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Investigating the pollution haven hypothesis in Ghana: An empirical investigation

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ABSTRACT

The aim of this research is to investigate the pollution haven hypothesis (PHH) in Ghana utilizing CO_2 emission as an indicator of air pollution for the period of 1980–2012. Moreover, we utilized gross domestic product (GDP), GDP square, energy consumption, renewable energy consumption, fossil fuel energy consumption, foreign direct investment, institutional quality, urbanization and trade openness as its main determinants. To achieve the goals of this research, different time series models were established utilizing the autoregressive distributed lag (ARDL) method. In addition to the fact that structural breaks are introduced into the estimation process, we contribute to the existing literature by focussing on a country that typifies the current scenario of increasing emission and foreign direct investment in the developing countries. The outcome of this research revealed cointegration which indicates the existence of long run relationship between the variables. Moreover, GDP, foreign direct investment, urban population, financial development and international trade have positive impact on CO_2 emission, while institutional quality decreases emissions in Ghana. This indicates that PHH does exist in Ghana. A number of policy recommendations were provided for Ghana according to the results obtained.

1. Introduction

It is well known that industries from the industrialized nations seek to operate their factories in developing countries that contain cheap labour and natural resources. These developing countries can attract many industries from around the world only not because of their cheap labour and resources but of their less stringent environmental policies. Therefore, the increase in foreign investments can escalate the pollution levels in the developing countries. Hence, there is a large number of empirical papers that investigated the pollution haven hypothesis (PHH) in different countries and regions.

To examine how the foreign industries cause pollution in the host countries (see Table 1); the previous studies utilized foreign direct investment (FDI) [3,4,8,10,12–14,22,23,28,30,33,35,37,39,43,47,52,61] and [19,58,60,62,64] industrial output from foreign companies [5,55] trade of goods and services (dirty imports and exports) [2,5,20,29,42] as indicators. Most of these studies found out that the increase in these variables will cause higher pollution which is basically consistent with the PHH [3,4,8,10,12,22,23,28–30,33,35,37,39,43,47,55] and [5,20,58,64].

Moreover, a number of empirical studies reached to the conclusion that more stringent environmental regulations reduce a country's attractiveness for investment by foreign industries especially the dirty industries [10,12,13,35,57]. However, countries with high levels of pollution have experienced increases in the level of foreign investment as countries with high levels of pollution shows weak environmental regulations which makes them more desirable for foreign dirty industries [10,23,29,54].

This research is motivated to investigate Ghana due to several reasons. Firstly the country has been experiencing increases in its foreign direct investment over the years. Foreign direct investment has increased by more than 10-fold in1980–2012 [56]. Moreover, efforts have been made over the years to stimulate foreign direct investment into the country. In the 1980, the government introduced several privatisation schemes in order to attract foreign direct investment. Ghana Investment Promotion Act of 1994 (and revised in 2013) was introduced for the same purpose of attracting foreign investors. Secondly, the country continues to witness an increasing level of CO_2 emissions. The total CO_2 emissions from the

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Table 1
Literature review summary.

Authors(s)	Country	Period of study	Methodology	Variables	The main results	PHH
Ren et al. [43]	China	2000–2010	Generalized method of moments (GMM)	CO_2 emission, Industrial output per capita, FDI and trade openness	FDI and trade openness increases CO_2 emission while industrial output per capita reduces it.	Yes
Lau et al. [33]	Malaysia	1970–2008	Autoregressive distributed lag (ARDL) and vector error correction model (VECM) Granger causality	CO_2 emission, GDP, GDP square, FDI and trade openness.	A long run relationship do exists between the variables. GDP, FDI and trade openness increases CO_2 emission while GDP square reduces it. GDP, GDP square, FDI and trade openness Granger causes CO_2 emission.	Yes
Cole & Fredriksson [12]	13 OECD and 20 developing countries	1982–1992	Fixed effect three stage least square	Lead content of gasoline, Checks and balances in government, Political constraints, FDI stock and flows, GDP per capita, manufacturing output, urban population, Telephone mainlines, Television sets, Inflation rate and economically active population.	FDI raises environmental policy stringency when the aggregate honesty is high.	NA
Shahbaz et al. [47]	High, middle, low income countries.	1975–2012	Pedroni cointegration, fisher type cointegration, fully modified ordinary least square (FMOLS) and Dumitrescu and Hurlin panel Granger causality.	CO_2 emission, GDP, energy consumption and FDI and the square of FDI.	GDP, energy consumption and FDI increases CO_2 emission. Bi-directional causality between FDI and CO_2 emission was found.	Yes
Zheng et al. [61]	China	1997–2006	Panel ordinary least square (OLS) model.	All the variables increase pollution while FDI reduces it.	Average home prices, city mean annual income, population, FDI per capita, labor market demand, manufacturing labor share of total labor, PM_{10} concentration, SO_2 concentration, Green space per-capita, total rain fall, temperature discomfort index, percentage of people with college degree or above.	No
Omri et al. [37]	Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, and sub-Saharan Africa	1990–2011	GMM	CO_2 emissions in metric tons, FDI inflows, capital stock, trade openness, financial development, urbanization, and the real exchange rate.	All the variables increase CO_2 emission in general.	Yes
Al-Mulali & Tang [4]	The Gulf Cooperation Council (GCC) countries	1980–2009	Pedroni cointegration, FMOLS and VECM Granger causality.	CO_2 emission, FDI, energy consumption and GDP.	GDP and energy consumption increases CO_2 emission while FDI reduces it. Bi-directional causality between the variables was found.	Yes
Wang & Chen [55]	China	2002–2009	Panel two-stage least square and fixed effects model.	SO_2 emission, the share of industrial output from foreign companies, industrial development, capital intensity, fixed investment ratio, GDP per capita and GDP per square kilometers.	All the variables influence SO_2 emission positively.	Yes
Chung [10]	South Korea	2000–2007	Fixed effect model.	SOx, NOx, CO, PM10, water waste, FDI outflows, the lax of environmental regulations, GDP per capita, capital intensity, Machinery intensity, Plant-level scale economies, Host country tariff rates, Home country tariff Rates.	The environmental regulations increases the FDI outflows while the increase in pollution indicators and capital intensity reduces the FDI outflows.	Yes
Pao & Tsai [39]	Brazil, Russian Federation, India, and China (BRIC) countries	1980–2007	Pedroni, Kao and Fisher type cointegration, OLS and VECM Granger causality.	CO_2 emission, energy consumption, FDI, GDP and GDP square.	The variables are cointegrated. All the variables increase CO_2 emission in the long run. Bi-directional causality was found between FDI and CO_2 emission.	Yes
Al-mulali [3]	Middle East	1990–2009	Pedroni cointegration, FMOLS and VECM Granger causality.	CO_2 emission, energy, FDI consumption, GDP and trade openness.	The variables are cointegrated, all the variables increase CO_2 emission in the long run. Bi-directional causality was found between the variables.	Yes
Kivyiro & Arminen [30]	Sub-Saharan Africa.	1971 2009	ARDL and VECM Granger causality.	CO_2 emission, energy consumption, FDI, GDP and GDP square.	All the variables have no significant effect on CO_2	

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Table 1 (*continued*)

