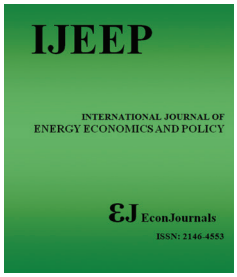

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(3), 144-153.

The Impact of Financial Development on Carbon Emissions in Africa

Kunofiwa Tsaurai*

Department of Finance, Risk Management and Banking, University of South Africa, South Africa.
*Email: kunofiwa.tsaurai@gmail.com

Received: 02 September 2018 **Accepted:** 20 January 2019 **DOI:** https://doi.org/10.32479/ijeep.7073

ABSTRACT

The paper explored the influence of financial development on carbon emissions in West African countries using pooled ordinary least squares (OLS), fixed and random effects with data spanning from 2003 to 2014. On the theoretical front, arguments for both financial development led positive impact on carbon emissions and financial development led negative impact on carbon emissions are quite compelling. Empirical studies on the role played by financial development on carbon emissions produced quite divergent and conflicting findings. It is clear from both theoretical and empirical sides that the influence of financial development on carbon emissions is still a contentious issue which is yet to be resolved in literature. Overally, pooled OLS approach (both lagged and non-lagged variable) shows that only domestic credit provided by financial sector resulted in the significant increase in carbon emissions in Western African countries.

Keywords: Financial Development, Carbon Emissions, Western African Countries
JEL Classifications: E44, N27, Q5

1. INTRODUCTION

According to Hoffmann (2011), poor nations like African countries can only afford to purchase material intensive industrial machinery which are unfriendly to the environment as they generate more pollution and excessive carbon emissions. Consistent with recent empirical studies (Mazzanti and Musolesi, 2013; and Piaggio and Padilla, 2012), among others, observed that high levels of carbon emissions are detrimental to economic growth. Whilst the negative impact of carbon emissions on economic growth is no longer a contestable issue in economics, the influence of financial development on carbon emissions is a subject dominating recent debates among academics and environmentalists but clearly still far from being conclusive. Two main theoretical views characterise the influence of financial development on carbon emissions, namely the financial development led positive impact on carbon emissions and financial development led negative impact on carbon emissions. The weakness of these two theoretical views is that they assume a linear relationship between financial development and carbon emissions. The assumption is not practical consistent with Tamazian and Bhaskara (2010) whose study noted that the institutional framework in place in the transitional countries determined the influence of financial development on carbon emissions. The argument was also supported by Hao et al. (2016) whose study observed that financial development only reduced carbon emissions at low levels of economic growth. Contradictions, lack of consensus and divergent views characterise the empirical literature on the impact of financial development on carbon emissions. For example, the findings that are coming out of the empirical literature can be categorised into five, namely, the neutrality hypothesis, the feedback view, the financial development inspired positive effect on carbon emissions, financial development inspired negative impact on carbon emissions and the perspective that certain macro-economic factors must be available before financial development reduces carbon emissions. These contradictions, divergent views and absence of consensus

is an indication that the role of financial development on carbon emissions is not yet a settled issue. It is still far from being resolved. Moreover, the available empirical literature on the subject matter has so far largely ignored the African continent, a region which receives cheaper and environment unfriendly machinery. The extraction of natural resources in the African continent requires the use of heavy equipment and machinery which produces a lot of carbon emissions, consistent with Kwakwa et al. (2018). It is against this backdrop that the current paper investigated the effect of financial development on carbon emissions in West African countries.

This study contributes to literature by investigating the impact of financial development on carbon emissions in West African countries. In other words, the paper hopes to tell the inadequately told story of the impact of financial development on carbon emissions in an African context. The closest available empirical study on the impact of financial development on carbon emissions was done by Onanuga (2017). The latter found out that financial development reduced carbon emissions in upper middle income Sub-Saharan African countries whilst financial development led to an increase in carbon emissions in low, low middle and high income Sub-Saharan African countries. The current study deviates from Onanuga's (2017) study in the following ways: (1) Focused on West African countries, (2) used a lagged variable approach for robustness tests, (3) used pooled ordinary least squares (OLS), fixed and random effects, (4) panel data used spans from 2003 to 2014 and (5) used three measures of financial development for robustness test purposes. The study enables Western African countries to develop financial management policies that reduces not only energy consumption but overall quantity of carbon emissions.

The rest of the paper is organised as follows: Section 2 discusses both theoretical and empirical literature on the role of financial development on carbon emissions, section 3 explains how other macroeconomic variables influence carbon emissions whereas section 4 describes the financial development and carbon emissions trends in West African countries during the period from 2003 to 2014. Section 5 is research methodology (econometric model specification, data analysis, robustness tests, results discussion and findings). Section 6 concludes the paper.

2. LITERATURE REVIEW ON IMPACT OF FINANCIAL DEVELOPMENT ON CARBON EMISSIONS

According to Aye and Edoja (2017), there are four theoretical perspectives on the impact of financial development on carbon emissions, namely the environment friendly technology, the foreign direct investment (FDI), the manufacturing sector enhancement and the increased consumer credit perspectives as discussed next.

Financial development reduces carbon emissions when the financial markets provide financial assistance to the domestic firms to acquire environment friendly and clean technology for manufacturing purposes. The theoretical view was supported by Yuxiang and Chen (2010) whose study noted that the financial sector provided funding and technical assistance that enabled Chinese companies to adopt new and advanced technology which increased production levels whilst at the same time reducing carbon emissions. It was also argued by Frankel and Rose (2012) that financial markets can effectively allocate financial resources to the domestic firms to enable them to purchase environment friendly technology.

