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EFFECT OF FEMALE POPULATION, URBANIZATION AND TRADE OPENNESS ON CARBON DIOXIDE EMISSIONS

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Abstract:
The agenda to reduce carbon dioxide emissions to mitigate climate change remains a global concern. Researchers, policymakers and governments have shown interest in this regard. While empirical studies on the subject matter have been increasing, conflicting results and little evidence on the effects of some variables necessitate further studies. In this study, the effect of female population, urbanization and trade openness on carbon dioxide emission in Ghana is assessed. The study used the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model as the foundation for empirical modeling. Time series data spanning from 1971-2018 was used for regression analysis. Urbanization was noted to influence carbon dioxide emissions positively in both long-run and short-run periods. In contrast, trade openness and the female population negatively affected carbon dioxide emissions. Thus, growth in urbanization increases carbon dioxide emissions, while the opposite is the case for trade openness and the female population. The study's findings suggest that intensifying women's empowerment could be a crucial catalyst for achieving Ghana's nationally determined contributions toward CO2 reduction. Also, trade negotiations that promote environmental protection should not be relaxed.

Keywords: Gender, Carbon Dioxide Emissions, Trade Openness, Urbanization

INTRODUCTION

The importance of environmental sustainability has become a topical issue over the last decade. Its importance lies in its promotion of human health, ecosystem, food security and prevention of the depletion of natural resources. As a global concern, it requires committed actions from developed and developing countries to change their way of life (Smith, 2020). The pace of forest degradation, climate change and global warming and their threats have heightened concerns for environmental sustainability among world leaders, researchers and practitioners (Alkhidir & Zailani, 2009; Gholami et al., 2016; Wiernik, Ones, and Dilchert, 2013). They are all geared toward balancing environmental, social, and economic needs (Caniato et al., 2012).

Towards the attainment of a sustainable environment, there is consensus to reduce greenhouse gas (GHG) emissions like carbon dioxide (CO2) emissions, methane (CH4) and nitrous oxide (N2O) (Kwakwa et al., 2022). The reason is that these gases trap heat from the sun and warm the earth/increasing the temperature of the earth and leading to global warming and climate change (Avishek and De, 2020; Kopidou & Diakoulaki, 2016; Wanapat et al., 2015). Among the GHGs, CO2 emissions form about two-thirds (Lim et al., 2022). Consequently, this has been the focus of many researchers over the years. World Bank (2021) World Development Indicators show that global carbon dioxide emissions have increased over the past decade. It saw an increment from 23.3 million kt in 2000 to 29.2 million kt in 2009; by 2018, it had reached 34.0 million kt. Similarly, carbon emissions (metric tons per capita) were 3.81 and reached 4.60 in 2013. Despite the reduction later to

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4.43 in 2016, an upward trend has been seen from 4.48 in 2018. It is worth mentioning that the emissions levels have not been equal among developed and developing countries. Although African countries are among the least carbon-emitting economies, they are the hardest hit by climate change (Alhassan et al., 2019; Alhassan et al., 2022).

The focus of researchers has thus been on identifying actors that are responsible for CO2 emissions (Amilia et al., 2023). It has been documented that related to energy consumption (through burning fossil fuels), solid waste, trees (forests), land use changes, industrial processes, specific chemical reactions (namely, cement manufacturing), and transportation indeed give rise to CO2 emissions (Ansu-Mensah & Kwakwa, 2022; Churchill et al., 2021; Osobajo et al., 2020; Ansu-Mensah & Murad, 2019). Other factors cited in the literature include the usage of electricity, agricultural production and development, industrialization, population explosion, and chemical application in industries (Kwakwa et al., 2022; Kwakwa, 2021; Lin & Agyeman, 2019; Karmellos et al., 2021; Liu et al., 2021; Jiang et al., 2021).

While empirical studies on carbon dioxide emission abound, urbanization, trade openness, and population effect on carbon dioxide emissions are gaining attention in recent studies (Ibrahim & Law, 2016; Zhang et al., 2017; Purnama et al., 2023; Ngong et al., 2022; Aboagye et al., 2020). This may be due to the increasing pace of population and urbanization. It is projected to be about 8.5 billion people worldwide by 2030 and 9.7 billion by 2050 (United Nations, 2022). While over 50% of the global population lives in urban towns, the global urban population is expected to hit 6 billion by 2045 (World Bank 2020). These situations affect the level of carbon dioxide emissions in many ways. Increased population pressure can increase the loss of forest cover, vehicular traffic congestion and waste management problems, leading to higher carbon dioxide emissions (Adom et al., 2018).

