumer credit and loans, thereby facilitating general consumption for buying costly items like automobiles, houses, air conditioners, among others, causing increased carbon dioxide emissions (Sadorsky, 2011). Likewise, a well-functioning finance system could reduce the problem of information asymmetry, broaden funding channels, and enable enterprises to have capital at lower costs, thereby facilitating production expansion and encouraging investments in high carbon footprint (Zhang, et al., 2022). Other researchers believe that financial development can help reduce carbon emissions by lowering production costs, upgrading technological assets, lowering energy prices, and indirectly lowering carbon emissions. In addition, governments typically undertake a variety of eco-friendly measures and policies to fight environmental degradation. Financial institutions may provide the necessary financing for these policies, whichhelp build the energy infrastructure and, eventually, reduce carbon emissions (Dasgupta et al., 2001).

Previous empirical framework

This literature review divides the previous empirical framework into three strands as follows:

First strand: Positive relation between financial inclusion and CO_2 emissions

Xu et al. (2018) measured environmental degradation relevant to financial development, in a study on Saudi Arabia between 1971 and 2016 using an Autoregressive Distributive Lag (ARDL) and Vector Error Correction Methods (VECM) controlling the model for electricity consumption and globalization. The results showed that FI acceleratesthe rate of CO_2 emissions in Saudi Arabia, where the coefficient of financial development indicated that a 1% increase in financial development increased CO_2 emissions by 0.167%. Adams & Klobodu (2018) conducted a study on 26 African countries between 1985 and 2011 using the Panel Regression Model for testing liquid liability to GDP and private credit to GDP. They found that FI increased the emissions taking into account the political regime followed in each country.

According to a study by Muhammad et al. (2020) done between 1999 and 2013 on the D8 and G8 countries using the PMG-panel ARDL technique to research the determinants' co-integration correlations across both the long and short terms, results showed that there is a positive link between CO_2 and financial development. Both D8 and G8 countries demonstrated that a 1% rise in financial development will accelerate carbon emissions by 0.499% and 1.204%, respectively, in the long term, with insignificant effects in the short term.

The study of Qin et al. (2021) tested using the Kao and Johansen panel co-integration tests on the emerging seven (E7) economies from 2004 to 2016. They found out that

greater FI leads to greater gross fixed capital formation which would in turn increase energy demand leading environmental quality to worsen.

In the study of Zaidi et al. (2021), they believed that in theory, FI reduces carbon emissions, but still, it can lead to a higher amount of carbon emissions indirectly through increased energy demand for instance, (Dynamic) Common Correlated Effects Estimator technique or CS-ARDL. The sample of the study included 23 OECD countries from 2004 to 2017, using variables such as FI, energy consumption, and carbon emissions while taking infrastructure, corruption, and economic growth as control variables. The findings proved that FI and CO_2 emissions have a positive relationship in both the short and long runs.

Another study made on the E7 by Lin and Wu (2022) between 2004 and 2019 adopted the panel quantile estimator for long-run estimations, using a panel causality test. They used other factors besides FI to test the emissions change during the given period, it was found that FI, economic growth, and globalization increased over time which led to environmental degradation and an increase in CO_2 emissions.

Second strand: Negative relation between financial inclusion and CO_2 emissions.

On the other hand, several researches found conflicting outcomes such as Charfeddine and Kahia (2019). Their study on the MENA region showed that financial developments slightly decreased carbon emissions. They utilized a regression model that used the panel vector autoregressive (PVAR) model between the years 1980 and 2015, and found that financial developments reduced carbon emissions in the MENA region slightly

In 2020, other scholars also investigated the connection between financial development and CO_2 emissions in China between the years 2001 and 2005 like Zhao et al., and they found that a 4–5% reduction in CO_2 emissions would result from a standard increase in provincial financial development. They made both static and dynamic analyses by group mean fully modified OLS (group mean FMOLS), dynamic OLS (DOLS), and the Impulse Response and Variance Decomposition based on the Panel Vector Auto Regression (PVAR) model (Zhao & Yang, 2020).