Financial development also increases carbon emissions when it attracts foreign investors (FDI) which boosts the amount of energy usage and the scale of economic activities in the host country. However, some of the foreign investors heavily invests in clean energy associated research and development projects and brings along their environment friendly technology which produces minimal amount of carbon emissions. Financial development might increase the number and scale of manufacturing activities in the country through availing more financial assistance to the domestic companies. The effect could be both an increase in land degradation, pollution and carbon emissions, consistent with Aye and Edoja (2017. p. 10). More consumer credit can increase the scale of purchase of items such as machinery and automobiles purchased which consume a lot of energy (Xing et al., 2017. p. 9).

On the empirical front, several studies investigated the impact of financial development on carbon emissions. For example, Sy et al. (2016) studied the interrelationship between financial development, carbon emissions, economic growth and trade openness in 40 European countries using OLS with panel data ranging from 1985 to 2014. Among other findings, their study detected the existence of a neutrality hypothesis between financial development and carbon emissions in the European countries. Alom et al. (2017) explored the relationship between carbon emissions, urbanization, financial development and energy consumption in Bangladesh using vector error correction model with time series data spanning from 1985 to 2015. One of the findings was that financial development had a positive effect on carbon emissions in Bangladesh. Using panel data analysis, Kong and Wei (2017) studied the relationship between financial development and carbon emissions using panel data (1997-2013) analysis in China's 30 provinces. Their study found out that low financial development reduced carbon emissions whereas higher levels of financial development led to an increase in carbon emissions in the China's provinces. Al-Mulali et al. (2015) explore the effect of financial development on CO_2 emission in 129 countries classified by the income level. A panel CO_2 emission model using urbanisation, gross domestic product (GDP) growth, trade openness, petroleum consumption and financial development variables that are major determinants of CO_2 emission was constructed for the 1980-2011 period. The results revealed that the variables are cointegrated based on the Pedroni cointegration test. The dynamic OLS and the Granger causality test results also show that financial development can improve environmental quality in the short run and long run due to its negative effect on CO_2 emission. Nasreen et al. (2017) investigate the relationship between financial stability, economic growth, energy consumption and carbon dioxide (CO_2) emissions in South Asian countries over the period 1980-2012

using a multivariate framework. Estimated results suggest that all variables are non-stationary and cointegrated. The results show that financial stability improves environmental quality; while the increase in economic growth, energy consumption and population density are detrimental for environment quality in the long-run.

In Table 1, the findings on the relationship between carbon emissions and financial development can be categorised into five main groups. (1) Financial development reduces carbon emissions, (2) financial development increases carbon emissions, (3) the relationship between financial development and carbon emissions is negligible, (4) the relationship between financial development and carbon emissions depend on other factors such as economic growth and institutional quality, among others and (5) a feedback effect characterises the relationship between the two variables. The contradictions in the empirical findings is a clear indication that the relationship between financial development and carbon emissions is far from being a conclusive issue. Only more empirical tests can help to clarify the relationship between the two variables. Empirical studies on the relationship between financial development and carbon emissions to a larger extent have so far ignored the African region. The current study seeks to unpack the intricacies of the impact of financial development on carbon emissions from an African point of view (Table 2).

3. OTHER MACROECONOMIC VARIABLES THAT INFLUENCE CARBON EMISSIONS

This section discusses the other factors that affect carbon emissions other than financial development(Table 2).

4. FINANCIAL DEVELOPMENT AND CARBON EMISSIONS TRENDS IN WEST AFRICAN COUNTRIES

The averages of carbon emissions and three different measures of financial development during the 12-year period (2003-2014) are shown in Table 3.

Gambia, Ghana and Liberia recorded the highest mean on domestic credit provided by the financial sector as a ratio of GDP above the overall mean of 28.65% of GDP. Liberia is the outlier because its domestic credit provided by the financial sector as a ratio of GDP during the period from 2003 to 2014 was found to be well above the overall mean ratio. Guinea-Bissau (10.20% of GDP), Mali (14.50% of GDP) and Niger (10.17% of GDP) are the three West African countries with the lowest mean domestic credit provided by the financial sector as a ratio of GDP below the overall mean ratio of 28.65% of GDP.

In terms of domestic credit to private sector by banks, Burkina Faso, Ivory Coast, Ghana, Mali, Nigeria, Senegal and Togo had their mean domestic credit to private sector by banks (% of GDP) ratios above the overall mean of 14.11% of GDP. Guinea-Bissau and Sierra Leone had the lowest mean domestic credit to private sector by banks (% of GDP) ratios below the overall mean of 14.11% of GDP. Five West African countries (Gambia, Ghana, Liberia, Senegal and Togo) had mean broad money (% of GDP) ratios which were above the overall mean of 28.05% of GDP. Gambia and Togo are the outliers since their mean broad money ratios were well above the overall mean.

In terms of carbon emissions, five West African countries (Ivory Coast, Ghana, Nigeria, Senegal and Togo) had their mean carbon emissions ratios above the overall mean carbon emissions ratio of 0.27 metric tons per capita. Ghana (0.41), Mali (0.07), Niger (0.07), Nigeria (0.64) and Senegal (0.51) are clearly the outliers given that their mean carbon emissions ratios deviated a lot from the overall mean carbon emissions ratio of 0.27 metric tons per capita.