On the other hand, the city compact theory argues that population pressure, especially urbanization, promotes efficiency in the usage of resources and, hence, can lead to lower carbon dioxide emissions (Adom et al., 2018). Since the late 1980s, when many developing countries, owing to their subscription to the IMF Structural Adjustment Programme/Economic Recovery Programme, were obliged to open their borders for more international trade, trade openness has increased among countries. The value of goods and services traded saw a 13% in 2020 and a 25% increment to reach $28.5 trillion in 2021 (UNCTAD, 2022). While trade openness can bring about competition to ensure efficiency and lower carbon emissions, it can equally trigger the acquisition of energy-intensive goods, which may increase carbon dioxide emissions (Twerefou et al., 2016).

Ghana's economy has witnessed some dynamics regarding urbanization, population and trade openness. Ghana's population prior to 2010 was mainly rural. However, since 2010, the number of urban population exceeded the number of rural population. Moreover, urban towns have increased since that period (Adams et al., 2017; Asabere et al., 2020; Songsore, 2020; World Bank, 2021). Trade openness has become a vital feature of the economy and trading activities. Although it has increased (Solarin et al., 2017; World Bank, 2021), it is expected to increase in the coming years, especially now that the country has become the headquarters of the Africa Continental Free Trade Agreement. The female population continues to dominate the male population in Ghana (Tawiah, 2011); however, there has been a reduction in the female share from 51.2% in 2010 to 50.7% (Ghana et al., 2021). The effect of gender on resource conservation has been explored in the literature (Kwakwa et al., 2022; Okumah et al., 2021; Odonkor & Adams, 2020; Adzawla et al., 2019; Mensah, 2012). However, when it comes to the effect of gender on environmental sustainability, there is scarce empirical evidence (Edumadze et al., 2013; Bugri, 2008; Gifford & Nilsson, 2014; McCright, 2010; Blocker & Eckberg, 1989) and scarcer for carbon dioxide emissions. It is argued that females are more concerned with the environment and thus protect it more than men (Lee, 2009; Davis & Fisk, 2014; Resurrección, 2013; Zelezny et al., 2000; Hunter et al., 2004). In developing countries, women suffer more when

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there is a scarcity of resources like water and firewood (Arku, 2015), for which reason they are more inclined to engage in activities that would protect the environment than men (Okumah et al., 2021; Hunter et al., 2004).

Following the above, this study examines the effect of trade openness, urbanization, and the female population on Ghana's carbon dioxide emissions to facilitate the development of appropriate policy formulation for attaining a low-carbon economy. The paper's contribution to the literature comes from the angle that it focuses on the effect of the female population on carbon dioxide emissions. Thus, although many studies have analyzed the effect of various population dynamics on carbon dioxide emissions (Kwakwa et al., 2020; Yakubu et al., 2021), it is challenging to come across any on the female population's effect.

The remainder of this paper is structured as follows: section two reviews related literature, section 3 presents the methodology, section four focuses on the empirical results, and section five spells out the conclusions and policy implications.

Brief Literature Review. Studies on carbon dioxide emissions have increased over the past few decades. It shows the extent of attention researchers have given to attaining a sustainable environment. It has often been argued that economic activities pressure the environment, degrading its quality. For instance, international trade relies on energy to produce, export, and import goods and services. Thus, expanding international trade may lead to higher carbon dioxide emissions. Also, trade facilitates households' accessibility to energy-intensive equipment, possibly leading to higher pollution.

On the other hand, international trade enables countries to import energy-efficient gadgets for households and industrial use, which may lead to lower energy usage and carbon dioxide emissions (Aboagye, 2017; Adom et al., 2018). Empirically, Leitão and Balogh (2021) found that international trade reduces carbon dioxide emissions among European Union countries. Earlier, Leitão (2021) found that trade intensity reduces carbon dioxide emissions in Portugal. However, Charfeddine and Khediri (2016) found that trade increases carbon dioxide in the United Arab Emirates. Vural *(2021) also obtained trade openness's positive effect on sub-Saharan Africa's carbon emissions. In Ghana, Abokyi et al. (2021) also showed that trade openness increases carbon emissions, but Boateng (2020) found the opposite effect for Ghana.