From a different perspective, Chen and Lee's study (2020) which was conducted in 96 countries between 1996 and 2018, found that the impact of technological innovation on reducing CO_2 emissions is more pronounced the more globalized a nation is. The spatial auto correlation is used first. A Spatial Durbin Model (SDM) is then used to study both direct and indirect effects. The conclusion showed that spillover effects can cut carbon emissions, a negative effect that still has to be considered.

Third strand: Other findings

Some studies tend to find differing results among their tested sample. In their study on China between 1997 and 2011, Wang et al.(2022) used a dynamic panel regression model testing the total loans to GDP, private loans to GDP, and the total deposits to GDP variables. In their model, they found that FI had different effects on different regions; it increased the emissions in developing areas and reduced them in the

developed ones.

Meanwhile, the study of Zaidi et al. (2019) on the G7 and N11 countries during 1990-2016 used some FI indices. They indicated that the results differed across the country groups; the indices that increased the emissions in the G7 countries happened to decrease them in the N11 countries and, vice versa.

Likewise, The study of Yao & Tang (2021) study on the G20 countries for the period from 1971 to 2014 used an expanded STIRPAT model with two-way fixed effects to conclude that results were heterogeneous such that financial developments were negatively correlated with the per capita CO_2 emissions of developed countries and positively correlated in the developingones.

Liu and Song's study (2020) on China from 2007 to 2016 used a three-step approach; first, they estimatedthe carbon intensity within each province in China, second, they investigated the spatial and temporal patterns, and the dynamic evolution of the financial development and carbon emissions in each province and finally analyzing the FI impact on carbon intensity via the spatial Durbin model. Results highly differed in each province whether a big city or not which they stated as the polarization of financial development and polarization of carbon emissions.

Lastly, the study of Hussain et al. (2023) used a pairwise causality test after computing a composite index for FI using the principal component analysis (PCA) technique. Applying that to a balanced set of panel data for 26 Asian countries from 2004 to 2014 after dividing the sample into 2 groups with 14 countries that fall under the categoryof high and upper-middle-income countries, and 12 countries that are categorized as lower and lower-middle-income countries. The findings suggest a negative effect of FI on CO_2 emissions in the short run and a positive effect in the long run.

Methodology

This section will cover model specification, data and variables, the model analysis, and findings and results.

Model Specification

Motivated by research objectives, this study examined the impact of FI on CO_2 emissions in developed and developing countries. It analyzes how this relationship varies betweendeveloping and developed countries using Stata. This research uses CO_2 emissions as a dependent variable and FII, GDP, GOV, and Trade as independent ones, where GDP, GOV, and Trade are used as control variables. All variables are transformed into their logarithmic form to reduce the collinearity between the variable and its quadratic form and to be able to interpret the regression coefficients as elasticities. Therefore, the estimated model is as follows:

$$\ln CO_{2\,it} = a_0 + a_1 \ln(FII_{it}) + a_2 \ln(GDP_{it}) + a_3 \ln(GOV_{it}) + a_4 \ln(Trade_{it}) + U_{it}$$

where,

subscripts i and t denote the country and time respectively. CO_2 denotes carbon dioxide emissions per capita, FII denotes financial inclusion index, GDP denotes GDP per capita, GOV denotes government effectiveness as a proxy for institutional quality, and Trade denotes trade as apercentage of GDP. The study begins with a calculation of the FII, followed by a Haussmann test to determine which panel regression to use, fixed or random. The regression is then made to answer the research question.