5. RESEARCH METHODOLOGY

5.1. Data

The paper used panel data from 2003 to 2014 on 12 West Africa countries. The countries include Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. Other West African countries were excluded because of lack of data on some of the variables of interest. Three measures of financial development were used, namely (1) domestic credit provided by financial sector as a ratio of GDP, (2) domestic credit to private sector by banks as a ratio of GDP and (3) broad money as a ratio of GDP. CO_2 emissions (metric tons per capita) is a proxy of carbon emissions used. All the data extracted from International Monetary Fund, World Bank Indicators and African Development Bank were converted into natural log before being used for main data analysis for two reasons, (1) to address the problem of outliers and (2) data not normally distributed.

5.2. Econometric Model

$$CE_{i,t} = \beta_0 + \beta_1 FIN_{i,t} + \beta_2 X_{i,t} + \mu_i + \varepsilon_{it} \quad (1)$$

CE represents carbon emissions, FIN is financial development, X stands for the explanatory variables. The latter include economic growth, FDI, trade openness, natural resources, population growth, renewable energy and infrastructural development. Equation 2 is an econometric equation which shows the dependent variable (carbon emissions), independent variable (FIN) and the explanatory variables.

$$CE_{i,t} = \beta_0 + \beta_1 FIN_{i,t} + \beta_2\ GROWTH_{i,t} + \beta_3\ FDI_{i,t} + \beta_4\ OPEN_{i,t} + \beta_5\ NATURAL_{i,t} + \beta_6\ POPUL_{i,t} + \beta_7\ RENEW_{i,t} + \beta_8 INFR_{i,t} + \mu + \varepsilon \quad (2)$$

The main objective of this paper is to investigate the impact financial development on carbon emissions in West African countries. The objective is addressed by estimating equation 2 using panel data analysis methods (pooled OLS, fixed and random effects). The study used three different proxies of financial development in order to establish whether the impact of financial development on carbon emissions in West African countries relied on the measure of financial development used.

Table 1: The impact of financial development on carbon emissions - An empirical view

Author	Country/Countries of study	Period	Methodology	Results
Basarir and Cakir (2015)	Turkey, France, Spain, Italy and Greece	1995-2010	Panel data analysis	Financial development reduced carbon emissions in the studied countries
Mugableh (2015)	Jordan	1976-2010	VECM and autoregressive distributive lag (ARRDL)	Financial development led to a decline in the amount of carbon emissions in Jordan in both the short and long run
Boutabba (2014)	India		Time series analysis	Financial development was found to have Granger caused carbon emissions in India
Ghorashi and Rad (2018)	Iran provinces	1989-2016	Panel data analysis	Carbon emissions were found to have been reduced by financial development in the Iran provinces studied
Muhammad and Siddique (2017)	Pakistan	1980-2015	ARDL	Financial development, energy consumption, economic growth and trade were all found to have increased carbon emissions in Pakistan in the long run
Ayeche et al. (2016)	European countries	1985-2014	Panel data analysis	The study showed that the relationship between financial development and carbon emissions was characterised by a neutrality hypothesis
Cetin and Ecevit (2017)	Turkey	1960-2011	ERDL and VECM	In the long run, a causality relationship running from financial development, trade openness and economic growth towards carbon emissions in Turkey
Hao et al. (2016)	China provinces	1995-2012	Generalized Methods of Moments (GMM)	At low levels of economic growth, financial development reduced carbon emissions. On the contrary, financial development led to an increase in carbon emissions when levels of economic growth were higher
Xiong and Qi (2018)	Chinese provinces	1997-2011	Panel data analysis	Financial development was found to have reduced the carbon emissions per capita in the Chinese provinces
Xing et al. (2017)	China		ARDL	The amount of carbon emissions reduced as a result of financial development
Onanuga (2017)	Sub-Saharan African countries	1989-2012	Static and dynamic analytical approaches	The findings are twofold: (1) Financial development reduced carbon emissions in upper middle income countries and (2) In low, low middle and high income countries, financial development was found to have increased the amount of carbon emissions
Muhammad and Fatima (2013)	Pakistan	1971-2011	ARDL	The quantity of carbon emissions was found to have increased in response to financial development in Pakistan
Zhang (2011)	China	1994-2009	VECM and variance decomposition approach	The study supported the financial development-led carbon emissions hypothesis in China
Sadeghieh (2016)	Turkey	1960-2011	Error correction model (ECM)	Among other findings, a uni-directional causality relationship running from both economic growth and financial sector development towards carbon emissions was detected in Turkey
Shahbaz et al. (2012)	Malaysia	1971-2008	Time series analysis	Carbon emissions were found to have been lowered down by financial development in Malaysia
Shahbaz et al. (2011)	Pakistan		ARDL	Carbon emissions were reduced by financial development in Pakistan in the long run
Rault (2015)	Middle East and North African (MENA) countries	1990-2011	Panel data analysis	The relationship between financial development and carbon emissions were found to have supported the neutrality hypothesis
Tamazian et al. (2009)	Brazil, Russia, India and China	1992-2004	Panel data analysis	Financial development lowered down the quantity of carbon emissions
Tamazian and Bhaskara (2010)	24 transitional countries	1993-2004	GMM framework	The impact of financial development on carbon emissions was found to be dependent on the institutional framework in place in the transitional countries

(Contd...)