Authors(s)	Country	Period of study	Methodology	Variables	The main results	PHH
					emission in Republic of the Congo and Zambia. With the expectation of GDP the variables have a negative effect on CO_2 emission in Democratic Republic of the Congo. Energy consumption, FDI, GDP increases CO_2 emission while GDP square reduces it in Zimbabwe.	Yes in some countries.
Tang & Tan [52]	Vietnam	1976–2009	Johansen cointegration test and VECM Granger causality.	CO_2 emission, energy consumption, FDI and GDP and GDP square.	The variables are cointegrated. GDP and energy consumption increases CO_2 emission while GDP square and FDI reduce it. Bi-directional causality was found between FDI and CO_2 emission.	No
Kearsley & Riddel [29]	OECD countries.	1980–2004	Fixed effects model.	CO_2 emission, greenhouse gases (GHGs), carbon monoxide (CO), nitrous oxides (NOx), sulfur oxides (SOx), suspended particulate matter (SPM), volatile organic compounds (VOCs), GDP, GDP square, manufacturing output, trade openness,	GDP and trade openness increases the pollution indicators while GDP square reduces it.	Yes
Neequaye & Oladi [35]	27 developing countries based on income.	2002–2008	Fixed effects model.	Environmental performance index, Environmental aid, Investment profile, corruption, Population density, CO_2 emission, gross national product, total reserves, Nitrous oxide (N_2O), industrial and energy waste, trade openness, employment, capital stock, Manufacturing percentage of GDP and FDI.	FDI increases some of the environmental pollution indicators. Stringency environmental regulation reduces FDI.	Yes
Azam et al. [8]	Indonesia, Malaysia and Thailand	1980–2012	OLS	Energy consumption, GDP, FDI, trade openness, urbanization and human development index.	GDP, FDI, urbanization, trade openness and human development increases energy consumption in Thailand. GDP, FDI and trade openness and human development increases energy consumption in Malaysia. GDP, FDI, urbanization, trade openness and human development increases energy consumption in Indonesia.	Yes
Zakarya et al. [58]	Brazil, Russia, India, China and South Africa (BRICS)	1990–2012	Pedroni cointegration, FMOLS, DOLS and Pairwise Granger causality.	CO_2 emission per capita, GDP, FDI and energy consumption.	The variables are cointegrated. GDP, FDI and energy consumption increases CO_2 emission per capita in the long run. CO_2 emission Granger causes all the independent variables. Energy consumption Granger causes FDI. FDI Granger causes GDP. GDP Granger causes energy consumption.	Yes
Jorgenson [28]	Developing countries	1980–2000	Prais-Winsten, Generalized least square and random effects model.	Industrial organic water pollution, FDI, government expenditures, environmental ministry presence, GDP per capita, urbanization, Exports as percentage of total GDP, Domestic investment, Level of democracy, Secondary education,	FDI, urbanization, exports increase industrial organic water pollution while GDP per capita, domestic investment and government expenditures reduces it.	Yes
Dick [14]	Developing countries	1990–2000	Panel OLS	FDI, SO_2 emission, CO_2 emission, State environmentalism index, International non-governmental organizations for the environment, Presence of environmental ministry, foreign capital penetration, Gross national product per capita, Regime repressiveness, Number of protests, Total external debt, Total road network,	CO_2 emission, gross national income per capita, external dept., road networks increases FDI. Protests and Presence of environmental ministry reduces FDI.	Na
Cole et al. [13]	13 OECD and 20 developing countries.	1982–1992	Fixed effects, random effect model and two stage least square.	Environmental regulatory stringency, FDI, corruption, GDP per capita, urbanization, pollutant incentive	FDI, corruption, GDP, pollutant incentive manufacturing	NA

Table 1 (*continued*)

Authors(s)	Country	Period of study	Methodology	Variables	The main results	PHH
				manufacturing, telephone mainlines and the number of television sets.	reduces environmental regulatory stringency.	
Hoffmann et al. [23]	112 countries based on income.	1971–1999	Vector error correction (VAR) Granger causality, error correction model, fixed and random effect models.	FDI and CO_2 emission.	CO_2 emission Granger causes FDI in low income countries. FDI Granger causes CO_2 emission in middle income countries. No causality was found between the variables in the high income countries. FDI increases CO_2 emission in low and middle income countries.	Yes
Waldkirch & Gopinath [54]	Mexico	1994–2000	OLS	Industry level FDI, sulfur dioxide (SO_2), nitrogen oxide (NOx), particulate matter (PT), foreign capital, skilled-labor endowments, GDP and trade openness.	Pollution indicators and skilled-labor endowments FDI while foreign capital reduces it.	Yes
Xing and Kolstad [57]	Developed and developing countries.	1985–1990	OLS	SO_2 emission, FDI and environmental regulation indicators.	FDI increases SO_2 emission in countries with low environmental regulations while FDI and SO_2 emission in countries with strong environmental regulations.	Yes
Lan et al. [32]	China	1996–2006	Fixed and random effects models.	Industrial pollution, human capital, FDI, energy consumption, capital intensity, unemployment, population intensity, public ownership.	FDI, energy consumption and capital intensity increase the pollution indicators. Capital reduces the pollution indicators. When human capital is high the relationship between FDI and pollution in negative while the relationship is positive if human capital is low.	Yes with low human capital cities.
Cole et al. [11]	China	2001–2004	Fixed and random effects models.	Water waste, waste gas, SO_2, soot, dust, FDI, FDI share of total GDP, GDP per capita and population.	FDI, GDP per capita and population increases pollution indicators.	Yes
He [22]	China	1994–2011	GMM	SO_2 emission, FDI and industrial output.	FDI and industrial output increase SO_2 emission.	Yes
Shahbaz et al. [47]	Different countries based on the income level.	1975–2012	Pedroni cointegration, Fully modified OLS (FMOLS) and Dumitrescu and Hurlin (DH) causality.	CO_2 emission, FDI, FDI square, GDP and energy consumption	The variables are cointegrated. FDI, GDP and energy consumption increase CO_2 emission in all income group countries while FDI square reduces it. Bi-directional causality was found between CO_2 emission and energy consumption and between FDI and CO_2 emission. Unidirectional causality was found from GDP to energy consumption.	Yes
Tamazian and Rao [50]	24 transitional economies.	1993–2004	Random effects and GMM model.	CO_2 emission, GDP, GDP square, inflation rate, FDI, price liberalization, forex and trade liberalization, trade openness, financial liberalization, institutional quality, energy consumption and energy imports.	GDP, energy consumption and trade openness increases CO_2 emission while Inflation rate, GDP square, FDI, price liberalization, forex and trade liberalization, financial liberalization and institutional quality.	No
Tamazian et al. [51]	BRIC countries.	1992–2004	Random effects model.	CO_2 emission, GDP, GDP square, industrial output share to GDP, research and development expenditure, stock market value, FDI, deposit money bank assets, capital account convertibility, financial liberalization, financial openness, energy imports, oil consumption and energy consumption.	GDP, industrial output, energy imports, oil consumption and energy consumption increase CO_2 emission while financial development indicators and research and development reduce CO_2 emission.	No
Zhu et al. [62]	ASEAN five	1980–2010	quantile regressions with fixed effects methods	CO_2 emission, GDP, energy consumption, population, trade openness, industrial output, FDI, financial development.	GDP and energy consumption increases CO_2 emission while trade openness, population, FDI, industrial output and financial development reduce CO_2 emission.	No
Hakimi & Hamdi [19]	Tunisia and Morocco	1971–2013		CO_2 emission, GDP, cross fixed capital formation, trade openness and FDI.	The variables are cointegrated. GDP and FDI have a negative	No

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Table 1 (*continued*)

Authors(s)	Country	Period of study	Methodology	Variables	The main results	PHH
			Pedroni, Fisher type and Kao cointegration tests. VECM long run elasticities		effect of CO_2 emission while gross fixed capital formation and trade openness increase CO_2 emission.	
Zhang & Zhou [60]	China	1995–2010	Pedroni and Kao cointegration tests. Fixed effects model.	CO_2 emission, population, urbanization, FDI, affluence, technology level, industrial output,	The variables are cointegrated. Population, affluence and urbanization increases CO_2 emission while FDI, technology level and industrial output reduce CO_2 emission.	No
Behera & Dash (2017) [64]	South and Southeast Asian.	1980–2012	Pedroni cointegration, fully modified and dynamic ordinary least square.	CO_2 emission, urbanization, primary energy consumption and FDI.	The variables are cointegrated. All the variables increase CO_2 emission in general.	Yes
Al-Mulali & Ozturk [5]	MENA countries.	1996–2012	Pedroni cointegration, fully modified OLS and VECM Granger causality.	Ecological footprint, energy consumption, urbanization, trade openness, industrial output and political stability.	The variables are cointegrated. Energy consumption, urbanization, industrial output and trade openness increase ecological footprint while political stability reduces it. With the exception of political stability a bi-directional causality was found among the variables.	Yes
Adewuyi & Awodumi [2]	West Africa	1980–2010	3 stage least square.	CO_2 emission, GDP, biomass energy consumption, trade openness and urbanization.	GDP reduces CO_2 emission while biomass energy consumption reduces it. Urbanization, and trade openness are not significant on CO_2 emission.	No
Halicioglu & Ketenci [20]	Transition countries.	1990–2013	ARDL and GMM model.	CO_2 emission, GDP, energy consumption and trade openness.	Energy consumption increases CO_2 emission in all countries. GDP increases CO_2 emission only in Latvia and Uzbekistan the rest of the countries the relationship is not significant. Trade openness increases CO_2 emission in Turkmenistan while trade reduces it in Latvia and Russia.	Yes
Rafiq et al. [42]	Emerging countries.	1980–2010	second-generation heterogeneous linear panel models, nonlinear panel estimation techniques.	CO_2 emission, population, affluence, renewable and non-renewable energy and trade openness.	Population, non-renewable energy and affluence increases CO_2 emission while renewable energy and trade openness reduce it.	No