Data and variables

This paper relies on secondary data from the World Bank and the IMF over the period of 18 years from 2004 to 2021. This period has been chosen as the FI is a recent phenomenon. To be able to accurately compare the impact of FI on CO_2 emissions in developed and developing countries and generalize the findings of the study, a panel dataset was chosen for conducting this model. The panel data is gathered from 22 developing and 22 developed countries based on the availability of data, especially the data related to CO_2 emissions. This data can be referred to in Table 1 in the appendix. Variables definitions and sources are represented in the following Table (1). For each variable, descriptive statistics are presented for developed and developing countries separately, as shown in Tables (2) and (3), respectively. The descriptive statistics included are the mean, standard deviation, maximum, and the minimum values for the countries under study.

Table 1.

Variables definitions and data sources

Variables	Definition	Data source
Trade of GDP	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World bank, 2023
Gov. effectiveness	Perceptions of the caliber of public services, the caliber of the civil service and the extent of its detachment from political considerations, the caliber of policy creation and implementation, and the credibility of the government's dedication regarding these policies are all included in the category of government effectiveness.	World bank, 2023
CO_2 emissions	Aggregate carbon emissions are measured in metric tons emitted in the air throughthe use of fossil fuels.	World bank, 2023
GDP/capita	GDP per capita is based on purchasing power parity, PPP GDP is gross domestic product converted to international dollars using PPP rates.	World bank, 2023
FII	The index includes the proxies of financial inclusion, namely ATMs, deposit accounts, bank branches, and outstanding loans.	IMF, 2023

Sources: https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1496861011734; https://www.worldbank.org/en/home

Table 2.
Descriptive statistics for developed countries

Variables	Obs.	Mean	St. Dev.	Min.	Max.
Trade of GDP	384	112.1951	61.2912	23.66435	322.675
Gov. effectiveness	378	82.76659	12.86207	44.71154	100
CO_2 emissions	336	7.154004	2.468861	2.964713	14.90288
GDP per capita	395	42007.27	15416.71	13702.34	102496.2
FII	396	0.7880914	0.1500397	0.3048597	0.9884334

***Source*:** Compiled by the authors**.**

Table 3.
Descriptive statistics for developing countries

Variables	Obs.	Mean	St. Dev.	Min.	Max.
Trade of GDP	392	80.66486	31.76981	22.48623	210.3743
Gov. effectiveness	393	52.59025	17.79326	17.30769	90.86539
CO_2 emissions	336	3.956831	3.526115	0.0846069	17.25779
GDP per capita	392	15620.24	10458.35	801.4271	47379.36
FII	396	0.68856	.2222403	0.1163755	0.9982543

***Source*:** Compiled by the authors.

To examine the extent to which the FII and the control variables are correlated with CO_2 emissions in both developed and developing countries, the study calculated the pair-wise correlation coefficients as shown in Tables (4) and (5), respectively. These relationships are examined holding all other factors constant. On one hand, as for the developed countries, it can be deduced that there is a weak positive correlation between both the GDP per capita and government effectiveness and CO_2 emissions. There is a weak negative correlation between both the FII and trade as a percentage of GDP and CO_2 emissions. On the other hand, as for the developing countries, it can be deduced that there is a weak positive correlation between the FII, trade as a percentage of GDP and government effectiveness, and CO_2 emissions, whereas there is a strong positive correlation between the GDP per capita and the CO_2 emissions.

Table 4

Correlation matrix for developed countries

	CO_2 emissions	**GDP per capita**	**FII**	**Gov. effectiveness**	**Trade of GDP**
CO_2 emissions	1				
GDP per capita	0.1178	1			
FII	-0.0922	-0.1457	1		
Gov. effectiveness	0.2397	0.4989	-0.0272	1	
Trade of GDP	-0.0238	0.127	0.1115	-0.1782	1

Source: Compiled by the authors

Table 5.