Table 1: *(Continued)*

Author	Country/Countries of study	Period	Methodology	Results
Jalil and Feridun (2011)	China	1953-2006	ARDL	Carbon emissions was negatively affected by financial development
Shahzad, et al. (2014)	Pakistan	1973-2011	ERDL and VECM	Financial development and carbon emissions were found to have affected each other in Pakistan in the long run
Phong (2019)	ASEAN-5 countries	1971-2014	Panel data analysis	Financial development was found to have had an increase on carbon emissions in the Asean-5 Countries Studies
Rasiah et al. (2018)	ASEAN countries	1970-2016	Panel data analysis	Financial development was not found to be a significant determinant of carbon emissions. However, macro-economic variables such as trade openness

Source: Author compilation

Table 2: Theory intuition and a priori expectation

Variable	Proxy used	Theory intuition	Expected sign
Economic growth (GROWTH)	GDP per capita	Aye and Edoja (2017) found out that higher economic growth had a positive influence on carbon emissions whilst low economic growth had a negative impact on carbon emissions in developing countries. Higher levels of economic growth increases carbon emissions as the resultant increase in energy use produce more pollution. On the contrary, the use of clean energy sources to boost economic growth leads to a decline in the amount of carbon emissions. Khobai and Le Roux (2017) noted however that carbon emissions had a positive influence on economic growth in South Africa whilst Rokhmawati et al. (2017) observed that carbon emissions had a strong impact on firm performance in Indonesia	+/−
Population growth (POP)	Population growth (annual %)	High levels of population can lead to increased carbon emissions as the people engage in deforestation activities and also use more energy for their day to day economic activities. Population growth was found to have had a positive and significant impact on carbon emissions in developing countries (Aye and Edoja, 2017. p. 15)	+
Trade openness (OPEN)	Total trade (% of GDP)	Trade openness increases the levels of energy usage inspired manufacturing activities in the economy as firms can easily source inputs for production from other countries and they are also under increased pressure to supply foreign markets. Trade openness alongside energy usage and economic growth were found to have had a significant positive impact on carbon emissions in selected ASEAN nations (Rasiah et al., 2018). On the other hand, trade openness allows countries to easily acquire (from other countries) and use new and clean technology which is associated with low levels of carbon emissions. These arguments were put forward by Grossman and Krueger (1991)	+/−
Renewable energy consumption (RENEW)	Renewable energy consumption (% of total final energy consumption)	By its nature, renewable energy is clean, reduce both pollution and carbon emissions	−
Foreign direct investment	Net FDI inflow (% of GDP)	According to Blanco et al. (2013), FDI inflows increase the number and magnitude of manufacturing activities in the host country thus pushing up the pollution intensity and carbon emissions per capita. Cheng and Yang (2016) noted that FDI reduced carbon emissions up to a certain extent only beyond which FDI started to increase carbon emissions in China.	+/−
Natural resources (NATURAL)	Total natural resources rents (% of GDP)	The process of extracting natural resources involves the use of heavy machinery which not only means the use of more energy but also implies increased pollution and carbon emissions. The argument was supported by Kwakwa et al. (2018)	+
Infrastructure development (INFR)	Individuals using the internet (% of population)	According to Salahuddin et al. (2016), internet infrastructure usage was found to have had a negligible positive effect on carbon emissions in the OECD group of countries. The same study however found out that internet infrastructure usage had a significant positive impact on both trade openness and financial development, thereby indirectly positively affecting carbon emissions through these two macroeconomic variables	+

Source: Author compilation. GDP: Gross domestic product

5.3. Pre-estimation Diagnostics, Panel Root and Co-integration Tests

Correlation analysis in Table 1 (Appendix section) shows that the correlation between carbon emissions and different variables is in line with theoretical predictions summarised in Table 2. Descriptive statistics (Table 2 in Appendix section) shows that financial development, trade openness and renewable energy data is not normally distributed as the probability of the Jarque-Bera criteria is equal to zero for the three variables. To address the problem of abnormally distributed data, all the data used in this study was transformed into natural logarithms before any further use.

All the data was found to have been stationary at first difference (Table 3 under Appendix section) whilst all the variables were found to have a long run relationship (Table 4 under Appendix section). These findings enabled the author to proceed to main data analysis.

5.4. Data Analysis

Domestic credit provided by financial sector as a ratio of GDP, domestic credit to private sector by banks as a ratio of GDP and broad money as a ratio of GDP are the different proxies of financial sector development used in model 1, 2 and 3 respectively (Tables 4and 5).

Under both fixed and random effects, domestic credit provided by financial sector and broad money had a positive but non-significant impact on carbon emissions. The finding is consistent with Aye and Edoja's (2017) observation that financial development increases the number and scale of manufacturing activities in the country through availing more financial assistance to the domestic companies, the effect of which include land degradation, pollution and carbon emissions. Both fixed and random effects also shows that domestic credit to private sector by banks had a negative but non-significant influence on carbon emissions in West African countries, a finding which is in line with Yuxiang and Chen (2010) whose study noted that financial sector funding allowed Chinese companies to adopt advanced technology which reduced the amount of carbon emissions. The pooled OLS (Table 6) also found out that carbon emissions were lowered down by broad money, further supporting Yuxiang and Chen's (2010) observation. According to the pooled OLS approach, domestic credit provided by financial sector had a significant positive effect on carbon emissions whilst domestic credit to private sector by banks positively but non-significantly influenced carbon emissions in West African countries. The results support Xing et al.'s (2017) argument that more credit availed to the consumers enable them to buy energy consuming machinery and automobiles.