consumption of energy rose from 2.23 million metric tons (oil equivalent) in 1980 to 5.32 million metric tons (oil equivalent) in 2000 and to 9.09 million metric tons (oil equivalent) in 2012 [16]. Thirdly, the authorities in the country are making efforts to reduce CO_2 emissions in a bid to ensure an environmentally sustainable development with efficient and sound resource management. Among these efforts were the introduction of Environmental Protection Act 1974 and the creation of Environmental Protection Agency (EPA). The environmental protection agency (EPA) have recently initiated measurable standards to resolve these problems. The vehicular emission reduction standard program was implemented to control vehicular emission, and other standard such as fugitive emission management service, varied CO_2 standard (VCS), Air quality and emission policy among others were initiated to control the emission of harmful gasses in the country [21]. Fourthly, despite the considerable number of the PHH literature there is lack of studies that examine this hypothesis in Ghana. This is despite the remarkable increase in pollution and foreign investment in the country. In addition to the fact that structural breaks are introduced into unit root testing and cointegration analysis, we contribute to the existing literature by focussing on a country that typifies the current scenario of increasing emission and foreign direct investment in the developing countries. The failure to incorporate break dates in either the unit root tests or the cointegration tests, when breaks actually exist may affect the results of the estimations [40].

The paper is organized as follows: methodology and data is given in Section 2, empirical results are presented in Section 3 and results are discussed in Section 4. Finally, the conclusion and policy implications are presented in Section 5.

2. Methodology

2.1. Model and data

Following the model specifications of Al-mulali and Tang [4]; Tamazian and Rao [50]; Shahbaz et al. [47] and Zakarya et al. [58]; we examine the impact of foreign direct investment, GDP, energy consumption and other variables on CO_2 emissions in Ghana. Our approach assumes that in addition to foreign direct investment (which is included for the purpose of testing the validity of the pollution haven hypothesis) there are several variables responsible for pollution. The empirical models to be estimated are as follows:

$$\ln TEM_t = \xi_0 \ln FDI_t + \xi_1 \ln GDP_t + \xi_2 \ln ENE_t + \xi_3 Z_t + \xi_4 + \xi_5 T + \xi_6 B + \upsilon_t \tag{1}$$

$$\ln PEM_t = \delta_0 \ln FDI_t + \delta_1 \ln GDP_t + \delta_2 \ln ENE_t + \delta_3 Z_t + \delta_4 + \delta_5 T + \delta_6 B + \upsilon_t \quad (2)$$

where TEM_t is total carbon dioxide emissions (oil equivalent) from the consumption of energy per capita, PEM_t is CO_2 emissions (oil equivalent) from the consumption of petroleum per capita, FDI_t is the real foreign direct investment (constant 2005 US$) per capita, GDP_t is real gross domestic product (constant 2005 US$) per capita, ENE_t is energy use (kg of oil equivalent) per capita. In addition to the aggregate energy consumption per capita, we also use fossil fuels energy consumption (kg of oil equivalent) or FOS_t and renewable energy consumption (kg of oil equivalent) per capita or REN_t. GDP_t^2 is the square of real gross domestic product. Z_t is a vector of control variables that include INS_t, URB_t, FIN_t and TRA_t and GDP_t^2.

The purpose of including the square of GDP per capita is to test for the presence of Environmental Kuznets Curve (EKC). The other control variables include INS_t or institutional quality, which is the average of "political rights" and "civil liberties" score.[1] The institutional quality index is measured on a one-to-seven scale, with seven (7) indicating the smallest level of institutional quality and one (1) representing the highest form of institutional quality. URB_t is the urbanization population ratio or urban population divided by total population. FIN_t is the financial development or domestic credit to private sector by banks as a percentage of GDP. TRA_t is proxy for trade openness or trade (exports of goods and services plus imports of goods and services) as a percentage of GDP. Due to the finite size of our sample, the control variables are included into the equation, sequentially. T is the trend, while B is the dummy that denote the structural break period, which is derived from the unit test of the level forms of CO_2 emissions.

This study covers the period of 1980–2012 and the data for total carbon dioxide emissions from the consumption of energy and CO_2 emissions from the consumption of petroleum were obtained from the Energy Information Administration database (http://www.eia.gov). The data for the other variables were obtained from *World Development Indicators* of the World Bank.

The role of the other variables (besides foreign direct investment, which has been explained) have been well-discussed in the literature. Higher economic activity generates higher wealth and wealthier residents often demand more energy intensive products (eg. automobiles, air conditioning, etc.). Economic growth leads to industrialization and increases the demand for energy. Pursuits of economic activities involve fuel combustion in the power generation, industrial, residential and transportation sectors, which add to GHGs [47]. Emissions of CO_2 caused by human activities are generally considered as the most important single source of potential future warming. If the structural or technological change in the economy is very limited, economic activities would result in a proportional growth in pollution and other environmental impacts. Ren et al. [43]; Lau et al. [33]; Cole and Fredriksson [12]; Shahbaz et al. [47]; Zheng et al. [61]; Omri et al. [37]; and Al-Mulali and Tang [4] have provided for GDP in the equation involving foreign direct investment-emission.

Energy consumption is widely known to be associated with emission and reducing energy consumption will decrease carbon emissions. Fossil fuel (such as coal, oil and natural gas) combustion produces carbon dioxide (CO_2) and other emissions resulting from human activities which are harmful to human health. The transportation sector involves cars, buses, airplanes, cargo ships and railroads, which are heavily dependent on petroleum and generate emissions. The energy consumption of houses and buildings (mostly through electricity consumption) is also responsible for emission. Fossil fuels are responsible for the largest quantity of emission with renewable energy contributing very minimal quantity. There are existing papers that have controlled for energy consumption in the foreign direct investment-emission regressions including Pao and Tsai [39]; Al-mulali [3]; Al-Mulali and Tang [4]; Kivyiro and Arminen [30]; Shahbaz et al. [47] and Tang and Tan [52].

Higher urbanization is associated with higher economic activities and can increase emissions [44]. Spatial organization and urban density are vital elements that affect energy consumption, particularly in the building and transportation sectors. As nations progress from low to middle phases of development, environmental issues might exacerbate because in these phases of development, economic performance takes precedence over environmental consideration. Cities account for the most of consumed energy in the globe and are therefore key contributors of greenhouse gas emissions. Spatial distributions of population are a key predictor of observed air quality. Cities consume about 60–80% of energy production worldwide and are responsible for the same share of worldwide CO_2. The rising level of urbanization will lead to an important rise in energy consumption and CO_2 emissions, especially in non-OECD nations in Africa and Asia where urban energy consumption usually shift from biomass and waste energy consumption to fossil fuels consumption [38]. The introduction of urbanization will reduce the omitted variables bias in the estimation. Studies such as Cole et al. [13]; Cole and Fredriksson [12]; Jorgenson [28]; Omri et al. [37] and Azam et al. [8] have provided for urbanization in the equation involving foreign direct investment-emission.

International trade involves activities that breed pollution including industrial production, transportation and, more indirectly, deforestation [26,48]. Globalization has facilitated the relocations of factories from high-income nations to low-income nations by multinational corporations. These firms do not only pay lower salaries than what it is expected in the home countries, but also do not often fulfil the environmental requirements that are often available in high-income countries [25]. International trade is also associated with the increasing number of freight in and out of the country. CO_2 emissions from international road freight transport are rising across the globe, and there isn't yet an indication that this scenario will abate in the near future. Studies such as Waldkirch and Gopinath [54]; Kearsley and Riddel [29]; Al-mulali [3] Ren et al. [43]; Lau et al. [33]; Omri et al. [37]; Azam et al. [8] and Neequaye and Oladi [35] have provided for trade openness in the regression involving foreign direct investment and emission.