Some studies have also reported mixed results. For example, Ansari et al. (2019) also found mixed evidence in their study when trade was found to reduce carbon dioxide emissions in the USA and Saudi Arabia but increased emissions in Canada and Saudi Arabia. In the case of Iran, Australia and Spain, they found insignificant effects. Kim et al. (2019) analyzed the effect of trade and found conflicting results in the sense that trade with the North is associated with an increase in CO2 emissions, whereas trade with the South reduces. Also, advanced countries' trading activities with the South or the North reduce carbon emissions, while developing countries trading with the North lead to higher CO2 emissions. However, the opposite is the case when they trade with the South.

Also, population pressure is noted to affect the level of carbon dioxide emissions. Population growth implies more mouths to feed, people to accommodate, and office spaces to be provided. Consequently, more energy is consumed, leading to higher carbon emissions. Land space also becomes limited due to population pressure. More lands are cleared for farming and accommodation as urban town population increases, reducing forest cover and increasing carbon dioxide emissions. However, some argue that population pressure like urbanization associated with a conglomeration of businesses tends to lead to lower carbon emissions due to economies of scale (Kwakwa & Alhassan, 2018; Adom et al., 2018).

Regarding population pressure, various studies have examined the effect of urbanization, population density and dependency ratio. For instance, the works of Adusah-Poku (2016) and

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Boateng (2020) showed that urbanization increases carbon dioxide emissions in Ghana; Boamah et al. (2021) found similar results for China. However, Saidi et al. (2017) found that urbanization reduces carbon dioxide emissions in emerging countries, and Asumadu-Sarkodie and Owusu (2017) found that urbanization positively affects Senegal. The effect of gender on carbon dioxide emissions has not been much investigated. Women are argued to be more concerned with a sustainable environment than men since the former suffer the most from environmental degradation (Kwakwa et al., 2022). Women are, therefore, noted to engage in conservation practices than men. Studies like Ghasemi et al. (2021) and Uliczka et al. (2004), among others, have also confirmed that women engage in activities that positively affect environmental management.

The above review shows that studies on carbon emissions have gained researchers' attention. However, only some studies have analyzed the effect of trade and urbanization in Ghana, with reported conflicting results. Also, the effect of the female population on carbon dioxide emissions has yet to be given much empirical analysis. These issues make it necessary for the current study to be embarked upon.

METHODS

Conceptual and Empirical Modeling. The concept of sustainable development since 1987 has been used to campaign that societies should meet their current needs without compromising the needs of future generations. It thus encompasses three main pillars: the economy, society and environment. The environment pillar focuses on protecting the environment from being destroyed by human activities geared towards meeting current needs. The idea from this pillar is the need to properly manage human activities that put pressure on the environment so as not to disadvantage future generations. Accordingly, the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model has been developed to assess which factors may have environmental effects. The model argues that environmental Impact (I) is attributed to population (P), affluence or economic activities (A), and technology (T). It is expressed in a stochastic form as:

$$I = a.P^{\beta}.\ A^{\lambda}.T^{\sigma}.v$$

The variables a, β, λ, σ, δ and v are parameters to be estimated. Since carbon dioxide emission (CO2) is a significant contributor to GHGs, it is considered an environmental problem (Minlah & Zhang, 2021). Carbon emission is taken as Impact (I). Female population (FEP) and Urban population (UBS) are used to denote (P) population pressure, and affluence is denoted by trade openness (TO), which contributes significantly to Ghana's income level. Trade has also been associated with the wealth of a nation (Froyen, 2013).

$$CO_2 = a.FEPO^{\beta}.UBS^{\lambda}.TO^{\sigma}.TEL^{\delta}.v$$

Transforming the natural logarithm of equation 2 gives:

$$LCO_{2t} = v + \beta LFEPO_t + \lambda LUBS_t + \sigma LTO_t + \delta LTEL + \vartheta_t$$

Data and Estimation Techniques. World Bank's (2021) World Development Indicators is the source for all the data used in this study. Carbon dioxide emission is measured by CO2 emissions in metric tons per capita; the female population is the share of females in the total population; urbanization is the urban population as a share of the total population; trade is measured as the sum of exports and imports as a share of GDP and telecommunication is measured as several telephone

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subscribers. These proxies are consistent with previous studies (Aboagye et al., 2020). Time series data usually contain unit roots, which can lead to spurious results. To avoid this, it is essential to ascertain the stationarity property of the variables. If a variable is stationary, it is free from the unit root. If a variable is not stationary at levels, the first difference is taken to verify whether stationarity is confirmed. This study used the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Zivot-Andrew (ZA) unit root tests to assess the stationarity property of the variables. The ADF and PP are appropriate for the sample size used for this study. However, a variable containing a structural break may not give credible results. Consequently, the practical ZA test in the presence of structural breaks is also employed to confirm the results.