Economic growth was found to have had a non-significant effect on carbon emissions in all the 3 models under fixed and random effects. On the other hand, economic growth had a significant positive impact on carbon emissions in all the 3 models under pooled OLS approach. The finding follows Aye and Edoja's (2017) view that higher levels of economic growth is associated with larger scale manufacturing activities which consumes and produce more energy and pollution respectively. Under both fixed and random effects, FDI had a non-significant positive influence on carbon emissions. The finding support Aye and Edoja's (2017) view that foreign investors not only increase the quantity of manufacturing activities but the amount of energy consumption, pollution and carbon emissions in the host country. FDI was found to have had a significant negative influence on carbon emissions in West African countries, in line with Aye and Edoja (2017) whose study noted that some of the foreign investors brings along their environment friendly technology which lowers down carbon emissions.

In line with theoretical predictions, trade openness was found to have had a significant positive impact on carbon emissions under all the three panel data analysis approaches except only in model 1 under pooled OLS approach (non-significant positive influence was observed). Natural resources had a significant positive influence in all the three models under both fixed and random effects. Model 2 under pooled OLS shows that carbon emissions were positively but significantly affected by natural resources whilst model 1 and 3 under pooled OLS shows that natural resources had a non-significant positive effect on carbon emissions. The findings support Kwakwa et al. (2018) whose study noted that heavy machinery which uses a lot of energy and contributes to more air pollution is required to extract natural resources.

Table 3: Financial development and carbon emission trends in West African countries (2003-2014)

Country	Domestic credit provided by the financial sector (% of GDP)	Domestic credit to private sector by banks (% of GDP)	Broad money (% of GDP)	Carbon emissions (metric tons per capita)
Burkina Faso	17.23	16.49	26.40	0.12
Ivory Coast	21.17	14.44	27.89	0.39
Gambia	33.10	12.94	45.16	0.23
Ghana	29.17	14.69	29.45	0.41
Guinea-Bissau	10.20	5.37	24.42	0.15
Liberia	116.94	11.89	29.02	0.20
Mali	14.50	14.97	24.26	0.07
Niger	10.17	9.15	17.25	0.07
Nigeria	19.76	18.05	24.13	0.64
Senegal	27.29	24.14	32.63	0.51
Sierra Leone	16.22	5.15	17.67	0.13
Togo	28.02	21.99	38.32	0.32
Overall mean	28.65	14.11	28.05	0.27

Source: Author's compilation. GDP: Gross domestic product

Table 4: The impact of financial development on carbon emissions (CO_2) -fixed effects

Variable	Model 1	Model 2	Model 3
FIN	0.0086	−0.0161	0.0344
GROWTH	0.0032	0.0038	0.0101
FDI	0.0069	0.0080	0.0056
OPEN	0.1675**	0.1734**	0.1664**
NATURAL	0.1739***	0.1768***	0.1737***
POPUL	−0.0148	−0.0025	−0.0180
RENEW	−0.5269**	−0.5314**	−0.5475**
INFR	0.0306	0.0337	0.0234
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.96	0.96	0.96
F-statistic	175.14	175.31	175.32
Prob (F-statistic)	0.00	0.00	0.00

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

Table 5: The impact of financial development on carbon emissions (CO_2) -random effects

Variable	Model 1	Model 2	Model 3
FIN	0.0136	−0.0086	0.0620
GROWTH	0.0214	0.0250	0.0512
FDI	0.0007	0.0004	0.0064
OPEN	0.1854***	0.1940***	0.1989***
NATURAL	0.1555***	0.1581***	0.1438***
POPUL	−0.0519	−0.0403	−0.0862
RENEW	−0.5793***	−0.5931***	−0.6443***
INFR	0.0312	0.0319	0.0179
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.56	0.55	0.53
F-statistic	25.83	23.47	22.19
Prob (F-statistic)	0.00	0.00	0.00

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

Table 6: The impact of financial development on carbon emissions (CO_2) -pooled OLS

Variable	Model 1	Model 2	Model 3
FIN	0.2647***	0.0528	−0.1691
GROWTH	0.2314**	0.2415**	0.2205*
FDI	−0.0766*	−0.0759*	−0.0860*
OPEN	0.1796	0.4440***	0.5581***
NATURAL	0.1002	0.1512*	0.1287
POPUL	−1.3697***	−1.2708***	−1.2093***
RENEW	−0.8044***	−0.9750***	−0.9048***
INFR	0.1333**	0.1183	0.1751**
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.62	0.59	0.59

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

Under fixed and random effects, all the three models show that population growth had a non-significant negative impact on carbon emissions whilst pooled OLS shows that population growth had a significant negative influence on carbon emissions. These results contradict most theoretical explanations on the relationship between population growth, energy consumption and carbon emissions. All the three panel data analysis methods show that the use of renewable energy reduced carbon emissions, in line with theory intuition (Table 2). Following Salahuddin et al. (2016), this paper to a large extent shows that infrastructural development had a non-significant positive effect on carbon emissions in West African countries.