We have also controlled for financial development because of its perceived relationship with emission. The basic function of financial institution is to provide liquidity to the real sector and in the process also aids pollution in the country. Besides, prosperous and efficient financial intermediation seems conducive to consumers' loan activities, which makes it easier for consumers to buy big

[1] The aggregate institutional quality is estimated by calculating the average of two components - political rights and Civil liberties. According to the *Freedom House* website, the existence of political rights is an atmosphere that allows the citizenry to partake in easily in the political process, including the right to vote in free and fair legitimate elections, right to associate with political parties and organizations of choice, right to vie for public office, and right to elect representatives who are accountable to the electorate. On the other hand, civil liberties ensure freedoms of belief and expression, organizational and associational rights, rule of law, and property rights. The total score awarded to the political rights is determined by a rating system, which ranges from one through seven with one representing the existence of the highest forms of political rights and seven the lowest forms of political rights. The same framework is utilized in the process of computing the total score awarded to civil liberties.

ticket items like automobiles [59]. Relative to direct form of financing, financial institutions provide access to lower financing costs, disperse operating risk and optimize asset/liability structure, which facilitates new installations and invest in new projects and then increase energy consumption and carbon emissions. A healthy financial system may lure foreign direct investment, which may increase carbon emissions and boost economic growth. The previous papers that have incorporated financial development in the regression involving foreign direct investment-emission include Shahbaz et al. [46] and Omri et al. [37].

Institutional quality serves as a control variable in the regression involving foreign direct investment and emission regression. Institutional quality may facilitate more equitable distribution of income and power and hence bring about improvement of the environment. Strong institutional framework can enable the government to have greater ability of regulating emission. The quality of institutions plays an important role to reduce environmental degradation in a country. Different components of institutional quality including democracy or corruption control can improve the environmental quality of countries [24]. With the inclusion of institutional quality, we reduce the probability of the regression suffering from omission of a relevant variable. Tamazian and Rao [50] provided for institutional quality in the equation involving foreign direct investment-emission.

2.2. ARDL bound test

For the purpose of autoregressive distribute lag (ARDL) bounds test approach, the following unrestricted error correction models are estimated:

$$\begin{aligned}\Delta \ln TEM_t = &\sum_{i=1}^{k}\kappa_0 \Delta \ln TEM_{t-i} + \sum_{i=1}^{k}\kappa_1 \Delta \ln FDI_{t-i} \\ &+ \sum_{i=1}^{k}\kappa_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{k}\kappa_3 \Delta \ln ENE_{t-i} \\ &+ \sum_{i=0}^{k}\kappa_4 \Delta \ln Z_{t-i} + \lambda_0 \ln TEM_{t-1} + \lambda_1 \ln FDI_{t-1} \\ &+ \lambda_2 \ln GDP_{t-1} + \lambda_3 \ln ENE_{t-1} + \lambda_4 \ln Z_{t-1} + \lambda_5 \\ &+ \lambda_6 T + \lambda_7 B + \varepsilon_t\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta \ln PEM_t = &\sum_{i=1}^{k}\chi_0 \Delta \ln PEM_{t-i} + \sum_{i=1}^{k}\chi_1 \Delta \ln FDI_{t-i} \\ &+ \sum_{i=1}^{k}\chi_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{k}\chi_3 \Delta \ln ENE_{t-i} \\ &+ \sum_{i=0}^{k}\chi_4 \Delta \ln Z_{t-i} + \eta_0 \ln PEM_{t-1} + \eta_1 \ln FDI_{t-1} \\ &+ \eta_2 \ln GDP_{t-1} + \eta_3 \ln ENE_{t-1} + \eta_4 \ln Z_{t-1} + \varphi_5 \\ &+ \varphi_6 T + \varphi_7 B + \varepsilon_t\end{aligned} \tag{4}$$

The null hypothesis of no-cointegration $\lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$ is tested against the alternative hypothesis of $\lambda_0 \neq \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$ in eq (3) and the null hypothesis of no-cointegration $\eta_0 = \eta_1 = \eta_2 = \eta_3 = \eta_4 = 0$ was tested against the alternative hypothesis of $\eta_0 \neq \eta_1 \neq \eta_2 \neq \eta_3 \neq \eta_4 \neq 0$ in eq (4). The short-run versions of eqs (1) and (2) can be tested as follows, respectively:

$$\begin{aligned}\Delta \ln TEM_t = &\sum_{i=1}^{k}\sigma_0 \Delta \ln TEM_{t-i} + \sum_{i=0}^{k}\sigma_1 \Delta \ln FDI_{t-i} \\ &+ \sum_{i=0}^{k}\sigma_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{k}\sigma_3 \Delta \ln ENE_{t-i} \\ &+ \sum_{i=0}^{k}\sigma_4 \Delta \ln Z_{t-i}\sigma_5 + \sigma_6 T + \sigma_7 B + \sigma_8 ECT_{t-1} + \varepsilon_t\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta \ln PEM_t = &\sum_{i=1}^{k}\vartheta_0 \Delta \ln PEM_{t-i} + \sum_{i=0}^{k}\vartheta_1 \Delta \ln FDI_{t-i} \\ &+ \sum_{i=0}^{k}\vartheta_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{k}\vartheta_3 \Delta \ln ENE_{t-i} \\ &+ \sum_{i=0}^{k}\vartheta_4 \Delta \ln Z_{t-i}\vartheta_5 + \vartheta_6 T + \vartheta_7 B + \vartheta_8 ECT_{t-1} + \varepsilon_t\end{aligned} \tag{6}$$

σ_8 is the parameter that depicts the speed of adjustment and the ECT in eq (5) is the residual derived from the estimation of the cointegration model of (1). ϑ_8 is the parameter that depicts the speed of adjustment and the ECT in eq (6) is residuals obtained from the estimation of the cointegration model of (2). For the ECT to be statistically meaningful in the two equations, it must not only produce negative but also statistically significant coefficients.

3. Empirical results

A descriptive analysis of the series is conducted in Table 2, which shows several statistics of all the variables in this study. Total carbon dioxide emissions from the consumption of energy per capita is very low at 4.609 metric tons, this volume is higher than what is obtainable in several African countries including Burkina Faso, Ethiopia, Kenya, Mozambique, Tanzania and Uganda [16]. With an average of real foreign direct investment per capita at $103.923, the country also has one of the biggest foreign direct investment on the continent [56]. The statistics further shows that with an average of 256.911 (kg of oil) or 68.7111% of the total energy consumption, renewable energy consumption dominates the energy mix in the country. However, the fossil fuels energy consumption has a faster growth rate relative to the renewable energy consumption and in the year 2012, it accounted for 43.642% of the total energy mix [56]. The Jarque-Bera shows that real foreign direct investment per capita, real GDP per capita, real GDP square per capita, renewable energy consumption per capita do not follow normal distribution. Therefore, we transform all the variables into natural logarithmic form for the purpose of econometric analysis.

The empirical analyses commence with the testing for unit root properties of the series. As a benchmark, we first apply the traditional unit root tests - including the Said and Dickey [45] or ADF and Phillips and Perron [41] or PP - to examine the nonstationarity of the five series. The results which are reported in Table 3 reveal that we cannot reject the null of nonstationarity when the variables are in level. Once the series are in the first differences, the null hypothesis can be rejected for all the series at 10% or better.

In the presence of structural break(s), the power of these conventional unit root tests becomes questionable. Hence, the Lee and Strazicich [34] test is subsequently presented. As shown in Table 4, we cannot reject the null of unit root for all variables, when specified in level form. When the variables are expressed in their first

Table 2
Descriptive analysis.