Then, we tested for the long-run relationships among the variables using the Autoregressive Distributed Lag (ARDL) Bounds approach, which is ideal for a mixture of variables integrated of order zero I (0) and one I (1). After establishing the long-run relationship, the study proceeded with ARDL regression to estimate equation 4. This technique uses the lags of both dependent and explanatory variables for regressors. The maximum lag selected was 4 based on the Akaike information criterion. The choice for this estimation method is predicated on the fact that it is ideal for cointegrated variables of different orders of integration and can address the potential endogeneities associated with the models, unlike estimators like the ordinary least squares technique. The ARDL framework of equations (4) can be presented as respectively follows:

$$LCO_{2t} = \upsilon + \beta LFEP_t + \lambda LUBS_t + \sigma LTO_t + \delta LTEL + \vartheta_t$$

$$\Delta LCO_{2t} = \rho_1 + \Sigma\pi_1\Delta LCO_{t-i} + \Sigma\beta_1\Delta LFEP_{t-i} + \Sigma\lambda_1\Delta LUBS_{t-i} + \Sigma\Omega_1\Delta LTO_{t-i} + \Sigma\eta_1\Delta LTEL_{t-i} + \varphi_{11}LCO_{t-i} + \varphi_{12}LFEP_{t-i} + \varphi_{13}UBS_{t-i} + \varphi_{14}LTO_{t-i} + \varphi_{15}LTEL_{t-i} + \upsilon_2 ecm_{t-1} + e_{1t}$$

P1 is drift components, and e_{1t} is the white noise error term. The terms with summation signs (Σ) represent the short-run dynamics, and the second part of the equation with the coefficient φij corresponds to the long-run relationship. The ecm_{t-1} is the error correction term, with coefficient υi referring to the speed of adjustment to long-run equilibrium and Δ is a difference operator. After the estimation of the short and long-run coefficients of the explanatory variables, diagnostic tests of normality, heteroscedasticity, serial correlation and stability were conducted to establish the adequacy of the model.

The Fully Modified Ordinary Least Squares (FMOLS) and the Canonical Cointegration Regression (CCR) were estimated to confirm the long-run results from the ARDL technique. The variance decomposition analysis is also used to ascertain the contributions of the drivers of carbon dioxide emission following a shock. Toda Yamamoto's causality analysis is used to ascertain the causal relations among the variables.

RESULT AND DISCUSSION

Unit Root and Cointegration Results. Unit root tests from the ADF, PP and Zivot-Andrews approach are Table 1. All three tests confirm that trade openness, telecommunication, and carbon dioxide emission are stationary in the first difference. Also, the ADF and PP do not confirm stationarity at levels, and the first difference between the female population and urbanization, ZA, reveals that they are stationary at levels. These results indeed show that the ADF and PP may give misleading results in the presence of structural breaks. The attainment of stationarity for the variables at levels and first difference implies the variables can be used for regression analysis without getting a spurious outcome. In Table 2, cointegration results using the ARDL approach were reported. The results reveal that cointegration exists between carbon emission, female

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population, urbanization, trade openness and telecommunication. Thus, female population, urbanization, trade openness and telecommunication can be behind Ghana's carbon dioxide emission level.

Table 1. Stationarity Tests Results

	ADF, t-statistic		PP, t-statistic		ZA, t-statistic	
Series	At levels	First difference	At levels	First difference	At levels	First difference
LTO	-0.8724	-8.3895***	-0.8174	-8.2845***	-4.1203 (1986)	-8.1243*** (1983)
LFEPO	-2.3353	-0.3106	-1.4922	-1.933	-8.9976*** (1984)	-
LUBS	-3.6128		0.7000		-5.5100*** (1985)	-
LTEL	-0.8724	-8.3895***	-0.8174	8.2845***	-4.1203 (1997)	-9.2872*** (2008)
LCO2	-0.7653	-8.4095***	-0.4531	-8.6065***	-3.9737 (1984)	-9.3560*** (1992)

*** means significant at a 1% level

Table 2. Results of the Cointegration Test

Test Statistic/Significance	Value	k
F-statistic	5.080604	4
Significance	Lower Bound	Upper Bound
10%	2.45	3.52
5%	2.86	4.01
1%	3.74	5.06

Regression Results. The regression results reported in Table 3 show that urbanization, female population and trade openness significantly determine Ghana's carbon dioxide emissions level in the long run. Trade openness and the female population have a negative relationship with carbon dioxide emissions, while urbanization positively affects carbon dioxide emissions. In the short run, results reported in Table 4 also indicate that trade, female population and urbanization significantly affect carbon emissions in Ghana.