Correlation matrix for developing countries

	CO_2 emissions	**GDP per capita**	**FII**	**Gov. effectiveness**	**Trade of GDP**
CO_2 emissions	1				
GDP per capita	0.9054	1			
FII	0.2256	0.2229	1		
Gov. Effectiveness	0.4333	0.5911	0.2427	1	
Trade of GDP	0.2293	0.0743	0.2614	0.1961	1

Source: Compiled by the authors

The financial inclusion index

As the widely known FII is not available for the chosen developed and developing countries, this paper intends to construct an FII rather than rely solely on a single indicator of FI due to its multidimensional nature. The data used in forming this index is gathered from the Financial Access Survey database, published by the IMF during the period 2004-2021. This study follows the methodology of Sarma (2012) in constructing the FII, which uses an approach similar to that used by UNDP for the computation of some well-known development indexes, such as the HDI. However, the proposed index is based on the notion of distance from a worst and an ideal situation. This distance-based formulated index is mathematically advantageous, as it satisfies the following properties: Boundedness, unit-free measurement, homogeneity, and monotonicity.

Despite those strengths, the proposed index has some drawbacks. Two of the most important ones are that it depends on the availability of data for the countries under

study, and that it does not account for the technological advancements that have taken place in the financial system—the indicators used do not fully reflect these advancements.

The multidimensional FII is constituted, using Microsoft Excel, based on three basic dimensions, which are banking penetration; availability of banking services; and the usage of the banking system. As the banking penetration dimension represents the size of the banked population, this study chose the number of deposit accounts with commercial banks per 1,000 adults as an indicator. For the availability of the banking services dimension, the study calculated a weighted average of the number of commercial bank branches per 100,000 adults and the number of ATMs per 100,000 adults. As the usage dimension captures how adequately the banking services are being utilized, this paper used the outstanding loans from commercial banks as an indicator of it. The choice of the indicators representing each dimension is based on the indicators suggested by the G20 FI Indicators, published by the World Bank. Constructing the index begins by computing a dimension index for each dimension of the FI. The dimension index (di), computed by formula (1), evaluates a country's performance in the ith dimension of the FI. Then, a weight (Wi) is assigned to each dimension i, representing the relative effect of dimension i in measuring the inclusiveness of the financial system.

$$\boldsymbol{d_i = w_i \frac{A_i - m_i}{M_i - m_i}} \quad \textbf{(1)}$$

where,

Wi = weight attached to the dimension I, $0 \leq Wi \leq 1$

Ai = actual value of dimension i

mi = lower limit on the value of dimension i, fixed by zero

Mi = upper limit on the value of dimension i, fixed by the 90th percentile.

This paper follows (Sarma, 2012) in choosing mi and Mi. Such that mi, the lower limit of dimension i, is chosen to be zero, while Mi, the upper limit of dimension i, is chosen to be the 90th percentile to remove excessively high benchmarks and smooth the value of the index. The weights (Wi) assigned to the banking penetration dimension, availability of the banking services dimension, and the usage of the banking system dimension are 1, 0.5, and 0.5, respectively. The banking penetration dimension was assigned a weight of 1, as it is the primary indicator of FI. Due to the limitations of data that completely characterize the availability of banking services and usage of the banking system dimensions, they were each assigned a weight of 0.5.

A country's performance in these three dimensions could be represented by a point $X = (d_1, d_2, d_3)$ on the three-dimensional space, where (0, 0, 0) is the worst situation and the ideal situation, expressed by the assigned weights, is (1, 0.5, 0.5). The smaller the distance between the X and the ideal situation, the higher the FI in this country. Thus, the FII formula shown by formula 2 incorporates distances from both the worst and the ideal situation.

$$IFF = \frac{1}{2}\left[\frac{\sqrt{d_1^2 + d_2^2 + d_3^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2}} + \left(1 - \frac{\sqrt{(1-d_1)^2 + (1-d_2)^2 + (1-d_3)^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2}}\right)\right] \quad (2)$$

The FII is a number from 0 to 1 that describes the country's performance in terms of FI, accounting for the three dimensions previously mentioned.