Variable	TEM	PEM	FDI	GDP	GDP^2	ENE	FOS	REN	INS	URB	FIN	TRA
Mean	4.609	4.606	103.9239	444.703	281723.532	373.900	91.074	256.911	4.000	38.475	8.351	61.423
Coefficient of variation	0.481	0.482	1.815	0.475	0.474	0.279	0.360	0.095	0.516	0.163	0.625	0.499
Skewness	0.670	0.670	3.533	0.996	1.563	0.037	0.663	−1.031	0.321	0.227	0.181	−0.148
Kurtosis	−0.632	−0.635	12.987	0.174	5.016	−1.161	2.807	3.004	−1.439	1.662	1.408	2.044
Jarque-Bera	3.107	3.106	401.547***	6.233**	19.0238***	3.626	2.473	5.845**	1.831	2.473	3.664	1.376

** and *** indicate significance at 5% and 1% levels respectively. FIN and TRA are in percentage.

Table 3
Conventional unit root tests.

Variables	ADF unit root test	PP unit root test
	T-statistic	Prob. value
ln TEM_t	3.401[1]	0.035[1]
Δln TEM_t	−4.368*** [1]	−7.164***[1]
ln PEM_t	3.402[1]	0.037[1]
Δln PEM_t	−4.368*** [1]	−7.277***[1]
ln FDI_t	−2.825[0]	−2.990[1]
Δln FDI_t	−5.078***[0]	−5.338***[1]
ln GDP_t	−2.432[0]	−2.582[2]
Δln GDP_t	−3.708**[1]	−3.639**[0]
ln ENE_t	−2.175[1]	−2.358[1]
Δln ENE_t	−4.483***[1]	−6.189***[0]
ln FOS_t	0.289[2]	−1.153[0]
Δln FOS_t	−6.631*** [1]	−7.740***[0]
ln REN_t	−1.619[2]	1.105[1]
Δln REN_t	−5.211***[1]	−3.360*[1]
ln GDP_t^2	−1.8123[1]	−2.301[2]
Δln GDP_t^2	−4.733***[1]	−3.403*[2]
ln INS_t	−2.378[2]	−0.448[1]
Δln INT_t	−3.611**[2]	−6.034*** [1]
ln URB_t	−1.747[1]	−1.294[1]
Δln URB_t	−3.800** [1]	−3.641**[0]
ln FIN_t	−2.605[0]	−2.628[2]
Δln FIN_t	−5.698*** [1]	−6.582***[2]
ln TRA_t	−1.442[0]	−1.682[1]
Δln TRA_t	−7.478***[1]	−4.794***[0]

*, ** and *** indicate significance at 10%, 5% and 1% levels respectively. The maximum lag is set at 2, the optimal lags in ADF are selected based on Schwarz Information Criterion, whereas the Parzen with Andrews bandwidth is used for PP. For the sake of consistency, the models for each test include a constant and trend. [] is optimal lag.

Table 4
LM unit root test.

Variable	T-statistics	TB1	DU1	DT1
ln TEM_t	−3.590[0]	2000	−0.092 (−1.046)	0.105**(2.405)
Δln TEM_t	−7.361***[0]	1997	−0.014 (0.142)	−0.009 (−0.276)
ln PEM_t	−3.597[0]	2000	−0.092 (−1.046)	0.106** (2.415)
Δln PEM_t	−7.371***[0]	1997	−0.011 (−0.112)	0.011 (−0.312)
ln FDI_t	−2.489[1]	1994	−1.161 (−1.525)	0.673* (1.890)
Δln FDI_t	−4.947**[0]	1984	−0.177 (−0.215)	0.605 (1.539)
ln GDP_t	−2.909[0]	1994	−0.007 (−0.266)	0.025*** (2.711)
Δln GDP_t	−5.185***[0]	1994	0.011 (0.459)	−0.023** (−2.492)
ln ENE_t	−3.343[0]	1998	0.052 (1.193)	−0.008 (−0.528)
Δln ENE_t	−6.455***[0]	1999	−0.045 (−0.967)	−0.018 (−1.081)
ln FOS_t	−1.765[0]	1989	−0.935*** (−4.957)	0.023 (0.138)
Δln FOS_t	−7.754***[0]	2002	−0.198*** (−2.910)	0.078 (0.952)
ln REN_t	−1.523[0]	1997	0.026*** (3.030)	−0.024*** (−5.440)
Δ ln REN_t	−4.211*[0]	1999	−0.006 (−0.906)	−0.011*** (−3.246)
ln GDP_t^2	−1.721[0]	1992	0.075 (0.165)	0.450*** (2.893)
Δln GDP_t^2	−4.430*[0]	1988	0.007 (0.262)	−0.029** (−2.470)
ln INS_t	−3.569[0]	1987	0.038 (0.276)	−0.425*** (−5.059)
Δln INS_t	−7.045***[0]	1992	0.082 (0.526)	−0.190*** (−2.999)
ln URB_t	−1.455[0]	1991	0.002 (0.360)	0.010*** (3.134)
Δln URB_t	−5.886***[1]	1989	−0.005*** (−3.156)	−0.001** (−1.971)
ln FIN_t	−4.127[0]	1997	0.005 (0.029)	0.175** (2.051)
Δln FIN_t	−6.203***[0]	1999	−0.113 (−0.518)	−0.018** (−2.332)
ln TRA_t	−4.075[1]	2000	−0.078 (−0.447)	−0.146** (−2.344)
Δln TRA_t	−5.811***[1]	2002	0.184 (0.916)	−0.213*** (−2.567)

*, ** and *** indicate significance at 10%, 5% and 1% levels respectively. The maximum lag is set at 2, the optimal lags are selected based on Schwarz Information Criterion. The critical values are −5.05, −4.50 and −4.18, respectively. The optimal lag is reported in the bracket, while the t-statistics is reported in the parenthesis. DU1 is the coefficient of break in intercept of the equation. DT1 is the coefficient of the break in slope of the equation. [] is optimal lag and () is the t-statistics.

differences, the null of unit root can be rejected in all cases. About 25% of the structural breaks (or 6 of the 24 breaks) are located in the late early 1990s, while another 33% of the breaks (or 8 of the 24 structural breaks) are in the late 1990s. These are the periods coinciding with the country's consolidation of economic liberalization, which started in the 1980s and the institution of political liberalization which culminated in 2000 with the country experiencing the first ever transfer of power via the ballot box in the country's history.

Having conducted the unit root test, we turn to the cointegration test and it is observed that there is long run relationship in the variables. The cointegration test for eight regressions with the emission per capita as the dependent variable is presented in Table 5. We include a dummy, which is based on the shift found in the unit root test of the dependent variable to capture the structural break in each equation. In the baseline model, which involves the real foreign direct investment, real GDP and energy consumption, the F-statistic (4.984) is above the upper bounds critical values at 1% significance level (4.888). The F-statistics (6.494 and 7.231) are above the upper bounds critical values at 10% significance level (5.795), with the inclusion of fossil fuel consumption and renewable energy consumption, respectively. For the equations with control variables, we observe that F-statistics (8.097, 8.468 and 7.567) are above the upper bounds critical values at 1% significance level (7.172), when real GDP square, institutional quality and urban population ratio are incorporated into the equation, respectively. Furthermore, when financial development and trade openness are introduced into the model, F-statistics (6.983 and 6.086, respectively) are bigger than the upper bounds critical values at 5% significance level (5.304).

The foregoing results suggest that there is at least a cointegrating vector in each of the eight models. As a robustness check, we further introduce emissions from petroleum as a proxy for emissions in Table 6. Most of the emissions associated with energy consumption in Ghana are derived from petroleum-consuming activities as more than 90% of the emissions in the country are due to these activities [16]. The results show that the F-statistic (4.907) is above the upper bounds critical values at 10% significance level (4.888) in the first model, which suggest that there is long run relationship in the variables. The results from the other models provide similar evidence of cointegration. The diagnostics tests reveal that all the models are free from serial correlation and

Table 5
Cointegration results (TEM_t).