The significant negative effect of trade on carbon emissions demonstrates that CO2 emissions are reduced with greater openness of the Ghanaian economy to international trade. Since trade openness comprises exports and imports, then greater trade openness and, for that matter, declining CO2 emissions implies a rise in either one of these components or both. Ghana's exports emanate primarily from the extractive and agricultural sectors, such as oil, gold, cocoa etc. At the same time, imports are widely diversified, including but not limited to daily consumables, durables, automobiles, technology etc. The very nature of the country's export composition has the potential to put upward pressure on CO2 emissions. However, the overall trade openness- CO2 emission nexus established by the study shows that this may have been entirely counteracted by its import composition to the extent that the net effect results in a decline in CO2 emissions. The results also indicate that trade openness has enabled the Ghanaian economy to benefit from importing energy-efficient technologies for industrial and household gadgets. Previous studies in Ghana, including Kwakwa et al. (2020), reported a negative coefficient of trade openness but an insignificant effect on

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carbon emissions. Aboagye (2017) estimated that trade positively affects carbon dioxide emissions. The differences in the results could be attributed to the variations in the data set used in the studies.

Moreover, recent efforts by the government to attain a low-carbon economy could have triggered trade openness to reduce carbon dioxide emissions. Estimated results by Ibrahim and Law (2016) showed that trade openness reduces carbon dioxide emissions in sub-Saharan Africa. Elsewhere, Zhang et al. (2017) have reported similar findings.

Table 3. Long Run Regression Results

	ARDL RESULTS		FMOLS RESULTS		CCR RESULTS	
Variable	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
LTO	-0.7476***	0.148103	-0.3435***	0.088610	-0.3443***	0.099691
LFEPO	-10.4583***	2.321671	-4.3930***	1.266702	-4.3425***	1.053916
LUBS	19.9188***	4.257700	9.1419***	2.427370	9.0854***	2.112345
LTELE	0.1009	0.115890	0.0641	0.116456	0.0604	0.120684
C	93.7154**	22.185746	35.6834***	12.06003	35.1354***	9.882797

*** and ** respectively means significant at 1% and 5% level

Table 4. ARDL Short Run Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTO(-1))	-0.267365	0.117607	-2.273377	0.0291
D(LFEPO)	-4.671102	1.205137	-3.875994	0.0004
D(LUBS)	8.896527	2.251196	3.951911	0.0003
D(LTELE)	0.045084	0.052553	0.857881	0.3966
ECM	-0.446639	0.097713	-4.570949	0.0001

It is also observed that an increase in the female population is associated with a decline in CO2 emissions. Researchers have indicated that women are more conservative regarding the environment than men (Kwakwa et al., 2022). Many females prefer to use cleaner energy sources to meet their domestic fuel needs since they tend to be adversely affected by fuelwood and other forms of traditional fuels (Das et al., 2014). They are also found to consume less processed meat and beverages, leading to lower carbon emissions. Although Ghana's gender population has closed recently, the female population remains dominant. Women in the country travel more in public transport than men, while those women who own private vehicles embark on fewer trips than men. Based on the above, it is not unreasonable to expect CO2 emissions to reduce as the country's population becomes increasingly female-dominant. At the household level, studies like Kwakwa and Adu (2015) have reported that female households engage in pro-environmental behavior. The gender structure implies that the country could harness its female population to achieve environmental sustainability, primarily through reduced CO2.

The study further reveals that increased CO2 emissions accompany urbanization in Ghana. It could result from rural-urban migration, which puts pressure on urban towns. Urbanization is often associated with clearing forest cover and putting up high-storey buildings. The former leads to the loss of forest cover, which could have absorbed carbon dioxide emissions. The latter also requires energy to transport many of the building materials. These two combined lead to higher carbon dioxide emissions.