Control variables

In an attempt to isolate the effect of FI on CO_2, this paper controls for the following variables: GDP per capita; trade as a percentage of GDP; and government effectiveness as a proxy for institutional quality. After thorough research, this paper used GDP per capita, as a control variable, as it is significantly correlated with CO_2 emissions (Tucker, 1995; Li & Lin, 2013). Moreover, trade openness was seen to have a profound effect on CO_2 emissions (Du e al., 2020). Additionally, the institutional quality playsa crucial role in determining the level of CO_2 emissions in a country (Jahanger et al., 2022).

Econometric strategy

This paper conducts two separate econometric models, one for the developing countries and the other for the developed ones, to examine the variation in the effect of financial inclusion on CO_2 emissions. The panel regression model is applied to the two sets of countries, specifically the traditional fixed and random effects models. A Haussmann test was conducted to determine which of them to use in each set. Panel Regression is most suitable for our data, as they are set across time and space. Panel Regression has several strengths that characterize it. Panel data give more informative data, more variability, less collinearity among the variables, and more efficiency. The panel data statistical methods were introduced by Airy in 1861.

Haussmann test

The null hypothesis of the Haussmann test states that the preferred model is random effects, while the alternative hypothesis states that the preferred one is the fixed effects model at a 5% significance level.

Table (6) shows that, in the case of the developed countries, the random effects model is the more suitable model. Nonetheless, the fixed effects model is shown to be more suitable in the case of developing countries. The random effects model has several advantages as it produces efficient estimators and allows the estimation of the impact of the time-invariant variables. The fixed effects model removes the impact of the time invariant characteristics enabling the model to assess the net effect of the independent variables on the CO_2 emissions.

Table 6.
Haussmann test

Haussmann test	Null hypothesis	Alternative hypothesis	P-value	Significant level "α"	Decision rule
Developed	Model is a random effect	Model is a fixed effect	0.0635	5%	Accept null hypothesis

Developing	Model is a random effect	Model is a fixed effect	0	5%	Reject null hypothesis

Source: Compiled by the authors based on software output**.**

Results and Discussion

This section will tackle the findings of models used to estimate the coefficients of the regressors in developed countries and developing countries.

Developed Countries. The generalized least squares random effects model is used to estimate the coefficients of the regressors for the developed countries.

$$\ln CO_{2it} = 3.9 - 0.2\ln(FII_{it}) - 0.14\ln(GDP_{it}) + 0.23\ln(GOV_{it}) - 0.34\ln(Trade_{it}) + U_{it} \quad \textbf{(3)}$$

The above equation shows that there is a significant negative relationship between FI and CO_2 emissions at a 10% significance level, and this is displayed in (Table 2) in the appendix. This is in agreement with this paper's review of past literature as Tamzian et al, (2008) showed that financial development, which included FI, encouraged the usage of more technological energy-efficient assets which in turn reduced CO_2 emissions. As for the significance of the effect of the GDP per capita on CO_2 emissions, it is perceived that GDP per capita has a significant reverse impact on CO_2 emissions at a 10% significance level. It could also be deduced from the above model that there is a significant negative relationship between trade openness and CO_2 emissions at a 10% significance level. Nevertheless, government effectiveness is seen to have an insignificant effect on CO_2 emissions. These relationships are examined holding all other factors constant.

Developing Countries. The Fixed Effects model is used to estimate the coefficients of the regressors for the developing countries.

$$\ln CO_{2it} = 3.85 + 0.17\ln(FII_{it}) + 0.48\ln(GDP_{it}) - 0.14\ln(GOV_{it}) + 0.21\ln(Trade_{it}) + U_{it} \quad \textbf{(4)}$$