No.	Model	F-stat	Lag	χ^2_{serial}	χ^2_{ARCH}	χ^2_{Normal}	χ^2_{amsey}
Model 1	$\ln TEM_t = f(\ln FDI_t \ln GDP_t \ln ENE_t)$	4.984*	(1,2,1,2)	0.181[1]	0.161[1]	0.881[2]	0.311[1]
Model 2	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln FOS_t)$	6.494**	(1,0,0,0)	0.138[1]	0.101[1]	0.396[2]	0.209[1]
Model 3	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln REN_t)$	7.231**	(2,1,2,2)	0.184[1]	0.402[1]	0.913[2]	0.418[1]
Model 4	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln GDP_t^2)$	8.097***	(2,0,0,0,2)	0.707[1]	0.562[1]	0.519[2]	0.391[1]
Model 5	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln INS_t)$	8.4683***	(1,1,0,2,2)	0.256[1]	0.825[1]	0.956[2]	0.709[1]
Model 6	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln URB_t)$	7.567***	(1,2,1,2,2)	0.841[1]	0.575[1]	0.745[2]	0.575[1]
Model 7	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln FIN_t)$	6.983**	(2,0,2,0,2)	0.726[1]	0.505[1]	0.316[2]	0.512[1]
Model 8	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln TRA_t)$	6.086**	(2,1,2,1,2)	0.162[1]	0.234[1]	0.862[2]	0.475[1]

For the four-variable model, the critical values (for lower and upper bounds) are (6.380 7.730) (4.568 5.795) (3.800 4.888), at 1%, 5% and 10%, respectively. For the five-variable models, the critical values (for lower and upper bounds) are (5.604 7.172) (4.036 5.304) (3.374 4.512), at 1%, 5% and 10%, respectively. The break included in the model is for 2000 and [] is the optimal lag.

Table 6
Cointegration results (PEM_t).

No.	Model	F-stat	Lag	χ^2_{serial}	χ^2_{ARCH}	χ^2_{Normal}	χ^2_{amsey}
Model 1	$\ln TEM_t = f(\ln FDI_t \ln GDP_t \ln ENE_t)$	4.907*	(1,2,1,2)	0.290[1]	0.438[1]	0.279[2]	0.446[1]
Model 2	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln FOS_t)$	6.664**	(2,1,1,1)	0.190[1]	0.304[1]	0.918[2]	0.696[1]
Model 3	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln REN_t)$	7.257***	(2,2,1,2)	0.270[1]	0.144[1]	0.100[2]	0.416[1]
Model 4	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln GDP_t^2)$	8.121***	(2,0,0,0,2)	0.715[1]	0.559[1]	0.514[2]	0.123[1]
Model 5	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln INS_t)$	8.479***	(1,0,0,2,2)	0.438[1]	0.606[1]	0.668[2]	0.757[1]
Model 6	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln URB_t)$	6.650**	(1,2,1,1,1)	0.649[1]	0.739[1]	0.805[2]	0.103[1]
Model 7	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln FIN_t)$	7.002**	(2,0,2,0,1)	0.291[1]	0.997[1]	0.304[2]	0.151[1]
Model 8	$\ln TEM_t = f(\ln FDI_t, \ln GDP_t, \ln ENE_t, \ln TRA_t)$	6.052**	(2,1,2,2,2)	0.360 [1]	0.591[1]	0.348[2]	0.365[1]

For the four-variable model, the critical values (for lower and upper bounds) are (6.380 7.730) (4.568 5.795) (3.800 4.888), at 1%, 5% and 10%, respectively. For the five-variable models, the critical values (for lower and upper bounds) are (5.604 7.172) (4.036 5.304) (3.374 4.512), at 1%, 5% and 10%, respectively. The break included in the model is for 2000 and [] is the optimal lag.

heteroscedasticity. The Jarque-Bera and Ramsey reset tests show that error terms are normally distributed and functional forms are well specified.

Having established the existence of long run relationship in the variables, the next stage is to analyze the impact of these variables on emission. We start the long run and short run analyses with the regression involving total emission as the dependent variable in Table 7. The long run results are reported in the upper panel, while the short run analysis is reported in the lower panel of the Table. In the baseline model, we observe that foreign direct investment has a significant positive impact on emission in the country. The estimates suggest that for every 1% increase in foreign direct investment, emission will increase by 0.026%. The estimates also show that real GDP and energy consumption have positive impact on emission.

In the second and third models, fossil fuels energy consumption and renewable energy consumption are used as proxy for the energy sector. The results show that fossil fuels energy consumption and renewable energy consumption have significant positive impact on emission.

In fourth model, we examine the possibility of EKC hypothesis in the country by introducing real GDP square into the equation. The results suggest that while real GDP produce positive output, real GDP square suggest a negative output. Therefore there is evidence for EKC in the country. In the remaining models, we observe that real foreign direct investment, real GDP, energy consumption, urban population ratio, financial development and trade openness have positive impact on emissions. The coefficients of the institutional quality is positive which suggests that with higher institutional quality, Ghana is likely to experience less emission. This interpretation of the institutional quality result is due to the fact that lower score of the institutional quality index is associated with higher level of institutional quality. The dummy for the year 2000 shows that the events of the year has led to an increase in CO_2 emissions.

Considering the short run relation, we observe that the results are not materially different from the long run output. In most cases, real foreign direct investment, real GDP, energy consumption have positive impact on emission. The negative and statistically significant estimate of error correction terms in all the models support the long-run relationship between the variables. The diagnostic tests show that there is no problem of heteroskedasticity or serial correlation, and the error terms are normally distributed. With these results, logarithmic transformation has erased normality problems in the estimation. CUSUM and CUSUMSQ tests largely support stability of the coefficients of the regression equations.

The emissions from petroleum is also utilized as the dependent variable for the eight models and the results are reported in Table 8. We observe that real foreign direct investment, real GDP, energy consumption, urban population ratio, financial development and trade openness positively affect CO_2 emissions. However, institutional quality has a negative impact on the environmental degradation. Moreover, there is evidence of EKC, which implies that an inverted U-shaped relationship between economic growth and CO_2 emission exists in the country. The dummy for the year 2000, shows that the events of the year has led to an increase in emissions. All the diagnostics tests conducted suggest that all the models are not suffering from heteroskedasticity or serial correlation, and the error terms are normally distributed. CUSUM and CUSUMSQ tests largely support stability of the coefficients of regression equations.

4. Discussion

The positive impact of foreign direct investment on emission is consistent with Al-mulali [3]; Al-Mulali and Tang [4]; Lau et al. [33]; Omri et al. [37]; Azam et al. [8] and Shahbaz et al. [47]; but in contrast with Tamazian et al. [51] and Tamazian and Rao [50]. The positive impact of GDP and energy consumption is consistent with the works of Pao and Tsai [39]; Al-Mulali and Tang [4]; Kivyiro and

Table 7
Long run and Short run results (TEM_t).