Moreover, it must be acknowledged that urbanization is frequently a by-product of industrialization, which entails significant use of materials and fossils that emit CO2. In addition to the above, the traffic congestion in Ghana's urban towns, the slum conditions and waste management problems could lead to higher carbon dioxide emissions. The findings fall in line with

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Yuzhe et al. (2016) for China, Wang et al. (2019) for China, Anser et al. (2020) for SAARC countries and Musah et al. (2021) for West African countries.

Table 5. Diagnostics Results

Diagnostic	Test	F-statistic	Probability
Normality	Jarque-Bera	3.68	0.15
Serial correlation	Breusch-Godfrey	2.14	0.15
Heteroskedasticity	Harvey	0.68	0.70
Stability	Ramsey RESET	0.58	0.56

In Table 5, diagnostic test results for the regression analysis are reported. It reveals that the regression results do not violate the critical assumption of the linear regression about the error term. Thus, normality, serial correlation, and heteroskedasticity tests confirm that the residual term is usually distributed and does not suffer from autocorrelation and heteroskedasticity. Also, the stability test confirms that the model is stable over the period. CUSUM and CUSUM of a square shown in Figure 1 and Figure 2, respectively, confirm the stability of the model over the period. These diagnostic tests, therefore, reveal the robustness of the model.

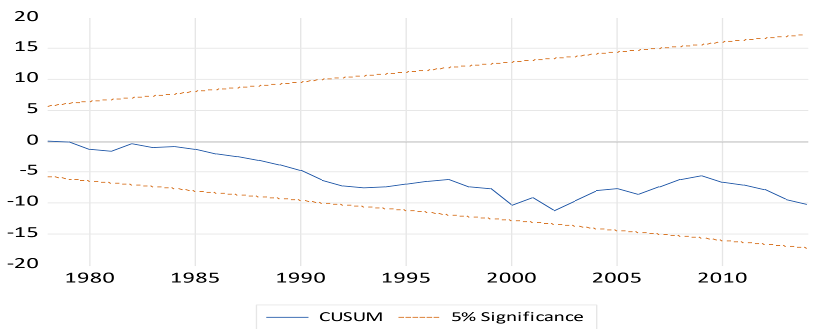

Figure 1. CUSUM stability

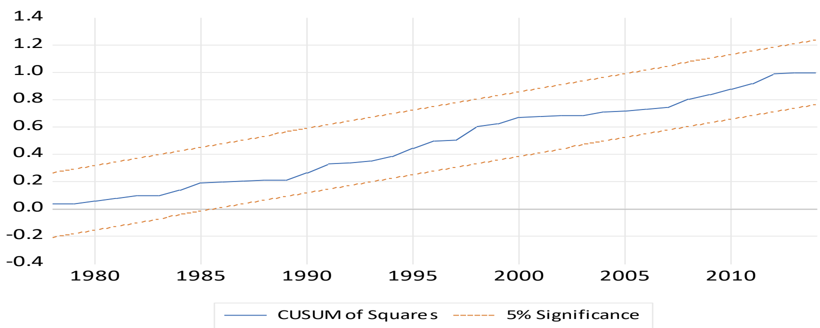

Figure 2. CUSUM of Squares Stability

Table 6. Causality results

	DEPENDENT VARIABLES				
	LCO_2	LTO	LTEL	LUBS	LFEPO
Explanatory variables		Chi-sq			
LCO_2		4.94*	0.08	4.758*	4.172
LTO	11.82**		5.66*	0.258	17.267***
LTEL	0.070	0.921		5.453*	2.443
LUBS	7.483**	7.43***	0.468		164.74***

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LFEPO	0.05	6.38**	1.414	9.357***