Table 7: Financial development and CO_2-Fixed effects: Lagged independent variable approach (t-1)

Variable	Model 1	Model 2	Model 3
FIN	0.0461	0.0207	0.1192
GROWTH	−0.0196	−0.0015	0.0211
FDI	0.0061	0.0013	0.0005
OPEN	0.1169*	0.1306*	0.1083
NATURAL	0.1779***	0.1910***	0.1898***
POPUL	−0.2050*	−0.1751	−0.1942*
RENEW	−0.1427	−0.1696	−0.2035
INFR	0.0466	0.0338	0.0132
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.95	0.95	0.95
F-statistic	158.25	156.71	159.28
Prob (F-statistic)	0.00	0.00	0.00

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

Table 8: Financial development and CO_2-random effects: Lagged independent variable approach (t-1)

Variable	Model 1	Model 2	Model 3
FIN	0.0541	0.0279	0.1351
GROWTH	−0.0137	0.0110	0.0340
FDI	−0.0005	−0.0089	−0.0072
OPEN	0.1374**	0.1642**	0.1315*
NATURAL	0.1492***	0.1544***	0.1620***
POPUL	−0.2559**	−0.2414**	−0.2456**
RENEW	−0.2498	−0.3255	−0.3270
INFR	0.0533*	0.0396	0.0154
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.55	0.54	0.54
F-statistic	24.12	25.13	23.54
Prob (F-statistic)	0.00	0.00	0.00

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

5.5. The Lagged Panel Data Analysis Framework

Following Matthew and Johnson (2014), Tsaurai (2018) and Tsaurai and Ngcobo (2018), the influence of one macro-economic variable on another is not immediate. It is in line with this argument that the author used a lagged panel data analysis model (refer to equation 3) to investigate the impact of financial development on carbon emissions in West African countries. This was done to see if the results are robust (Tables 7-9).

$$CE_{i,t} = \beta_0+\beta_1 FIN_{i,t-1}+\beta_2\ GROWTH_{i,t-1}+\beta_3\ FDI_{i,t-1}+\beta_4\ OPEN_{i,t-1} +\beta_5\ NATURAL_{i,t-1}+\beta_6\ POPUL_{i,t-1}+\beta_7\ RENEW_{i,t-1} + \beta_8 INFR_{i,t-1}+\mu+\varepsilon \quad (3)$$

The lagged variable approach shows that financial development had a non-significant positive influence on carbon emissions in all the 3 models under both fixed and random effects. The non-lagged variable approach differs in that it indicates that financial development had a non-significant negative effect on carbon emissions in model 2 under both fixed and random effects. All

Table 9: Financial development and CO_2-Pooled OLS: Lagged independent variable approach (t-1)

Variable	Model 1	Model 2	Model 3
FIN	0.2857***	0.0639	−0.1158
GROWTH	0.1671	0.1988*	0.1951*
FDI	−0.0520	−0.0557	−0.0628
OPEN	0.1389	0.4329***	0.5239***
NATURAL	0.0844	0.1643**	0.1485*
POPUL	−1.4723	−1.3301***	−1.2804***
RENEW	−0.6457	−0.8910***	−0.8578***
INFR	0.1764	0.1312**	0.1752**
Number of countries	12	12	12
Number of observations	144	144	144
Adjusted R^2	0.64	0.60	0.60

Source: Author's compilation from E-Views. ***, ** and *denote 1%, 5% and 10% levels of significance, respectively

other findings on the impact of financial development on carbon emissions are similar, an indication that the results of the study are quite robust.

6. CONCLUSION

The main aim of this paper was to explore the influence of financial development on carbon emissions in West African countries using panel data spanning from 2003 to 2014. On the theoretical front, arguments for both financial development led positive impact on carbon emissions and financial development led negative impact on carbon emissions are quite compelling.

Empirical studies on the role played by financial development on carbon emissions produced quite divergent and conflicting findings: (1) The effect of financial development on carbon emissions is negligible, (2) financial development and carbon emissions affect each other, (3) the presence of other factors such as economic growth and institutional quality influence the impact of financial development on carbon emissions, (4) financial development either positively or negatively affected carbon emissions.

It is clear from both theoretical and empirical sides that the influence of financial development on carbon emissions is still a contentious issue which is yet to be resolved in literature. In order to fill in this gap, the author investigated the impact of financial development on carbon emissions in West African countries. Overally, pooled OLS approach (both lagged and non-lagged variable) shows that only domestic credit provided by financial sector resulted in the significant increase in carbon emissions in West African countries. The study therefore encourages West African countries to implement credit policies that ensures that the loans availed by the financial sector to the domestic firms are used towards acquiring environmental friendly machinery and equipment that reduces carbon emissions.

REFERENCES

Alom, K., Uddin, A.N.M., Islam, N. (2017), Energy consumption, C02 emissions, urbanization and financial development in Bangladesh: Vector error correction model. Journal of Global Economics, Management and Business Research, 9(4), 178-189.

Al-Mulali, U., Tang, C.F., Ozturk, I. (2015), Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. Environmental Science and Pollution Research, 22(19), 14891-14900.

Aye, G.C., Edoja, P.E. (2017), Effect of economic growth on C02 emission in developing countries: Evidence from a dynamic panel threshold model. Cogent Economics and Finance, 5(1), 1-22.

Ayeche, M.B., Barhoumi, M., Hammas, M.A. (2016), Causal linkage between economic growth, financial development, trade openness and C02 emissions in European countries. American Journal of Environmental Engineering, 6(4), 110-122.

Basarir, C., Cakir, N. (2015), Causal interactions between C02 emissions, financial development, energy and tourism. Asian Economic and Financial Review, 5(11), 1227-1238.

Blanco, L., Gonzalez, F., Ruiz, I. (2013), The impact of FDI on C02 emissions in Latin America. Oxford Development Studies, 41(1), 104-121.

Boutabba, M.A. (2014), The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. Economic Modelling, 40, 33-41.

Cetin, M., Ecevit, E. (2017), The impact of financial development on carbon emissions under the structural breaks: Empirical evidence from Turkish economy. International Journal of Economic Perspectives, 11(1), 64-78.

Cheng, S., Yang, Z. (2016), The effects of FDI on carbon emissions in China: Based on spatial econometric model. Revista de la Facultad de Ingenieria U.C.V., 31(6), 137-149.