From equation 4, it can be perceived that there is a positive effect of FI on CO_2 emissions and this is shown in (Table 3) in the appendix. This conclusion corresponds with what Sadorsky (2011) concluded in his study. He explained this relationship by stating that higher loans and credit to the consumers encouraged them to increase their consumption of costly carbon-emitting products, such as automobiles. Zhang et al. (2022) also stated that a better and more easily accessible financial system motivates investors to invest in projects that increase their carbon footprint. GDP per capita is shown to havea significant positive impact on CO_2 emissions, whereas government effectiveness has a significant negative effect. Regarding trade as a percentage of GDP, the model shows that it has a significant positive impact on CO_2 emissions

Several arguments support the results reached in this research paper. In developed countries, higher FI is translated into higher investment in environmentally sustainable

projects. More specifically, higher access to financial services motivates start-ups and businesses to invest in green projects. However, developing countries make use of better access to financial services by increasing consumption. This can be explained by the fact that developing countries often tend to be low-income countries. Developed countries are often concerned with sustainability over growth, whereas developing countries prefer growth over sustainability. Therefore, technological advancements in developed countries are more sustainable, such as onlinebanking. However, developing countries tend to invest in unsustainable technology that contributes to emissions. Developed countries invest heavily in human capital, therefore expanding knowledge and education about low-carbon economies. Nevertheless, this does not apply to developing countries whose focus is centered on economic growth that is heavily reliant on physical capital. Governments of developed countries are keen to undertake a variety of eco-friendly measures and policies to fight environmental degradation. They place regulations such as carbon pricing to limit carbon emissions. Developing countries, though, are characterized by poor institutional quality and regulations. These arguments explain the conclusion reached that FI has a negative effect on the CO_2 emissions in developed countries, whereas the opposite is true for developing countries.

Conclusion

The purpose of this study is to examine how financial inclusion affects CO_2 emissions. within the framework of a comparison between developed and developing countries in the period of 2004–2021. The study analyzed previous literature that investigated the link between financial inclusion and CO_2 emissions, which helped in addressing the literature gap. Previous literature showed a literature gap in analyzing the relationship on a bigger scale, not individual countries, as well as testing the relationship in the current decade not previous ones, besides the absence of comparative studies. Moving on, the relationship is then tested using a panel regression model through afixed random effects model for developed countries and a random effects model for developing ones. The findings then show that financial inclusion has a negative effect on CO_2 emissions in developed countries, while it has a positive effect in developing countries.

Based on the previous findings, some policy recommendations are suggested in both cases of developing and developed countries.

Policy recommendations

The conclusions reached in this research paper call for strong measures by both developed and developing countries. The deduction that higher financial inclusion leads to increased CO_2 emissions in developing countries dictates for those countries to take action to halt or reverse this phenomenon. However, due to the importance of financial inclusion, the solution lies in finding ways to limit those emissions instead of reducing efforts towards financial inclusion. Financial institutions in developing countries could focus their credit loans on businesses that show a clear commitment to reducing activities that emit significant amounts of CO_2 and are fully conscious of the importance

of a green economy. This also includes facilitating funding for energy innovation investments. Financial institutions could, for instance, provide loans at lower interest rates to businesses committed to lowering their CO_2 emissions. Furthermore, mitigation and adaptation strategies to limit CO_2 emissions are often costly to engage in. Therefore, banks and international organizations, such as the World Bank, should assist such under privileged economies financially by providing them with finance to engage in those activities. Moreover, financial institutions should include efforts to raise awareness about activities that lead to environmental degradation within their attempts to reach all individuals and make them financially included. Also, a highlight on digital financial inclusion could significantly aid in lowering CO_2 emissions by lowering energy consumption as argued by Zhang, et al (2022).