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Panel A: Long run coefficients								
$\ln FDI_t$	0.026**	0.011**	0.056*	0.002**	0.060**	0.033	0.043***	0.010
	(2.446)	(2.390)	(1.684)	(0.083)	(2.974)	(1.088)	(1.191)	(0.569)
$\ln GDP_t$	2.676**	1.220***	0.826	58.218***	2.860***	2.839*	1.380	1.975***
	(2.385)	(2.363)	(1.116)	(3.377)	(2.907)	(−1.911)	(0.293)	(2.923)
$\ln ENE_t$	2.375*			2.121*	4.181**	3.395**	0.066	−1.607***
	(1.727)			(1.780)	(2.616)	(2.370)	(0.070)	(−2.989)
$\ln FOS_t$		1.142*						
		(1.829)						
$\ln REN_t$			2.116***					
			(2.799)					
$\ln GDP_t^2$				−4.506***				
				(−3.324)				
$\ln INS_t$					0.211***			
					(2.664)			
$\ln URB_t$						1.291***		
						(3.816)		
$\ln FIN_t$							0.489*	
							(1.898)	
$\ln TRA_t$								0.410***
								(4.335)
Constant	6.126***	7.815	−18.533	−1,83.672***	−15.969***	23.722**	11.486**	11.237***
	(6.443)	(1.594)	(−1.180)	(−3.110)	(−3.211)	(2.383)	(2.432)	(5.367)
Trend	0.035*	0.029**	−0.001	−0.059*	0.018	0.115** 1.987)	−0.003	−0.004
	(1.944)	(2.006)	(0.017)	(−1.878)	(0.206)		(−0.110)	(−0.417)
Dummy 2000	0.120	0.169	0.190*	0.077*	0.160**	0.115**	0.016	−0.001
	(1.530)	(1.542)	(1.865)	(1.845)	(2.639)	(2.318)	(0.410)	(−0.034)
Panel B: Short run coefficients								
$\Delta\ln FDI_t$	0.025***	0.008	−0.011	0.002	0.040***	0.028***	0.032**	−0.001
	(2.787)	(0.394)	(−0.388)	(0.083)	(2.418)	(2.904)	(2.388)	(−0.031)
$\Delta\ln GDP_t$	0.622	0.970	0.735	61.193***	1.679***	−0.884	1.292	1.460*
	(0.743)	(1.320)	(0.744)	(3.918)	(2.801)	(−0.934)	(1.450)	(1.968)
$\Delta\ln ENE_t$	0.269*			0.536	0.653	1.377**	0.049	−0.497
	(1.648)			(0.708)	(0.890)	(1.962)	(0.071)	(−0.868)
$\Delta\ln FOS_t$		0.942***						
		(3.335)						
$\Delta\ln REN_t$			0.092*					
			(1.763)					
$\Delta\ln GDP_t^2$				−4.736***				
				(−3.879)				
$\Delta\ln INS_t$					0.467***			
					(2.957)			
$\Delta\ln URB_t$						13.301		
						(0.955)		
$\Delta\ln FIN_t$							0.178*	
							(1.796)	
$\Delta\ln TRA_t$								0.179*
								(1.698)
Constant	4.072***	6.215***	−17.820	−193.057***	−14.651***	22.446**	8.544**	15.228***
	(4.672)	(4.353)	(−1.192)	(−3.661)	(−2.899)	(2.403)	(1.999)	(4.048)
Trend	0.024*	−0.018	−0.001	−0.063**	0.036	0.109**	−0.002	−0.006
	(1.715)	(−1.133)	(0.017)	(−2.160)	(0.425)	(2.166)	(0.112)	(−0.429)
Dummy 2000	0.080*	0.134	0.1823*	0.081**	0.118***	0.109**	0.012	−0.001
	(1.936)	(1.556)	(1.844)	(2.066)	(2.674)	(2.411)	(0.428)	(−0.034)
ECT_{t-1}	−0.665***	−0.795***	−0.962***	−0.951***	−0.984***	−0.946***	−0.744***	−1.355***
	(−3.718)	(3.917)	(−3.803)	(−5.064)	(−5.630)	(−4.350)	(−3.183)	(−6.300)
Joint significance test								
R2	0.266	0.255	0.293	0.521	0.695	0.481	0.397	0.701
F-statistics	2.734**	2.467**	2.714**	4.612***	4.568***	4.185***	3.172**	8.431***
Stability Analysis								
Test	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat
χ^2_{Normal}	0.782	1.581	0.702	1.433	0.666	0.476	0.888	0.616
χ^2_{serial}	1.426	0.515	0.417	0.334	1.514	1.061	0.446	1.590
χ^2_{ARCH}	0.095	1.695	0.126	0.112	0.473	1.123	0.231	0.504
χ^2_{Hetero}	1.399	1.435	1.192	1.774	0.937	1.938	1.766	0.460
χ^2_{Remsay}	2.352	1.164	2.613	2.180	1.608	1.021	1.562	1.072
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable

*, ** and *** indicate significance at 10%, 5% and 1% levels respectively. () is the t-statistics.

Table 8
Long run and Short run results (PEM_t).

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Panel A: Long run coefficients								
$\ln FDI_t$	0.026***	0.014***	0.033**	0.011**	0.041***	0.017	0.008**	0.040*
	(2.541)	(2.754)	(2.026)	(2.072)	(2.803)	(0.492)	(2.229)	(1.882)
$\ln GDP_t$	2.663**	0.281***	0.472	58.068***	1.701***	2.279**	0.093	0.554
	(2.367)	(2.722)	(0.585)	(3.384)	(2.814)	(2.384)	(0.057)	(0.622)
$\ln ENE_t$	2.357*			2.121*	2.990***	2.162*	0.728	−0.374
	(1.736)			(1.788)	(2.887)	(1.674)	(0.597)	(−0.504)
$\ln FOS_t$		0.010**						
		(2.261)						
$\ln REN_t$			0.033					
			(0.026)					
$\ln GDP_t^2$				−4.494***				
				(−3.331)				
$\ln INS_t$					0.231*			
					(1.938)			
$\ln URB_t$						0.676*		
						(1.795)		
$\ln FIN_t$							0.158***	
							(3.734)	
$\ln TRA_t$								0.416***
								(4.854)
Constant	6.113***	13.006***	−22.915	−183.187***	−14.933***	20.901**	9.544*	12.190
	(6.407)	(3.3756)	(−1.307)	(−3.116)	(−3.263)	(1.970)	(1.647)	(6.321)
Trend	0.035**	0.040***	−0.00	−0.059*	0.037	0.077	0.025	−0.001
	(1.959)	(3.443)		(−1.875)	(0.450)	(1.371)	(0.918)	(−0.007)
Dummy 2000	0.119	0.109	0.227**	0.078*	0.120***	0.103*	0.025	0.042
	(1.537)	(0.975)	(2.072)	(1.853)	(2.749)	(1.865)	(0.519)	(1.436)
Panel B: Short run coefficients								
$\Delta\ln FDI_t$	0.025	0.015	−0.017	0.001	0.040*	0.028***	0.006	0.019
	(0.787)	(0.457)	(−0.553)	(0.072)	(1.869)	(2.904)	(0.235)	(0.817)
$\Delta\ln GDP_t$	0.620*	0.498***	0.810***	61.227***	1.776***	0.884***	0.757	1.093*
	(1.741)	(2.617)	(2.681)	(3.924)	(2.892)	(2.934)	(0.733)	(1.661)
$\Delta\ln ENE_t$	1.270*			0.537	0.653	1.377**	0.517***	0.069**
	(1.681)			(0.711)	(0.916)	(1.962)	(2.648)	(2.131)
$\Delta\ln FOS_t$		0.032						
		(0.238)						
$\Delta\ln REN_t$			3.385					
			(0.891)					
$\Delta\ln GDP_t^2$				−4.739***				
				(−3.886)				
$\Delta\ln INS_t$					0.260			
					(1.503)			
$\Delta\ln URB_t$						3.301***		
						(3.955)		
$\Delta\ln FIN_t$							0.122	
							(1.062)	
$\Delta\ln TRA_t$								0.173*
								(1.890)
Constant	4.084***	10.695**	−21.932	−193.152***	−14.716***	20.307*	6.778	15.922***
	(4.668)	(2.803)	(−1.324)	(−3.667)	(−3.176)	(1.884)	(1.353)	(4.861)
Trend	0.024*	0.033**	−0.006	−0.062**	0.037	0.074	0.018	−0.001
	(1.726)	(2.218)	(−0.228)	(−2.155)	(0.425)	(1.390)	(0.812)	(−0.007)
Dummy 2000	0.080*	0.090	0.217**	0.082*	0.118***	0.100*	0.018***	0.055
	(0.025)	(1.088)	(2.082)	(2.074)	(2.803)	(1.859)	(2.559)	(1.614)
ECT_{t-1}	−0.668***	−0.822***	0.957***	−0.954***	−0.985***	−0.972***	−0.710***	−1.306***
	(−3.305)	(−2.663)	(−3.526)	(−5.082)	(−5.790)	(−3.609)	(−2.568)	(−6.963)
Joint significance test								
R2	0.268	0.124	0.197	0.522	0.695	0.190	0.156	0.775
F-statistics	2.750**	2.036*	2.150*	4.637***	4.819***	2.382	1.840	10.773***
Stability Analysis								
Test	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat
χ^2_{Normal}	1.103	1.538	0.619	0.781	0.144	1.043	0.619	0.144
χ^2_{serial}	0.540	0.515	0.457	1.429	1.472	0.394	0.457	1.472
χ^2_{ARCH}	0.237	1.657	0.198	0.049	0.524	0.192	0.108	0.524
χ^2_{Hetero}	1.117	1.435	1.881	1.990	0.578	1.774	1.381	0.457
χ^2_{Remsay}	2.283	1.116	2.576	2.352	0.882	2.108	2.762	0.880
CUSUM[a]	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable

*, ** and *** indicate significance at 10%, 5% and 1% levels respectively. () is the t-statistics.
[a] The diagram of CUSUM and CUSUMsq are available upon request from authors.