Frankel, J., Rose, A. (2002), An estimate of the effect of common currencies on trade and income. Quarterly Journal of Economics, 117(2), 437-466.

Grossman, G.M., Krueger, A.B. (1991), Environmental İmpacts of a North American Free Trade Agreement. National Bureau of Economic Research, Working Paper Number 3914.

Ghorashi, N., Rad, A.A. (2018), Impact of financial development on carbon emissions: Panel data evidence from Iran's economic sectors. Journals of Community Health Research, 7(2), 127-133.

Hao, Y., Zhang, Z., Liao, H., Wei, Y., Wang, S. (2016), Is C02 emission a side effect of financial development? An empirical analysis for China. Environmental Science Pollution Res, 23(20), 21041-21057.

Hoffmann, U. (2011), Some Reflections on Climate Change, Green Growth İllusions and Development Space. Discussion Paper Number 205. New York: United Nations Conference on Trade and Development (UNCTAD).

Im, K.S., Pesaran, M.H., Shin, Y. (2003), Testing unit roots in heterogeneous panels. Journal of Econometrics, 115(1), 53-74.

Jalil, A., Feridun, M. (2011), The impact of growth, energy and financial development on the environment in China: A co-integration analysis. Energy Economics, 33(2), 284-291.

Khobai, H., Le Roux, P. (2017), The relationship between energy consumption, economic growth and carbon dioxide emission: The case of South Africa. International Journal of Energy Economics and Policy, 7(3), 102-109.

Kong, Y., Wei, F. (2017), Financial development, financial structure and carbon emission. Environmental Engineering and Management Journal, 16(7), 1609-1622.

Kwakwa, P.A., Alhassan, H., Adu, G. (2018), Effect of natural resources extraction on energy consumption and carbon dioxide emission in Ghana, 'Munich Personal RePEc Archive (MPRA) Paper Number 85401. p1-19.

Levin, A., Lin, C.F., Chu, C.S.J. (2002), Unit root tests in panel data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1-24.

Matthew, O.H., Johnson, A. (2014), Impact of foreign direct investment on employment generation in Nigeria: A statistical investigation. IOSR Journal of Business and Management, 16(3), 44-56.
Mazzanti, M., Montini, A., Zoboli, R. (2006), Economic Dynamics, Emission Trends and the EKC New Evidence using NAMEA and Provincial Panel Data for Italy. Universita Degli Studi di Ferrara, Quaderno Number 19/2006.
Mugableh, M.I. (2015), Economic growth, C02 emissions and financial development in Jordan: Equivalent and dynamic causality analysis. International Journal of Economics and Finance, 7(7), 98-105.
Muhammad, J., Fatima, S.G. (2013), Energy consumption, financial development and C02 emissions in Pakistan. Munich Personal RePEc Archive (MPRA) Paper Number 48287. p1-23.
Muhammad, R., Siddique, H.M.A. (2017), Impact of financial development and energy consumption on C02 emissions: Evidence from Pakistan. Bulletin of Business and Economics, 6(2), 68-73.
Nasreen, S., Anwar, S., Ozturk, I. (2017), Financial stability, energy consumption and environmental quality: Evidence from South Asian economies. Renewable and Sustainable Energy Reviews, 67, 1105-1122.
Onanuga, O.T. (2017), The İmpact of Economic and Financial Development on Carbon Emissions: Evidence from Sub-Saharan Africa. University of South Africa, Unpublished Doctoral Thesis.
Piaggio, M., Padilla, E. (2012), C02 emissions and economic activity: Heterogeneity across countries and non-stationary series. Energy Policy, 46, 370-381.
Phong, L.H. (2019), Globalization, financial development and environmental degradation in the presence of environmental Kuznets Curve: Evidence from ASEAN-5 countries. International Journal of Energy Economics and Policy, 9(2), 40-50.
Rasiah, R., Guptan, V., Habibullah, M.S. (2018), Evaluating the impact of financial and economic factors on environmental degradation: A panel estimation study of selected Asean countries. International Journal of Energy Economics and Policy, 8(6), 209-216.
Rault, C. (2015), Financial Development, Environmental Quality, Trade and Economic Growth: What Causes what in MENA Countries. IZA Discussion Paper Number 8868.
Rokhmawati, A., Gunardi, A., Rossi, M. (2017), How powerful is your customers' reaction to carbon performance? Linking carbon and firm financial performance. International Journal of Energy Economics and Policy, 7(6), 85-95.
Sadeghieh, M. (2016), Financial Development, C02 Emissions, Fossil Fuel Consumption and Economic Growth: The Case of Turkey. Eastern Mediterranean University, Unpublished Masters Thesis.
Salahuddin, M., Alam, K., Ozturk, I. (2016), The effects of internet usage and economic growth on C02 emissions in OECD countries: A panel investigation. Renewable and Sustainable Energy Reviews, 62, 1226-1235.
Shahbaz, M., Islam, F., Butt, M.S. (2011), Financial Development, Energy Consumption and C02 Emissions: Evidence from ARDL Approach for Pakistan, MPRA Paper Number 30138.
Shahbaz, M., Solarin, S.A., Mahmood, H. (2012), Does Financial Development Reduce C02 Emissions in Malaysian Economy? A Time Series Analysis. Munich Personal RePEc Archive Paper Number 40603.
Shahzad, S.J.H., Rehman, M., Hurr, M., Zakaria, M. (2014), Do Economic and Financial Development İncrease Carbon Emissions in Pakistan: Empirical Analysis Through ARDL Co-İntegration and VECM Causality, MPRA Paper Number 60310.
Sy, A., Tinker, T., Derbali, A., Jamel, L. (2016), Economic growth, financial development, trade openness and C02 emissions in European countries. African Journal of Accounting, Auditing and Finance, 5(2), 1226-1235.
Tamazian, A., Chousa, J.P., Vadlamannati, K.C. (2009), Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. Energy Policy, 37(1), 246-253.
Tamazian, A., Bhaskara, R.B. (2010), Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies? Energy Economics, 32(1), 137-145.
Tsaurai, K. (2018), Greenhouse gas emissions and economic growth in Africa: Does financial development play any moderating role? International Journal of Energy Economics and Policy, 8(6), 267-274.
Tsaurai, K., Ngcobo, L. (2018), The role of liquidity in the remittances-human capital development nexus in emerging economies. Acta Universitatis Danubius Oeconomica, 14(7), 101-119.
Xing, T., Jiang, Q., Ma, X. (2017), To facilitate or curb? The role of financial development in China's carbon emissions reduction process: A novel approach. International Journal of Environmental Research and Public Health, 14(10), 1-39.
Xiong, L., Qi, S. (2018), Financial development and carbon emissions in Chinese provinces: A spatial panel data analysis. The Singapore Economic Review, 63(2), 447-464.
Yuxiang, K., Chen, Z. (2010), Financial development and environmental performance: Evidence from China. Environment and Development Economics, 16(1), 1-19.
Zhang, Y. (2011), The impact of financial development on carbon emissions: An empirical analysis in China. Energy Policy, 39(4), 2197-2203.