Regarding developed countries, it was found that higher financial inclusion reduced CO_2 emissions. This conclusion should motivate those countries to further exploit financial inclusion to reduce CO_2 emissions. Financial institutions could facilitate finance, such as car or mortgage loans to households, who will use this finance for low-carbon activities. For instance, banks should facilitate car loans for those seeking to purchase electric cars rather than gas-fueled ones. Furthermore, governments of both developed and developing countries should aim to expand the market for green finance, such as green bonds. The United States, China, and Germany have issued the greatest number of green bonds in 2021; it is recommended that other countries do so too as Flammer (2020) proved that green bonds are effective tools in reducing CO_2 emissions. In addition to those measures, both developed and developing countries could educate younger generations in universities about the means and importance of investing in green projects. Also, the usage of tax cuts to limit CO_2 emissions has a profound importance in both developed and developing countries. Tax cuts for low-carbon projects could encourage businesses to target investments in green projects.

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Appendix

Table 1.

Countries Included in the Study

Countries	
Developed	**Developing**
Austria	Argentina
Bulgaria	Azerbaijan
Croatia	Chile
Czech Republic	Costa Rica
Estonia	Georgia
Finland	Gambia
Greece	India
Hungary	Jamaica
Iceland	Kenya
Ireland	Korea, Rep.
Italy	Kosovo
Japan	Malaysia
Latvia	Mexico
Malta	Moldova
Norway	Montenegro
Netherlands	Mozambique
Poland	North Macedonia
Portugal	Peru
San Marino	Thailand
Spain	Türkiye
Sweden	Ukraine
Switzerland	Saudi Arabia

Source: Compiled by the authors

Table 2.

Generalized least square random effect in developed countries

Ln CO_2	**Coefficient**	**P-value**
Ln FII	-0.1905419	0.001
Ln GDP	-0.1432647	0.077
Ln gov.	0.2266773	0.214
Ln trade	-0.3419869	0
Constant	3.917052	0

Source: Compiled by the authors based on software output**.**

Table 3.

Fixed effect in developing countries

Ln CO_2	**Coefficient**	**P-value**
Ln FII	0.1658677	0
Ln GDP	0.4791398	0
Ln gov.	-0.1408315	0.004
Ln trade	0.2069739	0
Constant	-3.848055	0

Source: Compiled by the authors based on software output**.**

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تأثير الشمول المالي على انبعاثات ثاني أكسيد الكربون.. دراسة مقارنة بين الدول المتقدمة والنامية خلال الفترة (2004-2021)

المستخلص

حظيت مفاهيم الشمول المالي وانبعاثات ثاني أكسيد الكربون باهتمام كبير لدى معظم دول العالم في السنوات الأخيرة. وتهدف هذه الورقة البحثية إلى دراسة مدى وجود علاقة ديناميكية بين الشمول المالي وانبعاثات ثاني أكسيد الكربون في البلدان المتقدمة والنامية. وقد أجريت الدراسة على 22 دولة متقدمة و22 دولة نامية على مدار 18 عامًا خلال الفترة من 2004 إلى 2021. وتأخذ الدراسة في الاعتبار المتغيرات الأخرى التي قد تؤثر على انبعاثات ثاني أكسيد الكربون من خلال تضمين متغيرات التحكم التالية: الناتج المحلي الإجمالي للفرد، والتجارة كنسبة مئوية من الناتج المحلي الإجمالي، وفعَّالية الحكومة كبديل للجودة المؤسسية. والنموذج المستخدم لإجراء التحليل هو نموذج انحدار Panel Data. وقد أظهرت نتائج الدراسة أن هناك علاقة بين الشمول المالي وانبعاثات ثاني أكسيد الكربون، وأن هناك تأثيرا سلبيا كبيرا للشمول المالي على انبعاثات ثاني أكسيد الكربون في البلدان المتقدمة، ولكنه تأثير إيجابي كبير في البلدان النامية. وتشير النتائج إلى ضرورة اتخاذ تدابير خاصة بكل بلد لضمان ألا يؤدي ارتفاع مستوى الشمول المالي إلى تدهور البيئة.

الكلمات الدالة: انبعاثات ثاني أكسيد الكربون، الشمول المالي، الجودة البيئية، الدول النامية، الدول المتقدمة