Arminen [30] and Tang and Tan [52]. The negative impact of institutional quality on emission is confirmed in Tamazian and Rao [50] and Ibrahim and Law [27]. The positive impact of urbanization, financial development and trade openness is consistent with the work of Omri et al. [37].

The positive long run impact of real foreign direct investment on emission confirms the fear of the opponents of free flow of international trade and investment flows. They argue that the presence of foreign-owned firms (multinationals) impairs the environment and ensures that local environmental regulations becomes suboptimal and weak (Cole & Elliott, 2005) [63]. In Ghana, foreign investment is fuelling rapid economic growth in the country, which is also a cause of emissions. Most of the foreign investment in Ghana are in the extractive sector, which is a heavy and polluting industry [1]. The positive impact of foreign direct investment on emissions can also be explained based on the fact that scale effects of foreign direct investment is likely to be greater than technique effect of foreign direct investment as the country is still a developing country. Through the scale effect, the environment is impacted from economic activity in two ways: depletion of natural resources and degradation of the environment [6]. The technique effect refers to the assertion that, if increased foreign direct investment raises income, emission intensity may fall since environmental quality is a normal good [6].

Economic growth and energy consumption are found to have positive impact on emissions, which is not surprising given the fact that economic activities through the deployment of fossil fuels, particularly the use of coal and oil are the major contributors to both total CO_2 emission and the CO_2 emission from petroleum related activities. The energy sector also accounts for most of the emissions at 41% [53]. In the energy sector, there is increased use of fuels for thermal power generation and poor energy efficiency is present in road transport [53]. The study further shows that financial development increases emissions in Ghana. This is not surprising as long-term bank financing is generally not easy to access. Financing for large infrastructure projects is not easy to obtain in Africa, even in countries where financial markets are well developed and mature. Banks in developing countries focus more on short-term debt financing and consider renewable energy projects as long term projects. Most investors have faced several difficulties in getting banks to finance their projects [18].

The positive impact of urbanization on emissions is explainable based on the fact that most emissions in Ghana are produced in the urban areas. An increase in urban population has led to rise in the population of vehicles, which generates vehicular-related pollution. For instance, air pollution in Accra is almost twice the regional average in Africa, and even higher than the average level of pollution in Chinese cities. Emissions from vehicles are responsible for 70% of total emissions in the country. Usually, the quality of the urban environment has been worsened by pollution from cars. However, anecdotal evidence suggests that vehicles continue to be the main source of pollution in the cities [36]. Motor vehicle air pollution was once a problem exclusively associated with the developed nations, but with rapid pace of urbanization combined with more desire for travel and personal mobility, the same scenario is now experienced in the developing countries [17].

An explanation for the positive role of trade openness on emissions in Ghana is the type of goods that constitute the bulk of Ghana's exports. For instance, in a resource-endowed country like Ghana, there is the tendency for trade to lead to increased output in environmental resource-intensive goods as a result of higher demand in the international market. With Ghana's comparative advantage in the production of natural resource-intensive goods such as cocoa, minerals, forest products, and the oil deposits discovered recently, it is worth considering that the growth in the exports of these goods may have negative environmental consequences on the country [7]. After gold and cocoa, timber and timber derivative products are the main exporting commodity in Ghana. In 2006, timber exports contributed 5.5% of Ghana's foreign exchange earnings. Notwithstanding the importance of timber and forest products to Ghana's economy, its continuous harvest has serious environmental consequences. The illicit harvest of timber and forest products for export and domestic use has led to the rapid depletion of vast areas of Ghana's rain forests [7].

The results show that institutions reduce emission in the country, which is similar to the main arguments that have been made in the past. The quality of institutions and policies can meaningfully decrease environmental degradation at low income levels and accelerate improvements at higher levels of income. In other words, better policies can help flatten the EKC. Better institutional quality may promote technological spill-over provided by foreign direct investment. Usually, countries including Ghana are expected to enjoy improvements to the environment with higher future income levels because institutional quality can reduce the environmental cost of higher economic growth [33].

5. Conclusion and policy implications

The primary objective of this study is to examine the link between foreign direct investment and CO_2 emissions in Ghana, while providing for real GDP, real GDP square, energy consumption, fossil fuels energy consumption and renewable energy consumption. The other control variables included in the model are urban population, financial development and trade openness during the period of 1980–2012. We further conduct a sensitivity analysis by using emissions from petroleum resources to proxy the level of emission in the country. We augmented the conventional ARDL approach with structural break to investigate the long-run link between the variables.

Our results indicated that all the variables are cointegrated for the long-run relationship when both total emissions and emissions from petroleum activities are entered as the dependent variables. We are able to establish pollution haven hypothesis in the country as the findings further revealed that there is positive impact of foreign direct investment on both total emissions and emissions from petroleum activities. It is also shown that real GDP, urban population, financial development and international trade have positive impact on emissions, while institutional quality decreases emissions in the country. The study was able to establish EKC in Ghana.

The meaning of these findings is that foreign direct investment is also contributing to the growing emission level in the country. Ghana has developed a comparative advantage pollution-intensive industries and become one of the “havens” for the world's polluting industries. The country, due to weaker environmental policy, become dirtier as it will specialize in dirty-goods production. While this negative impacts of foreign direct does not call for concerted efforts to reduce foreign direct investment because of its enormous positive impacts on the economy of Ghana; adequate efforts must be taken to ensure that real foreign investment does not continue to contribute substantially to the emission and the multinational companies involved in the country are not there because of stronger environmental policy elsewhere.

Foreign investment has helped Ghana in covering up the shortage of financial resources, skill workers, and technological know-how. The movement of human resources and expertise into the country has been one of the catalysts for economic growth. The inflows of foreign direct investment in Ghana has also helped in building a strong capital formation in the country and has bridge the local market to the international market. Therefore, the government should strengthen its environmental laws. Ghana's Environmental Protection Act of 1994 should be expanded to regulate the emissions of foreign companies operating in the country. Beside, Environmental Protection Agency in the country must also be empowered to have a greater oversight over the emission activities of the foreign companies. The different liberalization policies should be mindful of the environment. However, tackling emission from foreign companies might not generate a comprehensive solution to the rising emission in the country.

The institutional quality in the country should be improved. In this sense, it is noteworthy that governments can help to develop environmental disclosure by instituting solid institutional and policy frameworks that possess long-term benefits for greenhouse gas emission reductions. Good institutional environment will not only help in decreasing emission but also in reaping the maximum benefits from foreign investment.

There should be provision of finance targeted at reducing emissions in the country. The provision of finance would increase the mix of public and private investors in low carbon energy investments. The availability of grants could help accelerate dissemination activities for clean energy options and provide the necessary funding research and development (R&D) to stimulate energy efficiency [15]. As most African countries have small energy usage, the increasing level of energy consumption in Ghana might not be chiefly responsible for the climate change problem faced in the continent. While the mandatory actions on the part of governments in Ghana may not fully address the problem of environmental degradation; however, this will definitely stimulate more awareness and may coerce the developed countries to follow suit as authorities in the continent may now be seen as being serious about their environment [49].

Other developing countries can be benefit from the foregoing results due to the fact that they share many similar characteristics with Ghana. Similar to the case of Ghana, most of the developing countries are continuously experiencing increased in foreign direct investment and CO2 emission. According to World Bank [56]; the share of foreign direct investment in GDP of the lower-income middle countries (which Ghana belongs) has increased more than ten-fold between 1980 and 2012. Moreover, emissions in lower-income middle countries increased from 0.75 metric tons (oil equivalent) per capita in 1980 to 1.50 metric tons (oil equivalent) per capita in 2012 [56]. The implication of the results is that these countries should pursue green foreign direct investment that will boost economic growth but with very limited impact on environmental degradation. Similarly, most developing countries share similar institutional qualities of Ghana. The implication of the results for these countries is that they should improve their institutional quality as one of the means of improving environmental quality.

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