APPENDIX SECTION

Table 1: Correlation analysis

	CO_2	FIN	GROWTH	FDI	OPEN	NATURAL	POPUL	RENEW	INFR
CO_2	1.00								
FIN	0.36***	1.00							
GROWTH	0.61***	−0.08	1.00						
FDI	0.03	0.44***	−0.23***	1.00					
OPEN	0.31***	0.69***	−0.19**	0.57***	1.00				
NATURAL	−0.05	0.25***	−0.22***	0.43***	0.32***	1.00			
POPUL	−0.48***	0.001	−0.38***	0.08	−0.13	−0.05	1.00		
RENEW	−0.44***	−0.19**	−0.39***	−0.03	−0.12	0.53***	0.09	1.00	
INFR	0.58***	0.10	0.77***	0.01	0.002	−0.17**	−0.11	−0.57***	1.00

Source: Author compilation from E-Views. ***, **, *denotes statistical significance at the 1%, 5%, 10% level respectively

Table 2: Descriptive statistics

	CO_2	FIN	GROWTH	FDI	OPEN	NATURAL	POPUL	RENEW	INFR
Mean	−1.56	3.03	6.38	1.19	4.23	2.46	1.03	4.27	0.70
Median	−1.53	2.99	6.32	1.09	4.21	2.46	0.99	4.35	0.86
Maximum	−0.26	5.43	8.08	4.49	5.74	4.12	1.56	4.52	3.24
Minimum	−3.02	1.53	4.89	−2.54	3.43	0.89	0.55	3.70	−3.47
Standard deviation	0.74	0.71	0.60	1.13	0.41	0.68	0.19	0.22	1.41
Skewness	−0.17	0.90	0.35	0.29	0.98	0.05	0.15	−1.12	−0.60
Kurtosis	2.00	5.27	3.22	3.74	5.37	2.80	3.31	3.12	3.15
Jarque−Bera	6.65	50.4	3.20	5.22	57.0	0.29	1.12	30.18	8.66
Probability	0.04	0.00	0.20	0.07	0.00	0.86	0.57	0.00	0.01
Observations	144	144	144	144	144	144	144	144	144

Source: Author compilation from E-Views. Note: ***,**,*denotes statistical significance at the 1%, 5%, 10% level respectively

Table 3: Panel unit root tests -individual intercept

Variable	Level				First difference			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
LCO_2	−1.0897	0.5713	18.90	17.52	−3.3062***	−2.771***	46.54***	76.31***
LFIN	0.5962	2.2889	10.0197	10.5150	−3.678***	−2.658***	46.106***	109.665***
LGROWTH	−3.514***	0.622	16.073	52.836***	−6.038***	−2.735***	48.684***	87.303***
LFDI	−1.952**	−0.723	28.255	33.139	−2.666***	−2.255**	43.450***	110.255***
LOPEN	−0.577	0.1669	20.342	28.661	−1.465*	−1.759**	36.832**	77.3395***
LNATURAL	−2.736***	−0.783	28.765	19.339	−4.173***	−2.665***	46.269***	98.7802***
LPOPUL	−10.044***	−1.331*	68.699***	25.546	−6.562***	−3.830**	36.383*	38.028**
LRENEW	−1.1808	0.7026	18.7387	18.7950	−4.5581***	−2.6053***	45.6190***	91.1501***
LINFR	1.9490	4.9335	8.8132	37.3367**	−15.7972***	−3.8640***	50.6317***	73.1034***

Source: Author's compilation from E-Views. LLC, IPS, ADF and PP stands for Levin et al. (2002); Im et al. (2013); ADF Fisher Chi square and PP Fisher Chi square tests respectively. *, ** and ***denote 1%, 5% and 10% levels of significance, respectively

Table 4: Kao residual co-integration test - individual intercept

	T-statistic	Probability
Augmented Dickey-Fuller (ADF)	−2.9043	0.0018

Source: Author's compilation from E-Views