***; ** and * respectively means significant at 1%; 5% and 10% level

Table 7. Variance Decomposition Results

Period	S.E.	LCOPC	LTO	LTELE	LUBS	LFEPO
1	0.121280	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.136305	98.40172	0.498004	0.002940	1.093810	0.003529
3	0.144387	96.58427	0.743530	0.034767	2.633994	0.003440
4	0.147798	95.47884	0.746063	0.043624	3.725477	0.005994
5	0.149202	94.93741	0.741769	0.043953	4.270788	0.006083
6	0.149782	94.65370	0.813411	0.045057	4.472337	0.015492
7	0.150117	94.40677	0.928835	0.050066	4.532675	0.081653
8	0.150439	94.09188	1.032673	0.055552	4.550324	0.269572
9	0.150840	93.66040	1.094467	0.058506	4.562950	0.623678
10	0.151355	93.09388	1.115277	0.058949	4.593087	1.138811
11	0.151980	92.41158	1.112346	0.058467	4.660355	1.757256
12	0.152665	91.67654	1.102468	0.058292	4.772024	2.390674
13	0.153329	90.98037	1.093954	0.058549	4.914617	2.952514
14	0.153885	90.41143	1.087721	0.058725	5.057952	3.384173
15	0.154277	90.02357	1.082631	0.058539	5.169386	3.665876
16	0.154495	89.81846	1.080088	0.058504	5.229801	3.813152
17	0.154581	89.74574	1.085452	0.059886	5.243985	3.864936
18	0.154615	89.71821	1.106357	0.064188	5.241971	3.869278
19	0.154687	89.63598	1.149400	0.072464	5.271531	3.870629
20	0.154881	89.41240	1.217041	0.084805	5.384770	3.900980

Causality and Variance Decomposition Analysis. Table 6 shows the causal relationships among the variables. Urbanization and trade openness granger cause carbon emission; urbanization and female population granger cause trade; female population, telecommunication, and carbon emission granger cause urbanization; and urbanization and telecommunication affect female population (Anjarasoa, 2024). It suggests a bidirectional relationship between trade and carbon emission, carbon emission and urbanization, and trade and the female population. A unidirectional causality is also noted when moving from trade to telecommunication. The variance decomposition analysis used the Cholesky decomposition to assess the actual contribution of urbanization, female population, trade organization and telecommunication to carbon dioxide emissions over the years. Table 7 shows that all variables increase their share of the impacts over twenty years. Urbanization throughout the period exerted the most significant influence, followed by the female population, trade openness and infrastructure. In period 1, the share of urbanization, female population, trade and telecommunication was 1.09%, 0.003%, and 0.49%, respectively. Urbanization's influence then increased to 4.27% in period 5, 4.59% in period 10 and 5.38% in 20th period. Within the same period, the female population also saw its effect increase to 0.006%, 1.13%, and 3.90%. The share of trade was 0.04% in period 5, 1.11% in period 10, and 1.21% in the 20th period.

CONCLUSION

Attainment of lower carbon dioxide emissions remains a critical concern to both developing and developed countries. Researchers have, therefore, investigated the drivers of carbon dioxide emissions. Since many issues are still of concern, this study investigated the effect of trade openness, female population and urbanization on Ghana's carbon dioxide emissions. A time series sourced from the World Bank (2021) was used for this study. Data was analyzed using regression and

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variance decomposition analysis. Regression analysis showed that trade openness translates into lower carbon dioxide emissions; the female population reduces carbon dioxide emissions, and urbanization increases carbon dioxide emissions. A variance decomposition analysis showed that the most significant effect comes from urbanization over 20 years. The female population and trade openness followed it.

The results from the above have many implications. Urbanization has become part of Ghana's economy. It has been occasioned by the high spate of rural-urban migration mainly because of the quest to seek greener pastures in the urban areas. Since it may be challenging to deurbanize Ghana, measures can be implemented to reduce further urban growth and the environmental pressure associated with urbanization. Thus, the government needs to begin to focus on rural development. It could balance the country's development and subsequently reduce rural-urban migration. Moreover, conscious efforts to reduce congestion by promoting an efficient public transport system are crucial. Law enforcement agencies must strictly ensure that industries mainly found in Ghana's urban areas adhere to safer environmental practices.

This. The finding suggests that Ghana can remain on its current trade openness trajectory as part of its broader objective to contribute meaningfully to the global fight against climate change. The positive environmental gains from trade openness in Ghana should draw the attention of authorities to be conscious of trade negations with trading partners. Negotiations with partners that promote environmental protection should not be relaxed. It is recommended to maintain, if not increase, import duties on gadgets harmful to the environment through carbon dioxide emission while imposing lower duties on equipment, leading to lower carbon dioxide emission.

The study's outcome implies that Ghana can rely on the female population to reduce carbon dioxide emissions. For this reason, efforts need to be put in place to enhance the living conditions of the female population in the country. The country can benefit from the female population in terms of the quality of the environment by further enhancing their capacity to engage in environmentally friendly practices. This way, intensifying women's empowerment through girl-child education, female literacy, female labor force participation, and women's parliamentary representation could be a crucial catalyst for achieving Ghana's nationally determined contributions toward CO_2 reduction.

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